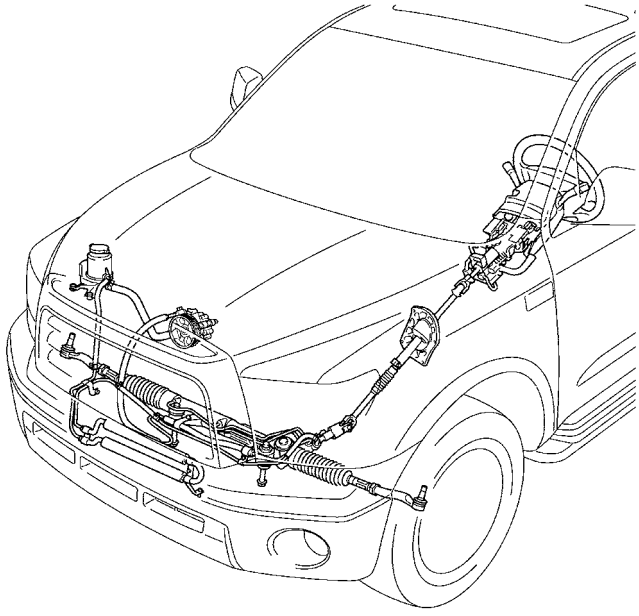
■STEERING

1. Description

- A rack and pinion type steering gear with a hydraulic power steering assist is used on the models with 1UR-FE engine.
- This hydraulic power steering uses a Variable Flow Control (VFC) power steering that controls the discharge flow rate in accordance with the steering angle, vehicle speed, and engine speed.



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▶ Specifications ◀

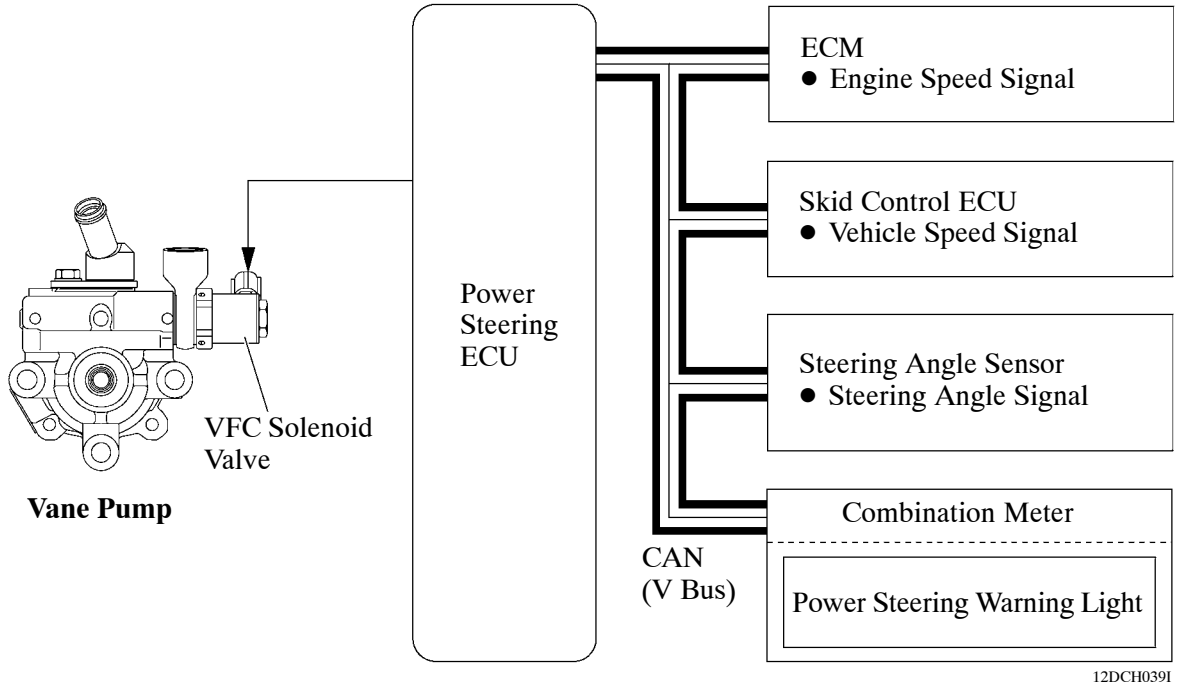
Gear Ratio (Overall)	18.0
No. of Turns Lock to Lock	3.71
Rack Stroke mm (in.)	198 (7.8)
Fluid Type	ATF Type DEXRON® II or III

2. Variable Flow Control (VFC) Power Steering

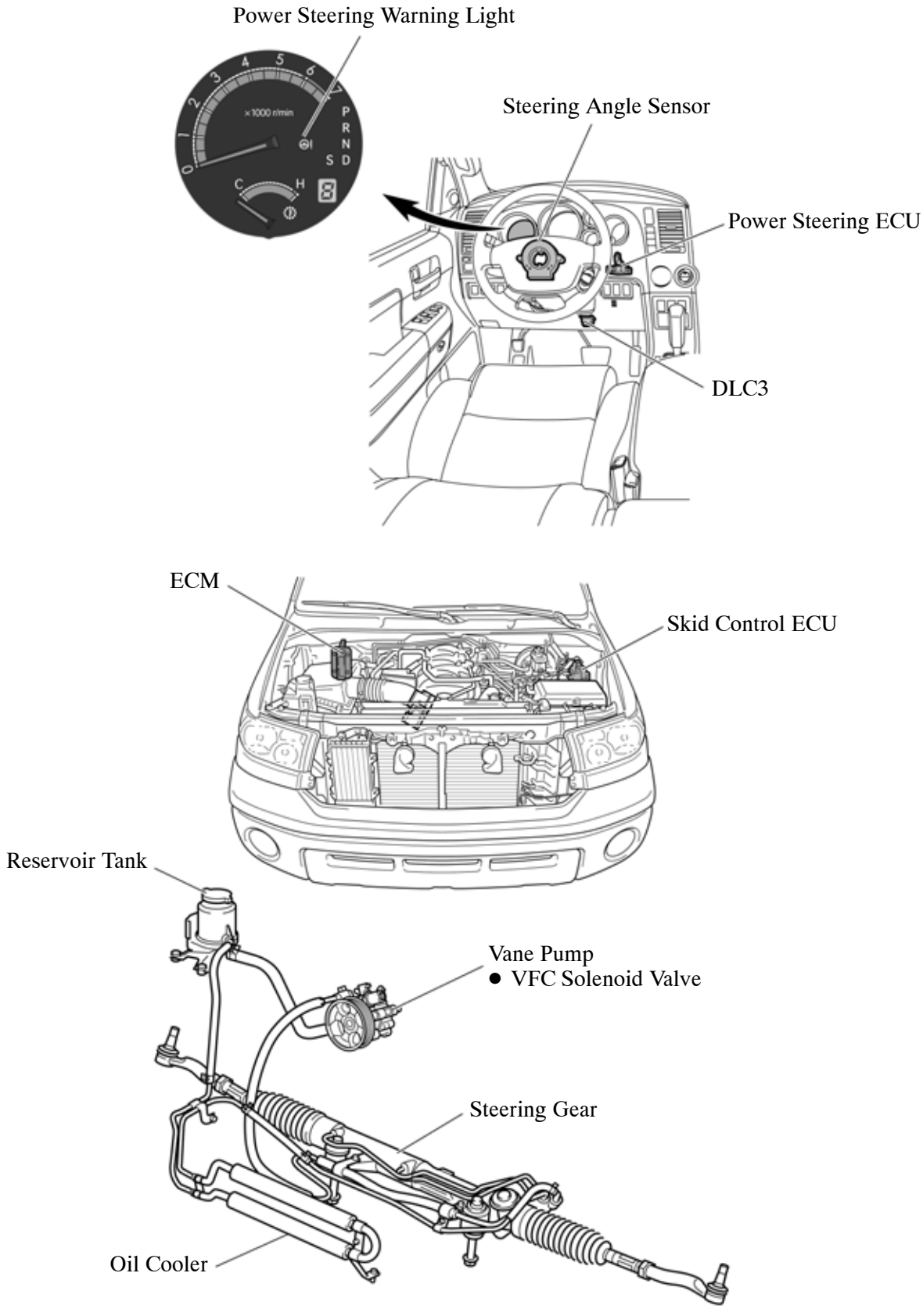
General

The VFC power steering is provided with a solenoid valve, which is controlled by the power steering ECU, in the vane pump. The solenoid valve controls the discharge flow rate of the power steering fluid in accordance with the operating conditions of the steering wheel, vehicle speed, and engine speed. Thus, it reduces the load on the engine applied by the actuation of the vane pump, and improves fuel economy.

▶ System Diagram ◀

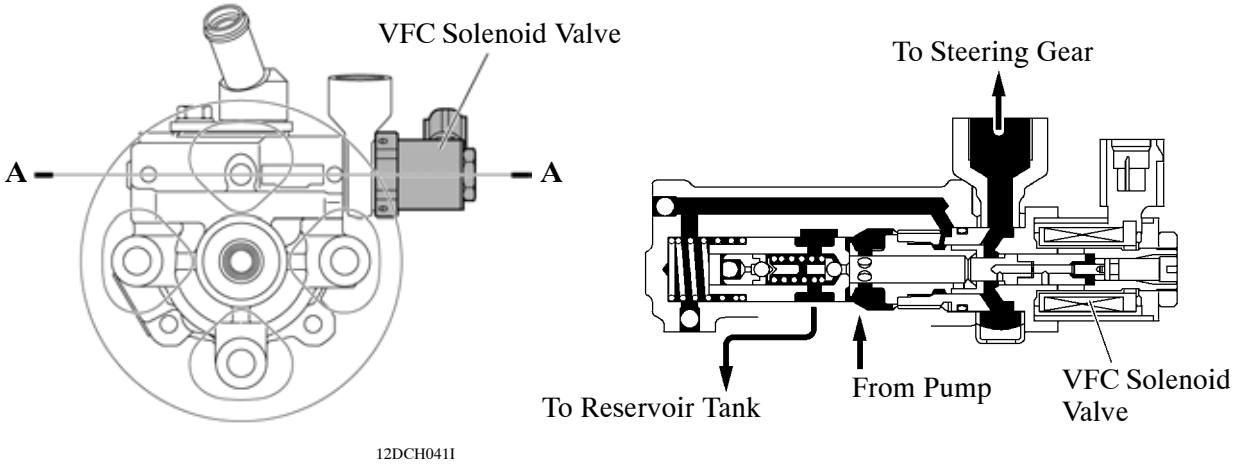


Layout of Main Components

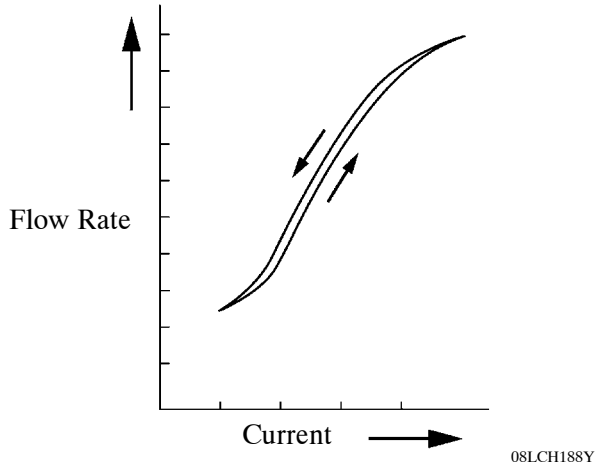


Vane Pump

- A compact and lightweight vane pump is used.
- A VFC solenoid valve is provided to control the discharge flow rate.



A – A Cross Section



Flow Rate Characteristic of VFC Solenoid Valve

▶ Specifications ◀

Theoretical Discharge Rate	l/min (@1000 rpm)	15
Relief Pressure	MPa (kgf/cm^2, psi)	10 (102, 1450)

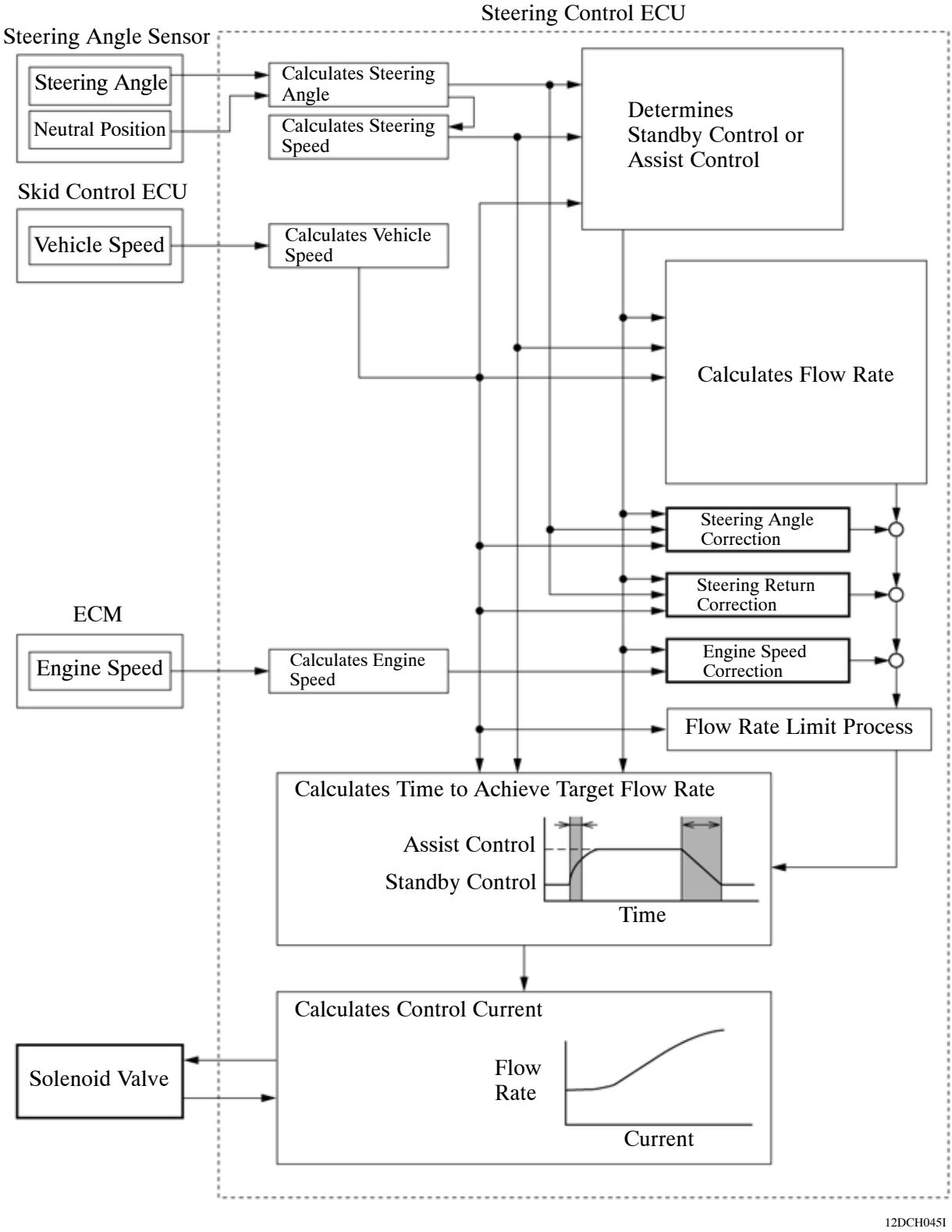
System Operation

1) General

The power steering ECU effects the following controls:

Control		Function
Flow Rate Control		Controls in accordance with the vehicle speed, steering angle, and steering speed conditions and also effects assist control when the steering wheel is being operated and standby control when the steering wheel is not being operated. Thus, it prevents the vane pump from discharging excessive flow, which lightens the load on the engine and improves fuel economy. Also, the following corrections are made to determine the optimal discharge flow rate:
	Steering Angle Correction	Determines the discharge flow rate in accordance with driving conditions, such as steering at standstill, cornering, or straightline driving.
	Steering Return Correction	Determines the discharge flow rate for returning the steering wheel to its neutral position after the steering wheel is operated.
	Engine Speed Correction	Determines the discharge flow rate in accordance with the engine speed.
Fail-safe		If the steering control ECU detects a malfunction in the VFC power steering system, it makes the steering feel heavier than normal, in order to inform the driver of a system failure.

▶ Control Diagram ◀



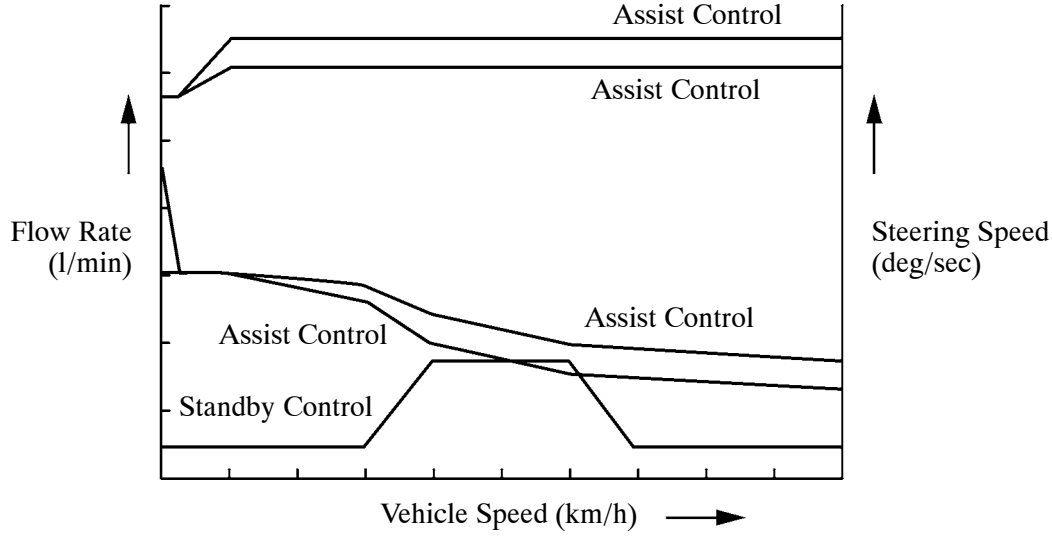
2) Flow Rate Control

a. Standby Control or Assist Control

- The standby control or assist control is performed in accordance with vehicle conditions such as vehicle speed, steering angle, and steering speed.

Control		Standby Control	Assist Control
Vehicle Condition	Vehicle Speed 0 km/h (0 mph)	Steering Speed = 0 deg/sec (for 10 Seconds or More)	Steering Speed > 0 deg/sec
	Vehicle Speed More than 0 km/h (0 mph)	Steering Angle < 4.5° (for 10 Seconds or More)	Steering Angle ≧ 4.5°

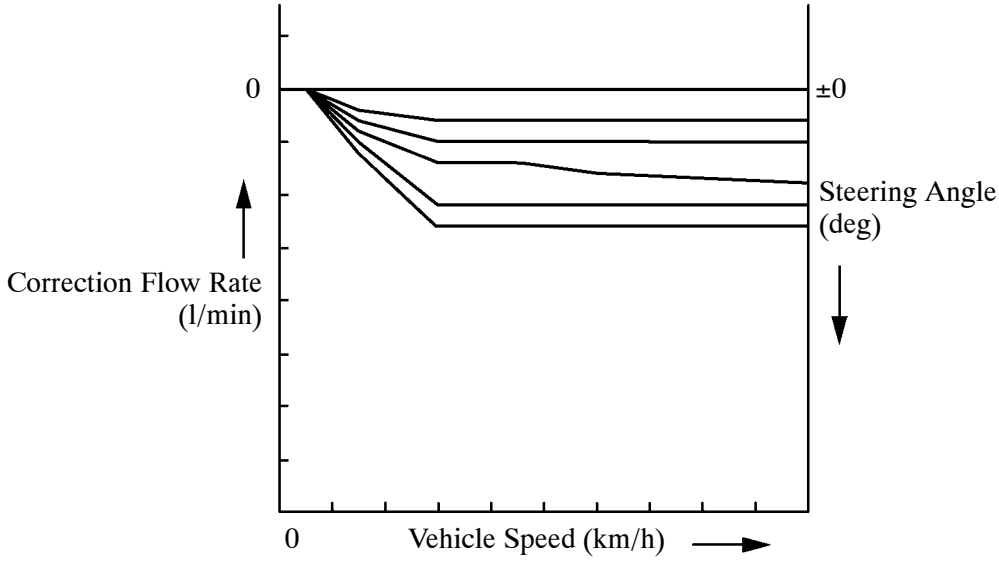
- The assist flow rate is determined in accordance with the vehicle speed and steering speed.
- For 3 seconds after the ignition switch is turned to ON, the flow rate is controlled at 10.5 l/min. After that, the flow rate is controlled as shown in the graph below:



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b. Steering Angle Correction

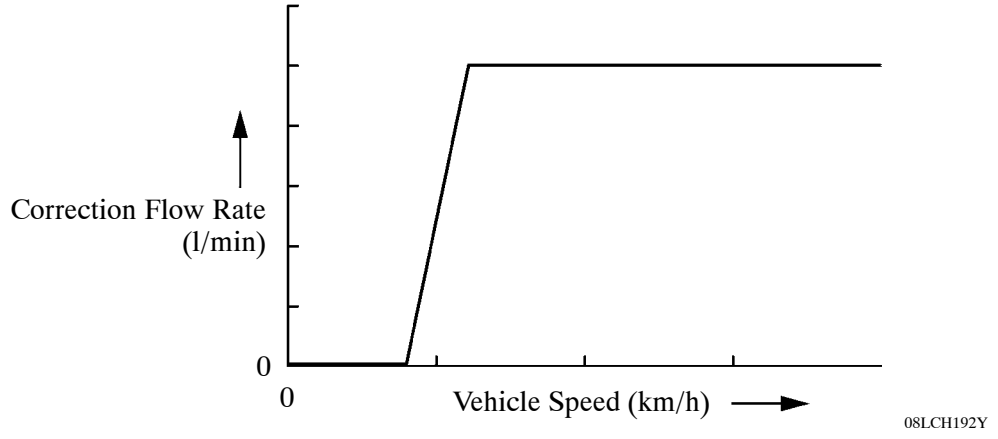
- Based on the steering angle and vehicle speed signals, this function corrects the flow rate in accordance with the driving conditions. Thus, an optimal steering feeling is ensured for every steering condition, such as steering at standstill, cornering, or straightline driving.
- The correction flow rate is 0 l/min while the steering is operated with the vehicle at standstill or driving straight (steering angle is ±4.5° or less).
- The correction flow rate decreases when the vehicle speed and steering angle increase.



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c. Steering Return Correction

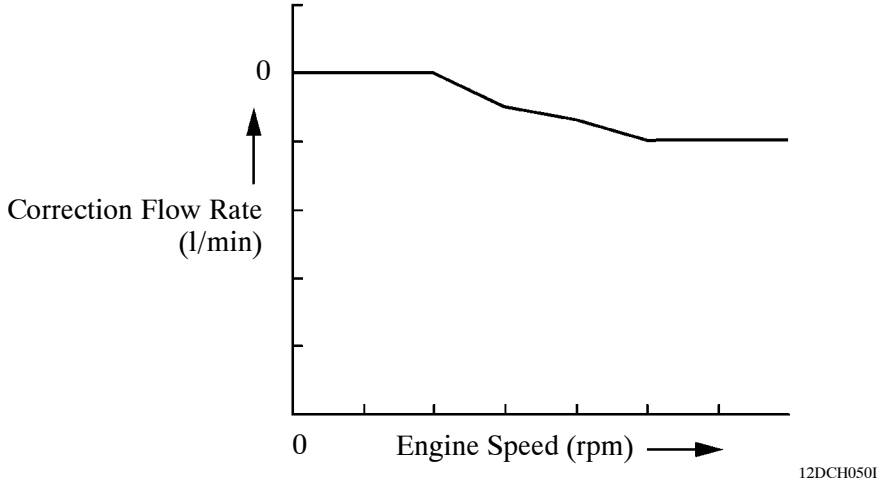
To return the steering wheel to the neutral position quickly after a sudden lane change, the ordinary flow rate is insufficient, as it makes the steering feel heavy. The steering return correction increases the correction flow rate in accordance with the steering speed and vehicle speed, in order to ensure an optimal steering force and vehicle stability.



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d. Engine Speed Correction

With the conventional vane pump, the flow rate increases when engine speed increases. The engine speed correction reduces the correction flow rate in accordance with the engine speed. This ensures optimal steering force, reduces engine load, and improves fuel economy.



3) Fail-safe

- If the power steering control ECU detects a malfunction in this system, it illuminates the power steering warning light to alert the driver of the malfunction.
- If a malfunction occurs in any of the sensors, the power steering control ECU effects the following fail-safe control:

▶ Fail-safe Control List ◀

Malfunction	Control			
	Flow Rate Control*	Correction		
		Steering Angle	Steering Return	Engine Speed
Steering Angle Signal	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Effects 330 deg/sec steering speed control	×	×	○
Neutral Position Signal	● Fixes steering angle at 0° ● Effects normal control	×	×	○
Vehicle Speed Signal	● Fixes vehicle speed at 80 km/h (49.7 mph) ● Effects 80 km/h (49.7 mph) vehicle speed control	○	○	○
Engine Speed Signal	● Fixes engine speed at 0 rpm ● Effects normal control	○	○	×
Steering Angle and Neutral Position Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Effects 330 deg/sec steering speed control	×	×	○
Steering Angle and Vehicle Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Controls flow rate at 8.5 l/min and over constantly	×	×	○
Steering Angle and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes engine speed at 0 rpm ● Effects 330 deg/sec steering speed control	×	×	×
Neutral Position and Vehicle Speed Signals	● Fixes steering angle at 0° ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Effects 80 km/h (49.7 mph) vehicle speed control	×	×	○
Neutral Position and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes engine speed at 0 rpm ● Effects normal control	×	×	×
Vehicle Speed and Engine Speed Signals	● Fixes vehicle speed at 80 km/h (49.7 mph) ● Fixes engine speed at 0 rpm ● Effects 80 km/h (49.7 mph) vehicle speed control	○	○	×

*: Fixes at assist control during fail-safe.

(Continued)

Malfunction	Control			
	Flow Rate Control*	Correction		
		Steering Angle	Steering Return	Engine Speed
Neutral Position, Vehicle Speed and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Fixes engine speed at 0 rpm ● Effects 80 km/h (49.7 mph) vehicle speed control	×	×	×
Steering Angle, Vehicle Speed and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Fixes engine speed at 0 rpm ● Controls flow rate at 8.5 l/min and over constantly	×	×	×
Steering Angle, Neutral Position and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes engine speed at 0 rpm ● Effects 330 deg/sec steering speed control	×	×	×
Steering Angle, Neutral Position and Vehicle Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Controls flow rate at 8.5 l/min and over constantly	×	×	○
Steering Angle, Neutral Position, Vehicle Speed and Engine Speed Signals	● Fixes steering angle at 0° ● Fixes steering speed at 330 deg/sec ● Fixes vehicle speed at 80 km/h (49.7 mph) ● Fixes engine speed at 0 rpm ● Controls flow rate at 8.5 l/min and over constantly	×	×	×

*: Fixes at assist control during fail-safe.