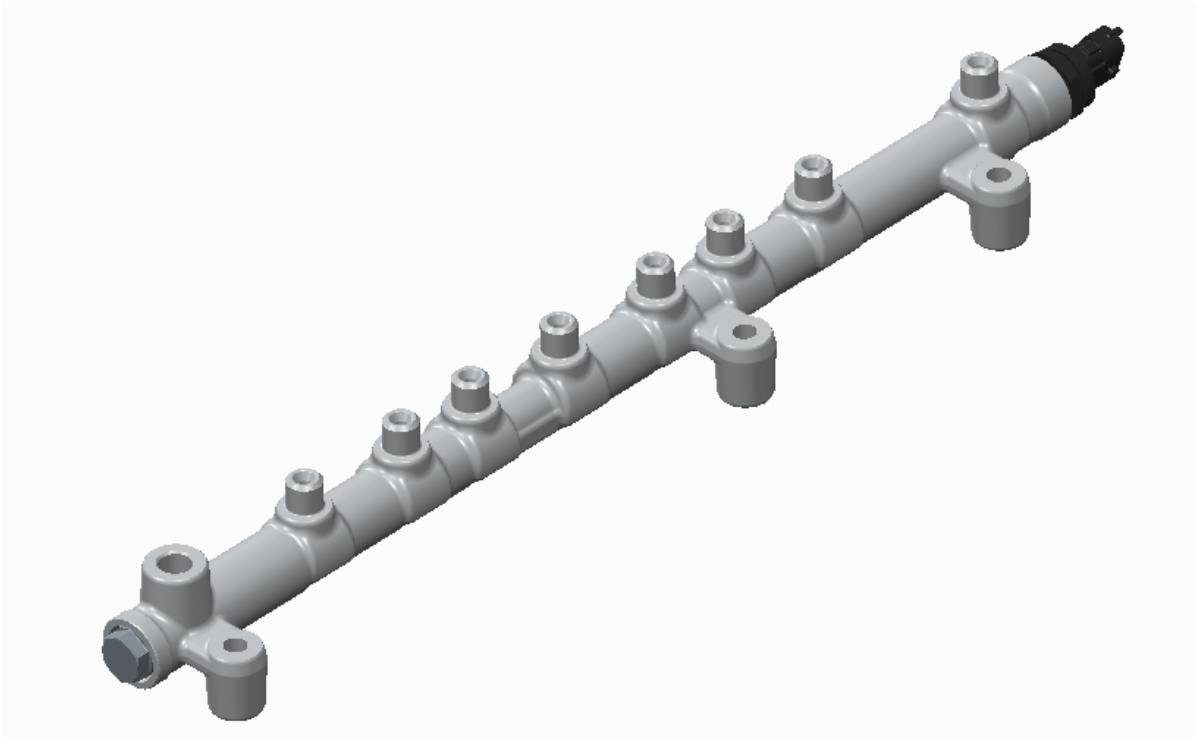
Division:	**Diesel Systems**
Product class / component:	**Rail / HFRN-18BL**
Sample / series status:	**Sample**
Bosch part number:	**B 445 526 118**
Customer:	**JMC_FO**
Customer project / engine:	**13l**
Customer part number:	**TBD**
Customer application: This product is only intended for use in vehicle <MD>.	

HFRN-18BL

Short product description:

A Rail is a fuel distributor line containing a volume for fuel under high pressure to equally feed the injectors.



Applicable Documents:	Doc. No.	Version	Valid from
Quotation drawing	A 445 226 974	1	18.12.2015
Test data sheet	0 449 C40 019	3	06.08.2009
Test method sheet: General Cleanliness HFR	 0 449 C00 013 0 449 C00 011	 4 2	 26.07.2010 15.02.2008

For measurement of test data, a DS-approved test bench connected to the DS inspection system must be used.
Returned products are considered good if they fulfill the specifications/test data for0-mileage and field listed in the TCD.

General:
The following sub-documents can be changed without the entire TCD losing its validity. The agreement between the customer and Bosch with regard to the change is to be registered.

Sub- documents	Doc. No.	Version	Valid from
Allowed fuels	0 449 D05 135	2	28.01.2014
Filtration specification	0 449 D00 023 @filter quality: C	1	06.06.2012
System requirement on water traps	0 449 D00 006	6	14.04.2010
Contamination test CR-components	0 449 D00 002	2	17.12.2007
TCD Rail Pressure Sensor (RPS)	0 261 K00 499-788	1	04.10.2011
TCD Pressure Control Valve (PLV)	KT 45 420 400	15	18.09.2014
Service instruction RPS PLV	Y 445 210 845 Y 445 210 846	5 2	29.08.2006 09.12.2009
Interface specification for high pressure fuel injection pipes	0 449 D05 088	1	12.12.2012

This preliminary TCD documents the present status of agreed specifications. It will be confirmed when all validation has been completed with positive results.

For accuracy of TCD-content:		For acceptance of the TCD:
Robert Bosch GmbH **Division** **DS** **DIESEL SYSTEMS**		**Customer** _____
Engineering **DS-B1/NE** Date _____ Signa-ture _____	**Technical Sales** **DS-XX/XXX** Date _____ Signa-ture _____	**Depart-ment** _____ Date _____ Signa-ture _____

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1. Introduction

1.1 Agreed product use:

Should Bosch have agreed that the product should be fit for the use or purpose intended and/or having a defined level of quality, such agreement is subject to the application of HFR within the conditions (environment, application, installation, loads) as described in this TCD and the agreed upon documents.

All contractual requirements, including the aforementioned, are deemed to be fulfilled, when the product successfully has passed the tests in accordance with the TCD and other related documents.

It is in the responsibility of the customer to ensure the proper application of the product in the vehicle.

Any deviation of the environment the product is exposed to from the agreed upon environment according to the TCD and agreed upon documents as well as all applications not released by Bosch must be notified to Bosch and require Bosch approval.

The product's operating safety is only ensured if the permissible conditions are maintained.

2. General Product Description

2.1 Common Rail System

The **HFR** (**H**ot **F**orged **R**ail) is to be used exclusively in fuel-injection equipments (FIE) for diesel engines. The HFRN-18BL(HFRN = version for commercial diesel engines) is developed for a system pressure of 1800bar.

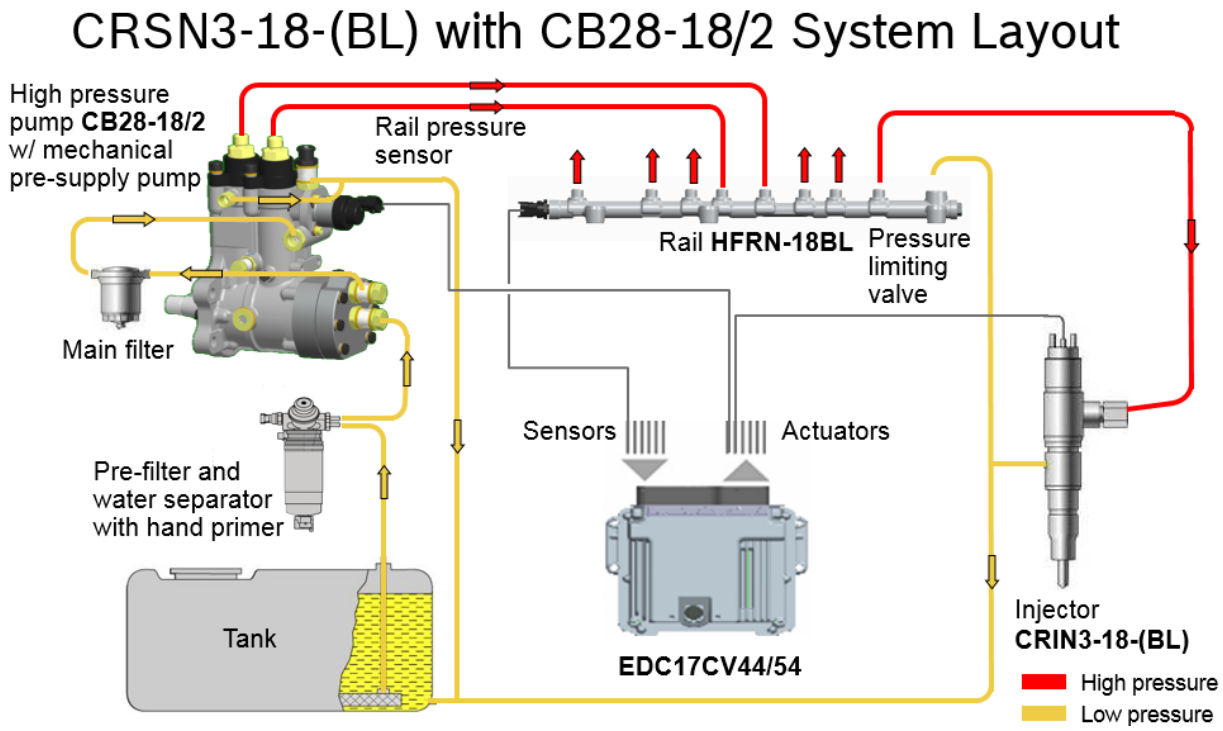

Figure 1 (system overview)

2.2 HFR Functions

The functions and sub functions of the HFR are (f*or the functions of rail attached components, see specific TCD)*:

- To store fuel at required pressure
- To distribute the fuel from the HP-pump to the injectors
- To ensure backflow from Pressure limiting valve (PLV) to the Low Pressure (LP)-circuit

For detailed description of the function see chapter 4.

3. Interfaces

The HFR is not designed for an assembly under valve cover or other locations with oil atmosphere.

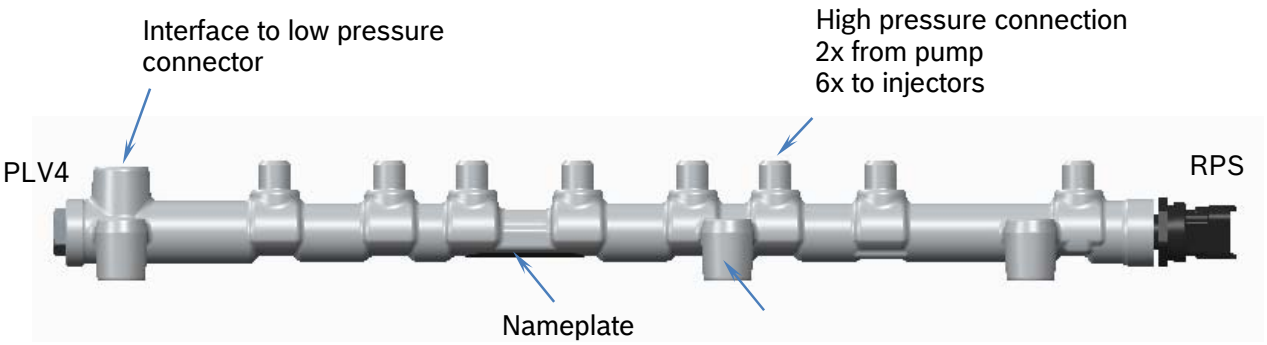

Figure 2

3.1 Interface to high-pressure tubes:

The high pressure connections are designed to adapt the high-pressure tubes connecting the rail to the high-pressure pump and to the injectors, and to enable a tight connection till the max allowed pressure.

Geometry and material:

Interface drawing of HP-pipe interface:	see offer drawing of rail
Diameter of theoretical sealing line:	see offer drawing of rail
Hardness of rail material:	see offer drawing of rail
Coating type:	see offer drawing of rail
Max coating thickness on rail high pressure interface:	10 µm at sealing cone

Assembly force:
The maximum permissible static axial force at HP-connection is to be secured regarding to the strength of the rail. See permissible loads in chapter 5.

Loaded thread:
The minimum length of thread engagement in assembly conditions has to be secured.
See permissible loads in chapter 5.

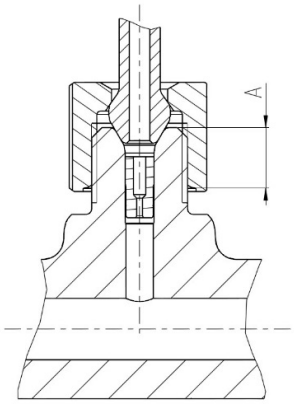

Figure 3

Attention:
Bosch is no high pressure pipe supplier and therefore Bosch takes no responsibility for high pressure pipes, assembly and tightness.
Bosch doesn't specify the assembly process of the high pressure lines for the series assembly at the customer.
Bosch bears no responsibility for leakage due to wrong assembly process or/ wrong design of high pressure pipes.
The correct assembly parameters, sequence and process have to be defined by the customer in co-operation with the high pressure pipe supplier.
The rail can be severely damaged, if the specified values in the Bosch TCD are exceeded.
The sequence of the assembly process has a strong influence on tightness over life time.
Bosch recommends the assembly of pipes with a minimum of bending and torsional stress under observance of the threshold values specified by the pipe supplier.
See "Interface specification for high pressure fuel injection pipes in Common Rail Systems" mentioned in the overview sheet.

3.2 Interface to low pressure circuit:

Type of low pressure connector: inner thread type

► In case of LP-connector assembled by Bosch (Tube connector or quick connector):

Attention:
- Customer side connection parts have to be designed to stand the max. Temperature load.
  Free tube / pipe length between low pressure connector and first fixation < 200 mm
  In case of using an low pressure adapter with low pressure connections from / to other system components the adapter has to be fixed to the engine.
- Bosch is no pipe supplier and therefore Bosch takes no responsibility for pipes, assembly and tightness.
- Bosch doesn't specify the assembly process of the low pressure lines for the series assembly at the customer.
- Bosch bears no responsibility for leakage due to wrong assembly process or/ wrong design of low pressure pipes.
- The correct assembly parameters, sequence and process have to be defined by the customer in co-operation with the low pressure pipe supplier.

► In case of LP-connector assembled by customer (screwed connector):

- Maximum allowed assembly torque: see permissible loads in chapter 5.

Bosch recommends the assembly of tubes / pipes with a minimum of bending and torsional stress.

Attention:
- The screwed LP-connector has to be designed to stand the max. temperature load.
- Bosch takes no responsibility for assembly and tightness of the connector on the rail.
- Bosch doesn't specify the assembly process of the LP-connector for the series assembly at the customer.
- Bosch bears no responsibility for leakage due to wrong assembly process or/ wrong design of LP-connector.
- The correct assembly parameters, sequence and process have to be defined by the customer in co-operation with the LP-connector supplier.
-

3.3 Interface to engine (fixation and packaging)

- The Rail should be used for its purpose within the CR-system (storage of fuel under high pressure condition). Mechanical stresses, e.g. impacts, falling down or similar incidents could lead to damages as far as leakages at the high pressure interfaces and could lead to a malfunction of the additional rail components (RPS, PLV, PCV).
  The handling is only allowed at the rail body and at the engine-fixations.
  Protection-caps should be removed just before final assembling.
- Rails, which are damaged before or during assembly have to be sorted out. Further usage for assembly is prohibited.
- Customer has to ensure a suitable connection between rail and engine over specified lifetime: therefore the contact surface of the rail fixations shall not exceed a flatness tolerance of 0.6mm over the 3 surfaces. Furthermore, customer has to ensure that the screw dimensions (length, head-diameter, ...) are in accordance with the rail bracket dimensions specified in the offer drawing.

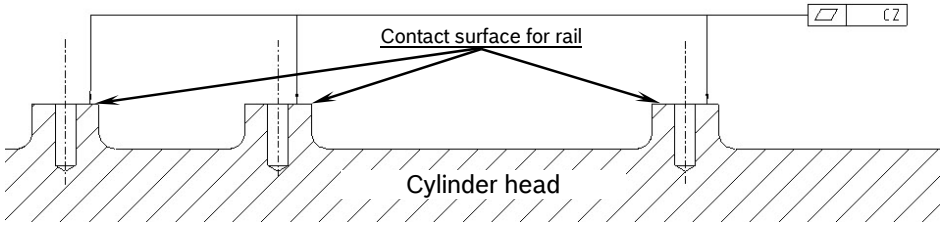

Figure 4

- Customer must also ensure with appropriate study, that there is no collision between the rail and other part of the engine or car components after assembly. For this purpose, the dimensions and tolerances given in the offer drawing must be considered.
  It must be paid attention that at the manufacturing of rail includes a forging step: due to the parting of forging dies, local geometrical deviations at the forged part are allowed according to ISO-standards, which are not described in Bosch offer drawing.
  These consist in:
  1. Mismatch of forging dies
  2. Residual flash
  3. Trimmed flat
  See figure 5. For details and allowed values, refer to the standard mentioned in the offer drawing. In case of critical motor packaging issue in this area, additional dimensioning should be required to Bosch.

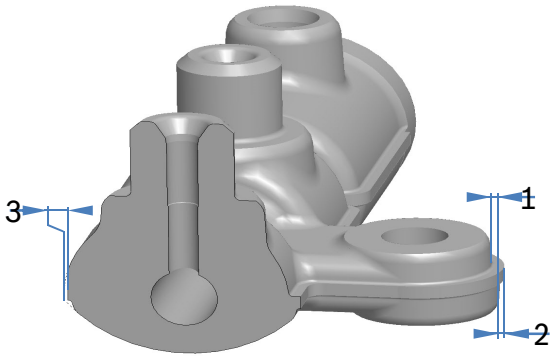

Figure 5
Exaggerated representation of the permissible deviations at the forged surfaces

- Customer has to ensure a suitable connection between rail and HP- pipes, LP- circuits over specified life-time.
- Rail inclination to be defined to fulfil the limitation required by the components (See specific TCD and offer drawing)

- In the delivery conditions small quantities of test oil can remain in the rail, particularly in those with throttles. It must be considered, that small quantities of test oil can drip out from the rail orifices.

3.4 HP-Interface to rail attached components (RAC)

The rail carries one or two RACs. These interfaces are described in the TCD of the respective component.

- Exchange is only allowed with original Bosch service add-on components.
- For available add-on components, contact Bosch- AA (Automotive Aftermarket).
- For technical information: see service documents mentioned in the overview sheet.

- For more detailed information, contact Bosch- AA (Automotive Aftermarket).

Attention:
- Assembly operations under running conditions of the fuel injection system are not allowed.
- Ambient pressure level within the rail before starting any assembly operation has to be ensured.
- New seals and intermediate parts must be used after the disassembly.

The rail is delivered to customer with assembled attached components (RAC).

- For Bosch attached components:

The geometrical interface of both rail and component, as well as the screwing process, are established to ensure the tightness till max rail pressure (see characteristic data chapter 5). The tightness test conditions are described in the respective test method sheet and test data sheet mentioned in the overview sheet.

- For non-Bosch attached components:

Based on the component specification (Offer drawing & TCD), the geometrical interface of rail as well as the screwing process are established to ensure the tightness till max rail pressure (see characteristic data chapter 5).
Attention: As Bosch is neither the designer nor the manufacturer of the component, the tightness validation is performed during the project phase. Bosch takes no responsibility in case of component characteristics changes performed after this validation.

3.5 Labeling of the product

Labeling of the product: see offer drawing.

4. Functions

For the functions of rail attached components, see specific TCD.

4.1 To store fuel at required pressure

The rail is designed to store diesel fuel in a required volume at high pressure. The rail volume is required to level out effects of pressure instabilities. These instabilities come from the pump and from the injectors.

The pump delivers the fuel to the rail in discrete quantities as compressed in the pump cylinders. This leads to pressure oscillations depending on pump speed.

The opening of the injectors creates pressure drops which are to be compensated by fuel supplied from the rail. Thus each injection creates pressure oscillations in the rail volume depending on engine speed and injection pattern (i.e. pilot, main or post-injection). A big rail volume reduces the pressure drops after the injection.

However a big rail volume has disadvantages during start. The injection is released (among other criteria), if the rail-pressure reaches a defined level. A small rail volume allows therefore quicker start-times.

The rail volume is defined by consideration of these both aspects within the project activities between Bosch and the engine manufacturer, and is documented in the offer drawing. The total high-pressure volume has to be considered, including the volume contained in the HP-lines and in other FIE-components such as the pump or the injectors.

The rail-pressure is governed by the regulation system chosen by the engine manufacturer. The rail attached components (RAC), consisting in a Rail Pressure Sensor (RPS) and if required a Pressure Control Valve (PCV) or a Pressure Limiting Valve (PLV), are part of this regulation system as well as the Fuel Metering Unit (FMU) of the High-pressure pump (CP).

The rail has to meet the service time targets of the given applications (see cover page). The lifetime of the rail depends on the number and the amplitude of the pressure cycles in the rail. These are quantified within a Load Collective Measurement (LCM), which is different for each application. A LCM results of a deterministic stress time-function (see below left) measured on the vehicle, which is then converted to a range-pair diagram summarizing the cycles relevant for the fatigue damage (see below right). The LCM represents a fatigue load for the rail and is the base for the lifetime calculation performed by Bosch.

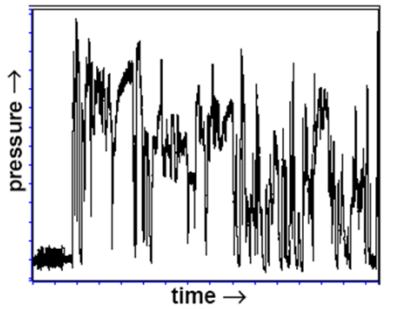

Figure 6: deterministic stress time-function

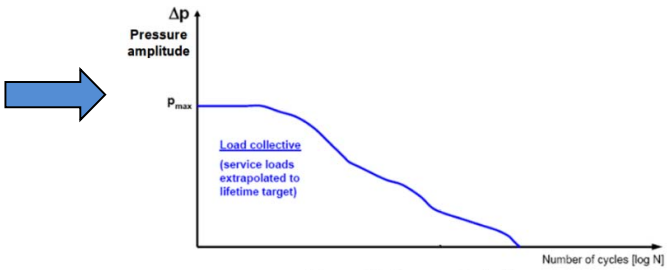

Figure 7: Range-Pair diagram

4.2 To distribute the fuel from the HP-pump to the injectors

The common-rail pump delivers fuel under high pressure to the rail (or to 2 rails in case of V-engines) by one or two high pressure tubes. The rail distributes the fuel to the injectors. As each injection creates pressure drops in the injector, a pressure wave travels from the nozzle through the injector and the high-pressure tube to the rail. This wave is reflected at each intersection and partially travels back to the nozzle. In a similar way, pressure waves generated by the pump travel to the rail. These waves are reflected by reaching the rail and partially travel back to the pump.

This phenomenon can influence the injection pattern quality and the components durability. The amplitude of pressure waves can be reduced thanks to throttles at each HP-interface (Refer to offer drawing).

Additionally, software functions implemented in ECU can reduce the influence of pressure waves on injection quantities.

The pressure drop over the throttle is one of the design parameters of each rail-platform, which is mainly depending on the throttle-diameter (see offer drawing). The throttle is designed for a pressure drop in injector-rail direction.

As add-on component, the throttles are pressed in the inner bore of high pressure connection. The sub-assembly throttle-rail is designed to ensure that the throttle will hold its assembly position under the pressure load met in service condition. Max pressure difference over the throttle, see permissible loads in chapter 5.

4.3 To ensure backflow from PCV/PLV to the LP-circuit

If the rail carries PCV or PLV, a backflow connection to the low-pressure circuit is provided, matching the requirement of the component.

For LP-connector assembled at customer see interface in chapter 3. This connection must be dimensioned to match the requirement of the component (See component TCD).

For LP-connectors assembled at Bosch:

- The tightness between LP-connector and rail is ensured till max allowed back-pressure (See component TCD)

5. Characteristic data

5.1 Operation conditions and Verifications (Permissible Loads)

The functions described above are valid for the following conditions.

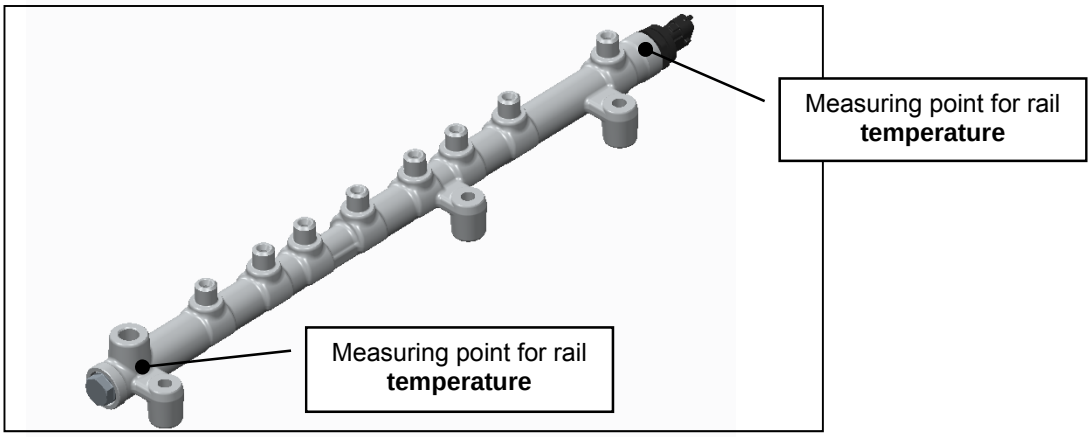

Figure 8: Rail view with measuring points

By vehicle tests under realistic worst case operation the following criteria have to be fulfilled. If the limits are exceeded appropriate measures have to be implemented (for example by calibration).

Permissible loads for attached components see specific component TCD.

5.1.1 Environmental loads:

Environmental conditions	Unit	Min. value	Nom. Value	Max. Value	Remarks	Verification
Fuel temperature @ pump inlet	°C	See component TCD			See component TCD	See component TCD
Max. fuel temperature in the LP-departure	°C	See component TCD				
Max temperature at rail body	°C			120*/ 140**	* without time limitation ** with time limitation (15min)	measured at rail-location in engine
Corrosive environment	h			240	Max hours in salt spray test, valid for rail body only	acc. DIN EN ISO 9227 (definition of salt fog conditions) ensuring Ri0 corrosion level (according to DIN EN ISO 4628-3)

5.1.2 Mechanical loads

Mounting position	Unit	Min. value	Nom. Value	Max. Value	Conditions, Remarks	Verification
Pressure load inside rail body			LCM			Load collective measurement performed on customer vehicle
Operating rail pressure	bar		1800*	1950**	* nominal system pressure ** maximum allowed pressure under normal operating conditions (including overshoot and taking into account the measurement&regulation …)	Operating rail pressure (LCM + theoretical calculation of error combination)
Max. rail pressure	bar			2250	Maximal allowed rail pressure in failure case (Max 50 events) Valid for Bosch rail and assembly process	Based on investigation on system failures SW-counter for number of events
Max pressure difference over throttle	bar			200	Rail pressure vs. pipe pressure close to throttle	Measurement of rail pressure with a calibrated RPS and a sensor in the pipe (distance <40mm from throttle)
Max assembly force at HP-connections	kN			25	Valid for HP-connection M14x1.5, valid for a thread engagement of 7mm (dimension A, see 3.1). Required for the fatigue strength of rail threads. Permissible load at pipe nut to be assessed with pipe supplier.	Force measurement + tolerance calculation of nut engagement (A), to be done by the customer based on Bosch offer drawing and data from the pipe supplier.
Max assembly torque of LP-connector	Nm			50	Valid for LP-connection M14x1.5, with thread lubricated before screwing	
Vibration load					See permissible values in the component TCD	

5.1.3 Fuels

	Reference	Conditions, Remarks
Allowed fuels	See overview sheet	Bosch refuses any guarantee of damages on PCV components caused by insufficient fuel quality
Filtration specification	See overview sheet	
Water trap	See overview sheet	

5.2 Lifetime

With respect to the use and usage conditions described in this TCD, the life of the product is designed for a maximum lifetime (indicated in below tables), or 15 years (whatever comes first).

5.2.1 Working time:

The lifetime estimation is based on the load and temperature collective measurement of the applications defined on the overview sheet. In all duty classes (On-Highway, Off-highway application), load and temperature collective measurement has to be done separately on the most critical application (see 1.1 Agreed product use).

The commercial warranty and liability is governed separately by the delivery conditions.

	Unit	Max. value	Conditions, Remarks	Verification
Number of key starts	starts	50 000*	*higher value only in accordance with Bosch development dept.	customer
Number of start/stop events	starts		Only for start/stop function, not valid for hybrid application	To be taken into account in the LCM & LTC
Lifetime	km hour	500.000		

The above values have been validated based on following application:

Application	LCM	LTC	Driving cycle
Ap1	dxxxx	Report N°	xx % City; xx % Rural; xx % Highway

It has to be checked if the new applications are covered by the above LCM/LTC, otherwise new LCM/LTC must be done before release by BOSCH.

The rail can be used on the same engine but multiple kinds of vehicles. It is a high effort to measure every kind of vehicle. It is possible to reduce the effort by choosing the vehicles which are the most critical concerning their load collective.
In a common assessment of the relevant parameters (vehicle, application data, ...) between the customer and Bosch, the measured load collectives cover the applications listed on the coverpage regarding pressure load (number of cycles at all pressure levels).

5.2.2 Storage time

Storage Times			
The rails have to be stored in original Bosch-packing (including frame) in dry, non-salty and clean environment.			
First Assembly Parts	Months	12	at -30°C ... 60°C, relative humidity 0 ... 80 % protected from rain, snow, light and dust
Replacement Parts with AA packaging	Months	48	Following maximum storage is only valid if: - Equipment is dealed with Bosch Automotive-Aftermarket (AA). - Equipment is stored in unopened original AA-packing. at -30°C ... 60°C, relative humidity 0 ... 80 % protected from rain, snow, light and dust

5.3 Service

Service and repair or replacement of the product may only be performed by authorized personnel.

Service Instruction	See overview sheet	Instruction only valid for components on rail Bosch.

6. Validation:

The product was tested at Bosch during the platform development stage on endurance test benches and was validated in respect of service life requirements. The conditions governing these endurance trials and their results as well as the relevant Product-FMEAs can be viewed at Bosch. The scope of testing carried out will be documented in the context of product development on the project-specific test sheet.

6.1 Platform Validations at development

Definition of terms:
Test conditions: Tests shall prove the durability and immunity of the HFR under artificial boundary conditions. Due to the fact that not all possible conditions can be tested, certain HFR tests are performed under standardized conditions with arbitrary product samples. Tests in contrast to specifications do not describe a property of the product and hence cannot assure the complete functionality under arbitrary conditions.

Specifications: The specifications of the HFR are valid for all delivered pieces and ensure their complete functionality within the given boundary conditions. These properties of the HFR shall provide the correct application and specify the requirements of the complete fuel injection system

Limitation:
The development process at Bosch is geared towards eliminating potential failures by means of internal processes. Use in the field exposes the Bosch components to interaction with the engine, the vehicle, environmental conditions, different applications, fuel quality. Such interactions are different for different components, engines, vehicles. It is possible that such interactions lead to load conditions that were not predictable and could not be tested in the internal development process. Such interactions can lead to failure of the Bosch components in the field.

According to the current state of technology, engine testing and vehicle testing in the typical vehicle usage are the most effective possibility to discover such interactions. Therefore the proper function of the HFR according such interactions has to be validated by the customer under realistic operation conditions in the engine/vehicle.

6.1.1 Mechanical dynamic tests

High pressure pulsation
Experimental determination of fatigue limit or of the complete Wöhler-curve of the rail body
Target: Basis for lifetime calculation considering load collective (< 1ppm)

6.1.2 Climatic tests

Salt mist
Test of resistance against salt fog.
Target: Validation general environmental conditions.
Test condition: According DIN EN ISO 9227 (2006–10), temperature, pH, concentration and mass share controlled.
Acceptance criteria: Degree of rusting according Ri scale

Water protection
Refer to component TCD.

Under hood climate resistance
Refer to component TCD.

6.1.3 Other tests

Load collective (pressure)
Determination of load collective (pressure) on a standardized road with application data in serial condition, vehicle in serial condition.
Target: basis for lifetime calculation (< 1ppm)
Test condition: See chapter 5.2.1

Temperature collective
Determination of load collective (temperature) on a standardized road with application data in serial condition, vehicle in serial condition
Target: verification of specified TCD limits regarding temperature (See chapter 5.1.1)
Test condition: Same driving cycle as pressure load collective

Remark: the temperature collective measurement is not replacing the temperature measurement in winter or summer testing!

Lifetime calculation
Target: Determination of life time assessment for high pressure components. In regard of life time target, defined application (vehicle, calibration) and defined load collective.

Test condition:
Input-data: load collective measurement and high pressure pulsation test.
Acceptance criteria: failure probability at lifetime target

6.2 Validation at customer

The functionality of this product in the context of the complete system must be assured by the customer through vehicle trials under realistic application conditions. These tests and the required parts investigation at Bosch must be agreed between Bosch and customer within the customer's project.

7. Abbreviations

PCV: pressure control valve, PLV: pressure limiting valve, HP: high pressure / LP: low pressure / FMU: Fuel metering unit, RAC: Rail Attached Component, LCM: Load Collective Measurement, LTC: LifeTime Calculation

No.	Page	Change	Date	Department responsible	Signature
0	-	**First version** / 0449X48400	22.08.2014	DS-B1/ERR1-Vx	Marceau
		Customer vesion	3/30/2016	RBCD/EPD5-Wx	Fan