SUBARU BOXER DIESEL

Subaru Legacy/Outback 2.0D

Press information

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Fuji Heavy Industries Ltd.

SUBARU BOXER DIESEL: Aims of Development

A commitment to developing Subaru's very own diesel engine

Subaru has forged a new style of driving focusing on our philosophy of providing a safe, exhilarating, comfort and confident ride at all times. One way this has been achieved is through the unique Symmetrical AWD drivetrain layout, which mounts the Subaru Horizontally-Opposed Engine and transmission longitudinally, coupled with the highly efficient AWD system. Customers who choose Subaru over cars produced by the many different manufacturers available in Europe are sure to be fully content with the comfortable and reliable driving experience that only Subaru can offer.

There is reasoning behind this level of devotion to develop our own diesel engine—the driving experience that Subaru has been striving for, perfected by the ideal combination of the lightweight and compact Horizontally-Opposed Diesel Engine and the symmetrical AWD system. The various features of the SUBARU BOXER engine, such as reduced vibration, low centre of gravity and high rigidity, are also ideally suited to the diesel engine Subaru worked towards creating.

There is yet another major reason. The sporty feel, one of the main characteristics of the Horizontally-Opposed Engine, is also available with the BOXER DIESEL engine. The superior accelerator response places the SUBARU BOXER DIESEL miles ahead of the rest.

Increasing Subaru's appeal to a broader range of customers by incorporating the world's first Horizontally-Opposed Diesel Engine in a passenger vehicle

Both the Legacy and the Outback receive the diesel engine as part of the 2008 model lineup for the European market. Subaru is looking to make this engine one of the major driving forces within the European market. The BOXER DIESEL will be made available in a wider range of vehicles in future models.

The SUBARU BOXER DIESEL is the world's first Horizontally-Opposed diesel engine designed for passenger vehicles. It retains not only the advantages of typical diesel engines but also offers the various performance advantages Subaru has incorporated into its Horizontally-Opposed Engine design. Europe has always had a long affinity with vehicles, and diesel engines are becoming more popular in this market as they are economical and well-suited to driving conditions in Europe. Subaru has made a firm commitment to the development of the diesel engine without sacrificing the benefits that are originally promised to its customers. To meet the demands of today's customers, incorporating the BOXER DIESEL engine into passenger vehicles has been the centrepiece of a new challenge facing Subaru. The benefits only Subaru can offer will be available to a greater number and a wider range of customers.

SUBARU BOXER DIESEL: Features

The world's first Horizontally-Opposed Diesel Engine for passenger car

The Horizontally-Opposed engine technology that has been continually perfected by Subaru and the forced induction expertise developed for the FIA World Rally Championship has been combined with the new diesel engine to create the world's first Horizontally-Opposed Diesel Engine for passenger car, offering both on-the-road and environmental performance.

Lightweight, compact and highly rigid

The bore pitch has been decreased and the left and right blocks holding the crankshaft provide a highly rigid design, which has also allowed use of an aluminium alloy cylinder block for weight savings. The result is the class-leading light weight diesel engine in the 2.0-litre class.

Low vibrations and noise

The movements of the horizontally-opposed pistons work in unison to effectively cancel out the second harmonic vibration (vibration with twice frequencies as engine revolution) with which human being feels uncomfortable. The layout results in minimal vibrations meaning a balance shaft found in many conventional straight and V-type engine layouts is not required. The crankshaft is short and highly rigid, minimising the vibrational noise characteristic of many ordinary diesel engines.

Superior engine response

The superior balance of the Horizontally-Opposed Engine layout leads to low rotational inertia and friction within the engine itself. The result is exceptional accelerator response.

Outstanding environmental performance

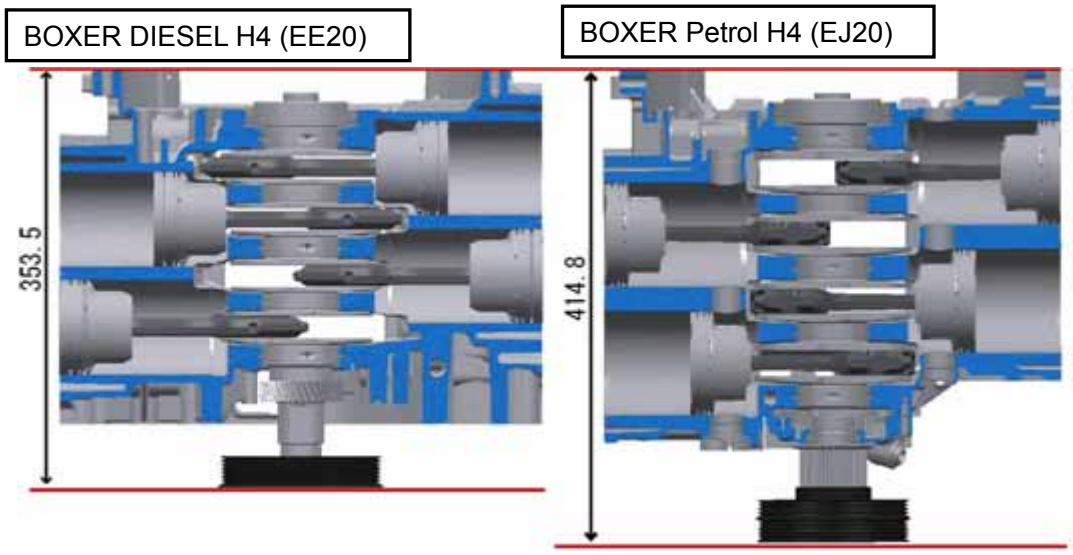
The engine offers the powerful torque output of a diesel while complying with European EURO 4 regulations. The design also results in the best fuel efficiency in the 4WD passenger vehicle class.

SUBARU BOXER DIESEL: Mechanisms

1. Cylinder block

Cylinder block

An aluminium alloy cylinder block has been used to maximise the potential of the highly rigid Horizontally-Opposed Engine layout. To obtain an ideal diesel combustion, the piston stroke was extended by 11mm while the bore was shortened by 6mm compared to the petrol engine. Subaru achieved longer stroke arrangement without increasing the overall engine width. On top of that, the bore pitch has been shortened to 98.4mm , which is similar to that of 6-cylinder Subaru Boxer petrol engine (EZ30), while the 4-cylinder Subaru Boxer petrol engine (EJ20) has 113.0 mm. This has led to a 61.3 mm reduction in engine block length for even more compact design.



Preliminary Specifications

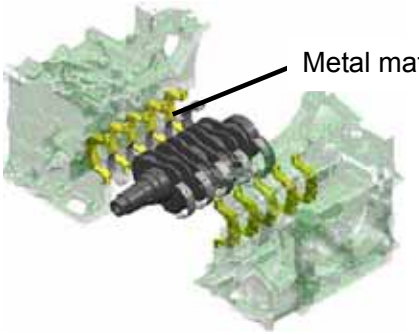
	EE20 (BOXER DIESEL)	EJ20	EZ30
Engine type	Horizontally-Opposed 4-cylinder diesel engine	Horizontally-Opposed 4-cylinder petrol engine	Horizontally-Opposed 6-cylinder petrol engine
Displacement	1,998	1,994	2,999
Bore × stroke mm	86.0×86.0	92.0×75.0	89.2×80.0
Bore pitch mm	98.4	113	98.4
Engine length mm	353.5	414.8	438.4

Semi-closed deck

The block design uses the semi-closed deck type that has proven its durability in the turbocharged petrol models. This increases rigidity around the head gasket mating areas.

Metal matrix composite journal:

All 5 main bearings (journals) in the cylinder block incorporate metal matrix composite journals (which are inserted during the casting process), resulting in superior levels of quietness due to its high rigidity and similarity in the thermal expansion ratio to that of crankshaft.

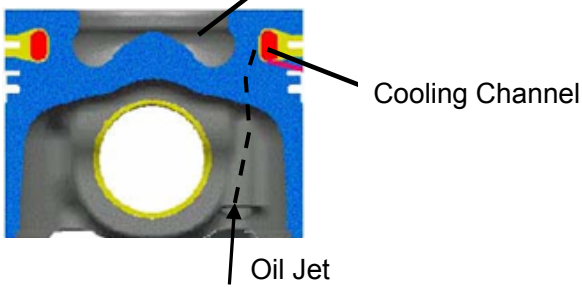


Extra cooling channels

Cooling slits have been given between the cylinder bores to operate as water cooling channels, thus improving cooling performance.

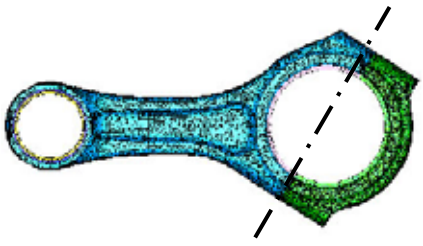
Pistons

High strength materials have been used to withstand the high combustion pressures of the diesel engine. Cooling channels within the pistons have been incorporated, with engine oil squirted via oil jets, which enhances piston cooling.



Connecting rods

The large ends of the connecting rods feature asymmetrical profile, which increases precision during assembly and in roundness of the surface connecting the crankpin for reduced friction. It has also contributed to minimize the rotational path thus enabled to employ extended piston stroke inside the compact cylinder block.



Crankshaft

The high strength crankshafts have undergone surface treatment to withstand the high combustion pressures that are found in a diesel engine. The superior layout of the Horizontally-Opposed Engine results in a much lighter weight than a similar straight engine layout.

2. Valve system / intake and exhaust system

Cylinder head

High strength cylinder heads have been used to withstand the high combustion pressures. Roller rocker arms: compact and low friction end pivot type roller rocker arms have been used in combination with double overhead cam (DOHC) system.

Valve System

The diameter of the intake valves have been optimised for enhanced breathing performance and swirl ratios, resulting in improved combustion efficiency.

Intake ports

Intake ports: the combination of an intake swirl pot system and optimised intake valve diameter results in ample swirl performance.

Cam Drive System

A highly durable chain system has been used to drive the camshaft to handle the variations in torque produced by the diesel engine.

3. Common rail system

A common rail system has been used for fuel delivery for better performance. The fuel is pressurised to 180 MPa before being fed into the common rail.

Solenoid injectors

Specially designed injectors have been used. A shorter overall length of the injector has contributed to maintain overall engine width as that of the regular petrol engine despite the longer piston stroke.

4. Turbocharger

A variable nozzle turbocharger has been specially designed to deliver ample turbocharged performance across the entire engine range. The turbocharger itself has been positioned under the engine and mounted directly to the catalytic converters for increased environmental performance. Response has been improved while also helping to lower the centre of gravity.

5. Exhaust

The exhaust system has been fine tuned for use with the diesel engine.

6. Exhaust Emission Control System

The exhaust emission control system mainly employs Oxidation catalytic converters, Diesel Particulate Filter (DPF) and Exhaust Gas Recirculation (EGR) system. gas purifier has been positioned below the engine together with the turbocharger. The unit delivers cleaner exhaust gas performance without affecting the low centre of gravity obtained through the combination of Subaru's Horizontally-Opposed engine and Symmetrical AWD system. Complies with EURO4 Exhaust gas regulations.

Oxidation catalytic converter

The oxidation catalytic converter has been positioned below the engine together with the turbocharger. The catalytic converter separates un-burnt fuel into water and carbon dioxide. The unit has been made compact enough to be activated soon after the engine has been started... If the temperature rises to 300 °C under certain driving conditions, the oxidation catalytic converter generates NO_2 which oxidize the collected Diesel Particulate inside the DPF.

Diesel Particulate Filter (DPF)

Diesel particulate is collected effectively by carbon filters inside the DPF. If the temperature rises to 600 °C under certain driving conditions, the collected particulate is burnt off and emitted through the exhaust pipe.

EGR (Exhaust Gas Recirculation) system

An EGR system has been used to comply with European EURO 4 exhaust gas regulations. The cooled exhaust gas is fed back into the combustion chamber to lower the combustion temperature and reduce NOx emissions.

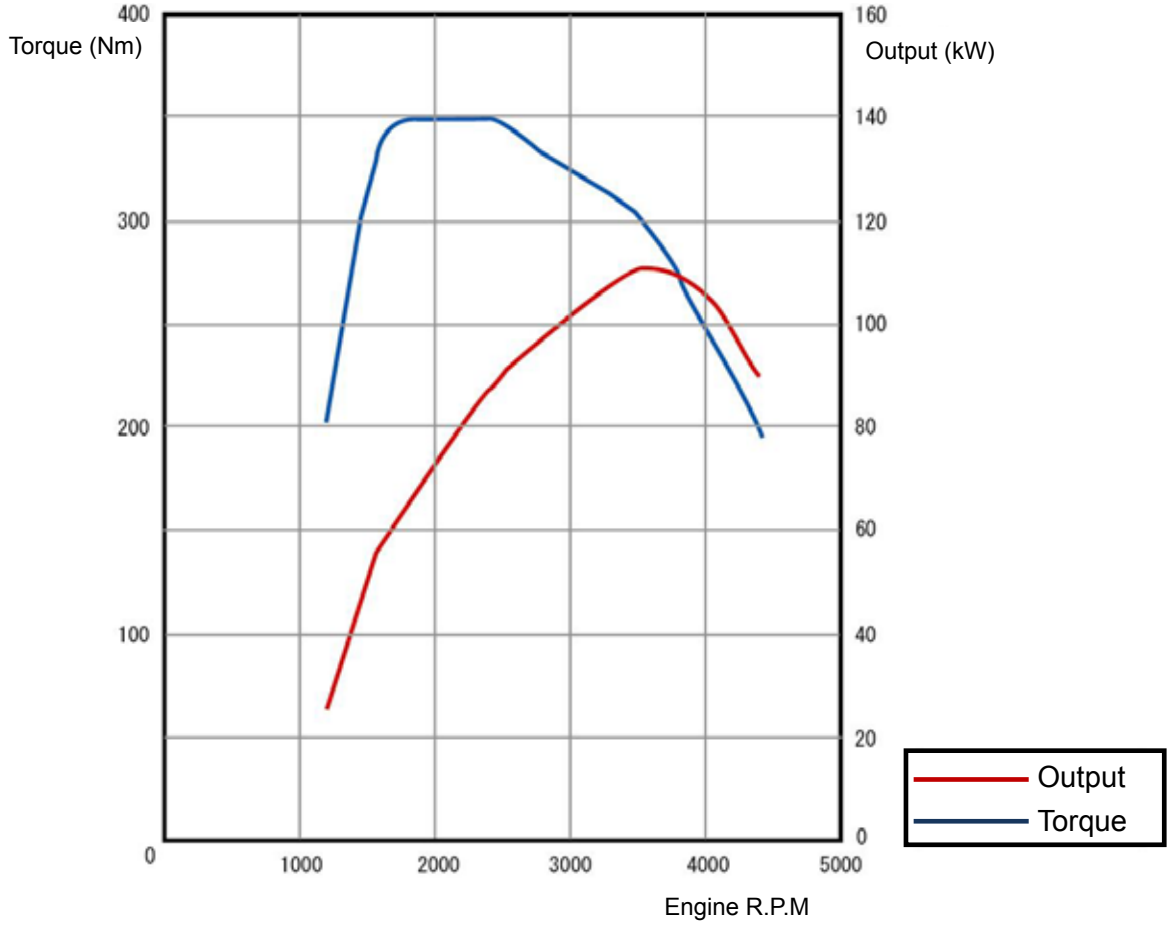
7. Engine mounting system

Liquid-filled engine mounting system has been employed for even less vibration and better handling performance.

Main engine specifications

		EE20 (BOXER DIESEL)	EJ20 (petrol)	EZ30 (petrol)
Displacement	cc	1,998	1,994	2,999
Maximum power output	kW(PS)/rpm	110(150)/3,600	110(150)/6,000	180(245)/6,600
Maximum torque output	Nm(kgfm)/rpm	350(35.7)/1,800	196(20.0)/3200	297(30.3)/4.200
CO_2 emissions	(g/km)	148 (Sedan)	209 (Sedan MT)	243 (Sedan MT)
Compression ratio		16.3	10.2	10.7
Bore × stroke	mm	86.0×86.0	92.0×75.0	89.2×80.0
Bore pitch	mm	98.4	113	98.4
Bank offset	mm	46.8	54.5	46.8
Deck height	mm	220	201	202
Journal diameter	mm	Φ67	Φ60	Φ64
Crankpin diameter	mm	Φ55	Φ52	Φ50
Effective Length of Connecting Rod	mm	134	130.5	131.7
Piston pin diameter	mm	Φ31	Φ23	Φ22
Compression height	mm	43.0	33.5	30.0
Fuel injection system		Common rail type	MPI	MPI
Turbo charger		Variable nozzle turbocharger	—	—
EGR layout		Water cooled	—	—
Diesel Particulate Filter		Open Type	-	-
Engine length	mm	353.5	414.8	438.4

Engine Performance Curves



Subaru Legacy/Outback 2.0D

1. Features

Levels of comfort, sportiness and silence unlike a diesel, while offering both driving and environmental performance

The combination of SUBARU's BOXER DIESEL and the Symmetrical AWD power train provide the Legacy/Outback with the following outstanding features.

The thrill of the drive

Superior driving stability: a superior weight balance, low centre of gravity and exceptional drivability achieved with the Symmetrical AWD and the lightweight and compact Horizontally-Opposed Diesel Engine centrepiece. By mounting the weight of the transmission and drive train within the wheelbase, outstanding drivability and linear handling are achieved, allowing the driver to control the car exactly as desired.

Sporty diesel

Outstanding accelerator response: the outstanding accelerator response of the BOXER DIESEL makes it a sporty package that is miles ahead of any other diesel powered vehicle.

Environmentally friendly and economical

Better fuel efficiency: friction loss within the engine, transmission and AWD system has been minimised, thus improving fuel efficiency.

Reduced CO_2 emissions: the improved fuel efficiency means the boxer diesel is the most environmentally friendly vehicle in the same AWD class of passenger vehicles. The BOXER DIESEL also complies with European EURO4 regulations.

Comfort and silence levels

Major reductions in vibrations and noise: reduced vibration thanks to the layout of the Horizontally-Opposed engine and vibration proofing installed throughout the vehicle's interior ensure that the vibrations and noise usually associated with diesel powered vehicles have been drastically reduced.

Clarity of conversations when cruising on the motorway: the exceptional levels of silence mean conversations can be had clearly with fellow passengers even when cruising at 200 km/h.

Electric power steering for driving and environmental performance: the Legacy features an electronic power steering system to improve fuel efficiency. The system has been meticulously designed to improve driving pleasure and reduce noise within the vehicle.

2. Transmission

A special 5-speed manual transmission for the BOXER DIESEL

A special manual transmission for the BOXER DIESEL has been designed. The gear ratios have been fine tuned to match the output characteristics of the diesel engine, and the shift feel has also been improved.

A special flywheel and clutch

A dual mass flywheel and the clutch damper character have been fine tuned to suit the diesel engine, reducing the uncomfortable sounds produced at low engine speeds.

Special gear ratios

The gear ratios have been optimised to suit the lower rev limit and higher torque output throughout the entire engine range of the diesel engine, covering urban driving to high speed driving on the motorway. By limiting the engine speed during high speed driving, (the engine speed is approximately 3,000 rpm when cruising at 150 km/h), exceptional levels of silence have been achieved.

		1st	2nd	3rd	4th	5th	Rev	FINAL
G	Sedan/wagon	3.454	2.062	1.448	1.088	0.825	3.333	4.111
	Outback	↑	↑	↑	↑	↑	↑	3.900
D	Sedan/wagon	↑	1.750	1.096	0.785	0.634	↑	3.700
	Outback	↑	↑	↑	↑	↑	↑	3.900

* G = petrol vehicles, D = diesel vehicles

3. Chassis and body

In parallel to the development of quality diesel engine, which has innately low noise and vibration character compared to other diesels, Subaru has further developed the chassis and body performance to achieve quality ride performance as its petrol models.
For this purpose, sound absorbing and sound proofing material has been added and increased throughout the vehicle. Vibrations and sound has been limited throughout the powertrain to result in the same levels of silence as the petrol powered vehicle. The exceptional levels of silence mean conversations can be had clearly with other passengers even when cruising at 200 km/h. A new electric power steering system has been specially developed to improve fuel efficiency and driving feel. Other parts, the front suspension and brakes in particular, have been fine tuned to improve drivability and silence levels.

Vibration and sound proofing

Sound proofing has been added within the newly designed fender protector. The lower cover has been increased in size to extend to below the transmission, and the silencer floor has been changed to use double layer sound proof materials. The cowl panel insulator now has Thinsulate added to improve protection against the high frequency noises of the engine. The toe board thickness has been increased to improve silence levels within the vehicle.

Electric power steering

A pinion type electric power steering system has been used to improve fuel efficiency. The steering gearbox is mounted to the crossmember in four points using floating bushes, limiting the amount of transmitted vibrations and increasing rigidity. The steering feel has been fine tuned for easier drivability across the entire engine range to provide the driving and environmental performance befitting of the Legacy and Outback.

Special suspension tuning

The front suspension has undergone special tuning to suit the changes to the front axle load with the installation of the diesel engine and the electric power steering. This has led to improved stability and better response for better drivability.

Axles

The size of the front drive shaft outer joints (constant velocity joints) has been increased to cope with the increase in torque of the diesel engine. The shaft diameter has been optimised to reduce vibrations and improve silence levels within the vehicle when driving at low speeds in a high gear.

Fine tuned braking system

With the additional weight over the front axle, the front brakes have been upgraded to 16-inch discs to improve braking performance. Brake booster performance has also been optimised to deliver reliable braking at any speed and increase braking feel.

4. Safety Features

- SRS Front & Side Airbags are standard.
- SRS Curtain Airbags are optional.
- Vehicle Dynamics Control System is standard.

5. Equipment

- A gear shift boot and shift knob designed specially for the diesel engine have been used. This provides a sporty yet luxurious looking interior.
- The gear shift lever has been shortened by 10 mm of that of the petrol models to improve the overall shift feel of the gearbox, resulting in better drivability.
- The fabric seat material and surface pattern are available exclusively for the diesel model for a unique appearance.

- A special air-conditioning system has been developed, providing ample heating immediately after starting the engine or in areas with extremely cold climates.

- Winter package including seat heaters and front wiper de-icer is standard.

- A Keyless Access and Push Button Start System has been incorporated for the same ease of use as the petrol vehicle.

- An engine collector cover and rear decorations have been used especially for the diesel powered vehicle.

Specifications: Subaru Legacy 2.0D Sedan

Dimensions (Length / Width / Height):	4,665mm / 1,730mm / 1,425mm
Wheel Base:	2,670mm
Minimum Round Clearance:	145mm
Minimum Turning Circle at tire:	10.8m
Engine Type:	Horizontally-Opposed, 4-cylinder, 4-stroke, diesel engine
Cam Drive System:	Doubled Overhead Cam (DOHC)
Displacement:	1,998cc
Maximum Output:	110kw (150PS) / 3,600rpm
Maximum Torque:	350Nm (35.7kgfm) / 1,800rpm
Compression Ratio:	16.3
Transmission Type:	5-speed Manual Transmission
Fuel Economy (CO_2 emissions):	
Urban:	184 g/km
Extra-urban:	128 g/km
Combined:	148 g/km
Fuel Consumption:	
Urban:	7.0 lit./100km
Extra-urban:	4.8 lit./100km
Combined:	5.6 lit./100km
Fuel tank capacity:	64 lit.
Maximum Speed:	208 km/h (at 5th gear)
All Wheel Drive Type:	Center Differential Gear with Viscous-coupling type LSD
Suspension Type:	
Front:	MacPherson strut type
Rear:	Multi link type
Front Brake System:	Ventilated disc brakes
Rear Brake System:	Solid disk brakes
Tires:	205/55R16
Towing Capacity:	1,700 kg
Seating Capacity:	5 Persons
Kerb Weight:	1,460 kg

Safety Features:

Standard SRS Front & Side Airbags
Optional SRS Curtain Airbags
Standard 4-sensor / 4-channel type ABS with Electronic Brake-force Distribution (EBD)
Standard Vehicle Dynamics Control System

Exterior Standard Equipment

Front fog lights
Power-folding door mirrors with built-in LED turn signal

Interior Standard Equipment:

Leather-wrapped steering wheels, shift knob and parking brake lever
Tilt & Telescopic-adjustable steering wheel with Cruise Control Switches,
Full-auto AC
Winter Package (Front wiper de-icer, Heated mirrors, Seat Heaters)
Radio (AM/FM/MW) + 6-CD Audio Unit

Major Optional Equipment:

HID headlamps & washers
215/45R17 Tires
17-inch Alloy Wheels (instead of standard 16-inch Steel Wheels + Hub Caps)
Audio & Visual Integrated DVD Satellite Navigation System (AVN) with 7-inch VGA monitor
Moonroof (glass lid / tilt & slide open functions)
Leather Interior Package
Power Seat (Driver's seat)
Key-less access and push button start system

Specifications: Subaru Legacy 2.0D Station Wagon

Dimensions (Length / Width / Height):	4,720mm / 1,730mm / 1,470mm
Wheel Base:	2,670mm
Minimum Round Clearance:	145mm
Minimum Turning Circle at tire:	10.8m
Engine Type:	Horizontally-Opposed, 4-cylinder, 4-stroke, diesel engine
Cam Drive System:	Doubled Overhead Cam (DOHC)
Displacement:	1,998cc
Maximum Output:	110kw [150PS] / 3,600rpm
Maximum Torque:	350Nm [35.7kgfm] / 1,800rpm
Compression Ratio:	16.3
Transmission Type:	5-speed Manual Transmission
Fuel Economy (CO_2 emissions):	
Urban:	186 (189) g/km
Extra-urban:	131 (134) g/km
Combined:	151 (154) g/km
Fuel Consumption:	
Urban:	7.1 (7.2) lit./100km
Extra-urban:	5.0 (5.1) lit./100km
Combined:	5.7 (5.8) lit./100km
Fuel tank capacity:	64 lit.
Maximum Speed:	203 km/h (at 5th gear)
All Wheel Drive Type:	Center Differential Gear with Viscous-coupling type LSD
Suspension Type:	
Front:	MacPherson strut type
Rear:	Multi link type
Front Brake System:	Ventilated disc brakes
Rear Brake System:	Solid disk brakes
Tires:	205/55R16
Towing Capacity:	1,700 kg
Seating Capacity:	5 Persons
Kerb Weight:	1,510 **(**1,565) kg

*Note Specifications in (parenthesis) are applicable to the versions equipped with tandem moonroof.

Safety Features:

Standard SRS Front & Side Airbags
Optional SRS Curtain Airbags
Standard 4-sensor / 4-channel type ABS with Electronic Brake-force Distribution (EBD)
Standard Vehicle Dynamics Control System

Exterior Standard Equipment

Front fog lights
Power-folding door mirrors with built-in LED turn signal

Interior Standard Equipment:

Leather-wrapped steering wheels, shift knob and parking brake lever
Tilt & Telescopic-adjustable steering wheel with Cruise Control Switches,
Full-auto AC
Winter Package (Front wiper de-icer, Heated mirrors, Seat Heaters)
Radio (AM/FM/MW) + 6-CD Audio Unit

Major Optional Equipment:

HID headlamps & washers
215/45R17 Tires
17-inch Alloy Wheels (instead of standard 16-inch Steel Wheels + Hub Caps)
Audio & Visual Integrated DVD Satellite Navigation System (AVN) with 7-inch VGA monitor
Tandem Moonroof (glass lid / Front tilt & Rear slide open functions)
Leather Interior Package
Power Seat (Driver's seat)
Key-less access and push button start system

Specifications: Subaru Outback 2.0D

Dimensions (Length / Width / Height):	4,730mm / 1,770mm / 1,545mm
Wheel Base:	2,670mm
Minimum Round Clearance:	195mm
Minimum Turning Circle at tire:	10.8m
Engine Type:	Horizontally-Opposed, 4-cylinder, 4-stroke, diesel engine
Cam Drive System:	Doubled Overhead Cam (DOHC)
Displacement:	1,998cc
Maximum Output:	110kw [150PS] / 3,600rpm
Maximum Torque:	350Nm [35.7kgfm] / 1,800rpm
Compression Ratio:	16.3
Transmission Type:	5-speed Manual Transmission
Fuel Economy (CO_2 emissions):	
Urban:	186 (189)g/km
Extra-urban:	135 (137)g/km
Combined:	153 (156)g/km
Fuel Consumption:	
Urban:	7.1 (7.2)lit./100km
Extra-urban:	5.1 (5.2)lit./100km
Combined:	5.8 (5.9)lit./100km
Fuel tank capacity:	64 lit.
Maximum Speed:	200 km/h (at 5th gear)
All Wheel Drive Type:	Center Differential Gear with Viscous-coupling type LSD
Suspension Type:	
Front:	MacPherson strut type
Rear:	Multi link type
Front Brake System:	Ventilated disc brakes
Rear Brake System:	Solid disk brakes
Tires:	215/60R16
Towing Capacity:	1,700 kg
Seating Capacity:	5 Persons
Kerb Weight:	1,505 (1,570)kg

*Note Specifications in (parenthesis) are applicable to the versions equipped with tandem moonroof.

Safety Features:

Standard SRS Front & Side Airbags
Optional SRS Curtain Airbags
Standard 4-sensor / 4-channel type ABS with Electronic Brake-force Distribution (EBD)
Standard Vehicle Dynamics Control System

Exterior Standard Equipment

Front fog lights
Power-folding door mirrors with built-in LED turn signal

Interior Standard Equipment:

Leather-wrapped steering wheels, shift knob and parking brake lever
Tilt & Telescopic-adjustable steering wheel with Cruise Control Switches,
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