



Questions have come up regarding the meaning of various abbreviations and measurement points of the common rail injector test specifications. Depending on the injector type and age of the injector, you will see different abbreviations for various test points. This bulletin is designed to help explain what the various test points are and what the test is looking for.

Note: Some test routines only have the test points called TP1, TP2, TP3, etc. There is no one to one correlation between the named points i.e.: VE, VL, LL, EM as the TP points only refer to the test sequence and not the measurement value. The key to understanding what these points are is to understand what is being measured.

### **Leak Test**

Most Bosch test plans start with two test points called “Leak Test”. These test points pressurize the injector without any actuation time to allow the technician to verify the injector nozzle is not stuck open and there is no external leakage present before the performance testing. These are visual tests and require the technician to observe and indicate if there is a leak present or not.

The first leak test is designed to build up to a pressure just beyond the bias pressure of the nozzle spring. This is the minimum rail pressure required to allow an injector to function on the engine.

This test confirms:

- the nozzle spring can keep the nozzle closed
- the needle is not stuck in the open position
- no debris is trapped between the nozzle needle and nozzle seat

The second leak test is designed to increase pressure to the maximum operating rail pressure of the injector.

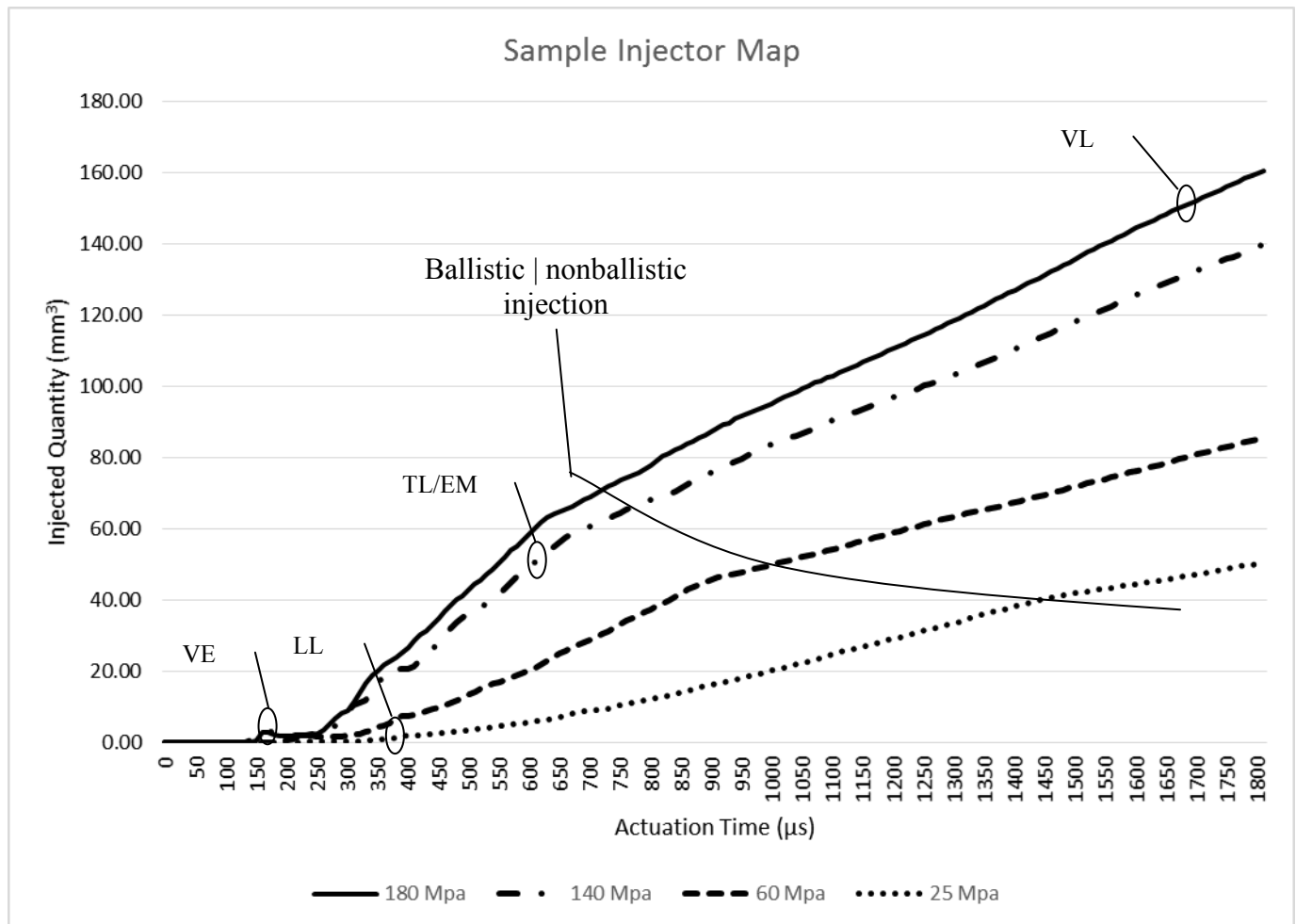
This test confirms:

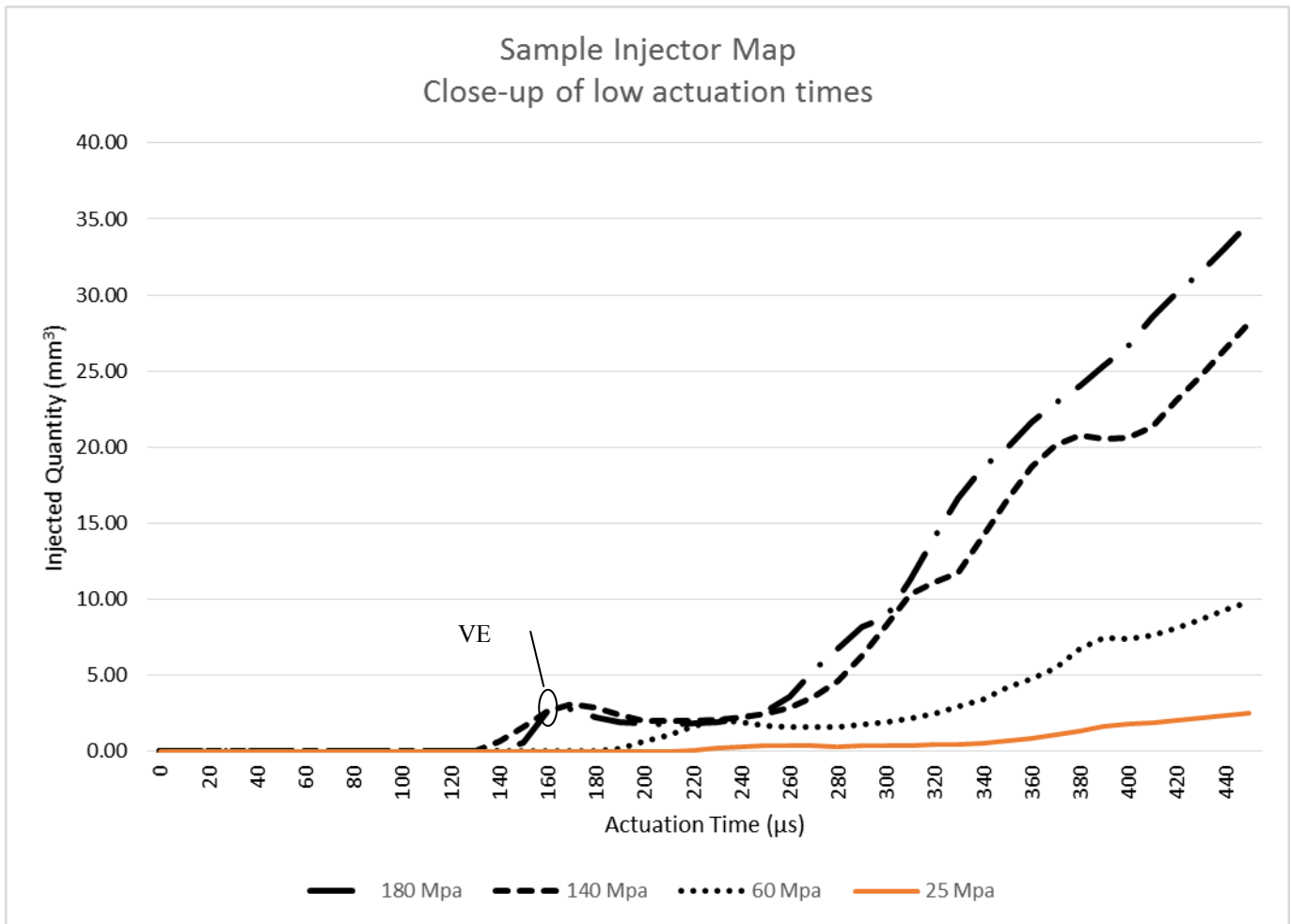
- there are no external leaks
- there are no cracks in the injector body
- the injector nozzle does not leak
- internal leakage is not excessive

During the development stage of a common rail injector, each part number injector is run through a process called mapping. In this process, the injector is operated at a fixed rail pressure and the actuation time is increased from 0  $\mu\text{s}$  to the maximum actuation time in 10  $\mu\text{s}$  increments. At each increment, the delivery quantity is measured and plotted. From this map, the test points and the engine calibration values are determined as an injector can be operated at any pressure and actuation time combination. A sample map is shown below.

Unfortunately, performing an injection map on every injector would be very time consuming. With production test equipment, injector mapping can take more than 2 hours depending on how many pressures are mapped, as each pressure curve measures the fuel delivery at 180 or more points. (Some OE maps use 10 different pressures.)

From this testing, Bosch and the OEM agree upon 4 or more points on the map to measure the performance of the injector to determine if the injector is within specification.





With injectors, a distinction is made in the fueling curve map between ballistic and nonballistic modes. The ballistic and nonballistic sections in the fuel curve map are separated by a kink in the fuel map. The kink indicates when the valve plunger/nozzle needle have reached maximum travel.

**Ballistic Mode:** an actuation time less than the amount of time for the valve plunger/nozzle needle to reach the hydraulic stop.

**Nonballistic Mode:** an actuation time of sufficient length that the valve plunger/nozzle needle reaches the hydraulic stop. Note that as the rail pressure is increased, the time to reach nonballistic mode decreases.

Another feature of the fuel curve map is the flat curve (region between 170 – 250 μs) that occurs with small actuation times. The flat curve is caused by the solenoid armature rebounding on opening. In this area, the injected fuel quantity is independent on the actuation period. Only after the armature has stopped rebounding does the injected fuel quantity curve continue to rise linearly as the actuation period becomes longer.

### *VL – Full Load*

This point can be identified by a long actuation time, typically  $> 1400 \mu\text{s}$  and a rail pressure equal to the maximum rail pressure of the injector. This is the only point where return quantity value from the injector is measured while actuating. This measurement is taken in the nonballistic area of injection.

This test confirms:

- Maximum fuel delivery of the injector
  - Low Power
  - Over fueling
- Excessive return quantity
  - Low rail pressure
  - Hard start

### *VE – Pre-injection*

This point can be identified by a very short actuation time, typically  $< 270 \mu\text{s}$  and a rail pressure equal to the maximum rail pressure of the injector. This verifies the injector is able to consistently deliver fuel at the minimum actuation time recommended. This is almost always at the beginning of the flat curve.

This test confirms:

- Injector components are able to react to the minimum actuation time
  - White smoke
  - Misfire
  - Engine noise
  - Aftertreatment issues

### *EM – Emission point*

#### *TL – Part load*

These points can be identified by an actuation time, typically between  $400$  and  $800 \mu\text{s}$  and a rail pressure below the maximum rail pressure of the injector. The selection of the test points are manufacturer specific. Typically they are looking for critical points in the engine calibration, especially in the ballistic area of injector operation.

This test confirms:

- Specific points of the performance map as agreed upon by the OEM and Bosch.
  - Mid-range performance
  - Misfires
  - Smoke

## LL – *Idle*

The name of this point is a bit misleading. While it is called “Idle”, it is not an engine idle point. This point can be identified by an actuation time, typically between 300 and 400  $\mu$ s at a rail pressure just above the minimum operating rail pressure of the injector. This is to look at the frictional forces within the injector and determine if there are any excessive forces on the moving parts of the injector that would affect performance at moderate rail pressures.

This test confirms:

- Specific points of the performance map as agreed upon by the OEM and Bosch.
  - Mid-range performance
  - Misfires
  - Smoke