Datsun camshafts & Valve Timing by Racer Brown

Chapter Thirteen

PISTON MODIFICATIONS FOR VALVE CLEARANCE

Now about those pistons. For some strange and mysterious reason, nearly everyone associates maximum valve lift with a panic-stricken thought of the need to gouge great holes in the pistons for piston-to-valve clearance. Ridiculous! With most L-series Datsun camshafts, maximum intake valve lift usually occurs from about 102 to about 110 degrees ATC, and maximum exhaust valve lift usually occurs at about the same number of degrees BTC. Now how in the wide world can a valve get tangled up with a piston when the piston is that far down the cylinder bore, out of reach of the valve? Obvious answer: It can't. The problem of piston-to-valve interference simply does not exist at maximum valve lift if the valve timing is correct. The problem occurs much earlier in the cycle with the intake valve and mush later in the cycle with the exhaust valve. Consider: Tracing the piston past TC of the compression stroke and the power stroke starts. Before the piston reaches BC of the power stroke, the exhaust valve starts to open and continues to do so until maximum valve lift is reached, then it starts to close. Meanwhile, the piston has passed BC and is heading toward TC again on the exhaust stroke. At a point before TC, the intake valve starts to open, and for some period of crankshaft rotation, and therefore piston travel, the intake valve and the piston are on a direct collision course. The only thing that prevents a catastrophe is that the piston slows down as it approaches top centre, meanwhile the intake valve continues to open, and the exhaust valve is still closing. As the piston passes TC of the exhaust stroke and heads toward BC on the induction stroke, first the exhaust valve closes at some point past TC while the intake valve is still opening. Later, but before the piston reaches BC, the intake valve reaches the point of maximum lift and starts to close. As the piston passes BC of the induction stroke and starts toward TC on the compression stroke, the intake valve closes at some point past BC. Both valves will stay closed for the remainder of the compression stroke and for the larger part of the power stroke, when the exhaust valve starts to open again to repeat the cycle.

So when are the valves closest to the piston? During the valve overlap period when both valves are open toward the end of the exhaust stroke and the beginning of the induction stroke. Before TC of the exhaust stroke, the piston is sort of "chasing" the exhaust valve closed, but the intake valve is opening directly toward the advancing piston. Therefore, with all but some freak camshafts, the intake valve comes closest to the piston at a point after TC of the induction stroke, and the exhaust valve comes closest to the piston at a point before TC of the exhaust stroke.

Let's assume the three worst condition:

1. Actual piston-to-valve contact.
2. Required depth of valve reliefs in the piston is unknown.
3. Correct location of the valve reliefs in the piston is unknown.

These conditions could be encountered in an engine with stock flattop pistons, and these pistons can indeed be machined for valve reliefs; not the excessively - but some - and probably more than you'd expect. An after market piston may be necessary to satisfy the piston-to-valve clearance requirement. Most of these are forgings equipped with valve reliefs, which can be sunk considerably deeper because the piston crown has additional material thickness.

It must be carefully noted and logged which valve touches the piston and at what point. Observe the degree wheel carefully to determine location, at the same time rotating the crankshaft slowly and pressing down on each rocker arm until contact is made. Assuming both valves tag the piston, the exhaust valve will make contact first at a point BTC on the exhaust stroke. When this point has been located and logged, simply remove the exhaust rocker arm and continue to rotate the crankshaft until the intake valve contacts the piston at a point ATC on the induction stroke and log this point too. This will give two starting reference points, which will change after the piston has been relieved. But for the purpose of actually relieving the piston, this must be done at exact TC.

In any case, number 1 piston must be installed correctly with the piston pin offset (if there is an offset) pointed in the right direction. With stock pistons, the offset side of the piston must be installed on the LEFT side of the engine when viewed from the front. Rotate the crankshaft until the piston is at exact top centre. Remove the number 1 intake and exhaust valve assemblies from the cylinder head. Replace the valves with a pair of junk valves, preferably about 1/8-inch larger in diameter than the service valve. The condition of these valves is unimportant as long as they are not bent. Hold them in place with pieces of masking tape around the stems close to the tops of the valve guides, then place the cylinder had on the block, again with a used but usable head gasket, install the cylinder head bolts around number 1 cylinder and torque them down fairly snugly. If wither or both valve heads are so large they contact the cylinder bore before they touch the top of the piston, grind a flat on the valve heads so they clear the cylinder bore but keep the valves oriented so the lower segment of the valves (the area closest to the piston) are still round. Double-check the degree wheel to be certain the crank hasn't moved. Remove the masking tape from the intake valve stem and let it drop down the valve guide until the valve head contacts the piston top. Give the valve stem tip a whack or two with the hammer; hard enough to leave a visible crescent-shaped indentation in the top of the piston, but not hard enough to drive the valve through the piston, or damage the piston in any way. If the valve stem tip drops too far down the guide bore to reach the tip with

a hammer, use a j-inch flat-faced pin punch to reach the valve stem tip, then whack the punch with a hammer. Repeat the process with the exhaust valve, raise the valve until they are seated, with the help of a small screwdriver poked through the spark plug hole if necessary, and re-tape the stems to hold the valves in place. Rotate the crank until the piston is about an inch down the bore, then insert a small medical probe light through the spark plug hole and observe your hammer-work. The crescent-shaped indentations must be sufficiently well defined to establish positive location of the required valve reliefs on the piston top. If they aren't, rotate the crank until the piston is at exact TC again, then have another flailing session with the hammer. It helps if the O.D. of the valve head is sharp so less effort is required to leave visible marks, thereby reducing the possibility of damaging the piston. If all is well, remove the cylinder head and the valves, remove the piston and connecting rod assembly and remove the piston pin from the piston. Now remove yourself to a friendly machine shop equipped with a Bridgeport or similar vertical mill and decent clamping devices so the pistons can be held firmly in the ring belt area without distorting or collapsing them. If the valves used to mark the piston were 1/8-inch larger in diameter than the service valves, the cutters that will form the valve reliefs in the pistons should be the same diameter and with a radius of 0.060-inch at the outer edges. Initially, the valves used to mark the pistons can be used in the mill spindle to align the marks in the piston with the mill spindle, if the valves weren't bent during the hammer exercise. If stock pistons, or other pistons with offset piston pin bores are to be modified with valve reliefs, the pistons MUST be oriented in the clamping fixture from the piston pin bores to prevent gouging the pistons on the wrong side. You don't need a spare set of ashtrays. The angle formed by the intersection of the centrelines of the valve stems and the cylinder bores is nominally 12-degrees, so either the clamping fixture or the mill spindle must be at this angle and locked in place. The angle may vary slightly from one cylinder head to another, but the 12-degree number is the place to start.
The piston crown of a stock piston is about 5/16-inch thick near the centre of the piston and slightly thicker toward the outer edge. This means that the stock pistons can be safely machined for valve reliefs to a depth of 0.125-inch from the top surface of the piston crown IF and ONLY if there is a radius of at least 0.060-inch at the bottom of each relief. This leaves a nominal crown thickness of about 3/16-inch at the thinnest point which, of course, is at the bottom of the relief. The crown thickness increases as the relief approaches the top surface of the piston. Normally, the remaining 3/16-inch crown thickness is adequate for any application involving the use of stock pistons. It must be pointed out that the 5/16-inch total crown thickness is an average figure; some pistons may be thinner in this area than others, so it is certainly advisable to make some careful measurements before arbitrarily gouging the pistons 1/8-inch and finding out later (the hard way) that the 1/8-inch was too much.

The purposes for using 1/8-inch larger diameter valves for marking the piston should be apparent. First, this practice permits a radius of 0.060-inch in each valve relief and this radius should be considered minimum and it will normally prevent the service valves from tagging any part of the radius. If a larger diameter cutter is used to form the valve reliefs, the corner radius of the cutter should be increased proportionally. Example: If a cutter j-inch larger in diameter is used to machine the valve reliefs, then increase the cutter's corner radius from 0.060-inch to 0.120-inch. The corner radius in the valve reliefs is highly important because it reduces the possibility of generating stress risers in the pistons, particularly at the higher temperatures under which the piston must function. Sharp corners in the piston reliefs are O-U-T, so don't even think about it. The larger the corner radius can be made, the better, as long as the edge of the valve doesn't interfere with the radius. The seemingly larger-than-maybe-really-necessary size valve reliefs also provide extra room around the vales for improved breathing. Remember? Lots of room around the valves? In addition, the oversize reliefs allow for slight variations of the location of the valves in the cylinder head in relation to the reliefs in the pistons. Some after-market pistons leave some doubts about the accuracy of valve relief location, size and depth, so the mark 'em and machine 'em process should be conveniently applied to these as well.

If you're a confirmed do-it-yourselfer and you want to save a few bucks and time is no object, the same results can be accomplished in the following manner. With a short length of air-hardening tool steel 3/16-inch square, grind it to size and shape to form a cutting tool, with a rake angle, relief angle, corner radius, etc. When this has been carefully done, finish off the cutting edges with a sharpening stone, then silver-solder the cutter across the head of a junk but straight valve with the radiused end overhanging the valve head enough so the service valve will clear the radius. Only one cutting edge is needed, from the centre of the valve to the end of the cutter, so the end opposite the cutting edge must be relieved so it cannot contact the piston. Silver soldering should bring the cutter to critical temperature, then let it cool in air and it will be hard enough for this operation. Two of these cutters are required; on for intake valve reliefs, on for exhaust valve reliefs. The cutting edge itself should be located as close to the centre of the valve head as you can eyeball it, otherwise the surface finish of the reliefs may no be as smooth as it should. Install all pistons, making certain the offset piston pin bores are pointed in the right direction. Bring number 1 piston to exact TC, install one cutter in its respective valve guide, orient the cutter to the spark plug side of the combustion chamber and gently drop the cylinder head in place, but don't bolt it down yet. Rotate the cutter stem by hand to see that it clears the piston. If the cutter hangs up on the edge of the cylinder bore, you're out of luck; the valve reliefs must be machined in the pistons with the pistons removed from the cylinder block. Usually, this will only occur with the largest valve head diameters, but may occur with the next-to-largest valve head sizes as well. If the cutter clears the bore edge, bolt the head in place.

Be careful here. You don't want an intake valve-sized relief for an exhaust valve. Or, much unfunnier, you don't want an exhaust valve -sized relief for an intake valve; the intake valve ain't gonna fit. And don't try to use both cutters at the same time; they overlap each other, or should if they're the right sizes.

If there are no entanglements, mark a small spot on the valve spring seat in the cylinder head. Rotate the cutter until the valve stem tip sticks as far out of the valve guide bore as it is going to. Use a depth micrometer to make this measurement from the valve stem tip to the mark in the valve spring pocket. This is not the time for yardstick measurements or guesstimates. Verify the cutter position by peeking through the spark plug hole.

 Back to Menu  Back to Twelve Chapter Fourteen