Nissan's New Engineering

The story behind the X-Trail.

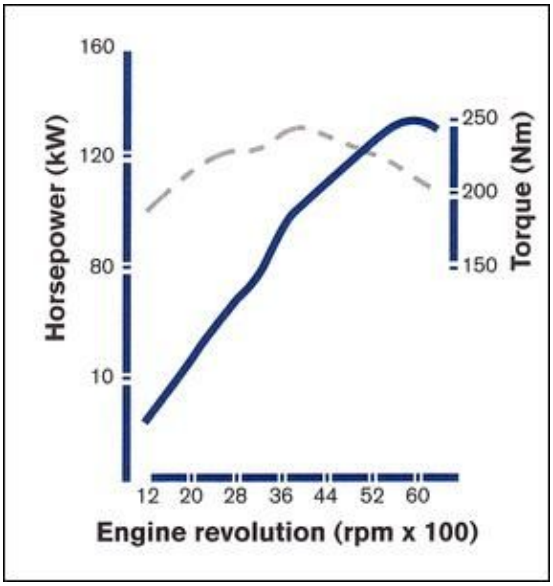
By Julian Edgar

Take a look at these specs and picture the car:

- Four wheel ventilated discs with twin spot front calipers, ABS, brake assist and electronic load proportioning
- 2.5-litre four cylinder with balance shafts, electronic throttle, variable valve timing, variable intake manifold and direct fire ignition - 132kW.
- Front MacPherson struts with forged alloy lower arms and rear parallel link rear struts
- Electronically-controlled active four wheel drive

Thinking along something exotic - perhaps European? Surely, a performance car?

Well, our pics give it away but if you hadn't worked it out, these are the specs of the humble Nissan X-Trail!

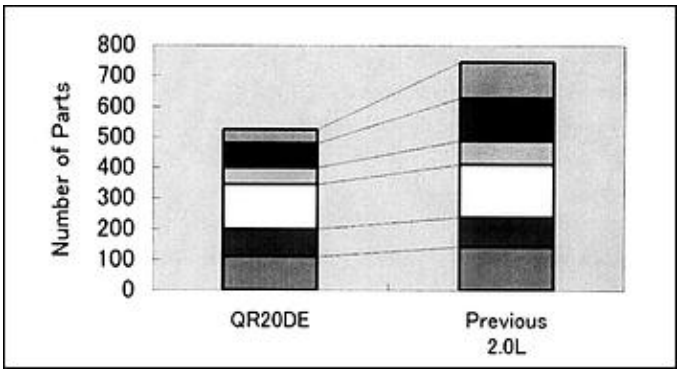


However, it's a dead-set certainty that many of these components will find their way into the coming range of small Nissan performance cars. After all, you don't replace both the SR 2-litre and KA 2.4-litre engines with a new design and then use it sparingly! Yes, this engine, - and perhaps the four-wheel driveline - spell out Nissan four cylinder performance after the end of the famous SR20 series.

And the good news is that the wonderful QR25DE engine is one that can follow in the steps of the L-series and SR-series, with its head held high. Apparently there's no turbo version yet, but even the NA engine is a superb four cylinder - torquey, powerful, smooth and sweet.

The New Engine

The QR engine series was specifically developed by Nissan engineers to replace both the free-revving SR20DE and the torquier KA24DE engines. To fill these roles it had to be both driveable and also develop sufficient power.



The engineers had five main criteria to meet:

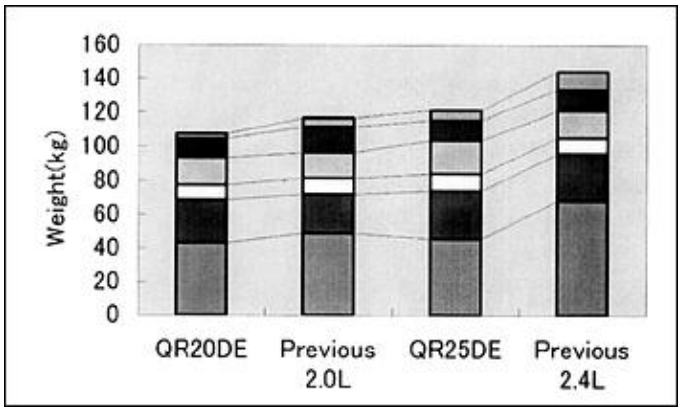
- Quietness - large swept volume four cylinder engines usually have high noise and vibration; the QR engine designs aimed for near six-cylinder refinement.
- High Performance - an engine that will be used across a wide range of cars requires good bottom end performance. As the Nissan engineers state, "Output torque at low to medium engine speeds is the most important contributor to driving pleasure in daily use."
- Low Fuel Consumption - an aim that these days that applies to all new engine designs.
- Lightweight and Compact - since it will be fitted in small, medium and large vehicles, the engine must be sized so that it can be packaged as required
- Parts Count Reduction - this results in a lighter, more compact engine that is cheaper to build.

The QR series of engines is - at the time of writing - available in four versions.

Name	QR20DD	QR20DE	QR25DD	QR25DE
Type	Water-cooled, gasoline, 4-cycle			
Displacement (cc)	1998		2488	
Arrangement and No. of cylinders	Inline 4-cylinder			
Type of combustion chamber	Cross-flow, pentroof			
Valve mechanism	Chain-drive DOHC with 4 valves/cylinder			
Fuel system	Direct injection	Port injection	Direct injection	Port injection
Bore x stroke (mm)	89.0 x 80.3		89.0 x 100.0	
Compression ratio	10.5:1	9.9:1	10.5:1	9.5:1
Valve head diameter (mm)	Intake: 35.5; Exhaust: 30.5			
Cylinder bore pitch (mm)	97.0			
Crankshaft pin-journal diameter (mm)	45.0			
Crankshaft main-journal diameter (mm)	55.0			
Connecting rod length (mm)	152.9		143.05	

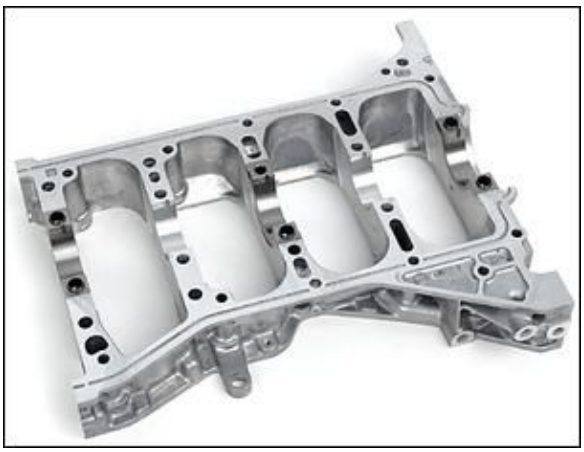
The 'DD' engines are direct injection, while the 'DE' engines are conventional port injection. As can be seen, the larger 2.5-litre versions are made by simply stroking the 2-litre; bore size remains the same at 89mm. This makes the 2.5 litre engine a very long stroke design - interesting, since the SR20 is 'square' (ie has identical bore and stroke dimensions). However, the QR25DE revs quite sweetly to its 6500 rpm cut, with peak power developed at 6000 rpm.

To smooth the inherent vibrations in a big four, the QR-series use a patented twin balance shaft system. The shafts are located in the sump, driven by a chain from the crankshaft at twice engine speed. The balancing rate was determined by measuring vibration at the front right-hand engine mount, which apparently was the most critical in producing booming noise.



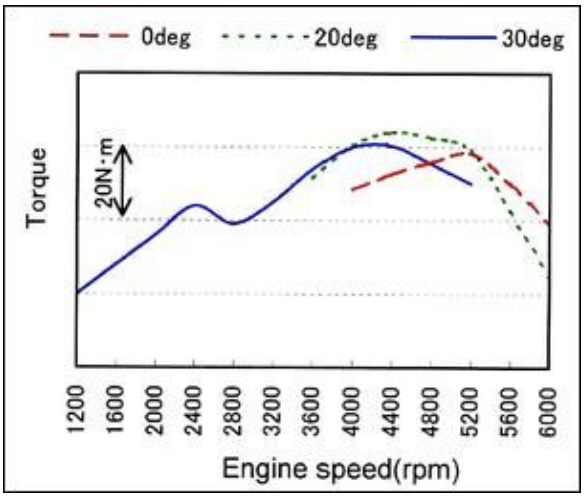
The QR series engines use lightweight, die-cast alloy blocks. Unlike the previous sand casting approach taken with both the SR and KA-series of engines, die-casting allows thinner wall sections. However, only open-deck block designs can be produced using this approach, so the closed-deck designs of the older engines are gone.

In addition to the weight reduction resulting from the casting technique, the QR series of engines have reduced mass over the previous designs by the use of a resin rocker cover, resin intake manifolds (some models only), stainless steel tubular exhaust manifold, and a serpentine belt drive of the accessories. Compared with the SR20, the QR20 at 110kg weighs approximately 10kg less, while the QR25 weighs about 20kg less than the superseded KA24. The QR20 is also 30mm shorter than the SR20.

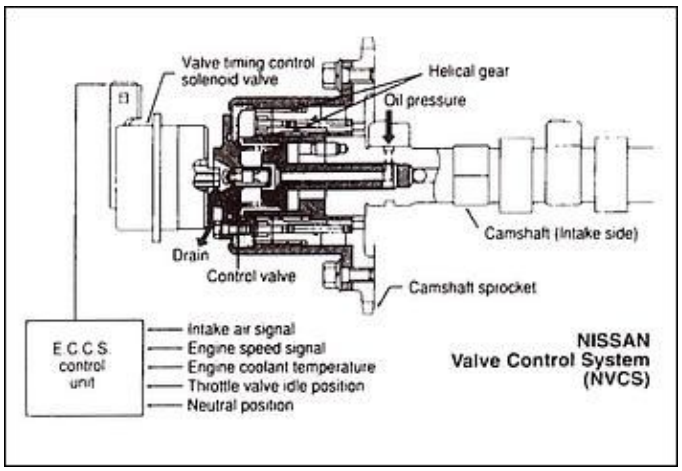


As with other Nissan engines, the internals are to a very high quality. The crankshaft is forged for strength and micropolished to reduce friction. The crankcase is split along the crankshaft centreline, with the lower half of the five main bearings supported by the bottom half of the crankcase. This section is termed by Nissan a ladderframe, although it is quite different to the similarly named item used in the RB-series engines where a ladder structure containing the lower half of the main bearing caps is bolted into place. The main bearing caps are made from either iron and aluminium - number 1, 3, and 5 main bearing caps are iron, while number 2 and 4 are aluminium. Aluminium is used in those caps which have only a small effect on reducing vibration.

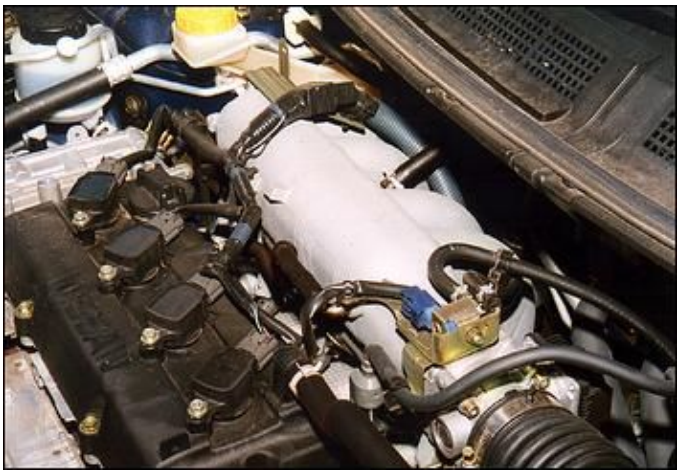
The QR series uses chain drive for the camshafts - belts seem to be going out of fashion. A new design 'silent chain' is used - it has a pitch of 6.35mm (0.25-inch), allowing a narrow included angle between the intake and exhaust valve and a compact combustion chamber shape. The valvetrain uses a direct-acting cam-on-bucket design, with valve clearances set via 26 lifter-crown-thickness variations... it's not expected that these will need to be changed while the engine is in service.



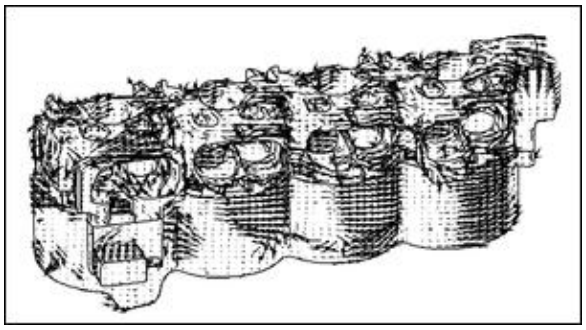
Low and medium engine speed torque is improved by the system, while pumping losses and oxides of nitrogen emissions are also reduced by the use of a greater valve overlap under partial load conditions (ie, internal EGR).



The intake camshaft timing can be varied to provide an overlap from 3 to 33 degrees. The stepless variable camshaft control uses a helical gear in the end of the intake cam, altered in its position by solenoid-controlled oil pressure.



The intake manifold is of a variable design, with dual-length parallel runners provided for each intake. Up until a high 5000 rpm, the short runners are blocked by a butterfly valve - above that engine speed they open, whereupon both intake runners can supply air. The intake air is regulated by an electronic throttle butterfly, so the relationship between the accelerator position and the actual throttle blade opening isn't fixed. In practice, this simply helps make the engine feel more responsive and predictable.

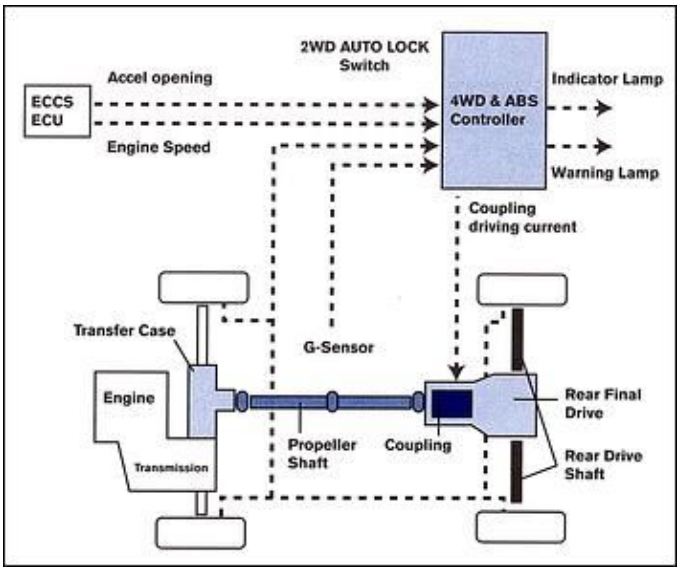


To improve resistance to detonation, extensive research was undertaken in the area of engine cooling. The water flow within the engine was analysed by computer simulation, and the velocity of the water was increased by 44 per cent over the base model. Cooling around the spark plug was improved by the use of a long-reach plug, which allowed the water jacket near the valve seats to be enlarged.

The cooling system is also two-stage. Under "normal operating conditions" the flow of cooling water to the cylinder block is closed off, raising the temperature of the bores and so reducing friction. However, when the water temperature reaches 95 degrees C, the valve opens to allow flow through the block.

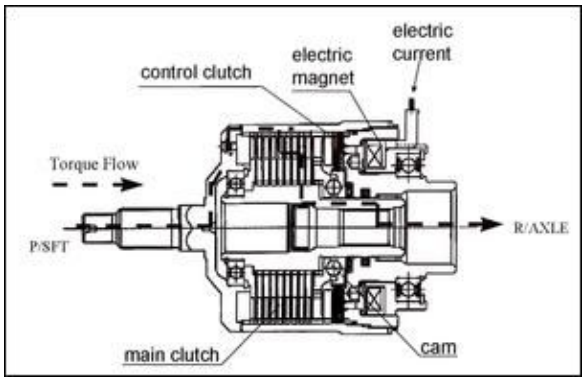
The Driveline

The X-Trail uses an electronic four-wheel drive system that owes more than just a hint of its design to the original ground-breaking Skyline GT-R system. Like the GT-R, it uses a wet multi-plate clutch to vary the torque split between the front and rear wheels, however, in the Skyline, the driveline was predominantly rear-wheel drive with torque directed frontwards only as necessary. In the X-Trail the opposite applies - the car is predominantly front-wheel drive, with torque directed rearwards as required.



This diagram shows the layout. A transfer case turns the drive through 90 degrees, sending it along a propeller shaft to the rear diff. In the extended nose of this differential assembly is a wet multiplate clutch ('coupling') that apportions torque to the rear wheels. With the coupling unlocked, no torque turns the rear wheels - the car is pure front-wheel drive. With the coupling fully locked, the front/rear drive is 57:43, a ratio determined by the transfer case. Thus the greatest amount of torque that can be directed through the rear wheels is 43 per cent.

The electronic control system uses inputs from the accelerator opening (not throttle opening - that doesn't vary in its opening angle linearly with the accelerator, remember!) and engine speed. Additionally, an accelerometer (g-sensor) inputs its signal into the control unit. It's not completely clear from Nissan literature, but we assume that the g-sensor measures longitudinal acceleration, as its input is also used by the ABS part of the system.



The wet multiplate clutch locks proportionally with the current that is sent to it by the controller.

Over purely mechanical systems used in some other mid-size four-wheel drives, the electronic system has the advantage in that it can predict when four-wheel drive will be needed - it can be proactive rather than simply react to front wheelspin. Driver selection of different four-wheel drive modes is also made simple. While from a performance point of view this type of system is limited by the transfer case gearing in the proportion of torque that can be sent to the back wheels, the electronic adjustability does give it some distinct advantages over a viscous coupling system. In addition fuel consumption can be improved.

Conclusion

The Nissan X-Trail uses a stunning array of technology - especially considering its pricing. Perhaps it represents the new Nissan?

It's certain that we will see the technology flowing through to other Nissans, and while the SR20DET Turbo engine was always a good 'un, we think that a QR25 engine with turbo - producing say 180kW - will be a whole new ball game.

And let's imagine a new 180kW Pulsar-sized coupe with the electronic four-wheel drive and blistering response right through the rev range...

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