Toyota engines - T24A-FTS

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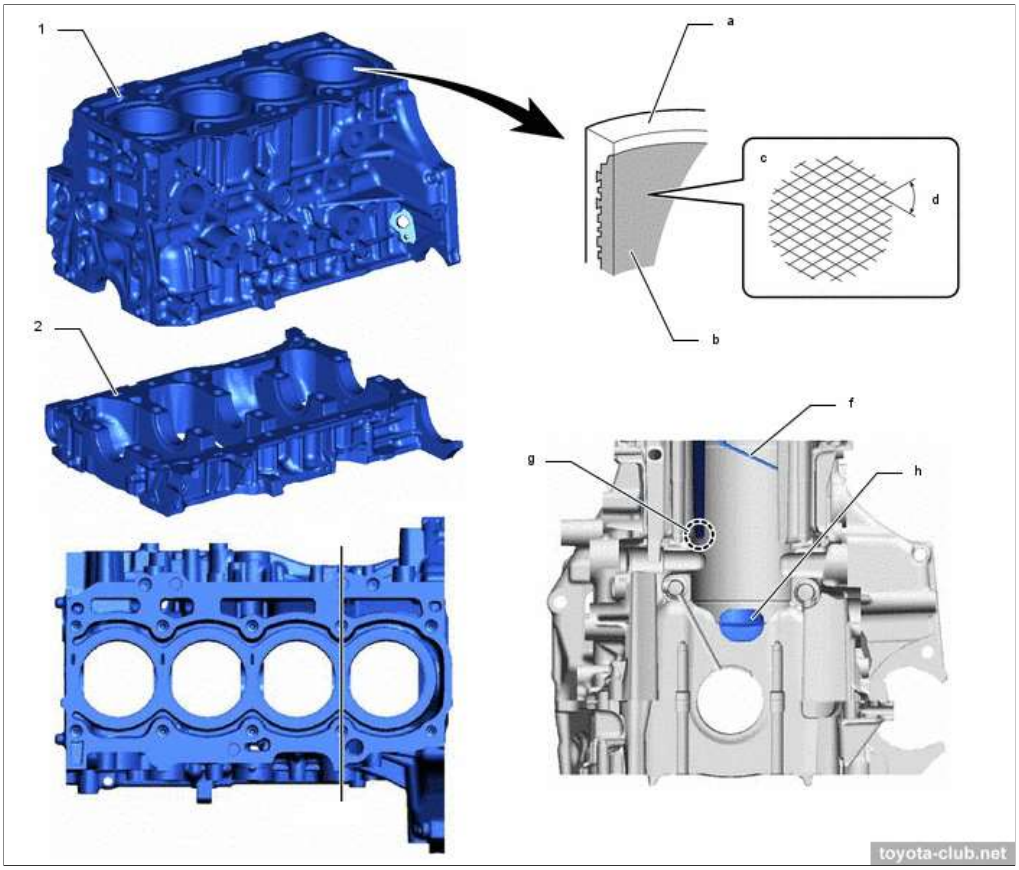
The new 2.4 turbo engine replaced the previous 2-liter 8AR-FTS and primarily appeared under the hood of FF-platform crossovers starting with the 2nd gen Lexus NX. And as recent practice shows, it is designed to replace the naturally aspirated V6 2GR- as well. Although technical affinity with A25 engine seems obvious, the differences are much more fundamental than just a crankshaft or turbine... let's take a closer look.

Engine	Displacement, cm^3	Bore x Stroke, mm	Compression ratio	Output, PS	Torque, Nm	RON	ECS	Market
T24A-FTS	2393	87.5 x 99.5	11.0	279 / 6000	430 / 1700-3600	95	D-4ST	EEC

T24A-FTS (2.4 D-4ST)

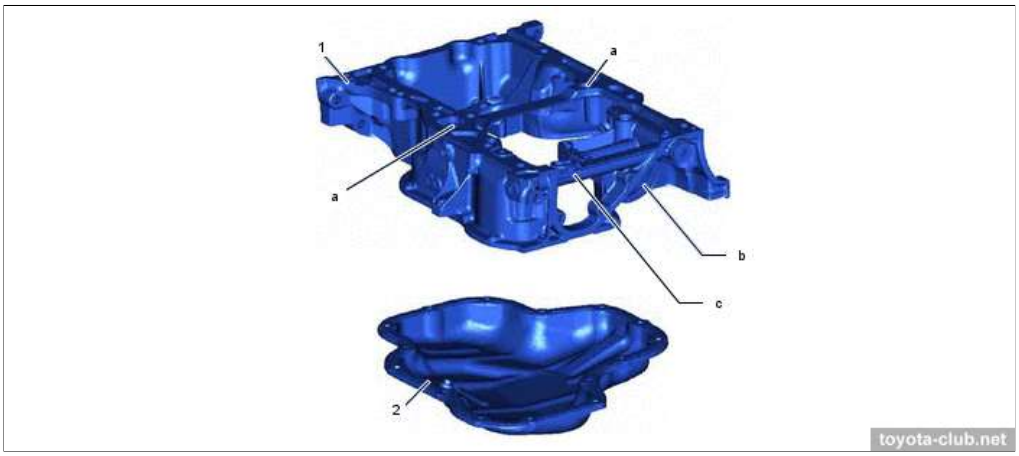
Engine mechanical

The cylinder block - open-deck type, made of aluminum (light-alloy). The cast iron liners are fused into the block material, and their special uneven outer surface provides the durable connection and improved heat sink. here are sloping coolant channels drilled between the cylinders.



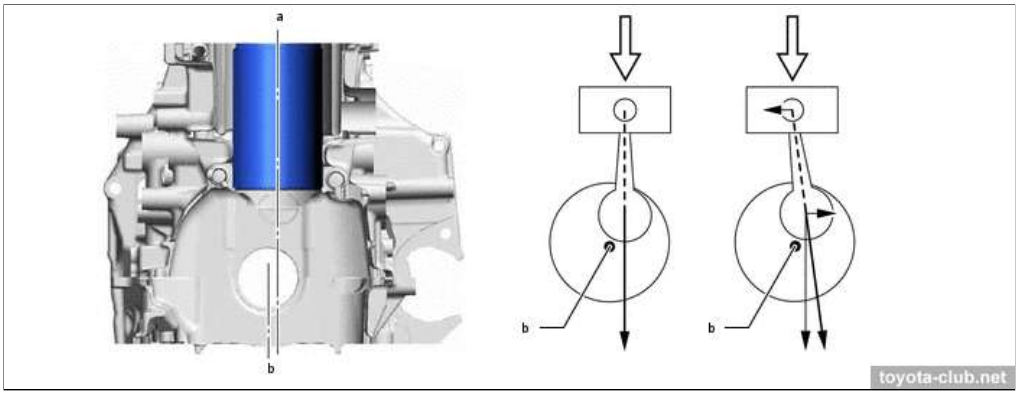
1 - cylinder block, 2 - crankshaft bearing cap. a - cylinder bore, b - cylinder liner, c - bore cross hatching, d - 30°, f - cooling passage, g - bottom of water jacket elliptical shaped, h - larger breather hole

The oil sump assy consists of a cast top and a steel bottom.



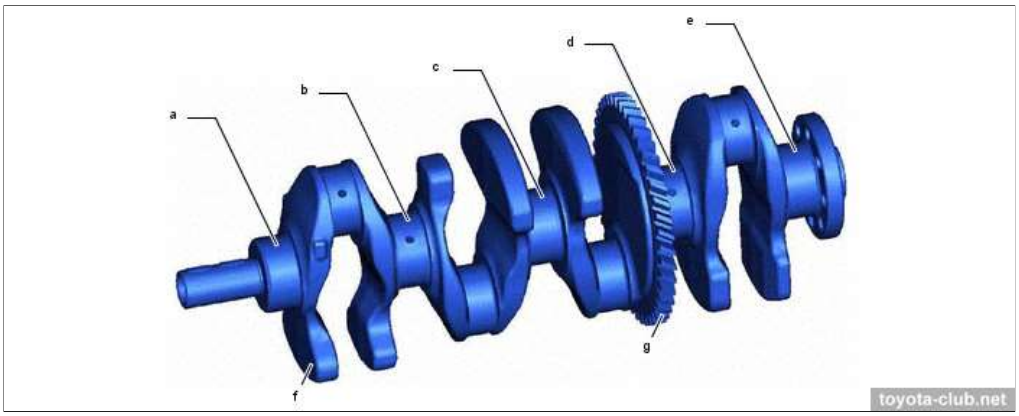
1 - stiffening crankcase, 2 - oil pan #2. a - oil drain passage, b - oil filter bracket, c - high pressure oil passage

The crankshaft is installed with a 10 mm offset (the axes of the cylinders do not intersect with the longitudinal axis of the crankshaft), thus reducing the lateral component of the force exerted by the piston to the cylinder wall, reducing wear.

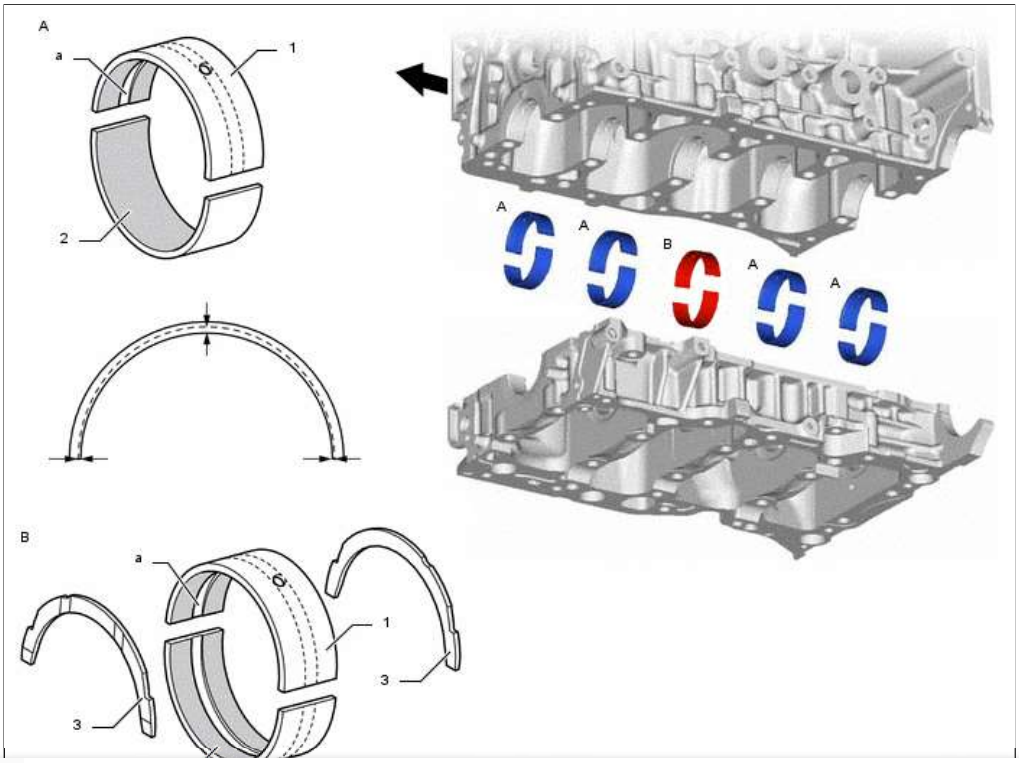


a - bore centerline, b - crankshaft center, c - intake side, d - exhaust side, e - maximum pressure, f - offset crankshaft, g - non-offset crankshaft

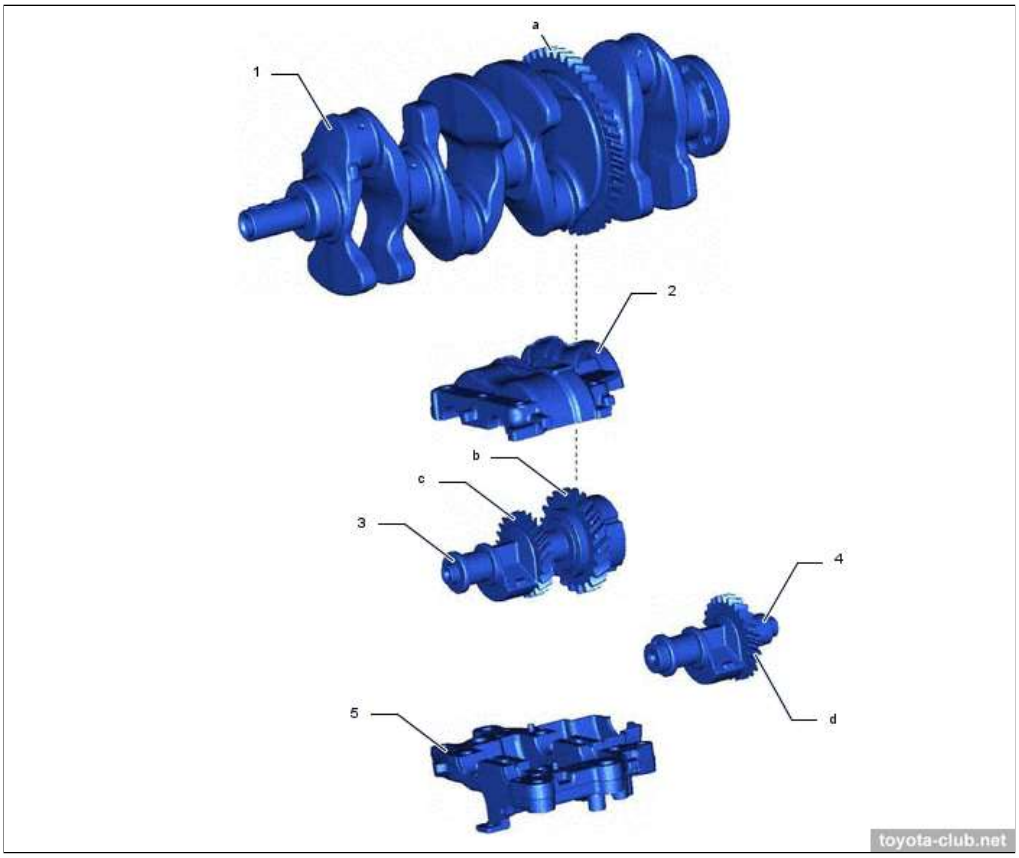
The crankshaft has 5 journals and 8 counterweights. The massive crankcase is integrated with crankshaft journal caps, which gives the structure the necessary rigidity. The conrod and main bearings - with a resin coating.



a-e - main bearing journal, f - balance weight, g - balance shaft drive gear

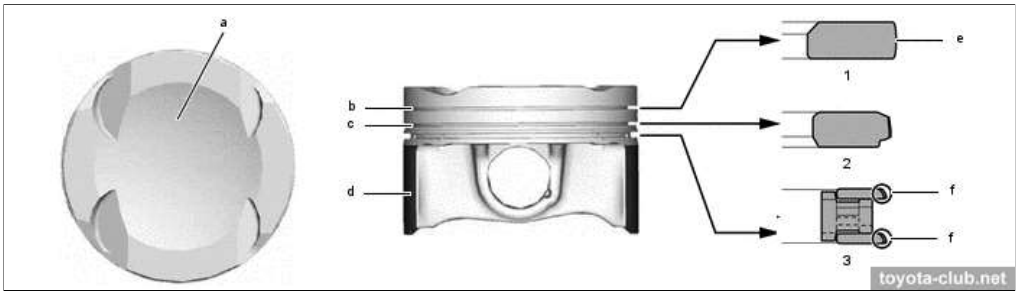


The separate balancer mechanism is driven by crankshaft via train with polymer gears.



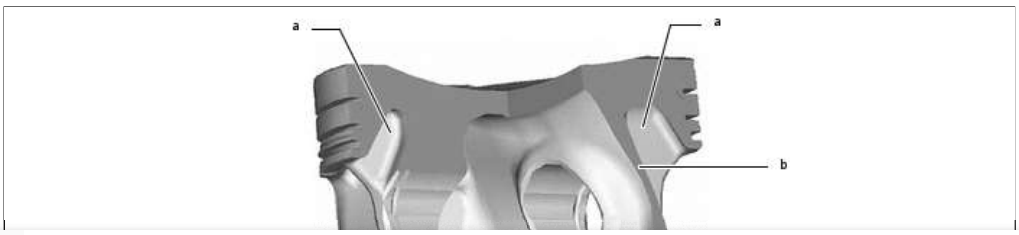
1 - crankshaft, 2 - balance shaft housing #2, 3 - balance shaft #1, 4 - balance shaft #2, 5 - balance shaft housing #1. a - balance shaft drive gear, b - resin gear, c - balance shaft gear #2, d - resin gear

The pistons made of light-alloy, T-shaped, lightweight. The upper compression ring is installed in Ni-resist insert. The edge of the upper compression ring has PVD-coating, oil rings edges have anti-wear carbon coating (DLC - "diamond like"). The skirt is covered with a polymer coating. Pistons are connected to the connecting rods by fully floating pins and locking rings.



1 - compression ring 1, 2 - compression ring 2, 3 - oil ring. a - spherical shaped, b - ni-resist cast iron, c - alumite coating, d - resin coating, e - PVD coating, f - DLC coating

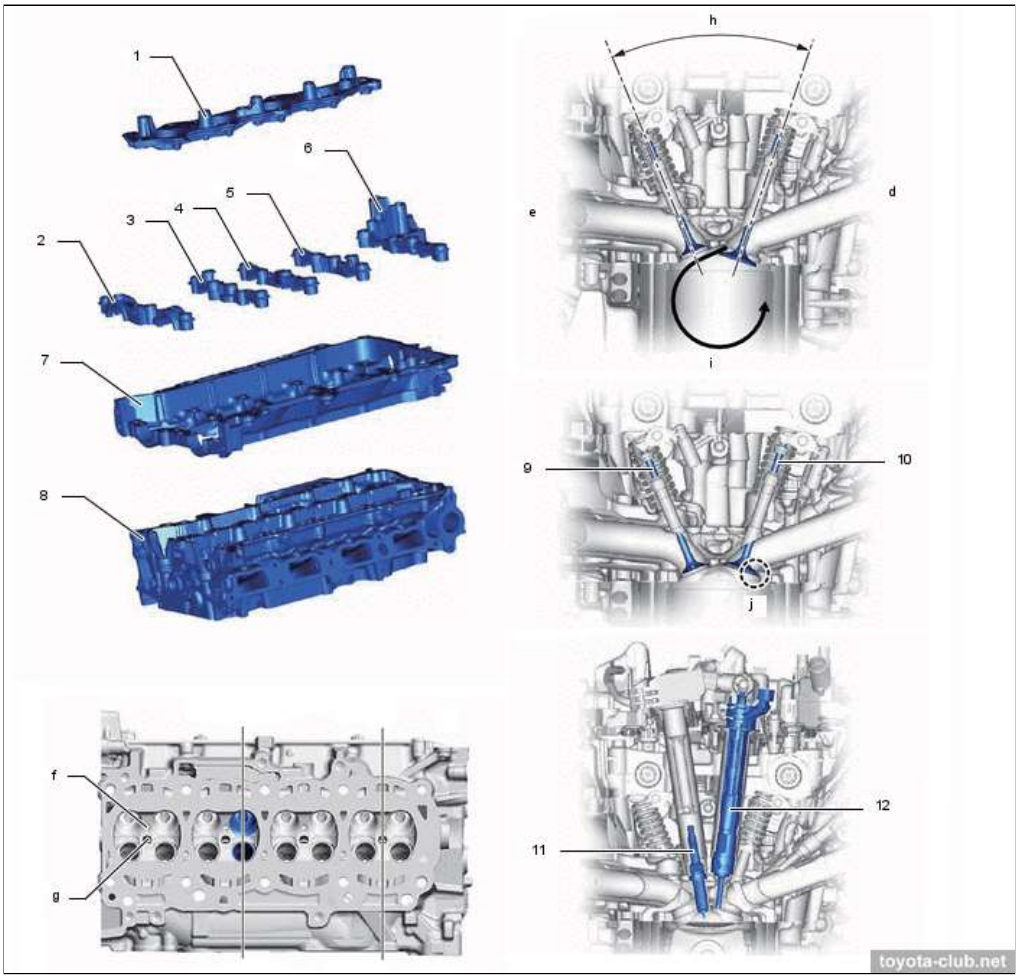
The "walls" of the piston are noticeable sloped, which should better distribute the load to the piston pin at the expansion stroke.



a - weight reduction, b - inclined side wall

Connecting rods - forged, with knock pins for caps; top heads tapered to reduce weight.

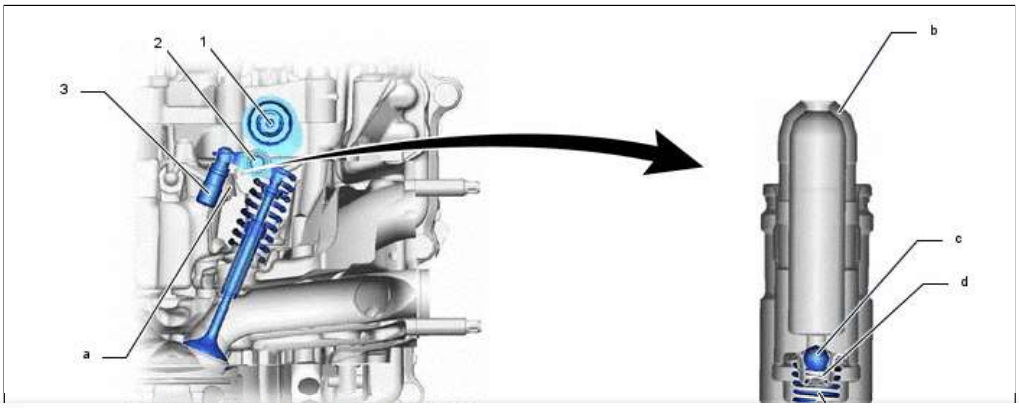
The camshafts are installed in a separate housing, which mounted on the cylinder head.



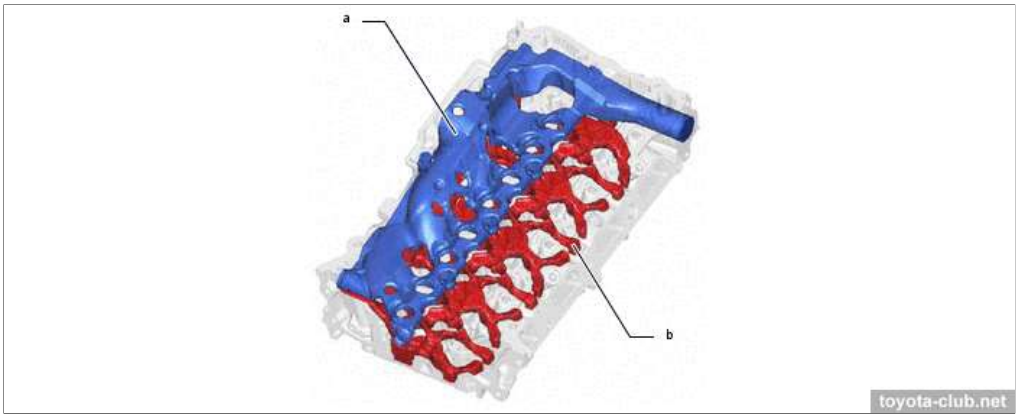
1 - injector holder, 2-6 - camshaft bearing cap, 7 - camshaft housing, 8 - cylinder head, 9 - exhaust valve, 10 - intake valve, 11 - spark plug, 12 - direct fuel injector. d - intake side, e - exhaust side, f - fuel injector hole, g - spark plug hole, h - 41°, i - tumble flow, j - laser cladded valve seat

Inlet valves have special "laser-clad" seats. Sodium cooling of hollow exhaust valves was implemented.

There are hydraulic lash adjusters and roller rockers in the valve mechanism.

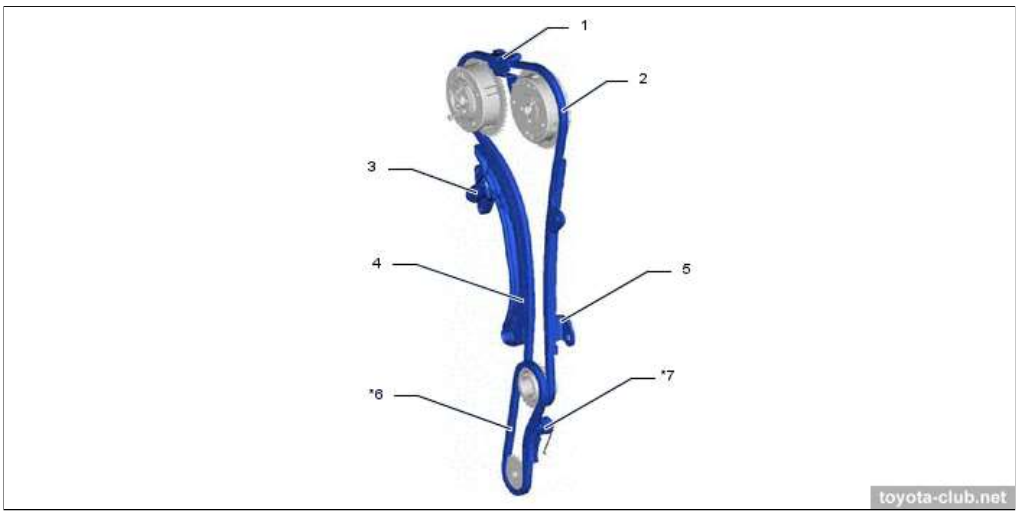


The cooling jacket of the head is divided into two levels to accelerate the flow of antifreeze.



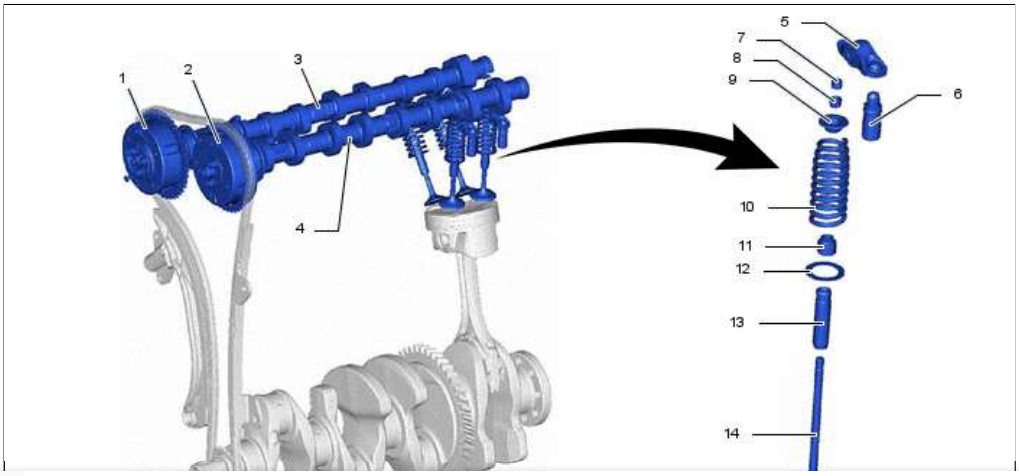
a - upper side, b - lower side

Timing drive - 16-valve DOHC, driven by single-row roller chain (pitch 8 mm), the chain tension adjusted by automatic hydraulic tensoiner. The other short chain drives the oil pump.



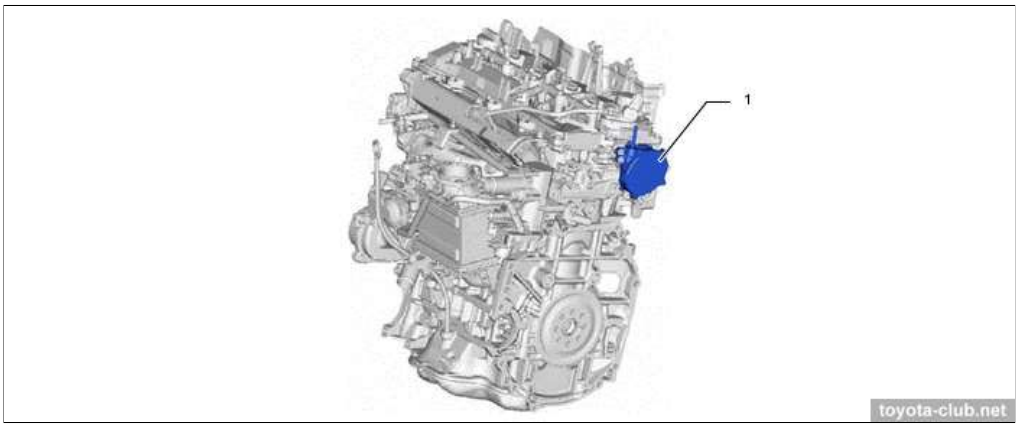
1 - chain vibration damper #2, 2 - timing chain, 3 - chain tensioner 1, 4 - chain tensioner slipper, 5 - chain vibration damper 1, 6 - oil pump drive chain, 7 - chain tensioner plate

VVT actuators both for the intake and exhaust camshafts are installed (DVVT - Dual Variable Valve Timing). The actuators - hydraulic type, timing variations range - 50° for intake and 50° for exhaust. More about Toyota VVT operation.



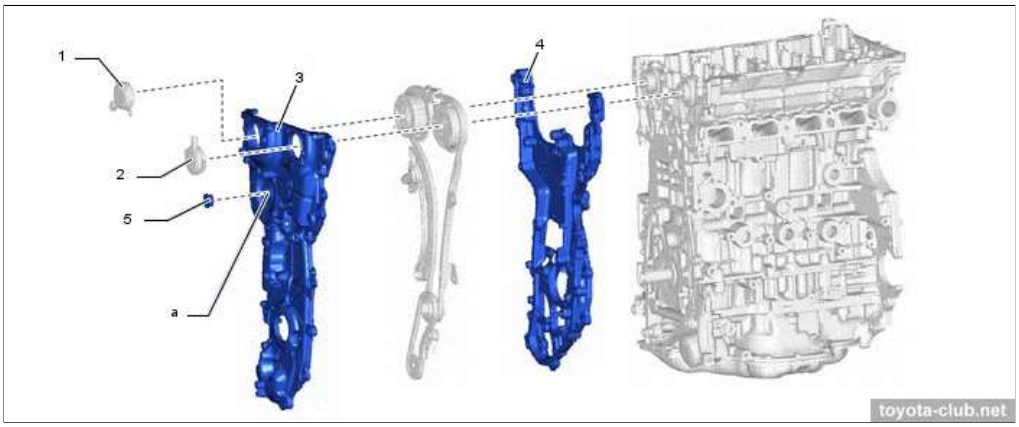
retainer, 10 - valve compression spring, 11 - valve stem oil seal, 12 - valve spring seat, 13 - valve guide bush, 14 - valve

The exhaust camshaft drives the injection pump by profiled cam and also drives the vacuum pump.



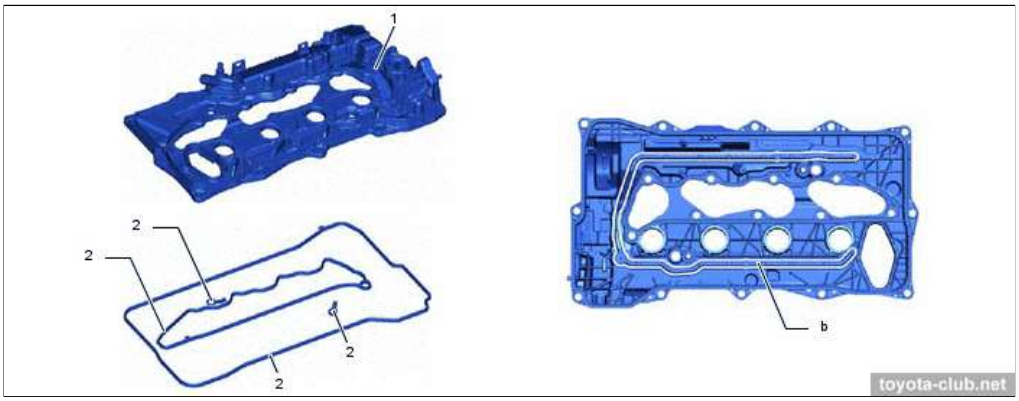
1 - vacuum pump

The timing chain is closed with two covers (VVT valves are attached to the upper cover).



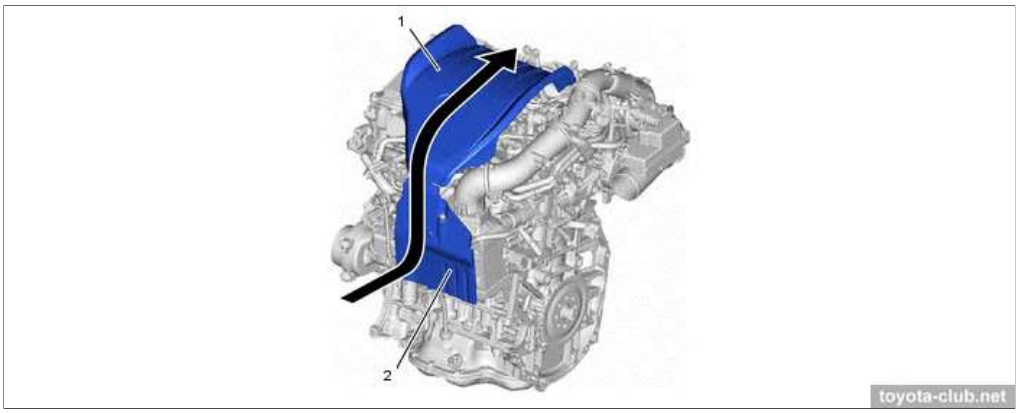
1 - VVT solenoid (exhaust), 2 - VVT solenoid (intake), 3 - timing chain cover 2, 4 - timing chain cover 1, 5 - straight screw plug. a - service hole

The cylinder head is covered with polymer cover, provided with oil delivery pipe for the rockers lubrication.



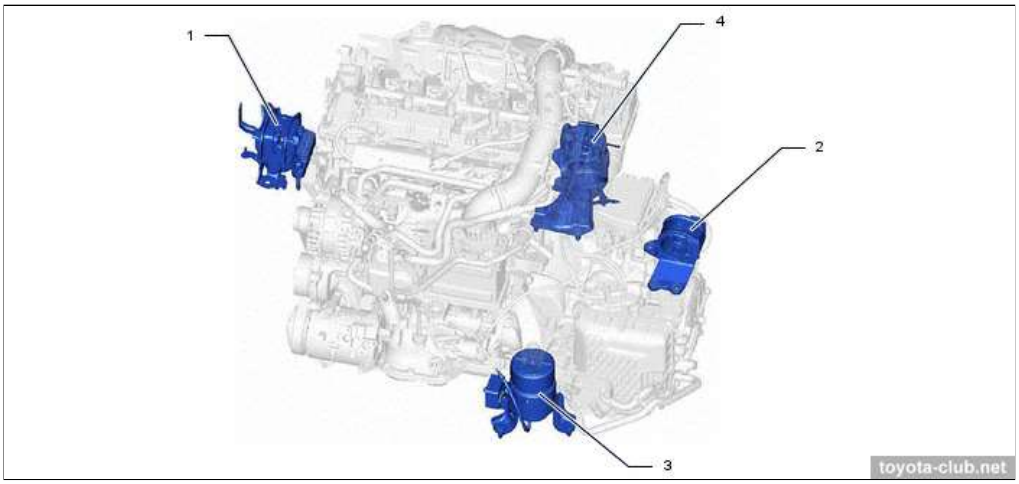
1 - cylinder head cover, 2 - gasket. b - oil delivery pipe

The engine is closed with 3D-shaped covers that allow for more efficient use of the airflow from the fan.



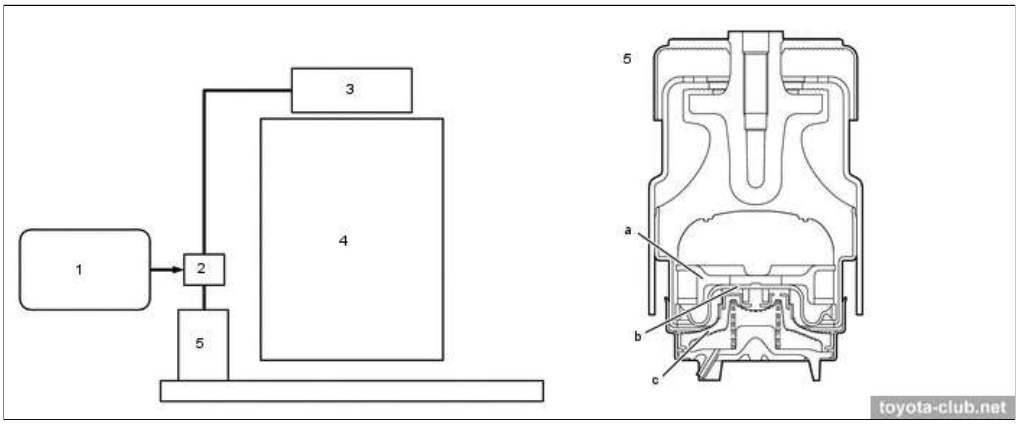
1-2 - engine cover

The powertrain is mounted with four supports: left and right - hydraulic-type, front - active type.



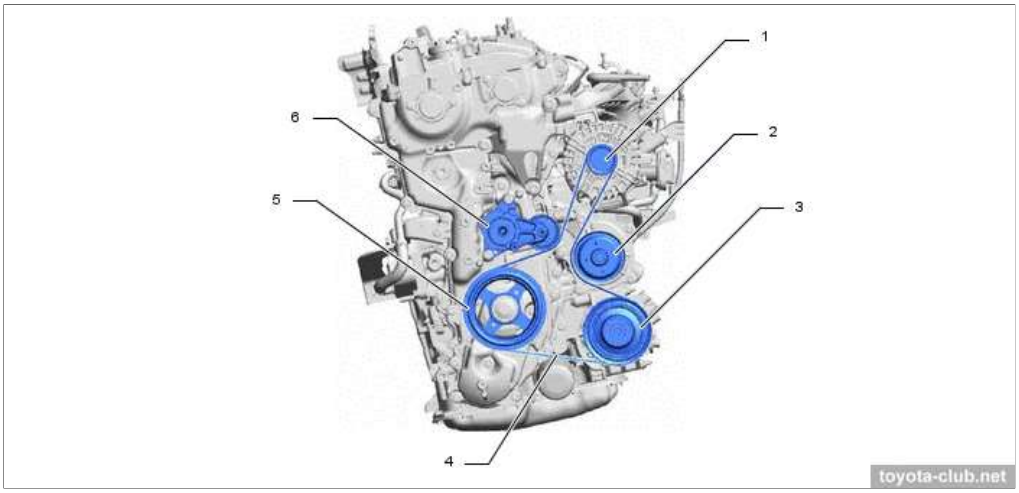
1-4 - engine mounting insulator

When the VSV is on, the vacuum is not supplied to the insulator, the diaphragm is closed, the fluid circulates through the "idle/lock-up" orifice. When the VSV is off, the vacuum is supplied to the insulator, the diaphragm is open, the fluid circulates through the "ride comfort" orifice.



1 - ECM, 2 - VSV, 3 - vacuum pump, 4 - engine, 5 - front mounting insulator, 6 - rear mounting insulator. a - idle/lock-up orifice, b - ride comfort orifice, c - diaphragm

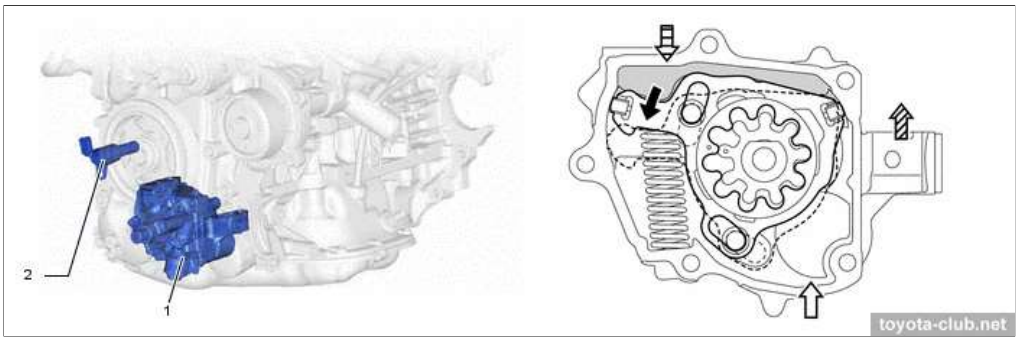
The drive belt is equipped with an automatic friction-type tensioner. A torsional vibration damper is installed in the generator pulley.



1 - generator, 2 - coolant pump, 3 - A/C compressor, 4 - V-ribbed belt, 5 - crankshaft, 6 - tensioner

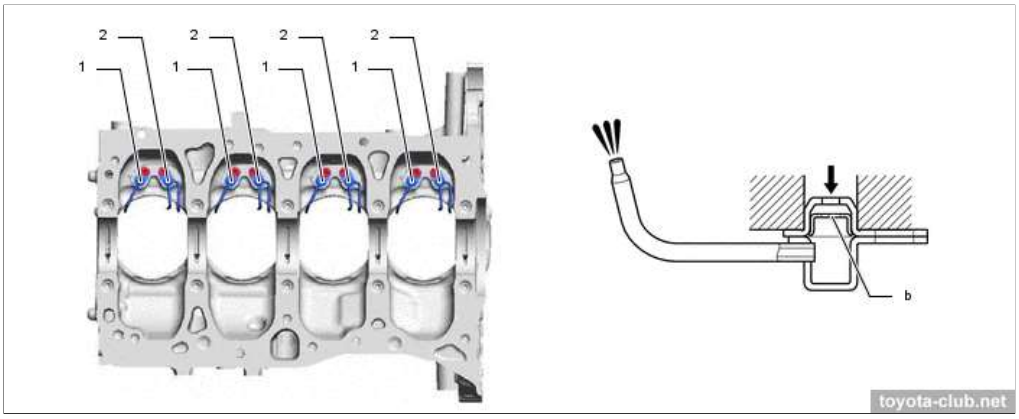
Lubrication

Variable displacement oil pump is driven by a short chain. The ECM controls the oil pressure and volume via an oil pressure control valve.



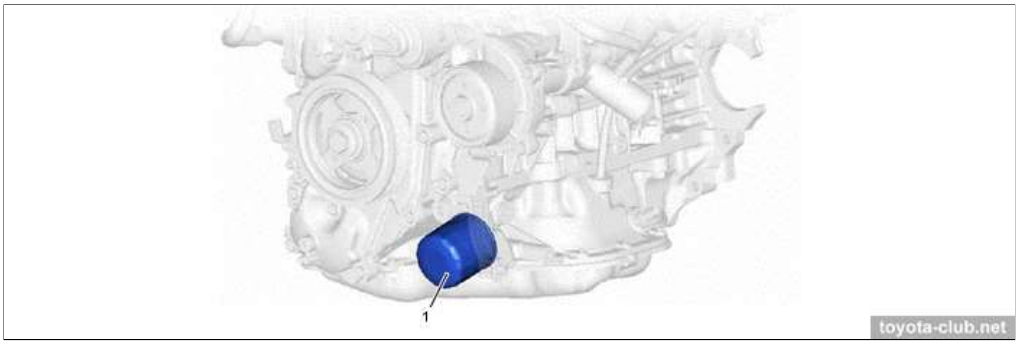
1 - oil pump, 2 - oil pressure control valve

Oil nozzles that lubricate and cool the pistons are provided (two oil nozzles for each, one of them with double sprayer). The oil to nozzles comes through built-in filters.



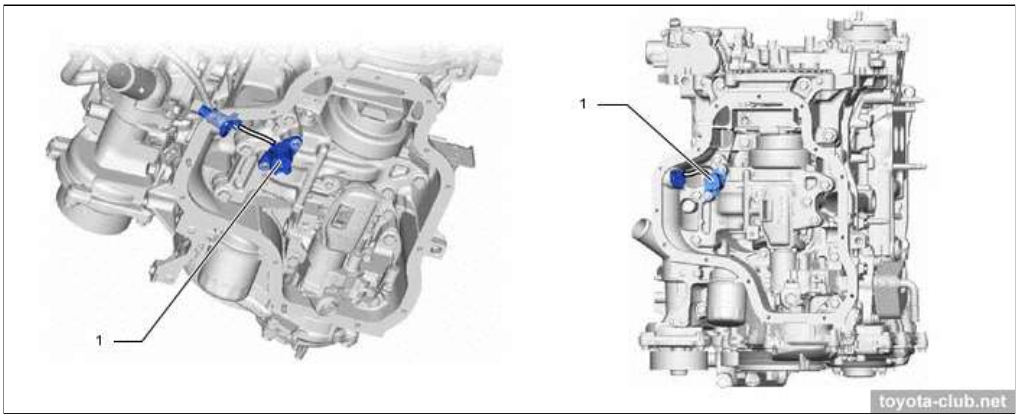
1 - oil nozzle #1, 2 - oil nozzle #2. b - filter

A normal spin-on type oil filter is installed horizontally at the front of the engine.



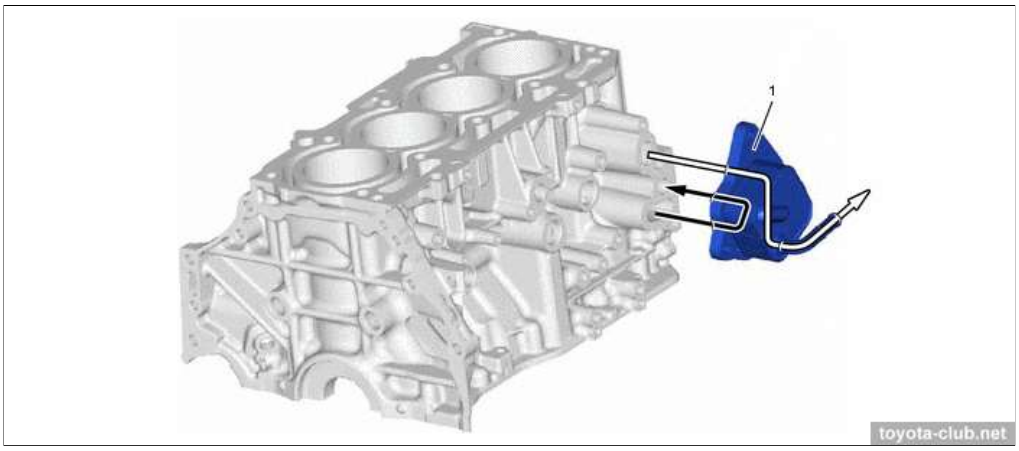
1 - oil filter

There is an oil level sensor under the balance shafts module.



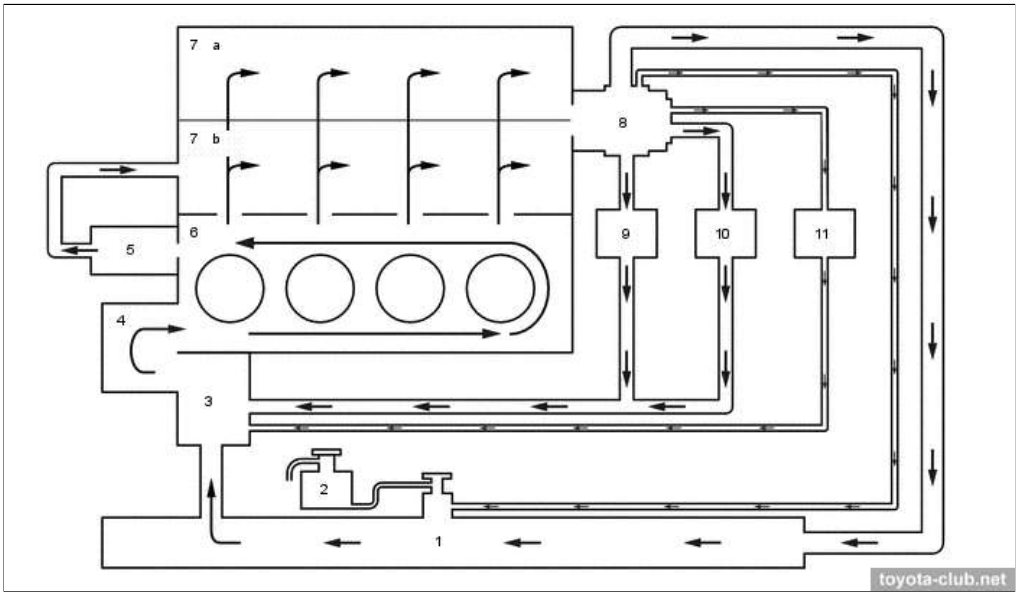
1 - engine oil level sensor

Water-type oil cooler is used.



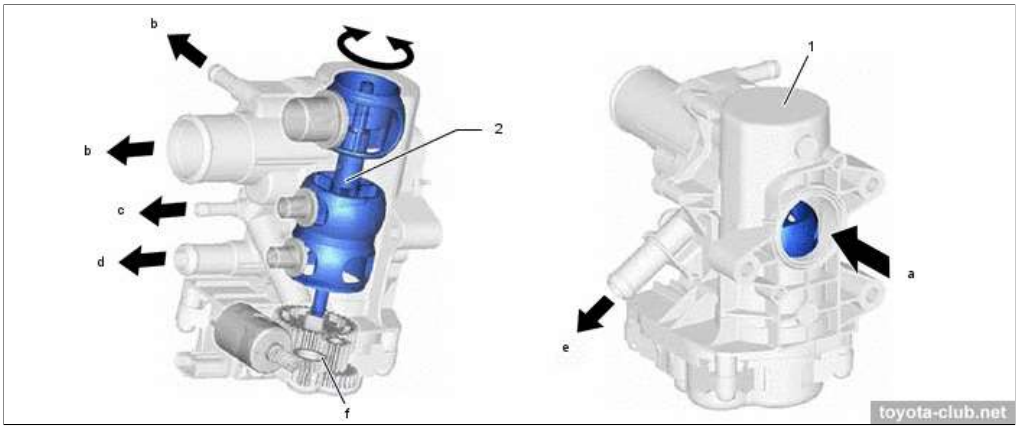
1 - engine oil cooler

Cooling



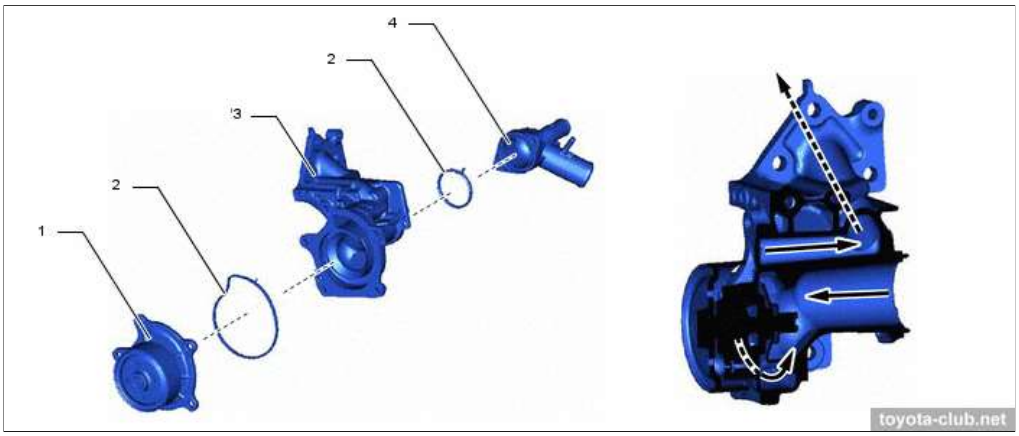
1 - radiator, 2 - radiator reserve tank, 3 - coolant inlet, 4 - engine coolant pump, 5 - oil cooler, 6 - cylinder block, 7 - cylinder head, 8 - water control valve, 9 - ATF cooler, 10 - heater radiator, 11 - throttle body. a - upper water jacket, b - lower water jacket

The principal innovation is the electric control valve, which replaces the thermostat and the shut-off valves. While the engine is warming up, the cooling channels are closed, and then the temperature is maintained at an optimal level.



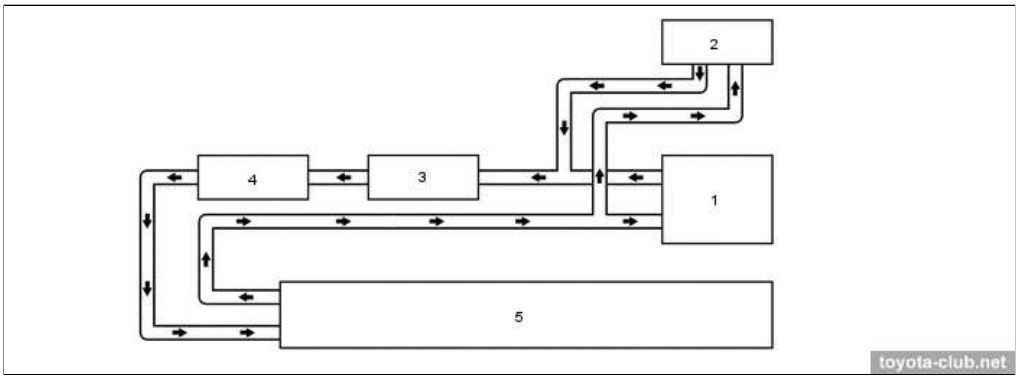
1 - water control valve, 2 - rotary valve. a - from engine, b - to radiator, c - to throttle body, d - to transmission oil cooler, e - to heater radiator, f - motor and 3-step deceleration gear

The coolant pump is a conventional belt driven.



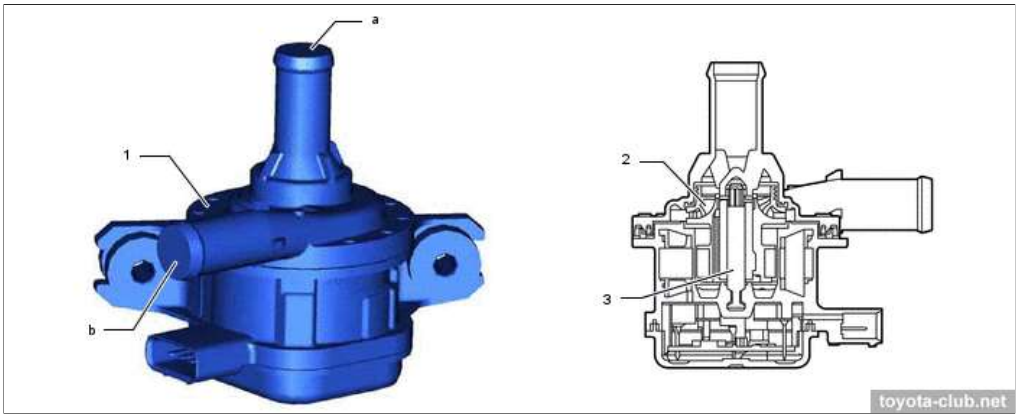
1 - coolant pump, 2 - gasket, 3 - inlet housing, 4 - coolant inlet

A separate cooling system serves the intercooler and turbocharger.



1 - intercooler, 2 - turbocharger, 3 - intercooler reserve tank, 4 - electric coolant pump, 5 - intercooler cooling radiator

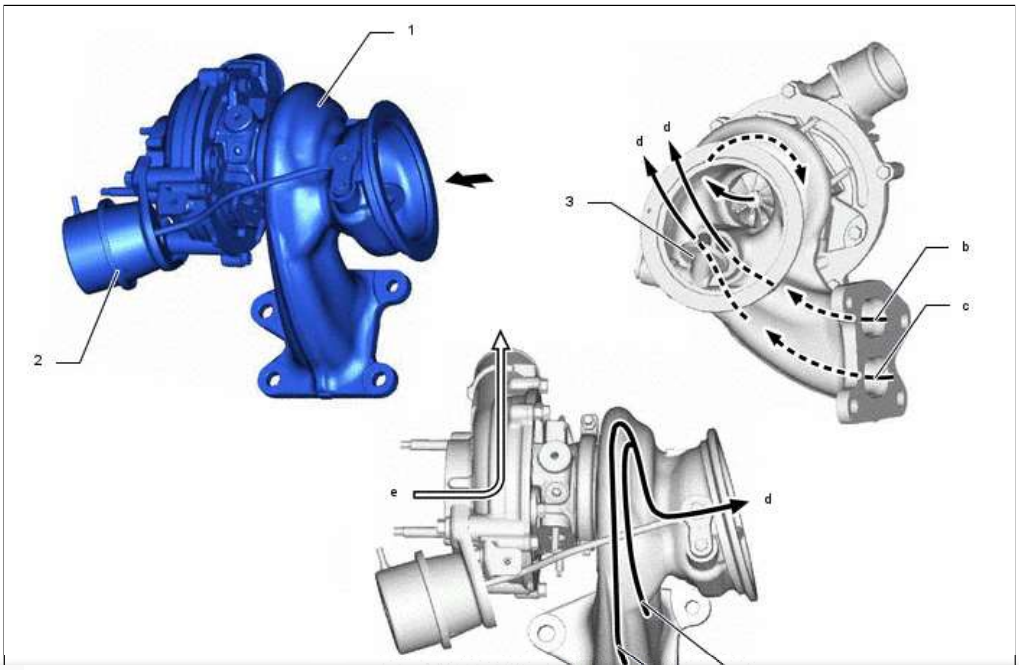
This circuit uses an electric pump and an additional radiator.



1 - electric coolant pump, 2 - rotor, 3 - shaft. a - inlet, b - outlet

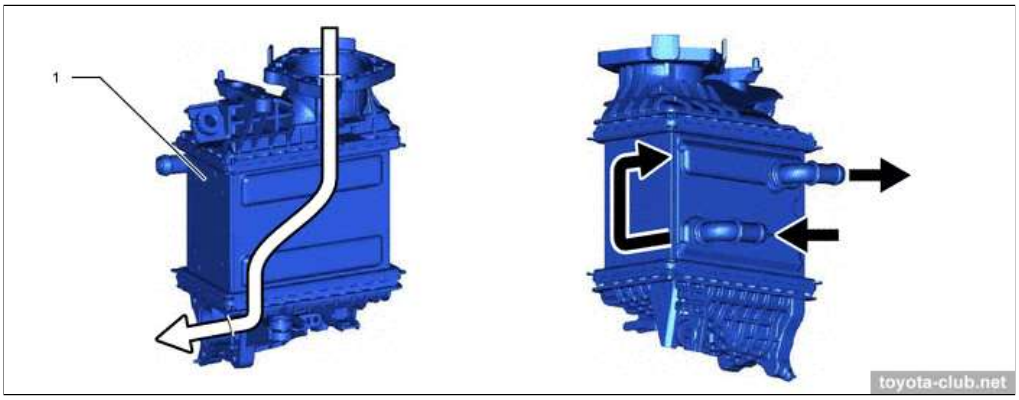
Intake and exhaust

Turbocharger - twin-scroll type with conventional vacuum WGT actuator.



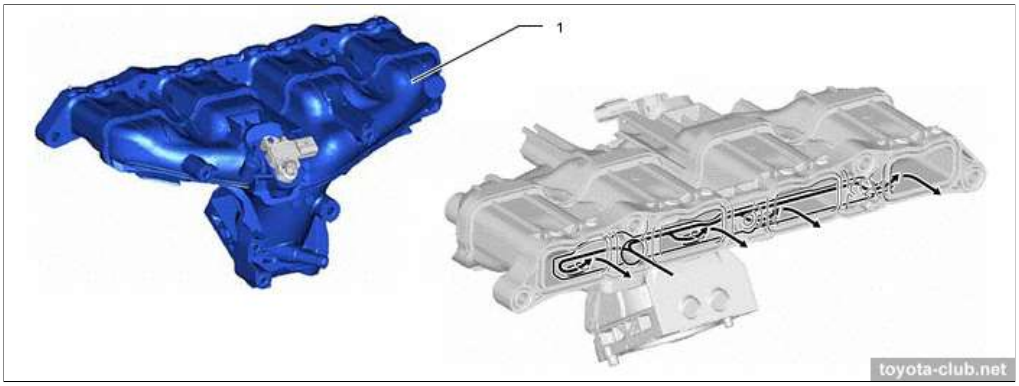
1 - turbocharger, 2 - actuator, 3 - wastegate valve. b - exhaust gas (from cylinders 2/3), c - exhaust gas (from cylinders 1/4), d - bypass gas flow, e - intake air flow

A compact liquid intercooler is used to cool the charge air.



1 - intercooler

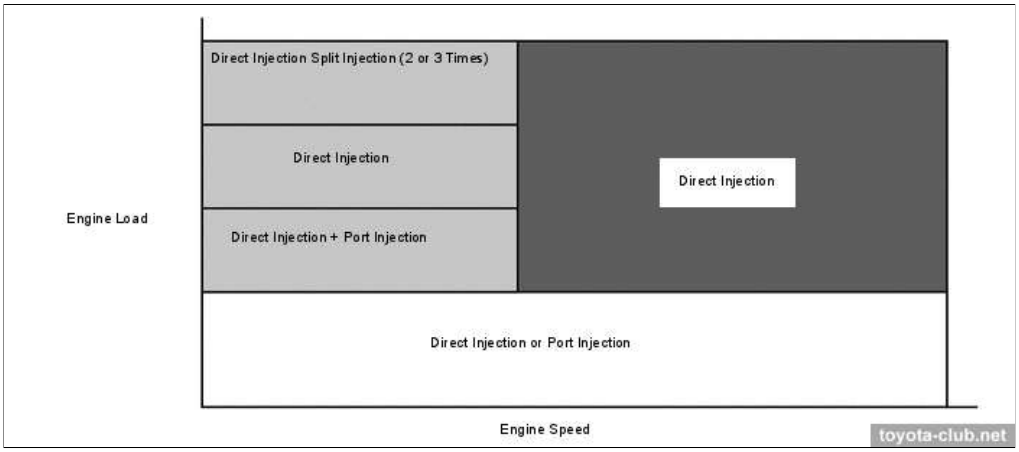
Intake manifold made of plastic, with integrated crankcase ventilation circuit.



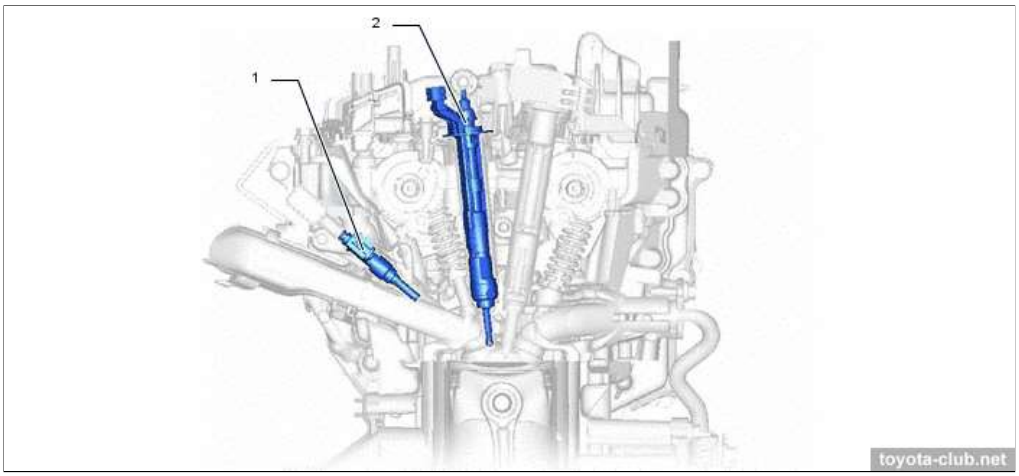
1 - intake manifold. a - blowby gas flow

Fuel system / Engine control (D-4ST)

Fuel injection - combined: directly in the combustion chamber and multipoint in the inlet ports. Main innovations: in comparison with previous engines, the dependence of the injection type on load and speed has become more complicated, and 2/3-times injection mode has appeared.

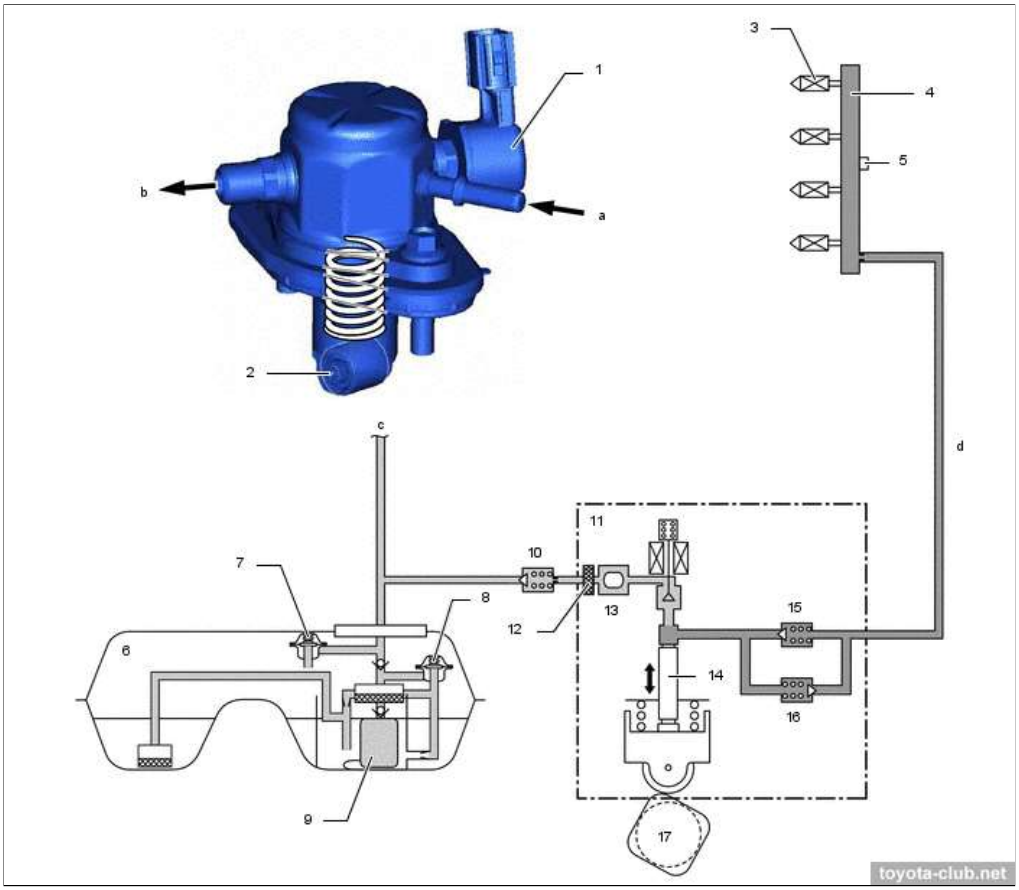


For the first time on Toyota D-4s, the high-pressure injector is installed vertically.



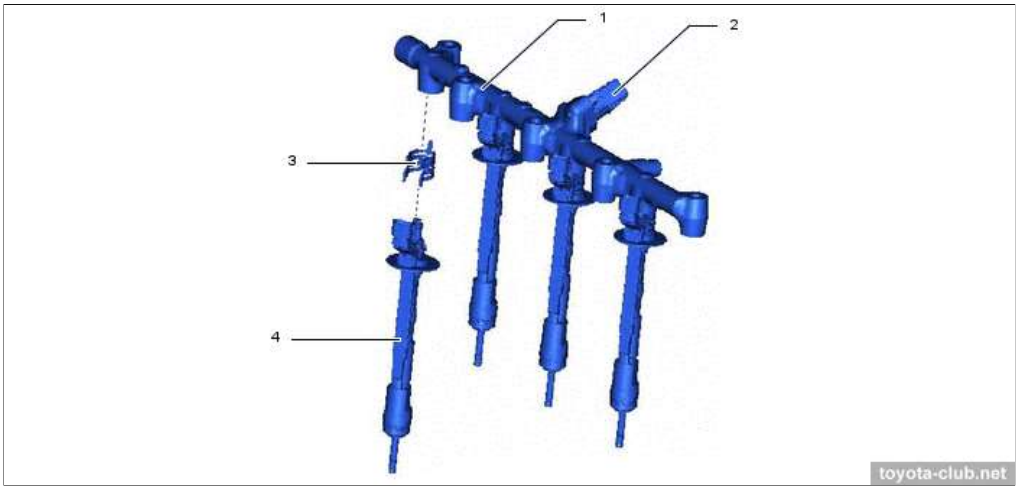
1 - port fuel injector, 2 - direct fuel injector

Injection pump (high pressure) - single-plunger with control valve, relief valve, check valve and pulsation damper. The fuel pressure is regulated in the range 2.4..30 MPa depending on the driving conditions, and about 3.1 MPa at idle.



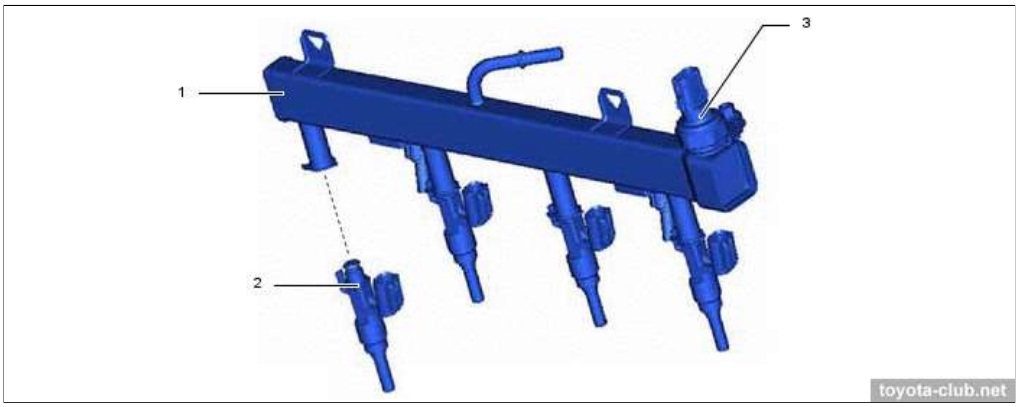
1 - spill control valve, 2 - roller lifter, 3 - direct fuel injector, 4 - fuel delivery pipe (direct injection), 5 - fuel pressure sensor, 6 - fuel tank, 7 - fuel main valve (fuel pressure regulator), 8 - fuel main valve (relief valve), 9 - fuel pump (low pressure), 10 - flow control valve, 11 - fuel pump (high pressure), 12 - fuel sus filter, 13 - fuel pressure pulsation damper, 14 - plunger, 15 - check valve (60 kpa), 16 - fuel relief valve (38.1 MPa), 17 - exhaust camshaft a - low-pressure fuel (from fuel pump), b - high-pressure fuel (to fuel delivery pipe), c - fuel delivery pipe (low pressure), d - high-pressure fuel pipe

High pressure fuel rail - forged iron, with pressure sensor.



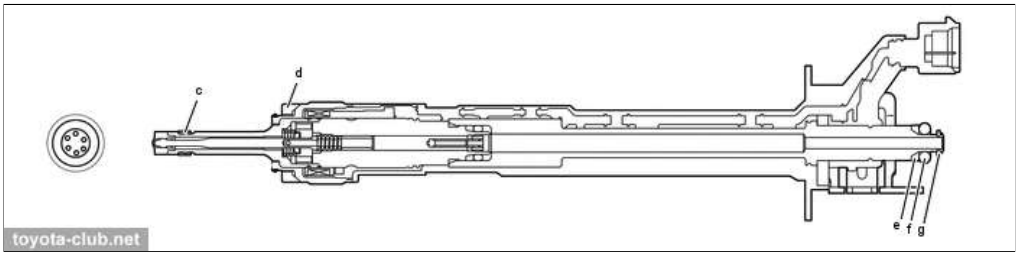
1 - fuel rail (direct injection), 2 - fuel pressure sensor, 3 - nozzle holder clamp, 4 - direct fuel injector

Low pressure fuel rail - stamped steel, with pressure sensor.



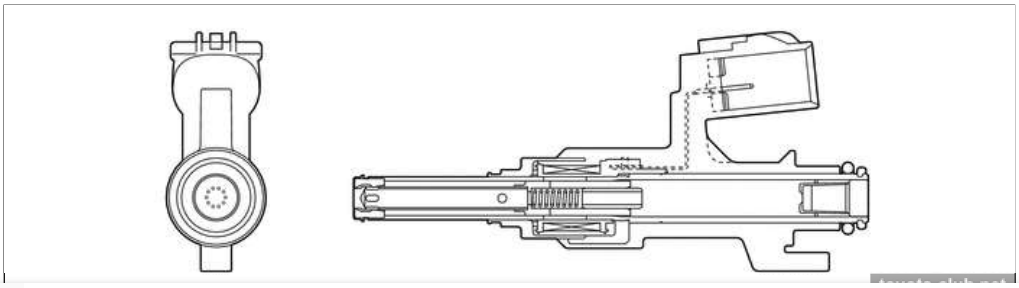
1 - fuel delivery pipe (port injection), 2 - port fuel injector, 3 - fuel pressure sensor 2

High pressure injector of a new type (long) with 6-point nozzle.



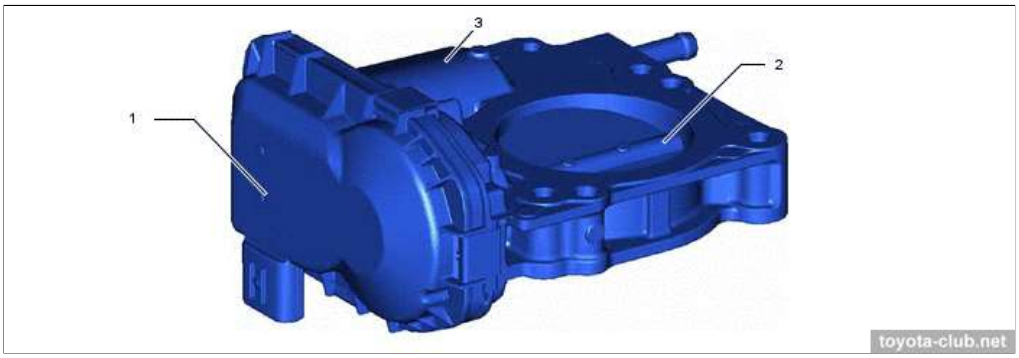
c - fuel injector seal, d - injector vibration insulator, e - fuel injector back-up ring 1, f - o-ring, g - fuel injector back-up ring 3

Low pressure injector - with a long 10-point sprayer that delivers fuel into the air stream and minimizes fuel impact to the walls.



- air-flow ratio sensors (AFS) - planar type upstream the first catalyst, and cup type downstream it
- accelerator pedal position sensor and throttle position sensor - Hall effect
- oil pressure, temperature and level sensors
- knock sensor - flat type
- fuel pressure sensors in high and low pressure circuits
- coolant temperature sensor
- boost pressure sensor

It is remarkable how much the throttle valve has been reduced over time.

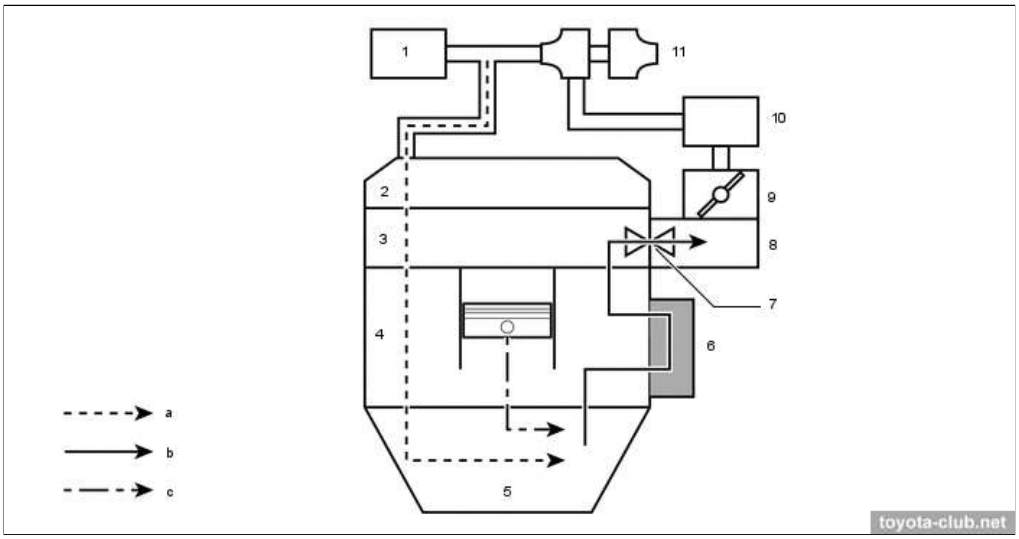


1 - throttle position sensor, 2 - throttle valve, 3 - throttle control motor

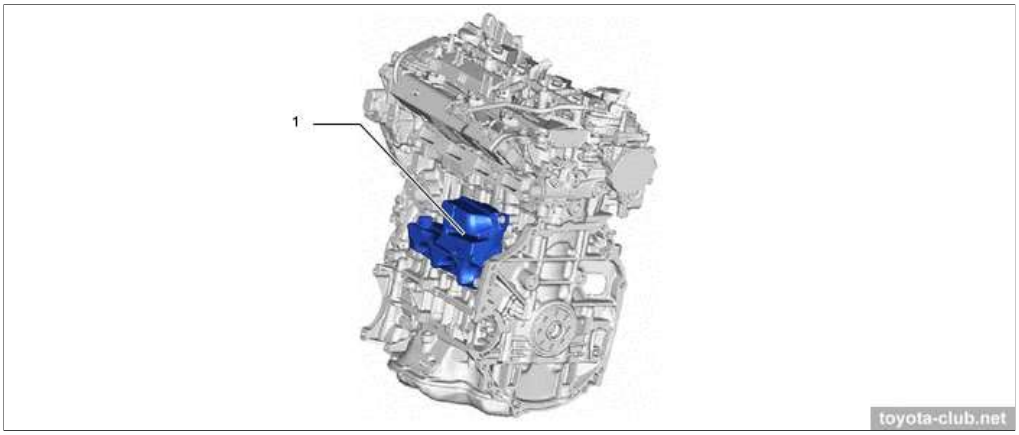
Emissions control

Declared compliance with the regulations - Euro 6b..6c.

Crankcase ventilation system (PCV) - with an oil separator unit and a PCV valve installed in the cylinder head.

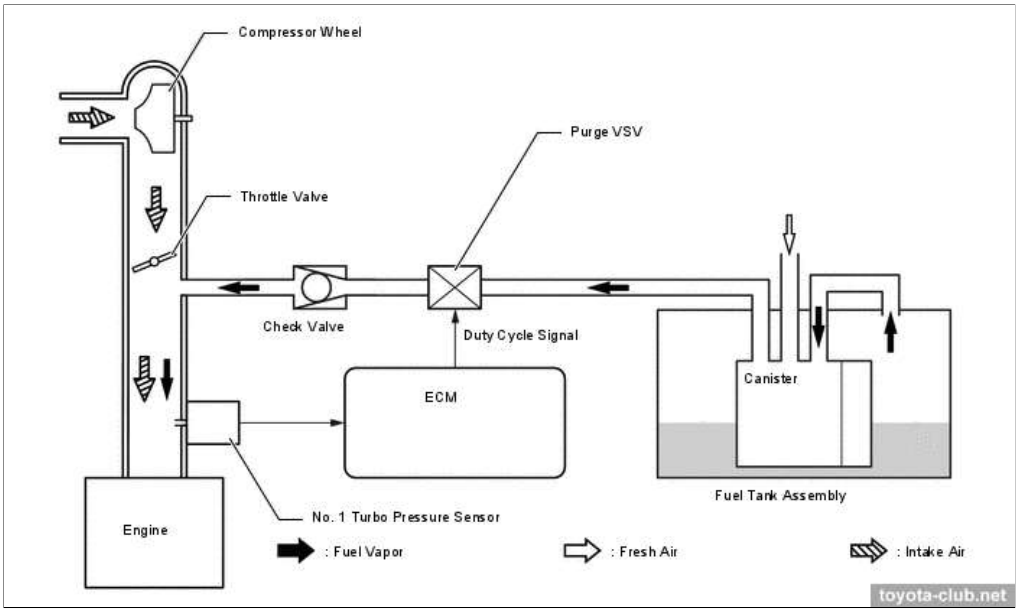


1 - air cleaner, 2 - cylinder head cover, 3 - cylinder head, 4 - cylinder block, 5 - stiffening crankcase, 6 - ventilation case #1, 7 - PCV valve, 8 - intake manifold, 9 - throttle body, 10 - intercooler, 11 - turbocharger. a - fresh air, b - blowby gas + fresh air, c - blowby gas

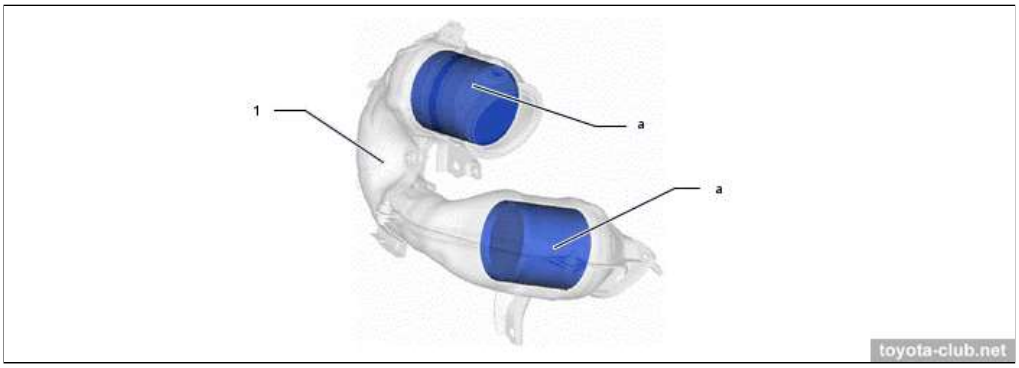


1 - ventilation case

EVAP system is performed rather simple, only with an purge VSV.



Emissions control system includes a pair of three-way catalysts installed in series.



1 - converter unit. a - TWC

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