Note_135

The "Small-Block" Chevrolet

Although the "Small-Block" Chevrolet was a series production engine, it deserves a mention on this website because it formed the basis of many sports-racing developments and was also very successful in the open-wheeled F5000 series. It also deserves it because it became probably the most-produced automotive piston engine ever. Over 100 million units of all capacities from 265 cubic inch displacement (cid) up to 400 cid were made in a 60 year life. Details of the many variants can be found on the internet. The bore spacing remained at 4.4'' (although the biggest bores of 4⅛''had to be Siamesed).

1955 265 cid

The General Motors Chevrolet Division design team in 1954 for, what was later named, the "Small Block" (after a bigger-block engine was introduced), was led by their Chief Engineer Ed Coles (who went on to become President of GM in 1967). The engine, which was tooled for production before its first run (!), appeared first in 1955. a major application being the *Corvette.* It transformed this "weedy" 6-cylinder 235 cid 150 HP vehicle and saved it from being dropped.

The initial engine was:

NA 90^0 V8 Bore 3 ¾''/Stroke 3'' = 1.25 V = 265.1 cid
[95.25 mm/76.2 4,344 cc]

R = 8; PROHV; 2v/c; Cast-iron thin-wall block & c-i head; Weight 575 lb (www.team.net)

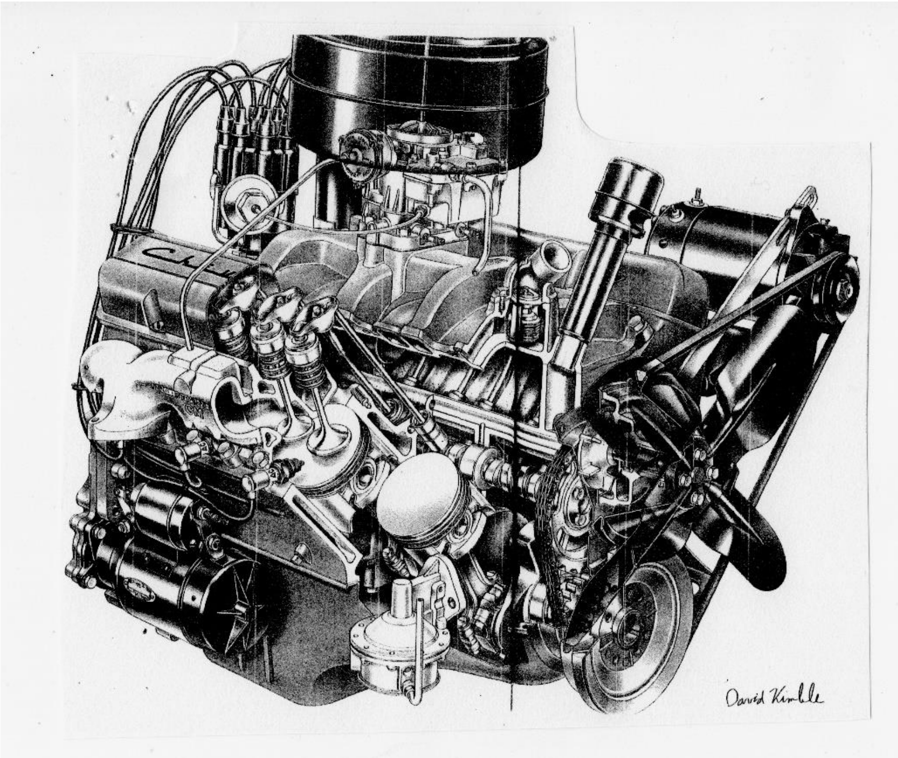
As provided tuned for the *Corvette* it gave an SAE gross power (see Note 2) of 195 HP @ 5,000 RPM (8 Bar @ 12.7 m/s).

[Main source:- Chevy 348 & 409 Brooklands Books 1992.].

An illustration is shown below as Fig. 1.

The OHV gear had steel stamped rockers on adjustable-height spherical pivots (a GM Pontiac patent design made specially-available to Chevrolet).

Wedge combustion chamber.



Classic & Sports Car June 2005

Scarab development

An early competition development was for the *Scarab* sports-racing car built by Reventlow Automobiles in 1958. In the USA this car was particularly successful, defeating European makes. The engine basis was the next small-block capacity built for production in 1957:- 3 7/8'' x 3'' 283 cid (98.425/76.2 = 1.292 4,638 cc). This was "Bored & Stroked" to give:-

4''/3 3/8'' = 1.185 = 339.3 cid
[101.6 mm/85.725 5,560 cc].

R = 10; Modified Hilborn port fuel injection; Retained c-i block & head; Weight about 550 lb.
365 HP @ 6,000 RPM (9.8 Bar @ 17.1 m/s).

(sources:- www: revsinstitute.org & ultimatecarpage.com).

An illustration of the induction system is given below as Fig.2.

automobilemag.com

The first *Corvette* at Le Mans

The first appearance of a *Corvette* at Le Mans was a team of 3 entered by Briggs Cunningham in 1960. The engine was a 1959 model 283 cid with all the high-power options, including fuel injection and R = 10.5, giving 290 HP @ 6,200 RPM (9.0 Bar @ 15.7 m/s). One car survived, although crippled late in the race by a worn distributor which over-advanced the timing, to finish 8^{th} and win the GT5000 class.

2000-2019 Corvettes at Le Mans

Since 2000 Corvettes have been entered continuously by GM at Le Mans and have won 8 class victories. Eg. the C6R introduced in 2005 gained 4 of these wins and was powered by a *nomina*l "Small Block" engine built by Katech, still PROHV 2v/c. However it had an Al-alloy block and head, was stretched to 4 3/16''/3 7/8'' = 1.08 and 426.9 cid (106.3625 mm/98.425 6996 cc) with Ti-alloy valves and rods, electronic f.i, plus dry sump lubrication, to give 590 HP @ 5,400 RPM (14 Bar @17.7 m/s).(source supercars.net). This BMPP was as good as any DOHC 4v/c pure racing engine.

Formula 5000

The engine of choice over the1968-1976 life of the F5000 for open-wheeled racing cars was the Small Block Chevrolet at the size specially produced in 1966 for the *Camaro in the* US TransAm series, which was 4''/3'' = 1.333 301.6 cid (101.6 mm/76.2 4942 cc). Retaining the c-i block and head for low cost but otherwise developed for racing it gave up to 550 HP @ 7.800 RPM on petrol (12.8 Bar @ 19.8 m/s). In the '70s the chassis of choice was the Lola 300 series. Eg. in 1974, 1975 and 1976 Brian Redman won the US 5000 Championships in one. An illustration of the 1976 engine in his Lola T332is shown as Fig.3 on P.3.

The tall intakes, tuned for improving mid-range torque, were covered in action by a very high-mounted ram intake.

Fig. 3

ultimatecarpage.com

The Small Block in NASCAR racing

Chevrolet dominated NASCAR racing between 1958 and 2015, winning 39 Manufacturer's Championships. This was with a mixture of small block and large block engines. The subject of NASCAR racing is specialised and the author, not having followed it through the years, admits to being rather uncertain of the details as available on the internet.

Certainly the 283 cid fuel-injected283 HP engine was so dominant in 1957 that it was banned. Over the following decade or so the big block engine up to 427 cid was being used. In 1974 a rule limit of 358 cid (5,867 cc) was imposed and this brought the small block engine back into play. The author cannot do better for notes on the other rule restrictions than to quote the following extract from an article by J. Kane in *Race Engine Technology* issue 029 of 2008 (author's insertions in [square brackets]):-

"....... Cup V8 is restricted to a 106.3 mm (4.185 inch) maximum bore, a 5.86 liter (358 cubic-inch) maximum swept volume [stroke 3¼', 82.55 mm], a 90° crankshaft, steel conrods, a single, valley-located camshaft, flat tappet cam followers...., pushrod & rocker-arm valve actuation using steel pushrods and aluminum or steel rockers, [cast iron block], (approved) aluminum cylinder heads with two [Ti-alloy] valves per cylinder [in a wedge-shape combustion chamber] using steel helical valve springs [CVRS], a single four barrel carburetor .... and a single, distributor-controlled ignition. Engine weight is approximately 260 kg (575 lbs).

Each car must, by regulation, use the same engine for one complete race meeting (practice, qualifying and the race) or be penalized. Races are typically 300 – 500 miles in length, so the design life of an engine [before allowed overhaul with many fresh parts] is up to 800 miles [note the big difference now from Grand Prix engines].

At the end of the 2006 season, Cup engines made peak power of about 820-830 BHP at about 9000 RPM [about 14 Bar @,24.8 m/s] and peak torque of about 520 lb-ft at about 7500 RPM. During a typical oval race, these engines continuously cycle between about 7000 and 10,000 RPM."

Presumably Chevrolet used developments of the original small block engine to suit these rules. In 1998 they introduced the Small Block Generation 2 (SB2) engine to NASCAR racing. This still retained the original 4.4'' bore spacing. It was used successfully up to 2007 when the company brought out their R07 engine. This, aimed entirely at racing from the start, with 4.5'' bore spacing, finally saw the end of the small block in NASCAR after 50 years.

An illustration of the SB2 is given below as Fig.4.

motorbiscuit.com

Generic NASCAR engine details

[Two rules not noted above:-

- Maximum permitted Compression ratio:- 12.
  Fuel currently 85% 104RON petrol + 15% ethanol;
- 90^0 Crank. Maximum exhaust extractor effect with this would require cross-coupling between blocks, which is not practical with front engine mounting.]

Piston rings

A generic NASCAR engine to the rule dimensions of Bore (B) 4.185''/Stroke (S) 3¼'', B/S = 1.288 357.65 cid, reaches Peak Power (PP) at NP = 9,000 RPM. With a Con.-rod Length (CRL) of 6.2'' (ref. A, see below) CRL/S = 1.91. This produces a Maximum Piston Deceleration (MPDP) of 4,717g.

In Note 13 Part 2 it is shown that an iron piston ring of axial width w flutters at about 4,000 mm.g. Therefore the NASCAR engine will avoid destructive piston ring flutter and excessive blow-by and oil blown overboard if the top ring has w less than 4000/4717 = 0.85 mm (0.033''), No data on the NASCAR w dimension is known to this author but the safe size is within known manufacturing capability, e.g. the 1967 Cosworth DFV, the first engine to avoid flutter with a thin ring, had w of 0.030''.

Coil Spring Valve Return System (CVRS)

NASCAR rules mandate CVRS. A Pneumatic Valve Return System (PVRS) would permit a higher Mean Valve Speed (MVS), be lighter at a high level, lowering C of G, and would avoid (what is practically certainly the case) scrapping the springs at a short life. Fatigue and wear caused by the essential interference frictional damping between double valve springs would require that.

In Ref. B the Inlet Valve Lift (IVL) of the pre-1998 Chevrolet SB2 NASCAR engine is quoted as 0.8'' (20.3 mm). The Inlet Opening Duration (IOD) was quoted as 270^0 *from 0.050''above the valve seat*. It is assumed that this is consistent with full IOD to the usual definition of 354^0, the off/on-seat figure known for the 1994 PROHV Ilmor 500I Indianapolis engine (DASO 468). If so, then MVS at NP = 9,000 RPM (MVSP) = 6.19 m/s. The 500I reached 5.06 m/s (see Appendix 5). Both had solid Ti-alloy valves (hollow valves are not permitted – info. from Del West). The higher MVSP may be attributed to the later known use of Diamond-like Carbon (DLC) surface treatment. The open load produced by the near-choc springs was 600 lb. Ref.C states that the springs have to be cooled by flooding the valve covers with (ultra-thin) oil. The SB2 had forged Al-alloy rockers with roller ends bearing on the valve caps.

Mean inlet Gas Velocity (MGV)

Ref. B quotes the SB2 Inlet Valve head Diameter (IVD) as 2.18'' (47 mm). With IVL = 20.3 mm, IVL/IVD = 0.366 (a high value) and Inlet Valve Area (IVA)/Piston Area (PA) = 0.272 (a low value, constricted by the in-line 2 v/c mandated configuration). At NP = 9,000 RPM Mean inlet Gas Velocity (MGVP) = 91.2 m/s, a very high value. The late Brian Lovell, former MD of Weslake Developments, proposed that 72 m/s was optimum (see also Grand Prix data for MGVP on Fig. A2 of Analysis Update Part 2.

Combined Efficiency

The product of

Volumetric Efficiency (EV) x Combustion Efficiency (EC) x Mechanical Efficiency (EM

= Combined Efficiency (ECOM).

The reasoning behind this factor and its definition are given in the 1st Naturally-Aspirated Era (1NA) at its Addendum. The values for all engines in this website are shown in the various Appendices at Row 132 of the standard format. Continued on P. A2

ECOM for the generic NASCAR engine is given below and compared with some other units.

	ECOM %	
<u>NA PROHV 2 v/c</u>		
• 2006 Generic NASCAR	58.5	
• 1998 Ford B. Mock NASCAR	58.6	See Appendix 1 at Eg. SO24
• 1963 Ford Indy	46.3	See Appendix 5 at col. AX
<u>NA Grand Prix DOHC 4 v/c</u>		
• 1982 Cosworth DFV	57.0	See Appendix 1 at Eg. 62
• 2000 Ferrari 049	56.7	" " Eg. 85
• 2006 Cosworth CA/6	59.7	" " Eg. SO25

Clearly, despite its NASCAR-mandated restrictions, the generic engine has nothing to apologise for in the area of Efficiencies! (But see the comment below).

<u>"Flash" Power output</u>

Ref. B shows an SB2 (converted to 6 cylinders) on dyno test. Modern equipment provides instant display of Power v. RPM on a screen. This ref. U-Tube shows that the time spent at Peak Power is *<u>well under 1 second</u>*! Therefore the Powers quoted in such tests must be regarded as "Flash"-type, possibly not sustainable when the engine has reached a stable temperature.

For safety reasons on Super-Speedways, NASCAR mandates a 4-hole restrictor plate fitted ahead of the carburetter. This approximately halves the power. Engine development for this condition is a specialised branch of an already specialised art!

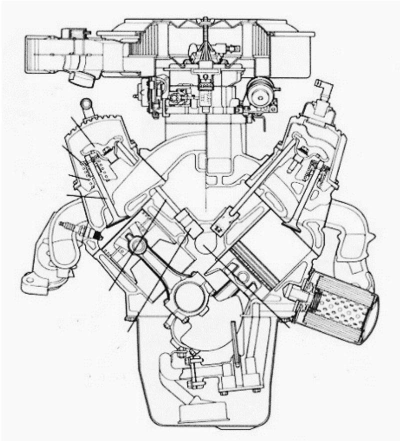
<u>References</u>

A. www.epi-eng.com/piston_engine_technology/comparison_of_cup_to_f1.
The author of this article provides a detailed analysis of comparative con.-rod stresses.
B. You tube "Nascar Chevy SB2 V8 turned into a racing V6".
C. www.hotrod.com/articles/small-block-perfection.

[It will be necessary to enter these references in full to access them.]

Generic NASCAR engine details, continued

Small Block Chevrolet section; the basic engine is shown below:-



epi-eng.com

Extractive Exhaust System for V8 90^0 crank

The illustration below of the Ford V8 4.7L in the GT40 mid-engined car shows the impossibility of using an optimum extractive exhaust system for a V8 90^0 crank in a front-engined NASCAR.
[If "*A bunch of bananas*" was appropriate for Bugatti exhausts, "*A snake's honeymoon*" could be the description of this masterpiece of the pipe-benders craft!.]

forum.clubcivicquebec.com

Piston Rings

The P.S. showed that, to avoid piston ring flutter, the top ring of a generic NASCAR engine needed the axial dimension w to be less than 0.85 mm if cast iron (CI). A trawl of the i-net has shown that rings with w = 0.6 mm are available for pistons of NASCAR size (and are presumably made for that specific application). They are Stainless Steel (SS) with a Ti coating. Allowing for the higher density of SS v. CI (10%) the required ring is then 0.78 mm. A 0.6 mm ring will therefore give a margin of safety for overspeed.

Inlet valve Open Duration (IOD)

A trawl of the i-net confirms that IOD for NASCAR engines is, as supposed, around 360^0 *off/on the seat* (as used to calculate Mean Valve Speed) (by SAE standard the values for IOD in cam catalogues must be stated at 0.50'' lift). Overlap (OL) about 135^0, which is in the low scatter of Fig. 2 in Note 124 but balances the high number for the Ilmor 500I.