The following procedure is applicable to both Formula Ford and Formula Vee. Where specific differences occur, the procedure will note such instances and list the variance. This procedure may be replaced in its entirety with the use of a Cam Pro Plus, Cam Doctor.

Equipment

1. Dial indicator – minimum .500 capacity reading .000".
   A more sophisticated fixture can be arranged than those normally supplied with dial indicator kits. One with a magnetic base or a fixture attaching to a stud which is pre-arranged and quickly used is essential.

2. Degree wheel – Iskenderian or similar type is recommended. If attached to distributor shaft, the degree wheel must be remarked to read a total of 720 degrees with two TDC's and two BDC's.

3. Indicating pointer made of a strip of metal or wire, to be attached to cover plate stud on Hewland or located on engine stud.

4. Top Dead Center Locator – A spark plug base with the insulation removed and threaded for a 3/8" – SAE x 2-1/2' cap screw. The cap screw is in turn threaded all the way to its head.

5. This cam must be plotted using the official SCCA graph. Additional copies available from SCCA National Office.

Procedure

1. There are four locations at which a degree wheel may be mounted.

   A. Front drive pulley (Formula Ford or Formula Vee)

   B. Flywheel (Formula Ford or Formula Vee)

   C. Lower output shaft of Hewland transmission (Formula Ford)

   D. Distributor shaft (Formula Ford)
   Use a 10-inch length of ½" EMT thin-wall tubing (conduit) slit 8 ways at one end and clamped to the distributor shaft in place of the rotor. The other end of the conduit should have a slip ferrule-to-box connector fitted to it. This fitting is used to secure the degree wheel to the conduit.

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2. Affix the indicating pointer in a convenient place on the engine or gearbox, so that it points directly over the degree wheel markings. Adjust it so that it reads T.D.C. when either the crankshaft pulley or flywheel is at manufacturer's T.D.C. marking.

3. The easiest way to rotate the engine (when installed in the vehicle) is to jack up the left rear wheel enough to clear the ground and place the gear selector in top gear. The engine can also be rotated by turning the front drive pulley nut or by prying against the flywheel teeth, of there is a timing access hole in the transmission adapter.

4. Remove all spark plugs.

5. Locate absolute Top Dead Center (TDC).

   A. Using a dial indicator

      1. Attach the dial indicator, either by magnetic base or post attached to head bolt so that its probe extends into the spark plug hole so as to contact the top of the piston as near its center as possible.

      2. Rotate the crankshaft until reaching what you guess to be the middle of TDC dwell. Set a stationary pointer at TDC on the degree wheel. Rotate the crankshaft one more revolution, and on the way up to TDC stop exactly .020" (dial indicator reading) below the maximum piston travel, which is TDC. Continue slowly on up to the TDC over the hump and down the other side. Watch the dial indicator closely, and when it reads exactly .020" down from TDC, stop and note the reading on the degree wheel. If you have a perfectly split overlap, it should read 10 degrees after TDC. If it doesn't, you have not hit TDC exactly and must try again.

      3. Split the difference (your error in degrees) by either bending the pointer slightly or moving the degree plate radially. After you have made the adjustment, come around with the crankshaft as before, stopping .020" below each side of TDC. When you get exactly the same degree readings .020" below each side of TDC, you have found absolute TDC.

      4. Extreme care must be used so that back lash through the gear train does not give a false TDC.

   B. Using A Top Dead Center Locator

      1. Insert the TDC locator into the #1 spark plug hole. The cap screw

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should be adjusted so that it touches the piston somewhere close to TDC (a lock nut should be used on the threaded shank of the cap screw so that it can be locked in its final position).

2. Rotate the engine in its normal direction of rotation. (If the degree wheel is mounted on the gearbox, a constant drag, by the use of a finger, must be maintained because of the backlash.) Read the angle on the degree wheel where the piston just touches the tip of the cap screw.

3. Rotate the engine in the opposite direction and read the angle on the degree wheel where the piston just touches the tip of the cap screw.

4. Adjust the pointer/degree wheel relationship so that the angles read in steps 2. and 3. Are equal.

5. "0" degrees, in the middle of 2. And 3., now represents an accurate TDC.

6. Using the exhaust/intake valve "set" for the same cylinder used to establish TDC, set the clearances to zero. Remove all valve lash. You should be able to just turn the two push rods between your fingers when zero valve lash is attained.

7. Fix the dial indicator firmly to the engine so that the plunger tip is located on either the exhaust or intake valve spring collar of the TDC zeroed "set" of valves. Make certain that the dial indicator plunger shaft is parallel with the valve stem. If not, scrubbing at the contact point will occur and a distorted reading or a non-return to zero will occur.

8. Pre-load the dial indicator to at least .100" greater than the lift-at-valve dimension you expect to read. This should be about .450" for F/F and .425" for F/V.

9. Zero the dial indicator and rotate the engine over a few times observing that the dial indicator returns to rest after each opening/closing cycle. Some fine adjustments of the zero point may be necessary.

10. Rotate the engine in a forward direction until absolute peak lift occurs. Record this amount and compare it to those maximums allowed for the category.

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	FF	FV w/ 1200 rockers	FV w/ 1300/1500 rockers
Intake	.356"	.334"	.354"
Exhaust	.358"	.3165"	.3365"

11. Move the dial indicator to the other valve of the "set" and repeat steps #7, 8, 9 and 10.

12. Remove the entire rocker assembly from Formula Ford or both banks of the Formula Vee engine.

13. Position the dial indicator so that the pick-up tip is centered on the tip of the selected push rod. (Formula F will be cupped and easy to center. Formula Vee can be carefully centered in the oil hole of the VW push rod.) Make certain that the push rod and the dial indicator plunger are exactly parallel.

14. Pre-load the dial indicator so that some pressure is placed against the push rod. Allow for the expected amount of travel so that the dial indicator is not jammed against its limit stop.

15. Zero out the dial indicator while the cam lobe is around on its heel. Back and forth rotation will determine absolute zero.

16. Using the official SCCA cam graph for the appropriate lobe (Intake and Exhaust) determine that point in relation to the degree wheel where opening should commence.

17. Rotate the crankshaft in its normal forward direction and note when the dial indicator starts its opening movement. Back off 10 or 20 degrees and slowly rotate the crankshaft forward until .001" lift is observed. Note the position of the degree wheel pointer. It should be approximately:

	FF	FV
Intake	75 degrees BTDC	60 degrees BTDC
Exhaust	35 degrees ATDC	70 degrees ATDC

NOTE: *This is approximate! Manufacturer's tolerances will be enough that variances during the first 10 to 15 degrees of opening and closing will be as much as 3 degrees or .0015" of lift.*

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18. On the official SCCA graph record the degree wheel positions during the opening and closing movement of the push rod.

FF (Intake and Exhaust)	FV (Intake)	FV (Exhaust)
.001"	.001"	.001"
.002"		
.005"	.005"	.005"
.010"	.010"	.010"
.015"	.015"	.015"
.020"	.020"	.020"
.025"	.025"	.025"
.030"	.030"	.030"
.040"	.040"	.040"
.050"	.050"	.050"
.100"	.100"	.100"
.150"	.150"	.150"
.200"	.200"	.200"
.210"	.250"	.250"
.220"		.275"
.225"	.280"	.280"
.230"		.285"
.231"		.288"
.232"		.289"
	.290"	
	.295"	
	.300"	
	.304"	

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NOTE: *If the degree wheel is mounted on the output shaft of the Hewland transmission, the backlash through the gears may be removed by lightly moving the degree wheel backwards after each movement of the crankshaft. This also applies to the distributor shaft method. ROTATE THE SHAFT ONLY! DO NOT TOUCH THE DEGREE WHEEL!*

19. After the one cam lobe has been checked and recorded, move the dial indicator to the other cam lobe of the "set" and repeat the previous steps

20. Analyze newly-plotted graphs using the following guide lines:

    A. If the plotted points are inside the official plot during the opening ramp and outside during the closing ramp, an equal amount at the same point of lift, the camshaft may be considered okay. If the opening ramp is inside the plot and the closing ramp outside a lesser amount, this would normally indicate wear. However, if the opening ramp is inside of the official plot while the closing ramp is outside the official plot by a greater amount (more than 1 degree) there is a possibility that the camshaft has been reprofiled.

    B. Similarly, if the plotted points are outside of the official plot on the opening ramp and inside on the closing ramp, the same amount or slightly less on the closing ramp, the camshaft is okay. However, if the opening ramp is outside the official plot by a greater amount that the closing ramp, there is again a possibility of a reprofiled camshaft.

    C. If the plotted points are outside of the official plot on the opening ramp and also on the closing ramp, there is no doubt that the camshaft has been reprofiled.

    D. Should the situation described in C be observed, yet the final .010" to .015" lift be below that of the official graph, do not feel that a disadvantage nulls out an advantage.

    In the case of restricted carburetion, increased duration provides more advantage than does loss of peak lift cause a disadvantage. Wear could be considered a factor regarding peak lift, but an increase in duration over a given range of lift points may have caused the peak lift to be reduced when the cam re-grinding was performed.

    E. Formula Vee as of 1/1/77 permits a tolerance of ± .002" to the plotted curve on the graph. This does not effect the maximum lift which is measured at the spring cap. (Reference B-10).

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Centerlines of Peak Lift

1. The most accurate method of determining the centerline of peak lift is through mathematical calculation. Pick an arbitrary point such as .050" or .100" opening and closing and by using the following procedure calculate the peak lift centerlines. This will enable you to determine whether or not the cam lobes are in correct relationship to each other.

EXHAUST

A. Total duration

+ exhaust valve opens	_____°BBDC, or	+ exhaust valve opens _____°BBDC
+ exhaust valve closes	_____°ATDC, or	- exhaust valve closes _____°BTDC
+	180°, or	+ 180°
= Total duration	_____°, or	= total duration _____°

B. Duration from exhaust valve opening to point of maximum lift (½ duration):

$$\frac{\text{Total duration ... } \_\_\_\_\_^{o}}{2} = \_\_\_\_\_^{o} \text{ ½ duration}$$

C. Point of maximum lift in relation to TDC.

+ ½ duration	_____°, or	+ ½ duration _____°
- exhaust valve closes	_____°ATDC, or	+ exhaust valve closes _____°BTDC
	_____°BTDC, or	_____°BTDC

INTAKE

D. Total duration

+ intake valve opens	_____°BTDC, or	+ intake valve opens _____°BTDC
+ intake valve closes	_____°ABDC, or	- intake valve closes _____°ABDC
+	180°, or	+ 180°
= Total duration	_____°, or	= total duration _____°

E. Duration from intake valve opening to point of maximum lift (½ duration):

$$\frac{\text{Total duration ... } \_\_\_\_\_^{o}}{2} = \_\_\_\_\_^{o} \text{ ½ duration}$$

F. Point of maximum lift in relation to TDC.

+ ½ duration	_____° or	+ ½ duration _____°
- intake valve closes	_____°ATDC, or	+ intake valve closes _____°BTDC
	_____°BTDC, or	_____°BTDC

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2. If the camshaft profile being plotted shows evidence that the camshaft has been reprofiled, the camshaft should be removed for physical inspection before making a final determination.

Formula Ford

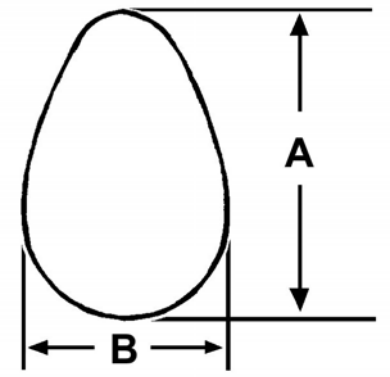
	A	B
Intake	1.311	1.080
Exhaust	1.312	1.080

NOTE: *The base circle radius of the Ford camshaft cannot be physically measured with a micrometer or a caliper due to the quietening ramp.*

Formula Vee

	A	B
Intake	1.527 min 1.532 max	1.228 min 1.233 max
Exhaust	1.511 min 1.516 max	1.227 min 1.231 max

NOTE: *These dimensions are those of a new camshaft. Wear will affect the minimum dimension.*



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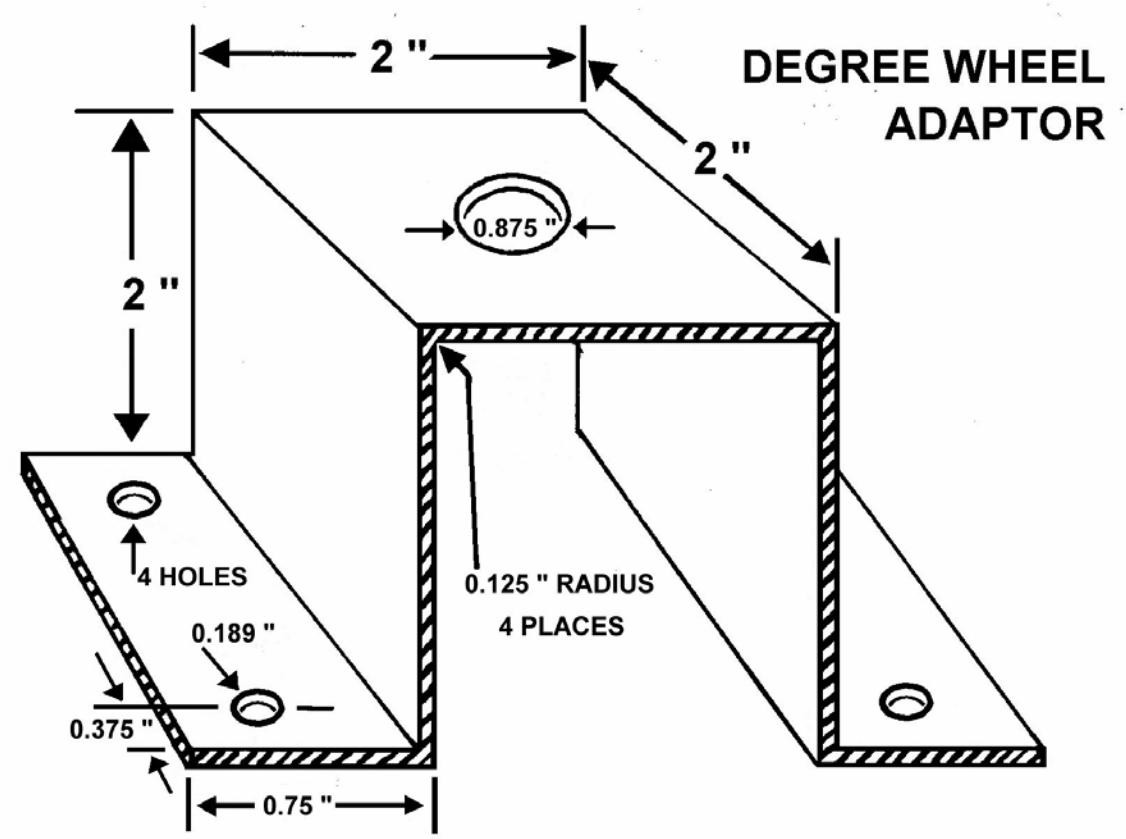
Cam Lobe Checking Procedure for FV and FF



Material: Aluminum Flat Stock 8" x 2" x .062" ST hardness
Alternate: Mild Steel Flat Stock 8" x 2" x .040"

Instructions: Remove the lock-nut from the lower shaft of the Hewland-type gearbox. Install the adaptor and a thin flat washer (aluminum adaptor only), and reinstall the locknut. Tighten until snug, using a ½" drive socket, remove the socket and insert a ½" x 1" cotter pin or shear pin. Replace the socket on the nut, install the degree wheel, and insert a ½" drive extension 6" long, through the degree wheel. Turn the assembly counter-clockwise at all times. Hold the degree wheel to the adaptor with 3/16" cap screws and flat nuts.

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Cam Lobe Checking Procedure for FV and FF

A sample problem for Formula Ford is illustrated. Formula Vee would be a similar calculation.

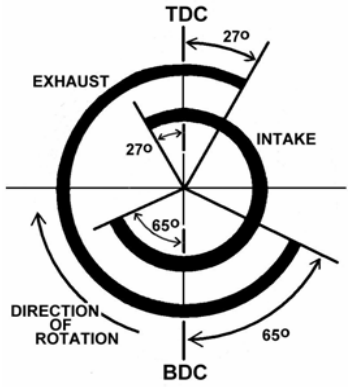
Exhaust opens at 65 degrees BBDC 65^o
Exhaust closes at 27 degrees ATDC 27^o
Add these two figures: 92^o
Plus 180 degrees of crank rotation 180^o
272^o

272 degrees is the total number of degrees that the exhaust valve is open.

272 degrees divided by 2 = 136^o

136 degrees is the centerline of duration at which point peak lift occurs.

To find at what exact point of crankshaft rotation that peak lift occurs, use 136^o
and subtract the number after TDC that the exhaust valve closes 27^o
109 degrees BTDC 109^o



Intake opens at 27 degrees BTDC 27^o
Intake closes at 65 degrees ABDC 65^o
Add these two figures: 92^o
Plus 180 degrees of crank rotation 180^o
272^o

272 degrees is the total number of degrees that the intake valve is open.

272 degrees divided by 2 = 136^o

136 degrees is the centerline of duration at which point peak lift occurs.

To find at what exact point of crankshaft rotation that peak lift occurs, use 136^o
and subtract the number before TDC that the intake valve closes 27^o
109 degrees ATDC 109^o

\\\\

When judging if the centerlines of peak lift between a given exhaust/intake lobe have been altered in relationship to each other, a one-degree tolerance is reasonable.

By moving the exhaust and intake centerlines of peak lift closer together, overlap is increased and some scavenging action may be accomplished. The following are factory specifications for centerline of peak lift.

FF					FV			
Exhaust	109^o BTDC	or	71^o ABDC		Exhaust	70^o 15′ ABDC	or	250^o 15′ ATDC
Intake	109^o BTDC	or	71^o ABDC		Intake	75^o 45′ BBDC	or	104^o 45′ ATDC

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