New-Generation VQ Engine Briefing

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Nissan Motor Co., Ltd.

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Agenda

1. The Powertrain concept
2. History of the VQ Engine
3. Concept behind the Newly-Developed V6 Engine
4. New-Generation VQ35/25HR Engine
5. Summary
1. The Powertrain concept
1-1. Nissan’s Core Technology Values

**Trusted Driving Pleasure**

*Trust:*
- Environment
- Safety

*Driving Pleasure:*
- Dynamic Performance

*Life on Board*

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Quality, Cost

Environment

Dynamic Performance

Life on Board
1-2. Development Concept (1)

Ultimate Powertrain

- CO2 reduction
- Fuel Efficiency
- Cleaner Emissions

Dynamic Performance

Environment
1-2. Development Concept (2)

Ultimate Powertrain

Emotion

Efficiency

Emission
1-3. Logic behind the VQ Engine (1)
1-4. DNA of VQ

- 1988: The FEATHER concept engine was developed with focus on smooth and agile revving.

- As agile as a feather

- The Initial VQ Engine Concept
  - Realizing the FEATHER concept
  - Consistent weight reduction of parts
  - Review of the basic structure

- DNA of VQ
  - The engine that revs smooth and agile
1-5. Emotional (1)

“Pleasant Acceleration Sound”
- Clear sound

“Maintaining the Exhilaration”
- Overwhelming power
- Long-lasting power

“The Ideal Agile Response”
- Quick throttle response
- Tangibly strong response at any point

“The engine that revs smooth and agile”
### 1-5. Emotional (2)

#### “Pleasant Acceleration Sound”
- Clear sound

#### Agile smooth performance
- Overwhelming power
- Long-lasting power

#### “The Ideal Agile Response”
- Quick throttle response
- Tangibly strong response at any point

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“The engine that revs smooth and agile”
1-6. Considering the VQ Engine (2)

- Emotion
- Agile smooth performance
- VQ

- Efficiency
- Fuel efficiency
- Emission
- Cleaner emissions
2. History of the VQ Engine
2-1. Evolution of the VQ Engine

- Constant improvements made to the VQ engine.
- Constant application of new technology.

<table>
<thead>
<tr>
<th>Year</th>
<th>Feature</th>
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<tbody>
<tr>
<td>'94</td>
<td>2 step VTC</td>
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<td>'99</td>
<td>Electromagnetic VTC</td>
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<td></td>
<td>Continuously Variable Timing Control</td>
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<td>'05</td>
<td>CVTC on, intake &amp; exhaust side</td>
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### 2-2. Evaluation of the VQ Engine (1)

- On “Ward’s 10 Best Engines” list for 12 consecutive years.

<table>
<thead>
<tr>
<th>Engine</th>
<th>'95</th>
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<td>Honda V6</td>
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<tr>
<td>Toyota V6</td>
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2-2. Evaluation of the VQ Engine (2)

- VQ’s DNA evaluated as an engine that revs smooth and agile.

“Ward’s 10 Best engines” Comments

- ’95 “The smoothest, rev-happiest V-6 on the planet”
- ’98 “The light-on-the-feet feel in any speed range is the VQ’s greatest delight”
- ’00 “It’s cat-quick throttle response and unmatched smoothness also mean it’s a genuine delight to drive”
- ’01 “Absolutely uncanny lack of vibration” “The throttle response is outstanding” “This is unquestionably the best-revving V-6 ever”
- ’06 “Spectacular in-gear acceleration” “This engine has brilliant throttle response in any speed range”
2-3. Evaluation of Cars Powered by VQ Engines
3. The Concept Behind the Newly-Developed V6 Engine
3-1. Considering Newly-Developed V6 engine (1)

- Start the development of a new V6 engine by reviewing principal dimensions aimed at even more agile and smooth revving.

- In continuation of VQ engine aspiration, the new engine name followed by “HR” which represents high rate of revolution and outstanding accelerator response.
3-2. Technology of New-Generation VQ Engine

- Increased height of cylinder blocks
- Change of cylinder head
- Symmetric Twin intake System
- Sound insulating engine cover
- Asymmetric piston skirt
- Equal length exhaust manifold
- High ignitability iridium plug
- Lengthening of Conrod
- Hydraulic CVTC on intake side
- Electromagnetic CVTC on exhaust side
- Increase spring power of valve spring
- Hydrogen-free DLC valve lifters
- Change oil pump rotor
- Reinforce chain cover durability
- Reinforce upper oil pan durability
- Enlarge crank journal diameter
- Change diameter of valve
- Enlarge lower oil pan durability
- Enlarge diameter of crankpin
- Equal length exhaust manifold
- Change diameter of valve
- Equal length exhaust manifold
- Improve cooling water flow
- Twin knock sensor
- Processing PVD Piston Ring
- Settings for ladder frame
- Spark plug modified into M12
- Increase compression ratio
3-3. Newly Built 2\textsuperscript{nd} Engine Facility at Iwaki Plant

Factory established for the sole purpose of VQ35HR, VQ25HR engine production

2\textsuperscript{nd} Engine Facility

Introduction of state-of-the-art processing equipment
4. New-Generation VQ35/25HR Engine
4-1. Aim of the New-Generation VQ35/25HR

| Smooth, pleasant drive | 1) High rate of revolution  
Max 7500rpm |
|------------------------|--------------------------------------------------|
| Response               | 2) Pleasant acceleration sound  
Clear sound |
| Exhilaration           | 3) Top level power performance in class  
Improved intake  
Exhaust  
Combustion Efficiency |
| Acceleration sound     | 4) Increased practical fuel efficiency  
Reduced friction |
| Fuel efficiency        | 5) Best-in-class emissions standard  
(SU-LEV in Japan) |
4-2. High Revolution Rate
4-2. High Revolution Rate

- Reduced friction and vibration at high speeds.
- Smoother piston action (reduced friction)
- Installation of ladder frame (reinforced stiffness and reduced vibrations)
4-2-1. Smoother piston action (reduced friction)

- **Extension of conrod length**
  By minimizing piston inclination, reduced friction.

- **Asymmetric Piston Skirt**
  Skirt width reduced on side with least amount of pressure resulting in reduced friction.

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- **Current conrod**
- **Stretched conrod**
- **Height of block deck**
- **Reduced friction**

Asymmetric Piston Skirt

Extend the height of block deck and the length of conrod
4-2-2. **Addition of ladder frame** *(reduced friction due to reinforced stiffness)*

- The ladder that supports the crank is placed at the bottom of the cylinder block to improve overall engine stiffness thereby minimizing vibrations at high revolution rates.
4-3. Pleasant Acceleration Sound
4-3. Pleasant Acceleration Sound (1)

- Linear and clear acceleration sound in response to Engine RPM.

![Graph showing noise level in db(A) versus Engine RPM for Current VQ35DE and New VQ35HR models, with a 10dB increase noted. Company B's performance is also highlighted.]
4-3. Pleasant Acceleration Sound (2)
- Reinforced sound clarity with reduced noise.

**New VQ35HR**

**Current VQ35DE**

High frequency noise reduced.
The symmetrical intake and exhaust system aids the production of clear and powerful sounds at high rates of revolution.

- Twin intake system
- Equal length exhaust manifold
- Optimized front pipe; Efficient merging structure
- Twin exhaust system

The clear sounds unique to V6 are emphasized and noise is controlled.
4-4. Top Level Power Performance in Class
4-4. Top Level Power Performance in Class

- Improvements in Intake - Exhaust - Combustion Efficiency.
  - Reduces resistance to intake by 18%
  - Utilizes VTC intake and exhaust controls on both sides
  - Suppresses exhaust loss
4-4-1. Reduces resistance to intake by 18%

- Dual intake and exhaust system.
- Straight intake port.

Ensures the efficient intake of air.
4-4-2. Utilizes CVTC intake and exhaust controls on both sides

- High degree of flexibility in setting valve timings improve the combustion efficiency for a wide range of engine rpms.

CVTC intake and exhaust controls on both sides

- Hydraulic CVTC on intake side
- Electromagnetic CVTC on exhaust side
4-4-3. Surpresses Exhaust Loss

- Equal length exhaust manifold.
- Symmetrical exhaust system.
4-4-4. Performance of VQ35HR powered vehicles (1)

- Powerful starting + stress-free long-lasting acceleration expandable to 7,500rpm.

Eg: Expressway entrance

The VQ35HR's formidable power is most strongly felt under driving conditions that demand smooth acceleration from low to high speed.

- After passing through the tollbooth, the vehicle gradually accelerates on the ramp
- It then accelerates in one burst on the approaching lane, reaching 100km/h
- The vehicle attains the expressway traffic flow and merges into the main lane.

Attains speed even on short approach!
4-4-4. Performance of VQ35HR powered vehicles (2)

Comparison of full-throttle acceleration

New VQ35HR vs Current VQ35DE

Acceleration G far outstrips existing models

Acceleration G does not drop even at high rpm--great acceleration power

Accelerates from 0-100km/h—one second faster!
4-4-4. Performance of VQ35HR powered vehicles (3)

0-100km/h acceleration time
4-5. Improved Fuel Efficiency
4-5. Improved Fuel Efficiency (1)

- Improved fuel efficiency in daily use situations.

Average actual fuel consumption (%)

(Figures are from in-house measurements)

- Average actual fuel consumption: Weighted average of fuel consumed running on city streets, suburban streets and expressways, including air-conditioner use, night driving and traffic jams.
4-5. Improved Fuel Efficiency (2)

VQ35HR/VQ25HR
- Cylinder heads: Improved water flow (alleviated knocking), iridium plugs (high ignitability)
- Main moving parts: Asymmetric pistons, low tension and low friction piston rings
- Mirror finish of roller bearings
- Valve operating system: Diamond Like Coating valve lifter (reduces friction by 40%)
- Hydraulic CVTC on intake side, Electromagnetic CVTC on exhaust side (Partial area operation)
- EGI parts: Atomizing fuel injector, long-discharge-type ignition coil,
- Engine control: Twin knock sensor, 32bit microcomputer control

Over 40 improvements to fuel efficiency have been incorporated, raising actual fuel efficiency by 10%.

- New low-friction AT
- Improved alternator generating efficiency
- Reduced electrical power consumption
- Reduced brake drag resistance
- Minimization of air conditioning system energy consumption
- Reduction of vehicle weight
- Reduced hub rpm resistance
- Reduced air resistance
- Reduced electrical power consumption
- Improved alternator generating efficiency
- New low-friction AT
- Over 40 improvements to fuel efficiency have been incorporated, raising actual fuel efficiency by 10%.
### 4-5. Improved Fuel Efficiency (3)

<table>
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<tr>
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<th>Description</th>
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<tbody>
<tr>
<td>Asymmetric piston skirt</td>
<td>32bit microcomputer control</td>
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<tr>
<td>Mirror finish of roller bearings</td>
<td>Increase compression ratio</td>
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<td>Long-discharge-type ignition coil</td>
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<td>Processing PVD Piston Ring</td>
<td>Atomizing fuel injector</td>
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<tr>
<td>Twin knock sensor</td>
<td>Improve cooling water flow</td>
</tr>
<tr>
<td>Improve cooling water flow</td>
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</tbody>
</table>
4-5. Improved Fuel Efficiency (4)

- Use of the world’s first hydrogen-free DLC.

Cam-valve lifter friction reduced by 40%
4-6. Best-in-class emissions standard
4-6. Realizing Best-in-class emissions standard (1)

- Ultra low heat mass catalyst supports
  - Shorten catalyst activating time

- Atomizing fuel injector
  - Reduce engine-out emissions

- Highly ignitable irridium ignition plugs
  - Reduce engine-out emissions

- Early activating A/F sensors Control system
  - Makes control of theoretical air fuel ratio possible immediately after starting

- Atomizing fuel injector
  - Reduce engine-out emissions

- Highly ignitable irridium ignition plugs
  - Reduce engine-out emissions

- Early activating A/F sensors Control system
  - Makes control of theoretical air fuel ratio possible immediately after starting
4-6. Realizing best-in-class emissions standard (2)

- Highly ignitable iridium plugs
  Stabilize combustion when starting.
  
  ![Image of spark plug with labels for iridium central electrode and platinum ground electrode]

- Early activating A/F sensors
  -> Fuel burns at theoretical air fuel ratio immediately after starting.

- Ultra-low heat mass catalysts

- Atomizing fuel injector
5. Summary
# 5-1. Aim of the New-Generation VQ35/25HR

| Smooth, pleasant drive | 1. High rate of revolution  
Max 7500rpm |
|------------------------|----------------------------------|
| Response               | 2. Pleasant acceleration sound  
Clear sound             |
| Exhilaration           | 3. Top level power performance in class  
Improved intake, Exhaust, Combustion Efficiency |
| Acceleration sound     | 4. Increased practical fuel efficiency  
Reduced friction        |
| Fuel efficiency        | 5. Best-in-class emissions standard  
(SU-LEV in Japan)        |
| Cleaner emissions      |                                   |
1-6. Considering the VQ Engine(2)

Emotion

Agile smooth performance

VQ

Efficiency

Fuel efficiency

Emission

Cleaner emissions
Thank you for your kind attention.