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Natural Vacuum Leak Diagnosis

Initial Print Date: 11/11 Revision Date: 07/12

Natural Vacuum Leak Diagnosis (NVLD)

Model: All with NVLD

Production: September 2011 to present.

This system will gradually be replacing the DMTL pump in all future models.

OBJECTIVES

After completion of this module you will be able to:

- Understand the function and operation of the NVLD system.

Introduction

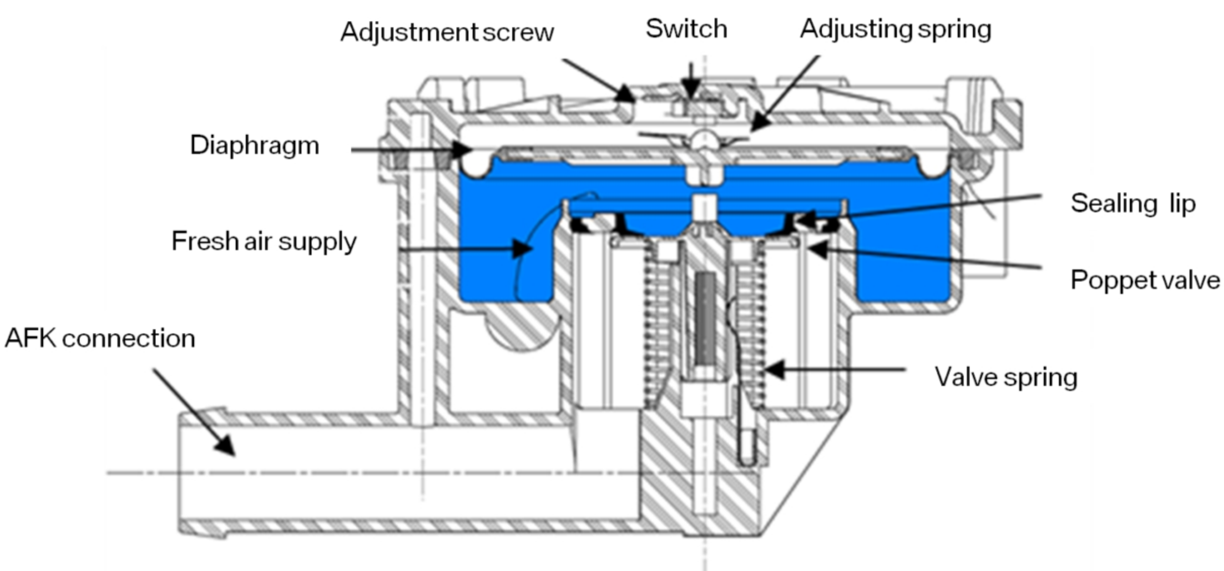
BMW's NVLD, or Natural Vacuum Leak Detection system will be first introduced in September 2011 as an alternative to its Leak Detection Pump (DMTL) method for the onboard testing of the evaporative emissions system. This method of leak detection is based on the "Ideal Gas" law that states, in part, that the pressure in a sealed vessel will change linearly as a function of the temperature of the gas in that vessel. Any loss of seal will allow the internal pressure to equalize with the atmospheric pressure outside the container.

In an automotive application, the fuel system is sealed when the vehicle is in a key off condition (KL_0). The Engine Control Module (ECM) monitors the state of a switch contained within the NVLD assembly via a DMTLH line. As the temperature in the fuel system drops, whether due to the cooling of the fuel or internal temperature change, pressure in the sealed system will drop.

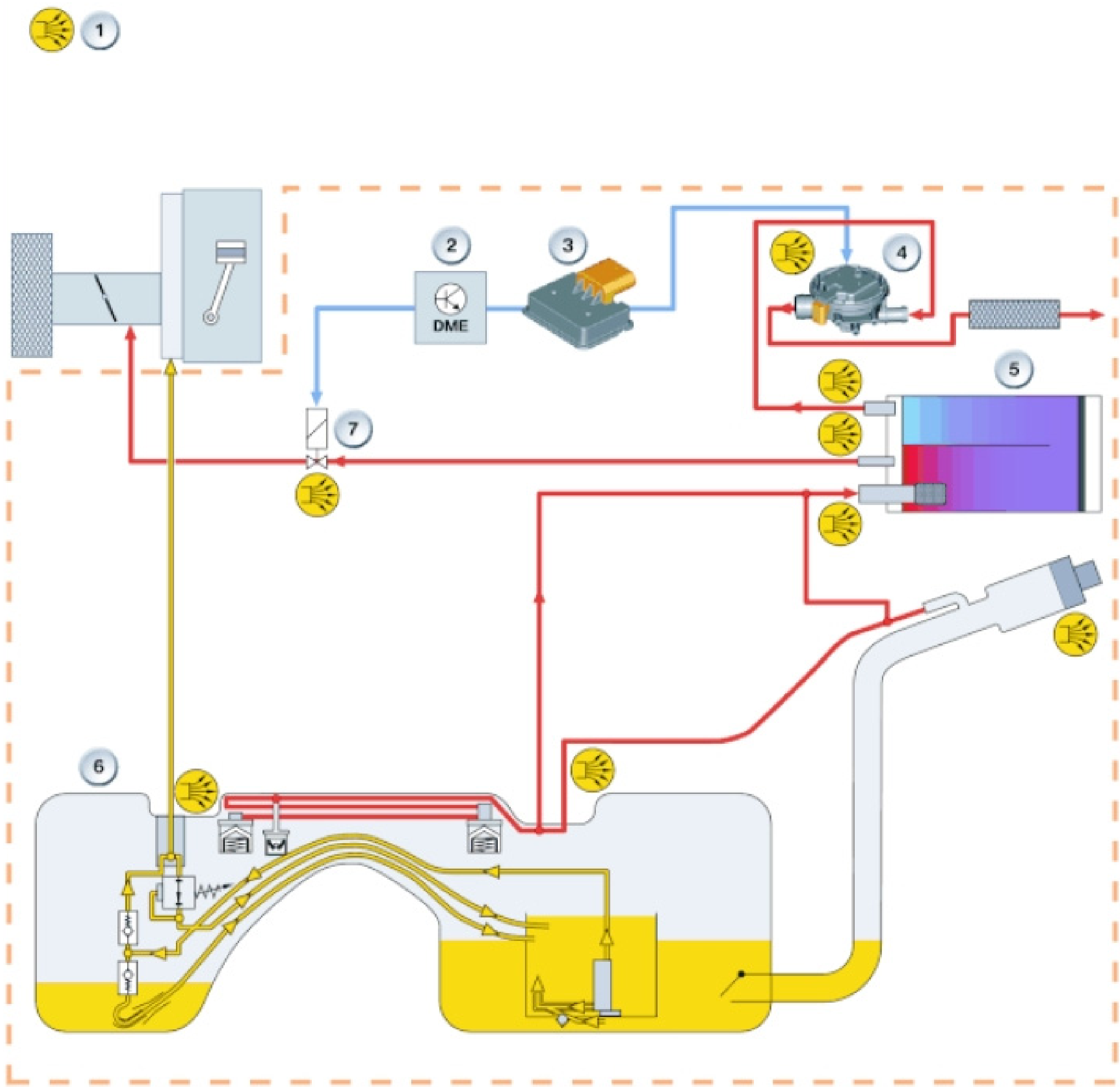
If the ECM does not see this change of state within a calculated time limit, it registers a failure and then tests to determine the size of the leak. Natural Vacuum Leak Detection (NVLD) is a passive diagnosis system for the fuel evaporation system. The NVLD requires a longer engine cutout time in order to identify a leakage. Therefore a short leakage test is not possible. Depending on the ambient conditions, the diagnosis normally requires that the engine is off for between 6 and 12 hours.

The NVLD system is basically a pressure system for the EVAP system. By monitoring vacuum, it can detect leaks throughout the system. In addition, during cool down it prevents an excess build-up of vacuum. When the engine is off, it maintains a seal on the EVAP system to prevent the release of fuel vapors. Finally, when the vehicle is refueling and pressure builds up in the evaporative system, it pressure then vents to the fresh air filter.

NVLD Unit



NVLD Complete System Overview



Index	Explanation	Index	Explanation
1	Points which must be checked first for leakage	5	Carbon Canister
2	Digital Motor Electronics (DME)	6	Fuel Tank
3	Natural Vacuum Leak Detection Electronics / Temperature sensor (used in the basic version only)	7	Tank Vent Valve
4	Natural Vacuum Leak Detection Temperature sensor / Pressure switch (intergraded version) Pressure switch only (basic version)		

EVAP System Monitoring

Principles of CARB Act (USA)

The CARB regulation serves as a basis for leak diagnosis:

>> Title 13, California Code Regulations, Section 1968.2, Malfunction and Diagnostic System Requirements for 2004 and Subsequent Model-Year Passenger Cars, Light-Duty Trucks, and Medium-Duty Vehicles and Engines (OBD II) **<<**

This regulation states that an overall leakage in the fuel evaporation system exceeding 0.51 mm (0.02 inches) must be identified.

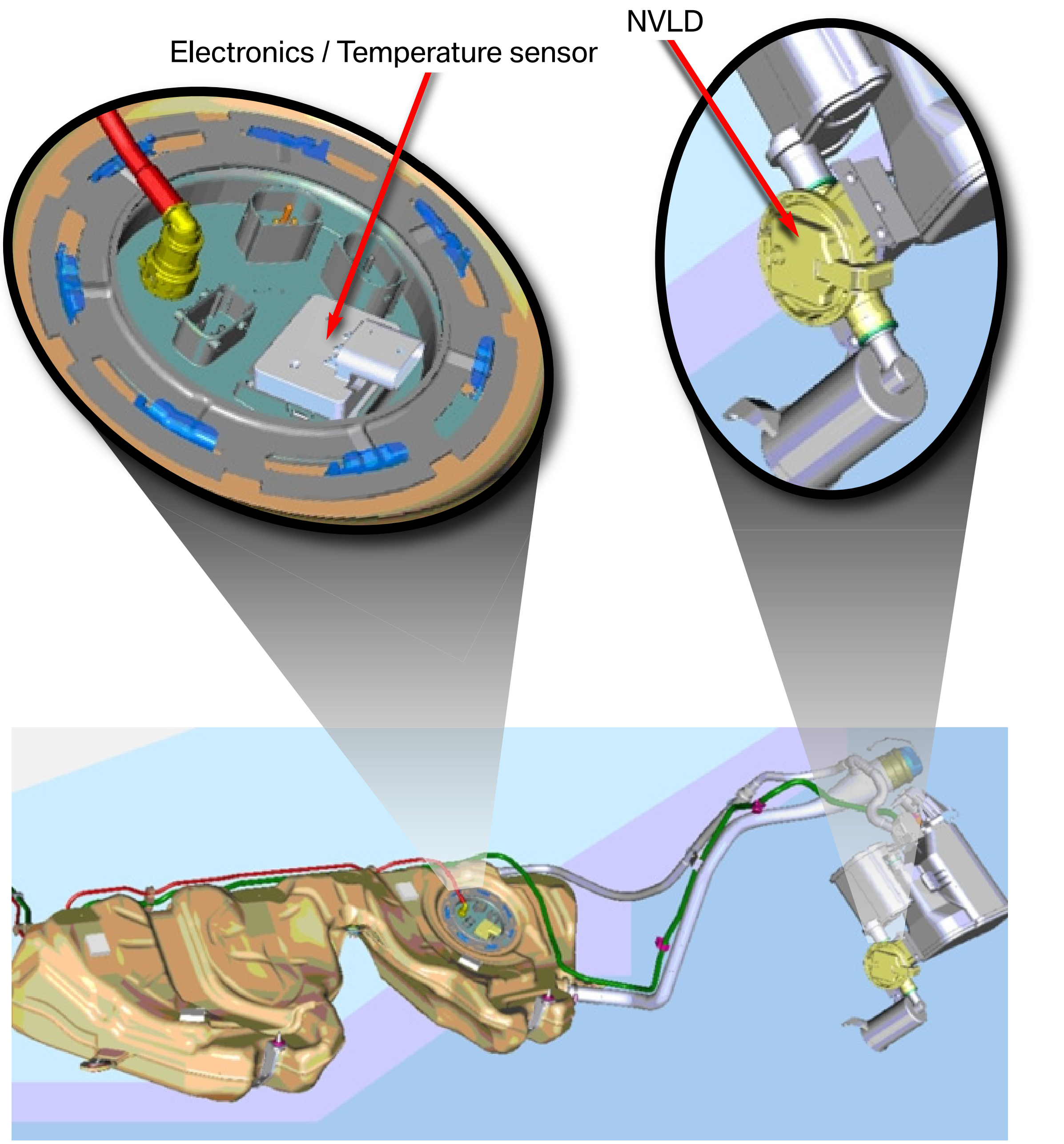
The fuel evaporation system must therefore meet the following requirements

- Sealed against the environment
- Identify and display a leak

EVAP System Components

- Tank
- Tank flange
- Filler tube
- Fuel filler cap
- AKF (Active Carbon Canister)
- Air filter
- Diagnosis module (NVLD)
- Vent pipes
- TEV (Tank Vent Valve)
- TAV (Fuel Tank Non-Return Valve)
- DME (software)

NVLD Basic Version Component Location



System Restrictions

The EVAP system is connected to the engine and the environment through diverse interfaces. All components mentioned on the previous page and their subsystems are part of the EVAP system. The EVAP system restrictions are defined at the following locations:

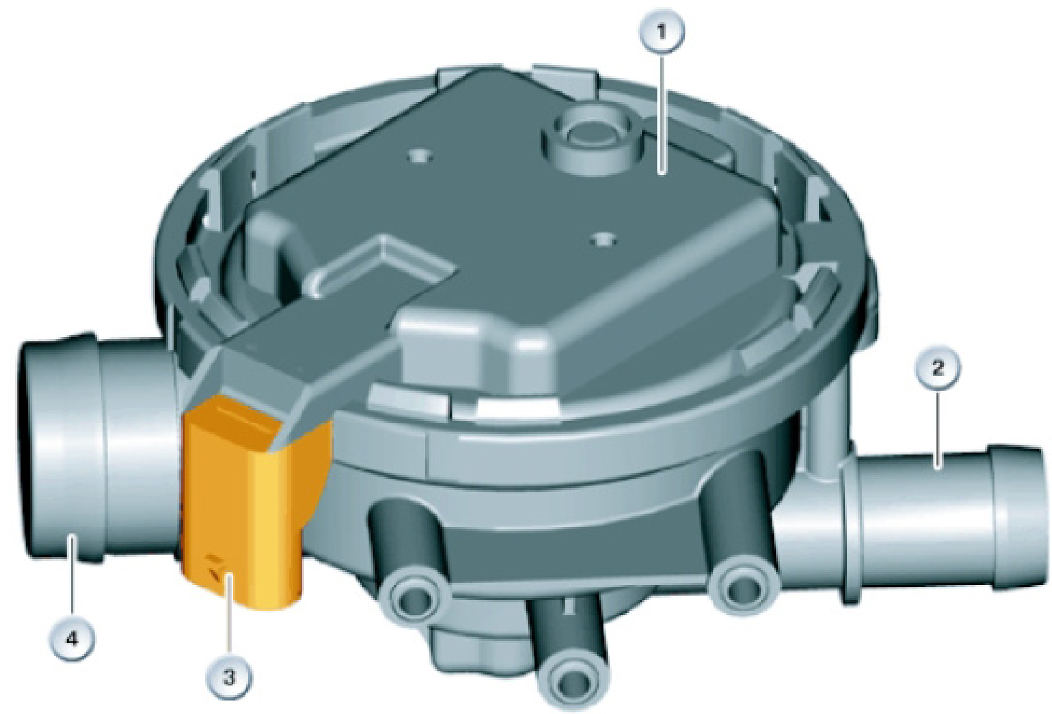
- Fuel filler cap (inclusive)
- Tank Vent Valve (TEV) (inclusive)
- Air filter (inclusive)

NVLD Variants

Integrated Version

Natural Vacuum Leak Detection temperature sensor and pressure switch in one unit.

NVLD Intergraded (F30) 2012MY



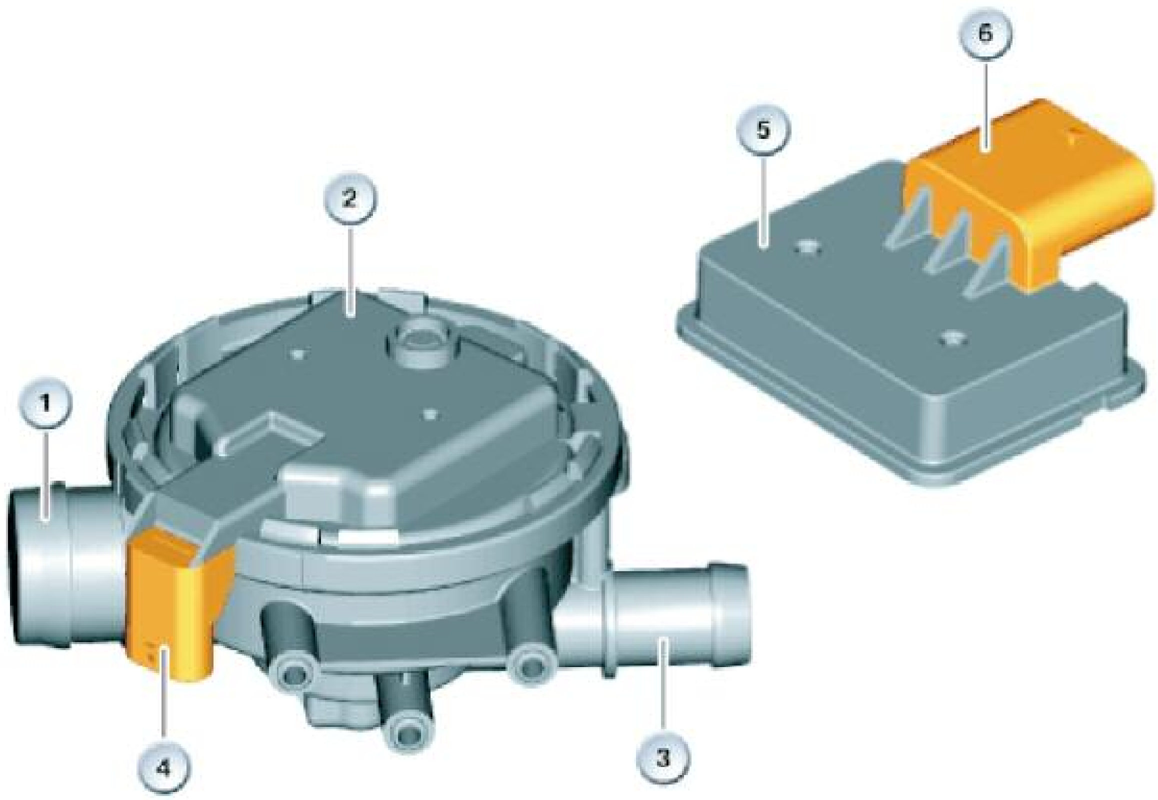
Index	Explanation	Index	Explanation
1	Temperature sensor and pressure switch	3	Three pin plug connection
2	To carbon canister	4	To fresh air filter

This system will gradually be replacing the DMTL Pump in all future models.

Basic Version

Natural Vacuum Leak Detection pressure switch and temperature sensor.

NVLD Basic for F10 with (N20 engine) as of September 2011



Index	Explanation	Index	Explanation
1	To fresh air filter	4	Three pin plug connection
2	Pressure switch	5	Electronics and temperature sensor
3	To carbon canister	6	Five pin plug connection

This system will gradually be replacing the DMTL Pump in all future models.

Physical Principle and Pressure Patterns

The physical principle is based on the Ideal Gas Law:

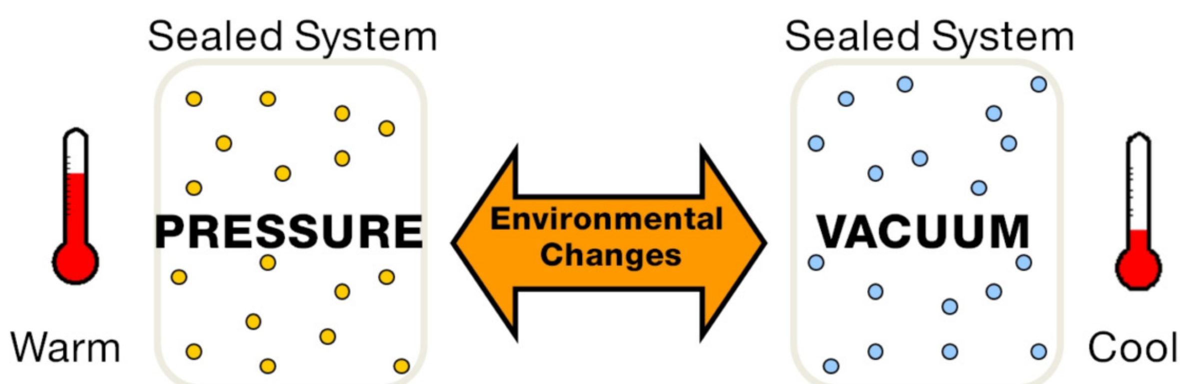
Pressure and temperature have a direct proportional relationship when quantity and volume remain constant. The NVLD uses this physical principle to identify leaks in the fuel evaporation system. This means that a vacuum forms when the temperature in the fuel tank drops. The NVLD uses a temperature sensor to measure the temperature. The NVLD uses the diaphragm-operated pressure switch to determine the vacuum. This diaphragm switches the pressure switch at a certain vacuum / ambient pressure combination.

The following graphic demonstrates the temperature profile and pressure pattern both when there is a leak in the fuel tank and when there is no leak.

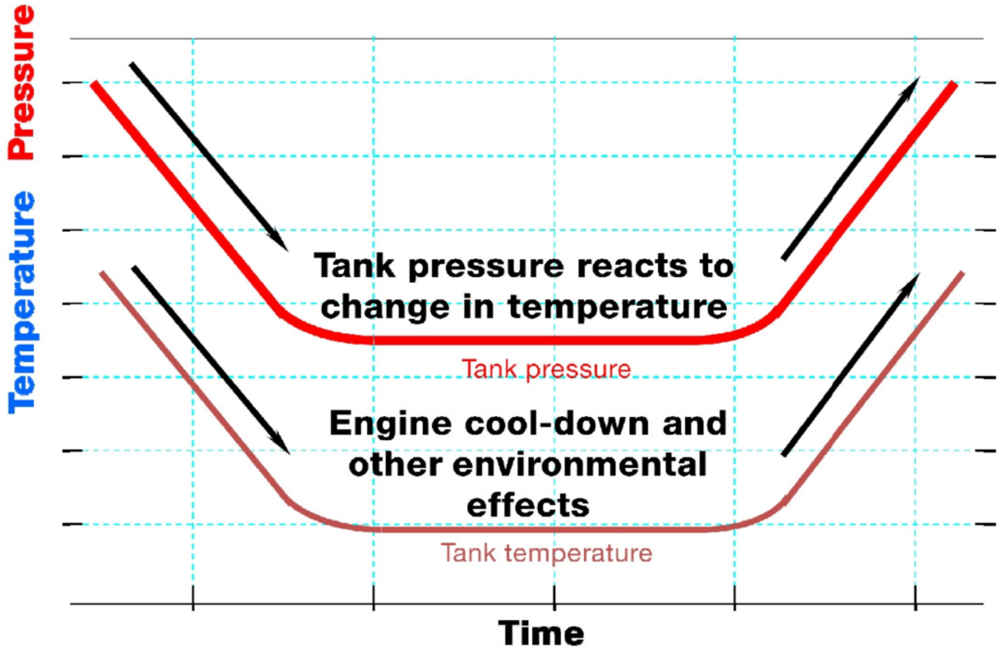
This property is described by "Charles' Law". Also known as the “Law of Volumes”

This phenomenon is used to detect leaks in the EVAP system via the NVLD.

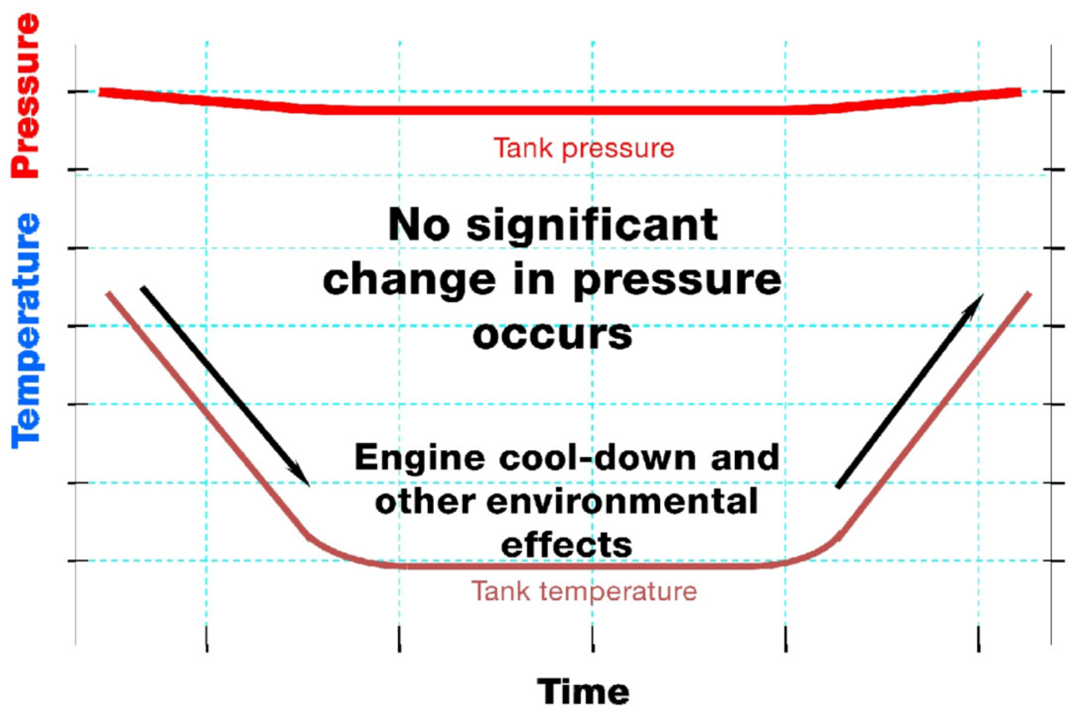
Ideal Gas Law



Pressure Patterns



Pressure pattern in the tank with temperature change and without leakage.



Pressure pattern in the tank with temperature change and leakage larger than 0.51 mm/0.02in.

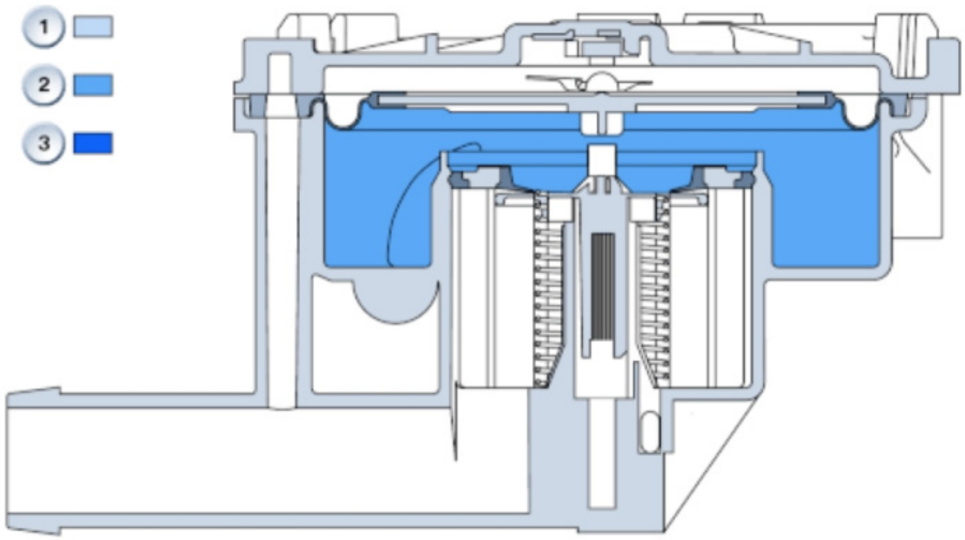
NVLD States of Operation

There are 5 possible mechanical functional states of the NVLD diagnosis module based on design and application.

The NVLD system is installed between the AFK (Active Carbon Canister) and the fresh air filter on the surrounding area side. The connection to the AFK is established via the small connecting branches. The module has a diaphragm and a poppet valve between the connection to the surrounding area.

Rest State

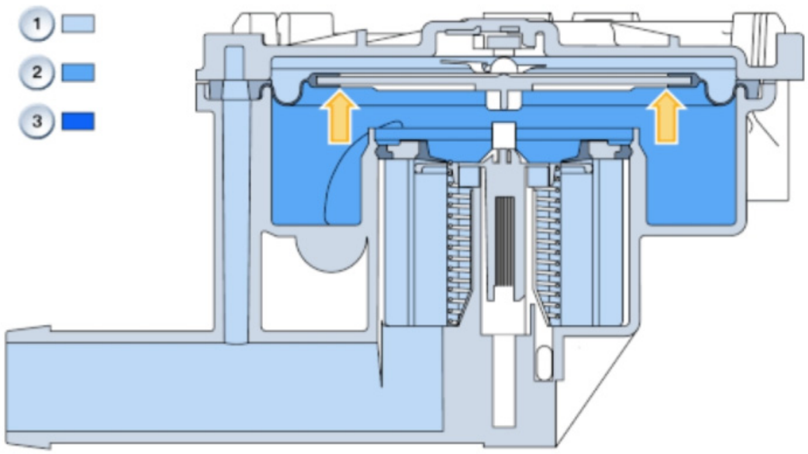
In rest state there is atmospheric pressure on the surrounding area side of the diaphragm and poppet valve. The pressure in the inside is not defined here. The switch is open. The poppet valve is tight. There is no gas exchange between the tank and surrounding area.



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

Switch Closed

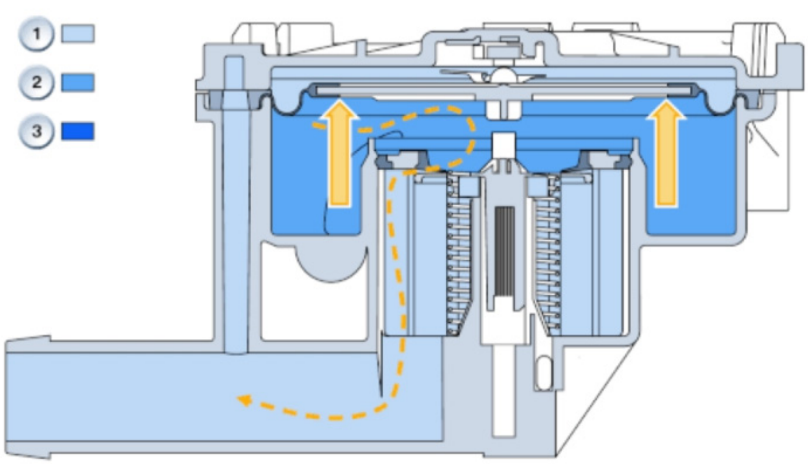
A vacuum in the tank system lifts the upper rubber diaphragm against the switch and closes it. There is no air exchange between the tank and surrounding area. The lower poppet valve is pressed onto the gasket by the springs. **The EVAP system is tight**.



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

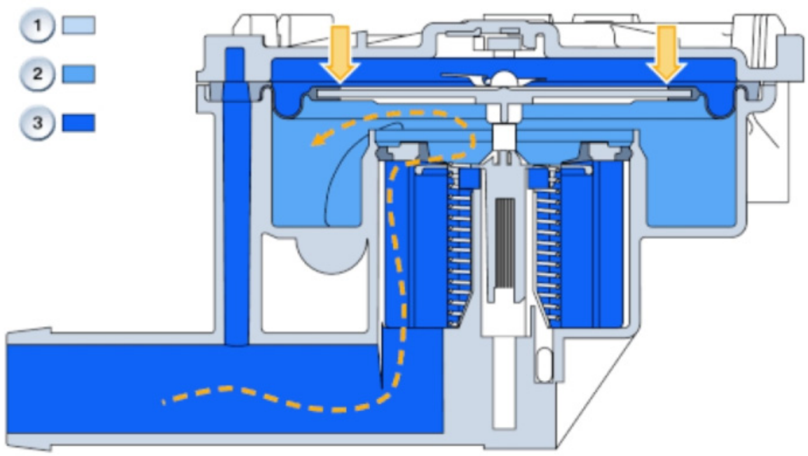
Scavenging Air Mode

In the case of an increased vacuum (scavenging air) in the tank system the poppet valve opens a fraction. Scavenging air flows from the air filter to the AKF. The prevailing vacuum still lifts the diaphragm against the switch. **The switch remains closed.**



Excess Pressure

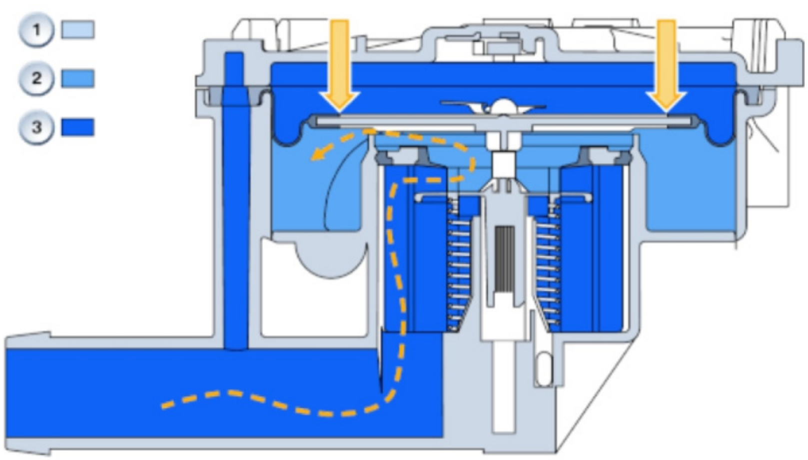
If the system pressure is slightly higher than the atmospheric pressure, the diaphragm presses down onto the poppet valve. This opens and gas flows outwards from the tank system via the fresh air filter. **The switch is open.**



Index	Explanation	Index	Explanation
1	Partial Vacuum	3	Excess pressure
2	Atmospheric pressure		

Refueling

The system pressure rises sharply during refueling. This causes the upper diaphragm to lower. At the same time, this presses down on the poppet valve underneath. Gases in the inner part of the system escape via the fresh air connection. **The switch is open.**



NVLD Diagnosis Module

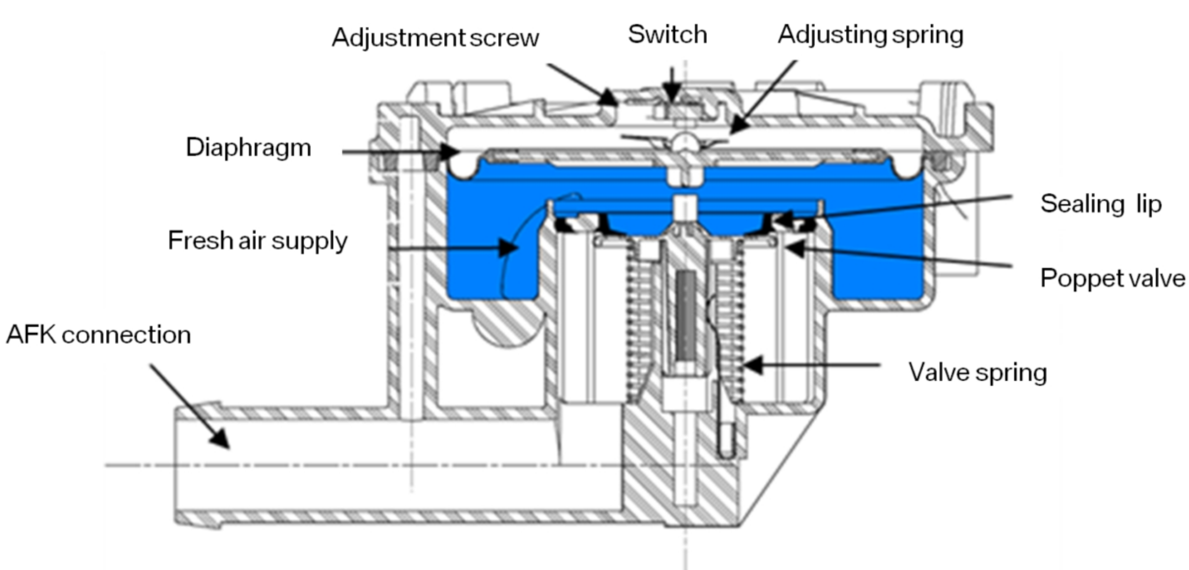
As required by CARB, the NVLD diagnosis module is used to detect leaks in the EVAP system. The physics principle applied here is used to detect excess pressure or a vacuum in the tank, based on the atmospheric ambient pressure. This diaphragm actuates a switch from a defined vacuum on the tank side (compared to the surrounding area side). In the case of reverse pressure ratios the diaphragm opens the poppet valve in order to dissipate the excess pressure from the tank. The same valve is opened when there is a large vacuum in the fuel tank This arrangement is designed so that when fuel is being extracted from the tank a large vacuum does not arise in the tank and the flow resistance is not too high.

The actual diagnosis takes place in rest state after stopping the vehicle. The fuel in the tank cools down at night day/night temperature difference. A natural vacuum develops in the tank. If there are no leaks, the vacuum in the system remains. The diaphragm lifts and closes the switch.

The system is leak proof. In the case of a leak, air flows into the tank system as the vacuum is no longer sufficient to keep the switch closed.

The EVAP system has a leak.

NVLD Unit



NVLD Components

The following subsystems within the NVLD diagnosis module must fulfill certain tasks:

- **Diaphragm**

Responds to pressure differentials by lifting and lowering the diaphragm area. A flexible rubber ring establishes a connection to the outer wall of the NVLD and guarantees freedom of movement of the diaphragm area with parallel tightness.

- **Valve spring**

Presses the poppet valve against the sealing ring. A defined spring force ensures corresponding functionality in relation to the desired state (open/closed).

- **Poppet valve**

The poppet valve positively seals the EVAP system with the sealing lip on the tank side against the environment.

- **Sealing lip**

See poppet valve.

- **Switch**

Opens/Closes electronic contact. It makes possible electronic state inquiry.

- **Adjusting spring**

Between the diaphragm and the switch it defines the lifting force of the diaphragm and thus determines the switching point of the switch.

- **Adjustment screw**

Controls the switching point of the switch via the adjusting spring.

- **Smart module**

Communication with DME via a DMTLH line.

Leak Diagnosis Starting Conditions

Overview of Leak Diagnosis Process

Start criterion	Start precondition
Driving cycle	No (motor cold start required)
Fuel tank	Level No
Ambient Temperature	> 4.5°C/40°F
Min. temperature difference	8°C (14°F) drop in temp (for > 1 Hour)
Height above sea level	< 2500 m/8,200ft
TEV setting	Closed (basic setting)
Cold start precondition	Yes
Terminal status	KL_0/Asleep
Battery voltage	> 11 V and < 16 V
Pressure difference for ambient pressure between engine OFF and engine start	Less than 6 hPa (6 mbar)

Taking into consideration the diagnosis starting conditions, the electronic unit solely detects the switch position. Two states are possible:

- Closed switch
- Open switch

The electronic unit checks the state of the switch by applying current. The determined state is requested by the DME at the next engine start.

Frequency of Leak Diagnosis
The leak diagnosis begins after each driving cycle (after stopping the engine) and positive check of the starting conditions.

A test is always completed for all leaks from 0.51 mm/0.02in. There is no differentiation between a fine/micro leak. The evaluation generally takes place overnight due to the diagnosis starting conditions.

Requirements
At the same time, the tasks of the EVAP system determine the requirements of the overall NVLD system:

- Tightness of the EVAP system vis-a-vis its environment
- Identification and display of a leak

Self-Diagnosis of NVLD

1. Switch (short circuit to ground, battery, line disconnection, plausibility)
2. Temperature sensor (value range, gradient, plausibility)
3. Internal timer (plausibility)
4. Communication line DMTLH to the DME (short circuit to ground, battery, line disconnection, plausibility)
5. Power interruption

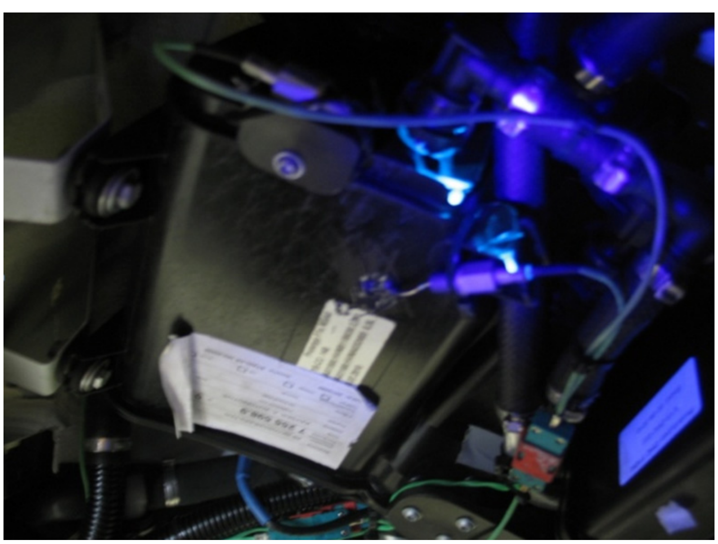
Abbreviations

- AKF: Active Carbon Canister
- CARB: California Air Resources Board
- DME: Digital Motor electronics
- KVS: Fuel Supply System
- NVLD: Natural Vacuum Leak Detection
- OBD: On-board Diagnosis
- TAV: Fuel Tank Non-Return Valve
- TEV: Tank Vent Valve

Workshop Hints

Detecting leaks in the evaporative system require the use of a smoke machine.

Leak at carbon canister found with smoke machine.



Wiring Diagram

Basic Version

2012MY F10 528i xDrive N20