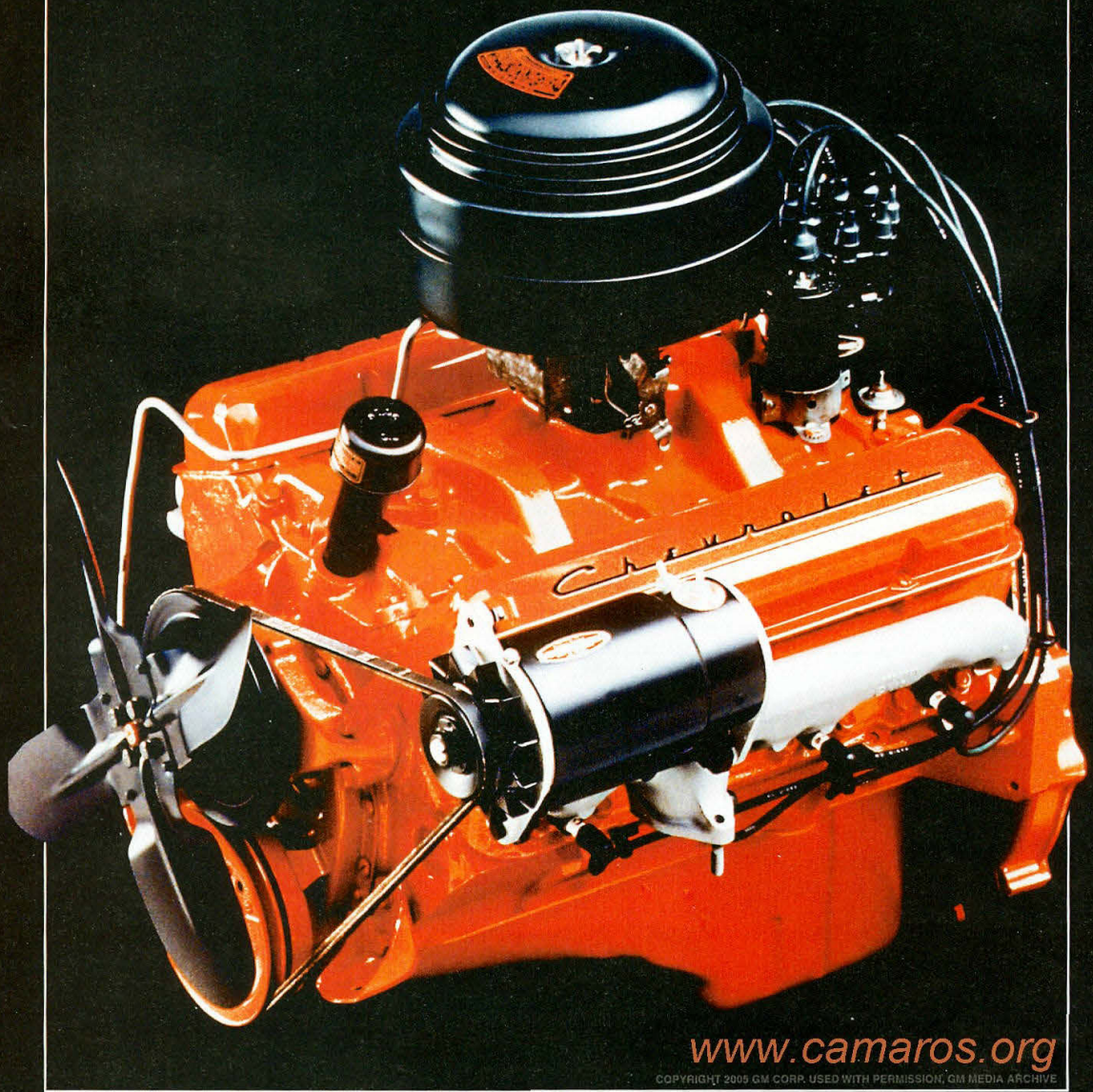
Small-Block Assembly Overview

Building the small-block V-8 at Flint Engine

BY JOHN HINCKLEY



1 The bare block looked like this when it came off the machining line and emerged from the high-pressure washer, ready for assembly.

2 This hole below the fuel pump boss was one of two master gauge holes used to register the bare block to its machining pallet; the other one is just inboard of the starter.

3 Here's the square-head 1/8" NPT oil gallery plug just above the timing cover that identifies a Flint block. Tonawanda engines don't have the hole or the plug.

4 The block started down the assembly line upside-down, beginning with the bore air-gauging station, cam and main bearings and core plugs, heading for cam and crank installation. Photo Dave McDufford

5 After piston-stuffing, the bottom end looked like this. Both master gauge holes for machining are visible in this photo. Photo Dave McDufford

Since this year is the 50th anniversary of the Chevrolet small-block V-8 engine, with about *90 million* of them produced since 1955 in various configurations, all based on the original block with 4.4" bore spacing, it is interesting to know how they were manufactured.

Thousands of books and articles have been written about how to rebuild or modify them, but almost nothing has ever been written about how they were originally manufactured. Even the plant that built all the C1-C4 Corvette iron small-blocks is gone, closed in 1999 and bulldozed, and now there's just a big open space on Van Slyke Road in Flint where the Chevrolet–Flint V-8 Engine Plant stood for 44 years. Let's go back in time to the '60s and see how this brilliant design was brought to life every day by the 4,000 folks at Flint V-8 who produced them.

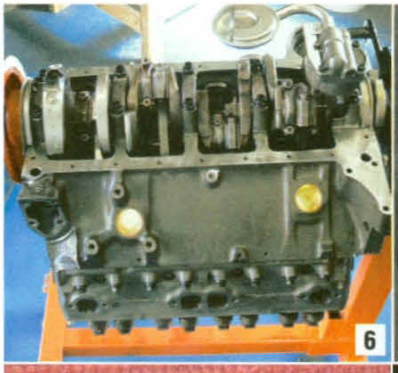
OVERVIEW: The Flint V-8 Engine Plant built the engines from scratch; raw castings for the block, heads, water pump, intake manifold, exhaust manifolds, oil pump, flywheel and camshaft were supplied from the Saginaw Foundry, and raw crankshaft and connecting rod forgings were produced at Chevrolet-Detroit Forge. Unfinished cast pistons, rings, main and rod bearings, valves, springs and retainers, harmonic dampers, clutches, and timing chains were purchased from outside suppliers, with distributors supplied by Delco-Remy.

Flint V-8 built 5,000 engines in up to 100 unique configurations every day on two shifts, on two lines. Line No. 1 ran at 170 engines per hour (one every 21 seconds), and line No. 2 ran at 110 per hour (one every 32 seconds). The combined output (one engine every 13 seconds) from both lines was routed to the final hot-test stands, then through the paint booth, and then to shipping, where they were placed in steel shipping racks and shipped out either by rail or truck to 20 different car and truck assembly plants in the U.S. and Canada. Flint V-8 was the exclusive supplier of small-block engines to St. Louis; all Corvette small-blocks were "Flint engines."

Aside from the difference in the casting date format between a Flint and Tonawanda small-block, the easiest way to tell a "Flint block" is to look for the square-head 1/8" NPT plug at 11 o'clock just above the timing cover. Tonawanda blocks don't have the hole or the plug. This was a result of different machining processes between the two plants for drilling the oil galleries.

MACHINING DEPARTMENT: 60,000 iron castings, 40,000 aluminum castings, and 45,000 steel forgings (blocks, heads, intakes, water pumps, oil pumps, flywheels, exhaust manifolds, camshafts, pistons, cranks and rods) were processed every day into finished parts through the Machining Department. Machining ran on three shifts, and occupied approximately two-thirds of the plant's floor space.

The block line consumed the most space, with the huge deck broaches feeding long, high-speed transfer lines that did the drilling and tapping of bolt holes, the boring and honing of cam, crank, cylinder and lifter bores, and gun-drilling of all the oil galleries. The block was clamped and precisely registered to its machining pallet by pins into two master locating holes in the pan rail surface adjacent to the fuel pump and starter pads on the right side of the block.



6 The timing cover, harmonic damper, and oil pump were added just prior to oil pan installation. Photo Dave McDufford

7 On later engines, the same casting was used for both valve sizes. This 461 head for the large 2.02"/1.6" valves shows the extra machining cut in the side of the chamber to unshroud the intake valve.

8 From my rare-photo file, here's a typical engine plant date/suffix gang-stamper. One stamp was set up each day for each suffix, and was used all day long.

9 A typical 1967 stamp pad; the characters on the right were stamped by the engine plant after the heads went on, identifying the date and engine suffix code. The one on the left is the VIN derivative, stamped at the car assembly plant. More on this one next month.

10 Later engines had a sticker applied to the back of the passenger side valve cover identifying the engine suffix code.

Machining operations were followed by high-pressure/temperature washers, and from there, the fully machined blocks entered a buffer system ahead of the engine assembly line. The other machined parts followed the same pattern – machining, washing, and buffer storage (and assembly for cylinder heads, oil and water pumps). Piston machining was physically located adjacent to the engine assembly area, for reasons we'll see shortly.

There was little storage space at Flint Engine for incoming raw castings, which arrived from the Saginaw Foundry 24 hours a day via a huge dedicated over-the-road truck fleet; most castings were machined within a day or two of their arrival, some literally within hours. What little "buffer" stock of castings existed was at the Saginaw Foundry, 40 miles north of Flint.

ENGINE ASSEMBLY: The first operation on the assembly line (with the block upside-down) was to assign a sequence number and engine configuration code (the same as the suffix letters that would be stamped on the pad later on) to each block. The letter code and sequence number were marked on the sides of the block with a grease pencil. The next operation was to air-gauge the finished cylinder bores for piston size, and to stamp a corresponding letter code on the pan rail adjacent to each cylinder; in those days there were up to eight different graded-tolerance sizes for each nominal bore diameter. That information was then "broadcast" electronically to the piston and rod subassembly area with the engine sequence number for later use.

Freeze plugs (which have nothing to do with "freezing" – those holes are there to provide an exit path for the sand cores in the foundry "shake-out" line) and oil gallery plugs went in next, followed by the cam bearings, camshaft, then the main bearings and the crankshaft, followed by the rear main seal, main caps, timing chain and sprockets and the unique-to-Corvette 1/8" spacer ring in front of the crank sprocket on the C1s.

PISTON STUFFING: At this point it got really interesting – time for piston/rod "stuffing." The piston type and gauged bore size codes had earlier been "broadcast" to the piston and rod subassembly area along with the engine sequence number. The piston department had many huge precision piston-finishing machines that cam-ground the pistons to the correct clearance for the eight graded bore sizes and finished the wrist pin bores. That area prepared a tray for each engine with eight numbered nests corresponding to that engine's cylinder numbers – 1,3,5,7 on one side, 2,4,6,8 on the other side.

Each of the eight nests on each sequence-numbered tray had a ringed piston machined to the correct graded size for that bore, assembled to a rod which already had the bearings assembled and the rod torqued to "crush" the bearing shells, then disassembled, with each rod's cap and nuts in a little compartment next to the end of the rod. That tray was hung on an overhead conveyor, which took the trays, in engine sequence, directly over the "piston-stuffing" operations on the main assembly line, within easy reach

11 Later engines also had a Flint Engine "Number One Team" sticker applied to the front of the passenger side valve cover.

12 Add the water pump, distributor, spark plugs and exhaust manifolds, and this is what a completed engine looked like when it left the paint booth on the way to the shipping area.

13 An actual photo of the 1955 V-8 being hoisted from the delivery conveyor for placement in its shipping rack. The generator brace shown was frequently damaged in shipping, and was later reallocated for installation at the car assembly plants. Note the "log" exhaust manifolds, no oil filter pad, and no side motor mount bosses. Copyright 2005 GM Corp. Used with permission, GM Media Archive

of the four operators in that station (two on each side of the line).

While the last engine was leaving the station, each operator reached up and grabbed the piston/rod assembly he needed for his assigned cylinder on the next engine, put protectors on the rod bolts, applied a ring compressor, and "stuffed" the assembly into the bore of the upside-down block. Then he grabbed the rod cap and installed it (after removing the bolt protectors) with the nuts finger-started.

The crew in the second station did the same thing for their four cylinders, and the empty piston/rod tray was conveyed back to the piston/rod subassembly area to be reloaded again. The rod cap nuts were torqued with twin-spindle air nutrunners in the next station. Piston-stuffing was an incredible thing to watch at 170 engines per hour; 42 seconds total in two work stations to install eight rods and pistons is quite a contrast to the way we carefully assemble our restoration engines today. In present-day engine plants, this operation is fully automated, done by machines, with no one in sight, and modern precision machining methods and process controls result in only one bore and piston size; select-fitting pistons to bores is no longer required.

Think about how many finished pistons there were, with two nominal bore diameters (for 283s and 327s), at least three different piston crown configurations for each displacement, and up to eight different tolerance-graded piston diameters for each nominal bore diameter and crown type.

FINAL ASSEMBLY: The timing cover and harmonic balancer went on next. The balancer was pressed on, using an overhead hydraulic tool that engaged both the balancer hub and the rear end of the crankshaft, to avoid damage to the crankshaft thrust bearing. The oil pump and shaft went on next, followed by the oil pan, then either the flexplate or flywheel and clutch assembly, bellhousing or (C1) Powerglide adapter, clutch fork, and clutch inspection cover (on manuals).

Next, the engine was turned upright to car position, and the lifters and heads were installed. The heads arrived from their machining and assembly department on a conveyor with the pressed rocker studs, valves, springs, retainers and locks already installed. The same cylinder head casting was frequently used for "small" (1.94" and 1.5") and "large" (2.02" and 1.6") intake and exhaust valves. In those cases, machining differences included a large cut on the intake side of the combustion chamber to un-shroud the flow around the intake valve.

The crankcase oil/vapor separator canister, intake manifold, pushrods, rocker arms, balls and nuts went on next, followed by valve adjustment and the valve covers. The engine build date and suffix code was gang-stamped on the block pad, based on the suffix code previously scrawled on the side of the block. One gang-stamp was set up each morning for each engine suffix type to be built that day. If there were 46 different types of engines scheduled to be built, there would be 46 gang-stamps set up and placed in a rack adjacent to the stamping operation for the stamping operator to select from. The operator selected the correct stamp holder, positioned it on the pad, and smacked it with a small sledgehammer.

Assembly of the water pump and the unique-to-Corvette engine-mounting bracket (on C1s) came next, followed by the coolant bypass fitting and hose on certain engines.

The distributor and spark plugs went in after that, followed by the exhaust manifolds, temperature sender, thermostat and housing, and the engine was ready for hot-test. It was hoisted off the end of the build line with a scissors hook under the exhaust manifolds, and hung on a delivery conveyor to hot-test, where it was placed in a hot-test stand.

HOT-TEST: The engine was clamped in place and four quarts of oil were pumped into the fill tube opening, which was then plugged. Adapters connected the thermostat housing and water pump to a circulating water supply; a shunt adapter was screwed into the oil filter cavity; and a slave spark plug wire harness with its own coil and timing light connection was attached to the distributor and the spark plugs, while a natural gas adapter elbow was attached to the carburetor pad and an air-powered starter was clamped to the front of the bellhousing, along with clamping exhaust manifold outlet adapters to the flex pipes that extracted the exhaust fumes.

The operators then fired the engine, checked for oil pressure and oil or water leaks, set the timing, tightened

the distributor hold-down clamp and chisel-staked the reference mark on the distributor base and intake, and listened for any unusual noises. Oil and water were drained, all test adapters were disconnected, and the engine was hoisted out of the test stand and placed on another conveyor that took it to the paint booth. Engines needing further attention due to test discrepancies were set aside for repairs. Once repairs were completed, those engines were re-tested and sent on their way.

PAINTING: As engines entered the paint booth (one every 13 seconds), plastic or cardboard masks were applied to the carburetor and fuel pump mounting pads, water pump hub, spark plugs, and temp sender, a can was placed over the distributor, and a piece of masking tape was applied to the stamp pad. Engines with aluminum intake manifolds and valve covers had those parts covered with vacuum-formed plastic masks. The engine was sprayed with the cheapest orange enamel available in bulk that month, with two spray operators on each side of the booth; then the masks were removed as the engine exited the booth, and the paint air-dried as the engine was conveyed to the shipping area.

SHIPPING: When the engine arrived in the shipping area, it was routed, based on its suffix code, to a specific dock location, where it was plucked off the delivery conveyor with an air hoist and placed in a steel shipping rack with two other identically coded engines. Full racks were then taken by a fork truck and loaded into a waiting railroad car, or into a truck if it was a rare "expedited" shipment. With up to 100 different engine configurations, and 5,000 engines per day shipping to 20 different assembly plants all over the country, Flint Engine was, for its day, an industrial miracle in terms of production control.

120 Corvette engines per day was only 2.5 percent of Flint V-8's daily volume, and filled only half a rail car, so St. Louis got a rail car of engines every other day. Chevrolet didn't waste money by shipping half-full rail cars.

When those engines left Flint, they were essentially "bare-naked." All other final dress components on the engine were installed at St. Louis, as indicated by the part number callouts in the applicable Assembly Instruction Manual. Fuel-injection engines departed from the carbureted-engine format somewhat, as their injection units and plumbing were installed at Flint Engine, leaving only a vacuum line, electrical connection, and throttle linkage to be assembled at St. Louis.

The Flint V-8 engine manufacturing sequence remained pretty much the same through the '50s, '60s and '70s, with only minor variations in conveyors, exhaust manifold installation, painting, and progressive improvement in machining processes that improved quality and reliability. Tonawanda Engine (New York) and McKinnon Industries (Canada – now St. Catherine's, where the LS1/LS6 current engines are built) also built small-block engines, but neither supplied them to the Corvette plant. Tonawanda was the sole source for big-blocks, and supplied them to all assembly plants.

Now that we have the engine built, tested, painted, and shipped, we'll follow it down the Engine Dress Line at St. Louis. Tune in next month for that trip! ■