CP4 rating catalog for visual findings

Roller surface

- Functions
  - Support axial forces
  - Axial guidance of the roller or lateral limitation

- Wear caused by
  - Mixed friction
  - Foreign bodies
- Types of wear
  - Smoothing
  - Abrasion
  - Adhesion

CP4 rating catalog for visual findings

Roller surface – Status Green

Rating	Images	Description
1		As new

 [redacted] | 05.23.2007 | [redacted]

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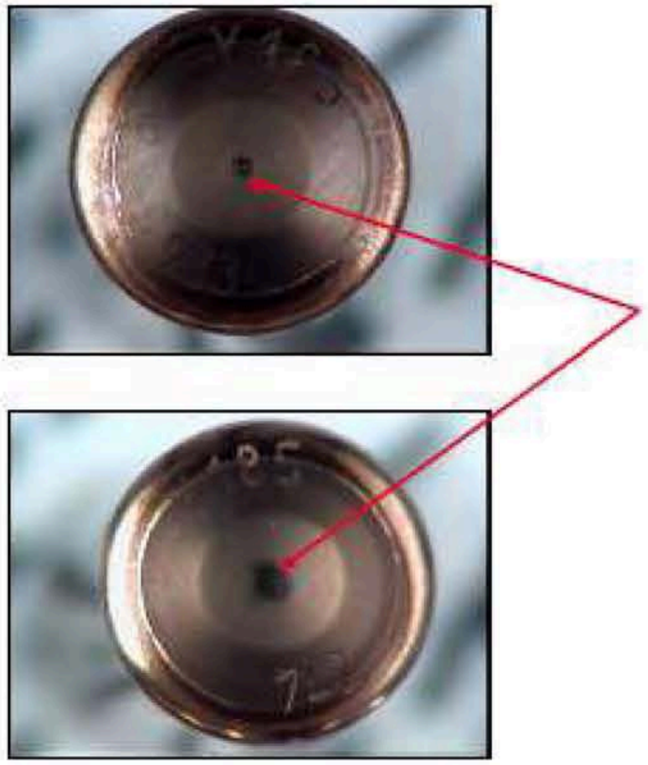
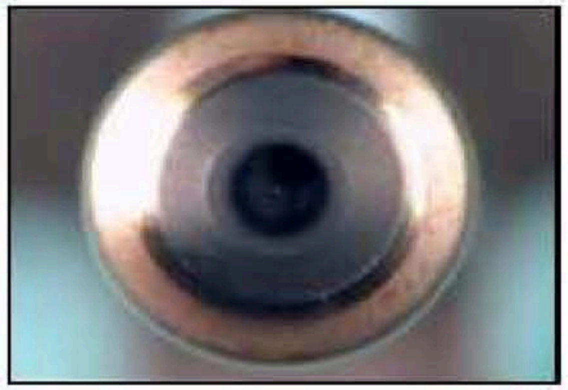
CP4 rating catalog for visual findings

Roller surface – Status Green

Rating	Images	Description
2		Used, smoothing of C coating on roller center identifiable

CP4 rating catalog for visual findings

Roller surface – Status Green

Rating	Images	Description
3	 	Clear, broad smoothing on center of roller

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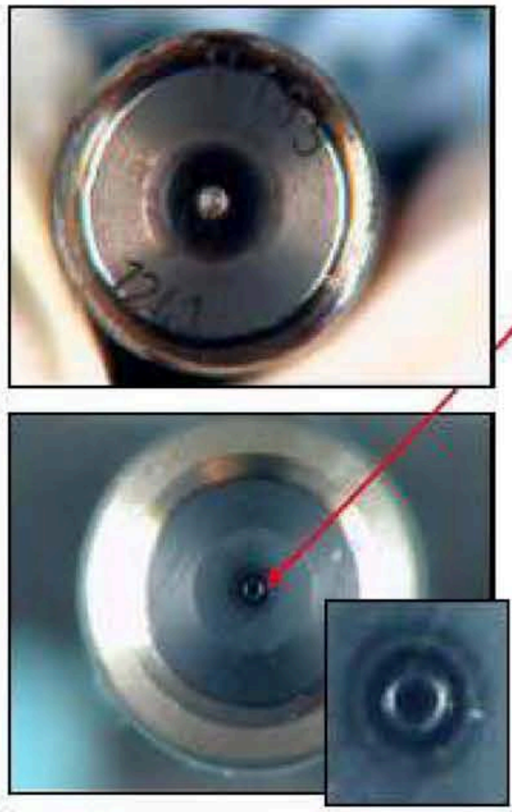
CP4 rating catalog for visual findings

Roller surface - Status Yellow

Rating	Images	Description
4		C coating starting to come away from contact area

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CP4 rating catalog for visual findings

Roller surface - Status Yellow

Rating	Images	Description
5	 	C coating up to Ø 3mm worn away, smoothing pattern

 [redacted] | 05.23.2007 | [redacted]

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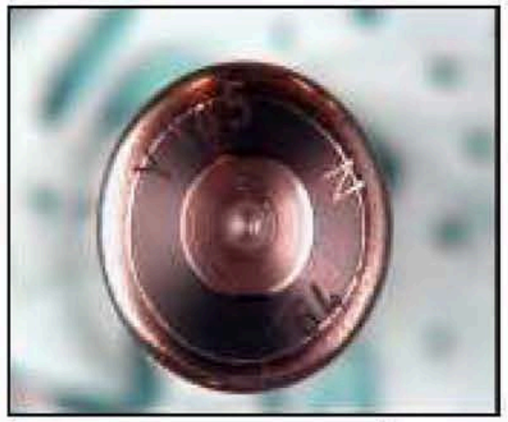
CP4 rating catalog for visual findings

Roller surface - Status Yellow

Rating	Images	Description
6	 	C coating more than Ø 3mm worn away, smoothing pattern

ENTIRE PAGE CONFIDENTIAL

CP4 rating catalog for visual findings

Roller surface - Status Red

Rating	Images	Description
7		C coating worn away + slight wear from abrasive material (or slight seizing) up to Ø 3mm

 [redacted] | 05.23.2007 | [redacted]

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CP4 rating catalog for visual findings

Roller surface - Status Red

Rating	Images	Description
8	 	C layer entrained to large extent + abrasive Material wear (or seizing) more than Ø 3mm

 [redacted] | 05.23.2007 | [redacted]

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EA11003EN-00029[9]

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CP4 rating catalog for visual findings

● Roller surface - Status Red

Rating	Images	Description
9	 	C layer almost completely entrained + abrasive Material wear (seizing) on whole face

 [redacted] | 05.23.2007 | [redacted]

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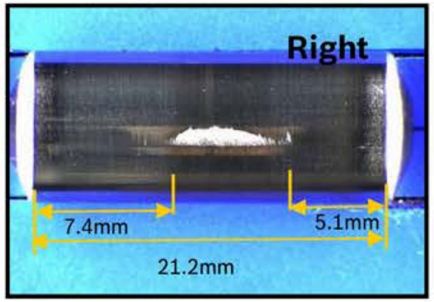
CP4 rating catalog for visual findings

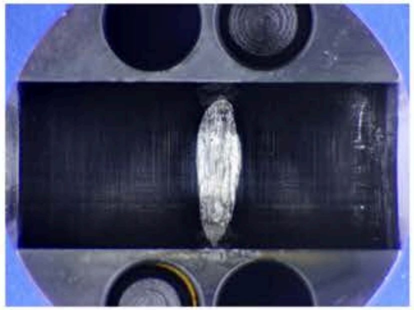
Roller surface - Status Red

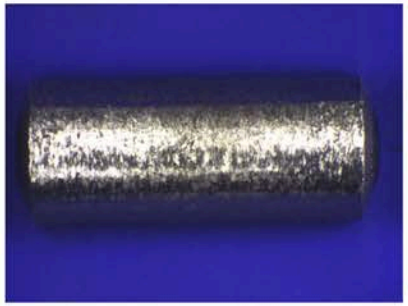
Rating	Images	Description
10	No occurrence	Component breakage

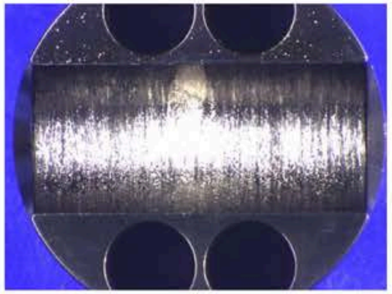
Damage sequence creation, brake plates, roller

Damage sequence: Preliminary damage to brake plate results in subsequent damage Abrasion wear to powertrain

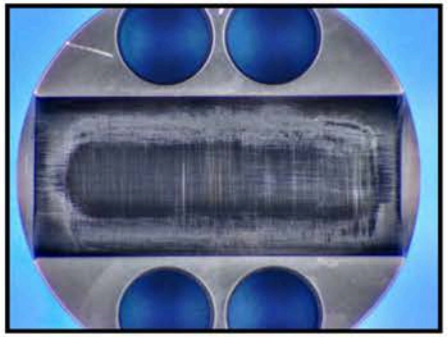


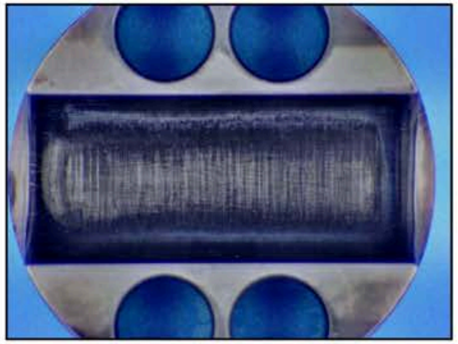






Cause: Temperatures >140°C in gap between roller and roller support result in deposit formation in roller support





Summer trial

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Damage sequence creation, brake plates, roller

Cause variables that prevent warm-up of the roller and are therefore potential causes of preliminary damage to the brake plate

Engine start
- Speed increase 400rpm/sec / 2000rpm/sec -
- Speed fluctuations
Inertia of roller ↑ → Slippage roller/camshaft

Fuel viscosity
Temperature ↑□ μ_{RS} ↑↑
v ↓ (kerosene, gasoline) μ_{RS} ↑↑

Preliminary damage middle brake plate roller

Fuel + temperature → Deposit formation
Biodiesel - aged
additives (tune up)
→ Lubricant shortage → Hydrodynamic build-up ↓

Insufficient lubrication of contact bearing
Prevention of lubricant intake to contact bearing
→ Hydrodynamic build-up ↓

Brown discoloration roller/ camshaft
Abrasion of oxides → μ_{RS} ↑↑
Smoothing camshaft → μcamshaft ↓
→Slippage roller/camshaft

Dry run/air in powertrain

Foam in fuel

No lubricants in contact bearing
→ Hydrodynamic build-up ↓↓

Powertrain empties at standstill

No lubricants in contact bearing
→ Hydrodynamic build-up ↓↓

Damage sequence creation, brake plates, roller

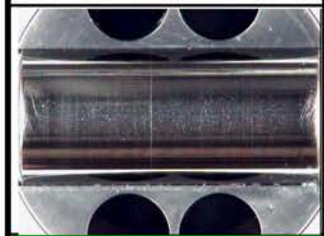
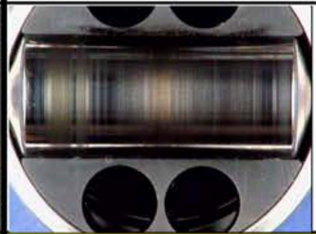
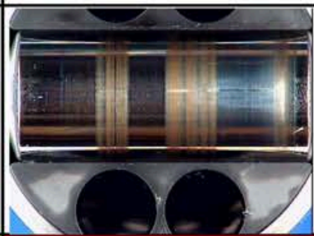
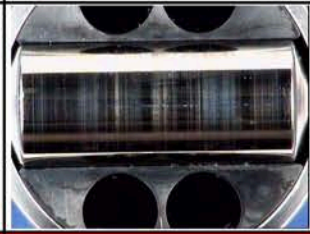
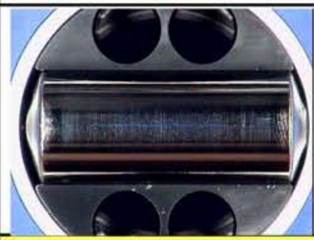
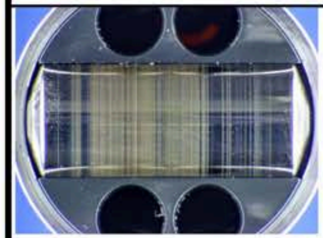
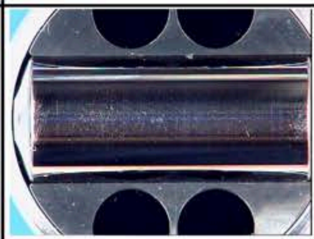
Cause variable	Mode of action	Finding	Possible measure
Engine start	'- Speed increase 400rpm/sec / 2000rpm/sec	Start attempts 400rpm/s and 1200rpm/s OK	Repeat attempted needed
	- speed fluctuations Inertia of roller ↑ →	No backing in start for W19 application	
Fuel viscosity	Temperature ↑ →μRS ↑↑	Analytics/simulation of contact bearing	Roughness of roller support Rp1, C3.1+
	ν↓ (kerosene, gasoline) →μRS ↑↑	Friction coefficient check	Powertrain cooling RP2,
		Test bench start attempts	return from connector bore
Fuel+temperature	Biodiesel - aged	Field returns	Powertrain cooling RP2,
-> Deposit formation	Additives (tune up)	Engine trials	return from connector bore
	→ Lubricant shortage → Hydrodynamic build-up ↓	Evacuation attempt biofuel, tuneup	
Brown discoloration roller/camshaft	Abrasion of oxides → μRS ↑↑	Failed pumps/field pumps	Roughness of roller Rp1, C3.1+
	Smoothingcamshaft → μ camshaft ↓	Friction coefficient examinations	Powertrain cooling RP2,
	→ Slippage roller/camshaft/camshaft	Oxide analysis: Hydrogen, oxygen, fluorine	return from connector bore
			Water separator, avoid air/foam
Dry warm-up/air in powertrain	Foam in fuel	Foam in fuel when tank fill level <16l and	Low-pressure circuit design
		GDK, GRV or China fuel	Tank content >16l
	No lubricants in contact bearing	Warm-up trial, friction coefficient check	
	→ Hydrodynamic build-up ↓↓	Vehicle trial	
	Powertrain empties at	Pump empties at standstill	Leakage prevention valve in tank module
	standstill	-Possible air leak: LP circuit, WDR	
	No lubricants in contact bearing	-Air in low pressure system, small circuit	
	→ Hydrodynamic build-up ↓↓		
Insufficient lubrication of contact bearing	Prevention of lubricant intake to contact bearing	Measures after simulation for hydrodynamics	Improvement to inlet geometry roller support
	→Hydrodynamic build-up ↓	not disadvantages, possible advantage only	Lubrication bore/grooves in roller support
		provable in functional trials	Reduction of wrap angle roller
			Increase roller diameter

ENTIRE PAGE CONFIDENTIAL

Robustness documentation, start behavior CP4

Test bench trials CP4.2 2x4.85 mm

80 starts, speed increased to 800 rpm, p_All 3.5 bar_rel, inlet delayed,

in TCD	Outside TCD		Rating: Discoloration/plates	
Arctic, 80 °C, 400 rpm/s	Kerosene, 80°C 400 rpm/s	Kerosene, 80°C 1200 rpm/s	Kerosene+air, 80°C 400 rpm/s	Dry run, 30°C 400 rpm/s, 20 starts
				
Rating: 1 / 1	**Rating: 5 / 1**	**Rating: 5 / 7**	**Rating: 3 / 7**	**Rating: 3 / 4**
	China Diesel, 22° 400rpm,<5min,2St.	Dry warm-up EN590 0-100rpm, 0-300 bar, 4 starts		
				
	Rating: 5 / 4	**Rating: 1 / 9**		

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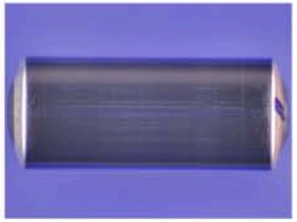
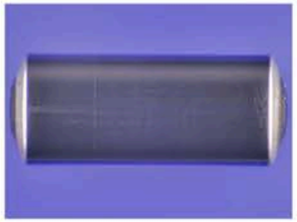
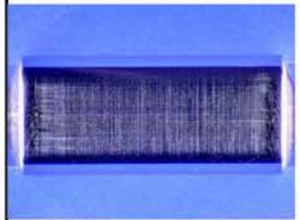
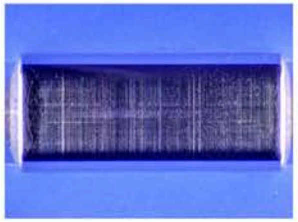
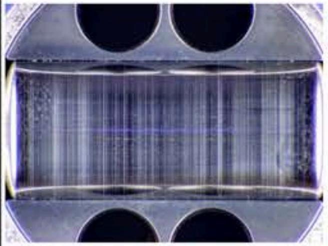
Robustness documentation, start behavior CP4

Vehicle trials, Q7, CP4.2 2x4.85 mm, start trials + idle

in TCD	Outside TCD Rating: Discoloration/plates			
EN590 howl-ing trial	Gasoline 30%, first start (Audi)	Kerosene, first start (Audi)	Kerosene, 10°C, one-time trial	Gasoline 70%, 10°C one-time trial
				
Rating: 1 / 1	**Rating: 1 / 4**	**Rating: 1 / 4**	**Rating: 3 / 4**	**Rating: 3 / 6**
	China Diesel	Kerosene, 80°C blown out	Operating conditions: see:	- Aged biodiesel - air in powertrain -Vehicle run hot- on roll (80°C) before switch-off - Stand time 20 days at ap-prox. 20°C
	Trial planned			
	Rating:	**Rating: 3 / 5**	**Rating - / 10**	

Diesel Systems

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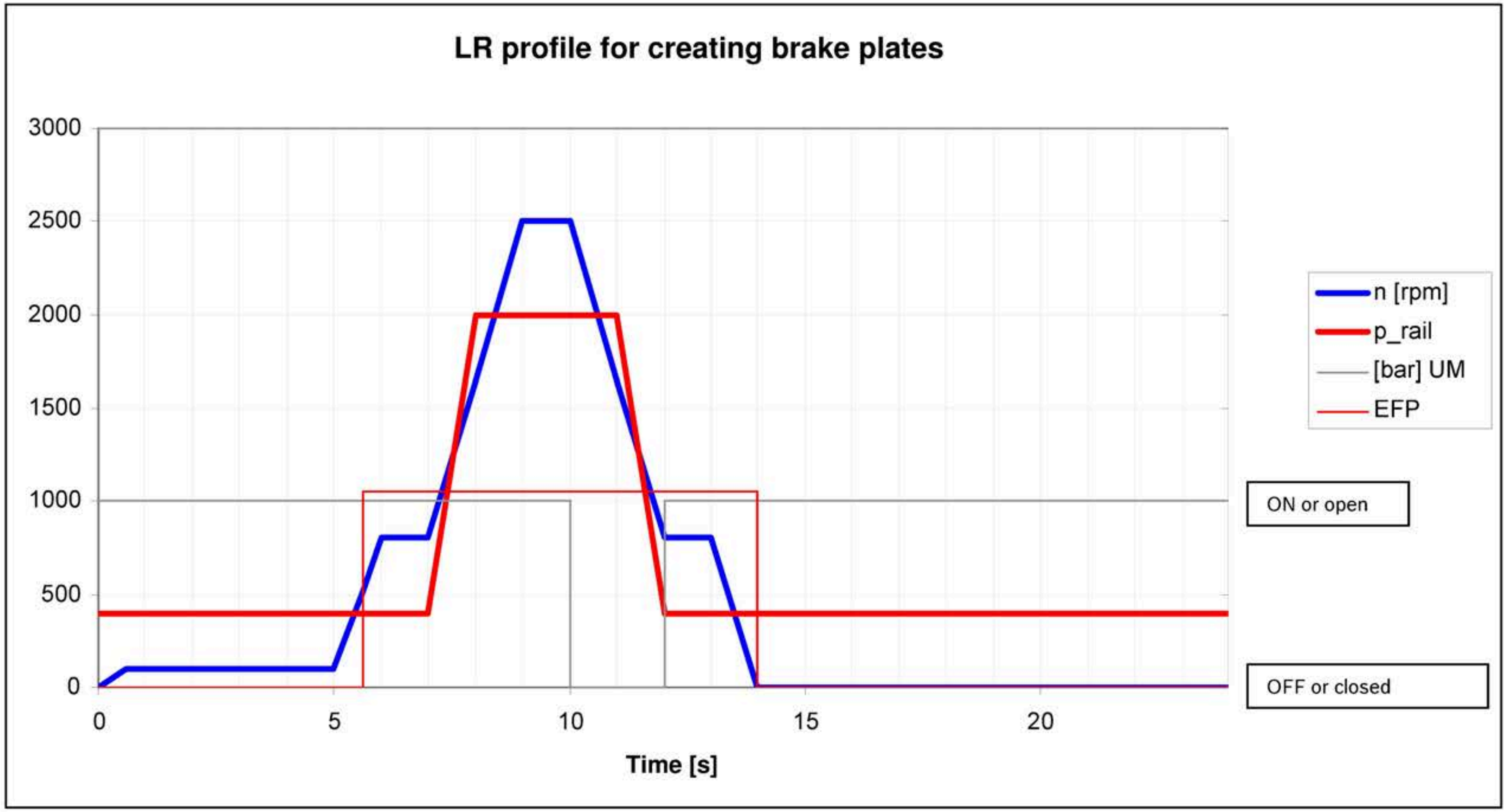
LR profile for creating brake plates

LR profile:



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EA11003EN-00130[6]

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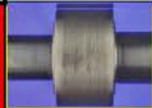
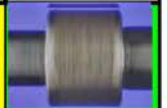
LR profile for creating brake plates

Trial status:

Fuel	T_All [°C]	Starts	Remark	RL_L	RL_R	RS_L	RS_R	CmSh LP	CmSh UP
B20	50% @120°C, 50% @140°C	54,000	Elements below 45°	 Discoloration: R7 wear: R5	 Discoloration: R7 wear: R7	 Lining R7 wear R3	 Lining R7 wear R3	 R4	 R3
EN590	80°C	9,900	With air in inlet. Elements below 45°	 Discoloration: R1 wear: R4	 Discoloration: R1 wear: R4	 Lining R3 wear R3	 Lining R3 wear R3	 R3	 R4
B20	140°C	18,000	Fuel foams with A4 tank, idle/venting at standstill, mounting position (right element vertical)	Disco Wear:	Plan, deadline: open Wear:	wear	g wear		
EN590 with 50% gasoline	140°C	18,000	Fuel foams with A4 tank, idle/venting at standstill, mounting position (right element vertical)	Discoloration: Wear:	Plan, deadline: open Discoloration: Wear:	Lining wear	Lining wear		

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VW-R4 2.0l EU5
– CRS3.2 –

Information about the initial commissioning of CRS with CP4.1 and pre-feed inline electrical fuel pump in connection with cold test.

27/06/2006

Note:
This slide replaces slides **14121d_Zu** and **14150d_Zu; 14911d_Zu**
[Changes marked in "red"]

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VW-R4_2.0l: Information about the initial commissioning

Note the following during assembly

- Cleanliness requirements, in particular, of feed lines into the diesel fuel filter.
- Assembly and service information.
- Assembly instructions (e.g. tightening torques), also see the relevant Component TKUs and offer drawings.

<u>Initial filling of the injection system</u>

- All TKU values must be enforced!
- recommended filling fluid: Diesel fuel compliant with DIN EN590 but HFRR ≤ 400µm

VW-R4_2.0l: Information about the initial commissioning

Test for detecting "major leaks" in the fuel system

A pneumatic leak test can be carried out before the initial commissioning in the cold test to detect any major leaks.

Background: For reasons of health, safety and cleanliness, the fuel system needs to be checked for serious assembly defects (e.g. defective bolt connections) prior to the engine being filled with diesel fuel in the cold test bench.

Pneumatic leak test of injection system:

In the CP4 feed with an
unpressurized return line and **stationary** high-pressure pump with **5bar_rel** for **$t_{max.}$≤20secs**.
the fuel system can undergo a pneumatic check.
The cleanliness requirements with respect to air must be respected here.

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VW-R4_2.0l: Information about the initial commissioning

Recommended before ventilation, initial commissioning/cold test:

➔ Carry out an electrical test (e.g. CRI3.2: contacting, capacity measurement at low voltages, etc. {Note cable lengths and resistances of contact points})

Ventilation of CR systems for
- low-pressure circuits via CP4 return line,
- the high-pressure part (CP4, rail) via the suction/HP valve through the DRVu in the overall return line.

For cold test commissioning:
➔ Control not via engine control unit ➔ engine test bench control needed
(Control of DRVu, ZME; CRI3.2 should not inject)

Ventilation of high-pressure pump CP4 (without reporting point) with pre-feed electric fuel pump

The following framework conditions must be satisfied during CP4 ventilation:

- **Drying running** the high-pressure pump is **not permissible**!
- Also ensure min. filling/pre-pressure ≥ 4.5bar_abs through pre-feed electric fuel pump:
  - **Feed pressure: 4.5 ≤ p_feed [bar_abs] ≤ 7***
    *(not a critical limit, but a larger value does not make sense)
  - **Volume flow > 80 l/h + HP quantity requirement**
    (Upper limit only restricted by max. feed pressure)
- max. **return line pressure ≤ 1.8bar_abs**[U] (continuous operation >1.8bar_abs can result in damage to the shaft seal ring).

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VW-R4_2.0l: Information about the initial commissioning

- At **0 bar rail pressure,** the **max. drag speed**[U] **n_{CP}=300…500 rpm.** (RB recommendation n_{CP}=500 rpm.)
  - An important prerequisite for the ventilation of the CP4 is that the rail pressure approaches zero.
  - If there is still a static pressure in the rail, one reason might be that even the compression ratio of the elements are not sufficient to pump the air.
  - In this case, the only venting path is via the HP piston guide into the interior which can take a very long time.
  - If the rail pressure is zero, the result is a requisite pressure difference of **3.1 ≤ Δp [bar_rel] ≤ 5.1** via the **suction and HP valve.**
  - Since the **overflow valve** is set to **approx. 3.3 bar_rel**, ventilation with an electric fuel pump without a spinning CP4 is only possible when the tolerances for the SV/HP valves are minimal.

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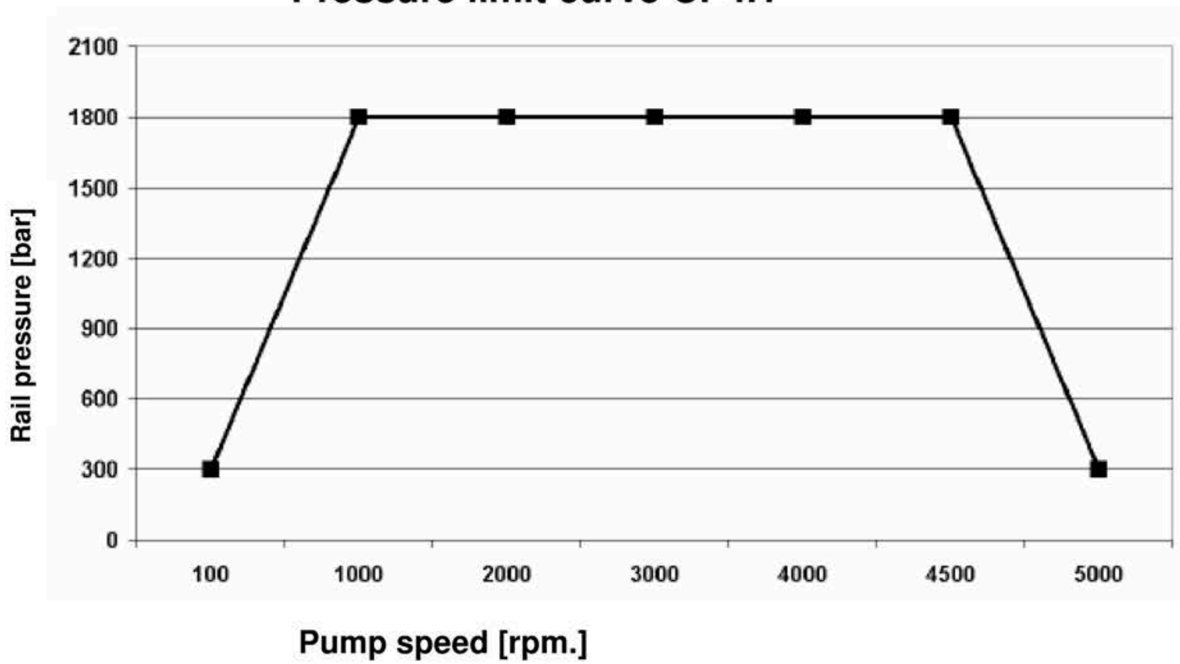
→ Pump only allowed to be operated within the **limit pressure curve CP4** (Tab.1, Diag.1).

Table 1:

Pump speed [rpm]	100	1000	2000	3000	4000	4500	5000
Engine speed [rpm]	100	1000	2000	3000	4000	4500	5000
Rail pressure [bar]	300	1800	1800	1800	1800	1800	300

Diagram 1:

Pressure limit curve CP4.1



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VW-R4_2.0l: Information about the initial commissioning

Step 1) LP/HP ventilation:

Continue to fill the high-pressure pump while in a stationary position until there are no more bubbles in the CP return line/overall return line. (transparent feed and return lines recommended).
Instructions: Open metering unit non-energized; open DRVu non-energized; more efficient ventilation though overall return line bottom/top without counter-pressure. Pre-feed pressure > 4.5bar_abs.

Step 2) Safe ventilation of HP part:
Depending on the setting tolerance of the suction/HP valve, it may already be completed in Step1 through electric feed pump pre-pressure.
Ventilation of suction/HP valve by rotating high-pressure pump with open (no-current) DRVu until no bubbles are present in DRVu return.

→ System ventilation is complete; the system is ready for use.

VW-R4_2.0l: Information about the initial commissioning

Venting steps in detail:

Step 1) Venting time without rotation speed: **10(…20*)s**
(the low-pressure area is secure, the high-pressure area is only vented to a limited extent depending upon the tolerance position of the suction/HP valves.)

and

Step 2) Venting time with rotation speed (**$300 \le n_{drag}$ [rpm] $\le 500^*$**)
After pre-venting of low-pressure area: **= 5 to 10s**

→ The following must hold for **Steps 1) + 2)**: p_Rail=0 bar

*RB recommendation

Ventilation
cold test commissioning in the engine plant

Step 1) Pre-venting of CP4.1 low-pressure area

Q_{Feed}	= 135 – 220 l/h (electric fuel pump or test bench supply)
alternative	
p_{Feed}	≥ 4.5 bar_abs (≤ 7 bar_abs); RB recommendation: 5.0 bar_abs additional increase p_{Feed} increases Q_{Return} by 400 l/(h*bar)
p_{Return}	≤ 1.8(…2.0)$_U$ bar_abs (static)
$t_{Ventilation}$	≥ 10 secs. (pure CP venting time)
n_{Pump}	= 0 min^{-1} (Pump stationary [!])
p_{Rail}	= 0 bar_rel (with respect to p_{Return}), DRVu open, i.e. no flow through it [!]

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VW-R4_2.0l: Information about the initial commissioning

Step 2) Final ventilation CP4.1 HP area

Q_{Feed} alternative	= 135 – 220 l/h (electric fuel pump or test bench supply)
p_{Feed}	≥ 4.5 bar_abs (≤ 7 bar_abs)

p_{Return} ≤ 1.8(…2.0)u bar_abs (average pressure)

$t_{Ventilation}$ = 5 to 10 secs.

n_{Pump} = 500 rpm

p_{Rail} = 0 bar_rel (with respect to p_{Return}), DRVu open, i.e. no flow through it [!]

Times must be determined via trials on the engine directly at the final function test (EFT).

→ System ventilation is complete; the system is ready for use.

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VW-R4_2.0l: Information about the initial commissioning

Tests for cold test commissioning:

Step 3) Measurement of rail pressure fluctuation, i.e. test whether ventilation was performed correctly or measure the air escaping during ventilation.

Step 4) Test (e.g. check high-pressure seal-tightness) with, e.g. a 1600 bar rail pressure and a pump speed of 1500 rpm. ($i=1 \rightarrow n_{CP} = n_{engine}$). Proposal: Duration u 30 sec.

VW-R4_2.0l: Information about the initial commissioning

Proposal: Check HP seal-tightness in pure DRV operation (due to ventilation; via DRVu is better)

Metering unit test: Function test by brief closing of metering unit → Monitoring of pressure troughs (continuous flow 1.7±0.1A; non-cyclical)

The fuel must be left in the system at the conclusion of the cold test. Tightly seal the feed and return connections of the injection system with plugs for the engine transport, as HP and LP system shorted when DRVu de-energized. This is intended to prevent the system from running out, especially the rail running empty.

Note: Filling of leak oil rail in cold test not specified; not until first start or hot test. Filling by means of control volume of injectors during injection.

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VW-R4_2.0l: Information about the initial commissioning

Venting steps in detail:

No.	Electric fuel pump [bar_abs]	Electric fuel pump [bar_rel]	CP4 Return flow counter pressure [bar_abs]	CP4 Engine speed [rpm]	Rail pressure [bar]	DRVu	Metering unit	Notes	min. Duration [sec.]	max. Duration [sec.]	Q [l/h] (Feed test bench)
1	min. 4.5 RB rec. **5.0**	min. 3.5 RB rec. **4.0**	1.0 - 1.2 max.1.8 **U**	0	0	opened *I=0A*	opened *I=0A* *(Max. permissible current 1.7A±0.1 A non-cyclical. max.60sec.)*	Ventilation in stationary position: CP-LP ventilation with electric fuel pump pre-pressure CP feed; ensure fuel lubrication and ventilation of overall system up to CP return top/bottom. DRVu/overall return free of bubbles	10	20	330l/h @ 4.0bar_rel
2	min. 4.5	min. 3.5	1.0 - 1.2 max.1.8 **U**	(300...) **500**	0	opened *I=0A*	opened *I=0A*	For reliable ventilation after suction/HP valve, vent HP part until no bubbles in the DRVu return	5	10	151l/h @ 3.5bar_rel
3	min. 4.5	min. 3.5	max.1.8 **U**	(300...) **500**	Start (250)	regulated	opened *I=0A*	• Ventilation test, i.e. measurement of rail pressure fluctuation • If a stable starting pressure is not reached after 60sec. cancel the test	to be determined	$\leq$ 180 **U**	151l/h @ 3.5bar_rel
4	min. 4.5	min. 3.5	max.1.8 **U**	Pressure/speed table1	Pressure/speed table1	regulated	opened *I=0A... 0.7A*	Leak test (temperature increase DRVu return)	---	30 **U**	165l/h @ 3.5bar_rel

Proposal: Agreement of initial commissioning at customer end in vehicle plant with RB.

The sizes marked with a **U** are currently in the process of being defined.

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VW-R4_2.0l: Information about the initial commissioning

<u>Note the following re the air entry into the LP system before CP4:</u>

If an air column of the CP4 is supplied (e.g. restart after running the tank empty, due to disconnection of CP feed, after a filter replacement) the CP4 cannot feed air column to the rail when the DRVu is closed; no pressure build-up possible.
In this case, the DRVu must be de-energized, i.e. open; only then is it possible to direct the air column into the rail via the CP piston and to divert the air further across the DRVu. Detectable in the case of CP4.1 → no build-up of pressure possible.

→ A SW[U] is provided in the vehicle for this eventuality.

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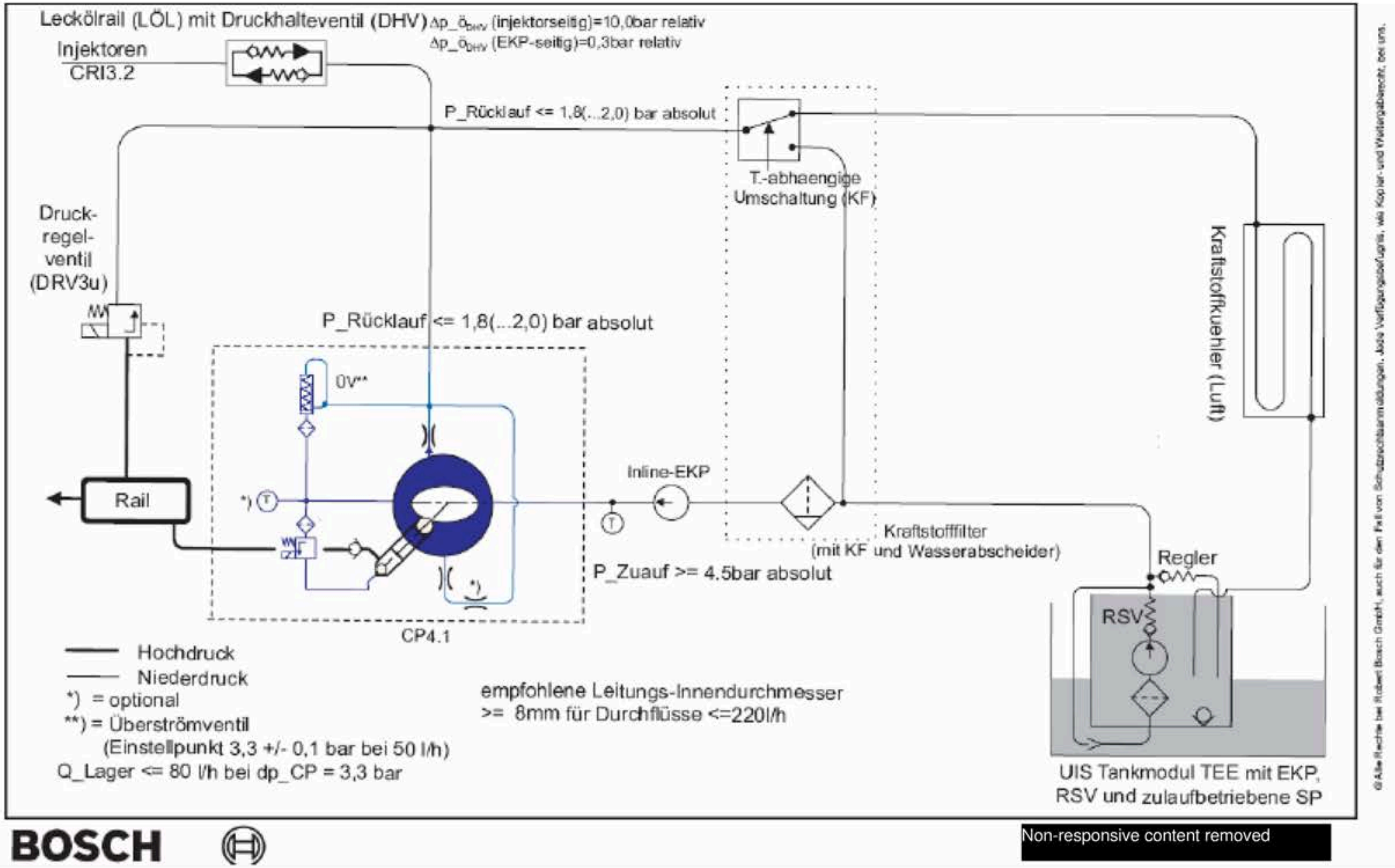
Version 3: CP4.1 + inline electric fuel pump after filter

Common Rail System (CRS3.2) 1800bar, (LP version 3) -temp-
low-pressure circuit VW 4 cyl. (2.0l) with CRI3.2, CP4.1 with tank and inline electric fuel pump after filter



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German	English
Common Rail System (CRS3.2) 1800bar, (ND-Variante 3)	Common Rail System (CRS3.2) 1800 bar, (LP variant 3)
Niederdruckkreis VW 4Zyl. (2,0l) mit CRI3.2, CP4.1 mit Tank- u. Inline-EKP nach Filter	Low pressure circuit VW 4-cyl. (2.0 l) with CRI3.2, CP4.1 with tank and inline electric fuel pump after filter
-vorläufig-	-preliminary-
Leckölrail (LÖL) mit Druckhalteventil (DHV) (injektorseitig)=10,0bar relativ	Leakage oil rail (LÖL) with pressure retaining valve (DHV) (injector side)=10.0 bar relative
(EKP-seitig)=0,3bar relativ	(Electric fuel pump side)=0.3 bar relative
Injektoren	Injectors
P_Rücklauf <= 1,8 (...2,0) bar absolut	P_return <= 1.8 (...2.0) bar absolute
T-abhaengige Umschaltung (KF)	T-dependent changeover (KF)
Kraftstoffkühler (Luft)	Fuel cooler (air)
Druckregelventil	Pressure control valve
Druckregelventilöl	Pressure control valve oil
Rail	Rail
Inline-EKP (RB)	Inline electric fuel pump (RB)
P_Zulauf >= 4,5bar absolut	P_inlet >= 4.5 bar absolute
Kraftstofffilter (mit KF und Wasserabscheider)	Fuel filter (with KF and water separator)
Regler	Regulator
Hochdruck	High pressure
Niederdruck	Low pressure
= optional	= optional
= Überströmventil	= overflow valve
(Einstellpunkt 3,3 +/- 0,1 bar bei 50 l/h)	(setpoint 3.3 +/- 0.1 bar at 50 l/h)
Q-Lager <= 80 l/h bei dp_CP = 3,3 bar	Q-bearing <= 80 l/h at dp_CP = 3.3 bar
Empfohlene Leitungs-Innendurchmesser	Recommended inside line diameter
>= 8mm für Durchflüsse <=220l/h	>= 8 mm for flow rates <=220 l/h
UIS Tankmodul TEE mit EKP	UIS tank module TEE with EKP
RSV und zulaufbetriebene SP	RSV and inlet-operated SP

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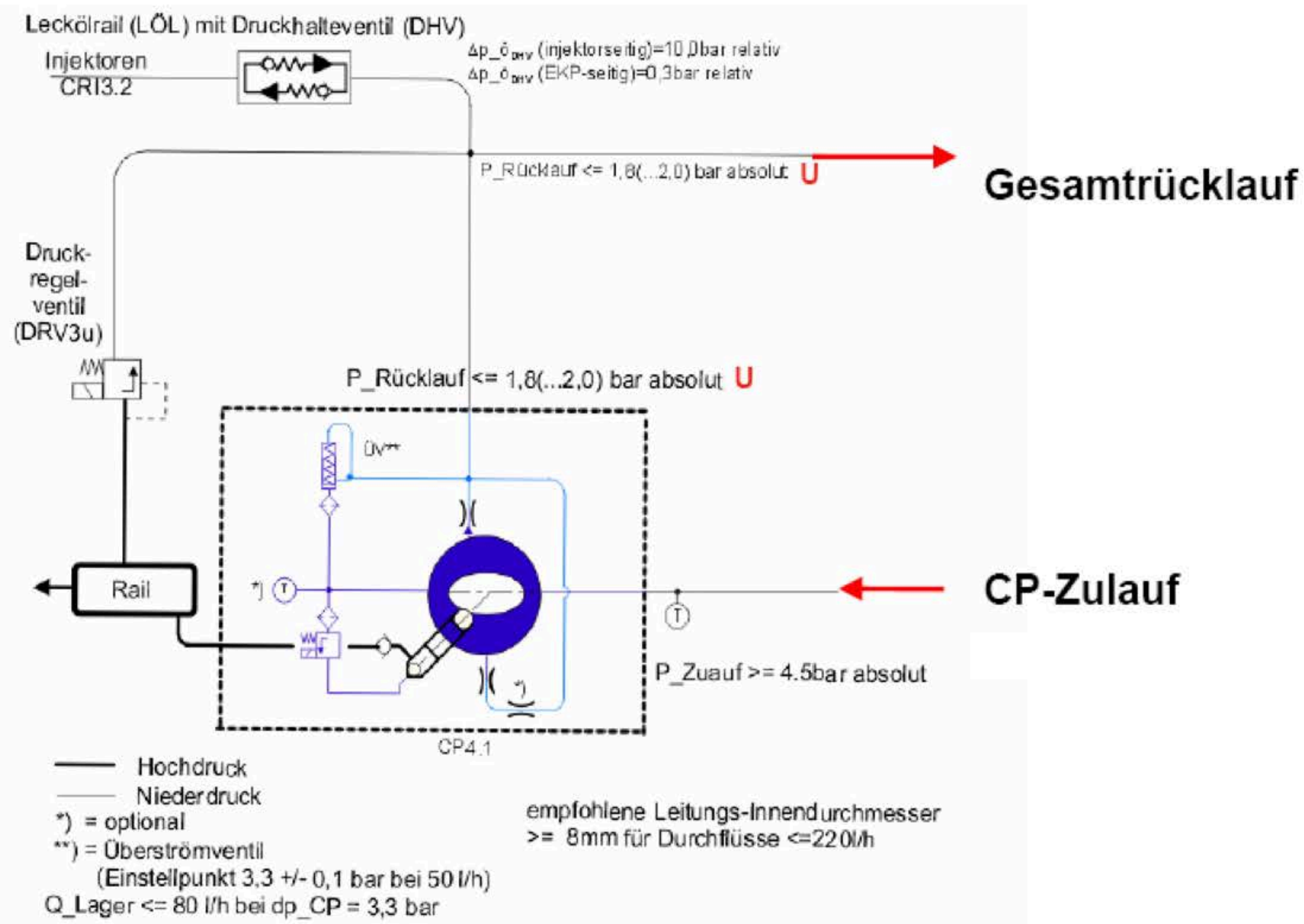
Niederdruckkreis VW-R4 2.0l nach Motorenfertigung



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BOSCH

German	English
Common Rail System (CRS3.2) 1800bar, (ND-Variante 3)	Common Rail System (CRS3.2) 1800 bar, (LP variant 3)
Niederdruckkreis VW 4Zyl. (2,0l) mit CRI3.2, CP4.1 mit Tank- u. Inline-EKP nach Filter	Low pressure circuit VW 4-cyl. (2.0 l) with CRI3.2, CP4.1 with tank and inline electric fuel pump after filter
-vorläufig-	-preliminary-
Leckölrail (LÖL) mit Druckhalteventil (DHV) (injektorseitig)=10,0bar relativ	Leakage oil rail (LÖL) with pressure retaining valve (DHV) (injector side)=10.0 bar relative
(EKP-seitig)=0,3bar relativ	(Electric fuel pump side)=0.3 bar relative
Injektoren	Injectors
P_Rücklauf <= 1,8 (...2,0) bar absolut	P_return <= 1.8 (...2.0) bar absolute
T-abhaengige Umschaltung (KF)	T-dependent changeover (KF)
Kraftstoffkühler (Luft)	Fuel cooler (air)
Druckregelventil	Pressure control valve
Druckregelventilöl	Pressure control valve oil
Rail	Rail
Inline-EKP (RB)	Inline electric fuel pump (RB)
P_Zulauf >= 4,5bar absolut	P_inlet >= 4.5 bar absolute
Kraftstofffilter (mit KF und Wasserabscheider)	Fuel filter (with KF and water separator)
Regler	Regulator
Hochdruck	High pressure
Niederdruck	Low pressure
= optional	= optional
= Überströmventil	= overflow valve
(Einstellpunkt 3,3 +/- 0,1 bar bei 50 l/h)	(setpoint 3.3 +/- 0.1 bar at 50 l/h)
Q-Lager <= 80 l/h bei dp_CP = 3,3 bar	Q-bearing <= 80 l/h at dp_CP = 3.3 bar
Empfohlene Leitungs-Innendurchmesser	Recommended inside line diameter
>= 8mm für Durchflüsse <=220l/h	>= 8 mm for flow rates <=220 l/h
UIS Tankmodul TEE mit EKP	UIS tank module TEE with EKP
RSV und zulaufbetriebene SP	RSV and inlet-operated SP

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CP4 drivetrain damage

2 x CP4.2 drivetrain damage cases in US vehicle endurance runs

1 x 45,700 mls in GQ VW endurance run (7L69D025); details p. 2, 3
Pump data: Series pump 0445 010 613; date of manufacture 22/01/2008; copy number 898
Analysis result: Drivetrain damage (cat. 2)

1 x 162,000 km in Audi endurance run (AU716E218); details p. 4, 5, 6
Data: Sample pump 0445B20169_07, date of manufacture 782 (= February 2007);
copy no. 4254
Analysis result: Drivetrain damage (category 2) with red deposits

Notes:
Pumps corresponds to **old** production status -> without straightedge testing & without improved roller support visual inspection catalog for detection of irregularities -> thus, higher potential for failure with regard to fuels with a low viscosity

Pumps have a roller with supplier 1 -> since WK 20 2008, only supplier 2

Precautionary exchange action on US vehicles done by mid-2008

Overview of all implemented / planned production measures on page 7/8

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CP4 drivetrain damage

1) Damage hypothesis for VW GQ failure (7L69D025, 45 700 mls)

Stiff right roller due to manufacturing abnormalities in combination fuel with low viscosity (lubricant film thickness is not sufficient).
Stiffness of the right roller leads to slip between the roller and cam (braking flats) and overload of C coating (main loading zone) with final turned tappet.
The right tappet damages the camshaft bearing surface and thus, the left tappet assembly.

Further analysis steps @ R.B.

Survey of undamaged areas (right roller support, roller)	01.20.2009
Detailed microscopic analysis (adhesion of coating on right roller support)	01.23.2009

Inquiries @ Audi

Data on fuel quality (HFRR, kinematic viscosity, water) available?
Refueling data of the last locations known?
Was water found in the water separator?

CP4 drivetrain damage

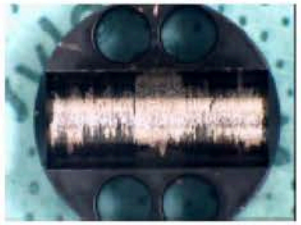
Pictures of VW GQ failure (7L69D025, 45. 700 mls)

Roller to the left

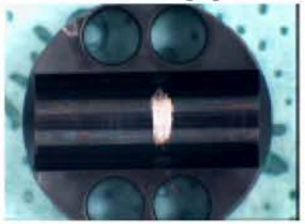
Roller to the right

Type plate

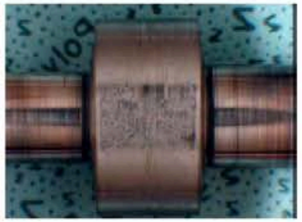
Roller support to the left



Roller support to the right



Camshaft



CP4 drivetrain damage

2) Damage hypothesis for Audi failure (AU716E218, 162,000 km)

Stiff rollers due to fuel with low kinematic viscosity (lubricant film thickness is not sufficient).
Stiffness of the rollers leads to slip between the rollers and cams (braking flats) and overload of C coating (main loading zone) with final turned tappets.

Further analysis steps

Analysis of the brownish deposits 01.15.09; finished
Result: Corrosion detected -> presence of free water suspected
Survey of undamaged areas (right roller support, roller) 01.20.2009
Detailed microscopic analysis (adhesion of coating on roller support) 01.23.2009

Inquiries @ Audi

Data on fuel quality (HFRR, kinematic viscosity, water) available?
Refueling data of the last locations known?
Was water found in the water separator?

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CP4 drivetrain damage

Pictures of Audi failure (AU716E218, 162,000 km, date of manufacture: February 2007)

Brownish deposits (corrosion?)

Intake valve

Intake valve disk

Metering unit

Cylinder head

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CP4 drivetrain damage

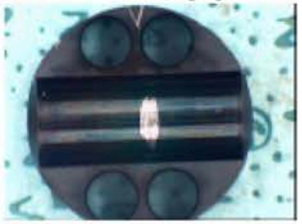
Pictures of Audi failure (AU716E218, 162,000 km, date of manufacture: February 2007)

Roller to the left

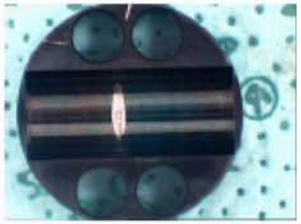
Roller to the right

Type plate

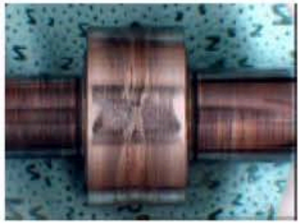
Roller support to the left



Roller support to the right



Camshaft



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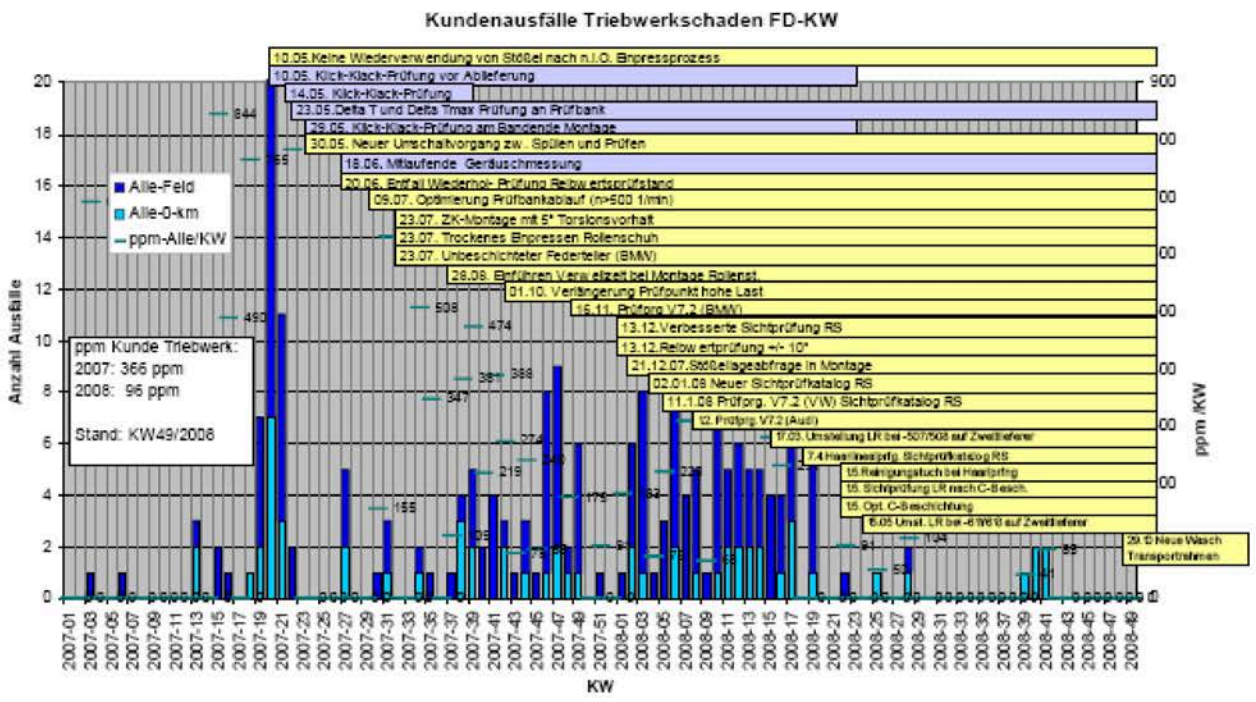
CP4 drivetrain damage

Implemented production measures



ppm customer drivetrain:
Number of failures
Status:

Customer failures - drivetrain damage - date of manufacture WK

05.10. No reuse of tappet after not OK Press-in process
10.05. Click-clack test prior to delivery
14.05. Click-clack test
05.23. Delta T and Delta Tmax test on test bench
29.05. Click-clack test at the end of line of installation
30.05. New switching step between flushing and testing
18.06. Simultaneous noise measurement
20.06. Omission of retest on friction coefficient test bench
09.07. Optimization of test bench sequence (n > 500 rpm)
23.07. Cylinder head assembly with 5° torsion suspension
23.07. Dry pressing in of roller support
23.07. Uncoated spring plate (BMW)
28.08. Introduction of delay time during assembly of roller tappet.
01.10. Extension of high-load inspection point
16.11. Test program V7.2 (BMW)
12.13. Friction coefficient test + / - 10°
12.13. Improved visual inspection rail system
12.21.07. Tappet position query during assembly
01.02.08 New visual inspection catalog rail system
11.1.08 Test program V7.2 (VW) visual check catalog of rail system
1.2. Test program V7.2 (Audi)
17.03. Switching of roller at -507 / 508 to second source supplier
1.5. Cleaning cloth for straightedge testing
1.5. Visual inspection of roller after C coating.
1.5. Optimized C coating
05.15. Switching of roller at -611 / 613 to second source supplier
10.29 New washing transport frame
All on-field
All 0-km
ppm all / WK

CP4 drivetrain damage

Planned production measures

A) Avoidance of C coating entrainment (pressing in of roller support)

- Crash trials with roller tappets contaminated with C coating particles D. 09.01

B) Large-scale functional testing with increased load (high rail pressure, low engine speed to increase "detection" in coordination with Audi T.09.01

D) Detection of metal chips with objective system D. 09.04

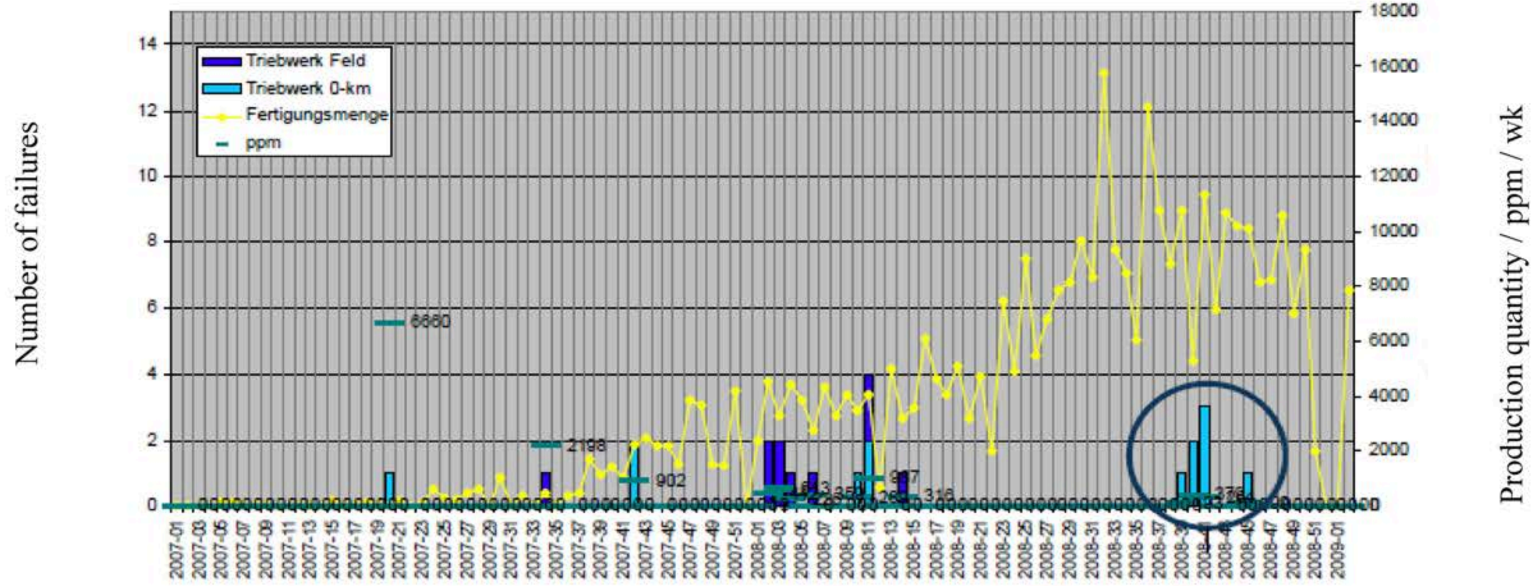
C) Process to avoid melting-induced surface defects on the roller

New substrate holder of roller; trials have started, **long-term measure**

Status CP4 drivetrain damage @ VW & Audi

Quality situation CP4.1 @ VW & Audi

Drivetrain damage to VW / Audi CP4.1 (-507/-508 or 03L 130 755 / 03L 130 755 A)
0- km and on-field / date of manufacture WK



Drivetrain on-field
Drivetrain 0-4 km
Production quantity
ppm

Failures CP4.1@R4 in IN: Cause is under review

Significant decline since CW 20

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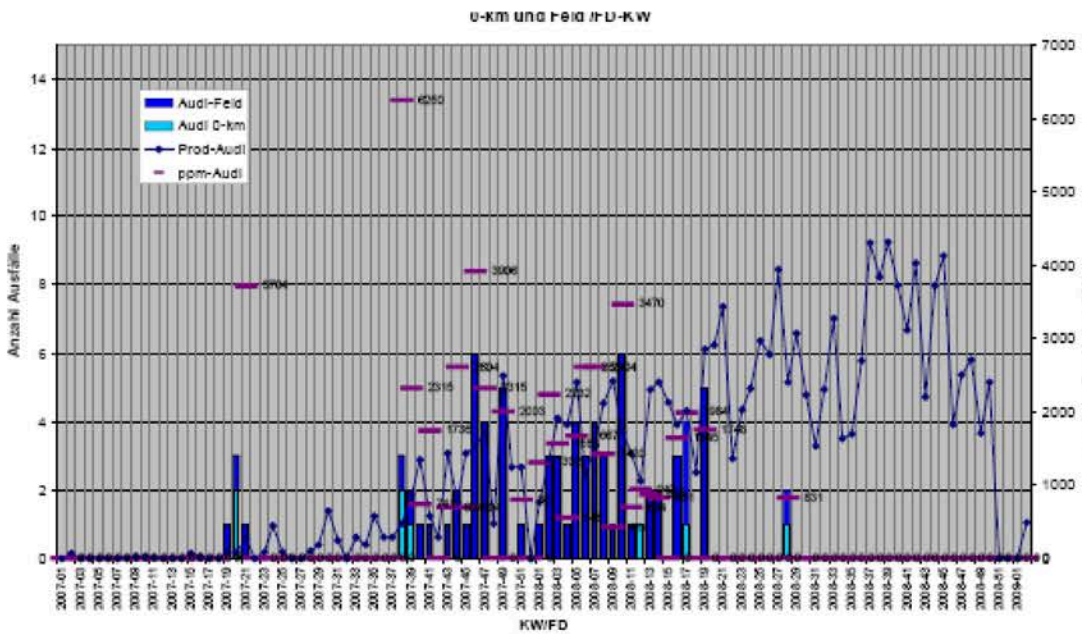
Status CP4 drivetrain damage @ VW & Audi

Quality situation CP4.2 @ VW & Audi

Drivetrain damage VW/Audi CP4.2 (-611/613 and/or 059 130 755 AB / AG)
0 km and on-field / date of manufacture WK

Number of failures



ppm or produced / WK

Significant decline since WK 20

Audi Field
Audi 0-km
Prod-Audi
Ppm-Audi

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Status CP4 drivetrain damage @ VW & Audi

Summary

Significant decline in CP4 drivetrain damage - especially on-field since WK 20 2008

Adopt measures to prevent or detect faults in the plant. Other measures are being implemented.

Transition to roller from secondary source supplier shows significant improvement

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<u>New finding:</u>

Influence on coefficient of friction in conjunction with fuels with a low viscosity.

Further optimization of robustness increase planned, especially for first source supplier by switching to Güntert manufacturing process.

This explains the difference in failure rate between CP4.1 and CP4.2, as CP4.1 are equipped exclusively with Güntert rollers.

Since WK 20 2008 primarily RB internal failures and ZP7 failures (0-km). Causes of these failures are being analyzed.

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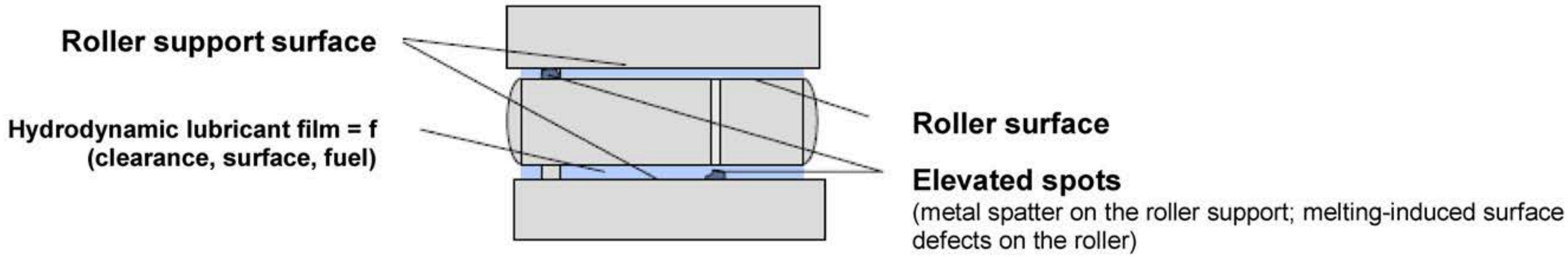
Status CP4 drivetrain damage @ VW & Audi

CP4 drivetrain damage: Damage mechanism:

- unacceptably high mixed friction between roller and roller support cause "local" contacts during operation
- the C coating is disrupted (wear and erosion of the C coating), the coefficient of friction between the roller and roller support increases
- when coefficient of friction between roller and roller support > coefficient of friction between roller and cam -> braking flats
- Abrasive wear, particle formation -> drivetrain damage

Intensification factors: Fuel with a low viscosity, elevated spots on the roller (e..g melting-induced surface defects) and in the roller support (e.g. metal spatter) surface of roller / roller support



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Status CP4 drivetrain damage @ VW & Audi

Measures to detect and prevent elevations

Detection of melting-induced surface defects on the roller

➔ Straightedge testing for detection of minute raised portions on the rollers (WK15/2008)

➔ (Cleaning cloth with straightedge testing (WK 18 / 2008)

➔ Visual inspection for roller after C coating (WK 18 / 2008)

Detection of metal spatter in roller support

➔ Optimized roller support visual inspection catalog (WK 18 / 2008)

Avoiding melting-induced surface defects on the roller and metal spatter in roller support

➔ Optimierung der Abdeckungen in der C-Beschichtungsanlage zur Vermeidung von Aufwürfen an Rollenschuhen (WK 50/2008)

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Status CP4 drivetrain damage @ VW & Audi

Friction coefficient examinations

Task

→ Determination of coefficient of friction with different roller suppliers & fuels

Results

→ **Supplier 1** @ EN590 is comparable with supplier 2, **significantly worse** with low-viscosity fuels (Sweden diesel, Arctic diesel)

→ **Supplier 2** shows **little** effect on the fuel viscosity

→ Influence of different surface coefficients of the rollers explainable

Note: Switching from supplier 1 to supplier 2

@ CP4.1 WK 12/08(Fe); WK 04/08(Jihlava plant)
@ CP4.2 WK 20/08(Fe); WK 44/08(Jihlava plant)

Further work

→ Detailed geometric analysis and repetition of friction coefficient tests with "marginal" rollers 1 & 2

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Status CP4 drivetrain damage @ VW & Audi

Results from friction coefficient tests

		Roughness - nominal value	Roughness - tolerance patterns
Fuel designation:	**Viscosity** at 40 °C [mm²/s]	**Friction coefficient** at 300 rpm (600 N)	**Friction coefficient** at 300 rpm (600 N)
EN590	2.88	0.01	0.01
GDK570	1.92	0.01	0.04
Sweden diesel	1.94 to 2.07	0.01	0.04
Arctic diesel	1.44	0.02	0.06
Limit:	/	*0.035*	*0.035*

Finding: Marginal rollers (roughness) in combination with fuels with low kinematic viscosity show abnormal friction.

Status CP4 drivetrain damage @ VW & Audi

Measures package for reduction of drivetrain damage

No.	Measures to reduce drivetrain damage	Feuerbach plant launch		Einführung JhP	
		Today's date	WK	Today's date	WK
1	No reuse of tappet after OK press-in process	5/10/2007	WK19/07	1/31/2008	WK04/08
2	Click-clack test prior to delivery	5/10/2007	WK19/07	1/31/2008	WK04/08
3	Click-clack test	5/14/2007	WK0/07	1/31/2008	WK04/08
4	Delta T and Delta Tmax test on test bench	5/23/2007	WK21/07	1/31/2008	WK04/08
5	Click-clack test at the end of line of installation	5/29/2007	WK22/07	1/31/2008	WK04/08
6	Review new switching process between flushing and inspection	5/30/2007	WK22/07	1/31/2008	WK04/08
7	Simultaneous noise measurement	6/18/2007	WK25/07	1/31/2008	WK04/08
8	Omission of retest coefficient of friction test rig	6/20/2007	WK25/07	12/1/2007	WK48/07
9	Optimization of test rig sequence (n > 500 rpm)	7/9/2007	WK28/07	1/31/2008	WK04/08
10	Cylinder head assembly with 5° torsion suspension	7/23/2007	WK30/07	12/1/2007	WK48/07
11	Dry pressing in of roller support	7/23/2007	WK30/07	2/6/2008	Wk05/08
12	Uncoated spring plate (Customer C)	7/23/2007	WK30/07	1/31/2008	WK04/08
13	Introducing delay time during roller tappet assembly	8/28/2007	WK35/07	2/6/2008	Wk05/08
14	Extension of high-load inspection point	10/1/2007	WK40/07	1/31/2008	WK04/08
15	Testing point V7.2 (Customer C)	11/16/2007	WK46/07	1/31/2008	WK04/08
16	Improved visual inspection of roller support	12/13/2007	WK50/07	1/31/2008	WK04/08
17	Friction coefficient test + / -10°	12/13/2007	WK50/07	2/7/2008	Wk05/08
18	Tappet position query during assembly	12/21/2007	Wk51/07	2/7/2008	Wk05/08
19	New visual inspection catalog for roller support	1/2/2008	WK01/08	1/20/2008	WK02/08
20	Test program V7.2 (VW), visual inspection catalog for roller support	11.01.2008	WK02/08	1/31/2008	WK04/08
21	Test program V7.2 (Audi)	2/1/2008	Wk05/08	1/31/2008	WK04/08
22	Switching of roller for models ... 507/...508	3/17/2008	WK12/08	1/31/2008	WK04/08
23	Straightedge testing, visual inspection catalog for roller support	07.04.2008	(WK5/08)	07.04.2008	WK14/08
24	Cleaning cloth with straightedge testing	5/1/2008	WK8/08	5/1/2008	WK7/08
25	Visual inspection of the roller after C-coating	5/1/2008	WK8/08	5/1/2008	WK7/08
26	Optimization of the C-coating	5/1/2008	WK8/08	5/1/2008	WK7/08
27	Switching of roller for models ... 611/...613 to second source supplier	5/15/2008	WK0/08	03.11.2008	WK4/08
28	New washing and transport frame for the roller	10/29/2008	WK4/08	10/29/2008	WK4/08
29	Graphite / boron nitride deposits, holder in C-coating system	12.12.2008	WK50/08	12.12.2008	WK50/08
30	Camera system for detecting metal spatter on roller support		WK19/09		WK19/09
31	Modified rail system holding tool when pressing in the tappet body	24.11.2008	WK48/08		WK6/09
32	Optimized substrate holder to prevent melting-induced surface defects on roller, at the earliest		from WK 32/09		from WK 32/09

Legend
- Measure implemented
- Implementation overshot the schedule
- launch date
- Implementation is not target-oriented and/or effectiveness is reviewed

→ ~ WK20

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Cleanliness status FeP/JhP CP4, Status WK11/2009

Cleanliness status CP4 FeP/JhP

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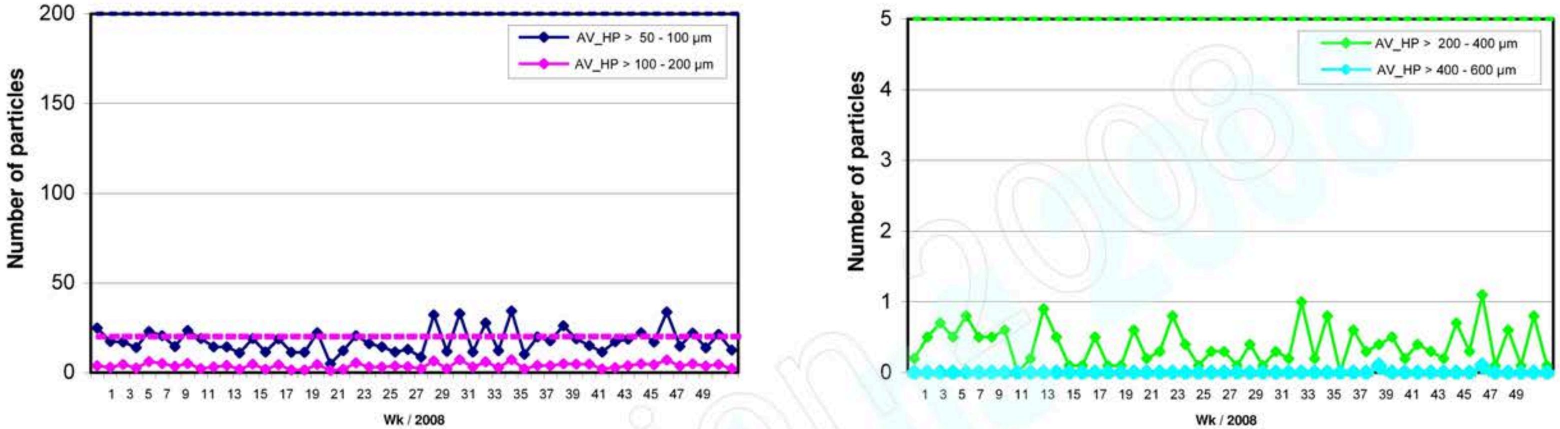
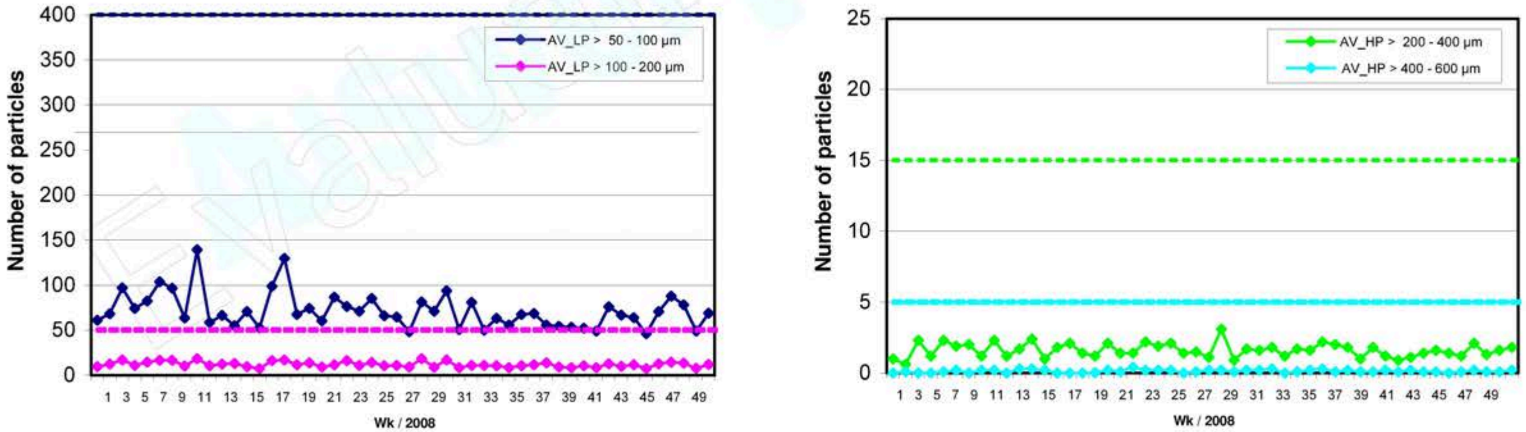
Cleanliness status FeP/JhP CP4, Status WK11/2009

FeP: Residual contamination CP4 in the high-pressure range according to particle classes



FeP: Residual contamination CP4 in the low-pressure range according to particle classes



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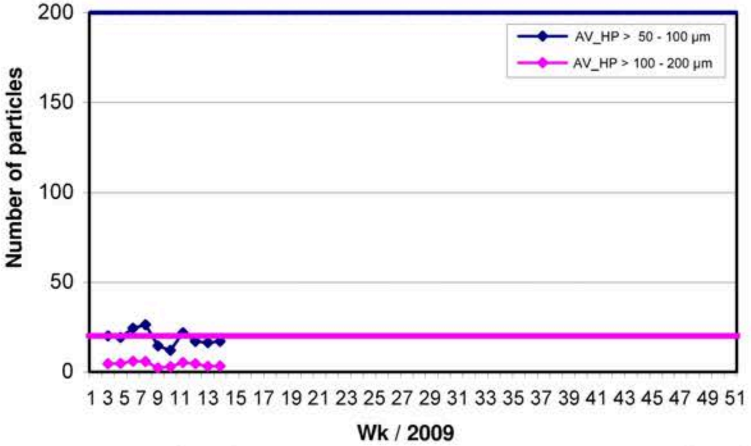
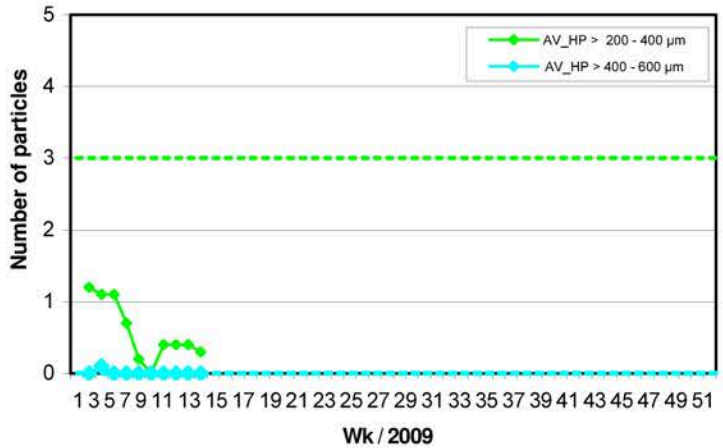
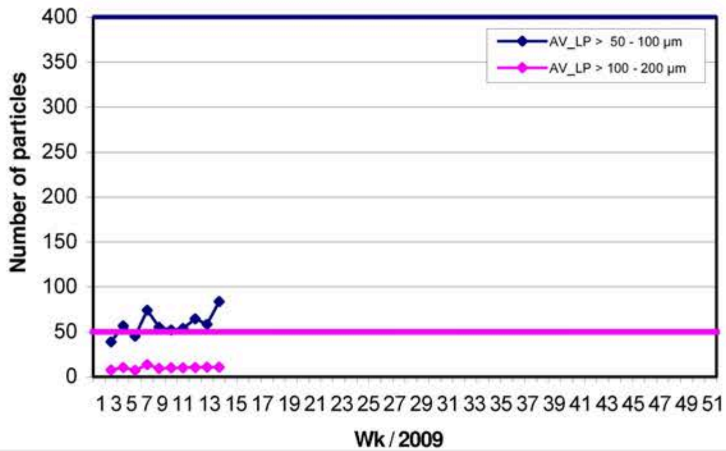
Cleanliness status FeP/JhP CP4, Status WK11/2009

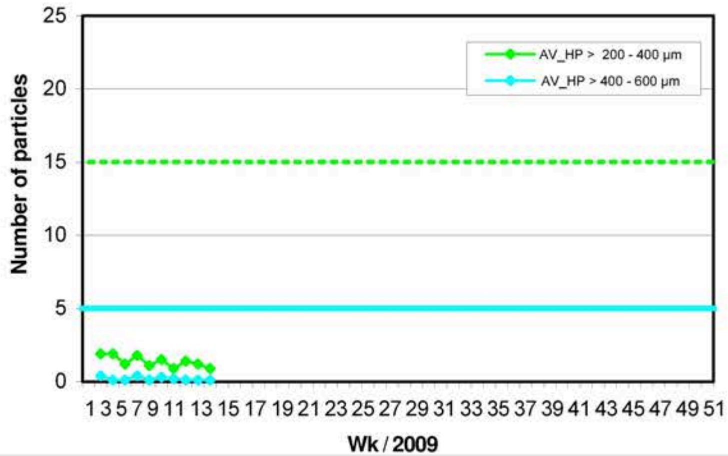
FeP: Residual contamination CP4 in the high-pressure range according to particle classes





FeP: Residual contamination CP4 in the low-pressure range according to particle classes





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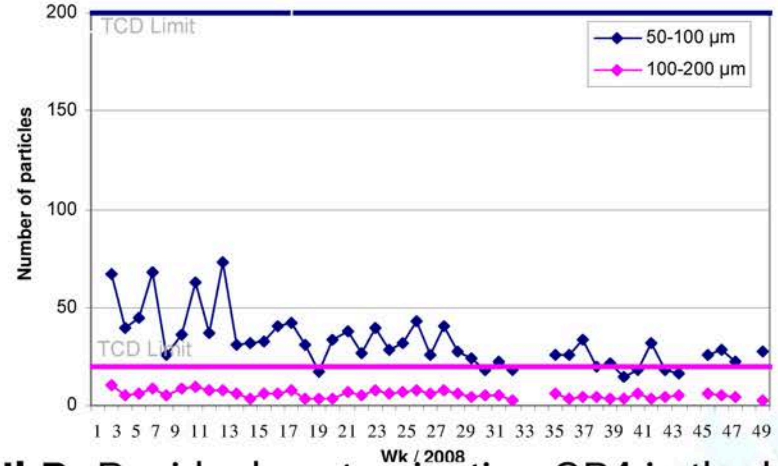
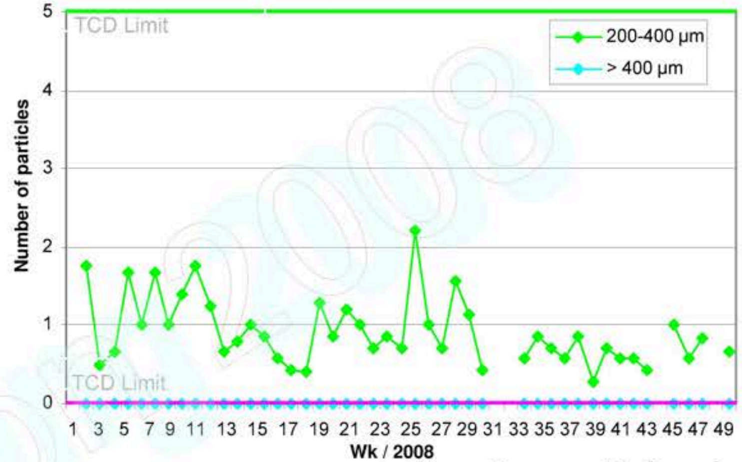
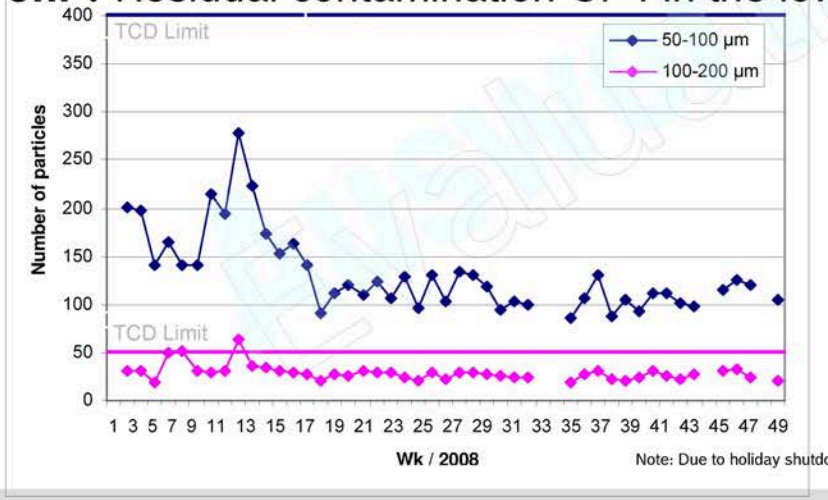
Cleanliness status FeP/JhP CP4, Status WK11/2009

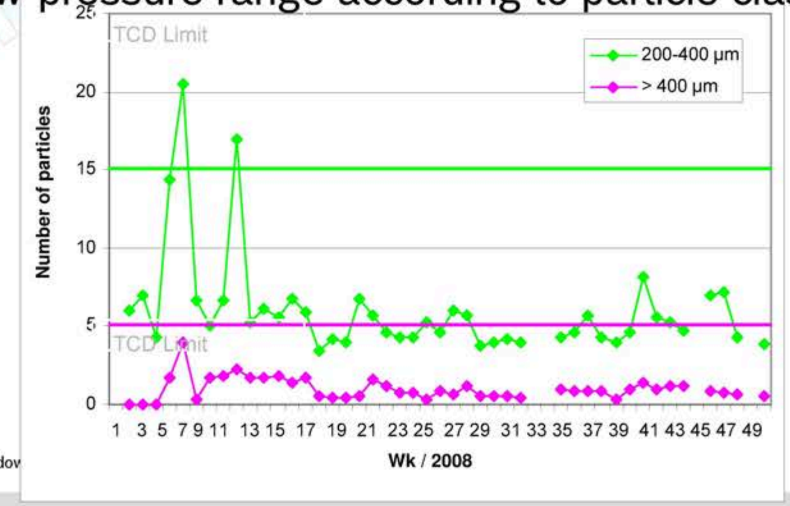
JhP: Residual contamination CP4 in the high-pressure range according to particle classes





JhP: Residual contamination CP4 in the low-pressure range according to particle classes





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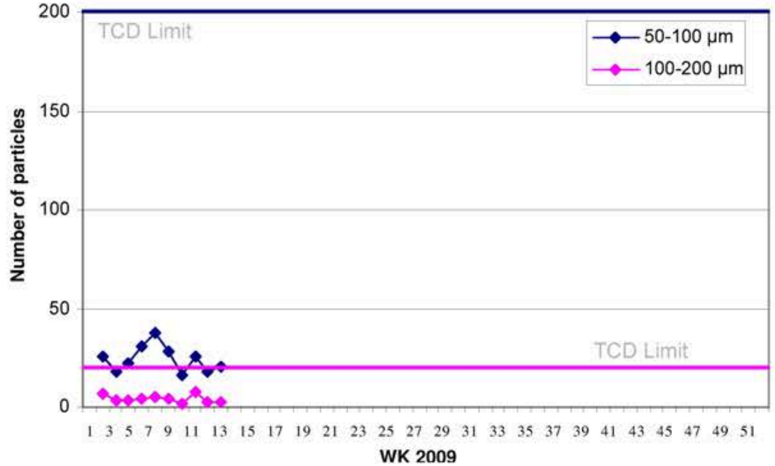
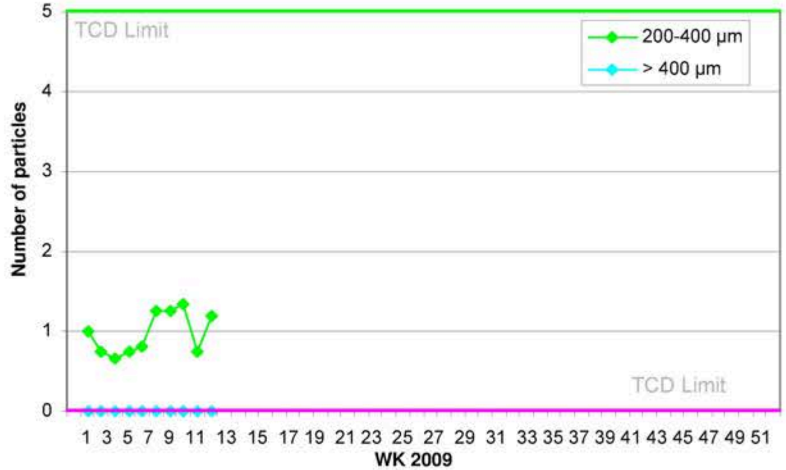
EA11003EN-00473[4]

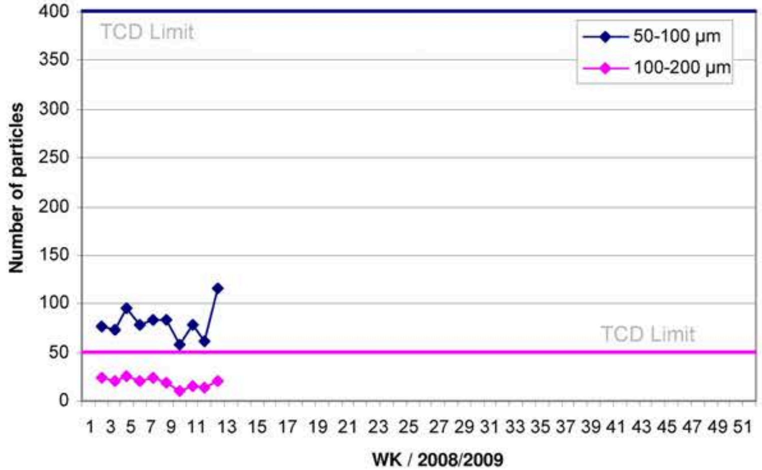
Cleanliness status Bosch FeP/JhP CP4, Status WK11

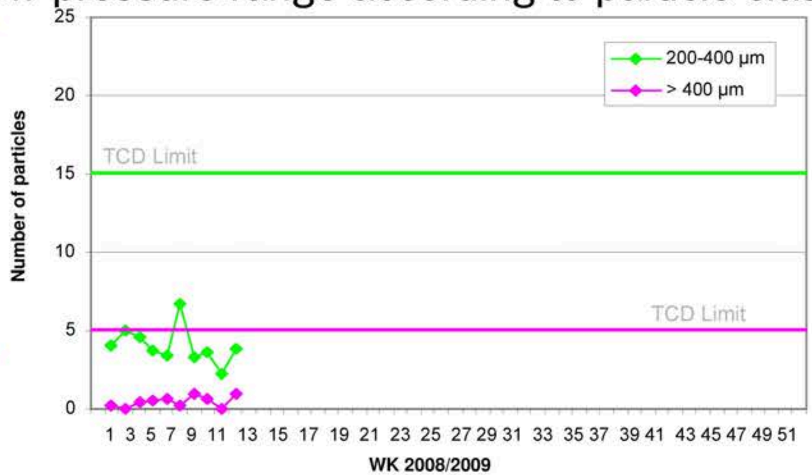
JhP: Residual contamination CP4 in the high-pressure range according to particle classes





JhP: Residual contamination CP4 in the low-pressure range according to particle classes

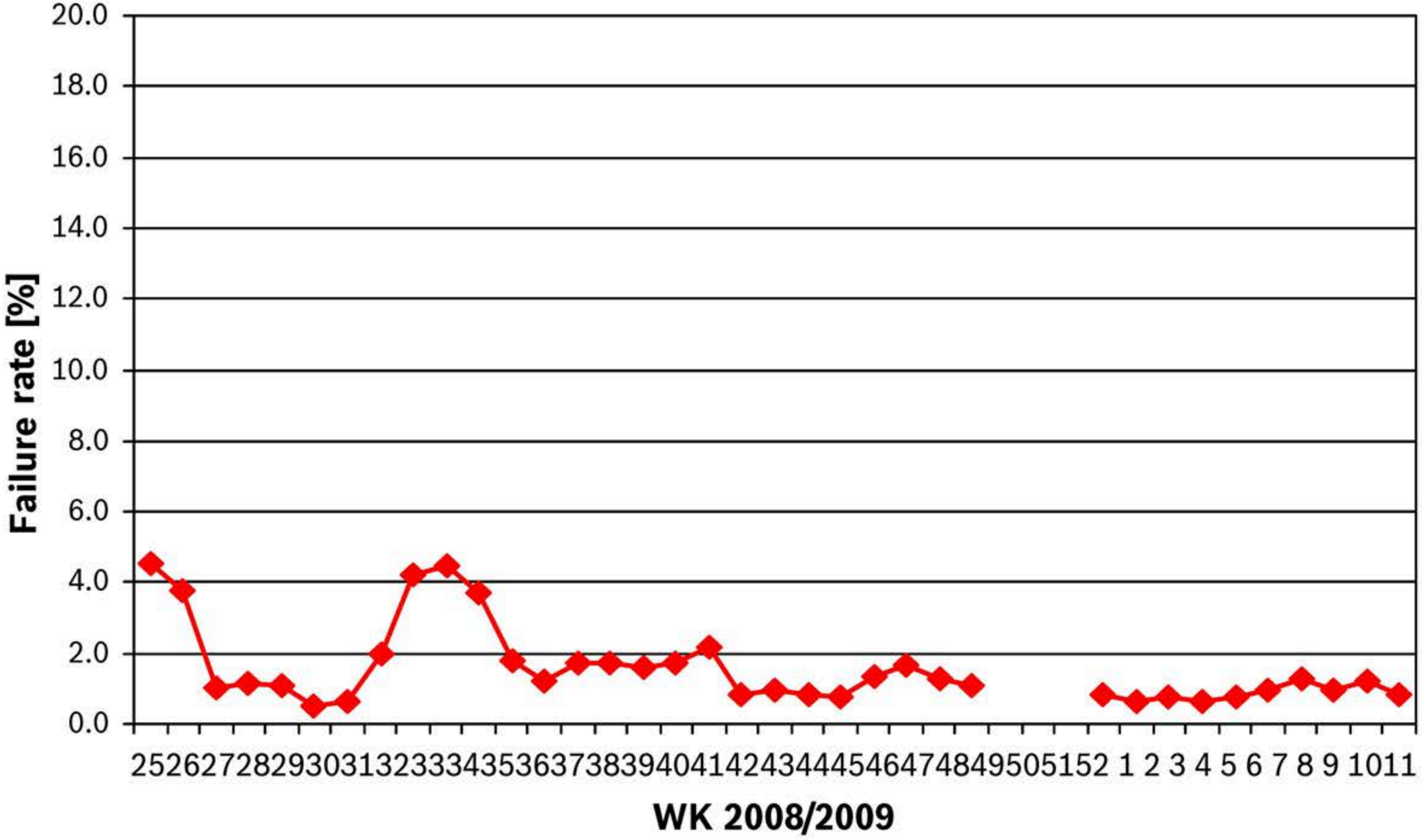




BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

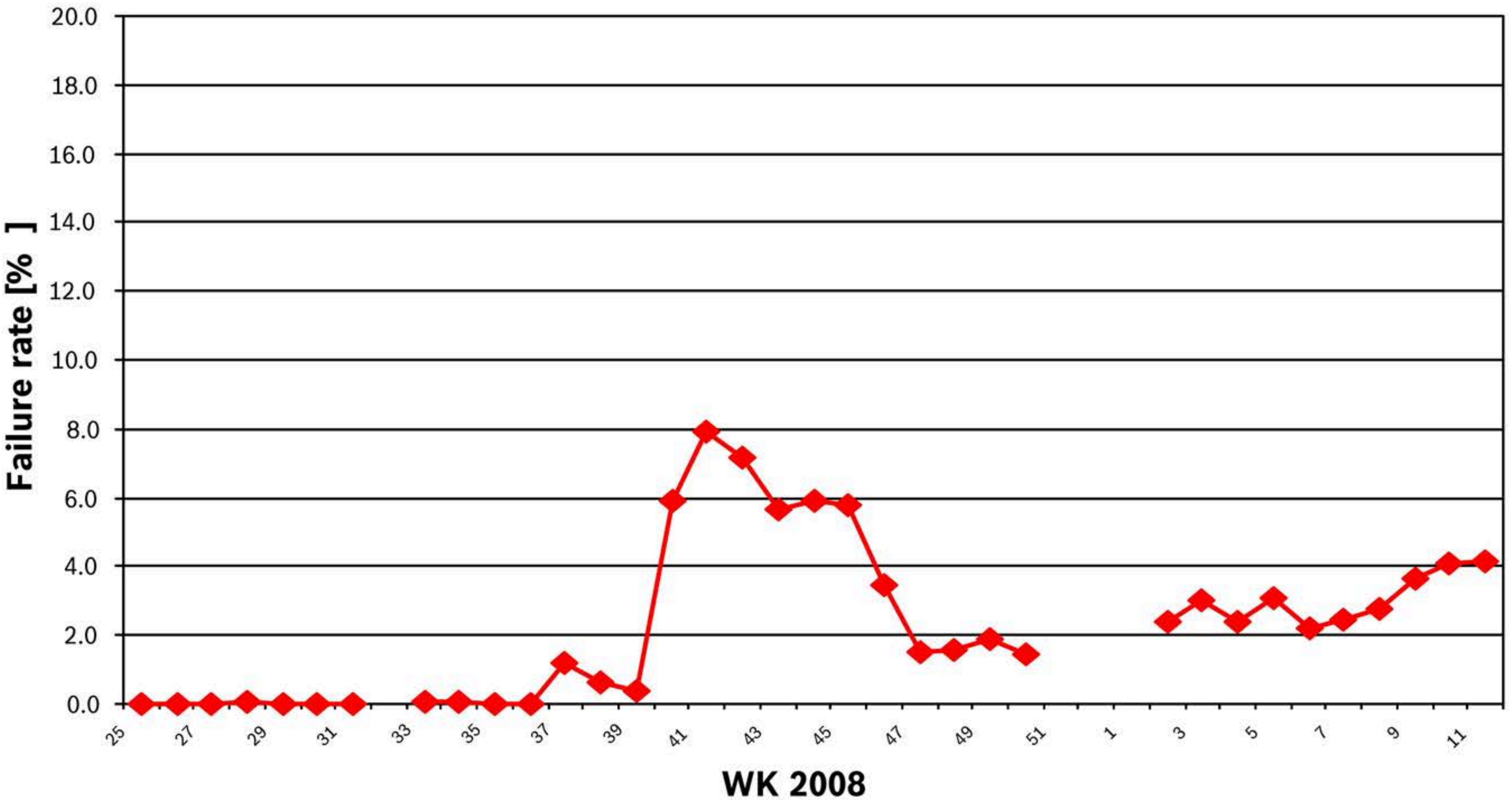
FeP: Visual check of MU4 (Failure rate due to particles in %)



BOSCH

Cleanliness status Bosch FeP/JhP CP4, Status WK11

JhP: Visual check of MU4 (Failure rate due to particles in %)

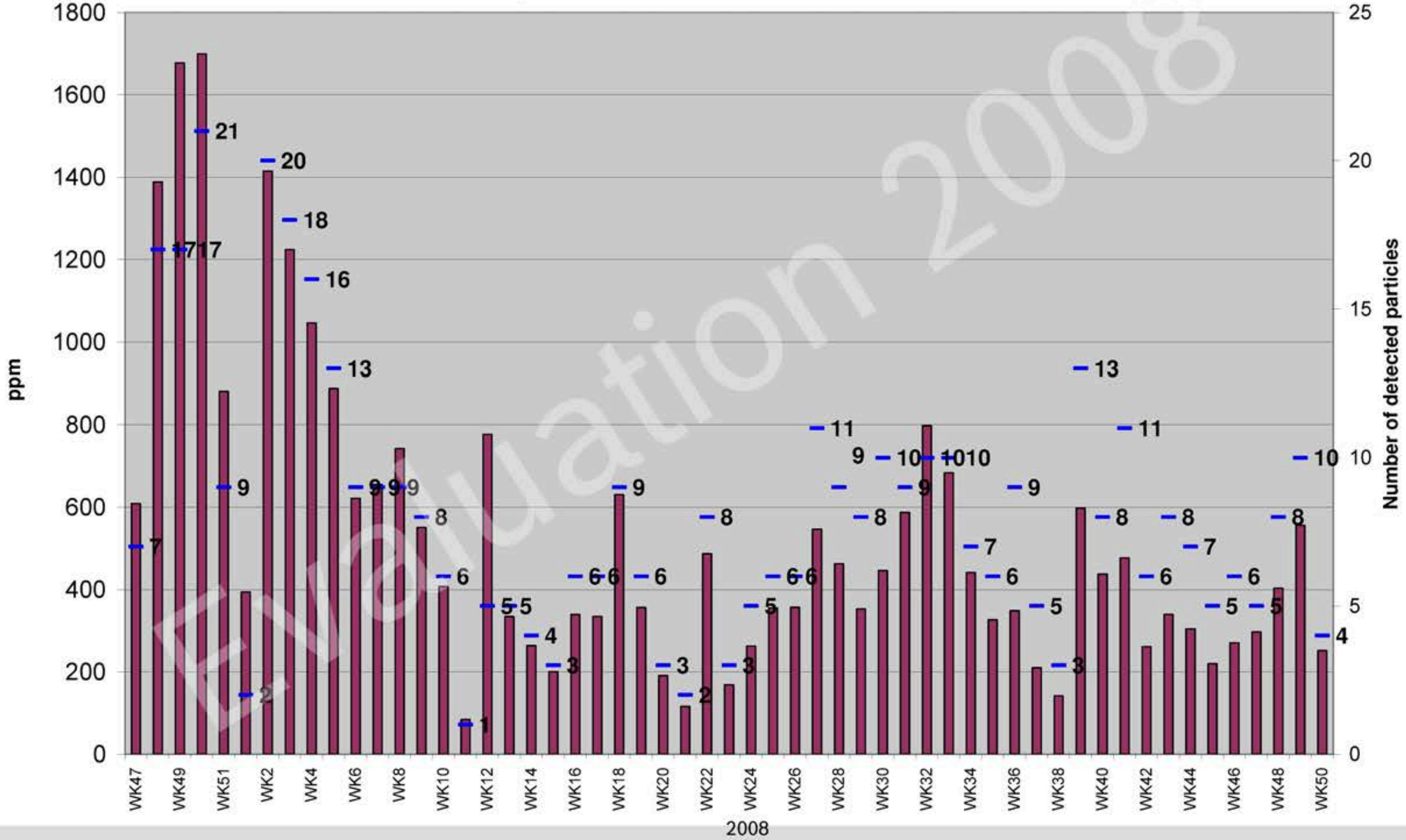


Note: Due to holiday shutdown, there is no data available for WK 32-33.

BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

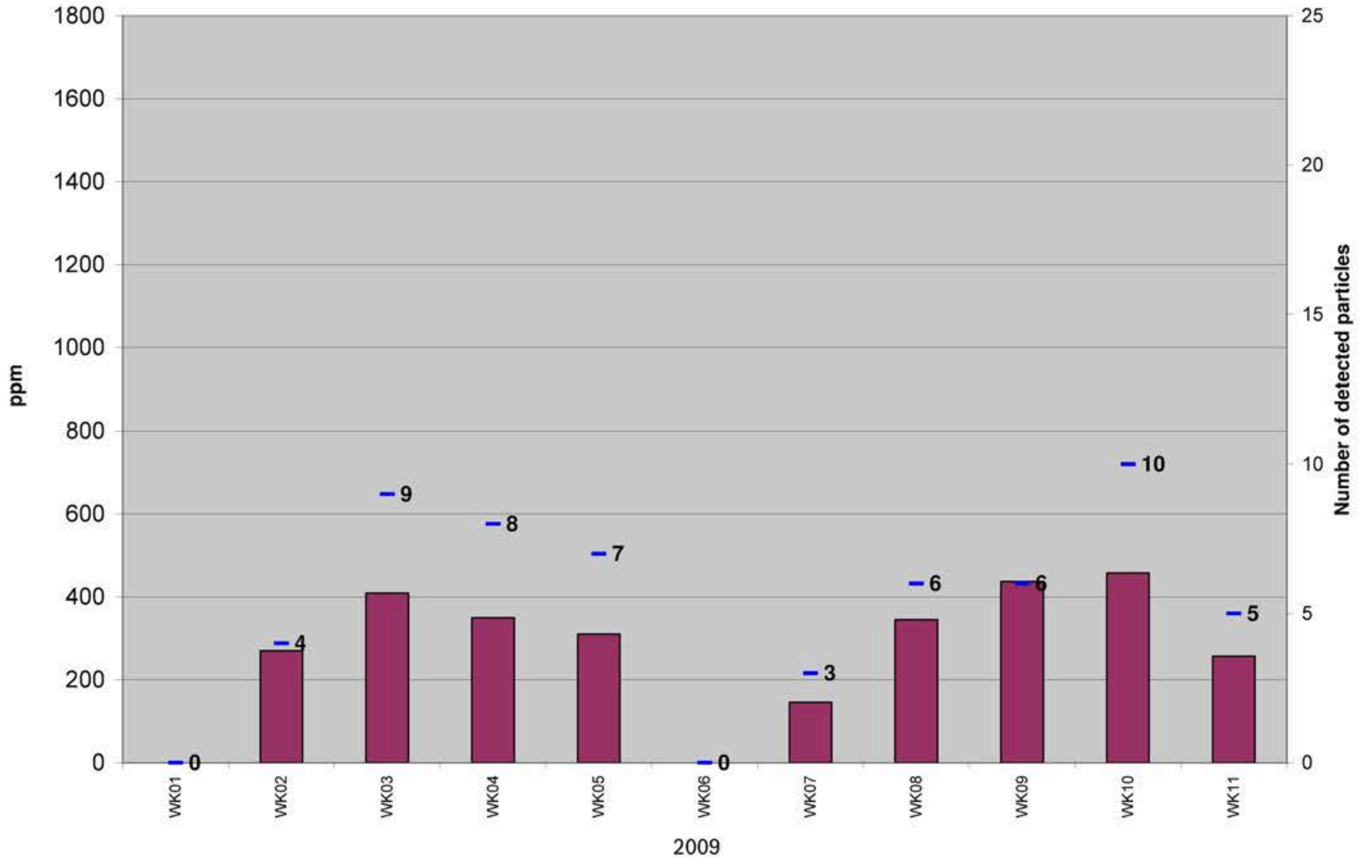
FeP: CP4 product, internal rail pressure failures with particles detected in the intake valve / non-return valve



BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

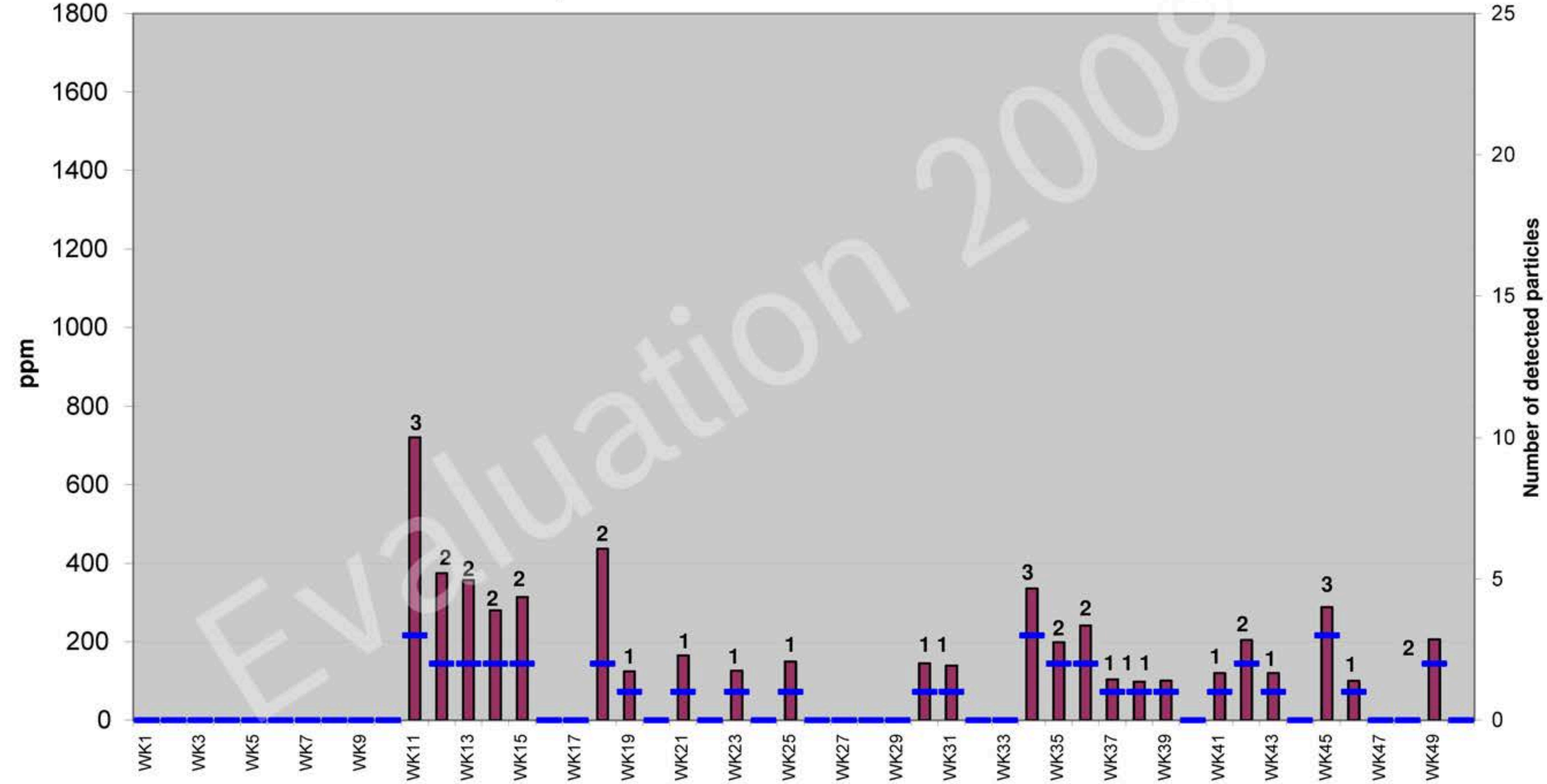
FeP: CP4 product, internal rail pressure failures with particles detected in the intake valve / non-return valve



BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

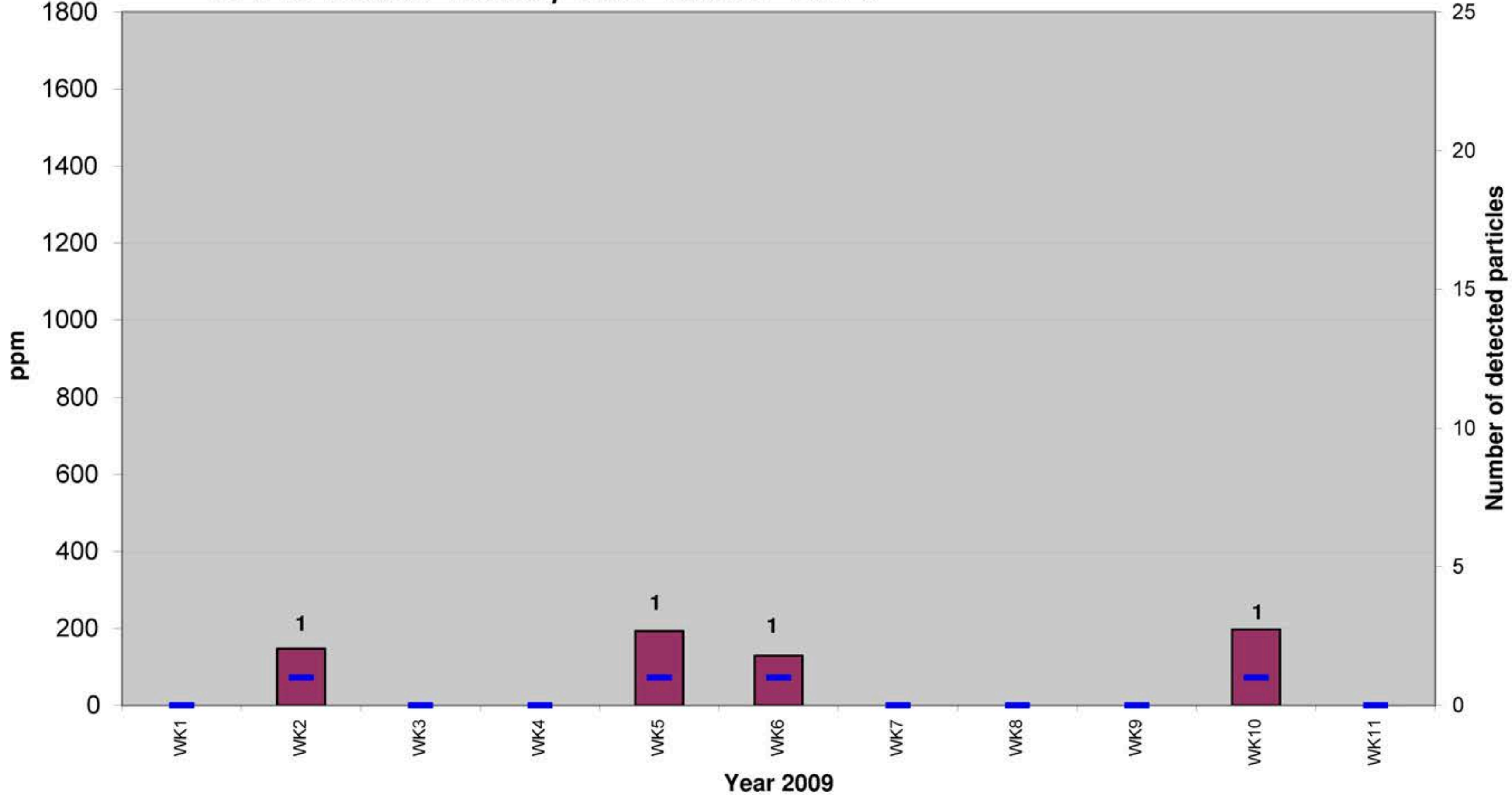
JhP: CP4 product, internal rail pressure failures with particles detected in the intake valve / non-return valve



Note: Due to holiday shutdown, there is no data available for WK 32-33.

Cleanliness status Bosch FeP/JhP CP4, Status WK11

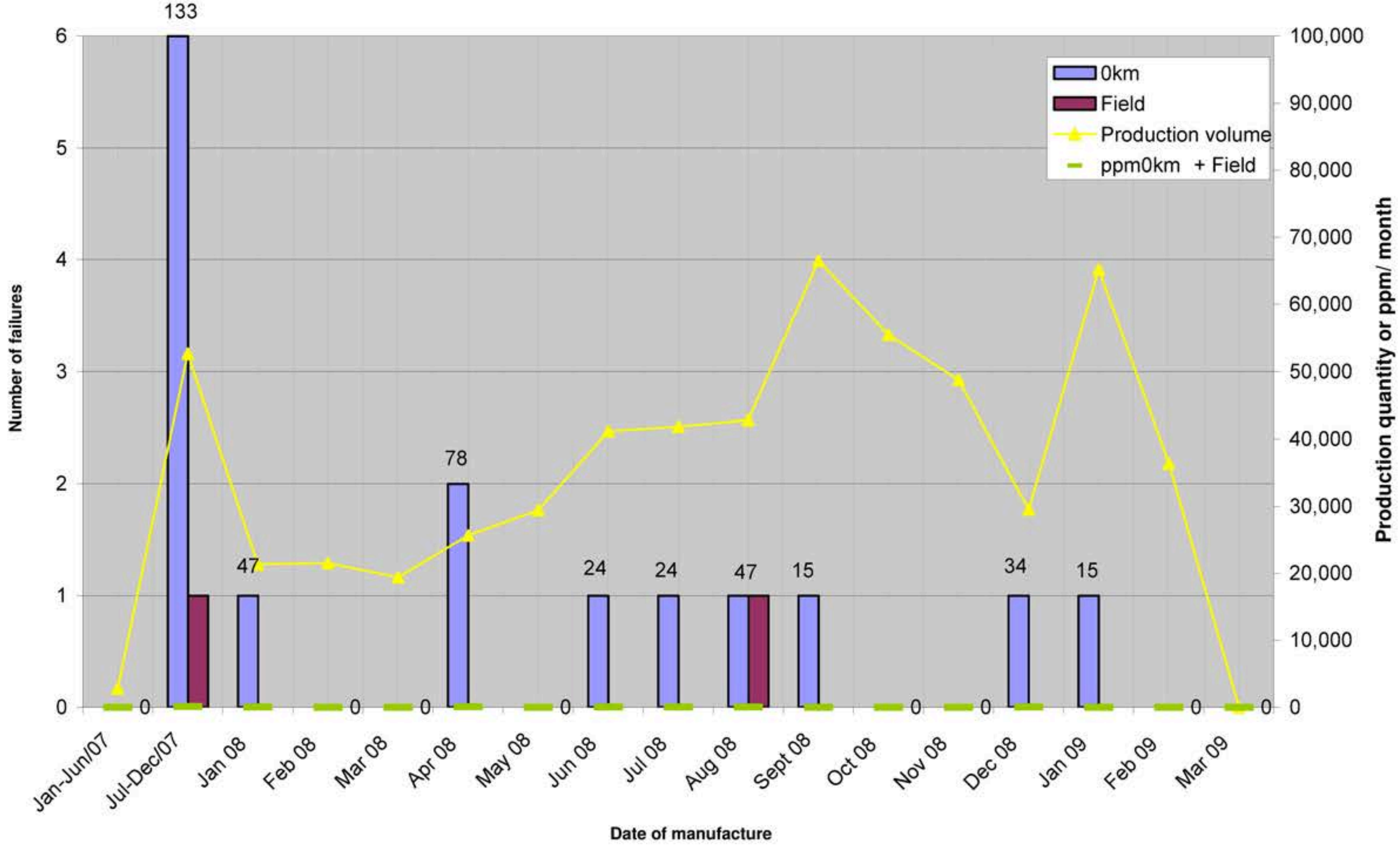
JhP: CP4 product, internal rail pressure failures with particles detected in the intake valve / non-return valve



BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

FeP: Particle complaints confirmed in CP4 at VW/Audi

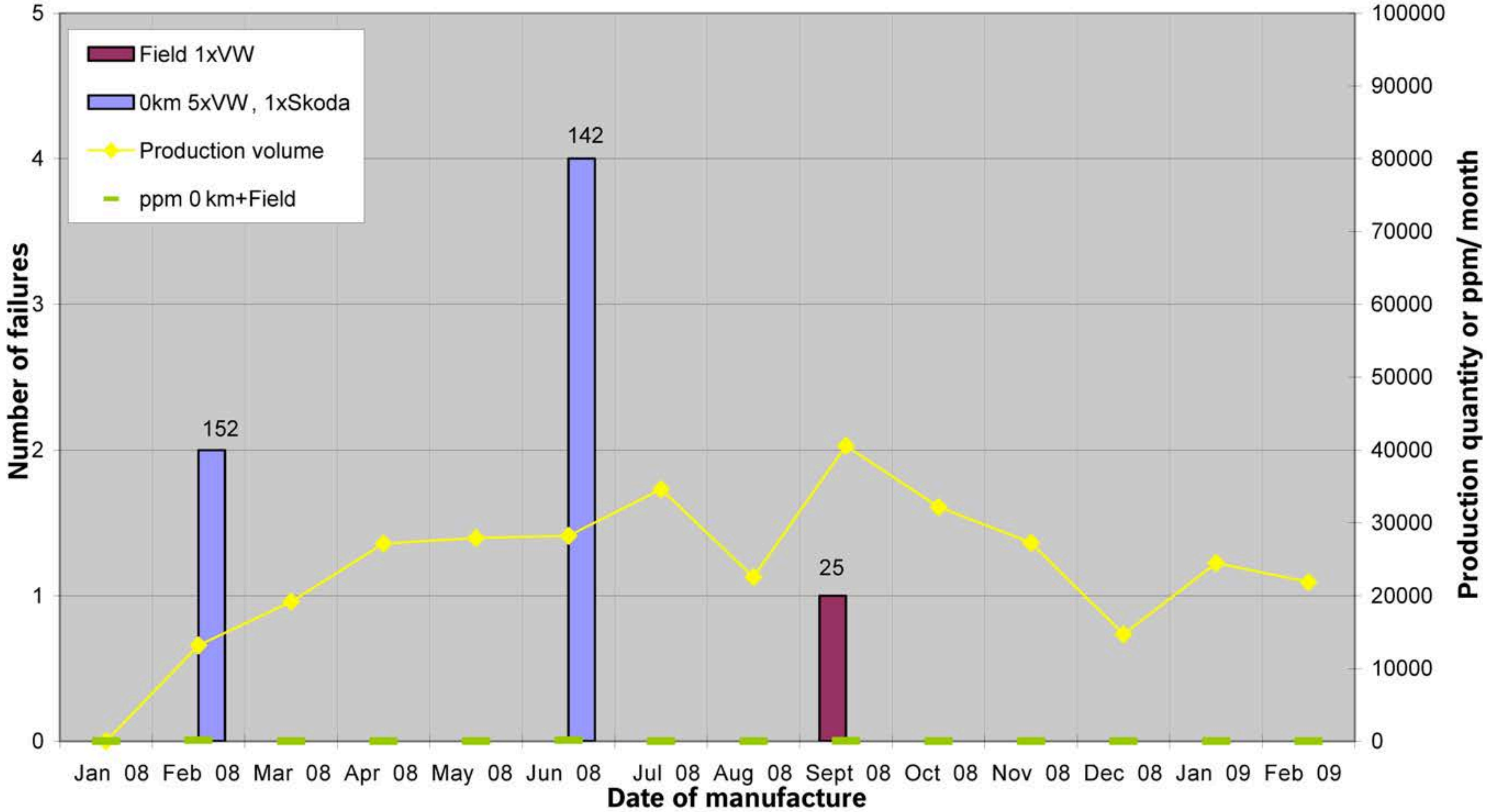


 [redacted]

BOSCH

Cleanliness status Bosch FeP/JhP CP4, Status WK11

JhP: Particle complaints confirmed in CP4 at VW/Audi



BOSCH

Cleanliness status FeP/JhP CP4, Status WK11/2009

FeP/JhP: Measures for reducing residual contamination: Housing and flange manufacturing for CP4

No.	Measure to reduce residual dirt	Housing	Flange	Introduction FeP		Introduction JhP	
				Date	WK	Date	WK
1	Detachment of joint bore Metering unit CH	x		2/7/2008	6	2/18/2008	8
2	Housing holder on robot gripper	x		2/15/2008	7	2/20/2008	8
3	Ventilation of vacuum chamber, dry cleaning system	x		2/14/2008	7	3/3/2008	10
4	Housing holder on onward transport	x		2/15/2008	7	2/22/2008	8
5	Processing, clamping concept	x		02/8/2008	10	2/20/2008	8
6	Chamfer on 90 degree cutting (external contour)	x		02/8/2008	10	2/20/2008	8
7	Outlet, processing of clamping concept (external contour)	x		02/8/2008	10	2/20/2008	8
8	Optimized version of gripper pins (housing holder in dry cleaning system)	x		2/6/2008	10	3/10/2008	11
9	Floating housing holder (in x, y and z direction in the dry cleaning system)	x		2/15/2008	7	3/10/2008	11
10	MU barreling out "acute-angled" intersection	x		4/10/2008	15	6/15/2008	24
11	O-ring recess, cyl. intake Head	x		4/10/2008	15	4/18/2008	16
12	Axial "lubrication indent with inclined cast	x		1.Q. 2009		1.Q. 2009	
13	Processing of installation clamping surface	x		Q3 2009		Q3 2009	
14	Chamfer towards tappet	x		3/10/2008	11	3/3/2008	10
15	"Press" chamfer to the sleeve	x		3/12/2008	11	3/12/2008	11
16	Incorporation of a radial groove		x	postponed		postponed	
17	Deburring of the outward size 19 chamfer edge		x	2/15/2008	7	3/12/2008	11
18	Replacement of the cast casting stamp in "embossed"	x		5/5/2008	19	5/5/2008	19
19	Cleaning chamber is flushed after every cleaning process (3 cleaning levels)		x	2/15/2008	7	2/20/2008	8
20	Application of 45 degree chamfer to blank	x		1.Q. 2009		1.Q. 2009	
21	Cast optimization in clamping concept	x		1.Q. 2009		1.Q. 2009	
22	Cast chamfer on DMC surface	x		Q1 2009		Q1 2009	
23	Discharge treatment Clamping concept	x		Q1 2009		Q1 2009	
24	Use of ball cutter to improve burr situation, cylinder head intake for MU	x		4/20/2009	17	4/20/2009	17

Legend: Introduced | Introduction to plan | Introduction date has passed | Implementation is not effective/ effectiveness will be checked

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Cleanliness status FeP/JhP CP4, Status WK11/2009

FeP/JhP: Measures for reducing residual contamination: Assembly and preassembly of CP4

No.	Statemen **Measure to reduce residual dirt**	Pre-assembly cylinder head	Assembly	Introduction FeP		Introduction JhP	
				Deadline	WK	Deadline	WK
1	Optimization of the press stamp to avoid particles as the stamp moves backwards		x	2/18/2008	8	3/27/2008	13
2	Milk runner: Statement concerning empty gripper container from filling with suction gun		x	2/23/2008	8	3/5/2008	10
3	Clearing of the metering unit support in the area of the MU strainer to avoid picking up particles		x	2/18/2008	8	3/5/2008	10
4	Reduction of the area of the support of the MU lubrication unit to avoid picking up particles		x	2/18/2008	8	3/5/2008	10
5	Masking MU and intake bore to avoid particles from being picked up during transport and handling in main assembly		x	12/19/2007	51	1/31/2008	5
6	Remove pinch points on housing supports to prevent production of particles		x	3/18/2008	12	4/16/2008	16
7	Reduction flange surface for avoiding absorption of particles		x	3/10/2008	11	3/5/2008	10
8	Workpiece support: Reduction of the area of the support of the roller tappet as a mandrel to avoid picking up particles		x	2/29/2008	9	3/14/2008	11
9	Housing delivered in a blister pack instead of steel frame to avoid producing particles		x	3/14/2008	11	3/7/2008	10
10	Fix the control console position to avoid collisions with the station frame		x	3/14/2008	11	4/4/2008	14
11	Clad the guide rails of the safety door to avoid carrying particles on roller tappets		x	3/7/2008	10	4/17/2008	16
12	Masking intake bore in the cylinder head to avoid particles from being picked up during transport and handling in main assembly	x		2/19/2008	8	3/5/2008	10
13	Pneumatic purging of pre-assembled cylinder head to remove particles from assembly processes in return intake valve and intake valve	x		3/5/2008	10	4/17/2008	16
14	Optimize the cylinder head geometry to avoid the creation of splintering during the screwing process	x		~~6/18/2008~~ ~~9/15/2008~~ partial from Wk 40; complete from 10/13/2008	~~25~~ ~~-38~~ 40	~~6/18/2008~~ ~~9/15/2008~~ partial from Wk 40; complete from 10/13/2008	~~25~~ ~~-38~~ 40
15	Optimize the EOL test (better detection of functional testing)		x	6/9/2008	24	7/21/2008	30
16	Improved bolting process locking screw> monitoring by the laser measurement system	x		4/30/2009	18	4/30/2009	18
17	Addition of the MU with reduced degree of freedom		x	5/31/2009	22	5/31/2009	22

Legend: Introduced | Introduction to plan | Introduction date has passed | Implementation is not effective/ effectiveness will be checked

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From: Non-responsive content removed [redacted]
To: [redacted]
CC: [redacted]

Date: 7/19/2007 6:27:25 PM
Subject: Re: Minutes from OEM meeting on CP4.x turned tappet from 7/13/2007 - Item 4 Inspection oil quality CP4

Dear Non-responsive content removed [redacted]
Regarding your question relating to the HFRR value, please consider the following:
- Inspection oil contains anti scuff additives. The effect is specified and must be proven by the supplier in a FBBD (Four Ball Bearing) test.
- HFRR is a standardized test used to determine wear (ball on plate). In other words, it is a measure of the amount of wear. The test runs in the mixed friction area.
- It is possible to measure wear and friction in the HFRR test. However, a correlation of these parameters cannot be proven. This is partly due to the wide dispersion of the HFRR results in the test per se and also to the fact that different wear mechanisms (tribochemical wear/abrasive wear/adhesive wear) are involved here.
- This means that the HFRR value is not a suitable parameter with which to assess friction behavior.
- The HFRR value is relatively high for the inspection oil used in order to ensure a certain running in (abrasion/ smoothing of the surface tips of the parts).
Friction is affected by the following parameters:
- For the hydrodynamic element of friction: f (viscosity of the inspection oil) --> viscosity is specified and is tested (per delivery batch)
- Impurities in the inspection oil:
1. Caused by particles: --> inspection oil is filtered or tested with regard to contamination in the circuit (on a weekly basis).
2. Chemicals in the inspection oil: --> The chemical composition is tested using the FTIR (Fourier Transform Infrared Spectrometry) spectrum (per delivery batch)
- In our opinion therefore, the key parameters that influence the friction properties of the inspection oil are monitored.

Best regards / Mit freundlichen Grüßen / Cordiali saluti

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From: Non-responsive content removed
Sent: Thursday, July 19, 2007 12:54 PM
To: Non-responsive content removed
Subject: Re: Minutes from OEM meeting on CP4.x turned tappet from 7/13/2007 - Item 4 Inspection oil quality CP4

As discussed, please reply.

Best regards / Mit freundlichen Grüßen

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From: Non-responsive content removed
Sent: Thursday, July 19, 2007 8:08 AM
To: Non-responsive content removed
Cc:
Subject: ANS: Minutes from OEM meeting on CP4.x turned tappet from 7/13/2007 - Item 4 Inspection oil quality CP4

Hello [redacted]

Why is the lubrication not being monitored? I thought that was the whole idea?

-----Original message-----
From: Non-responsive content removed
Sent: Wednesday, July 18, 2007 6:26 PM
To: Non-responsive content removed
Non-responsive content removed
Cc Non-responsive content removed
Non-responsive content removed
Subject: Minutes from OEM meeting on CP4.x turned tappet from 7/13/2007 - Item 4 Inspection oil quality CP4

Hello,
In the meeting on 7/13/2007, a presentation on the monitoring of the inspection oil quality at RB was requested.

1) Inspection oil used: Shell V-Oil 1404 (trade name)

2) The following parameters are monitored: appearance, viscosity, color, density. These are verified by the supplier by means of a certificate.

In the goods receiving inspection at RB, these parameters and the water content and the FTIR spectrum are determined.

Attached are the results of the goods receiving inspection in 2007

<<V1404_AnfrageCP4_VW.pdf>>
Best regards / Mit freundlichen Grüßen

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70442 Stuttgart
GERMANY
www.bosch.com

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Paynter Chart 0km and field failures CP4.1 for all plants (VW and AUDI), FeP

[redacted]

Status: 4/9/2008 [redacted]

Production period		Jan 07	Feb 07	Mar 07	Apr 07	May 07	June 07	Jul 07	Aug 07	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb 08	Mar 08	No of units 07/01-08/01	PPM
Supply Qty to Györ/ Chemnitz/Salzgitter		0	155	0	168	300	1,082	976	1,701	3,168	6,432	13,056	9191	13,920	13,248	12,192	75,589	
Drivetrain damage / Turned tappet	0km					1					2					3	6	79
	Field																0	0
Particles IV	0km									1	2	1		1			5	66
	Field									1							1	13
Particles NRV	0km																0	0
	Field																0	0
MU O-ring damaged	0km										5						5	66
	Field										2						2	26
Leaky shaft seal	0km										1						1	13
	Field																0	0
Crack on cylinder head	0km																0	0
	Field																0	0
Chemnitz pressure retaining test not OK, RB OK according to spec.	0km	1						1	2	1	3	7					15	198
	Field																0	0
OK according to specification	0km				1	1											2	26
	Field																0	0
Customer error (shaft seal folded)	0km											2					2	26
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	**0km**	1	0	0	1	2	0	1	2	2	13	10	0	1	0	3	36	
	Field	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	3	
Total ppm-quota	**ppm 0km**	-	0	0	5,952	6,667	0	1,025	1,176	631	2,021	766	0	72	0	246		476
	ppm Field	-	0	0	0	0	0	0	0	316	311	0	0	0	0	0		40
Total number of acknowl-edged complaints	**0km**	0	0	0	0	1	0	0	0	1	10	1	0	1	0	3	17	
	Field	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	3	
acknowledged ppm-quota	**ppm 0km**	-	0	0	0	3,333	0	0	0	316	1,555	77	0	72	0	246		**225**
	ppm Field	-	0	0	0	0	0	0	0	316	311	0	0	0	0	0		**40**

acknowledged complaints

[redacted]

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Paynter Chart 0km and field failures CP4.1 for Chemnitz and Salzgitter plants (VW), FeP

Status: 4/9/2008 [redacted]

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Production period		Jan 07	Feb 07	Mar 07	Apr 07	May 07	June 07	Jul 07	Aug 07	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb 08	Mar 08	No of units 07/01-08/01	PPM
Supply Qty (..507) (to Chemnitz / Salzgitter)		0	100	0	168	246	384	864	1,317	2,880	4,704	5,376	4,800	5,472	1,920	2,688	30,919	
Drivetrain damage / Turned tappet	0km					1					2						3	97
	Field																0	0
Particles IV	0km																0	0
	Field																0	0
Particles NRV	0km																0	0
	Field																0	0
MU O-ring damaged	0km																0	0
	Field										1						1	32
Leaky shaft seal	0km										1						1	32
	Field																0	0
Chemnitz pressure retaining test not OK, RB OK according to spec.	0km	1						1	2	1	3	7					15	485
	Field																0	0
OK according to specification	0km				1	1											2	65
	Field																0	0
Customer error (shaft seal folded)	0km																0	0
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	0km	1	0	0	1	2	0	1	2	1	6	7	0	0	0	0	21	
	Field	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	
Total ppm-quota	ppm 0km	0	0	0	5,952	8,130	0	1,157	1,519	347	1,276	1,302	0	0	0	0		679
	ppm Field	0	0	0	0	0	0	0	0	0	213	0	0	0	0	0		32
Total number of acknowl-edged complaints	0km	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	4	
	Field	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	
acknowledged ppm-quota	ppm 0km	0	0	0	0	4,065	0	0	0	0	638	0	0	0	0	0		129
	ppm Field	0	0	0	0	0	0	0	0	0	213	0	0	0	0	0		32

acknowledged complaints

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Paynter Chart 0km and field failures CP4.1 for Györ plant (AUDI), FeP

[redacted]

Status: 4/9/2008 - [redacted]

Production period		Jan 07	Feb 07	Mar 07	Apr 0 7	May 07	June 07	Jul 07	Aug 07	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb 08	Mar 08	No of units 07/01-08/03	PPM
Supply Qty (..507) (to Györ)		0	55	0	0	54	698	112	384	288	1,728	7,680	4,391	8,448	11,328	9,504	44,670	
Drivetrain damage / Turned tappet	0km															3	3	67
	Field																0	0
Particles IV	0km									1	2	1		1			5	112
	Field									1							1	22
Particles NRV	0km																0	0
	Field																0	0
MU O-ring damaged	0km										5						5	112
	Field										1						1	22
Crack on cylinder head	0km																0	0
	Field																0	0
OK according to specification	0km																0	0
	Field																0	0
Customer error (shaft seal folded)	0km											2					2	45
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	0km	0	0	0	0	0	0	0	0	1	7	3	0	1	0	3	15	
	Field	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	
Total ppm-quota	ppm 0km	0	0	0	0	0	0	0	0	3,472	4,051	391	0	118	0	316		336
	ppm Field	0	0	0	0	0	0	0	0	3,472	579	0	0	0	0	0		45
Total number of acknowl-edged complaints	0km	0	0	0	0	0	0	0	0	1	7	1	0	1	0	3	13	
	Field	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2	
acknowledged ppm-quota	ppm 0km	0	0	0	0	0	0	0	0	3472	4051	130	0	118	0	316		**291**
	ppm Field	0	0	0	0	0	0	0	0	3472	579	0	0	0	0	0		**45**

acknowledged complaints

[redacted]

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Paynter Chart 0km and field failures CP4.1 and CP4.2 for all plants (AUDI and VW), FeP

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Status: 4/9/2008 - [redacted]

Production period		Jan 07	Feb 07	Mar 07	Apr 0 7	May 07	June 07	Jul 07	Aug 0 7	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb. 08	March 08	No of units 07/01-08/03	PPM
Production volume (.. 507/611		77	189	149	277	756	1,636	3,023	1,905	5,678	12,498	19,032	12,091	20,544	21,120	18,816	117,791	
Drivetrain damage / Turned tappet	0km					3				3	2					3	11	93
	Field																0	0
Particles IV	0km									1	2	1		1			5	42
	Field									1							1	8
Particles NRV	0km								1								1	8
	Field																0	0
MU O-ring damaged	0km										5						5	42
	Field										2						2	17
Crack on cylinder head	0km																0	0
	Field									1		1					2	17
Leaky shaft seal	0km										1						1	8
	Field																0	0
Chemnitz pressure retaining test not OK, RB OK according to spec.	0km	1						1	2	1	3	7					15	127
	Field																0	0
OK according to specification	0km				1	1				1		1					4	34
	Field																0	0
Customer error (shaft seal folded)	0km											2					2	17
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	0km	1	0	0	1	4	0	1	3	6	13	11	0	1	0	3	44	
	Field	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	5	
Total ppm-quota	ppm 0km	12.987 0		0	3,610	5,291	0	331	1,575	1,057	1,040	578	0	49	0	159		374
	ppm Field	0	0	0	0	0	0	0	0	352	160	53	0	0	0	0		42
Total number of acknowl-edged complaints	0km	0	0	0	0	3	0	0	1	4	10	1	0	1	0	3	23	
	Field	0	0	0	0	0	0	0	0	2	2	1	0	0	0	0	5	
acknowledged ppm-quota	ppm 0km	0	0	0	0	3968	0	0	525	704	800	53	0	49	0	159		195
	ppm Field	0	0	0	0	0	0	0	0	352	160	53	0	0	0	0		42

acknowledged complaints

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Paynter Chart 0km and field failures CP4.1 and CP4.2 for Györ plant (AUDI), FeP

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Status: 4/9/2008 - [redacted]

Production period		Jan 07	Feb 07	Mar 07	Apr 07	May 07	June 07	Jul 07	Aug 07	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb 08	Mar 08	No of units 07/01-08/03	PPM
Supply Qty (..507/611) to Györ		72	55	45	90	504	1,148	490	1,728	2,304	5,184	14,016	8,903	15,072	19,200	16,128	84,939	
Drivetrain damage / Turned tappet	0km					2				3						3	8	94
	Field																0	0
Particles IV	0km									1	2	1		1			5	59
	Field									1							1	12
Particles NRV	0km								1								1	12
	Field																0	0
MU O-ring damaged	0km										5						5	59
	Field										1						1	12
Crack on cylinder head	0km																0	0
	Field									1		1					2	24
Customer error (shaft seal folded)	0km											2					2	24
	Field																0	0
OK according to specifi-cation	0km									1							1	12
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	0km	0	0	0	0	2	0	0	1	5	7	3	0	1	0	3	22	
	Field	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	4	
Total ppm-quota	ppm 0km	0	0	0	0	3,968	0	0	579	2,170	1,350	214	0	66	0	186		259
	ppm Field	0	0	0	0	0	0	0	0	868	193	71	0	0	0	0		47
Total number of acknowl-edged complaints	0km	0	0	0	0	2	0	0	1	4	7	1	0	1	0	3	19	
	Field	0	0	0	0	0	0	0	0	2	1	1	0	0	0	0	4	
acknowledged ppm-quota	ppm 0km	0	0	0	0	3968	0	0	579	1736	1350	71	0	66	0	186		**224**
	ppm Field	0	0	0	0	0	0	0	0	868	193	71	0	0	0	0		**47**

acknowledged complaints

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Paynter Chart 0km and field failures CP4.2 for Györ plant (AUDI), FeP

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Status: 4/9/2008 - [redacted]

Production period		Jan 07	Feb 07	Mar 07	Apr 07	May 07	June 07	Jul 07	Aug 07	Sept 07	Oct 07	Nov 07	Dec 07	Jan 08	Feb 08	Mar 08	No of units 07/01-08/03	PPM
Supply Qty (611) to Györ		72	0	45	90	450	450	378	1,344	2,016	3,456	6,336	4,512	6,624	7,872	6,624	40,269	
Drivetrain damage / Turned tappet	0km					2				3							5	124
	Field																0	0
Particles IV	0km																0	0
	Field																0	0
Particles NRV	0km								1								1	25
	Field																0	0
MU O-ring damaged	0km																0	0
	Field																0	0
Crack on cylinder head	0km																0	0
	Field									1		1					2	50
OK according to specification	0km									1							1	25
	Field																0	0
Customer error	0km																0	0
	Field																0	0
t.b.d.	0km																0	0
	Field																0	0
Total of complaints	0km	0	0	0	0	2	0	0	1	4	0	0	0	0	0	0	7	
	Field	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	
Total ppm-quota	ppm 0km	0	0	0	0	4,444	0	0	744	1,984	0	0	0	0	0	0		174
	ppm Field	0	0	0	0	0	0	0	0	496	0	158	0	0	0	0		50
Total number of acknowl-edged complaints	0km	0	0	0	0	2	0	0	1	3	0	0	0	0	0	0	6	
	Field	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	
acknowledged ppm-quota	ppm 0km	0	0	0	0	4,435	0	0	832	1,562	0	0	0	0	0	0		**149**
	ppm Field	0	0	0	0	0	0	0	0	521	0	186	0	0	0	0		**50**

acknowledged complaints

Diesel Systems

BOSCH

From	Processor	Tel	Fax
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[redacted]
7/15/2008
No. 887188

Minutes – 6th Steering Committee VW / Bosch

Recipients: See participants

For info: Non-responsive content removed

Host

Participants

Head

Minutes

Organiz.

Date/location: **07/15/2008, Sales House** Non-responsive content removed

Topic: **6th Steering Committee VW /**

Bosch 6th Steering Committee VW / Bosch

- Plan in Wk40/08

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[redacted]
7/15/2008
No. 887188

Minutes

6th Steering Committee VW / Bosch

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[redacted]

7/15/2008

No. 887188

Minutes

6th Steering Committee VW / Bosch

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- **Status R4 EA189 Gen1**
  - » Impact of Bosch internal measures against drivetrain damage to CP4.1 show success
  - » Measures against drivetrain damage:
    - ⇨ Straightedge check

Diesel Systems

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From	Processor	Tel	Fax
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[redacted]
7/15/2008
No. 887188

Minutes

6th Steering Committee VW / Bosch

- ⇨ Straightedge check with cleaning cloth
- ⇨ Visual inspection after C coating
- ⇨ Optimized C coating

have been implemented and further measures defined:

- ⇨ Avoid metal spatters (graphite / boron nitride covers on holders in C coating plant)
- ⇨ Detection of metal spatters (feasibility study of objective measurement procedure)
- ⇨ Avoid C layer carry-over (new wash/transport frame)
- ⇨ Avoid "fusing" (investigation of new holders in C coating with spring-centering for better contact)
- ⇨ Design change (layer system of cam roller group C3 in C2)

» Audi will involve VW in searching for the cause of faults for Clean Diesel with Bosch, to capture synergy effects and save time

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Status R4 EA189 Gen2 Evo1 (CRS2.5)

» Delivery of D sample for PPS (PPD Wk09/09)

» Conclusion of reliability test by PPS not possible

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Diesel Systems

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[redacted]
7/15/2008
No. 887188

Minutes

6th Steering Committee VW / Bosch

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[redacted]
7/15/2008
No. 887188

Minutes

6th Steering Committee VW / Bosch

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6th Steering Committee VW / Bosch

Agenda

6th Steering Committee VW / Bosch on 07/15/2008 in [redacted] Sales House

BOSCH

6th Steering Committee VW / Bosch

[redacted]

3. Status of projects:

3.1 R4 EA189 Gen1

[redacted]

4.3 Development status CP4 22/1

4.4 Project status VW

RB / [redacted]
RB / [redacted]
VW [redacted]

RB [redacted]

RB / [redacted]
RB / [redacted]
RB / [redacted]

RB / [redacted]
VW / [redacted]
RB / [redacted]
RB / [redacted]
VW / [redacted]

Diesel Systems

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Diesel Systems

From	Processor	Phone	Fax
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6/10/2009
No. 986-166/01

Log

Recipients e-mail Distribution List
For Info e-mail Distribution List
Host Non-responsive content removed
Participants Non-responsive content removed

Head Non-responsive content removed
Log
Organiz.
Date/Location **06/10/09, 2:00-5:00 PM,**
Non-responsive content removed **B12 middle conference room**
Topic **CP4 technical discussion**

1) CR overview (attachment 1)

-The only ongoing CR is the cavitation CR.

2) Difference between W36 and current series (attachments 2, 3)

- Optimized tappet assembly will be pursued as a measure for the current series in the medium term.
- Why does the omission of the manganese layer result in reduced friction in case of the CP4 (reduction of dissipation)

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7/1/2009

3) Optimization of C layer (attachment 4)

- AUDI asks how droplets in the C3 coating can be reduced
- Friction coefficient examinations, feedback of substance analysis values
- Participation of QA and workshop representatives required.

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7/1/2009

4) Powertrain damage

Not covered because Non-responsive content removed were absent.

5) VFA delivery

5.1) Differences B/D samples

- No design changes between B and D samples, i.e. running period from B sample CR can be used for approval.
- Describe differences to D sample series

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CP4.**x:** US fuel trial

Type	PNR	Vers.	Pump. No	M status	WDR	cold seal.	Pitch	CR progr.					02/11	02/18	02/25	...	...	12/15	...	01/12	01/19	01/26	02/02	02/09	02/16	...	06/08			
PF CP4.1S 1800bar, US fuel	063_02	AWP1	686-4106	B1 (C2)	KACO	-	6	PDL_2000	2000	CR passed																				
	063_02	AWP1	686-4107	B1 (C2)	KACO	-	6	PDL_2000	2000	CR passed																				
	060_088	No AWP	690-4592	B1 (C2)	KACO	-	5.25	PDL_2000	2000	CR passed																				
	060_088	No AWP	690-4594	B1 (C2)	KACO	-	5.25	PDL_2000	2000	CR passed																				
CP4.1S 1800bar, US fuel EE customer VW R4 Bin5	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	PDL_2000	2001	CR passed																				
	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	PDL_2000	2001	CR passed																				
	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	PDL_2000	2000	CR passed																				
	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	PDL_2000	2000	CR passed																				
	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	KDL_500	500	CR passed																				
	060_12	AWP1	[illegible]	C2	Bruss	-40°C OK	5.25	KDL_500	500	CR with restriction																				
	060_12	AWP1	[illegible]	C2	Bruss	-	5.25	KDL_500	549	CR passed																				
PF CP4.2HS, 2000bar, US fuel	154_07	AWP1	690-4589	B2 (C2)	KACO	-	6	PDL_2000	2000	CR passed																				
	154_07	AWP1	690-4590	B2 (C2)	KACO	-	6	PDL_2000	2000	CR passed																				
	154_10	AWP1	781-4837	B2 (C2)	Bruss	-40°C OK	6	PDL_2000	2000	CR passed																				
	154_10	AWP1	781-48388	B2 (C2)	Bruss	-40°C OK	6	PDL_2000	2000	CR passed																				
CP4.2HS, 2000bar, US fuel EE customer Audi V6 Bin5	169_088	AWP1	783-4680	C2	Bruss	-40°C OK	5.6	PDL_2000	2000	DL not passed lateral roller warm-up; MU finding OK																				
	169_088	AWP1	783-4681	C2	Bruss	-40°C OK	5.6	PDL_2000	2000	DL not passed lateral roller warm-up; MU finding OK																				
	169_09	AWP1	785-4263	C2	Bruss	-40°C OK (2000h)	5.6	PDL_2700	2000	Interim diagnosis 2000h OK				Continue run			2700													
	169_09	AWP1	785-4264	C2	Bruss	-40°C OK (2000h)	5.6	PDL_2700	2000	Interim diagnosis 2000h not OK MU O ring sheared off				Continue run (with new MU O ring)			2700													
	169_088	AWP1	783-46788	C2	Bruss	-40°C OK	5.6	KDL_500	500	CR passed																				
	169_088	AWP1	783-4679	C2	Bruss	-40°C OK	5.6	KDL_500	500	CR passed																				
	169_09	AWP1	785-42688	C2	Bruss	-	5.6	PDL_2000					1720	1887	2000	CR passed														
	169_09	AWP1	786-4533	C2	Bruss	-	5.6	PDL_2000					1164	Failure; CR not passed																
	169_17	AWP1	889-4345	D	Bruss		5.6	PDL_2000										1293	...	1750	19088	2000	CR passed							
	169_17	AWP1	889-4352	D	Bruss		5.6	PDL_2000		Recursion pump like series, but roller crest C2.1								1293	...	1750	19088	2000	CR passed							
	169_17	AWP1	889-4353	D	Bruss		5.6	PDL_2000										1102	...	1465	1619 1783 1889			2000	CR passed					
	169_17	AWP1	889-4354	D	Bruss		5.6	PDL_2000										1102	...	1465	1619 1783 1889			2000	CR passed					
"Cavitation CR" 1800bar/2000bar; CP4.1 GDK570	010 5088	AWP1	161008-0895		Bruss	-	5.25	KDL_500																			314			
	010 5088	AWP1	221008-1051	Series, however 2.9bar OV	Bruss	-	5.25	KDL_500										46	...	489	500	CR passed								
CP4.2 EN590	010 624	No AWP	081015-05388		Bruss	-	5.63	KDL_500										0	...	91	...					Continue run after CP4.1 Kav.DL				
	010 624	No AWP	081015-0539		Bruss	-	5.63	KDL_500													6	1488	316	482	500	CR passed				

From: Non-responsive content removed
To: [redacted]
CC: [redacted]
Date: 2/15/2010, 10:22:00 AM
Subject: Statement from [redacted] laboratory on peculiarities of [redacted] fuel

For your information:

(DF stand for diesel fuel; Gs stand for gasoline)

Best regards

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From: Non-responsive content removed
Sent: Monday, February 15, 2010, 7:54 AM
Non-responsive content removed
Subject: Re: Slides for meeting on 02/12/2010

Hi all,

For your information.

Best regards

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From: Non-responsive content removed
Sent: Wednesday, February 10, 2010, 11:22 AM
Non-responsive content removed
Subject: ANS: Slides for meeting on 02/12/2010

Hello Non-responsive content removed

I'm afraid everything isn't really specified precisely.
One thing after another:

Brown deposits: It looks like aged DF, possibly decomposition products from FAME. Theoretically limited through the maximum residue levels or soiling.
Sugar solution: doesn't belong in DF at all, but is not explicitly forbidden.

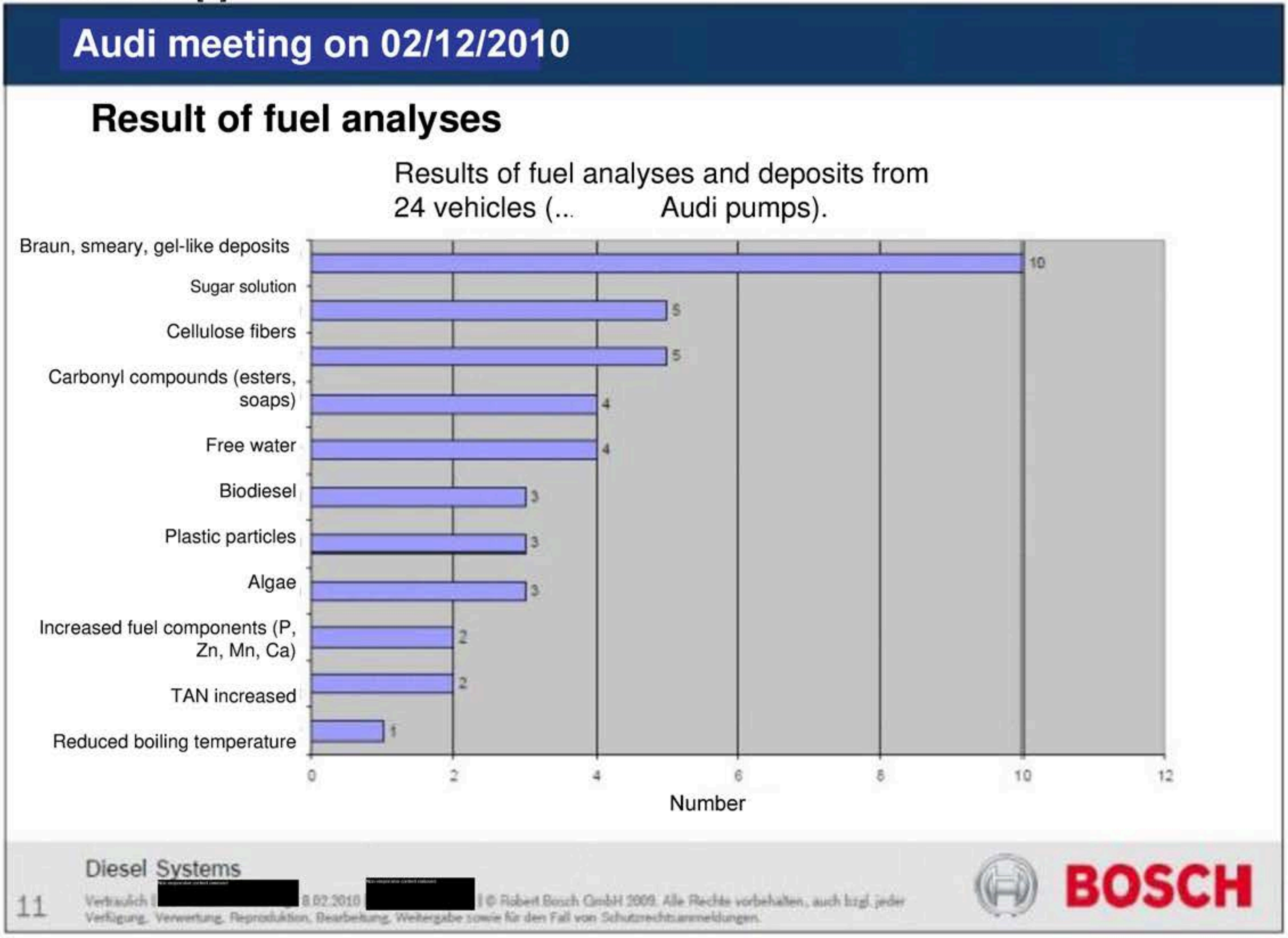
Cellulose fibers/plastic particles: depending on size, they should get caught up in the fuel filter; otherwise only solid particles with max. 24 mg/kg are defined in EN 590.
Carbonyl compounds: biodiesel belongs to this class of compounds

Free water: 200ppm water content is allowed, this low quantity dissolves in B7; therefore, no free water should be present. If free water is found, then the general water content of the B7 DF is too high.
Biodiesel: up to 7% allowed in DF

Algae: = biological contamination, results from water + biodiesel. The fuel had some water input (see above limits) and might have been stored for too long, creating ideal conditions for growth of algae/bacteria/fungus. This is not mentioned explicitly in the EN, however (only indirectly through water, Ox stability and solid particles).
Fuel components: are not mentioned explicitly, but only defined through the so-called "ash content" with max. 0.01 %m/m.

TAN: is not defined for DF/biodiesel blend. TAN for pure biodiesel (B100) is defined.

red. boiling temperature: is generally not defined; the conventional value of approx. 160-170°C is generally maintained through the product mix in the refinery. (If Gs or other light volatiles are blended, it may not be possible to achieve the flash point of min. 55°C.)



With best wishes

[redacted]

From [redacted]
Sent: Wednesday, February 10, 2010, 9:17 AM
To [redacted]
Subject: Re: Slides for meeting on 02/12/2010

Hello [redacted]

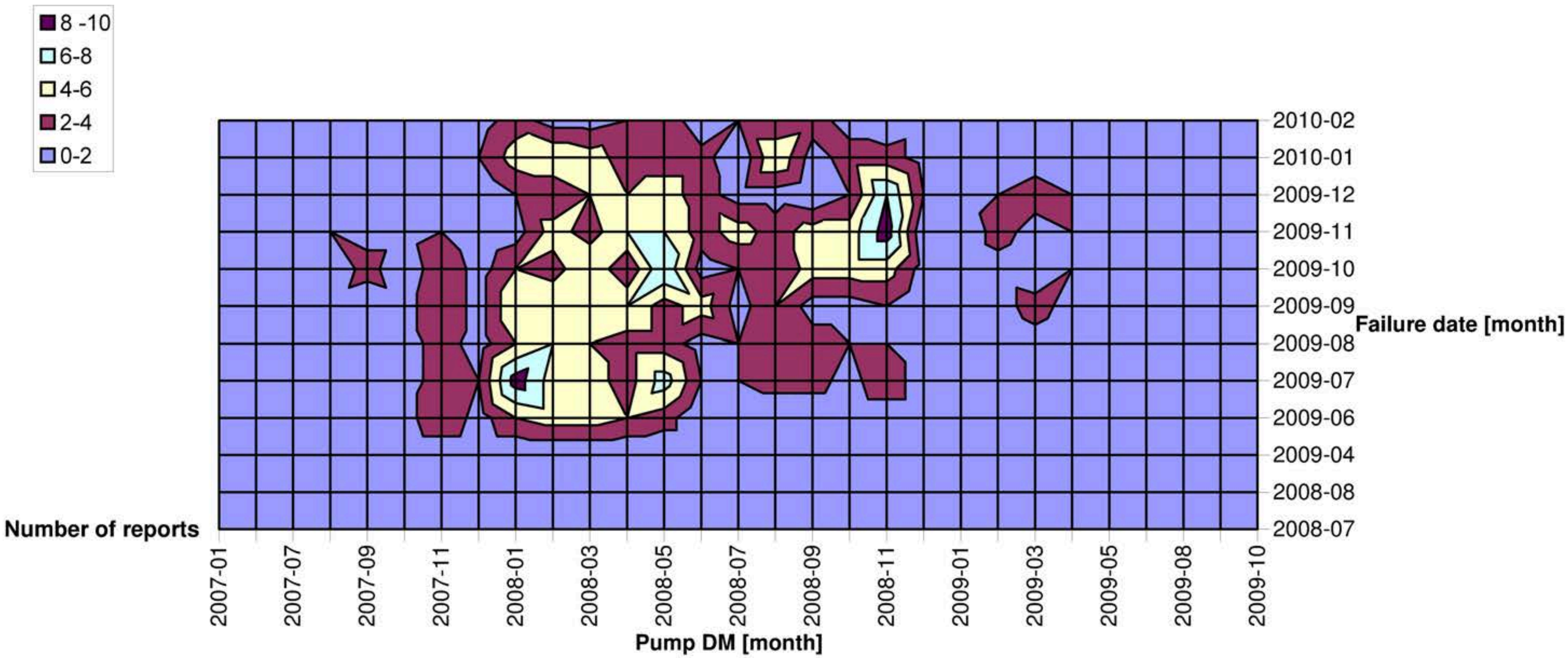
See slide 11.
What is allowed according to the standard?

With best wishes
[redacted]

EA11003EN-01800[0]

ENTIRE PAGE CONFIDENTIAL

Audi CP4.2 failures [redacted]



From: Non-responsive content removed
To:
CC:

Date: 5/26/2010, 1:38:46 PM
Subject: Findings CP4.1 Non-responsive content removed
Attachments: Überblick Befundung Rücklieferung [redacted] Stand-2010-05-26.pdf

Hi all,

It's popped up in the R4-CR again - like with the V6, but in a weakened form:

- The most cases of drivetrain damage up to 05/2008 (AWP 1)
- or 06/2009 (AWP 2) at the latest

Significant improvement from late 2008
→ failure 09/2009 !!!

- And it's high time for the intake valve strainer.

Hello [redacted]
Please send the information to Non-responsive content removed

Attention: Preliminary information!!
Best regards

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From: Non-responsive content removed
Sent: Wednesday, May 26, 2010, 2:06 PM
Non-responsive content removed

Subject: Repeat findings CP4 Non-responsive content removed
Dear Sirs,

Please find attached the initial preliminary analysis results from the CP4 pumps sent back from [redacted] Total: 139 pieces
of which: 35 x CP4.1 (preliminary findings)
104 x CP4.2 (open)

Mit freundlichen Grüßen / Best regards

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Robert Bosch GmbH
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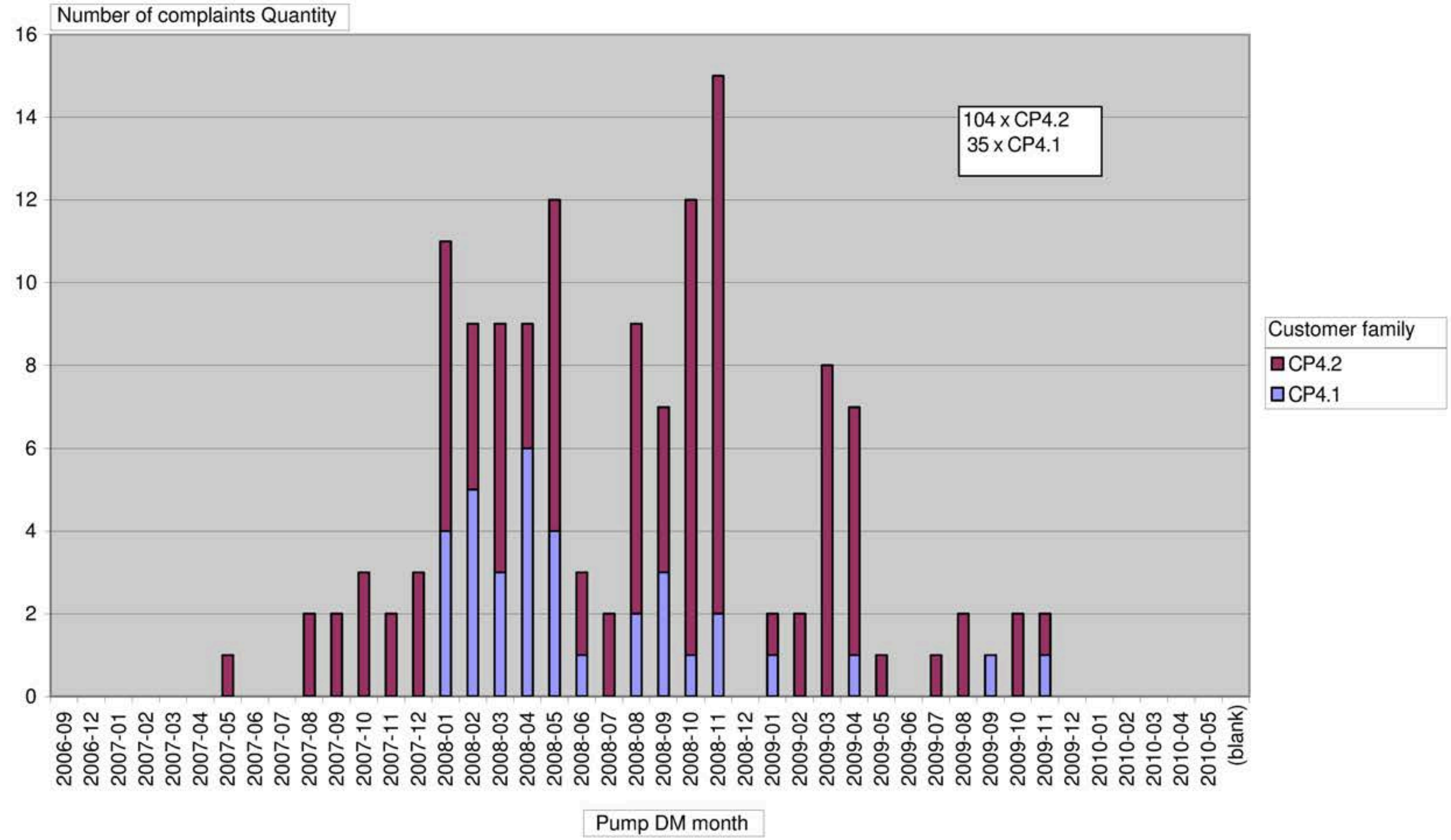
Diagnosis of return delivery CP4 Non-responsive content removed

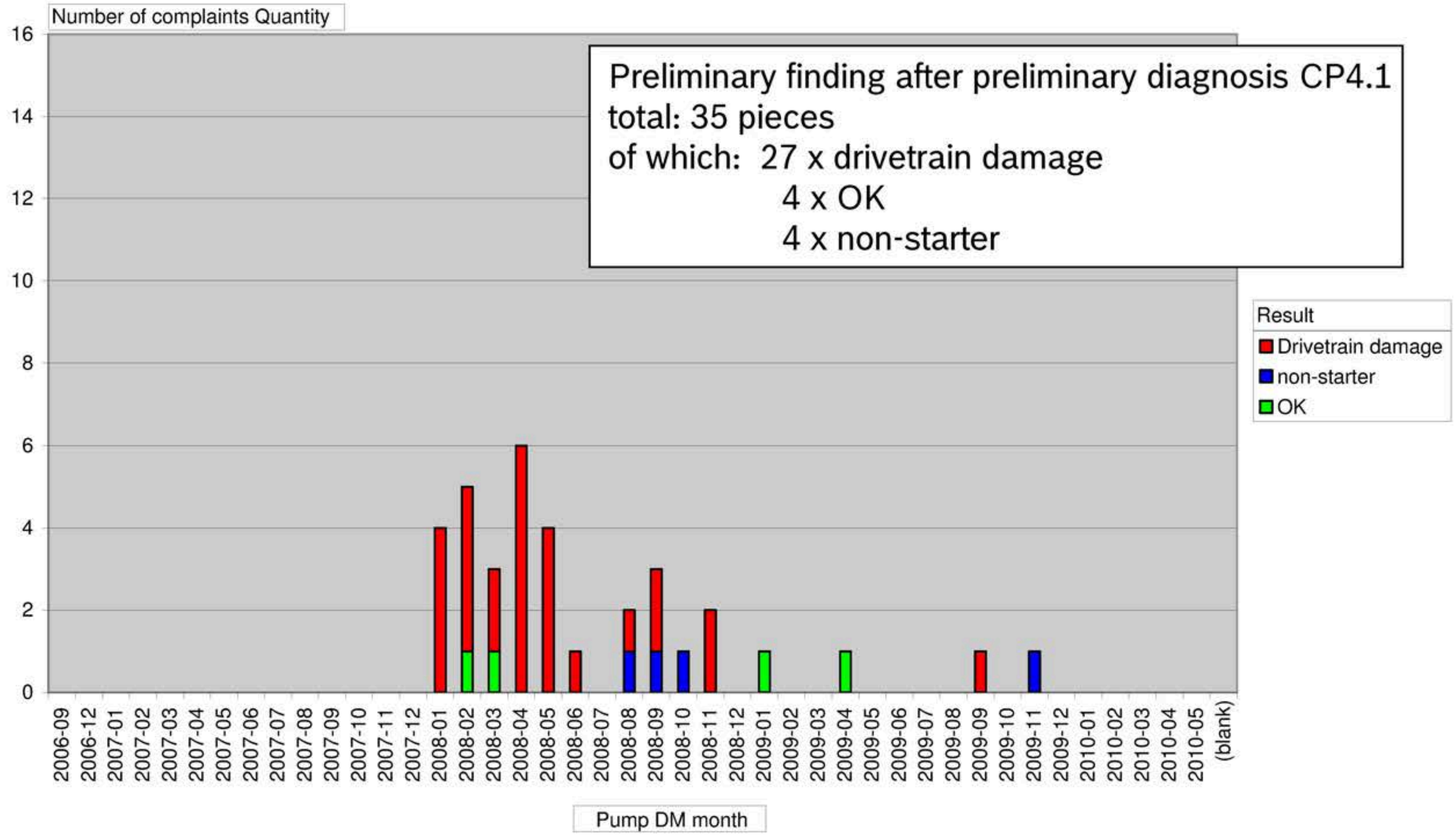
Overview CP4.1 / CP4.2



ENTIRE PAGE CONFIDENTIAL

Diagnosis of return delivery CP4 Non-responsive content removed

Preliminary diagnosis CP4.1



BOSCH

EA11003EN-01852[0] **ENTIRE PAGE CONFIDENTIAL**

From: Non-responsive content removed [redacted]
To: [redacted]

CC: [redacted]

Date: 10/8/2010, 1:14:30 PM
Subject: ANS: IQIS:230003014652_QTS 3731540_Info.

Hello [redacted]

We will invite you to the next appointment and get you up to date on the latest information; this e-mail ping pong just doesn't make sense.
We don't have any problem with the current status after clean date in the customer service case - where did you get that from? Everything beyond that will be given to you as quickly as possible, but according to priority, beginning with the AWP countries - [redacted], as a DIN 590 country, is not among them. Otherwise, please clarify with Q[redacted] whether you really assume the same necessity. Until then, we will continue with the additional measures in CP4.1 development.
Regards

Non-responsive content removed [redacted]

From: Non-responsive content removed [redacted]
Non-responsive content removed [redacted]
Sent: Fri Oct 08 13:32:35 2010
Subject: ANS: IQIS:230003014652_QTS 3731540_Info.

Hello [redacted]

Sorry, but I'm not aware of any CP4.1 task force.
And I'm not familiar with any coordination with Audi colleagues (QA) either.
The fact is that I don't get information from you until asking several times (if at all); I just had to get that off my chest.

On the CP4.1 in [redacted]
Our importer expects a fast CS solution, so customers get a "reliable" pump that will not fail a second time.
Can we offer him an AWP pump that will fit the "old series" in the field?
If I am reading your lists correctly, then the 03L 130 755 A is not slated for RP1; does the lift fit at all?
Or:
Could we produce a larger lot of gen. 1 pumps in advance for [redacted] CS?

Best regards

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Subject:ANS: IQIS:230003014652_QTS 3731540_Info.

Hello [redacted]

Let's please stop the unproductive mail correspondence on the CP4 failures with the large distribution list immediately, and check and coordinate our statements better in future. The task force for the CP4.1 failures, which consults the Audi colleagues regularly, has currently reached a status that can only conditionally confirm your statements after a detailed examination. We and AUDI are in the same place in the failure analysis and therefore support the same corrective measures that you are already familiar with as "anti-wear packages". The only difference is the implementation of the RP packages in the field, where across-the-board introduction is planned by 03/2011 for the CP4.1, due to the project variety and volume requirements in association with limited capacity on the Bosch side. We are regularly tracking this at Bosch, so it should not be conveyed to Bosch from a variety of instances.

The evaluation of the cases of damage in the [redacted] market carried out in AQUA confirms the effectiveness of the measures introduced so far. The failure figures have declined rapidly in manufacturing year 2010.
While it is correct that we have recorded a large number of failures in 2010, most of them are due to pumps with DM before the clean date To respond to this and if you want to prevent further failures with the old design status, you will have to request a field cleanup.
We hope to further improve the field situation through the anti-wear packages that have already been approved and scheduled, and are also working on further anti-wear measures together with Bosch, which are currently in the development and validation phase.

P.S. BOSCH has been intentionally left out of the e-mail distribution list.

Best wishes,

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From: Non-responsive content removed
Sent: Thursday, October 07, 2010, 10:14 AM
Non-responsive content removed
Subject: Re: IQIS:230003014652_QTS 3731540_Info.

... and even [redacted] has encountered (relatively late / 28,000 km) drivetrain damage cases with the CP4.1 (transverse installation MY10), <u>without</u> any indication of poor fuel quality.

Best regards

[redacted]

From: Non-responsive content removed
Sent: Wednesday, October 06, 2010, 5:11 PM
Non-responsive content removed

Non-responsive content removed
[redacted]

Subject: IQIS:230003014652_QTS 3731540_Info.

Hello,

Please find attached information on the analysis of the CP4 pump

Fault scope
RB Part no. 0445.010.507
AUDI part no. 03L130755
SN: BPT 0260
DM: 10/16/2009
ML: 05
IQIS: 230003014652
Ref. no: IGG000006033-001
Customer ref. no. QTS 3731540
Engine no. CBAB 05204
Vehicle No.: WAUZZZ8P5AA[redacted]
Mileage: 27,818 km
Failure country: [redacted]

Description of problem
No specification from AUDI

RB analysis:
Roller support worn
No deposits or corrosion traces
Fuel analysis OK

RB finding
Drivetrain damage
Complaint was acknowledged as Bosch defect

Regards

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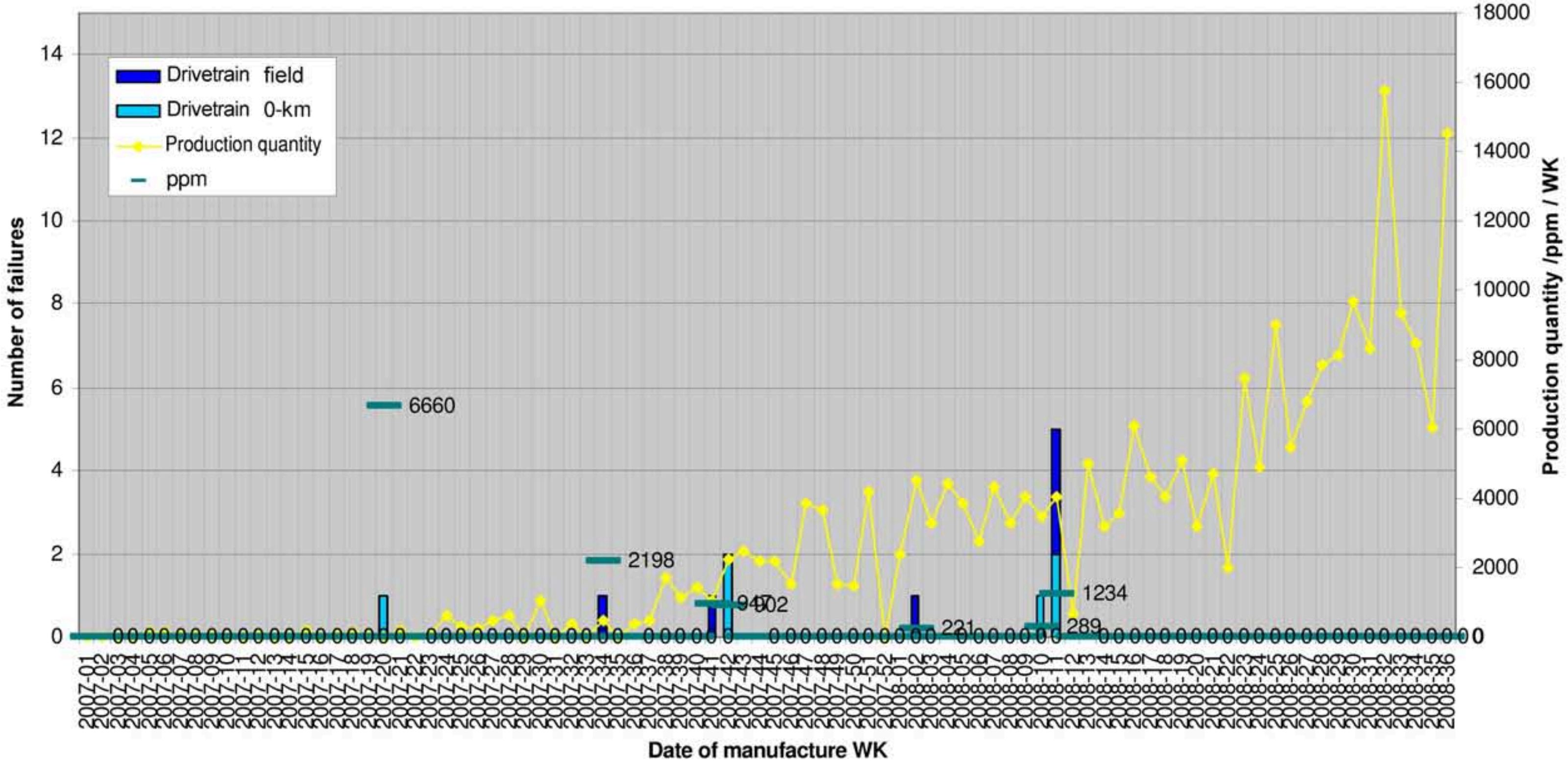
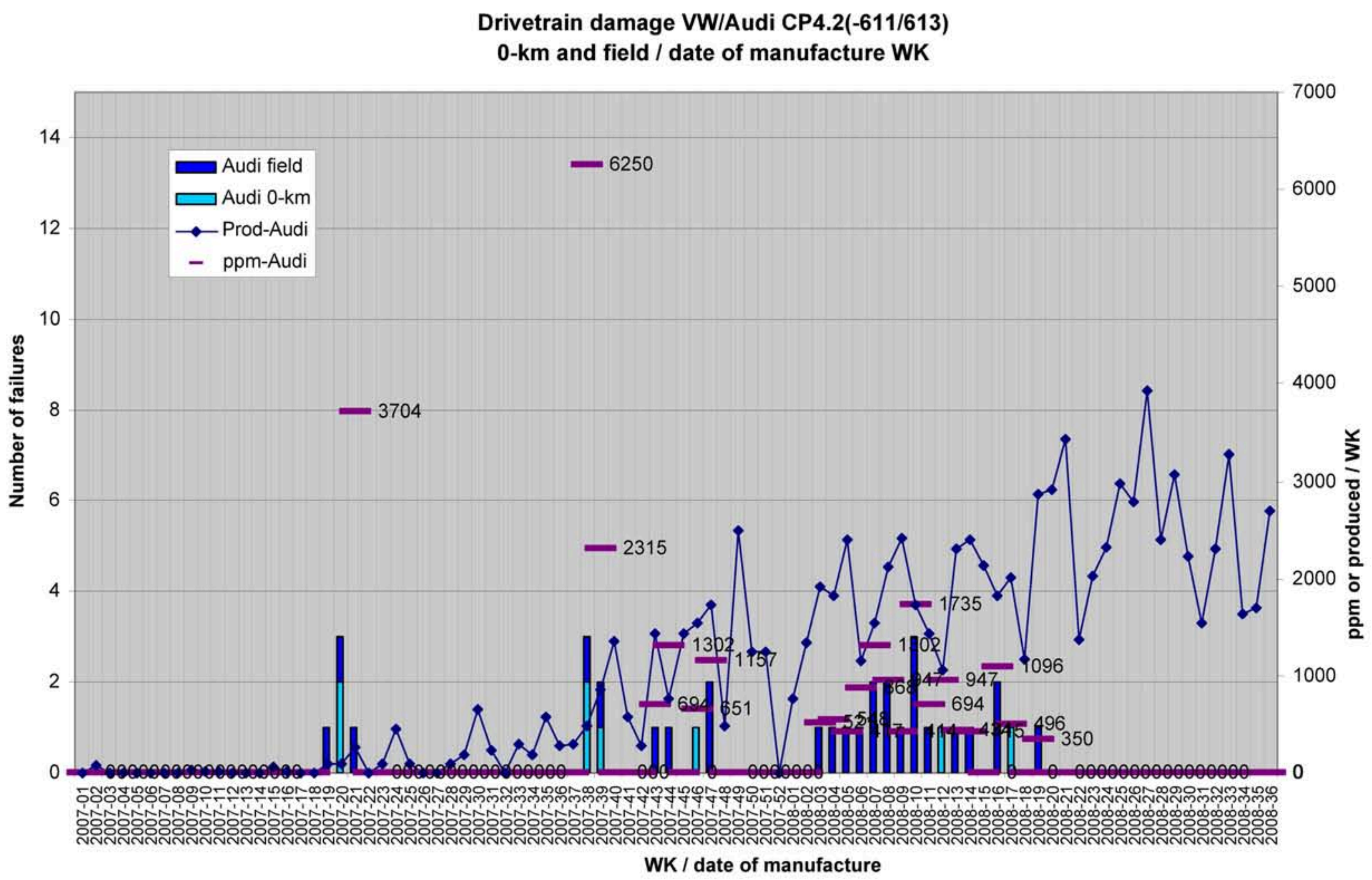
[redacted]

Activities to reduce drivetrain damage

Drivetrain damage VW/Audi CP4.1(-507/508)
0-km and field / date of manufacture WK



Activities to reduce drivetrain damage



Diesel Systems

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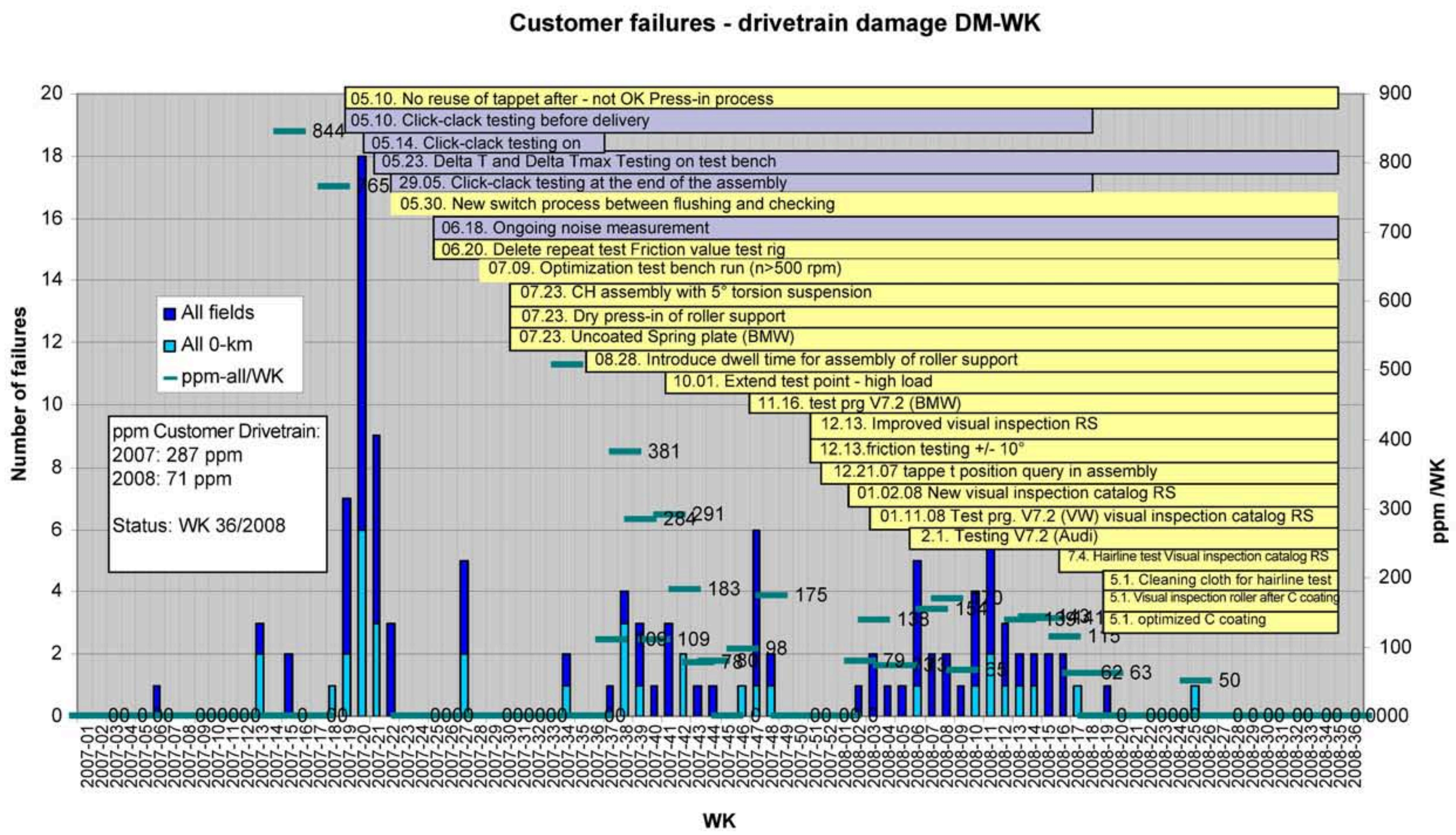
Activities to reduce drivetrain damage



Diesel Systems

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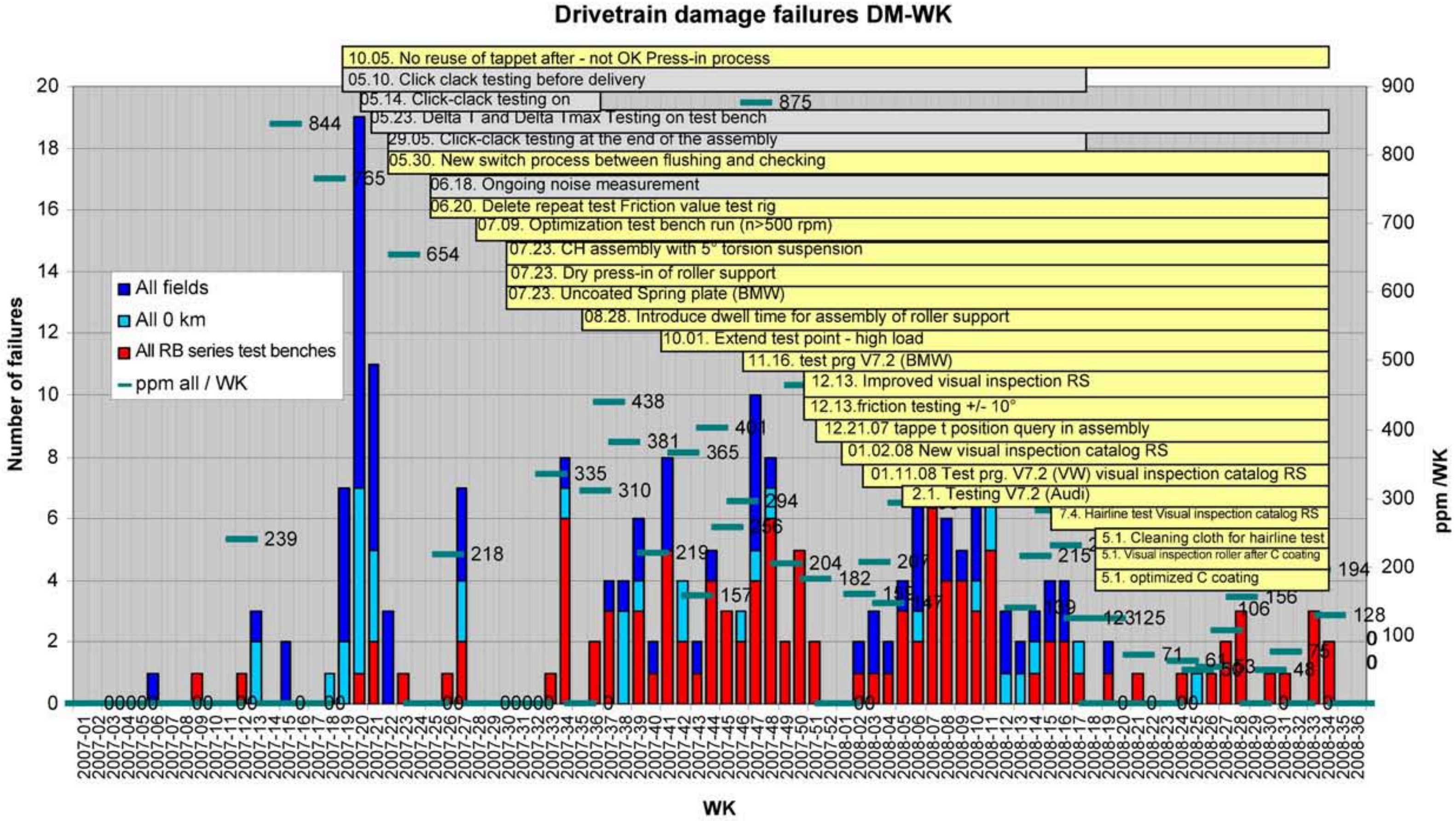
Activities to reduce drivetrain damage



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Q situation of drivetrain damage CP4 (09/10/2008)

- Clear decline in the failure figures since DM WK 12 in 0km and field with CP4.1 for VW/Audi
- Clear decline in the failure figures since DM WK 12 in 0km and field with CP4.2 for VW/Audi
- Drivetrain damage continues to be found in internal testing

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Activities to reduce drivetrain damage

Task force activities to reduce drivetrain failures

1) Metal splashes

1.1) Avoiding metal splashes

Graphite / boron nitride covers on bracket in the C-coating unit

- Testing new unit — as of WK 36
- If test successful, planned introduction — as of WK 42

1.2) Recognizing metal splashes

- Feasibility study for objective measurement processes — (completed)
- Check received quotes&, technical detailed discussions — WK 43
- Decision about series launch — WK 44

3) Avoid C coating spreading

New washing / transport frameworks

- First 100 — (completed)
- Complete conversion — WK 40

VW Q meeting - CP4 drivetrain damage

4) Avoiding "fusing"

Test new brackets in the C coating with spring centering for better contacting

- Sample, testing, modification, if necessary manufacture again Objective series introduction if testing positive WK48

5) Change to construction layout

- Change to the coating for on the roller end from C3 to C2 (testing W24 D4, VW package 3)
- Improve secure fit of the roller support / tappet bodies R.B. internal testing WK43

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VW Q meeting - CP4 drivetrain damage

VW/Audi counts 75 (+20 since 08/01/2008) field failures worldwide

- 44 not submitted failures
- 30 of RB confirmed failures
  - 25 x CP4.2
  - 5 x CP4.1

Focus: CP4.2

- Vehicles affected: Audi Q7; Audi B8; VW Touareg
- Focus countries: Non-responsive content removed
- DM of the confirmed failed pumps: before 05/07/2008

Comment: Introduce last production measures 05/01/2008
(offset can be explained by parts breaking off & Optimize testing -> efficiency)

• Hairline testing	04/07/2008
• Cleaning cloth for hairline testing	05/01/2008
• Visual inspection of roller after C coating	05/01/2008
• Optimize C coating	05/01/2008

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VW Q meeting - CP4 drivetrain damage

KT analysis of the CP4 drivetrain damage (focus on [redacted]

(Version 09/09/2008, confirmed failures based on list from Mr. [redacted]

Failure hypothesis(es)

Combination of pump components with production susceptibilities in connection with country-specific influencing factors	High
Fuel, transport ([redacted] and other markets?)	Medium
&/ or	
Drive torsional vibrations (stronger torsional vibrations on 2.7 l ?)	Low
&/ or	
Engines from the Audi plant (only 1 x VW Tiguan)	Medium

- The following lists key activities and questions concerning the confirmation / refutation of the above-mentioned failure hypotheses. Detailed tracking will take place via OPL at [redacted]

VW Q meeting - CP4 drivetrain damage

Activities

Analyze [redacted] fuel (basic map of failures) 10/06/2008; [redacted]

Engine measurements at Audi (min. / max. belt tension) 9/26/2008; [redacted]

- Simulation of belt tension (completed)
- Reappear-tests 10/6/2008; [redacted]
  - Marginal roller with min. belt tension
  - Marginal roller with kerosene in the fuel

Testing of coverings on pumps 09/24/2008; [redacted]

Provocation test with water (completed)

(Background: Drivetrain damage without visible traces of corrosion possible?)

Test air entry with Q7 NDKL (simulation leasing vehicle) 9/24/2008; [redacted]

VW Q meeting - CP4 drivetrain damage

Focus questions to Audi

Is Audi more affected than VW (influence of engines / vehicle plant)?
Update VW model vs. delivery figures in list from Mr. [redacted] — 09/10/2008 [redacted]

How are vehicles transported from VW/Audi to [redacted] — 10/06/2008; [redacted]

What is the failure situation Inline EFP? — 9/15/2008; [redacted]

Are failures on leasing vehicles (random sample)? — 10/06/2008; [redacted]

Is fuel from vehicles being adulterated en-route?
(random sample after delivery)

10/06/2008; [redacted]

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Audi meeting on 02/12/2010

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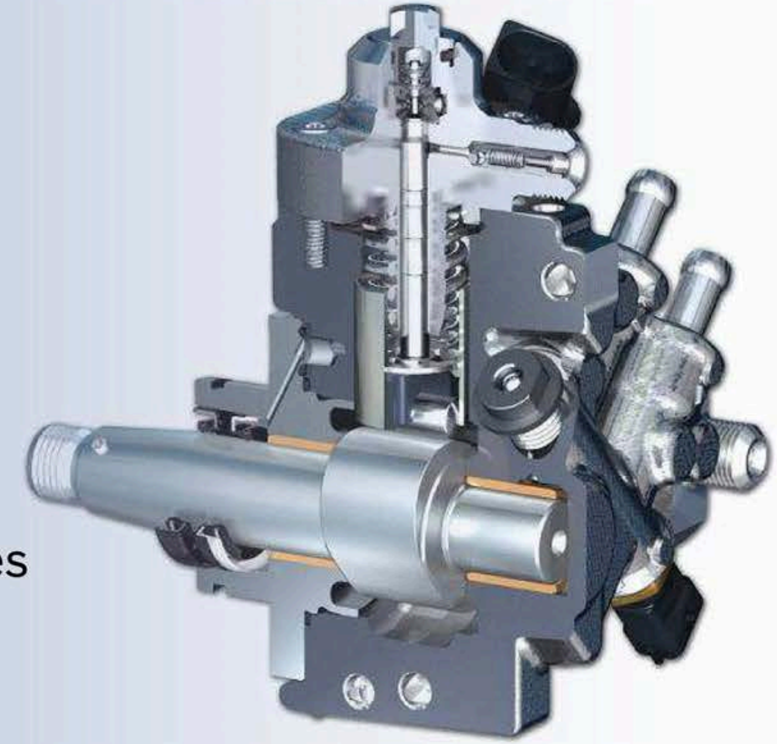
1. Ishikawa of influencing factors
2. Analysis of failed pumps / fuels
3. Component sensitivity
4. Good pumps
5. Hypothesis
6. Anti-wear package 1
7. Proof of robustness: Stribeck curves
8. Assessment of measures



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1) Ishikawa of influencing factors

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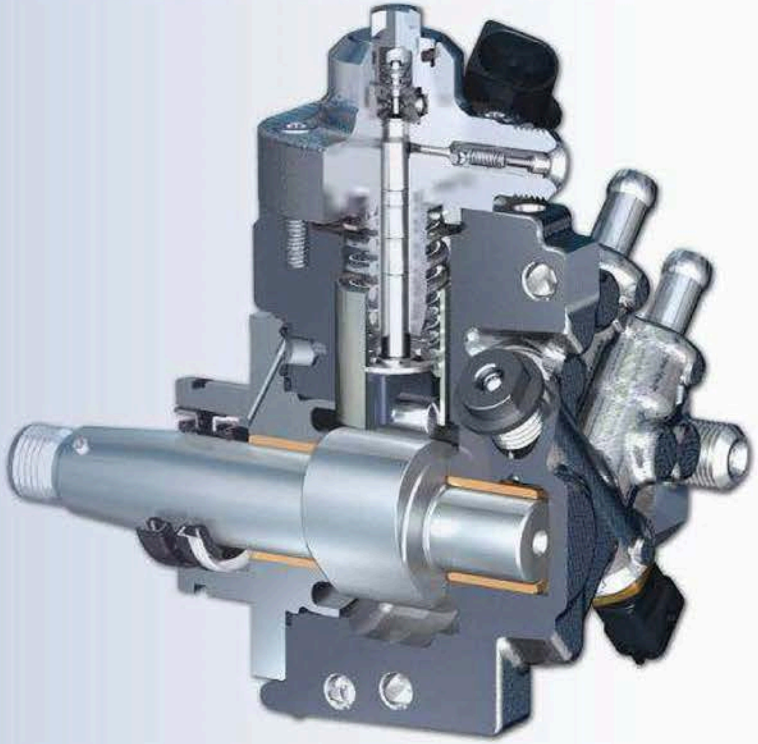

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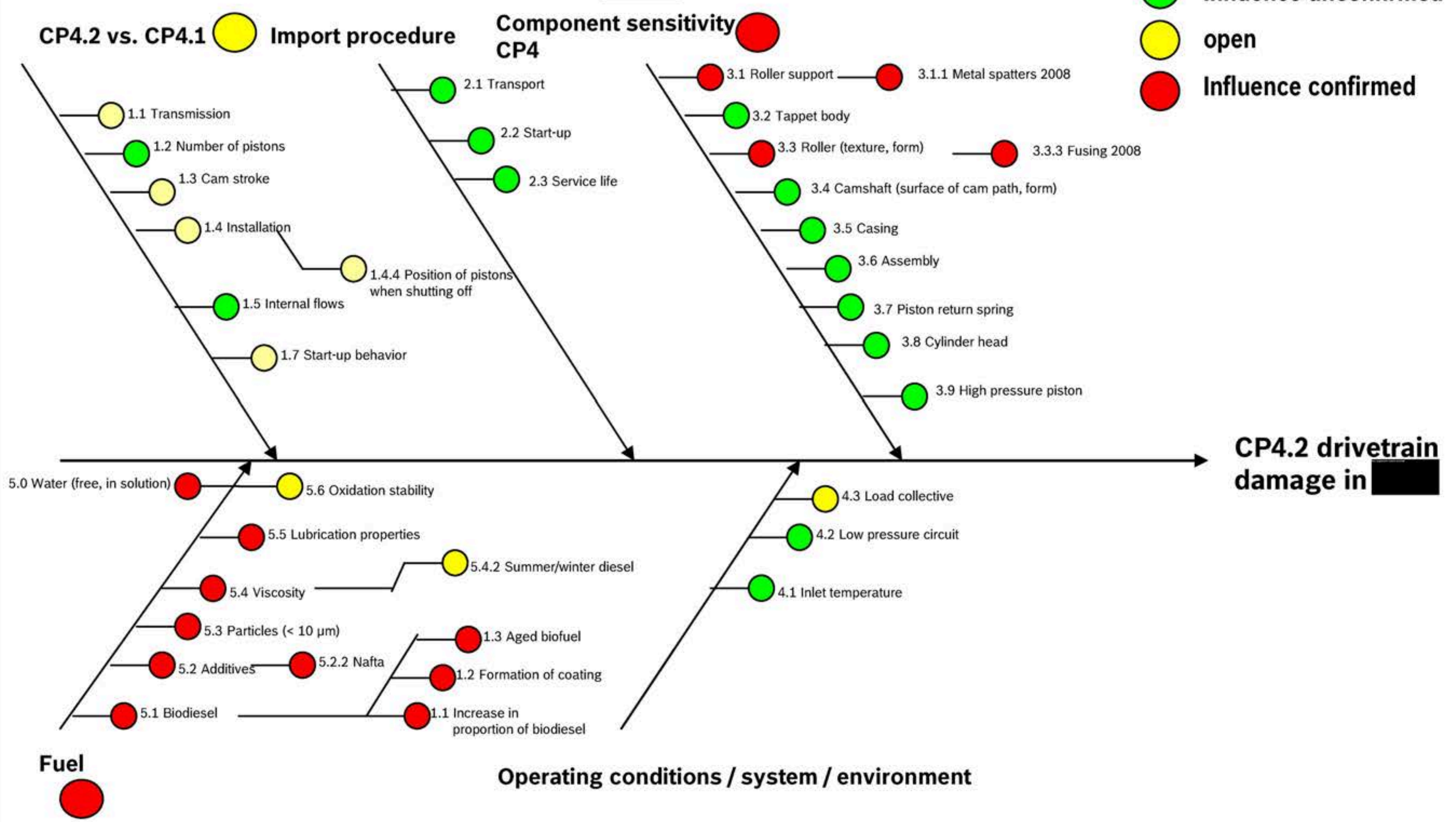
Ishikawa – drivetrain damage CP4.2 [redacted]



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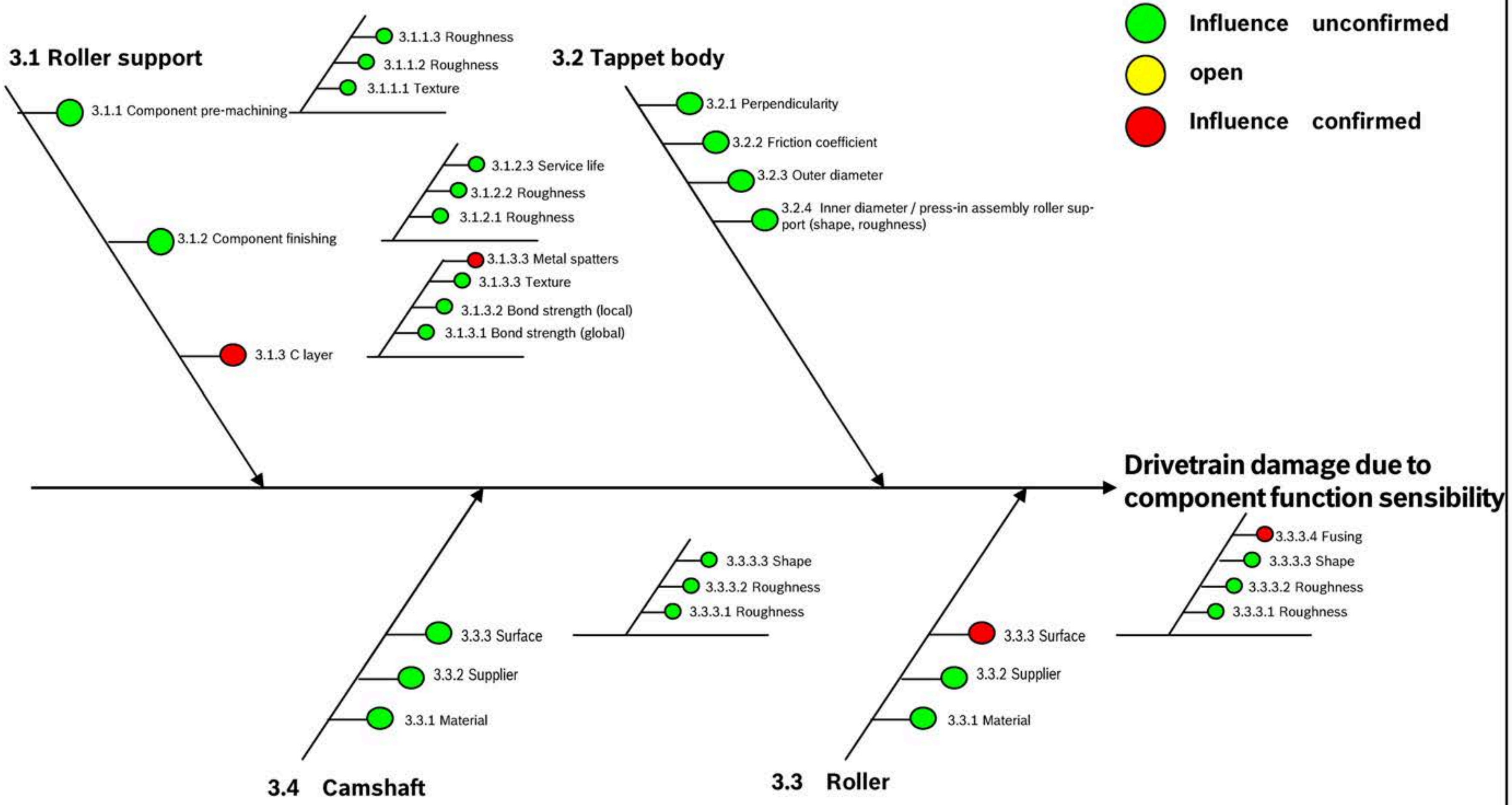
Audi meeting

Audi meeting on 02/12/2010

Ishikawa – drivetrain damage CP4.2 [redacted]



Diesel Systems

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Audi meeting on 02/12/2010

Summary of areas of action from Ishikawa:

1. Fuel influence
2. Component sensitivity: Metal spatters / fusing
3. Differences between CP4.2 – CP4.1 in application and design

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2) Analysis of failed pumps / fuels

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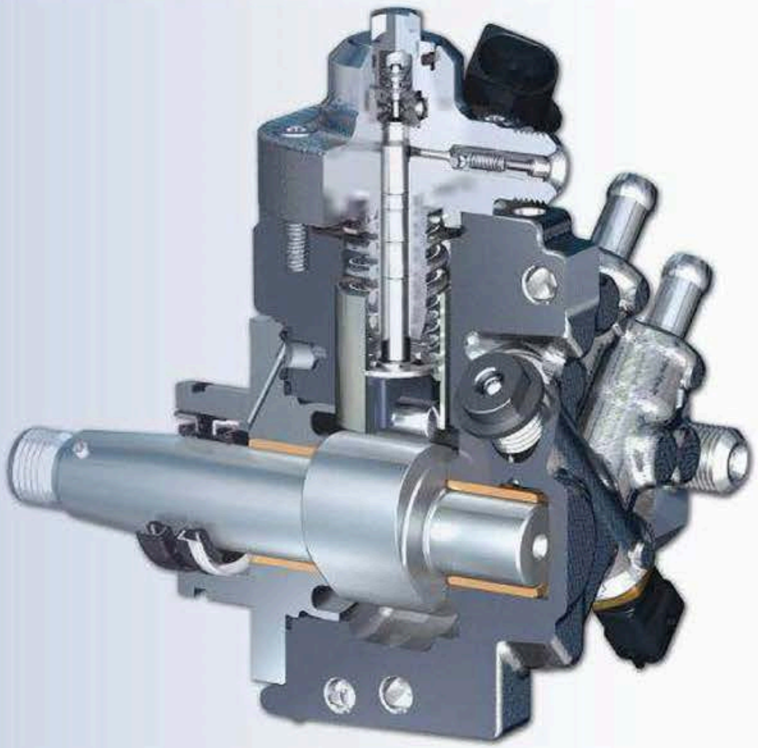

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Audi meeting on 02/12/2010

Determination of causes for failure focus Non-responsive content removed

Analysis of field pumps and fuel samples from Non-responsive content removed

➢ FAME deposits	11 of 54 pumps
➢ Corrosion indicators, evidence of water	45 of 54 pumps
➢ Free water in fuel sample	4 of 24 samples
➢ Cellulose residue, algae, glycerin	9 of 24 pumps
➢ Heavy wear of shaft seal	17 of 17 pumps
➢ Good pumps with preliminary damage - Non-responsive content removed	6 of 13 pumps

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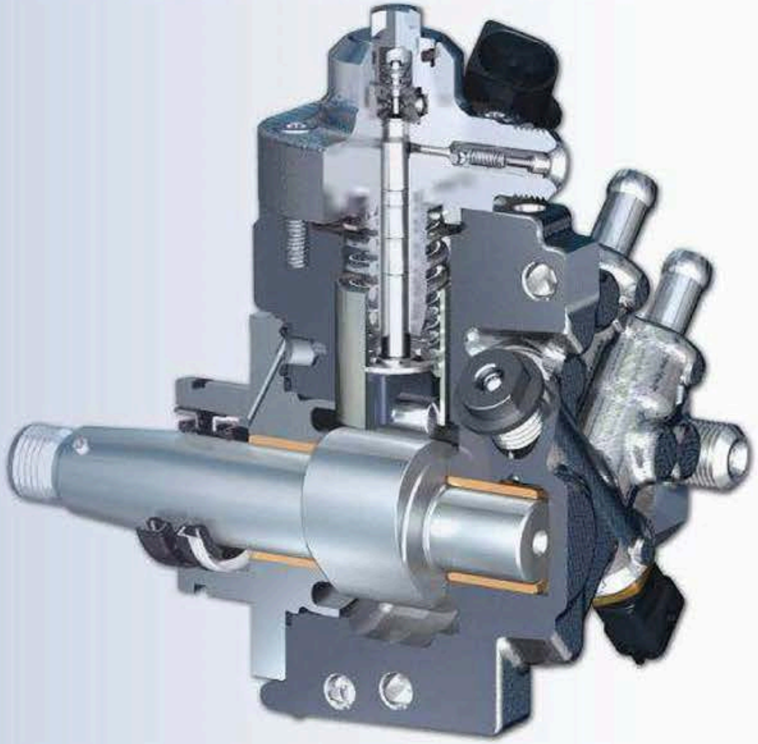
3) Component sensitivity

[redacted]



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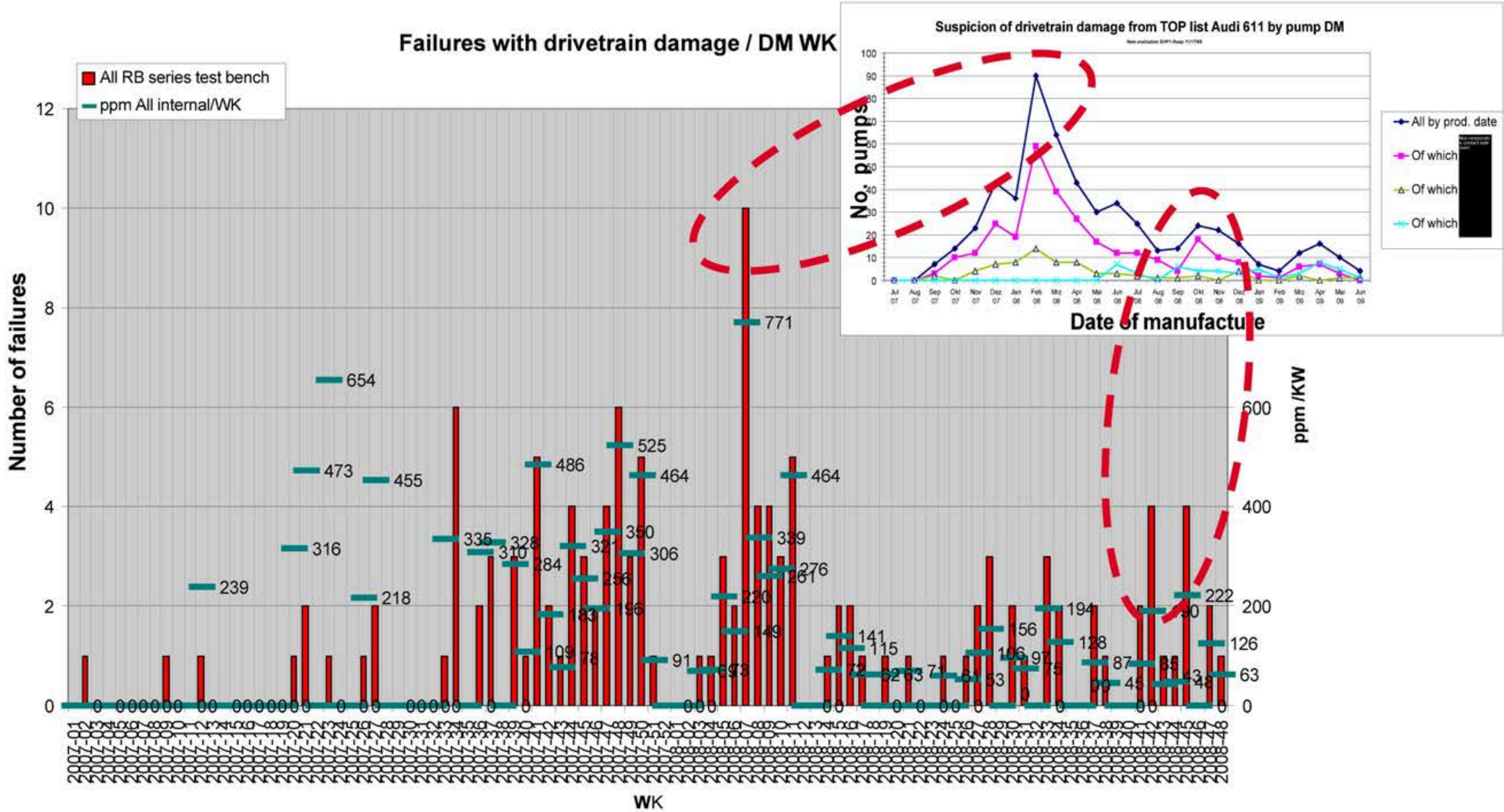
Audi meeting on 02/12/2010

Overview of failures, internal test bench & Field Non-responsive content removed (failure peaks)



-> Increased internal test bench failures correlate with increased field failures

Diesel Systems

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Audi meeting on 02/12/2010

Component sensitivity

1. **Metal spatters in roller support C3 coating**
   Metal spatters significantly reduced through optimization of plants
   5/2008 Sensitivity to small metal spatters with EN590/ BDF570 verified from 5/2008.
2. **Roller with fusing**
   To select rollers with fusing, the straightedge test was introduced in 5/2008.
   The conversion of the roller edge end to C2 in 5/2009 eliminated the fusing.

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4) Good pumps

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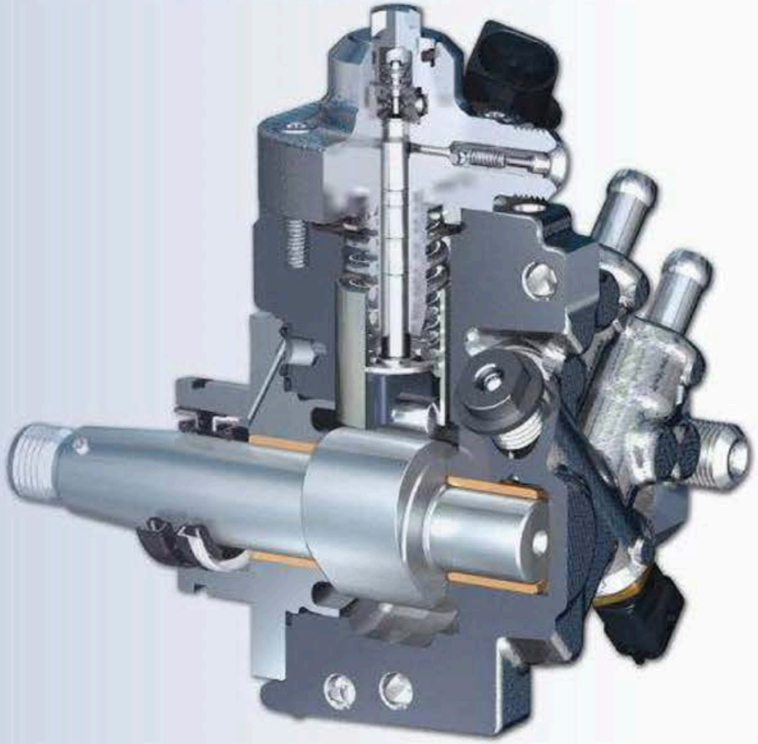

Diesel Systems

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Audi meeting on 02/12/2010

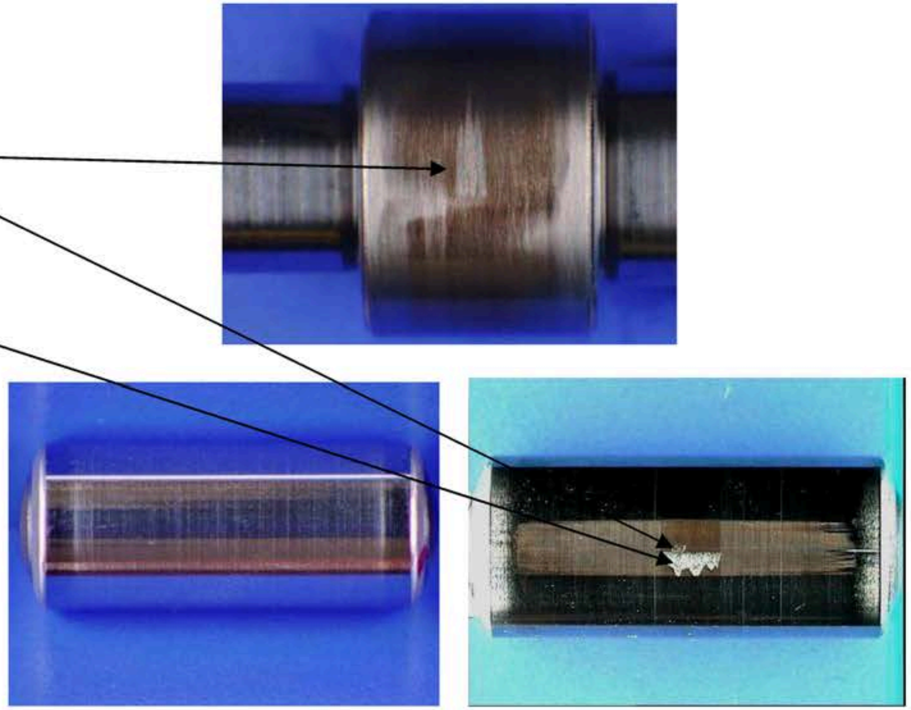
TF AUDI [redacted]: Good pump (2009-CP4_0685)

5,125 km (no failure)

Summary analysis results

→ Transfer of material from roller to cam

→ Braking flat from non-starter



Left roller   Right roller

Interpretation:
Roll does not start when engine is started (sluggish)

6 of 13 OK pumps from [redacted] have the same symptoms.
Preliminary damage does not necessarily result in failure (failure primarily due to continued driving with poor fuel).
Experience from initial reappear tests.

Diesel Systems

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5) Hypotheses

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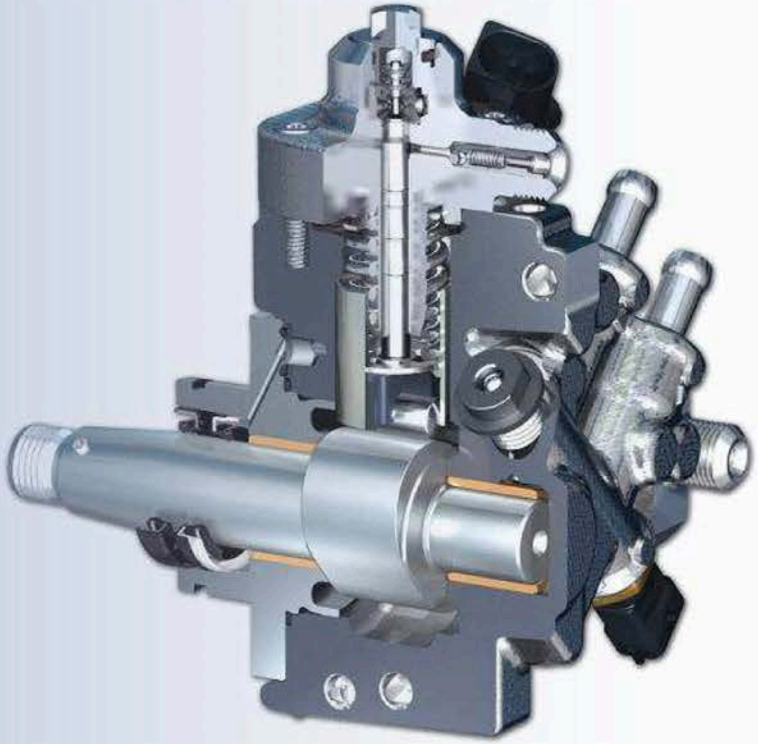

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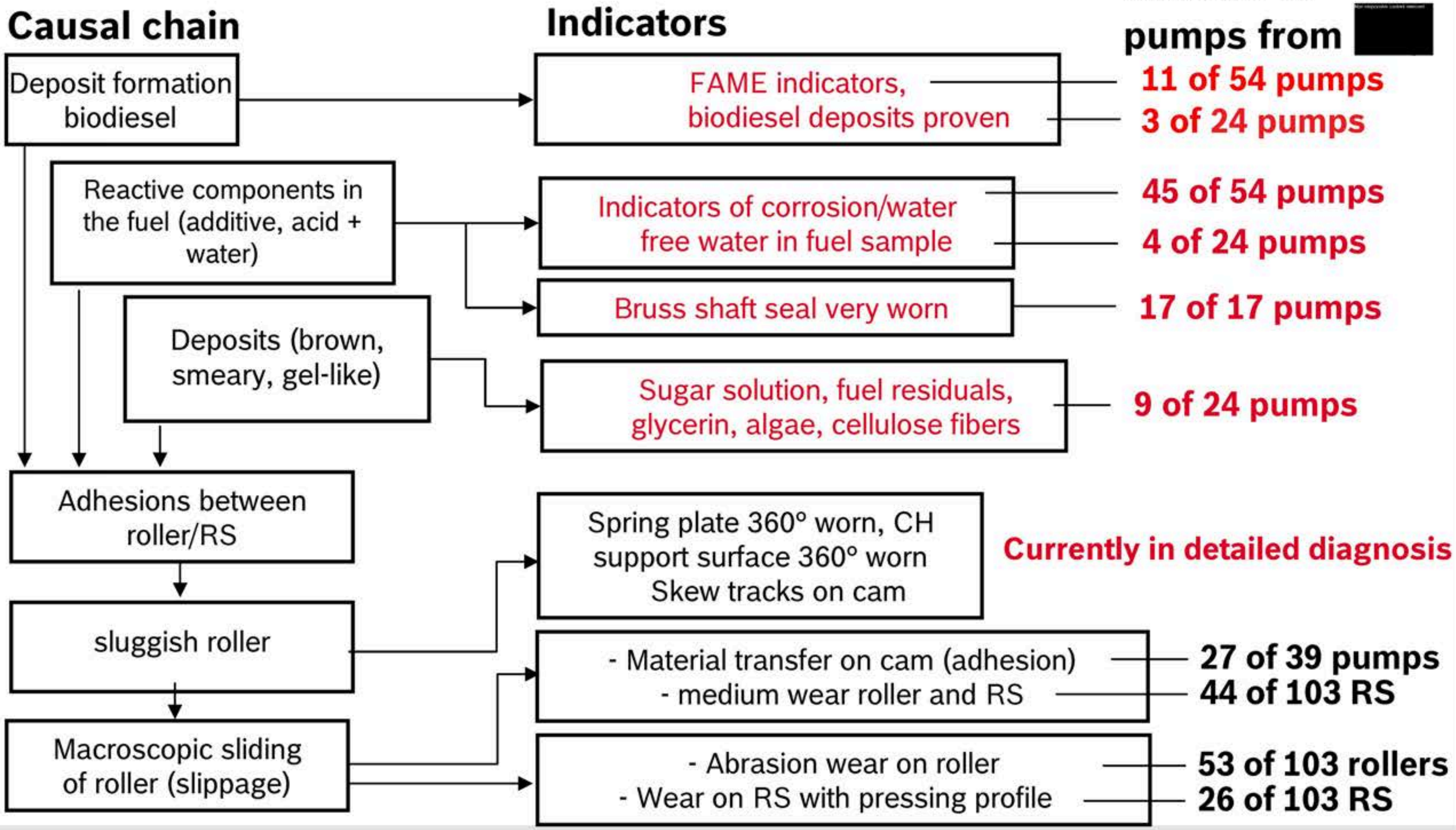
Potential damage based on hypotheses 3 and 4
(aged fuel with presence of water)



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Differences between CP4.2 and CP4.1

Hypotheses: Based on poor start-up of the pump (analysis of good pumps), the following hypotheses for the differences can be examined:

1. Different start/pressure build up speed between 4-cylinder and 6-cylinder engine -> start-up worse with poor-quality fuels
2. Different position of roller on cam when shutting down engine. Mounting situation of pump on 4/6-cylinder engine
3. Belt tension during pump start-up (pre-tension)
4. Different flow patterns in pump interior (no influence)

Further work:

High-speed camera & start-up examinations with poor quality fuel 2/26/2010

Damage case with stopped (seized) roller can be reproduced with reappear test and Arctic Diesel.

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6) Anti-wear package 1

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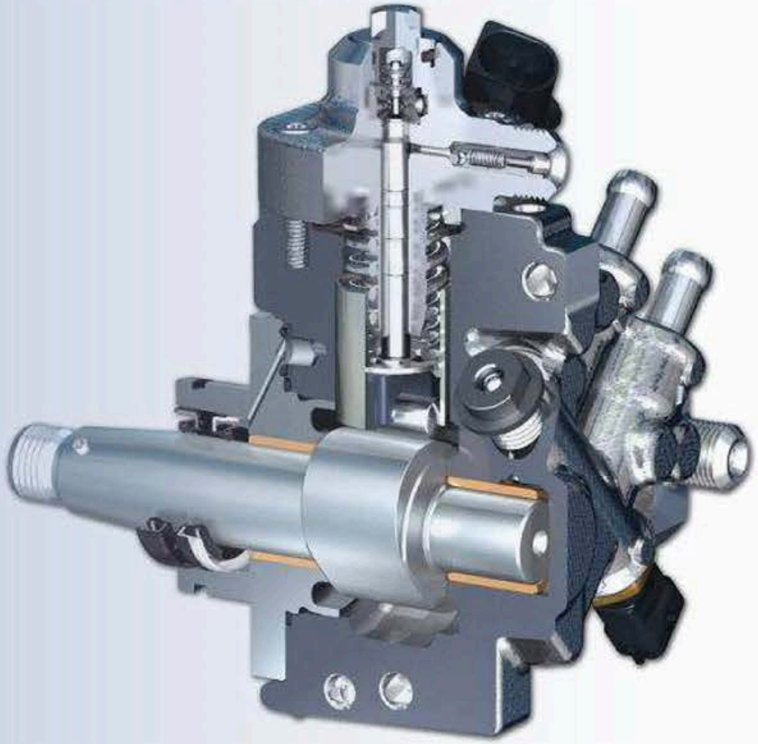

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Audi meeting on 02/12/2010

Anti-wear package 1 (task; features)

Assignment

Increase robustness of drivetrain by increasing the height of the lubricating film between roller support bore and roller.

Features of anti-wear package 1

1) Reduction of roller support roughness in combination with change to C2 layer on roller support.

2) Reduction of roller play by shifting average tolerance and tolerance range of roller support bore.

Results from simulation: Increase in robustness of ~ 50%*

(*compared to today's borderline tolerances)

Further work: Verification & RP1 **by WK8**

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Introduction of anti-wear package 1 in current series

Status

Basic test of C2.1 layer incl. release for 3 customers with EN590 & ASTM975 (US fuel) available. No engine start/stop test for ASTM975. Verification with poorly lubricating fuel (kerosene, Arctic, aged biodiesel, ...) started.

Open items

Verification of reduced play

• Risk assessment with DRBFMpositive	done
• Borderline part provision	done
• Functional & endurance runs	see schedule

Audi meeting on 02/12/2010

Verification of RP1 in overload tests

WK5

Level	Target number		Status	End date
Tappet "good" after visual inspection of C3 RS	2	150h		WK5
Tappet "bad" after visual inspection of C3 RS	2	150h	100% 100%	WK5
Best of series C2.1 with RP1 (24µm)	2	150		WK6
	20			WK
	36	400h		WK
	12	1,000h		WK
	24	2,000h		Done WK
	12	400 h		Done WK

Will be revised & submitted later

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7) Robustness increase based on Stribeck curves

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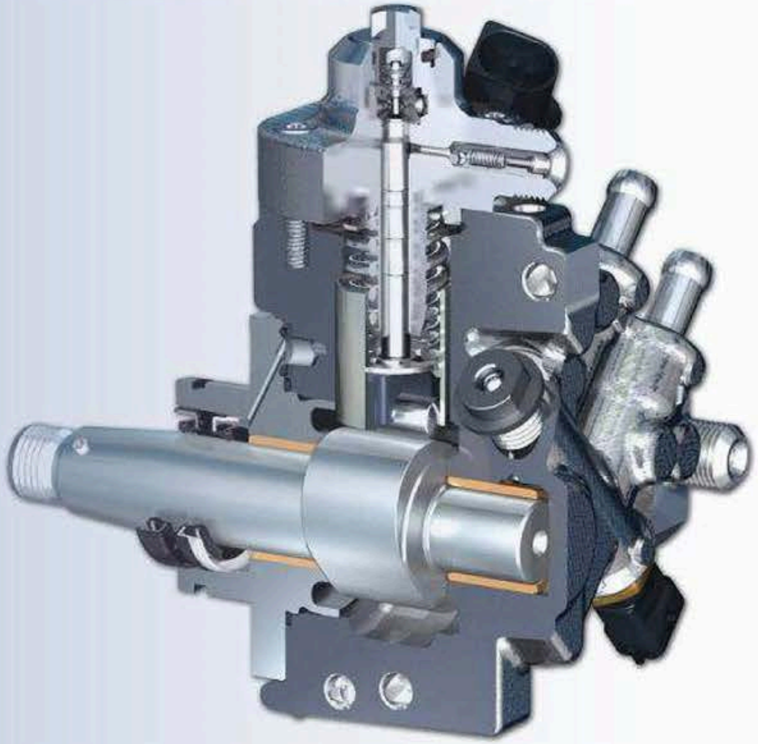

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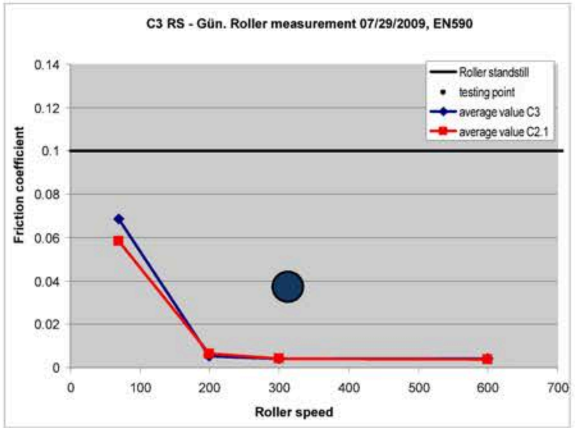
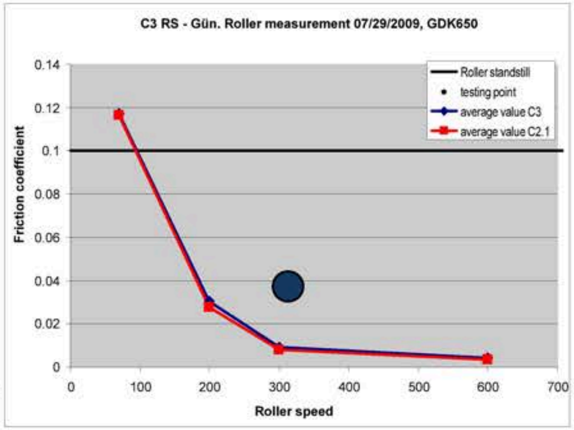
Comparison of layer system* C3-C2.1 on friction coefficient test bench at

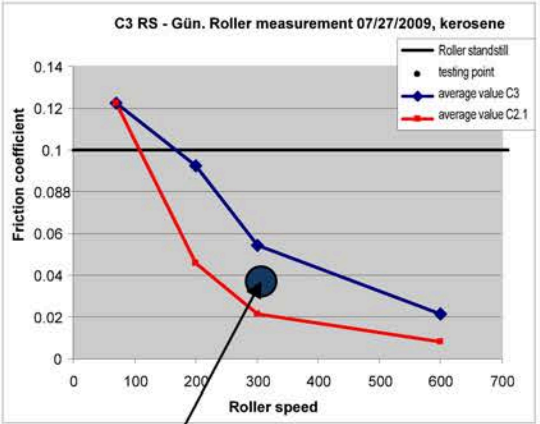
EN 590



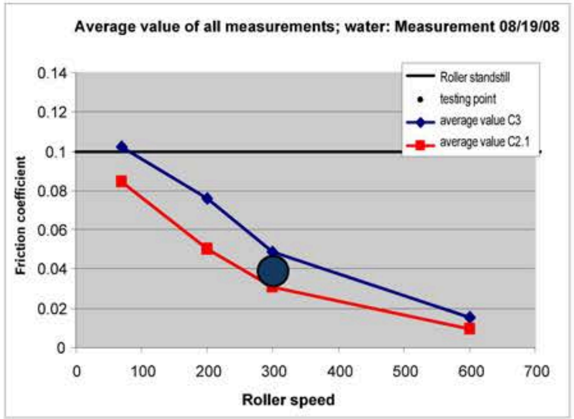
BDF 650



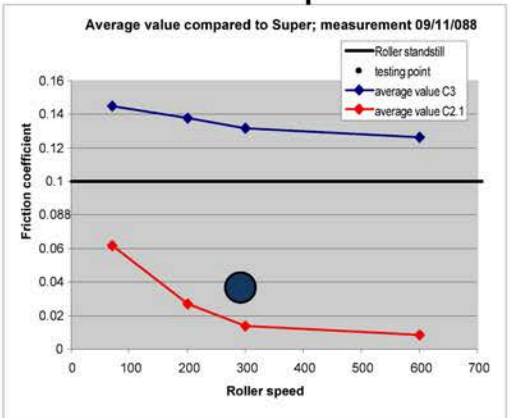
Kerosene



Water



100% Super



Assessment criterion:
friction coefficient

***average comparable play**

Diesel Systems

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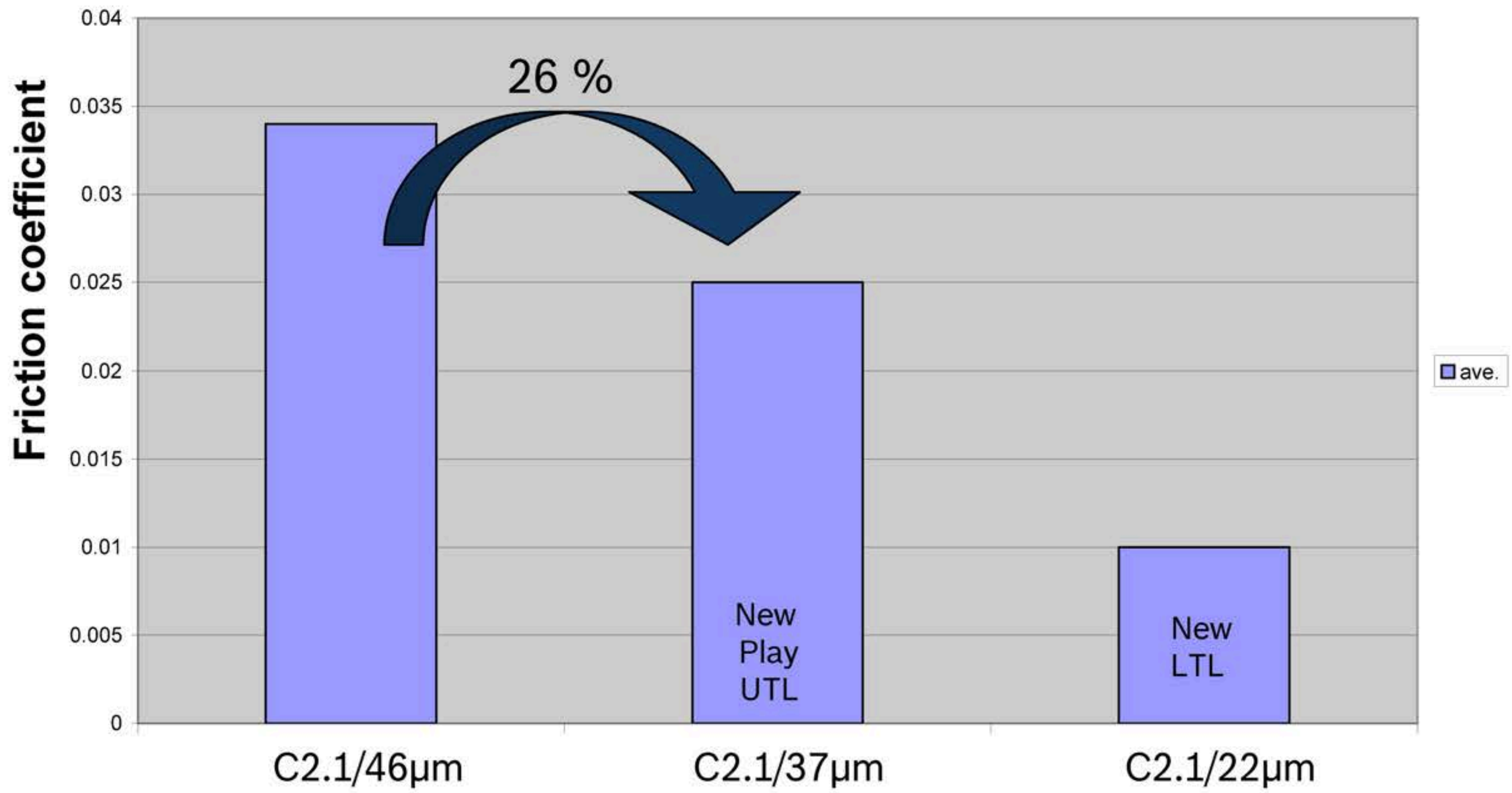
Examination with viscosity 1.4mm²/s @40°C (Arctic Diesel)

Testing point 300rpm



Diesel Systems

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8) Assessment of measures

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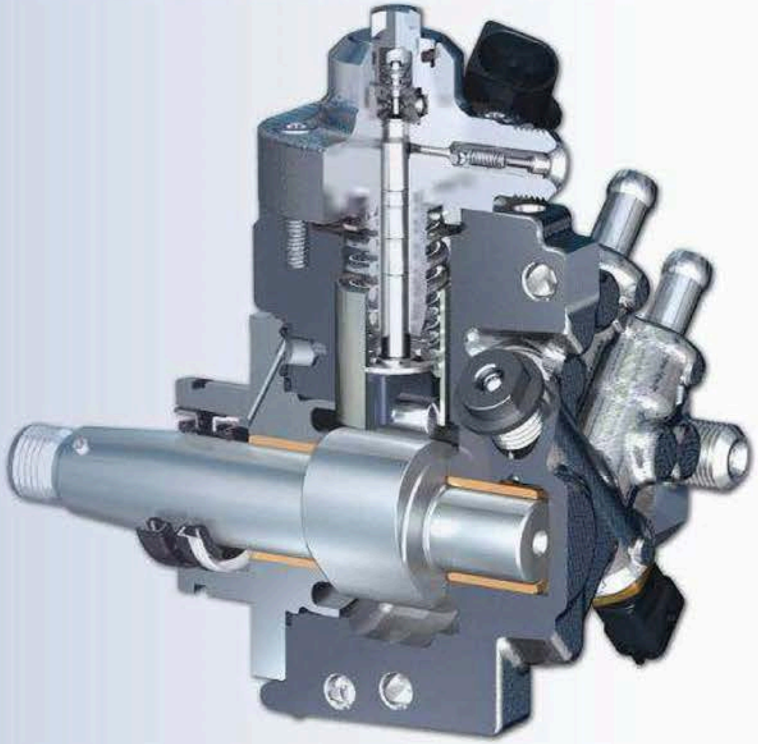

Diesel Systems

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Audi meeting on 02/12/2010

Effectiveness of robustness system:

Fuel quality	Problem	Series production	RP1	LLPx*	Water separator
EN590 / BDF520		+**	++**	++	
BDF650	Lubricity	(+)**	+**	+	
Kerosene	Viscosity	-	(+)	+	
Aged fuel	Gumming Lubricity	-	(-)	+*	
Water > 200ppm	Viscosity Lubricity Corrosion	-	-	-	+

*LLPx: Dependent on examination of differences between Cp4.2 and CP4.1, as well as results of FCF and WCF test with RP1. Definition of measures in the next 8 weeks.

** with C coated piston (USA)

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1. Ishikawa of influencing factors
2. Analysis of failed pumps / fuels
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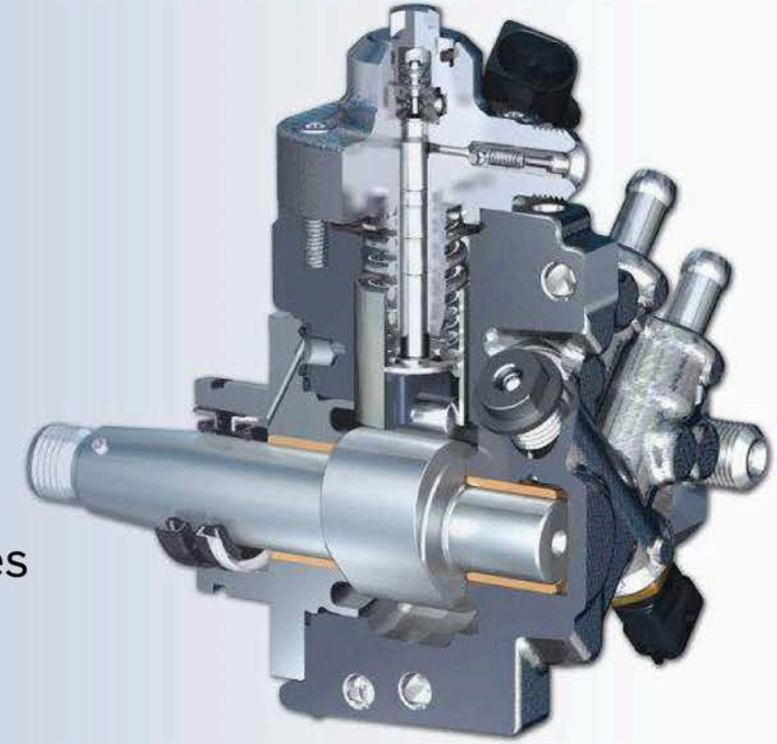

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1) Ishikawa of influencing factors

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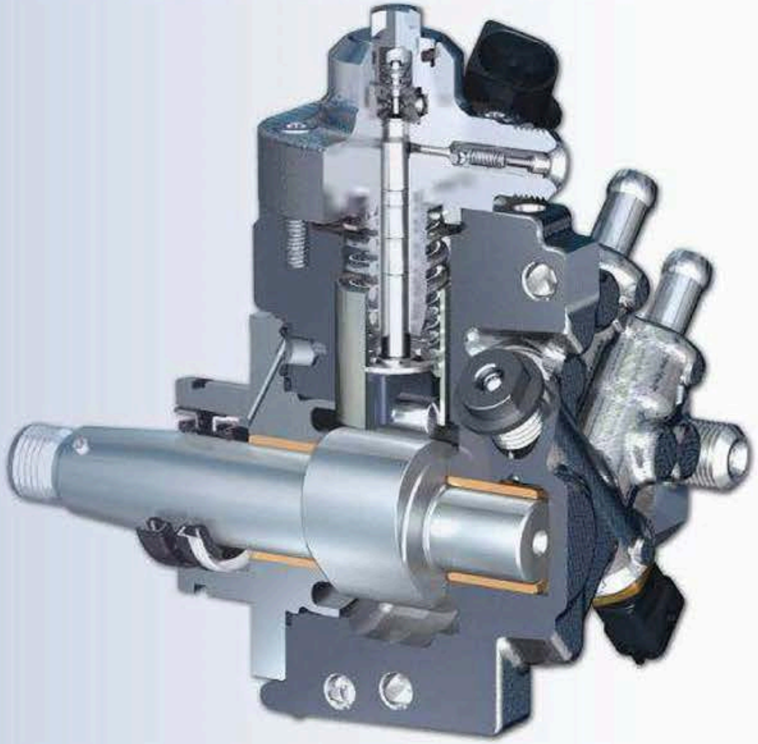

Diesel Systems

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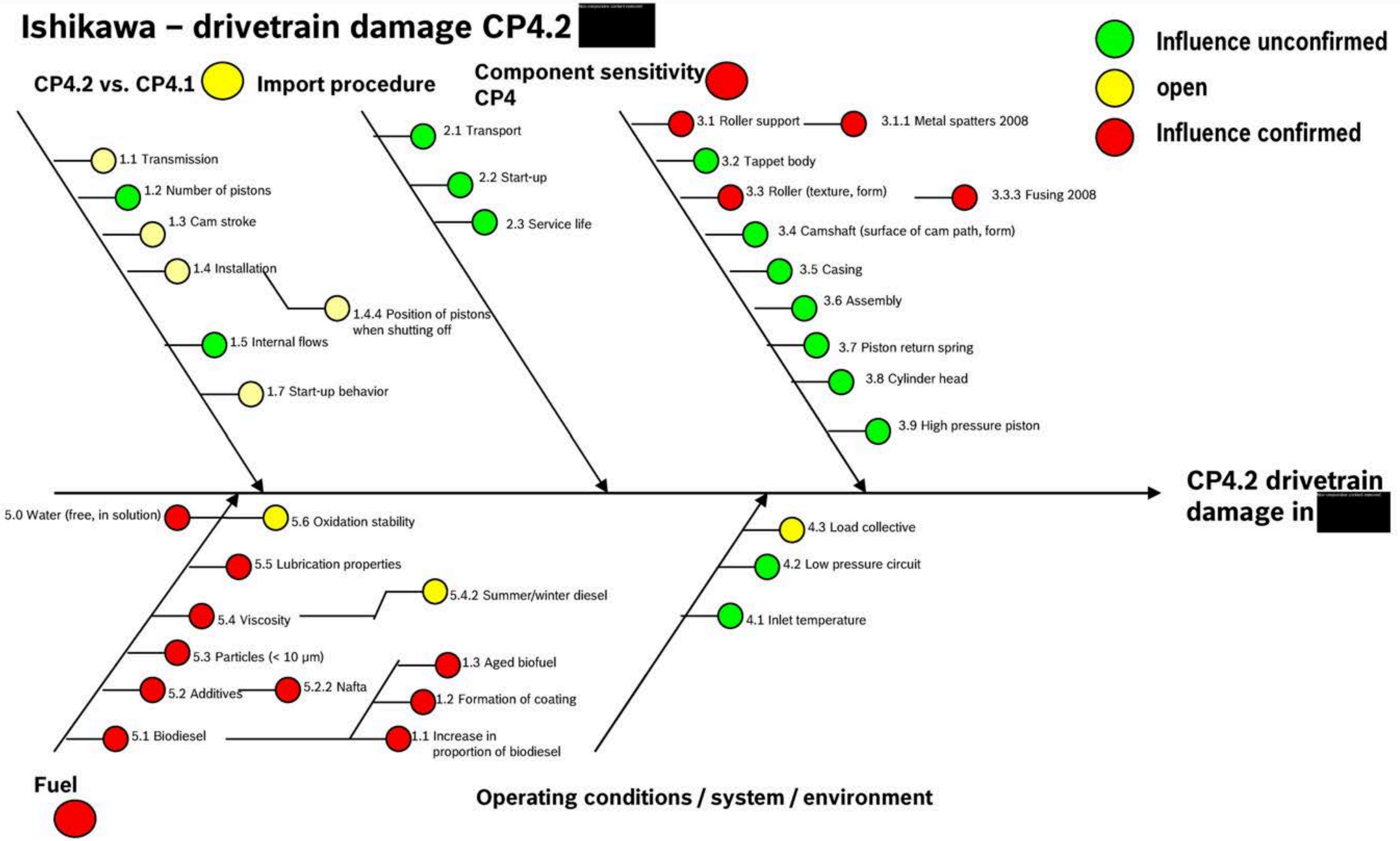
Audi meeting on 02/12/2010

Ishikawa – drivetrain damage CP4.2 [redacted]



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Audi meeting

Audi meeting on 02/12/2010

Ishikawa – drivetrain damage CP4.2

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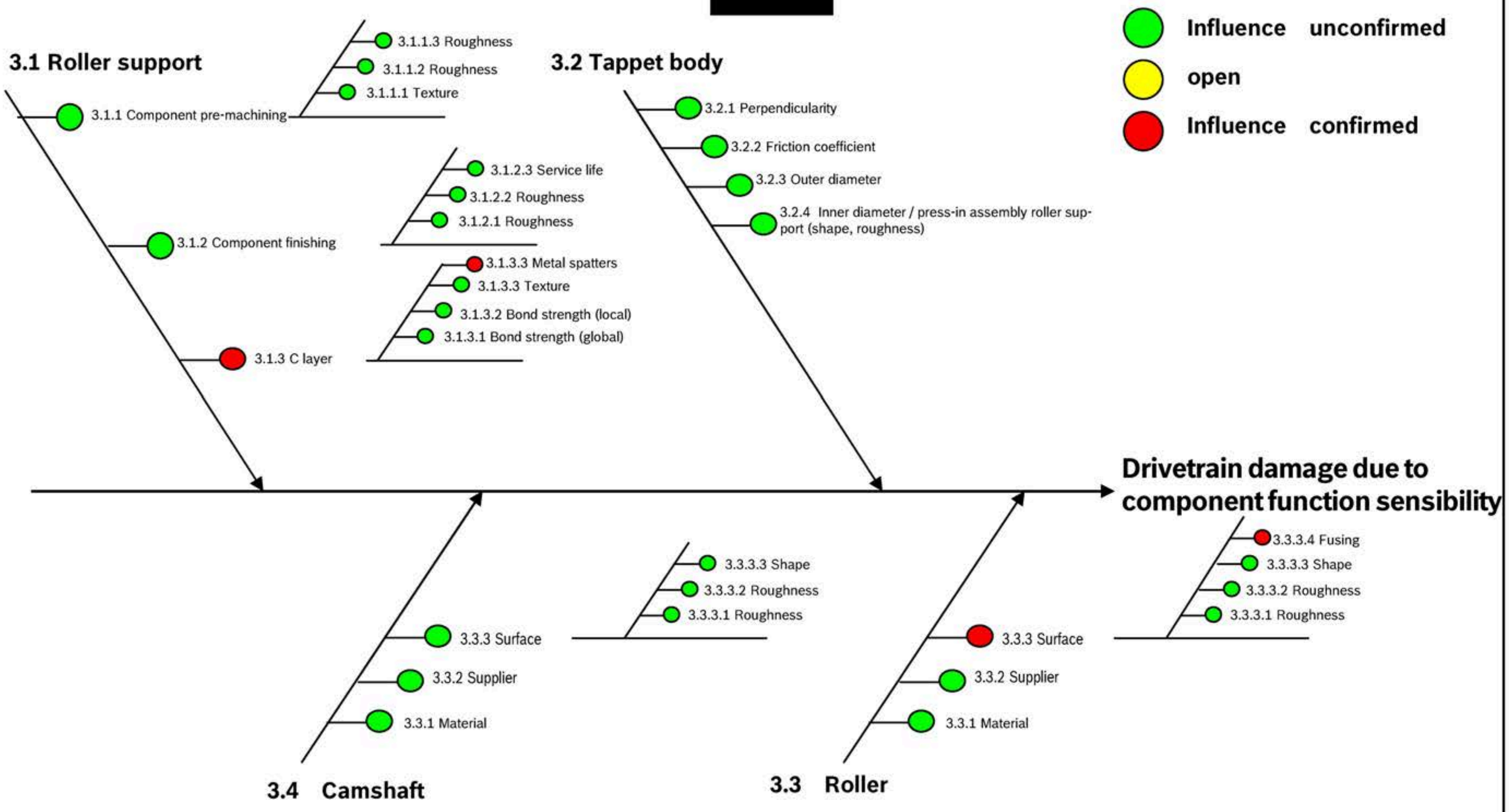

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Summary of areas of action from Ishikawa:

1. Fuel influence
2. Component sensitivity: Metal spatters / fusing
3. Differences between CP4.2 – CP4.1 in application and design

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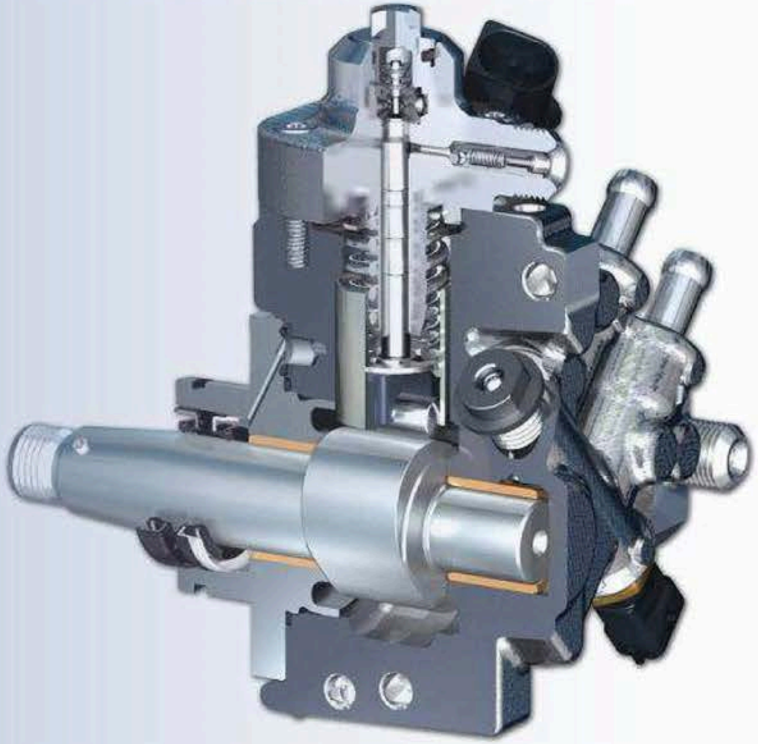
2) Analysis of failed pumps / fuels

[redacted]



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Determination of causes for failure focus [redacted]

Analysis of field pumps and fuel samples from [redacted]

- FAME deposits — 11 of 54 pumps
- Corrosion indicators, evidence of water — 45 of 54 pumps
- Free water in fuel sample — 4 of 24 samples
- Cellulose residue, algae, glycerin — 9 of 24 pumps
- Heavy wear of shaft seal — 17 of 17 pumps
- Good pumps with preliminary damage - [redacted] — 6 of 13 pumps

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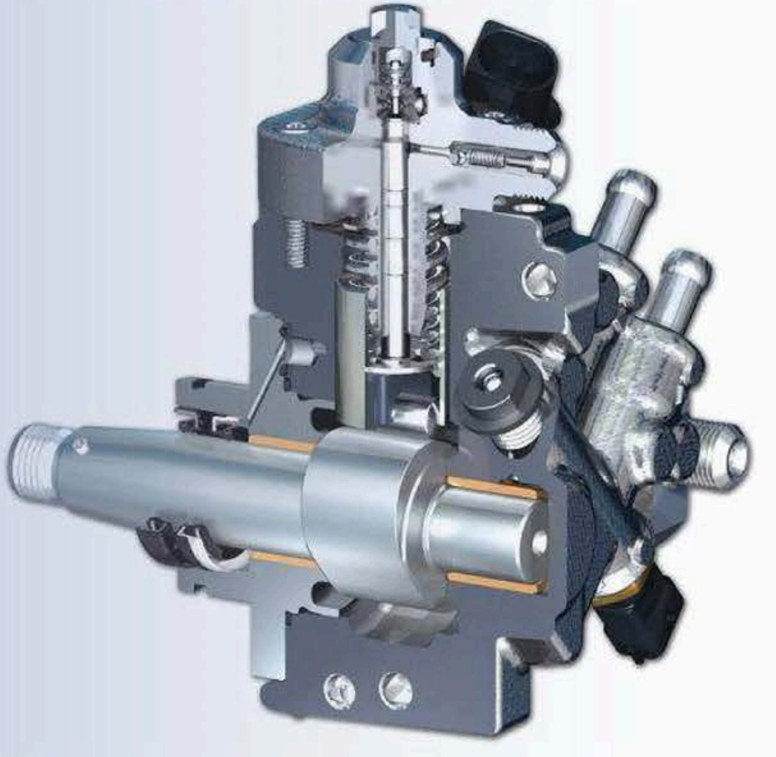
3) Component sensitivity

[redacted]



Diesel Systems

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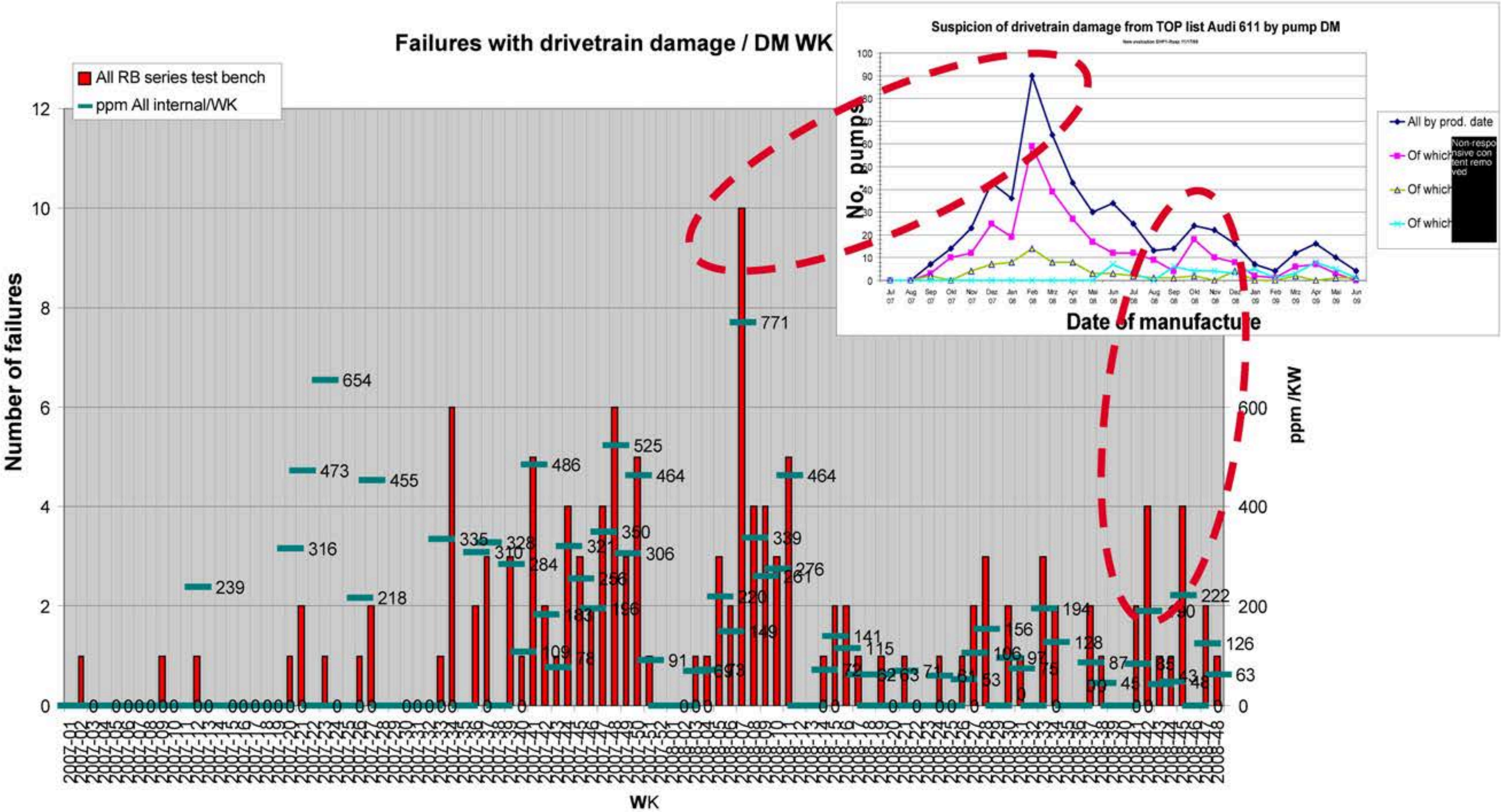
Audi meeting on 02/12/2010

Overview of failures, internal test bench & Field [redacted] (failure peaks)



-> **Increased internal test bench failures correlate with increased field failures**

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Component sensitivity

1. **Metal spatters in roller support C3 coating**

   Metal spatters significantly reduced through optimization of plants 5/2008 Sensitivity to small metal spatters with EN590/ BDF570 verified from 5/2008.

2. **Roller with fusing**

   To select rollers with fusing, the straightedge test was introduced in 5/2008.

   The conversion of the roller edge end to C2 in 5/2009 eliminated the fusing.

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4) Good pumps

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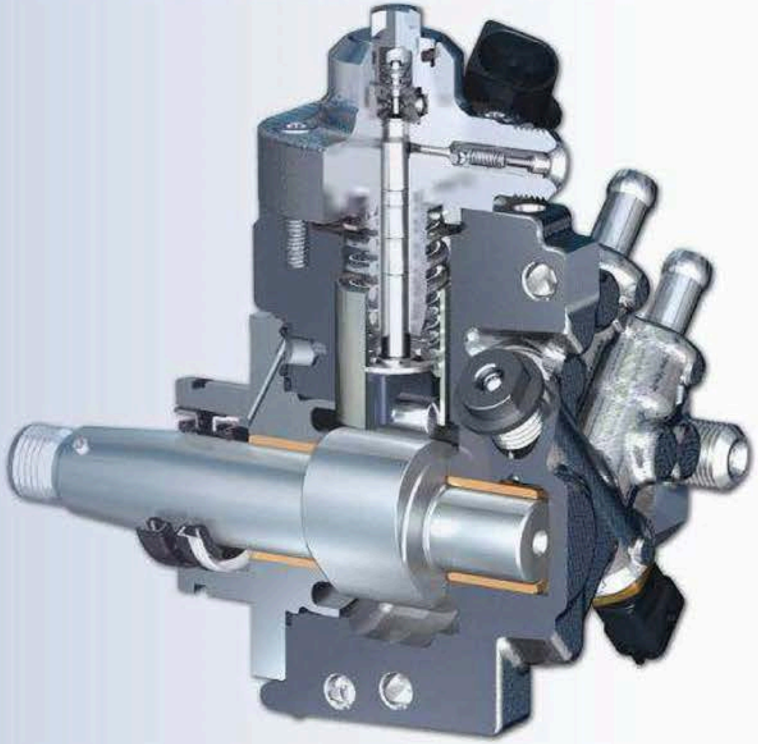

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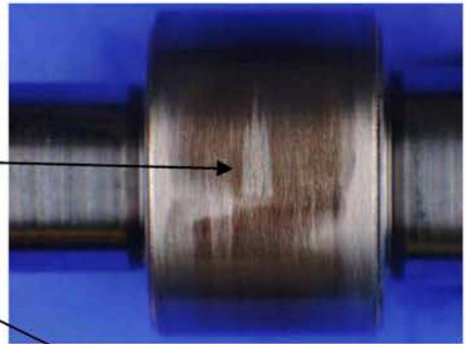
TF AUDI [redacted]: Good pump (2009-CP4_0685)

5,125 km (no failure)

Summary analysis results

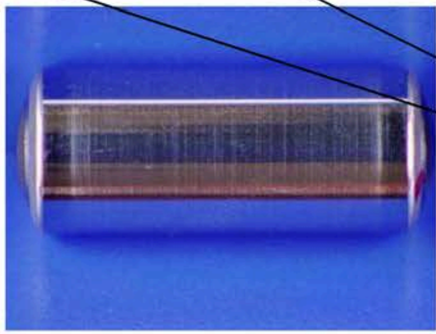
→ Transfer of material from roller to cam

→ Braking flat from non-starter

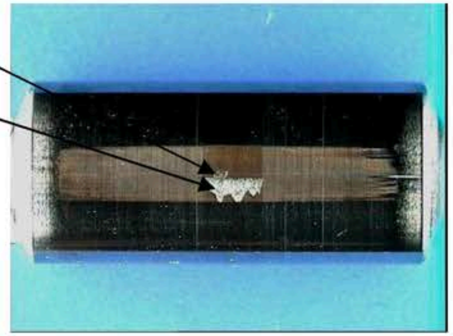


Interpretation:

Roll does not start when engine is started (sluggish)



Left roller



Right roller

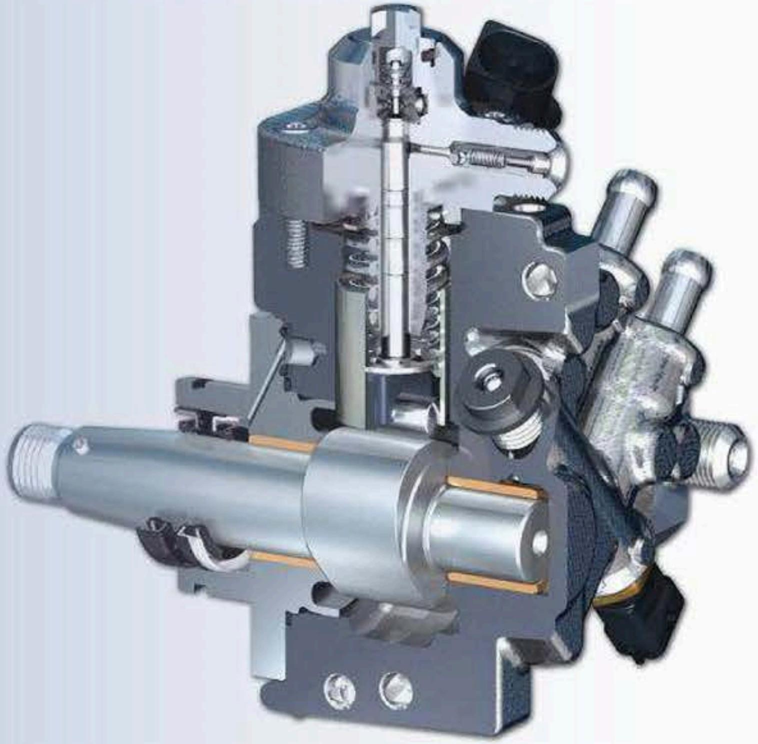
6 of 13 OK pumps from [redacted] have the same symptoms.

Preliminary damage does not necessarily result in failure (failure primarily due to continued driving with poor fuel).

Experience from initial reappear tests.

5) Hypotheses

[redacted]



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Audi meeting on 02/12/2010

Potential damage based on hypotheses 3 and 4
(aged fuel with presence of water)

Causal chain	Indicators	Number of pumps from Non-responsive content removed
Deposit formation biodiesel	FAME indicators, biodiesel deposits proven	11 of 54 pumps 3 of 24 pumps
Reactive components in the fuel (additive, acid + water)	Indicators of corrosion/water free water in fuel sample	45 of 54 pumps 4 of 24 pumps
	Bruss shaft seal very worn	17 of 17 pumps
Deposits (brown, smeary, gel-like)	Sugar solution, fuel residuals, glycerin, algae, cellulose fibers	9 of 24 pumps
Adhesions between roller/RS		
sluggish roller	Spring plate 360° worn, CH support surface 360° worn Skew tracks on cam	Currently in detailed diagnosis
Macroscopic sliding of roller (slippage)	- Material transfer on cam (adhesion) - medium wear roller and RS	27 of 39 pumps 44 of 103 RS
	- Abrasion wear on roller - Wear on RS with pressing profile	53 of 103 rollers 26 of 103 RS

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Audi meeting on 02/12/2010

Differences between CP4.2 and CP4.1

Hypotheses: Based on poor start-up of the pump (analysis of good pumps), the following hypotheses for the differences can be examined:

1. Different start/pressure build up speed between 4-cylinder and 6-cylinder engine -> start-up worse with poor-quality fuels
2. Different position of roller on cam when shutting down engine. Mounting situation of pump on 4/6-cylinder engine
3. Belt tension during pump start-up (pre-tension)
4. Different flow patterns in pump interior (no influence)

Further work:

High-speed camera & start-up examinations with poor quality fuel 2/26/2010

Damage case with stopped (seized) roller can be reproduced with reappear test and Arctic Diesel.

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6) Anti-wear package 1

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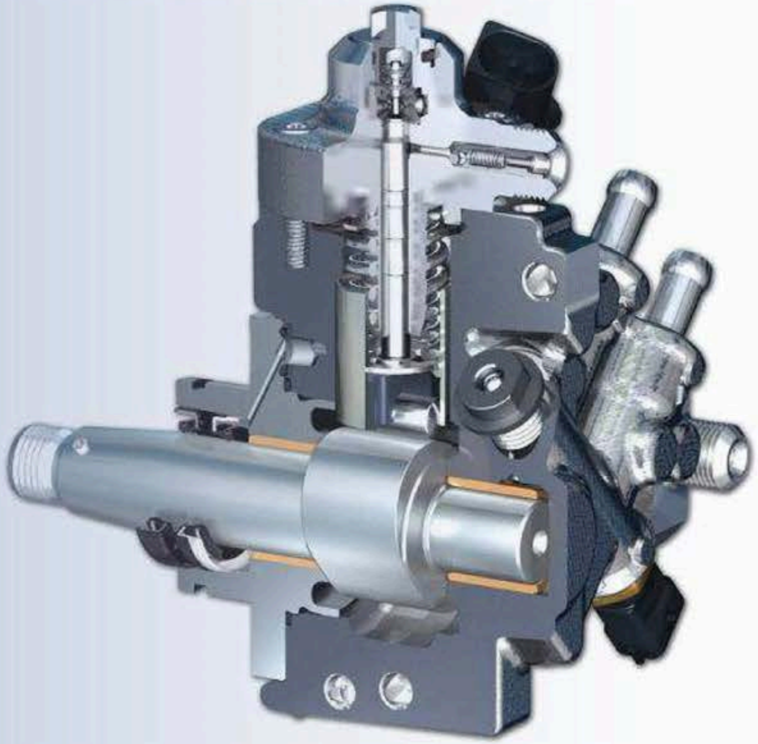

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Audi meeting on 02/12/2010

Anti-wear package 1 (task; features)

Assignment

Increase robustness of drivetrain by increasing the height of the lubricating film between roller support bore and roller.

Features of anti-wear package 1

1) Reduction of roller support roughness in combination with change to C2 layer on roller support.

2) Reduction of roller play by shifting average tolerance and tolerance range of roller support bore.

Results from simulation: Increase in robustness of ~ 50%*

(*compared to today's borderline tolerances)

Further work: Verification & RP1 **by WK8**

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Audi meeting on 02/12/2010

Introduction of anti-wear package 1 in current series

Status

Basic test of C2.1 layer incl. release for 3 customers with EN590 & ASTM975 (US fuel) available. No engine start/stop test for ASTM975. Verification with poorly lubricating fuel (kerosene, Arctic, aged biodiesel, ...) started.

Open items

Verification of reduced play

• Risk assessment with DRBFMpositive	done
• Borderline part provision	done
• Functional & endurance runs	see schedule

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Audi meeting on 02/12/2010

Verification of RP1 in overload tests

WK5

Level	Target number		Status	End date
Tappet "good" after visual inspection of C3 RS	2	150h		WK5
Tappet "bad" after visual inspection of C3 RS	2	150h	100% 100%	WK5
Best of series C2.1 with RP1 (24µm)	2	150		WK6
	20			WK
	36	400h		WK
	12	1,000h		WK
	24	2,000h		Done WK
	12	400 h		Done WK

Will be revised & submitted later

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7) Robustness increase based on Stribeck curves

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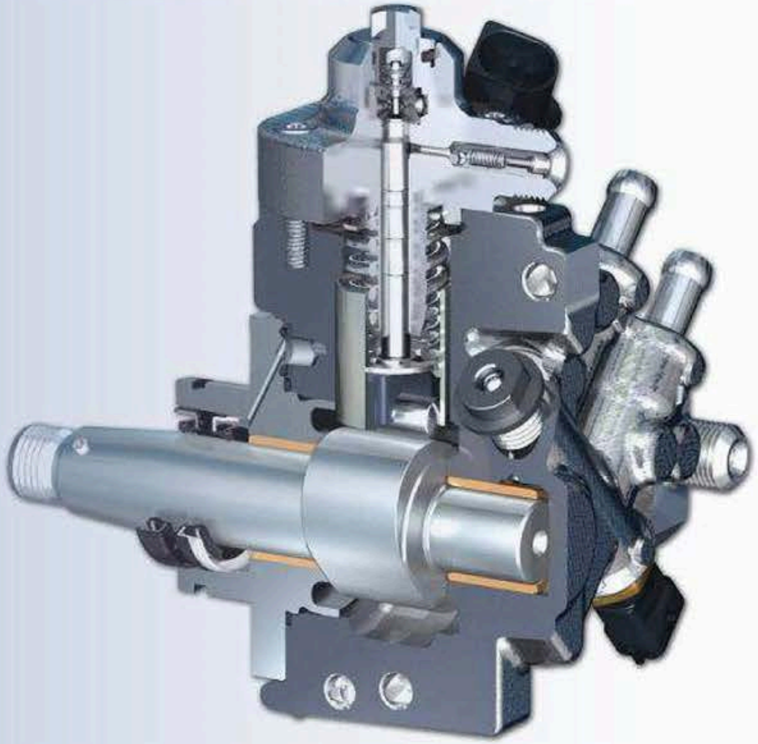

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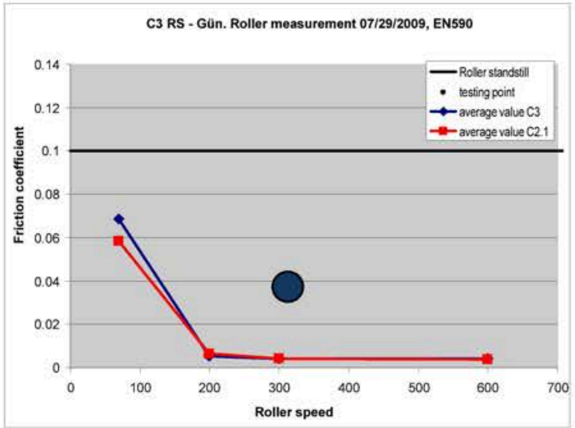
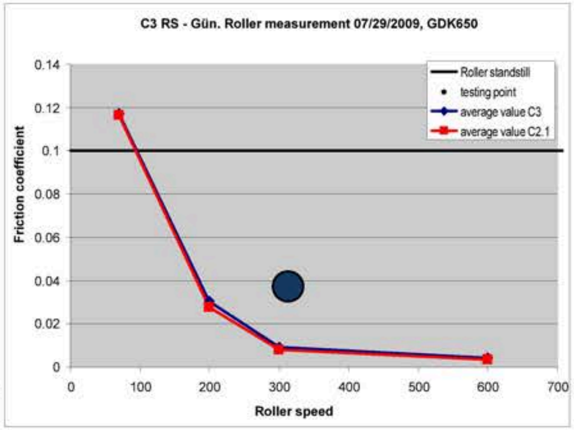
Audi meeting on 02/12/2010

Comparison of layer system* C3-C2.1 on friction coefficient test bench at

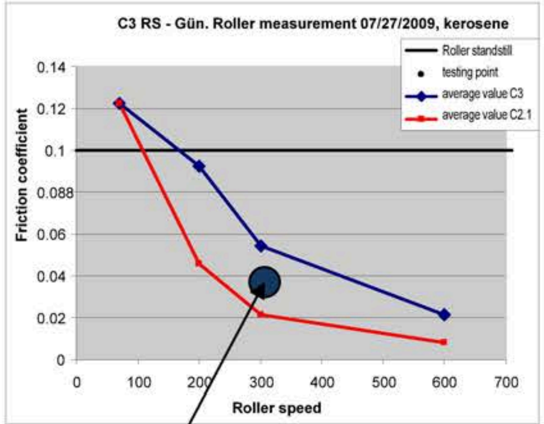
EN 590



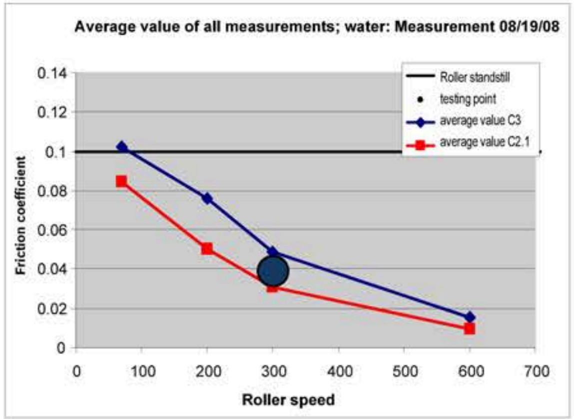
BDF 650



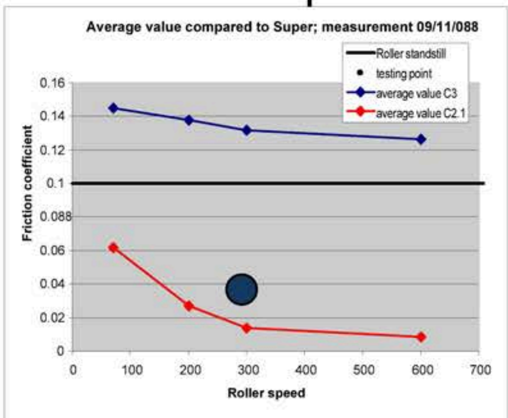
Kerosene



Water



100% Super



Assessment criterion:
friction coefficient

***average comparable play**

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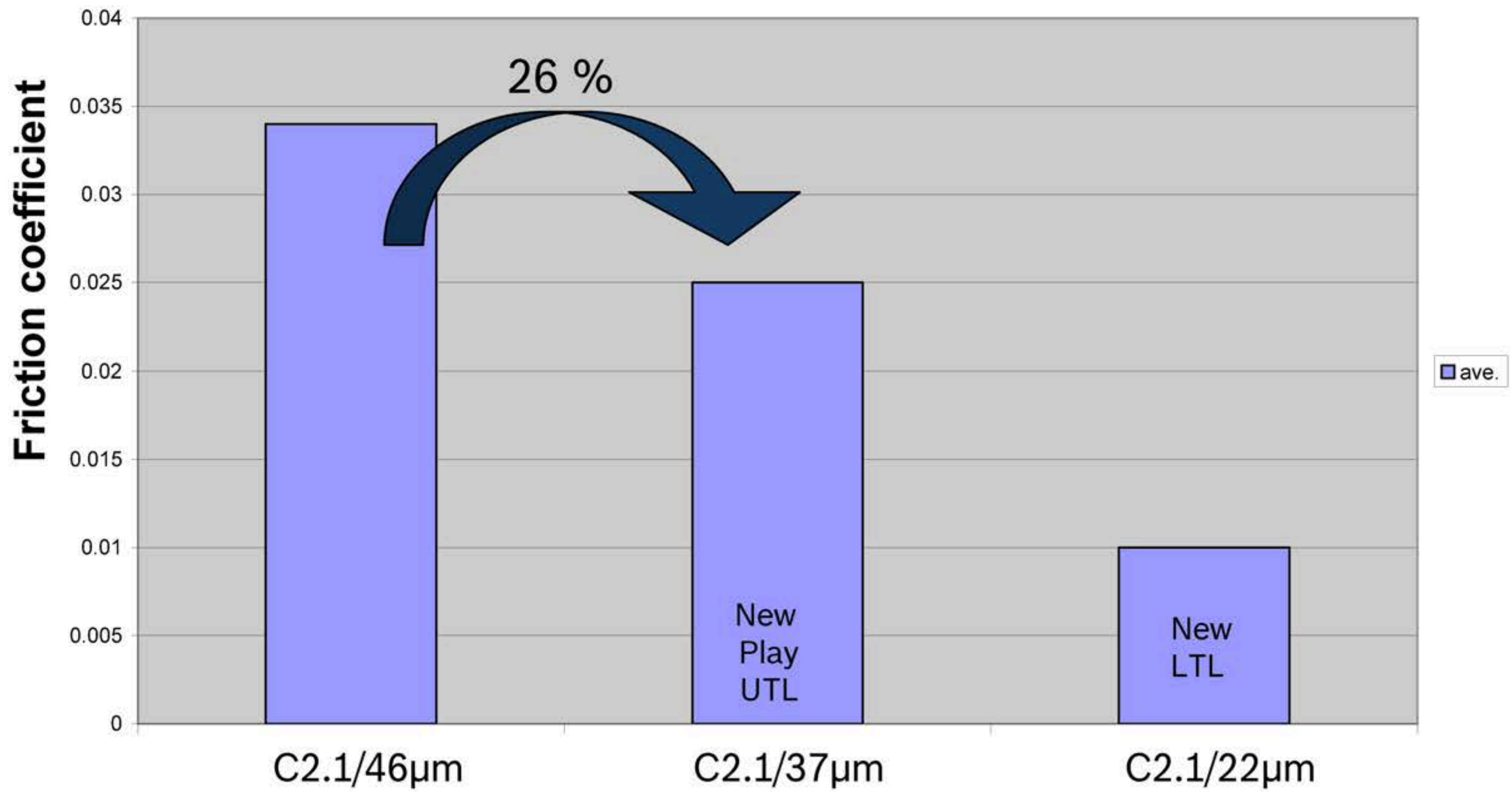
Audi meeting on 02/12/2010

Examination with viscosity 1.4mm²/s @40°C (Arctic Diesel)

Testing point 300rpm



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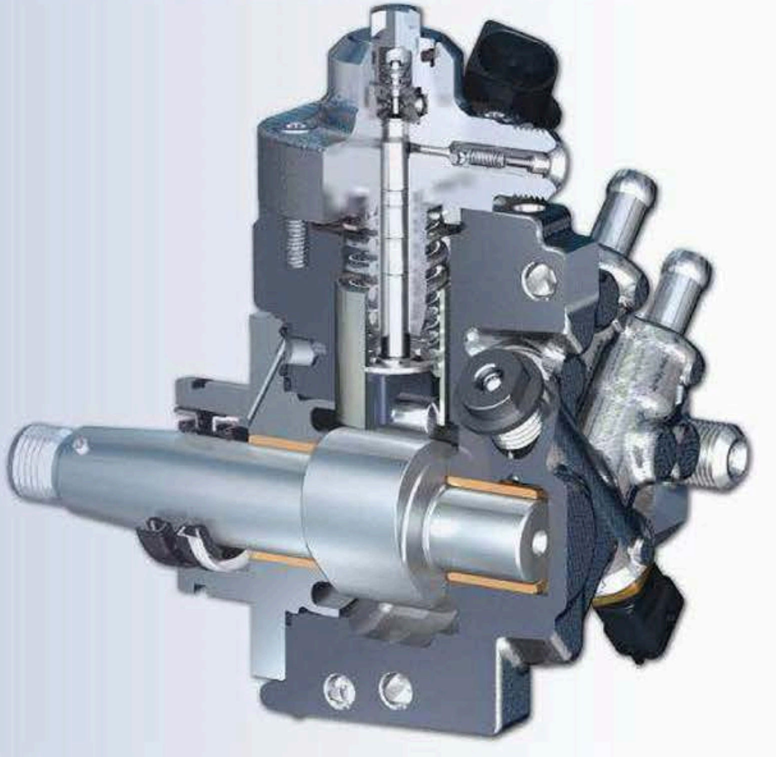
8) Assessment of measures

[redacted]



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Audi meeting on 02/12/2010

Effectiveness of robustness system:

Fuel quality	Problem	Series production	RP1	LLPx*	Water separator
EN590 / BDF520		+**	++**	++	
BDF650	Lubricity	(+)**	+**	+	
Kerosene	Viscosity	-	(+)	+	
Aged fuel	Gumming Lubricity	-	(-)	+*	
Water > 200ppm	Viscosity Lubricity Corrosion	-	-	-	+

*LLPx: Dependent on examination of differences between Cp4.2 and CP4.1, as well as results of FCF and WCF test with RP1. Definition of measures in the next 8 weeks.

** with C coated piston (USA)

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From | person responsible | Telephone | Fax [redacted]

[redacted]

Minutes

Recipient Participant

for info Audi:[redacted]

Host

Participants [redacted]

Line

minute

Organis.

Date/location **Audi [redacted], 02.12.2010**

Topic **Top meeting high-pressure fuel pump CP4.2**

1. For an executive discussion in [redacted] (WK9/10) with [redacted]
   - Presentation of how the anti-wear package 1 (RP1) works
   - Presentation of the anti-wear package 2 (RP2 or LLPx), including schedule

2. Proof of function RP2 (LLPx) WK14/10:
   - RP2 is required against seizing and sticking of the roller through the fuel components.
   - Objective: Robustness against the customary fluctuations in fuel quality

3. RP1:
   - Decision: After the successful testing, RP1 will be introduced for all V-Diesels Conclusion of tests E WK08/10
   - Bosch reports extra costs of [redacted]
   - Position Audi:
     - Cost-neutral series introduction RP1
     - A refusal of warranty for fuel, which doesn't meet the EN580, will not be accepted.
   - Position Bosch:
     - The RP1 introduction doesn't include the market approval for critical markets [redacted]; approval by Bosch according to the technical customer documentation (TCD).
     - Through the introduction of RP1 the acceptable water content of <200 ppm is not increased
   - The clarification of the extra costs and the warranty takes place following the series introduction

4. Comparison CP4.1 / CP4.2
   - In comparison with CP4.1, CP4.2 shows higher failure rates. The reasons must be determined as soon as possible. The results must be included in RP2

5. Water separator
   - Audi develops a high-performance water separator, including sensor
   - No longer used in 2010

[redacted]

Appendices: Presentations by Audi and Bosch

Audi
Vorsprung durch Technik

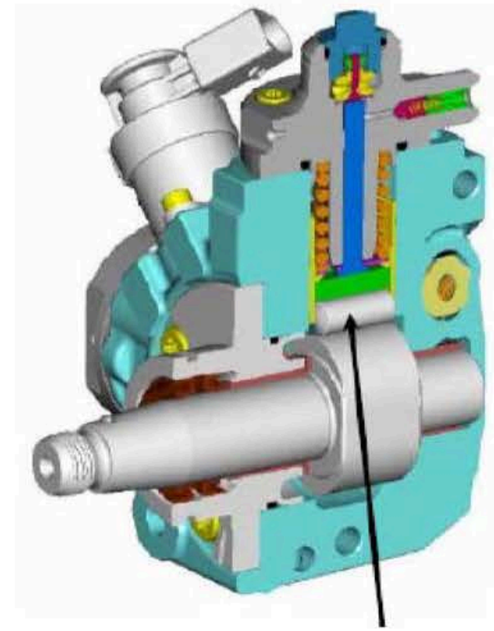
Drivetrain damage, high-pressure diesel fuel pump CP4.2

TOP meeting between Bosch and Audi on 02/12/2010 in Non-responsive content removed

Drivetrain damage, high-pressure diesel fuel pump CP4.2

The "sensitive heart" of the pump is the **drivetrain** with:

- Roller
- Roller support
- Twin camshaft



The **roller** with a very smooth surface must over the entire service life and at all operating conditions:

- glide smoothly in the C coated roller support
- roll over a very smooth cam without slippage

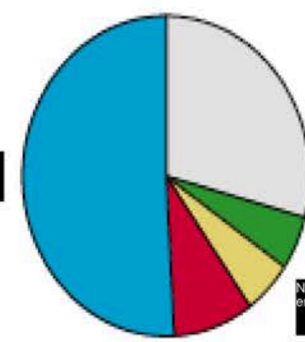
This is not achieved in all situations, **drivetrain damage** can occur in the case of **sluggishness** of the roller in the roller support due to production and country-specific fuel impacts.
The field failure rate for the CP4.2 (V6-TDI) is several times greater than that of the CP4.1 (R4-CR).

Current field situation:

V6-TDI Audi – worldwide 1035 settlements/526 [redacted] of which...

- MY08 632 units / 338 [redacted] = critical production period
- MY09 377 units / 180 [redacted] = after package of measures 1 (see slide 3)
- MY10 26 units / 8 [redacted] = after package of measures 2 (see slide 3) [redacted]

V8-TDI – 1 case [redacted]
V12-TDI – 2 cases in [redacted]



[redacted]

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AUDI-CP4 field situation Non-responsive content removed

Status : 02.03.2010

AQUA: active quality analysis
Status as on 12/09-01.16.10 08:43 AM
Source/User Non-responsive content removed

Audi,*,Market : [redacted] CP4.2
MY 2008 – 2011, offset : all (Max : 2)
Customer no. / Groups: High-pressure fuel pump

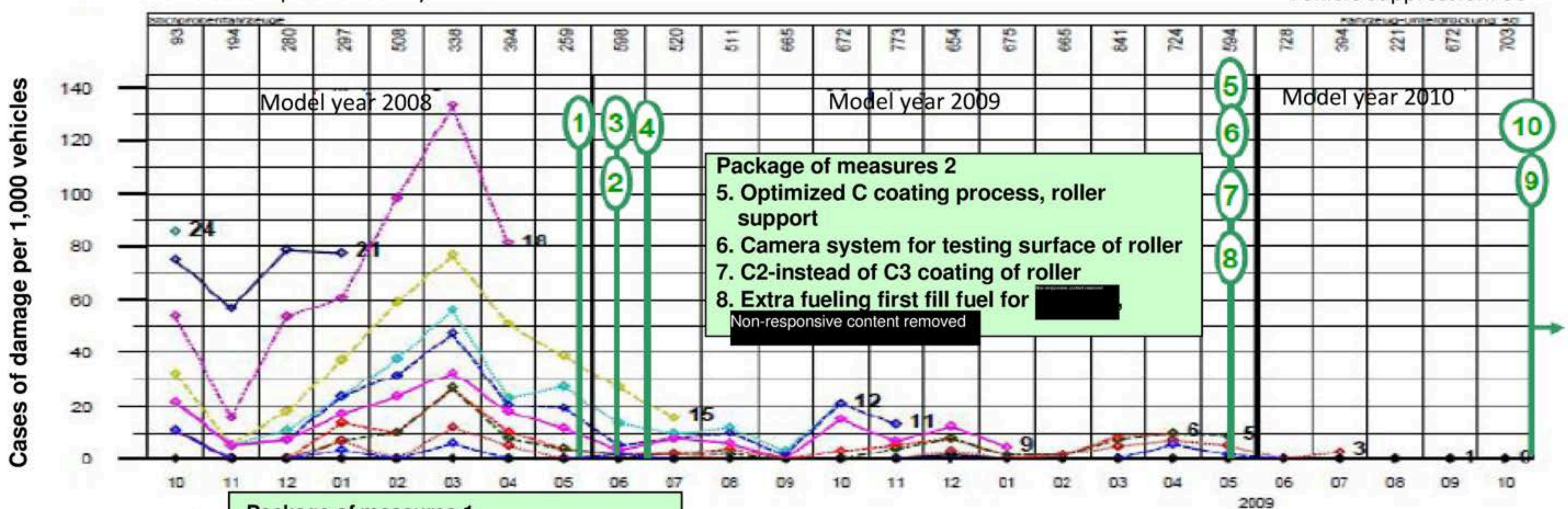
Confidential
Without PR - numbers
CNR 2374

CAMA | CAMB | CAMD | CANA | CANB | CANC | CAND | CASA | CASB | CASC | CASD | CATA | CATB | CCLA | CCMA | CCWA | CCWB | CDYA | CDYB | CDYC | CGK

MY	MIS 0	MIS 1	MIS 3	MIS 5	MIS 6	MIS 9	MIS 11	MIS 12	MIS 15	MIS 16	MIS 21	MIS 24	MY	Replacement	BD	SA10	SA17
2008	0.0	1.7	3.9	9.0	10.3	18.0	23.6	27.8	44.5	78.5	103.2	119.7	2008	100.0%	81.3%	75.6%	14.2%
2009	0.1	0.8	1.9	3.8	4.4	7.8	11.7	14.3	23.0				2009	97.2%		79.4%	13.1%
2010	0.0	0.0 -	2.1	3.1	3.1								2010	100.0%		50.0%	50.0%
Diff%	-100	-100	8.53	16.22	29.13											MECFAULT	MAJOR

Vehicles sampled randomly

Vehicle suppression: 50



Vehicles: 3,389+12,041+6 2.

Package of measures 1
1. Straightedge test on roller
2. Visual inspection roller after C coating.
3. Optimized C coating
4. Improved texture of roller (new second supplier)

6-13,841: MY: 200

Package of measures 3
9. HC wash of roller support (Jan 2010)
10. Implementation of anti-wear package 1, SOP Bosch (March 2010

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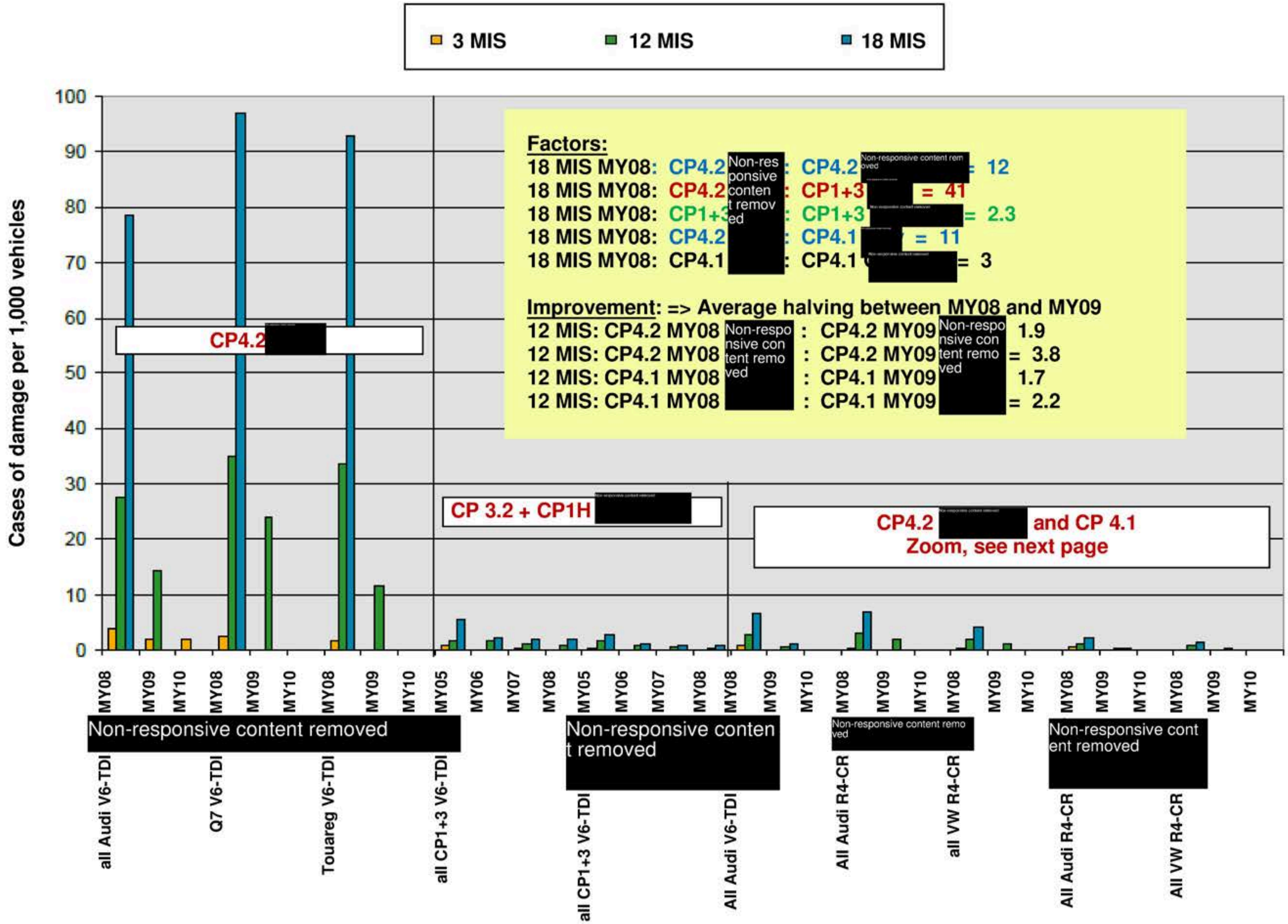
Drivetrain damage, high-pressure diesel fuel pump CP4.2

Comparison of damage case rates of Audi-VW /Non-responsive content removed / V6-TDI to R4 CR/CP4 to CP1+3



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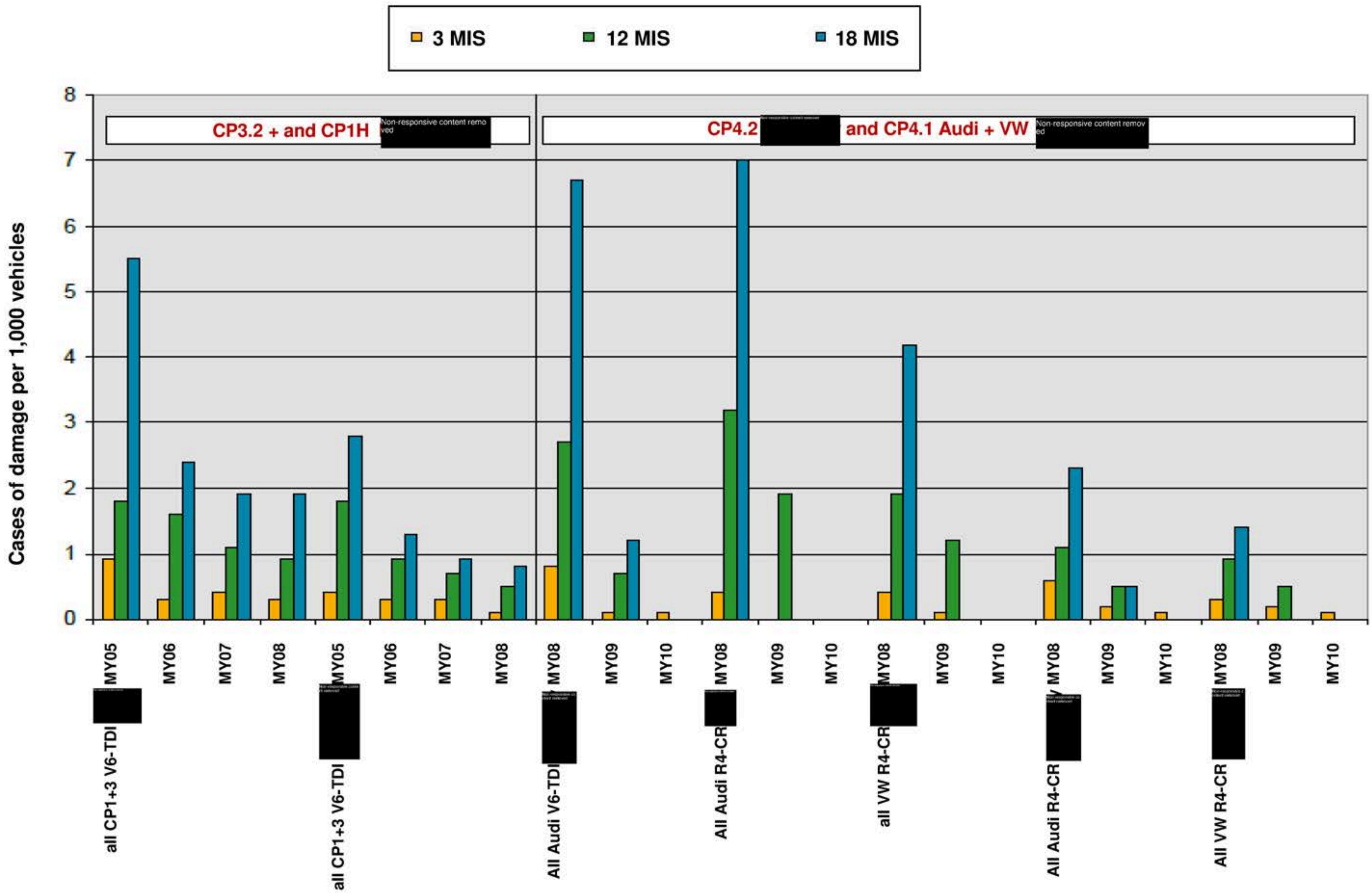
Drivetrain damage, high-pressure diesel fuel pump CP4.2

Comparison of damage case rates of Audi-VW [redacted] / V6-TDI to R4 R4-CR (without V6 [redacted]



Drivetrain damage, high-pressure diesel fuel pump CP4.2

- **Anti-wear package 1 (RP1):**
  - C2 coating on roller support instead of C3 for better surface roughness (Rv = 0.8 instead of 1.3 µm)
  - C2 coating also prevents metal splashes
  - Play reduction between roller / roller support by offsetting the tolerance band (18 - 40 µm instead of 24 - 46)
  - Bosch has specified extra costs of [redacted] no development costs.
- **Brief test and efficiency of RP1:**
  - Basic testing of C2 coating on account of use with competitors in 2010 has been concluded
  - Brief test with Arctic diesel - (was originally kerosene) →poor lubrication, lower viscosity fuel up to **WK 08/10** →Objective: Establish potential for improvement - RP1
  - Efficiency statement: Potential for improvement cannot be evaluated at present.
  - no measure in view of new main error hypothesis in [redacted] regarding "sluggishness due to the sticking" of the roller
- **Readiness for production and introduction date:**
  - Readiness for production - Bosch from **WK 09/10** ensured
  - Planned approval by Development + QA Bosch + Audi **start of WK 09/10**
  - Production deliveries Bosch from **WK 10/10** for comprehensive implementation in all V-diesel in the Group
  - First 400 parts initially planned for customer service implementation

Drivetrain damage, high-pressure diesel fuel pump CP4.2

- **Long term testing RP1 quantitative potential for improvement (e.g. in ER hours, etc.)**
  - Worst-case fuel VW Group / Bosch is defined →Testing from WK 12/10
  - "Aged" diesel with biodiesel 20% (B20) →1. Test running since WK 05/10

- **Anti-wear package 2 (RP2) is still open**
  - Possible objective: Avoid turned tappets, sticking or differences between the CP4.2 and CP4.1
  - Engine measurements R4 still not concluded → Deadline to be clarified
  - critical: may be necessary for new design and construction elements (no anti-turning lock today).

- **Fallback solution for high-pressure fuel pump CP1H or CP3 (1,650 bar) for EU4 markets:**

→ Requirement of QA middle 2010 in the case of insufficient efficiency of RP1 + RP2

→ Field situation, [redacted] (MIS18 / MY08): CP4.2 factor 41 greater than CP3+1 !!!

→ Implementation of CP1H or CP3 may have to be evaluated by N/EA-6 with regard to technical and timing factors.

Drivetrain damage, high-pressure diesel fuel pump CP4.2

- **Requirement - Bosch: →Introduction of water separator in the diesel filter**
  - Water separator with extraction capability in the main failure models Q7 and Touareg right from the start in series production (→efficiency in view of Bosch recommendation must still be evaluated)
  - Currently no available water separating technology for horizontal diesel filters in the Audi B / C7 series
  - Diesel filter manufacturer, Bosch, does not provide a water separation system
  - FIAT (connoisseur of the indigenous market) provides a water separator with sensor system and in some cases display symbol in the instrument cluster

- Non-responsive content removed [redacted]

Audi CP4 field situation **11.16.2010**

Management summary

- TOP Q meeting between RB and AUDI held on 10/28/2010.
  Worldwide failures in total of 2,635 Audi V6 TDI, 6 x V8-TDI and 12 x V12-TDI (CP4.2), distribution to countries, see page 7
  For the development of the failure situation see page 6.

- Since vehicle production date. 06/2009 very few failures in Q7 and VW Touareg in [redacted] but disproportionate increase in [redacted] RP1 introduced since 04/2010, effectiveness in the field still not sufficient.
  RP2 introduced (temperature drop in the right roller support) since 10.29.2010, effectiveness in the field is still to be proven (initial failure in [redacted] on 11.11.10).

- Results of the findings of failures in [redacted] show extensive abrasive wear of the roller and camshaft, which is a typical indication for use of low-viscosity fuels (e.g. kerosene).

- Use of on-site team in [redacted] since 11.08.2010 for the systematic analysis of the causes of failure with the support of RB. Results see Back-up.

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Audi CP4 field situation **11.16.2010**

Management summary

- USA testing
  - 2 failures of the Touareg NF Bin5 in Q-AL, 1 vehicle with previously damaged HPP
- Analysis
  - Both failures after 10,000 km with Master 04 (since 09.01.2010) **(Q7 with same data as Master 05 and all Touaregs with Master 03 no striking features)**
  - Fuel temperature in inflow of HPP: In driving mode, about 50 °C on average in the post heating max. temperature peaks up to about 100 ° C.
  - Presupply volume of tank EFP at engine start:
    - Master 03: Maximum delivery from start request (200 l / h) until uncritical inflow temperatures are reached
    - Master 04: requirement-based pumping (130 l/h) due to CO2 reduction and coagulation
  - Hypothesis: At hot start, high-pressure fuel pump is not sufficiently flushed with fresh fuel during a hot start with poor quality fuel (low boiling point, low viscosity).
- Measures
  - **Master 05** with maximum delivery when engine is started and at fuel temperature >70°C (same as Q7)
  - Bin5 dataset changed for market launch
  - EU5/EU4 changed for WK 45

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Audi CP4 field situation 11.16.2010

Management summary

Problem:

At engine start

→ mixed friction between the roller and roller support with poor quality fuel leads to delayed start-up of the roller (braking flats)

→ which in turn leads to a failure of the HPP

Other measures above and beyond TCD may be introduced. Optimization of cooling and lubrication of high-pressure fuel pump when starting the engine.

- Control of the EFP with terminal 15
- EFP control in after run with hot fuel temperatures for cooling the CP4
- EFP control through door contact (also for 6 bar tank system)

Dates:

→ SW specification 2 bar tank system by the end of WK 45
Achievement of the field activities in Non-responsive content removed by the end of 2010/start of 2011 is questionable.

→ SW specification 6 bar tank system to WK 47, EA approval WK 06/2011 Non-responsive content removed ??

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Audi CP4 field situation 11.16.2010

Management summary

- Pumps taken from the end of the line in the Non-responsive content removed plant had a thick deposit and pre-existing damage. Pumps in Non-responsive content removed were also slightly discolored. Vehicle measurements will take place shortly in Non-responsive content removed

- Pumps removed when the engines were delivered to the Non-responsive content removed plant had no build-up of deposits or other damage.
  Therefore, the pre-existing damage is caused most likely by the fuel and implementation process in Non-responsive content removed and not in the engine plant in Non-responsive content removed

- Production in Non-responsive content removed A6 2.7l remain closed. New vehicle project Q7 3.0l EU4 is not approved. 102 Workshop complaints, 79 warranty settlements, including 8 x with RP1 of about 4,300 vehicles.

- Further action: From each of 12 assembly lines in 8 car plants
  5 pumps will be removed and analyzed (60 in all) In addition, joint analysis of the processes carried out on site in the plants.
  25 of these pumps have already been delivered to Bosch.

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Audi CP4 field situation 11.16.2010

Management summary

- Provisional delivery of 130 pumps (40[redacted] 40 [redacted] 50 [redacted]) with RP2. So far, 40 units are mounted in [redacted] and about 30 in [redacted] Replacement in faulty vehicles in order to prove effectiveness in actual operation. First failure of RP2 on 11/11/2010 in [redacted] approx. 2,000 km after installation. Vehicle checked in WK 46 by local Audi/Bosch team.

- It was suggested that risk should be shared for EU-4 markets until the end of testing. No agreement was reached in follow-up talks in September 2010 either.

- Negotiations on who would cover the costs of RP1/OV were held in September. No agreement reached. Bosch will cover the cost of RP2.

- Preventive measures are planned in the field (approx. 34,000 vehicles) for the markets of [redacted] until RP2 is launched. Audi already orders spare part pumps and fuel hoses, the first deliveries have been carried out.

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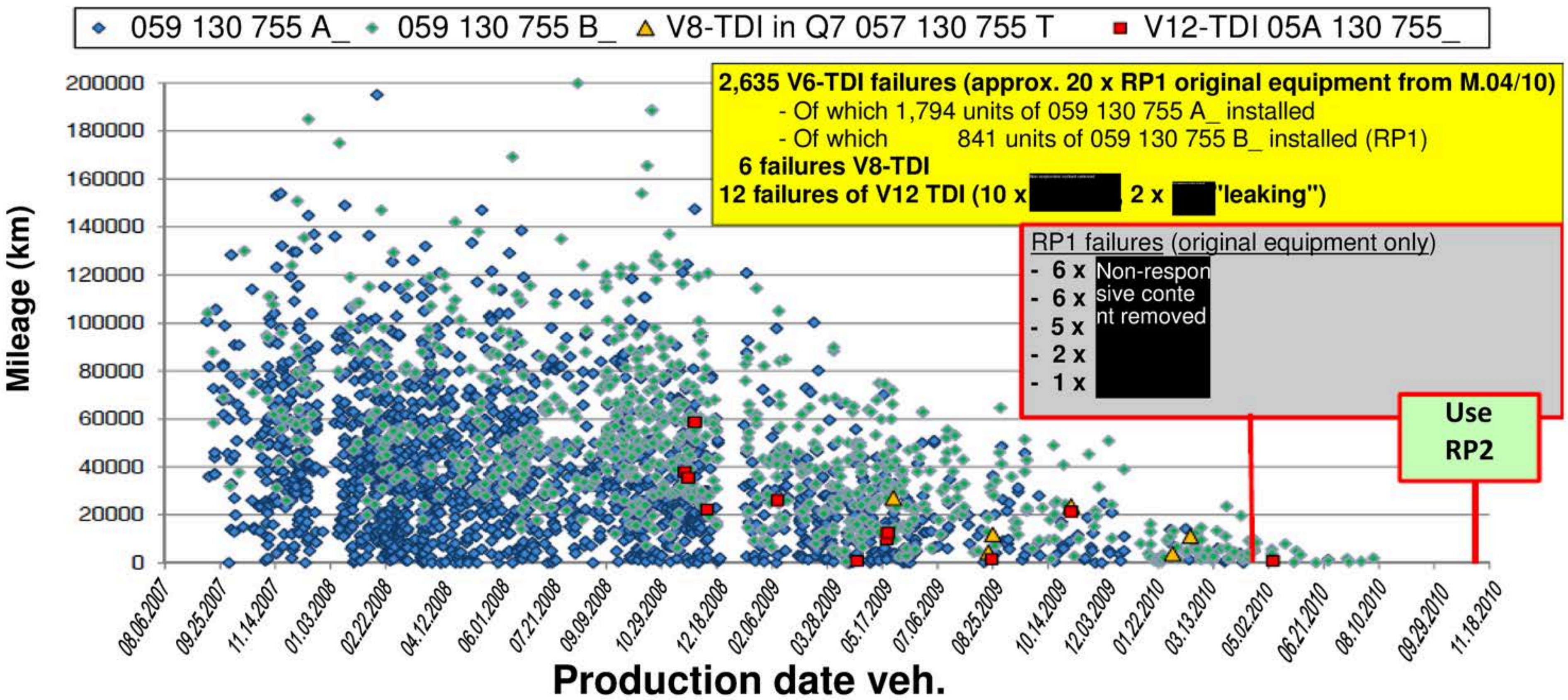
Audi CP4 field situation

11/16/2010

All settlements of high-pressure fuel pumps V6-/V8-/V12-TDI Audi

(SAGA Status as on 11.16.2010)



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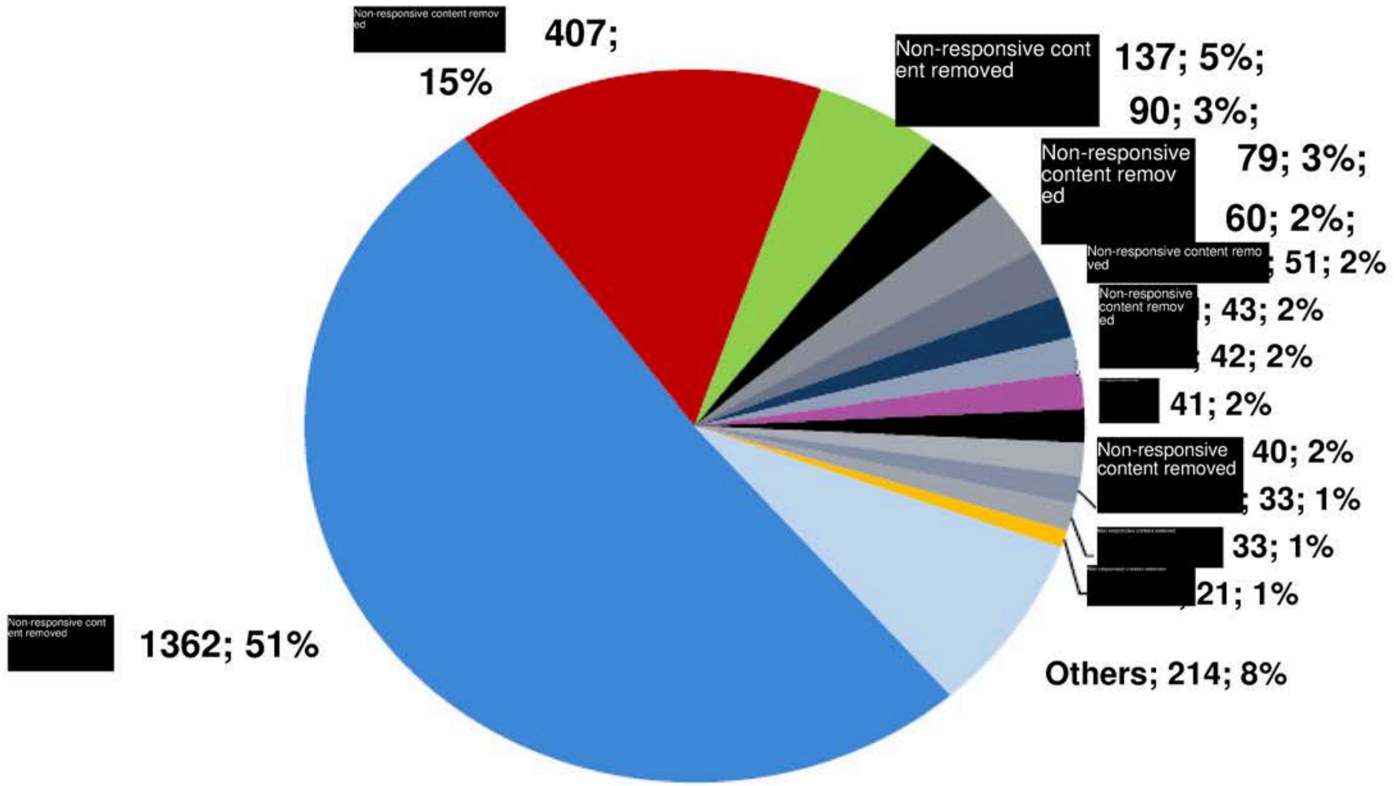
Audi CP4 field situation 11/16/2010

Field failures V6/V8/V12 TDI (Audi only) broken down by country



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Initial results of field analysis of Non-responsive content removed

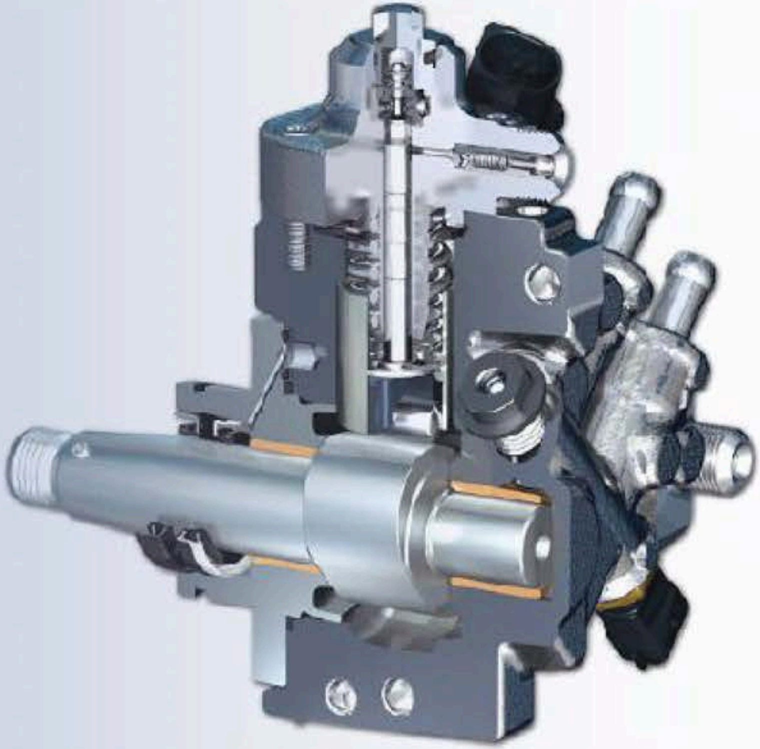
Preliminary conclusion:

→ No obvious errors of low-pressure fuel system, tank or fuels

- Striking features:
  - Dust loading of outside tank
  - Particles in the tank
  - Report on fueling behavior of customers (Kerosene or gasoline admixture possible)
- Fuel samples removed from 7 vehicles and 4 gas stations for analysis
- Quality of the workshops and workshop processes vary
  - High-pressure fuel pumps are not mounted in an oriented manner when being replaced
  - High and low pressure components are partly not replaced
  - But makes repeat repairs plausible at the most, not the first-time failures
- In few instances, suspicion of electronic manipulation
  - Flash counter implausible
  - Tuning protection bracket removed
  - Electronic theft protection upgraded with a second main relay

→ So far, no obvious explanation for the large number of failures

Audi on 4.16.2010



Diesel Systems

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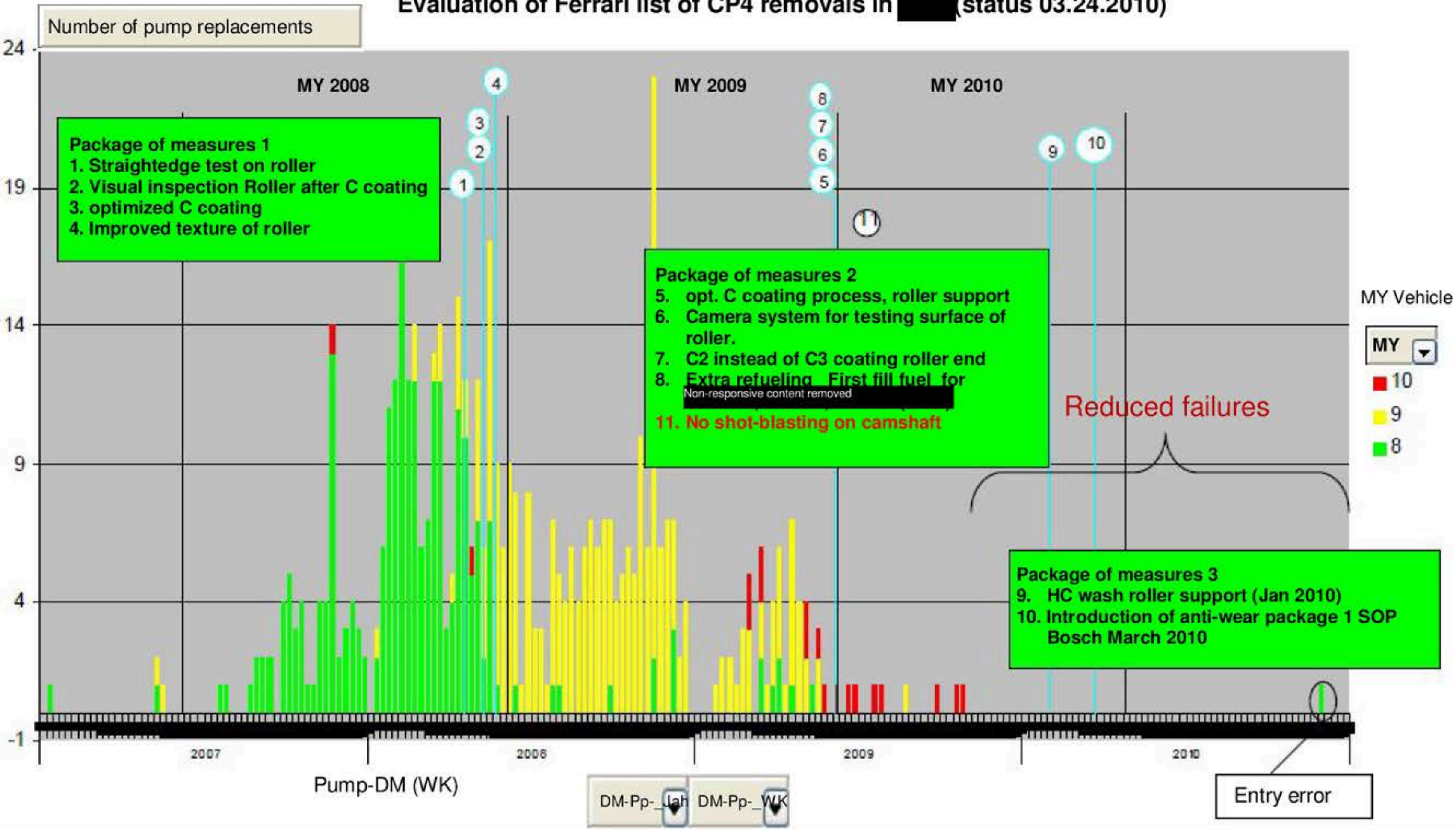
Engine (All) Model- (All)

Evaluation of Ferrari list of CP4 removals in [redacted] (status 03.24.2010)



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Status task force

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Description of problem:

<u>We have two different field problems requiring different measures</u>

1. [redacted] New findings
   - Mixed friction in roller support leads to high local temperatures. The mixed friction can be caused by the fuel quality, insufficient venting and poor lubrication.
   - Due to the high temperature, deposition products arise from additives in roller support which clamp the roller in the roller support at the start. (local ~140[°C])
   - CP4.1 from [redacted] does not show the deposits (evaluation from failed pumps)
   - Overload test (arctic diesel, 2,300 bar, 90 °C, 600 rpm) show the same effect (This fuel has high levels of additives (see later slides)
   - CP4.2 clockwise shows pre-existing damages to the right roller support at 5 of 6 good pumps with deposits
   - Counter-clockwise rotating pumps are far less affected (8/12 cylinders)

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Status task force

Description of problem:

2. [redacted]

   Due to fuels with low viscosity and / or lubricity, e.g. kerosene, water in fuel, Arctic diesel, ... the hydrodynamic lubricant film in roller supports is greatly reduced, which leads primarily to abrasive wear of the roller in the roller support, as the system roller / roller support runs for a long time under mixed friction. Good pumps from [redacted] show no deposits, and for failed pumps nearly always abrasive wear instead of turned tappet

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Status task force

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RP1 measures to increase the lubrication gap in the roller support at a lower viscosity and poorer lubricity
(RP1 also lowers the temperature in the roller support; verification via Q old Arctic diesel test, with no C2 deposits such as CP4.1)

- Reduction in roughness in the roller support due to changeover to C2 coating
- Secure prevention of metal splashes
- Reduction of play between roller and roller support
- Reduction in roughness of roller
- Optimization of the edge taper on the roller (slender taper)

RP1 introduced in RB since WK 10;
effective in Audi from WK 12

Effectiveness proven in individual parts
Significant increase of the lubrication gap detected
Statistical verification with in total of 12 pumps in Qalt
(2,300 bar, 600 rpm, 90°C Arctic diesel)

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Status task force

Summary from RP1 verification with additional 14 pumps:

The pumps with RP1 continue to show a significantly lower wear (rating difference 1.5 to 7) in the roller support (scale to 10) and very little hard deposits. (Rating difference 1.5 to 7)

Conclusion:

The RP1 package is effective against low viscosity / lubricity and reduces the temperature in the roller support such that Arctic diesel only brings in very little hard deposits from additives

The lubrication gap is increased by at least a factor of 2

Detail:

In the 14 endurance runs the fuel change intervals were changed from 100 hours to 200 hours, thereby, the fuel has a greater age than in the first endurance run results:

- **The aged fuel leads to partial seizing of the tappet. and thus to failure of 4 pumps that would otherwise continue to run, Not field relevant.**
- **Stopping all ER in order to evaluate the wear at the end of WK14**
- **Result:**
  Old series: 6 pumps rating: 7
  RP1 : 4 pumps rating: 1.5
- **A roller support shows unilateral increase (not cleanly honed) (series is reviewed and measurement window adjusted)**

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Testing summary RP1, overload test, release RP1

Status overload endurance run for proof of robustness

End of Life	VVT running time*		Right roller support deposit	Left roller support deposit	RS l. wear	RS r. wear	Total Rating	
RS C3 + roller with edge	0192	317 h	6	7	4	7	6	
	0193	317 h	6	8	5	7	7	
	0236	209 h	8	3	8	5	6	
RS C3 + Roller with edge	0194	**115 h**	n.d.**	n.d.	n.d.	n.d.	n.d.	7
	0195	242 h	5	5	5	6	5	
RS C3 + Roller without edge	0237	209 h	5	9	6	10	8	
RS C3 + Roller without edge	0238	98 h	8	5	8	4	7	
RP1.1 RS + roller without edge	0188	**150 h**	**1**	1	n.d.	n.d.	n.d.	
	0189	293 h	1	1	2	2	2	
	0191	**200 h**	1	1		n.d.	n.d.	
RP1.1 RS + roller without edge	0239	98 h	2	1	1	1	1	1.5
RP1.1 RS + roller without edge	0190	**198 h**	**1**	**1**		n.d.	n.d.	
	0234	242 h	2	1	1	1	1	
	0235	242 h	1	1	(3)	2	2	

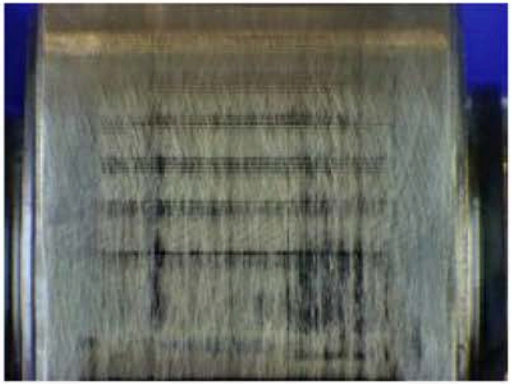
*** Running time without break-in period** n.d.: cannot be evaluated**

gray = clarification for striking feature

Testing summary RP1, overload test, release RP1

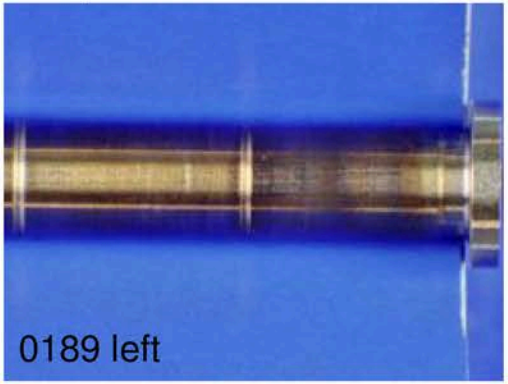
Status overload endurance run for proof of robustness

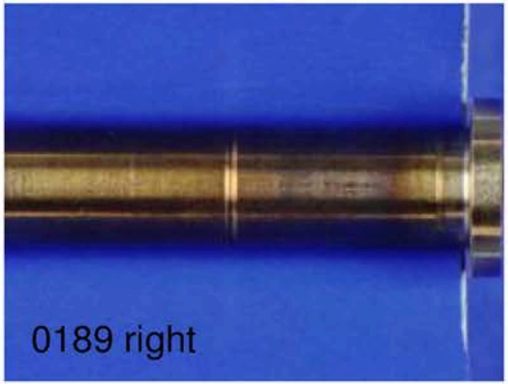
Chatter marks of cams



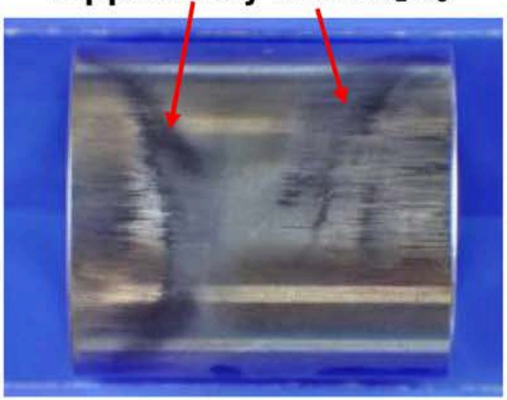
0189 cam drop

piston discolored





tappet body with Al_2O_3

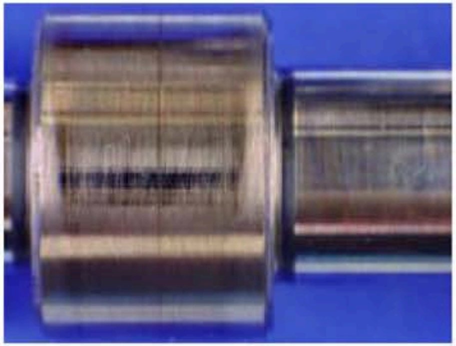


0238 left

Testing summary RP1, overload test, release RP1

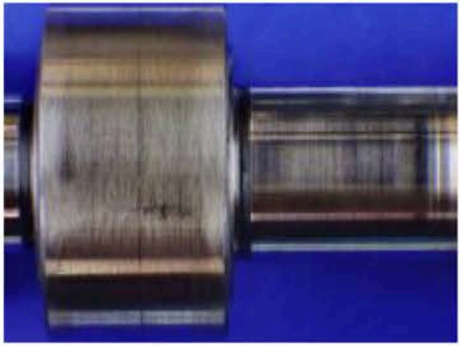
Images RS C3 series+ roller with edge (hollow) A1) VVT_0192 317 h

TDC



Cam track: Chatter marks

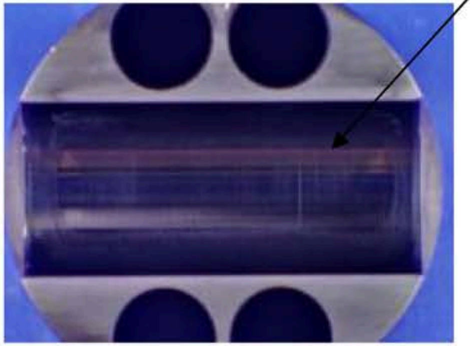
BDC



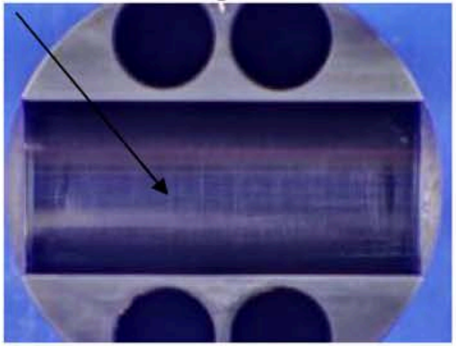
left

Deposit

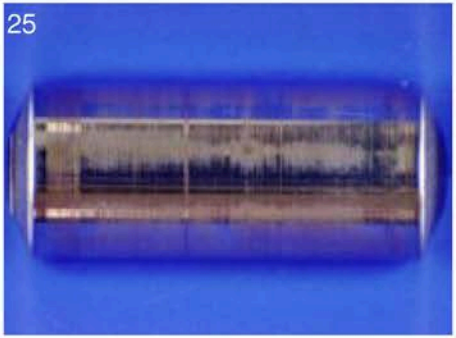
right



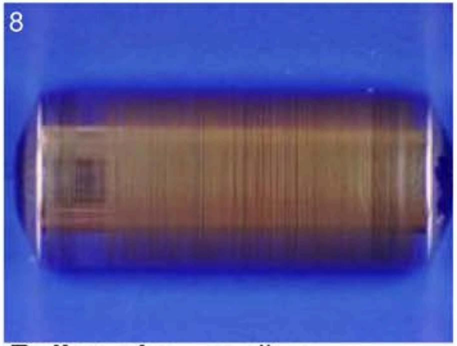
Smoothing of roller edge: medium
Run marks: medium



Smoothing of roller edge: medium
Run marks: medium



Roller edge: medium
Run marks: high



Roller edge: medium
Run marks: high

Roller

BOSCH

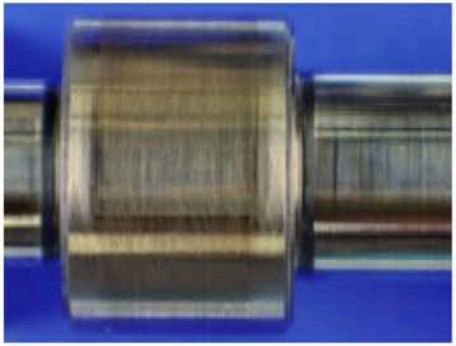
ENTIRE PAGE CONFIDENTIAL

Testing summary RP1, overload test, release RP1

Images RS C3 series+ roller with edge (hollow) C1) VVT_0193 317 h

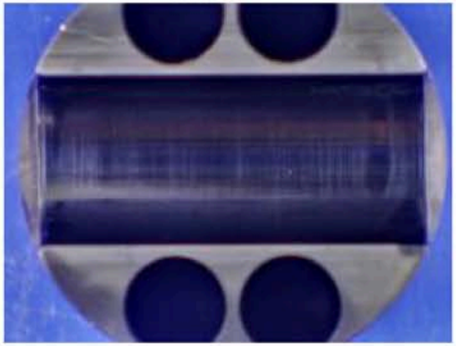
Deposit

TDC



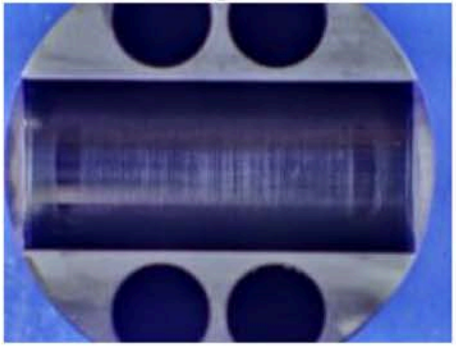
cam track: Chatter marks

left



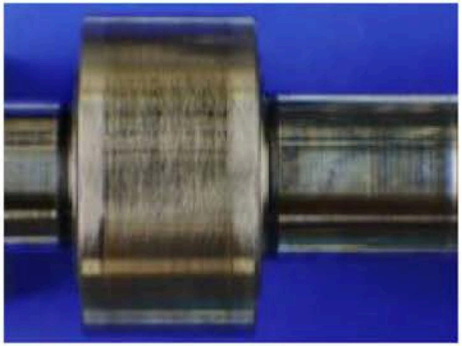
Smoothing of roller edge: medium
Run marks: medium

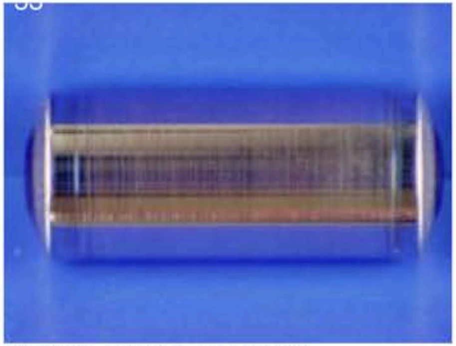
right



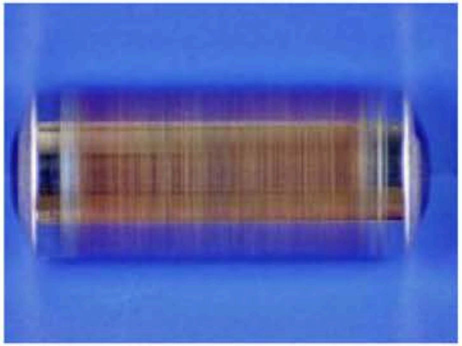
Smoothing of roller edge: high
Run marks: medium

BDC





Roller edge: medium
Run marks: medium



Roller edge: high
Run marks: high

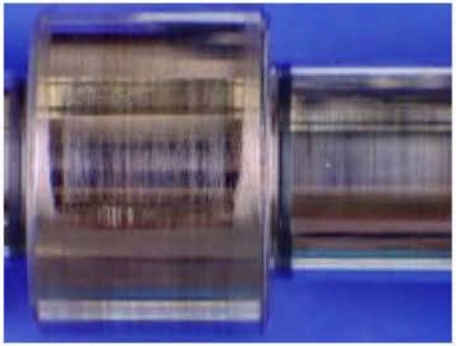
Roller

ENTIRE PAGE CONFIDENTIAL

Testing summary RP1, overload test, release RP1

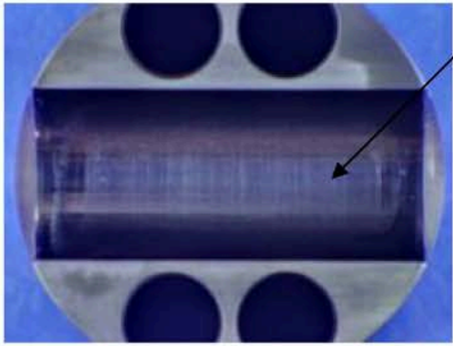
Images RS C3 series+ roller with edge (hollow) A3) VVT_0236 209 h

TDC



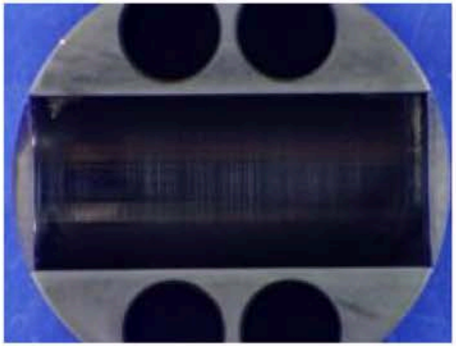
left

Deposit



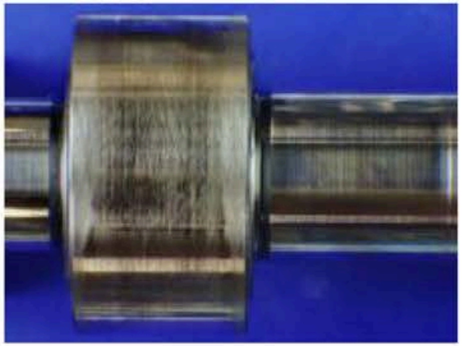
Smoothing of roller edge:
Run marks:

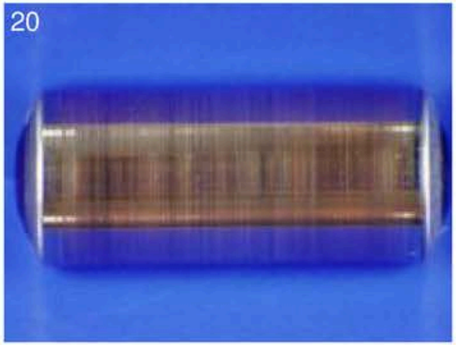
right



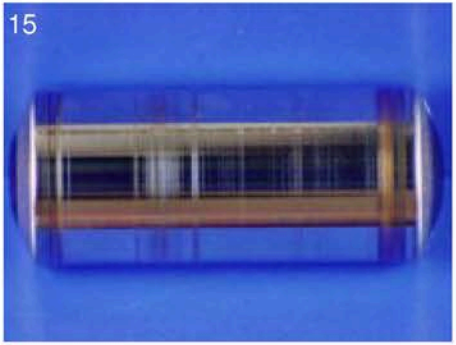
Smoothing of roller edge: medium
Run marks: medium

BDC





Roller edge: low
Run marks: medium



Roller edge: medium
Run marks: low

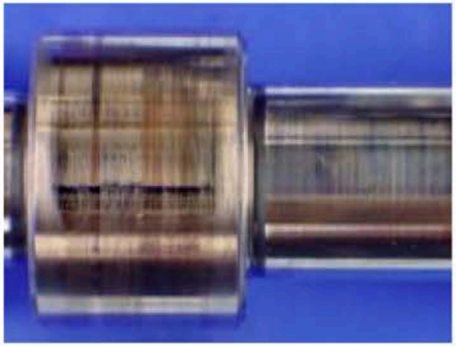
Roller

BOSCH

Testing summary RP1, overload test, release RP1

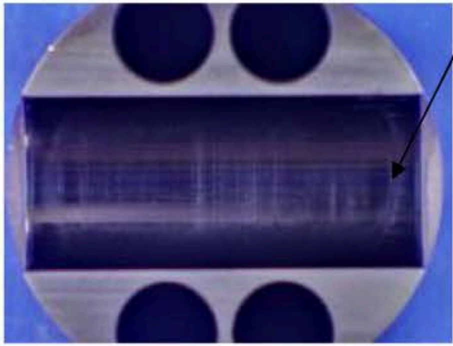
Images RS C3 series+ roller with edge (straight) VVT_0195 242 h

TDC



Cam track: Chatter marks

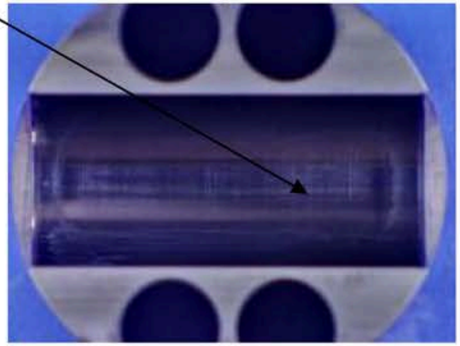
left



Smoothing of roller edge: low
Run marks: medium

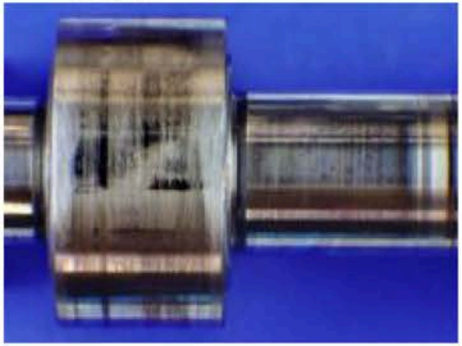
Deposit

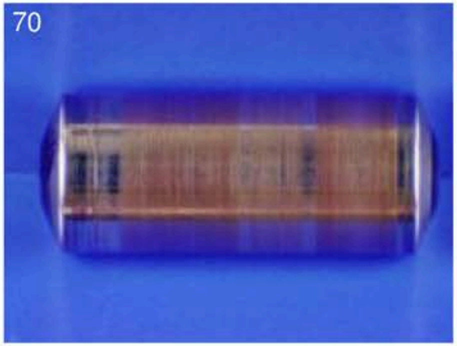
right



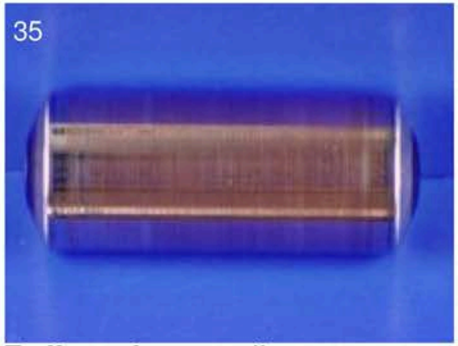
Smoothing of roller edge: low
Run marks: medium

BDC





Roller edge: medium
Run marks: medium



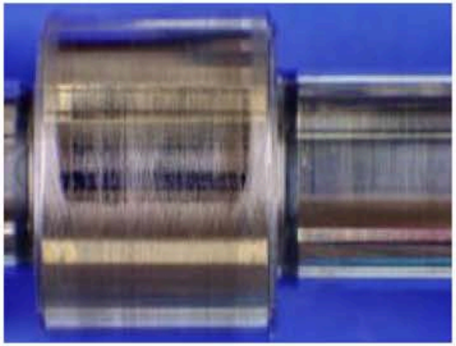
Roller edge: medium
Run marks: high

Roller

Testing summary RP1, overload test, release RP1

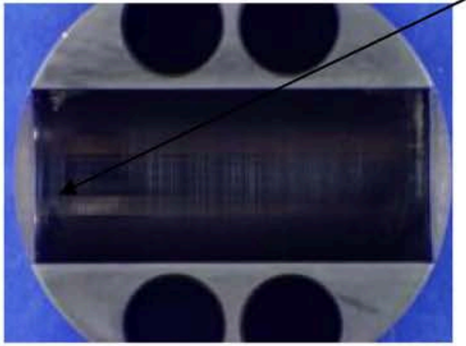
Images RS C3 series + roller without edge (straight) C3) VVT_0237 209 h

TDC



left

Deposit



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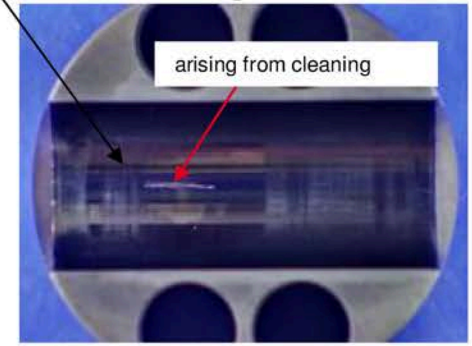
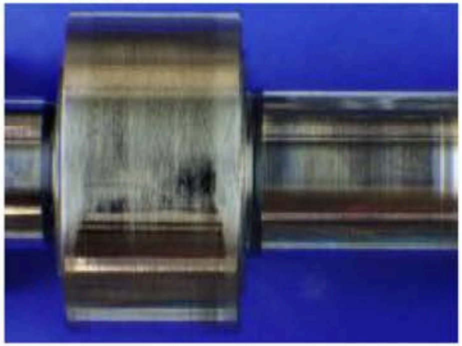
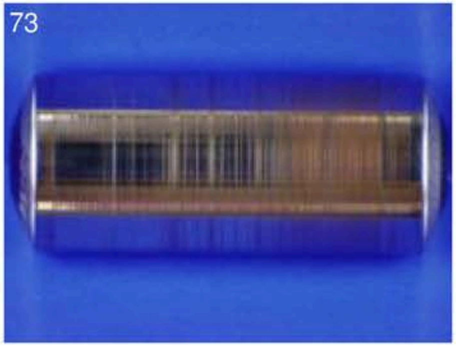


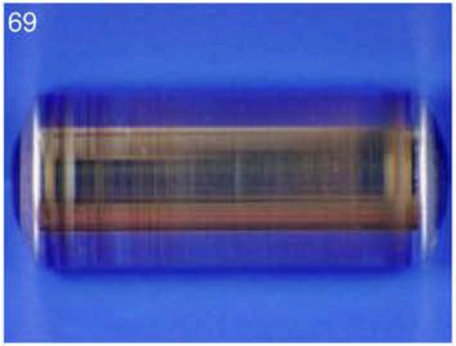
Smoothing of roller edge: low
Run marks: high

Smoothing of roller edge: medium
Run marks: high

BDC







Roller edge: low
Run marks: medium

Roller edge: medium
Run marks: low

Roller

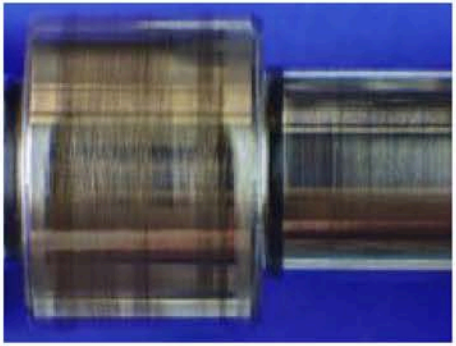
BOSCH

ENTIRE PAGE CONFIDENTIAL

Testing summary RP1, overload test, release RP1

Images RS C3 series + roller without edge (hollow) A4) VVT_0238 98 h

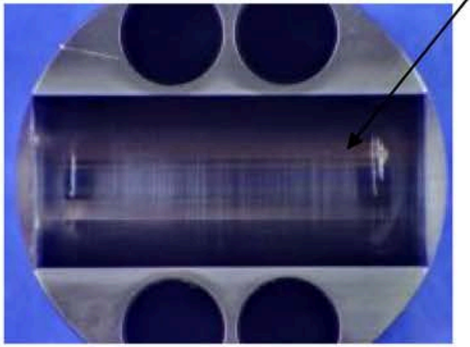
TDC



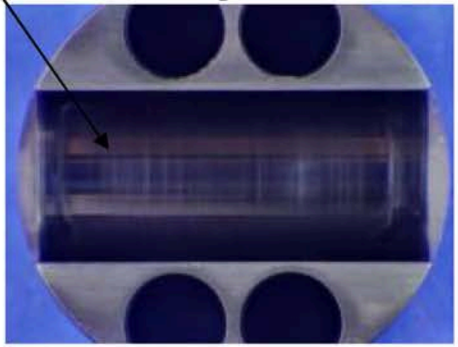
left

Deposit

right

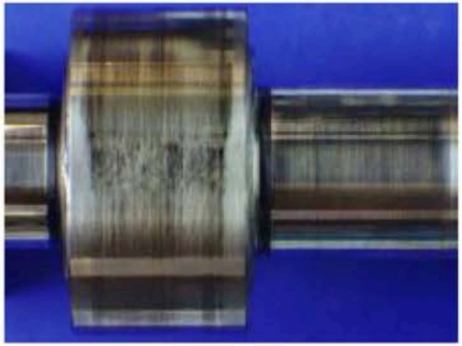


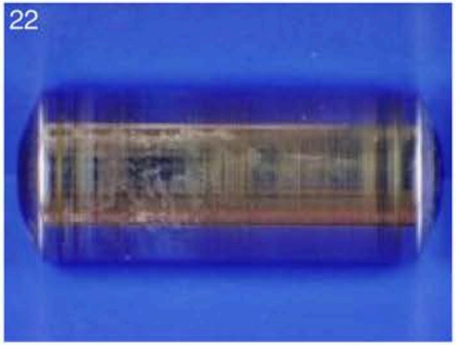
Smoothing of roller edge: high
Run marks: high



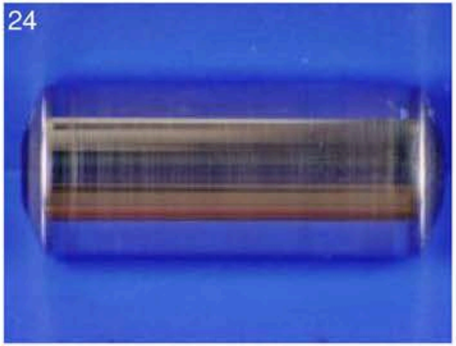
Smoothing of roller edge: high
Run marks: high

BDC





Roller edge: medium
Run marks: medium



Roller edge: medium
Run marks: low

RT

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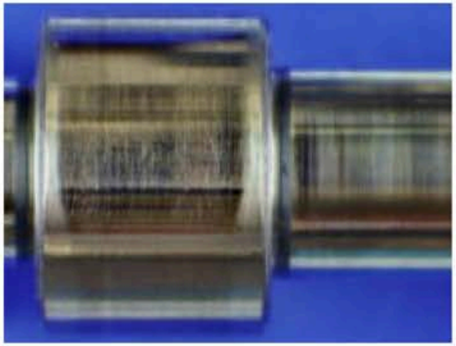
Testing summary RP1, overload test, release RP1

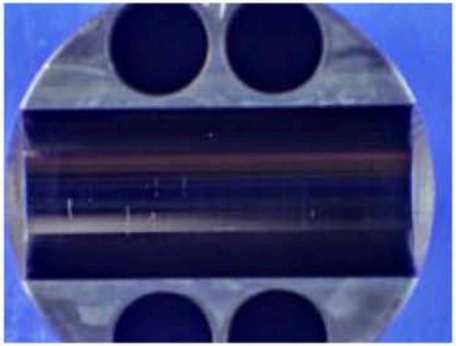
Images RP1 RS + roller without edge (straight) S2) VVT_0189 293 h

TDC



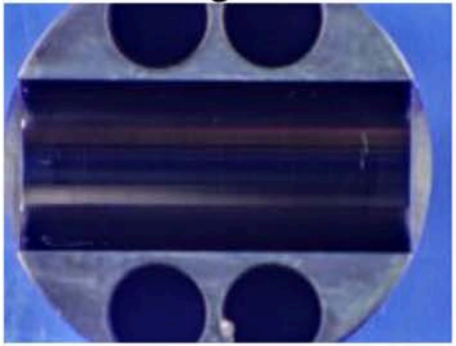
Cam track: Chatter marks

left



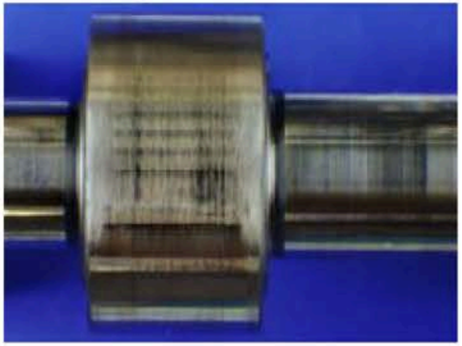
Smoothing of roller edge: low
Run marks: low

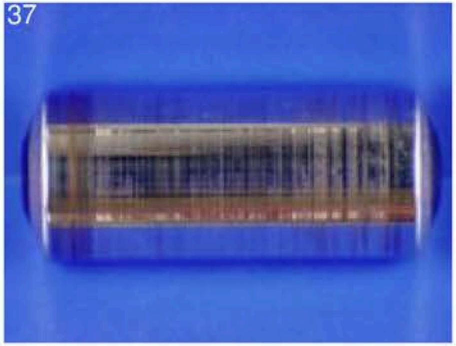
right



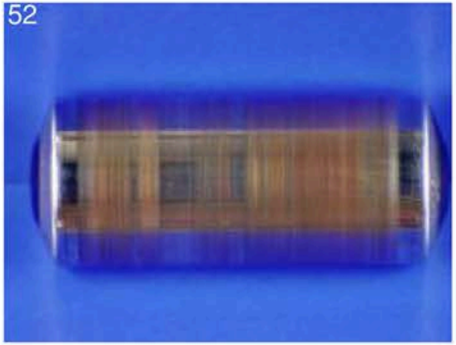
Smoothing of roller edge: low
Run marks: low

BDC





Roller edge: medium
Run marks: medium



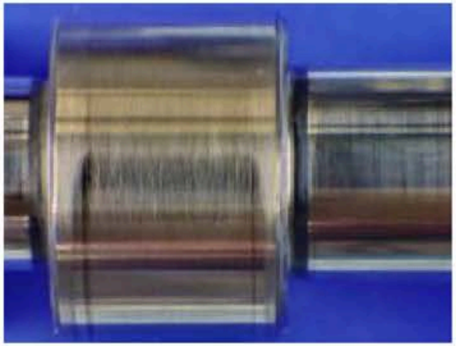
Roller edge: medium
Run marks: medium

Roller

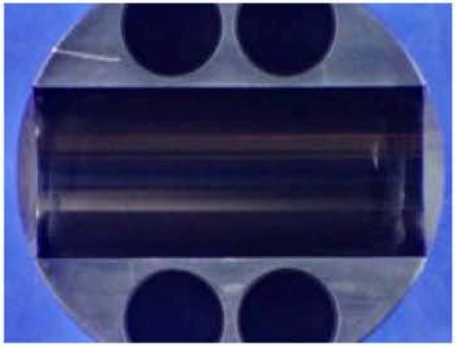
Testing summary RP1, overload test, release RP1

Images RP1 RS + roller without edge (straight) S3) VVT_0239 98 h

TDC

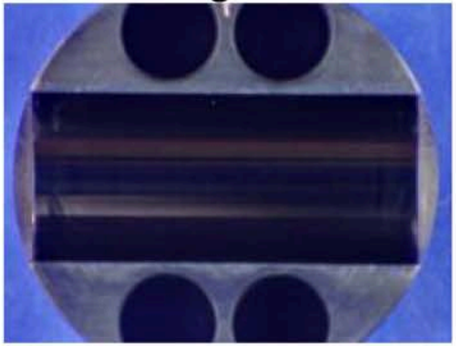


left



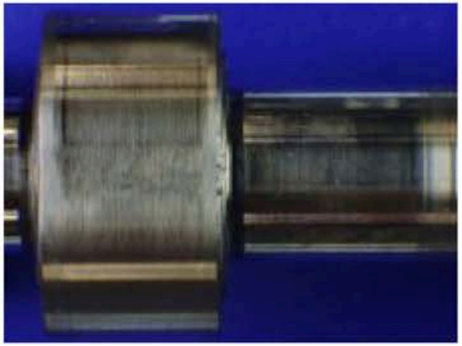
Smoothing of roller edge: high
Run marks: low

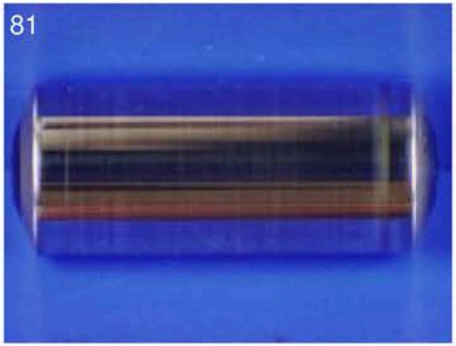
right



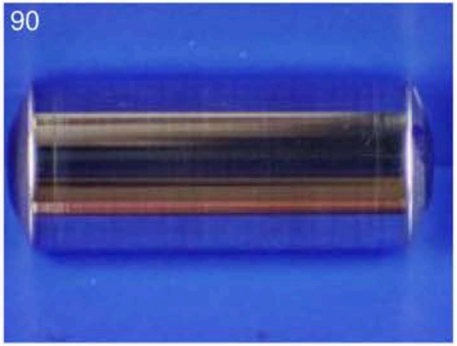
Smoothing of roller edge: medium
Run marks: low

BDC





Roller edge: medium
Run marks: low



Roller edge: low
Run marks: low

RT

BOSCH

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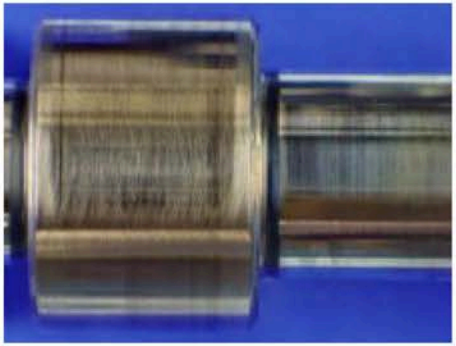
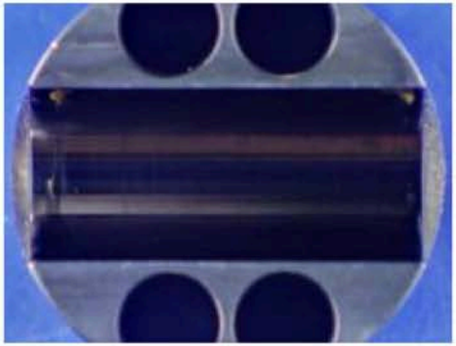
Testing summary RP1, overload test, release RP1

Images **RP1.1** RS + roller without edge (spherical) B3) VVT_0234 242 h

TDC

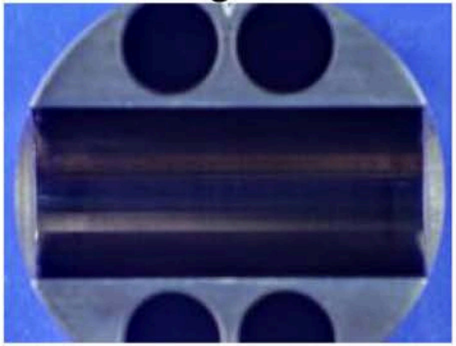


left



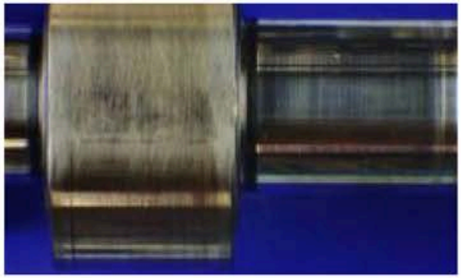
Smoothing of roller edge: medium
Run marks: low

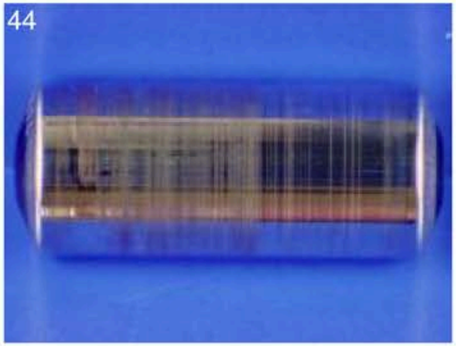
right



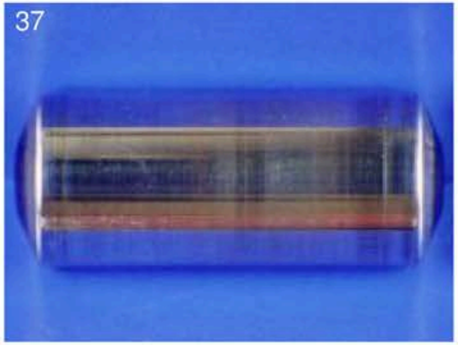
Smoothing of roller edge: low
Run marks: low

BDC





Roller edge: low
Run marks: medium



Roller edge: low
Run marks: low

Roller

BOSCH

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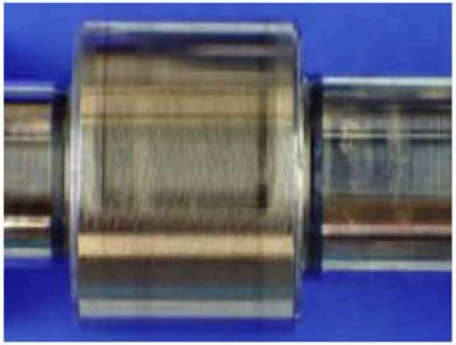
Testing summary RP1, overload test, release RP1

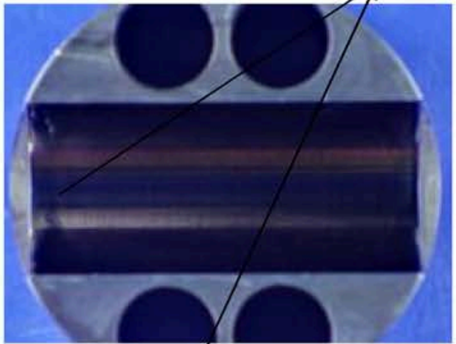
Images RP1.1 RS + roller without edge (spherical) D3) VVT_0235 242 h

Roller support geometry

TDC

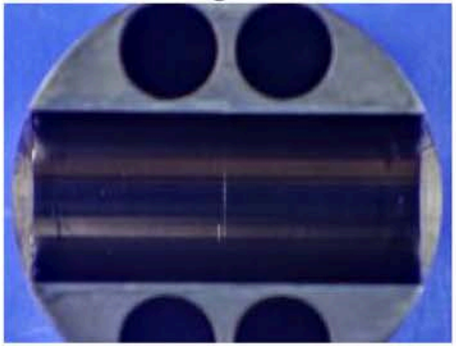


left



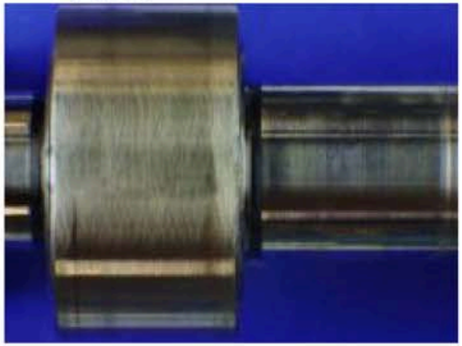
Smoothing of roller edge: low
Run marks: low

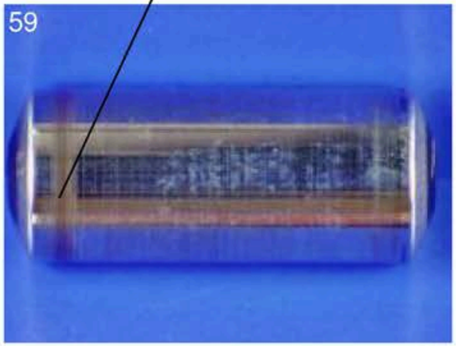
right



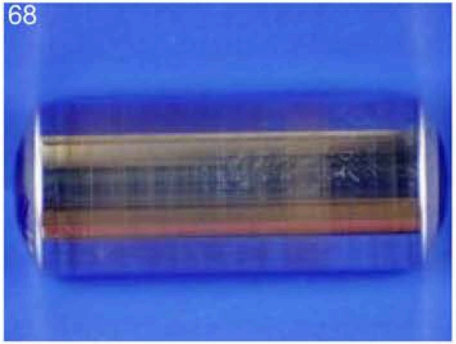
Smoothing of roller edge: low
Run marks: medium

BDC





Roller edge: high
Run marks: low



Roller edge: medium
Run marks: low

Roller

Status task force

Further work:

Implementation of the Q old test as a QC endurance run (batch release?) Development of a ratings catalog
Shortening of ER to less than 50 hours

Repetition of the 12 ERs with graduated running times	WK 16- WK19
Modification of QC ER test benches for Arctic diesel	WK 20
Creation of rating catalog with release levels	WK 20
Start QC ER with RP1	from WK 21

This will simultaneously create a broader basis for comparison

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Status task force

Status RP2:

Temperature measurement on the right counter-clockwise rotating pump with Arctic diesel (clear temperature increase of the right roller support in clockwise rotation)

Displacement of the supply from left to right (no positive effect)

Displacement of the supply as GP: pattern in production measurements WK 16 (Positive impact to expected results, such as counter-clockwise rotation)

Summary:
RP2 has the potential of 15-20°C on the roller support RP1 and RP2 on the basis of manufacturing after 6/2009 has the potential RoW boundary fuel / Arctic diesel / additives / to pass

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CP4.2 temperature measurement in roller support

Temperatures CP4.2: Measurement with Arctic diesel, speed: 598 rpm, rail pressure 2,298 bar

Clockwise Counter-clockwise

Supply/return temperatures

Supply	39.7	39.6
Return	48.3	50.0

Inlet pressure/volume

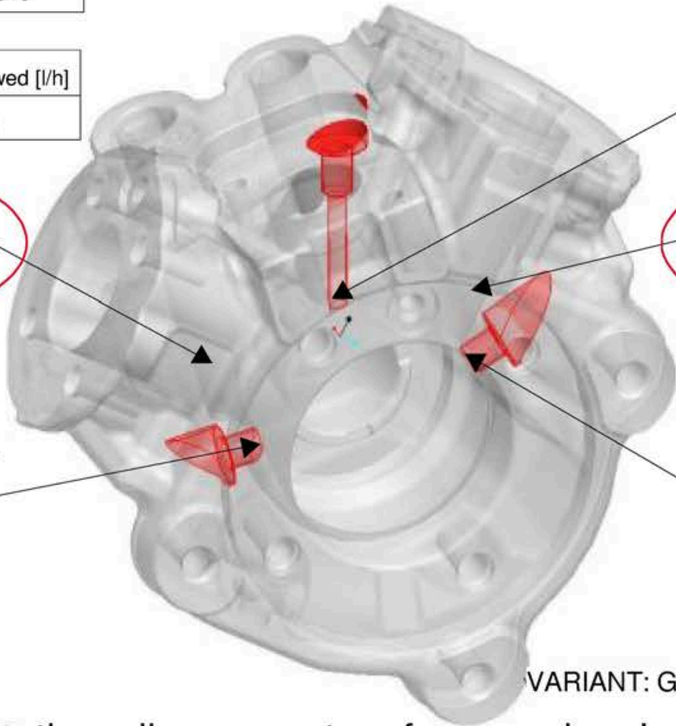
p allowed [bar rel]	Q allowed [l/h]
3.6	107.3

Roller support temp. left Cyl.

61.5	59.7

Interior temperature left Cyl.

52.8	52.8



Interior temperature above

62.4	53.7

Roller support temp. right Cyl.

67.6	60.0

Interior temperature right Cyl.

62.2	51.0

VARIANT: GENERIC

Temperature on the roller support surface can be significantly higher. Measuring point 1 mm away from surface. Potential min. 15-20 ° C on the surface

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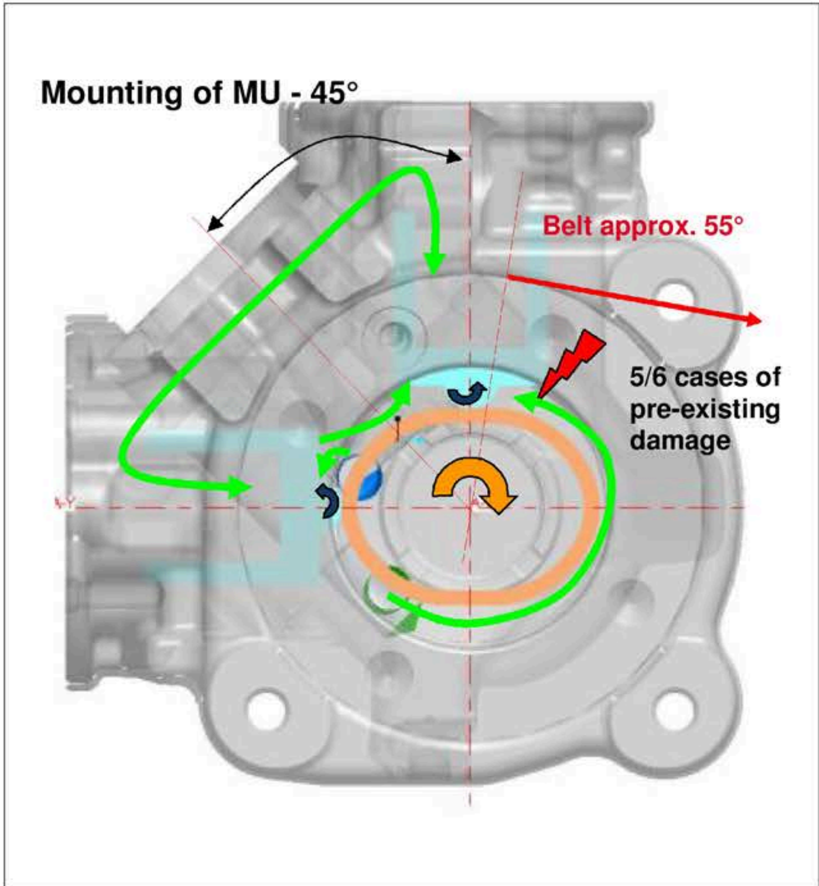
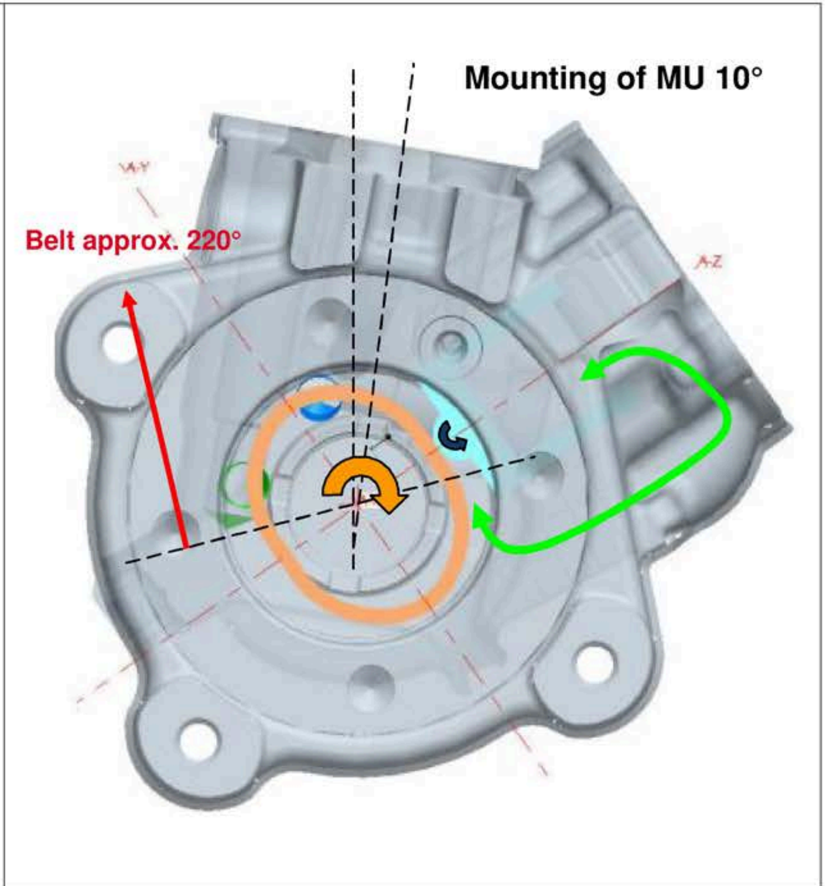
Status Task Force





CP4.2-EFP cw Audi 0 445 010 611 (W19)	CP4.1-EFP cw VW / Audi

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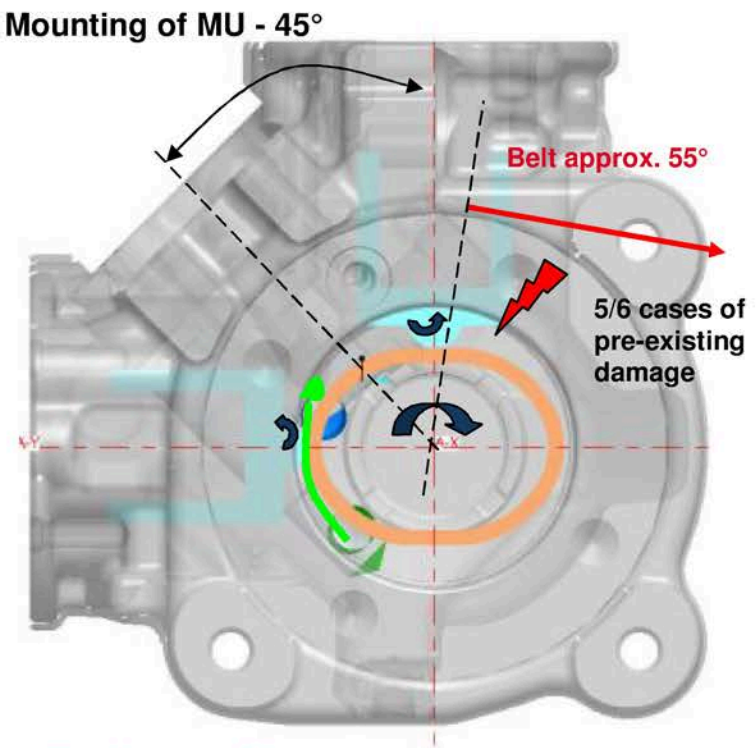
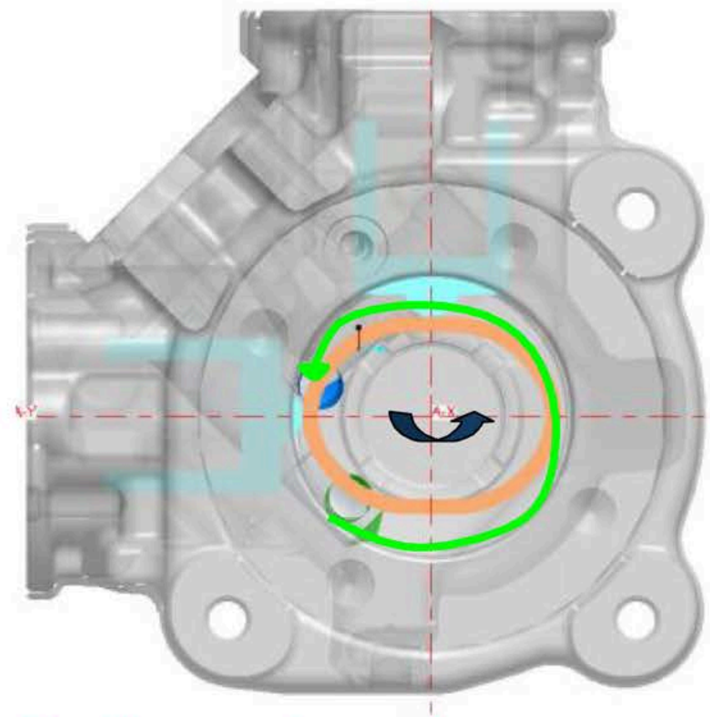
Status Task Force



Fuel goes direct to return



Fuel is pumped around once

CP4.2-EFP cw Audi 0 445 010 611 (W19)	CP4.2-EFP ccw

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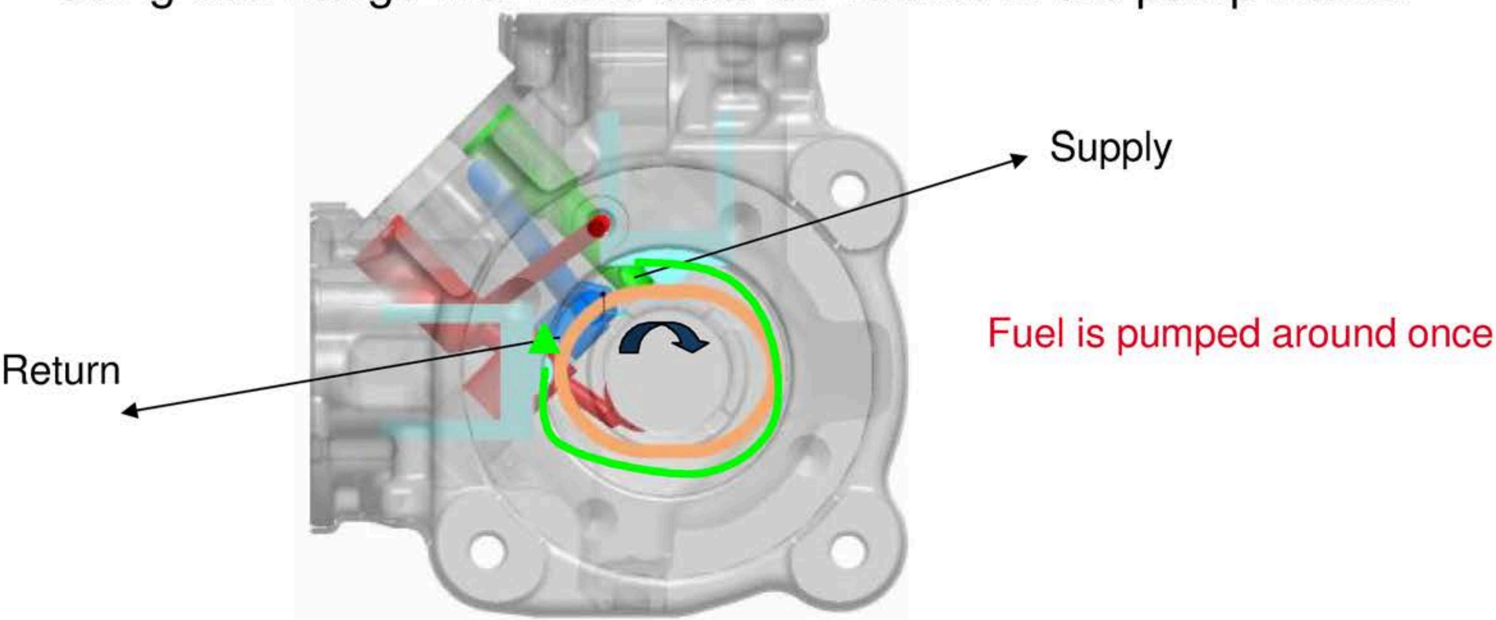
RP2 measures to reduce the temperature in the CP4.2

1. Better local cooling of the critical roller support with fuel (relocating the supply to the temperature critical point) producing a similar condition of the supply / return processes associated with the CP4.1
2. Using new flange with more balance volume in the pump interior



Status task force

RP2 measures to reduce the temperature in CP4.2 Initial estimate:

1. Better local cooling of the critical roller support with fuel (relocating the supply to the temperature critical point) producing a similar condition of the supply / return processes associated with the GP version
   1. Functional analyses (Pump, system) WK16
   2. Robustness-tests with Qalt WK24
   3. Preparation for production by WK28

2. Flange changes can be checked in the same time window; possible introduction from WK 21

Status task force

ENTIRE PAGE CONFIDENTIAL

New analyses on the possible influence of the camshaft on the formation of deposits.

- Influence of no shot-blasting
- Pre-damaged [redacted] parts show no metal splashes, fusing

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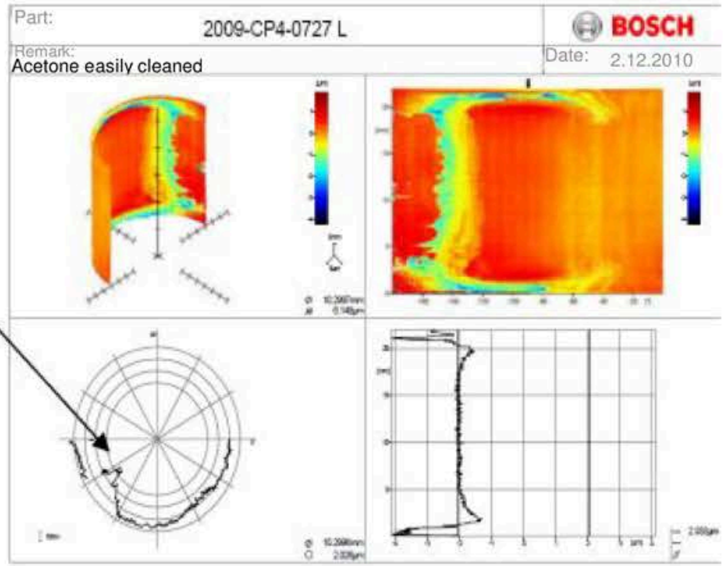
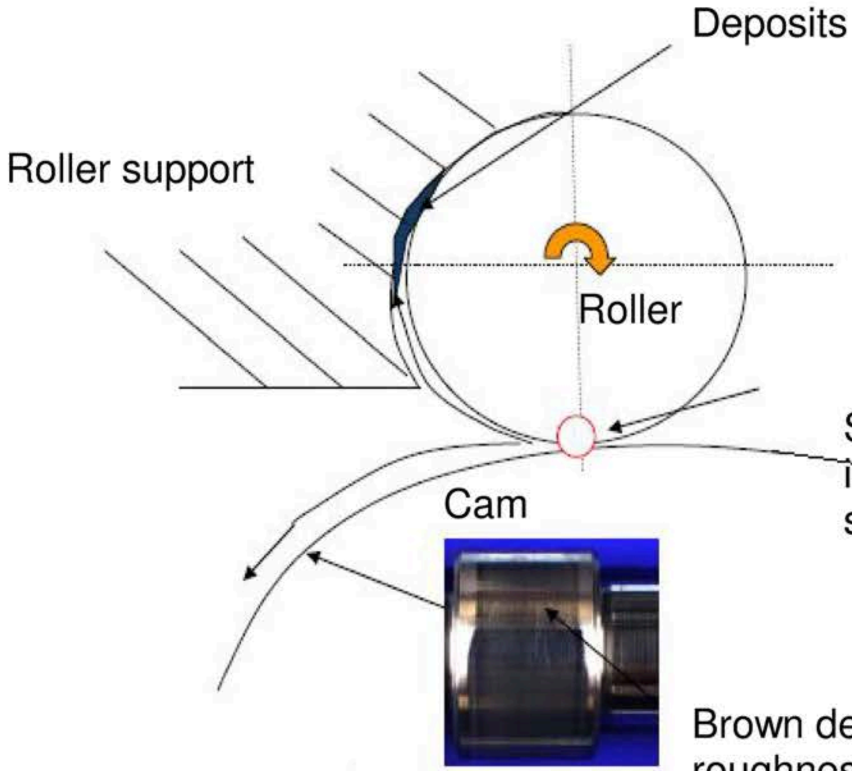
Status task force

Another hypothesis of location of the deposits





Slip of the roller on the cam after introduction of fuel on the cam surface

Brown deposits on the camshaft; roughness of the shaft reduced

Status task force

Further action on camshaft influence

1.	Investigation of fine geometry shot-blasted / non shot-blasted camshaft	WK16
2.	Investigation of the brown deposits on camshaft	WK16
3.	ER with shot-blasted and non shot--blasted camshafts in Q old Arctic diesel	WK19

Release Strategy ROW from RB perspective

- **Procedure for RoW release**

  Different - possibly alternating - fuel conditions currently do not allow national releases by Bosch (see [redacted]

  Environmental influences must be proven & secured with vehicle endurance runs@ OEM (water, altitude, temperature, ...)

- **That is why RB release* involves tested boundary fuels (incl. RoW fuel)**

  Viscosity -> Arctic diesel

  Additive -> Arctic diesel

  Biofuels -> open

  Lubrication -> BDF650

  Vapour pressure -> Kerosene

  RoW fuel_1 -> Combination viscosity, lubricity, vapour pressure, water (no additives)

*Same as current release process Release compared with tested fuel EN590 and not national release, e.g. [redacted]

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Release of FIE Components

step 4 is for confirmation of common market understanding for better end customer satisfaction

Step	Test Type	Fuel	old product	new product
④ **CRS** **RoW user**	active field surveillance (e.g. 1000 vehicles 1 year)	**BRIC**		**X**
③ **CRS** **Vehicle @ OEM**	Test Fleet(10 Veh.) per Region	**BRIC**	**(X)**	**X**
② **CRS** **Engine Tests @ OEM**	Engine TB RP1-RP2-RP3	**RoW & GDK**	**(X)**	**X**
① **CRI-CP-CRR** **Component Tests @ ETC**	Component TB RP1-RP2-RP3	**RoW & GDK**	**(X)**	**X**

SOP

Step

Schedule

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Backup

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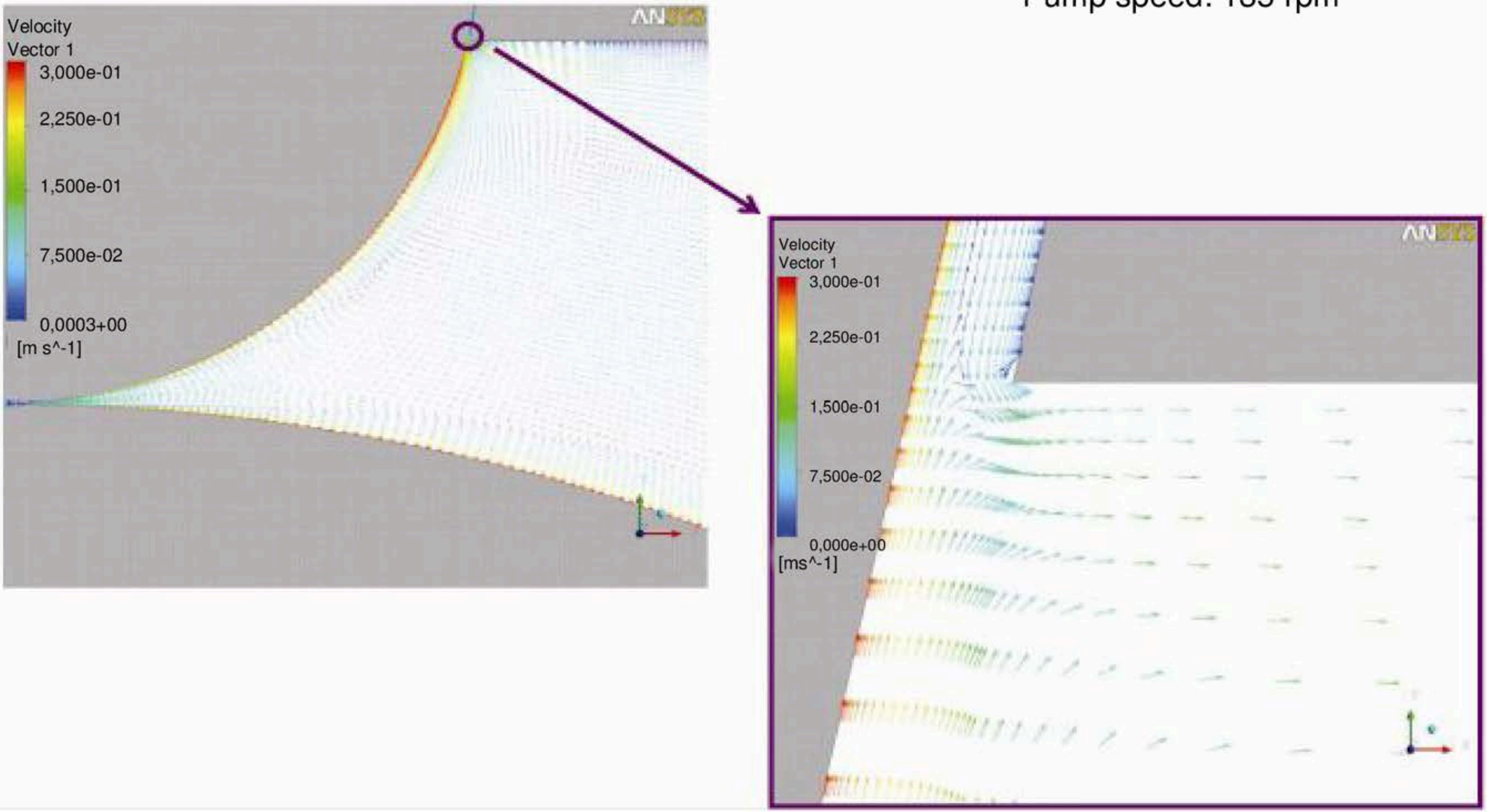
CP4-simulation: particle transport at area cam/roller/roller support

Velocity vectors:

Pump speed: 135 rpm



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Testing summary RP1, overload test, release RP1

Part: **One-sided roller wear**

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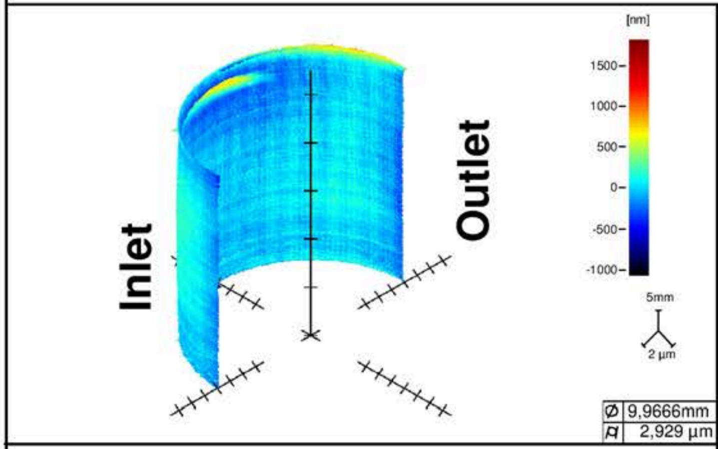
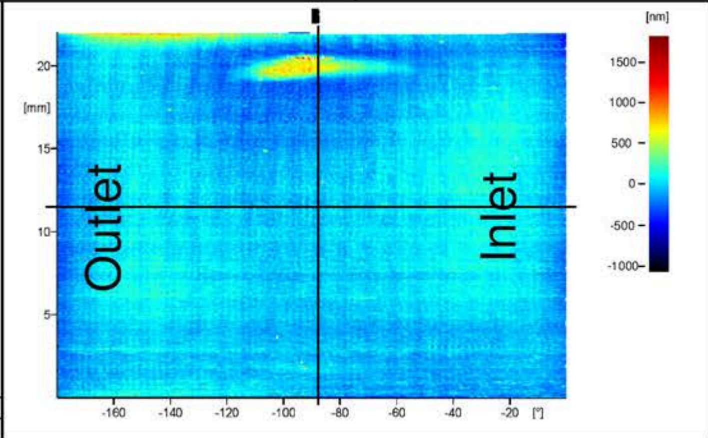
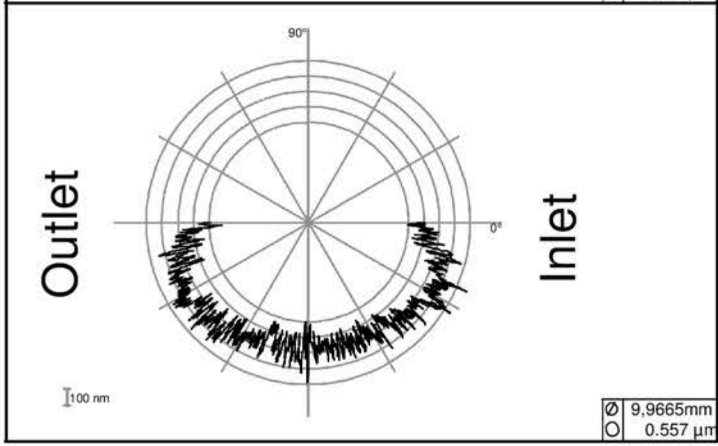
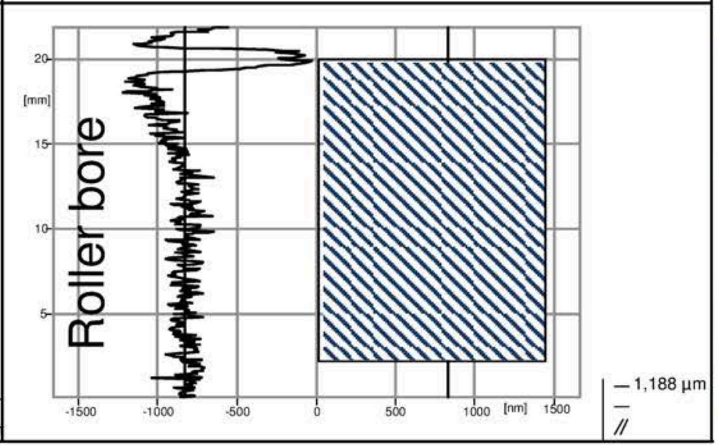
Remark: drivetrain QALT, 165 h

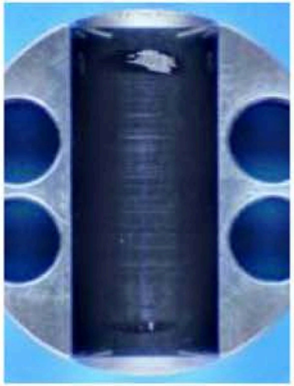
Date: 03/23/2010











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Overview of CP4 robustness

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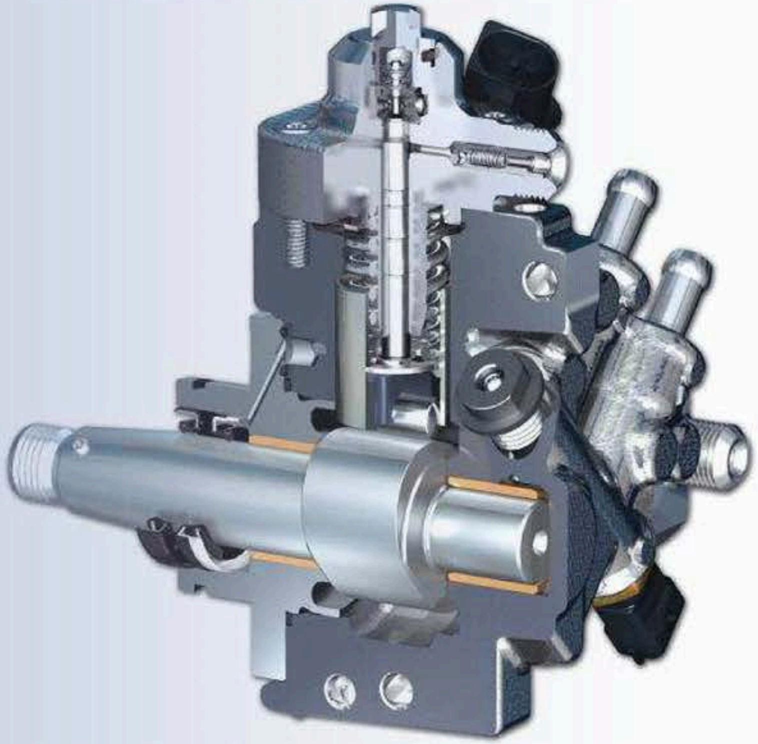
1) **Anti-wear package 1 (RP1)**
2) **Anti-wear package 2 (RP2)**
3) **Failure statistics CP4** Non-responsive content removed



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1) Anti-wear package 1 (RP1)

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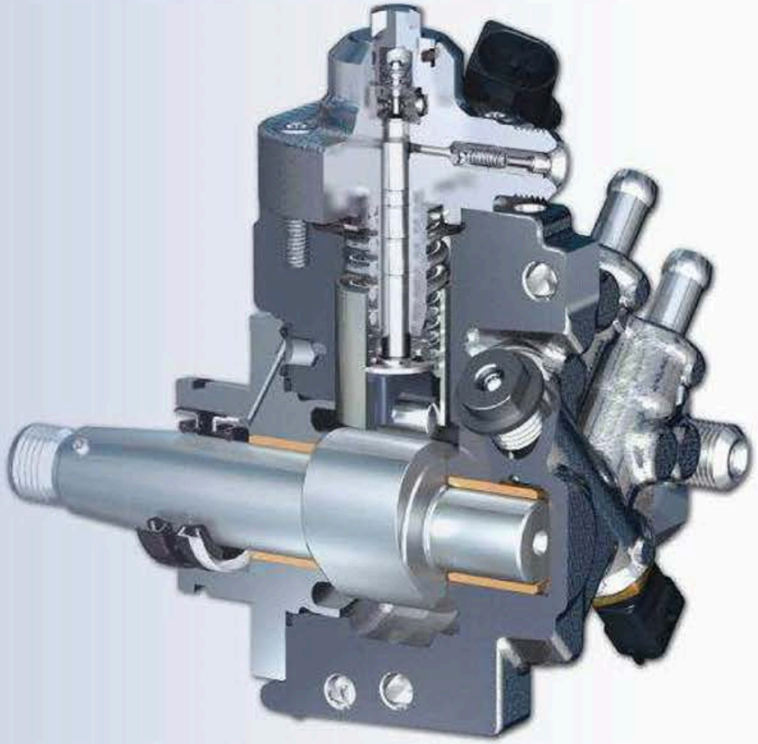

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CP4 robustness

Anti-wear package 1

Assignment

Increase lubricating film between roller support and roller for fuels with lower viscosity (reduction of mixed friction fraction & temperatures)

Measures (derived from simulation results)

- Reduction in roughness in the roller support due to changeover to C2 coating
- Prevention of metal splashes (for process-related reasons there are no metal splashes with C2)
- Reduction of play between roller and roller support (smaller roller support bore)
- Reducing the roughness of the roller
- Optimization of edge taper on the roller (slender taper)

Execution

Testing RP1 vs. series in QHALT (600 rpm; 2,300bar; Arctic diesel; 90°C)

Result

RP1 increases lubricating film by 2 x (derived from findings)

RP1 in series for all CP4.2 at Audi since WK12

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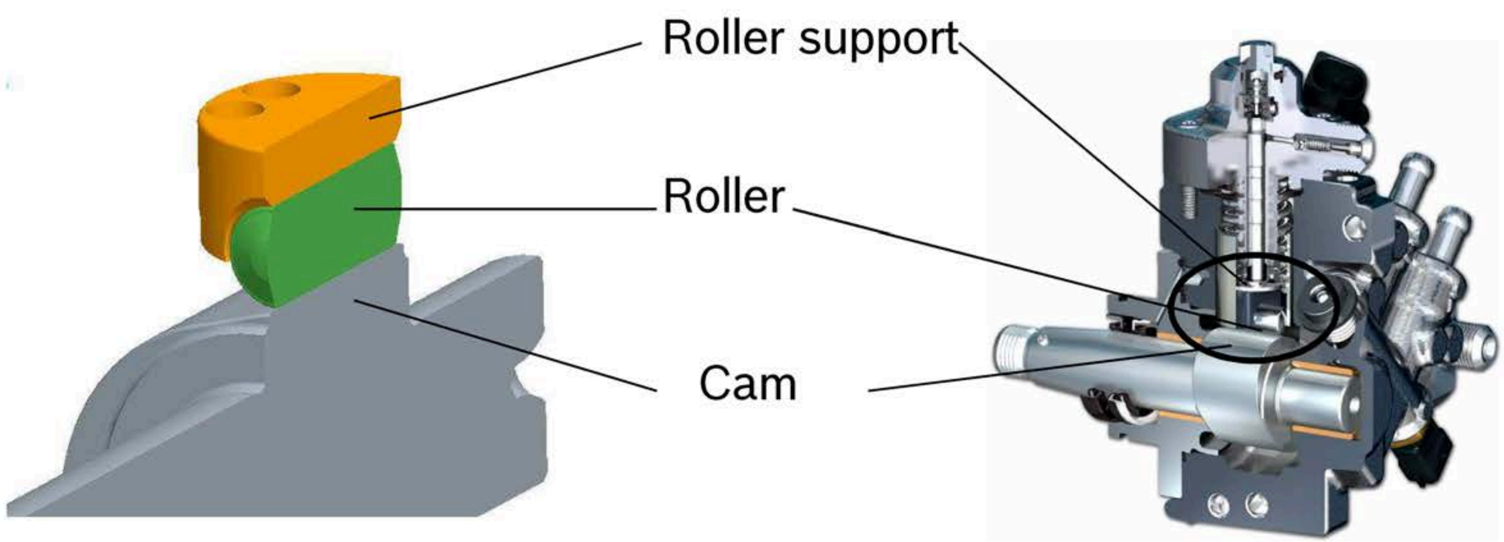
CP4 robustness

Anti-wear package 1



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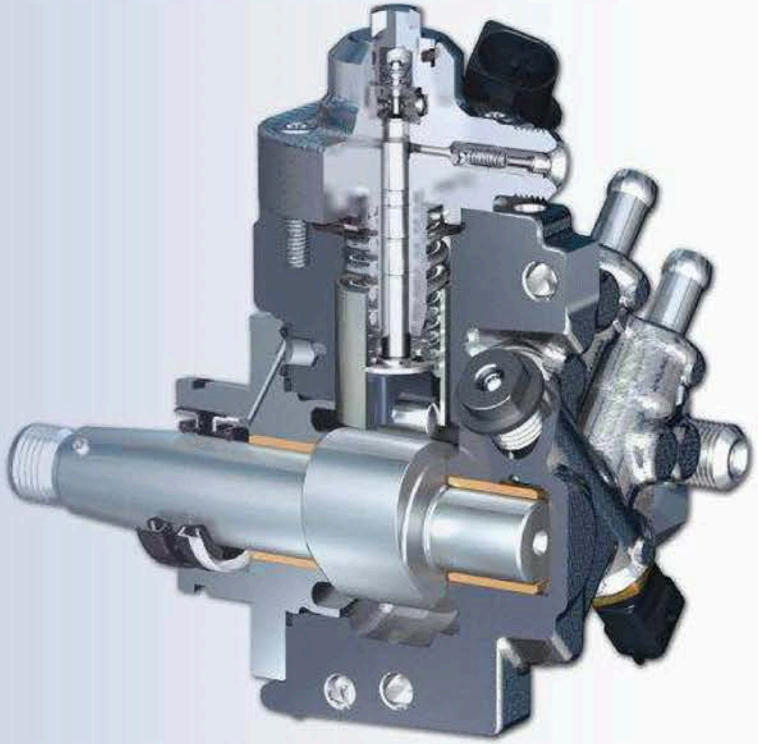
Anti-wear package 2 (RP2)

[redacted]



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Anti-wear package 2

Assignment

Reduction of local temperatures of the right (critical) roller tappet with target level CP4.1 for clockwise CP4.2 (Audi V6, not Audi V8)

Measures

- Optimized arrangement of supply & return position (result: Swapping of supply / return connections

Execution

Temperature measurements on roller support	done
Testing RP2 in QHALT (600 rpm; 2,300bar; Arctic diesel; 90°C)	WK24

Result

Function measurements show by the optimized supply/return adjustment that temperatures as in CP4.1 can be achieved (temperature reduction of > 15°C in lubrication gap).

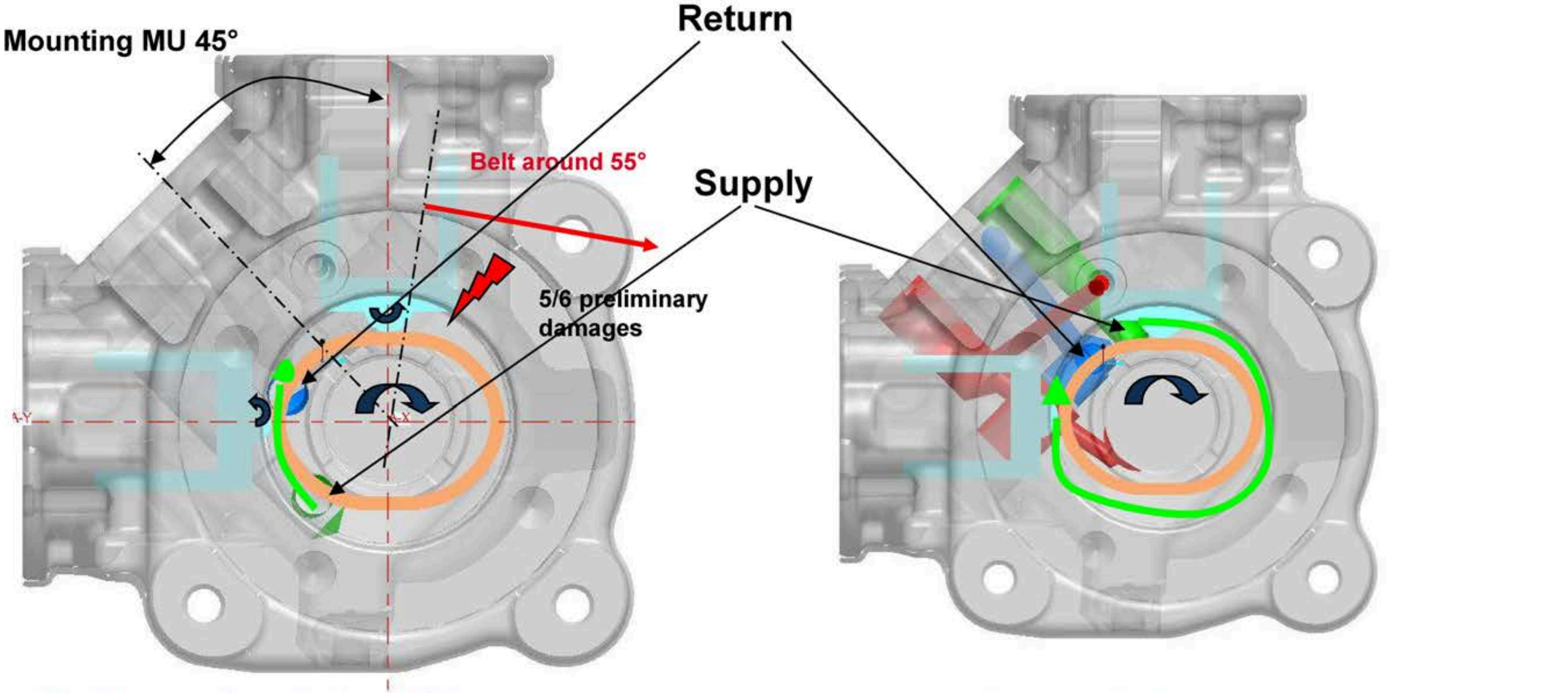
Further work

Confirm effectiveness in QHALT endurance run	WK24

Pumps for testing delivered to Audi. Introduction in series possible from WK 28.

CP4 robustness

Anti-wear package 2



Fuel goes directly to outlet

CP4.2-EFP cw Audi W19

Fuel is recycled once

CP4.2 EFP cw **AWP2** for Audi W19

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3) Failure statistics

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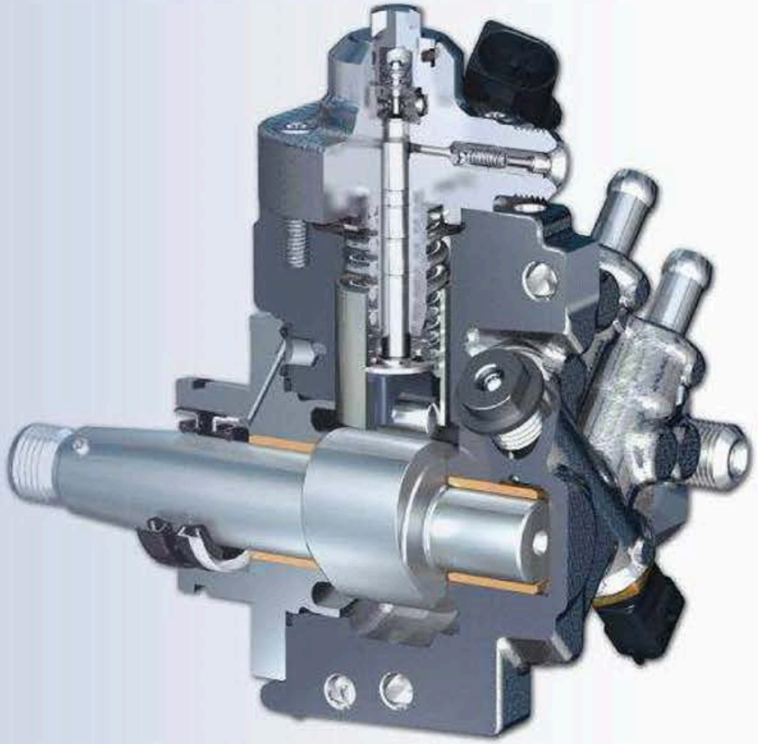

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CP4 robustness

Failure statistics [redacted]

Italy (see page 10, 11, 12)

- Decline in complaints CP4.2 with pumps DM after Jun 2009 (page 10)
- Absolute increase in complaints CP4.2 & CP4.1 in [redacted] from 03/2010 (page 11, 12)
    - Presentation of relative values (CP4.2 / CP4.1 / total / vehicle model) agreed up on with Audi
    - Joint analysis “Influence of vehicle model as part of task force
    - CP4.1 complaints likely not 100% drivetrain damage, but rather
        - Non-starters due to shavings in intake valve
        - Pump exchange due to noise complaint

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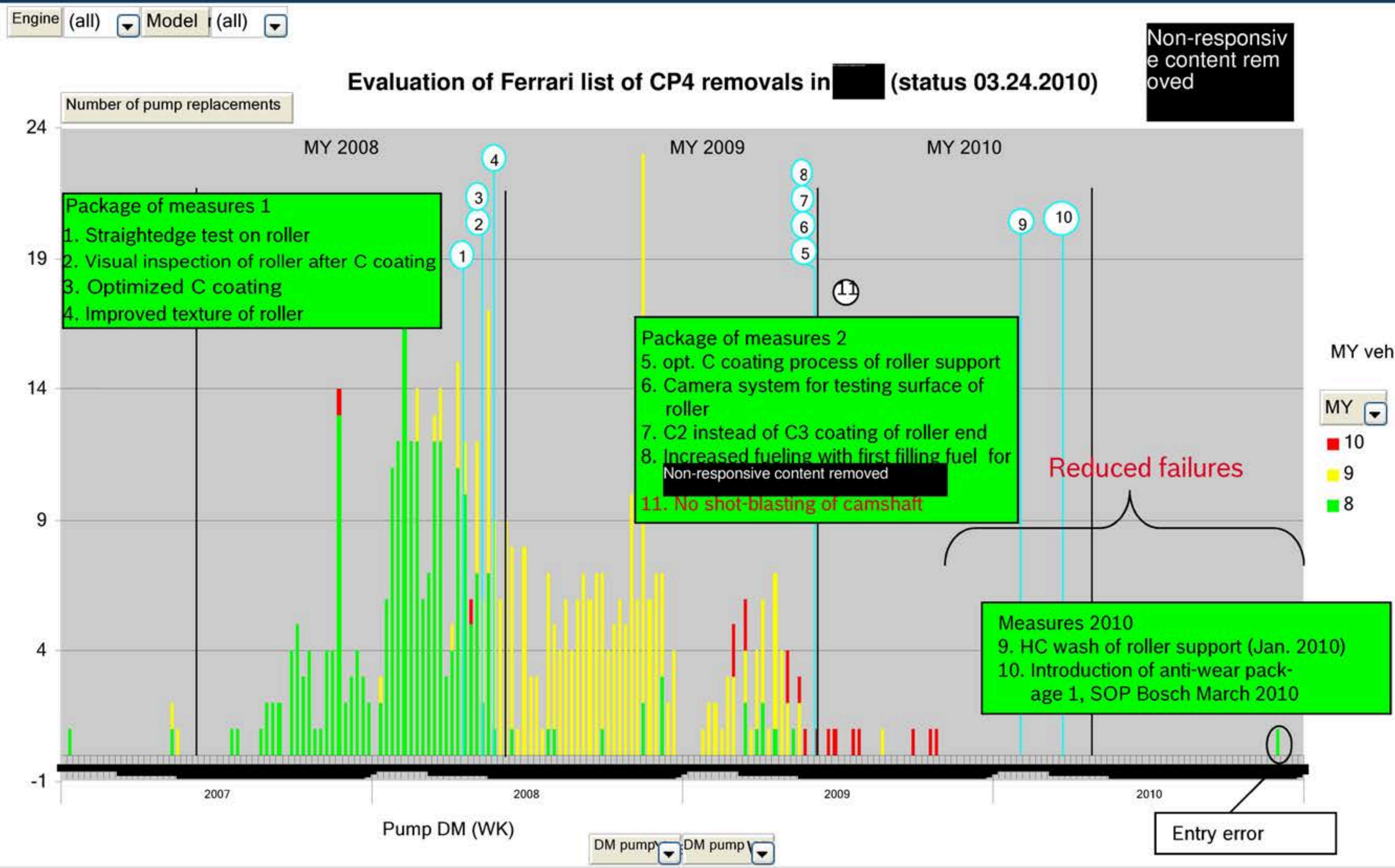
CP4 robustness



Diesel Systems

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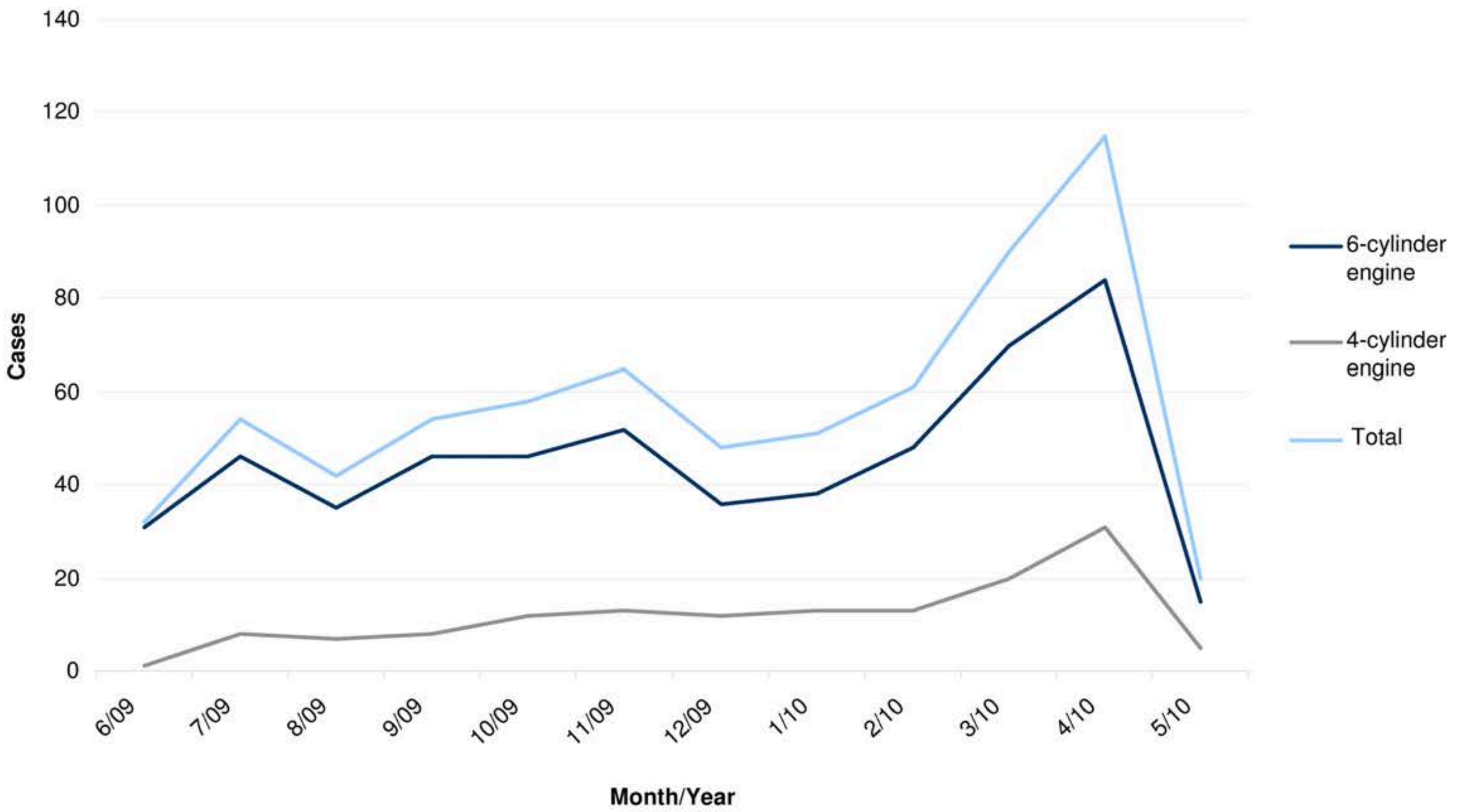
CP4 robustness

Failure statistics - Non-responsive content removed (total of all vehicles)

Failure of diesel CR high-pressure fuel pump - cases of damage by month (status: 05/11 WK 18)



Diesel Systems

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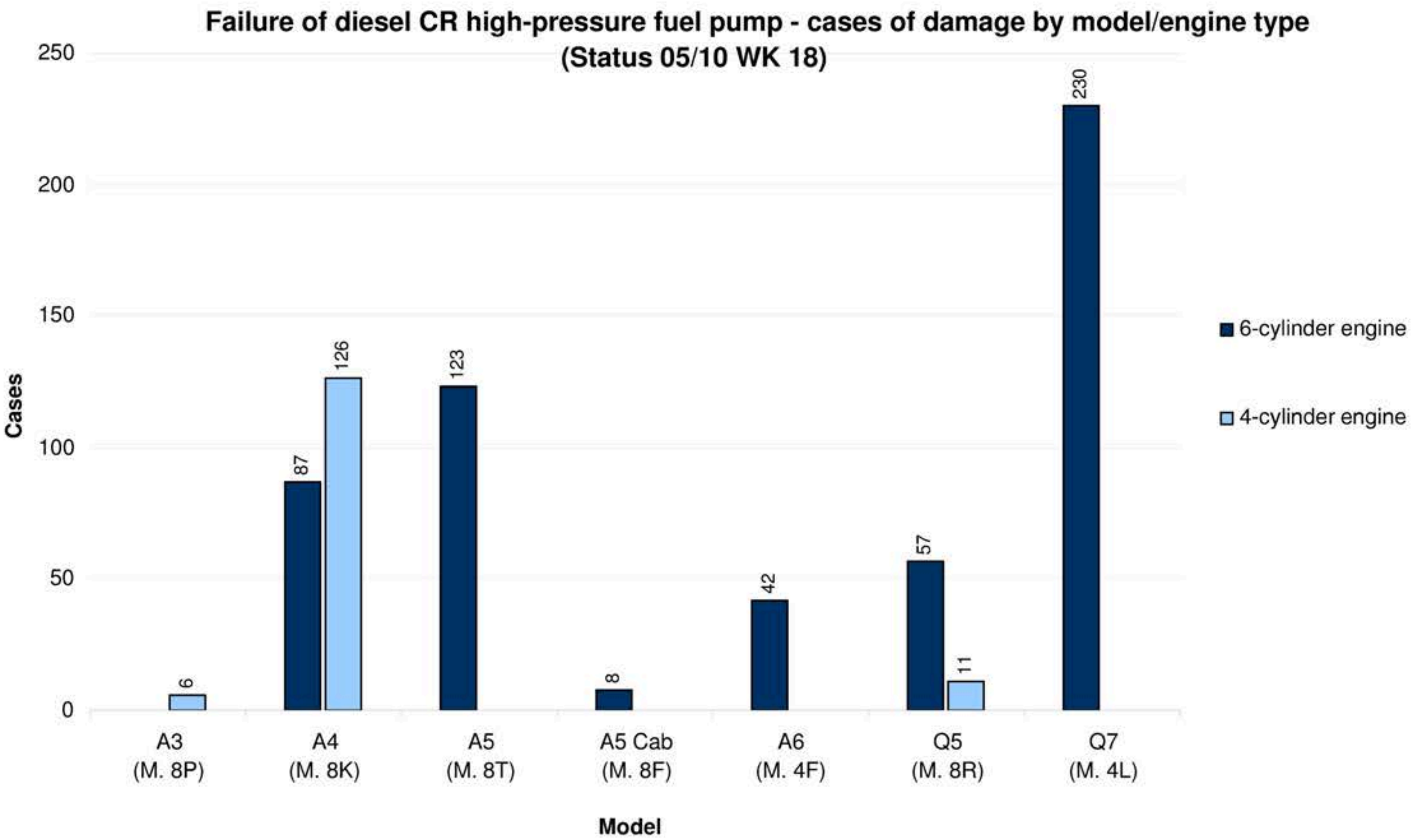
CP4 robustness

Failure statistics Non-responsive content removed (vehicles)



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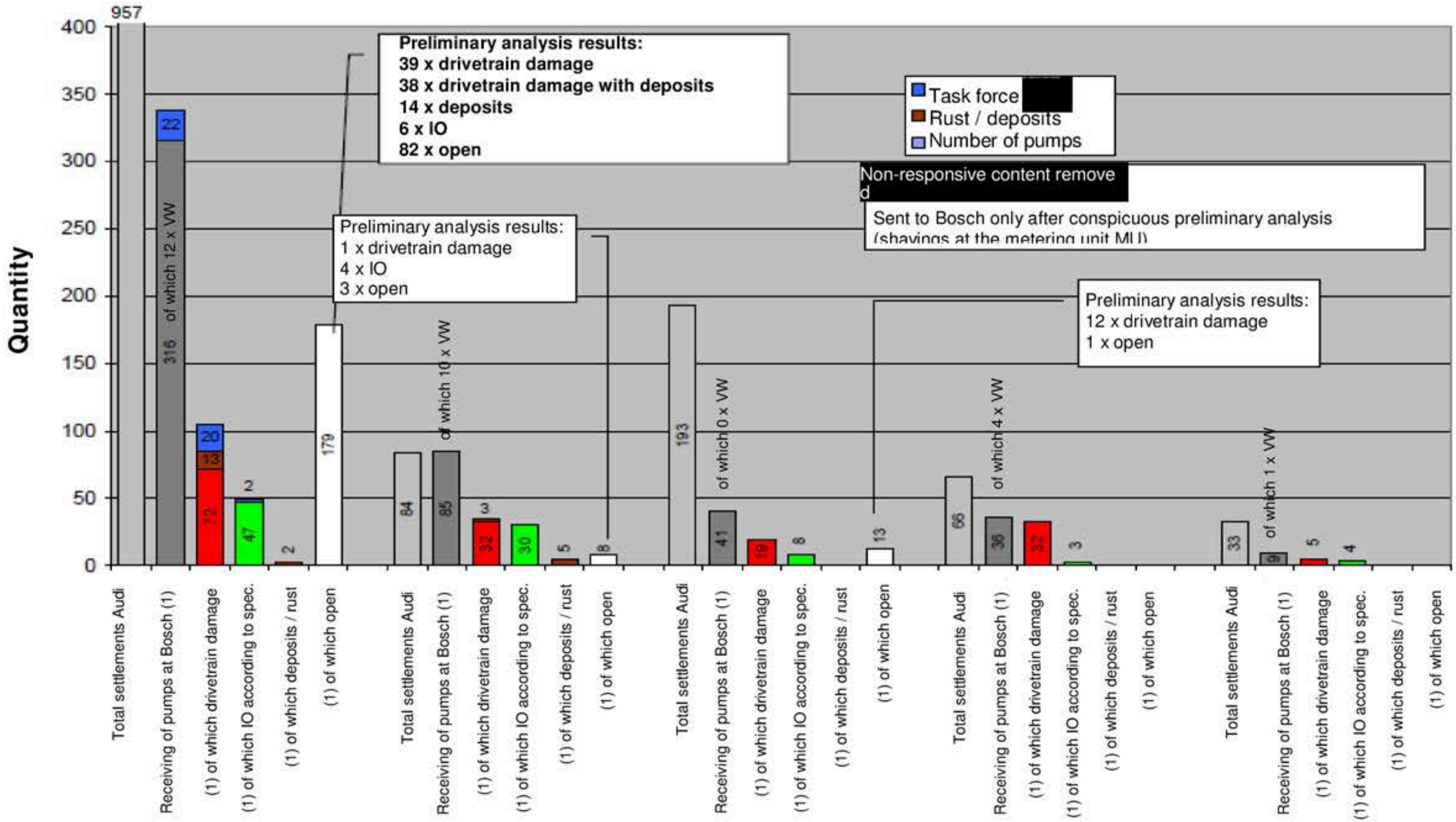
Audi CP4.2 field failures

TOP 5 countries

Base: Audi: SAGA analysis as of 07.04.2010 from TOP meeting on 07.12.2010
Bosch: IQIS as of 07.20.2010



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Diesel Systems

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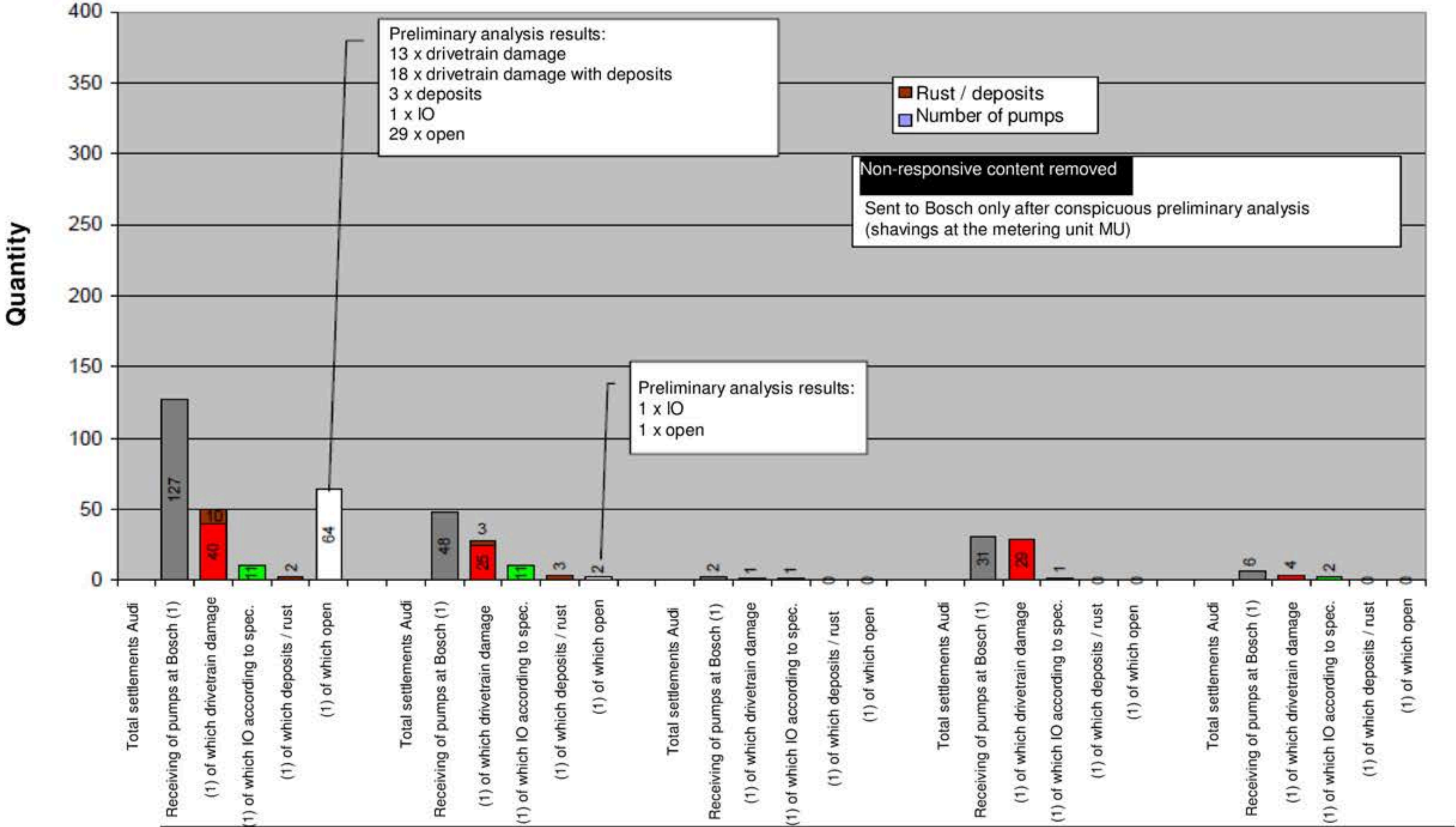
Audi CP4.2 field failures

TOP 5 countries (DM of pump **before** 06.01.2008)

Base: Bosch: IQIS as of 07.20.2010



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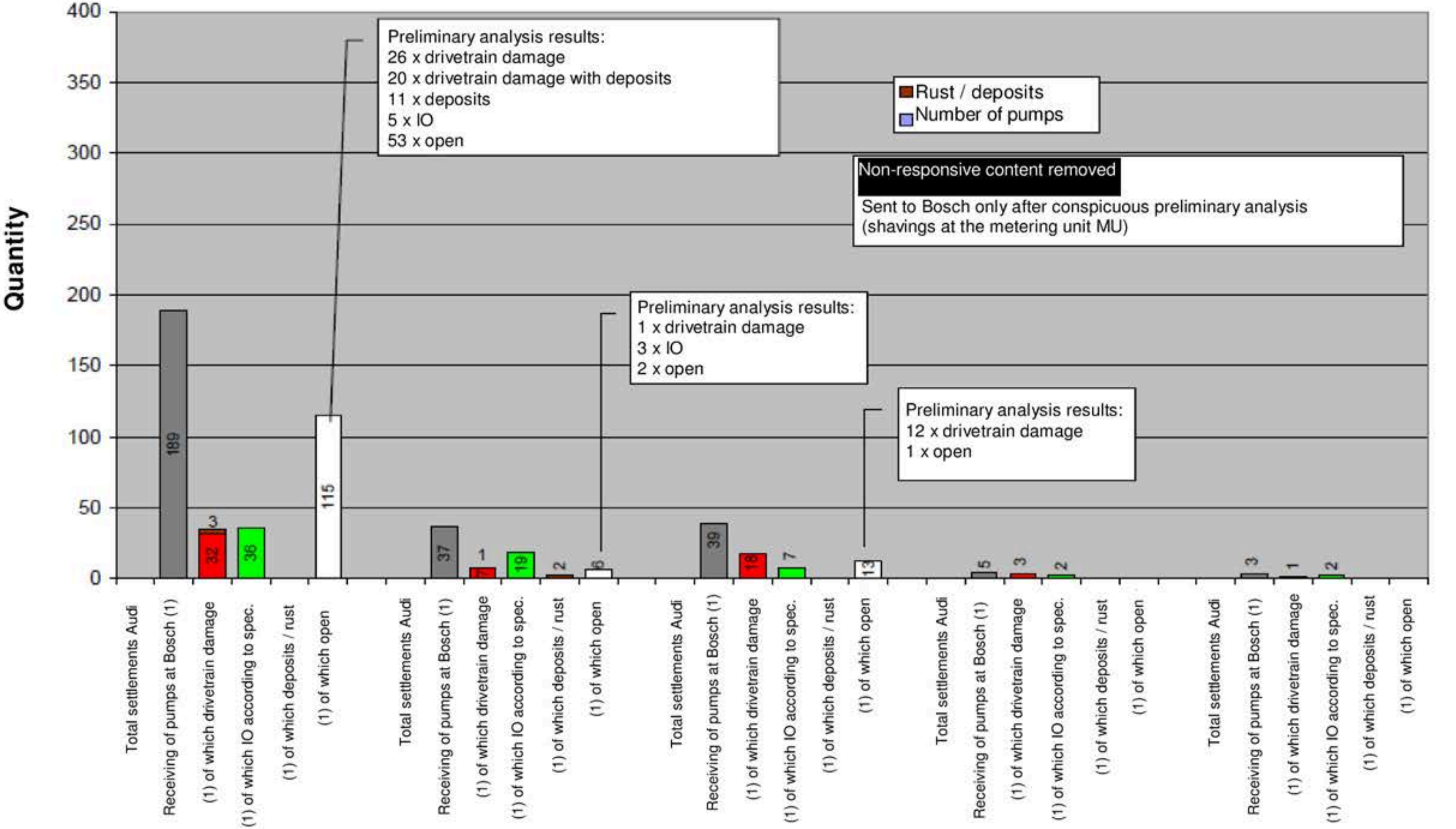
Audi CP4.2 field failures

Base: Bosch: IQIS as of 07.20.2010

TOP 5 countries (DM of pump starting **from** 06.01.2008)



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Diesel Systems

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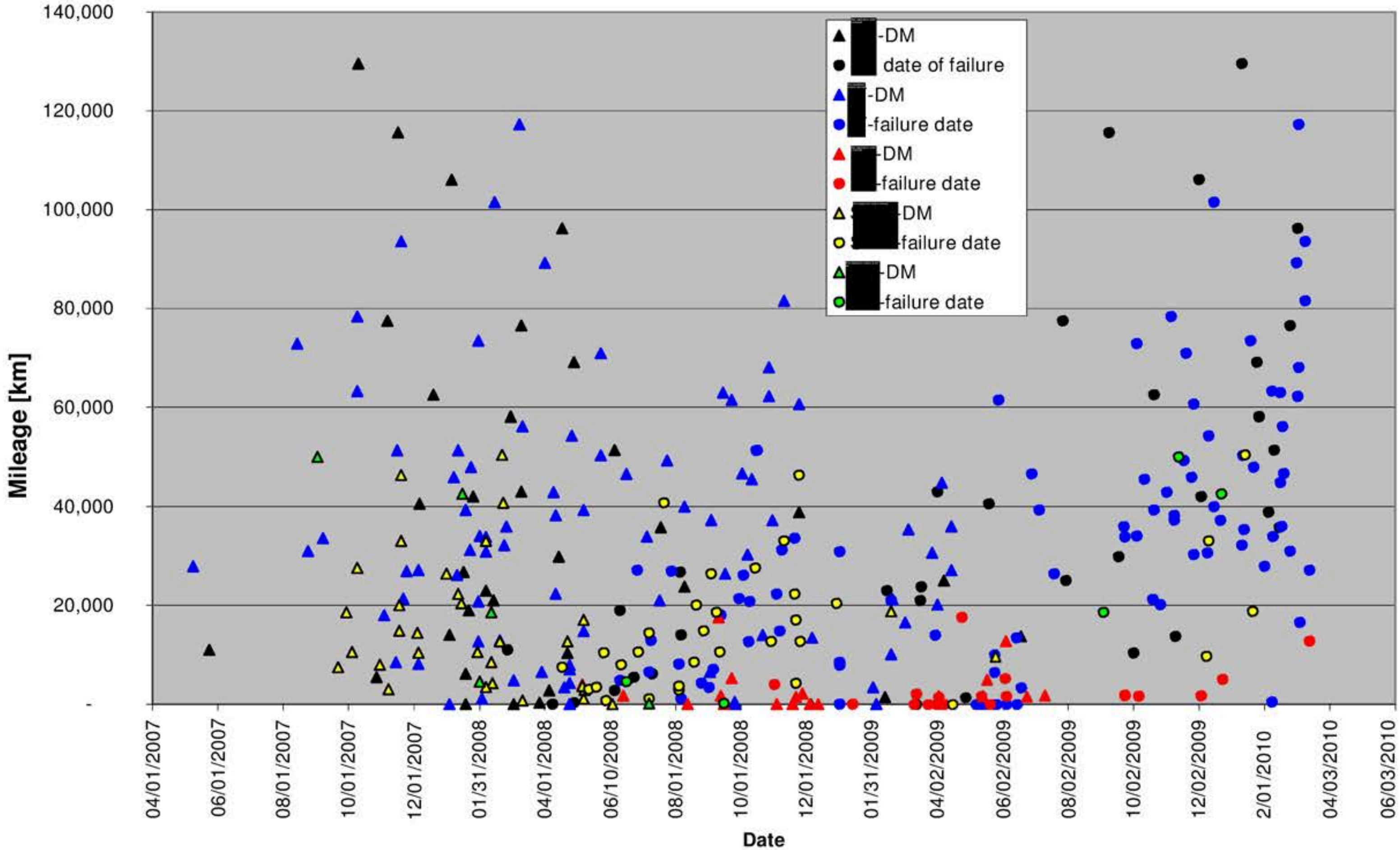
TOP 5 countries



Diesel Systems

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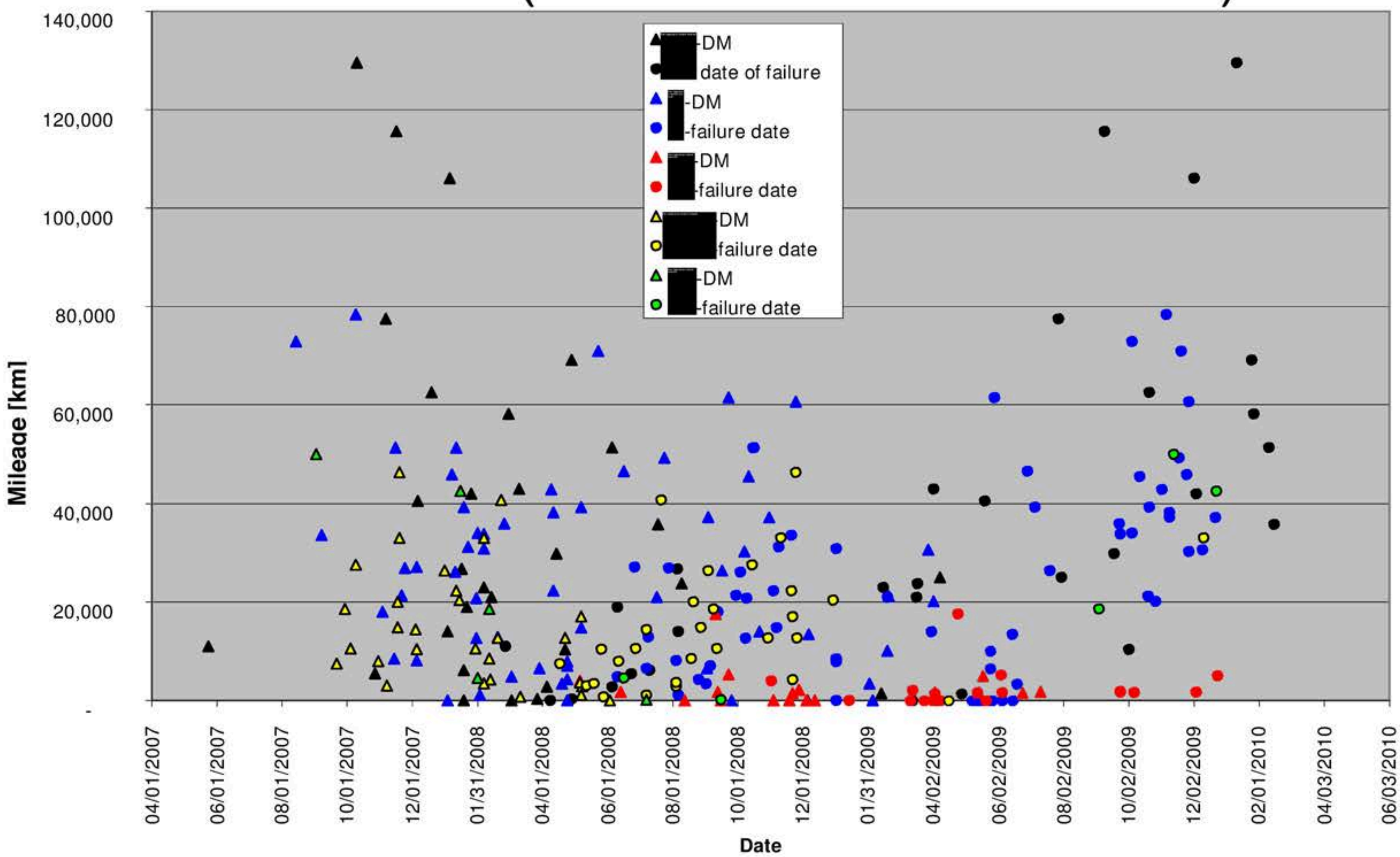
Audi CP4.2 field failures

Status: IQIS 03/16/2010

TOP 5 countries (Status as no: 3/16/2010)



Diesel Systems

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EAD Quality strategy 2.0l TDI BIN5

	Field failures BIN5		
	Topic	Cause	Responsibility
1	HPP CP4.1 Bosch	Failures/ drivetrain damage	[redacted]

Team	
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Problem: HPP failures due to drivetrain damage
(Tribo system: Roller support, roller, camshaft)

Cause:
- Q problems RB (tolerances, friction pairing, etc)
- Fuel properties (HFRR, water content, etc)

Measures:
- Implemented measures, see measures package RB
- Task force CP4 (Audi/ Bosch/ VW)
- Validation of initial CP4.1 sample pumps with anti-wear package 1 in NMS / NCS since WK 08/10. RP1 at Audi V6 with CP4.2 already into series production.
- Requirement: Incorrect fueling guard in tank connector for NMS, NCS and all subsequent CR installations

Deadline: continuous

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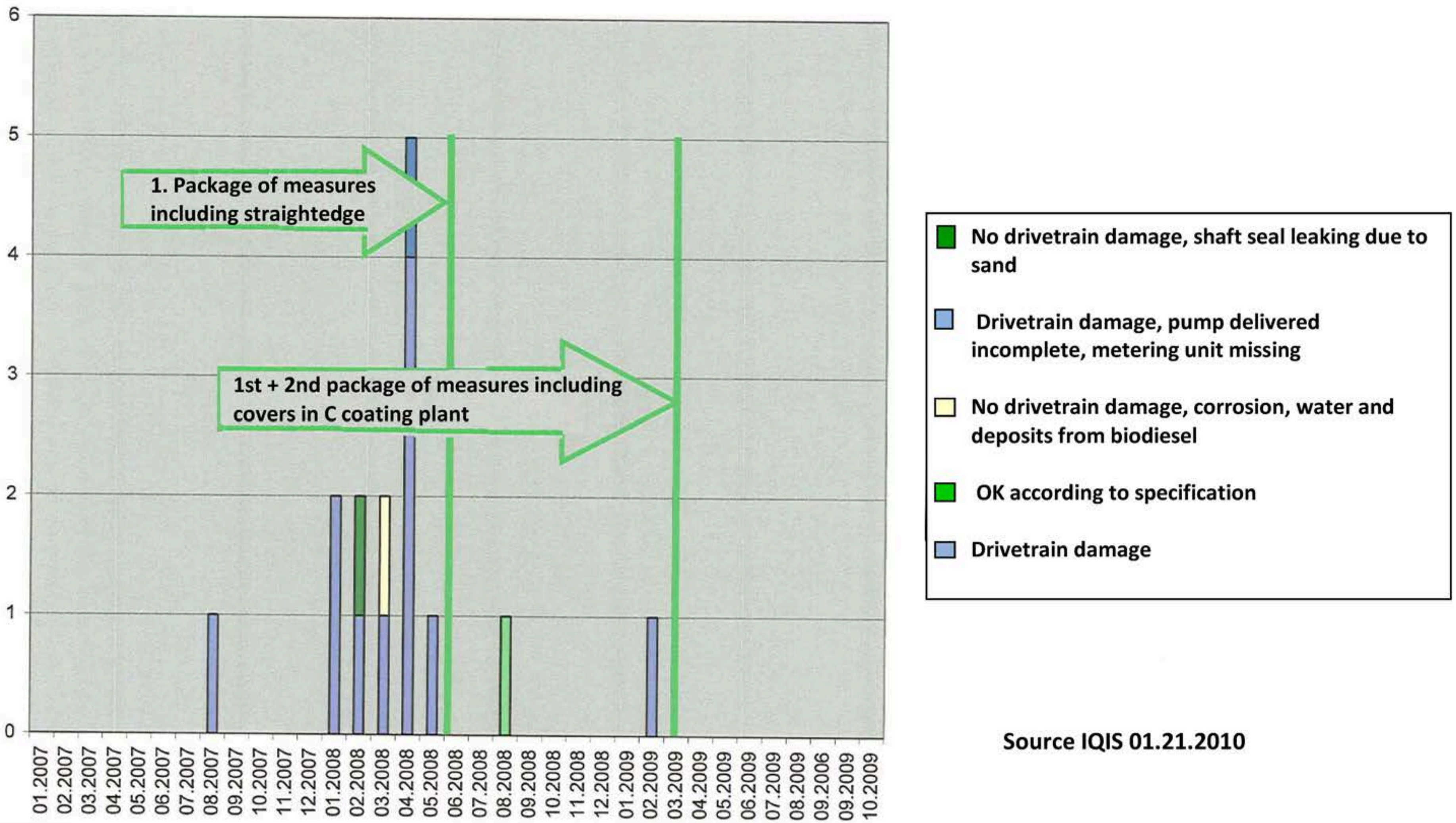
VW CP4.1 field complaints from USA (03L 130 755A)

CP4.1 Field complaints from the USA, Status as on 10.21.2010



Source IQIS 01.21.2010

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VW CP4.1 field complaints from USA (03L 130 755A)

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Previous measure

No.	Measures to reduce drivetrain damage		Introduction FeP		Introduction JhP	
			Today's date	WK	Today's date	WK
1	No reuse of tappet after OK press-in process		5/10/2007	WK19/07	1/31/2008	WK04/08
2	Click-clack testing before delivery		5/10/2007	WK19/07	1/31/2008	WK04/08
3	Click-clack test		5/14/2007	WK20/07	1/31/2008	WK04/08
4	Delta T and Delta T max test at test rig		5/23/2007	WK21/07	1/31/2008	WK04/08
5	Click-clack test at the end of assembly line		5/29/2007	WK22/07	1/31/2008	WK04/08
6	new switching process between flushing and testing		5/30/2007	WK22/07	1/31/2008	WK04/08
7	Simultaneous noise measurement		6/18/2007	WK25/07	1/31/2008	WK04/08
8	Repeat inspection on friction coefficient test rig dropped		6/20/2007	WK25/07	12/1/2007	WK48/07
9	Optimization of test rig sequence (n>500 rpm)		07/09/2007	WK28/07	1/31/2008	WK04/08
10	Cylinder head installation with 5° torsion allowance		7/23/2007	WK30/07	12/1/2007	WK48/07
11	Dry pressing in of roller support		7/23/2007	WK30/07	02/06/2008	WK05/08
12	Uncoated spring plate (customer C)		7/23/2007	WK30/07	1/31/2008	WK04/08
13	Introducing dwell time during roller tappet assembly		8/28/2007	WK35/07	2/6/2008	WK05/08
14	Extension of high-load testing point		10/1/2007	WK40/07	1/31/2008	WK04/08
15	Testing point V7.2 (Customer C)		11/16/2007	WK46/07	1/31/2008	WK04/08
16	improved visual inspection of roller support		12/13/2007	WK50/07	1/31/2008	WK04/08
17	Friction coefficient testing +/- 10°		12/13/2007	WK50/07	2/7/2008	WK05/08
18	Tappet position query during assembly		12/21/2007	WK51/07	2/7/2008	WK05/08
19	New visual inspection catalog for roller support		01/02/2008	WK01/08	1/20/2008	WK02/08
20	Test program V7.2 (VW), visual inspection catalog for roller support		01/11/2008	WK02/08	1/31/2008	WK04/08
21	Test program V7.2 (Audi)		02/01/2008	WK05/08	1/31/2008	WK04/08
22	Changeover of roller for models …507/…508		3/17/2008	WK12/08	1/31/2008	WK04/08
23	Straightedge testing, visual inspection catalog for roller support		04/07/2008	(WK15/08)	4/7/2008	WK14/08
24	Cleaning cloth with straightedge test		05/01/2008	WK18/08	5/1/2008	WK17/08
25	Visual inspection of the roller after C coating		05/01/2008	WK18/08	5/1/2008	WK17/08
26	Optimization of the C coating		05/01/2008	WK18/08	5/1/2008	WK17/08
27	Changeover of roller for models ... 611/...613 to second source supplier		05/15/2008	WK20/08	11/3/2008	WK44/08
28	New washing and transport frames for the roller		10/29/2008	WK44/08	10/29/2008	WK44/08
29	Modified RS holding tool when pressing in the tappet body		11/24/2008	WK48/08	5/6/2009	WK19/09
30	Carbon covers / holders in system N for roller support		12/12/2008	WK50/08	12/12/2008	WK50/08
31	Camera system for detecting metal spatter on roller support System installed / trial Series launch at the earliest from middle 06.2009			WK19/09	Roller support will be supplied from FeP	
			No. of parts	WK 25/09	Roller support will be supplied from FeP	
32	Optimized substrate holder to prevent fusing on roller, at the earliest		Activity broken off because not expedient ~~WK32/09~~		Activity broken off because not expedient ~~WK32/09~~	
33	Carbon covers / holders in system O for roller support		3/16/2009	WK12/09	3/16/2009	WK12/09
34	introduction of C2.1 coating instead of C3 coating on roller front surface		5/23/2009	WK22/09	5/23/2009	WK22/09

Legend
Measure implemented
Introduction to plan
Introduction date has passed
Implementation not expedient, or effectiveness being checked

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Anti-wear package 1 for CP4

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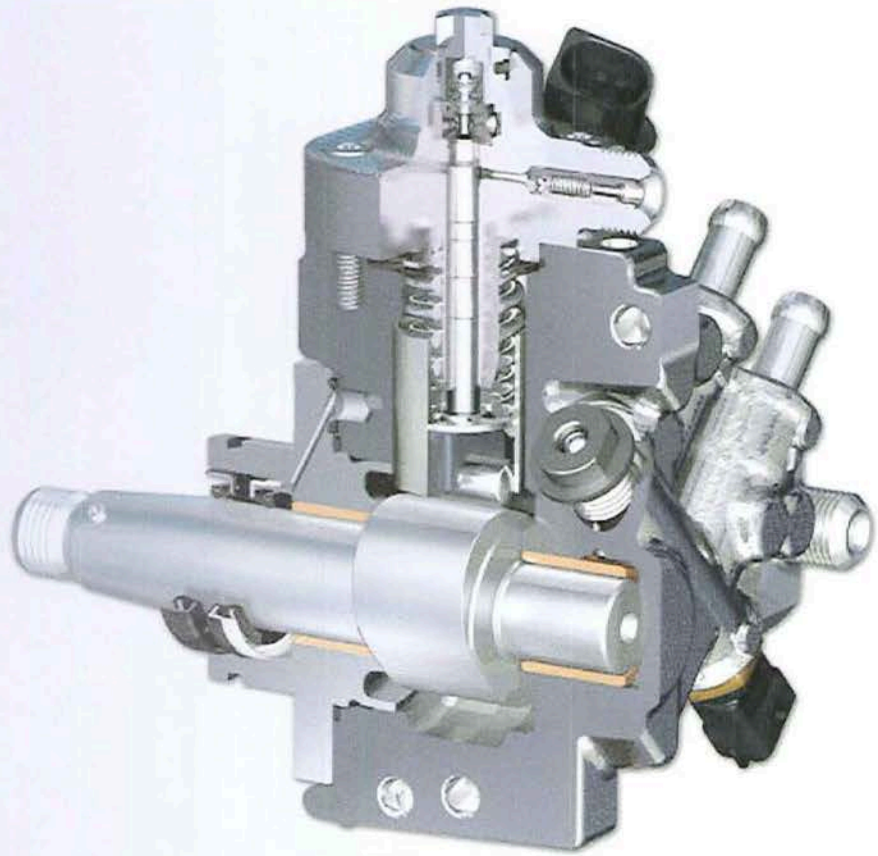

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Anti-wear package for CP4

Anti-wear package 1

Task

Increase in robustness of drivetrain by increasing the lubricant film thickness between the roller support hole and the roller.

Features of anti-wear package 1

1) Reduction of the roller support texture in combination with changeover to C2 coating on roller support
2) Reduction of play between the roller support and the roller by shifting the tolerance center and the tolerance width of the roller support hole.

Results from simulation: Increase in robustness of ~ 50%*
(*compared to today's borderline tolerances)

Further work: Verification in component verification **WK8**

Anti-wear package for CP4

Anti-wear package 1

Basic testing of C2 coating including approval at two customers with EN590 and BDF520 (USA) exist (total runtime of the test ~ 70,000h)

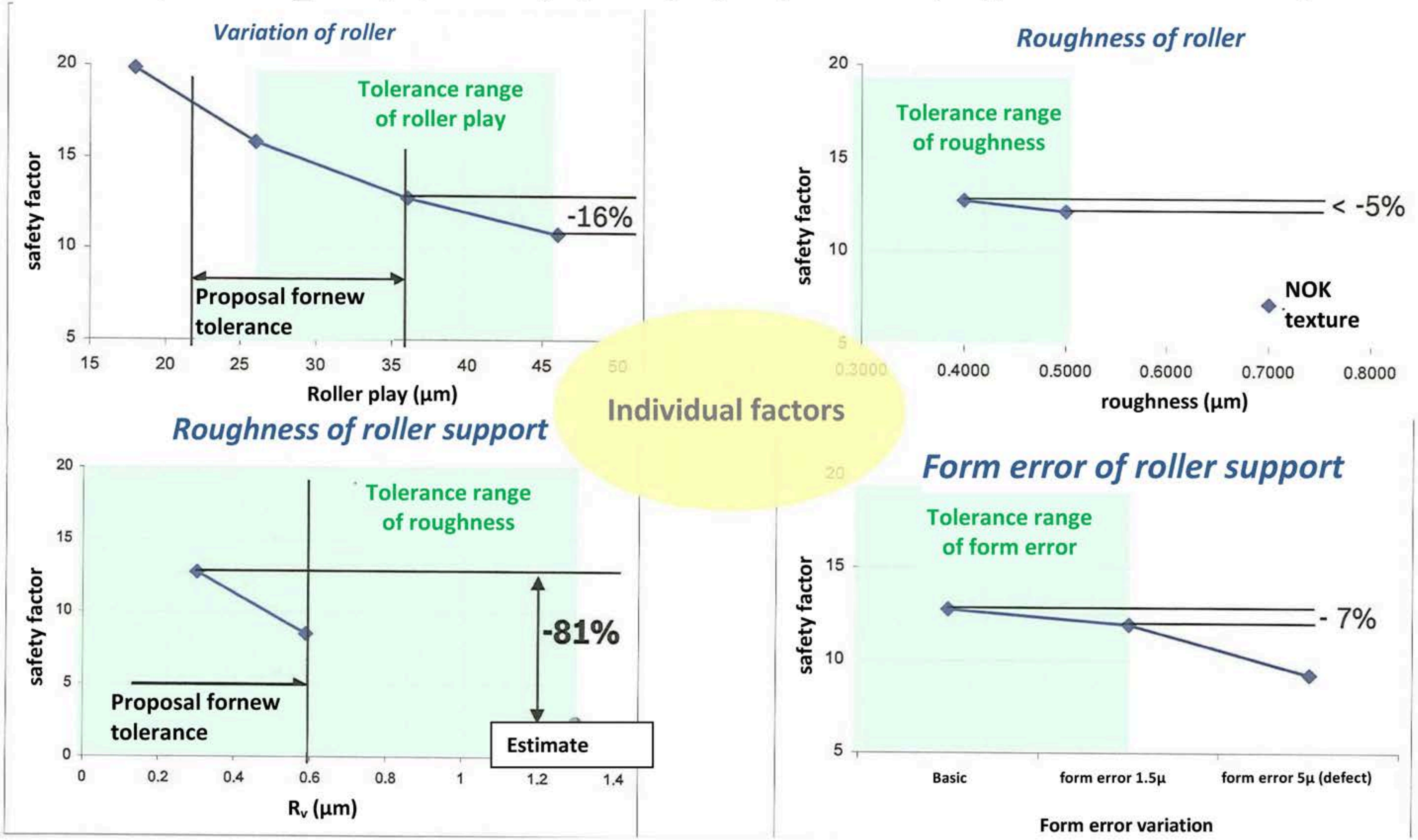
Audi wants short-term use for W19 6 cylinder engines (pump type .. 611).

RB will check by 01.27.2010 the changeover possibilities and the risks related to it.

Anti-wear package for CP4

Presentation of safety factor against slip in TDC:

CP4.1, 2 x 5.25_s032, 1,800 bar, 1,000 rpm, 36 µm Roller play, kin. visc. = 2.7 mm^2/s



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Anti-wear package for CP4

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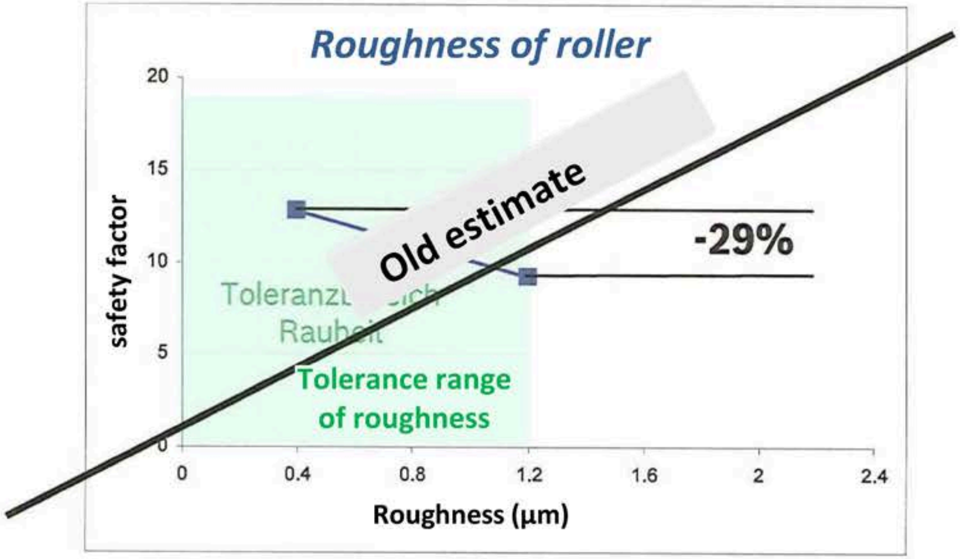
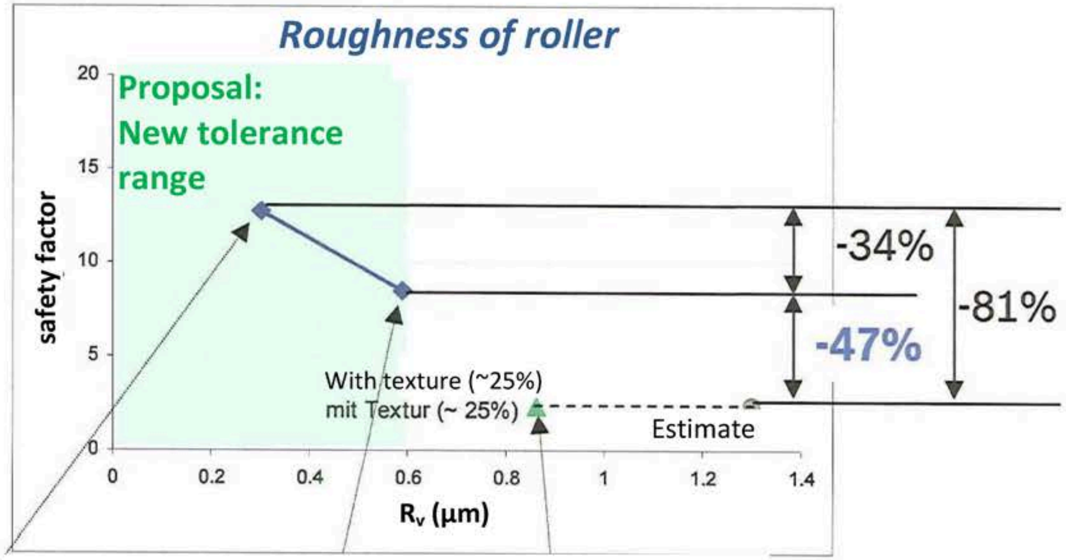
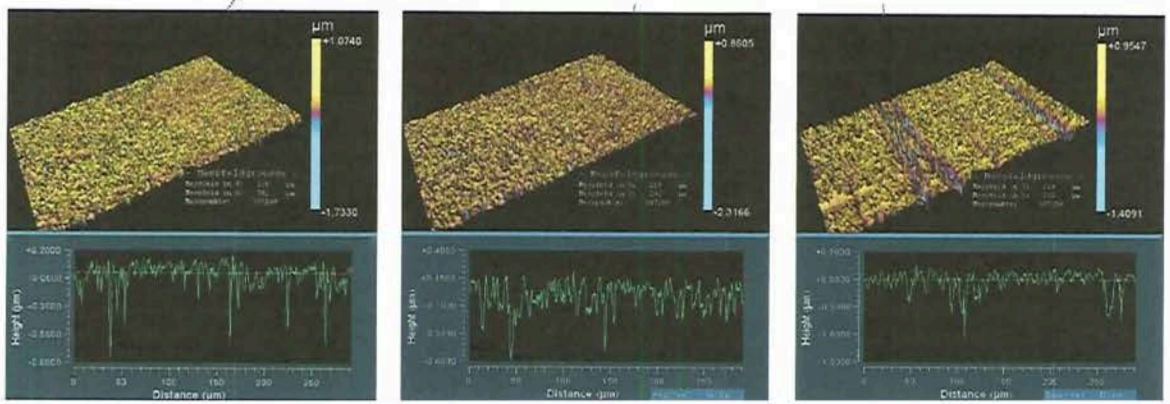
CP4.1, 2 x 5.25_s032, 1,800 bar, 1,000 rpm, 36 µm Roller play, kin. visc. = 2.7 mm²/s



Application safety factor against estimated roughness!



Application safety factor against R_v (tactile measurement)



BOSCH

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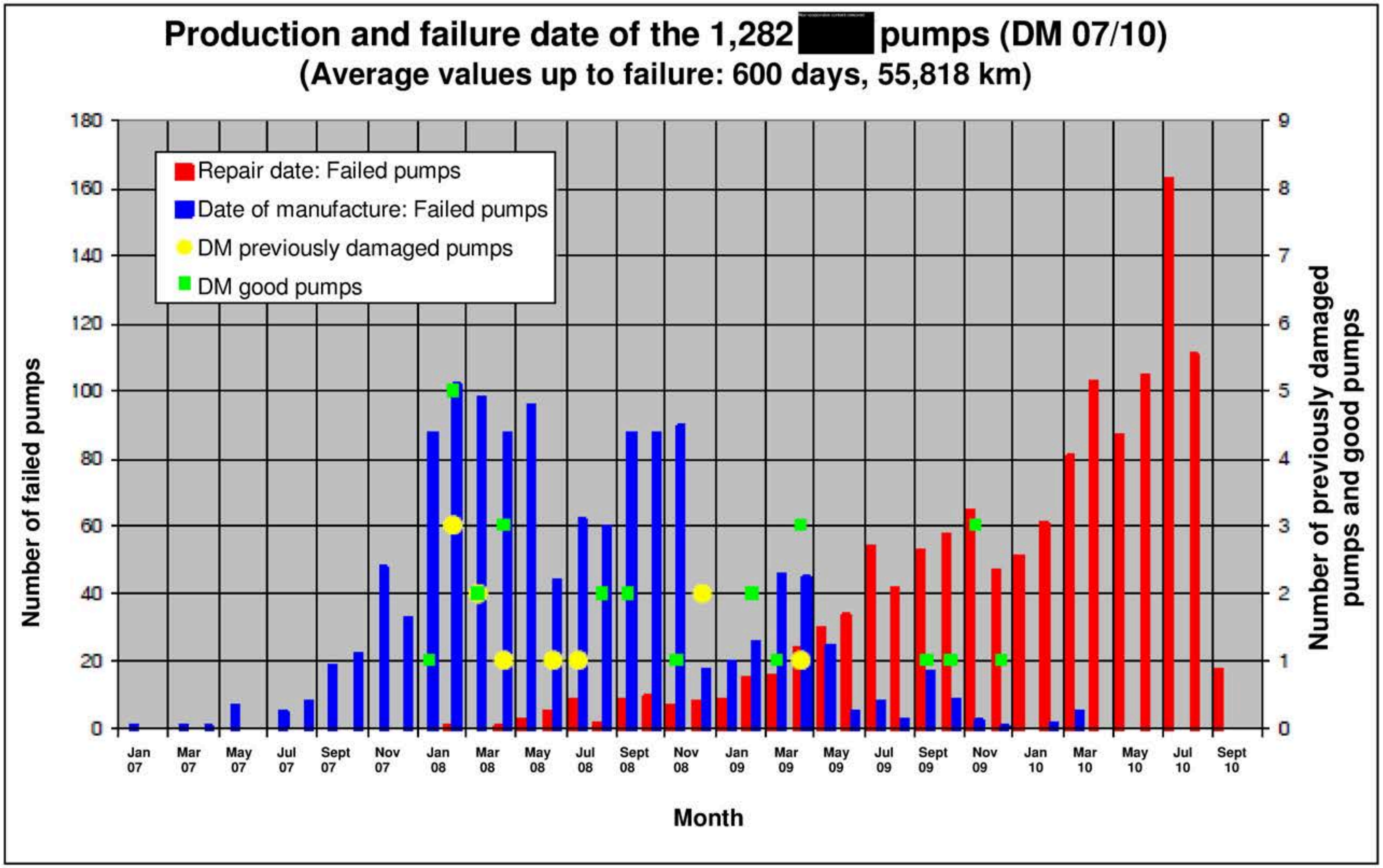
Audi CP4 Task Force, failures [redacted]



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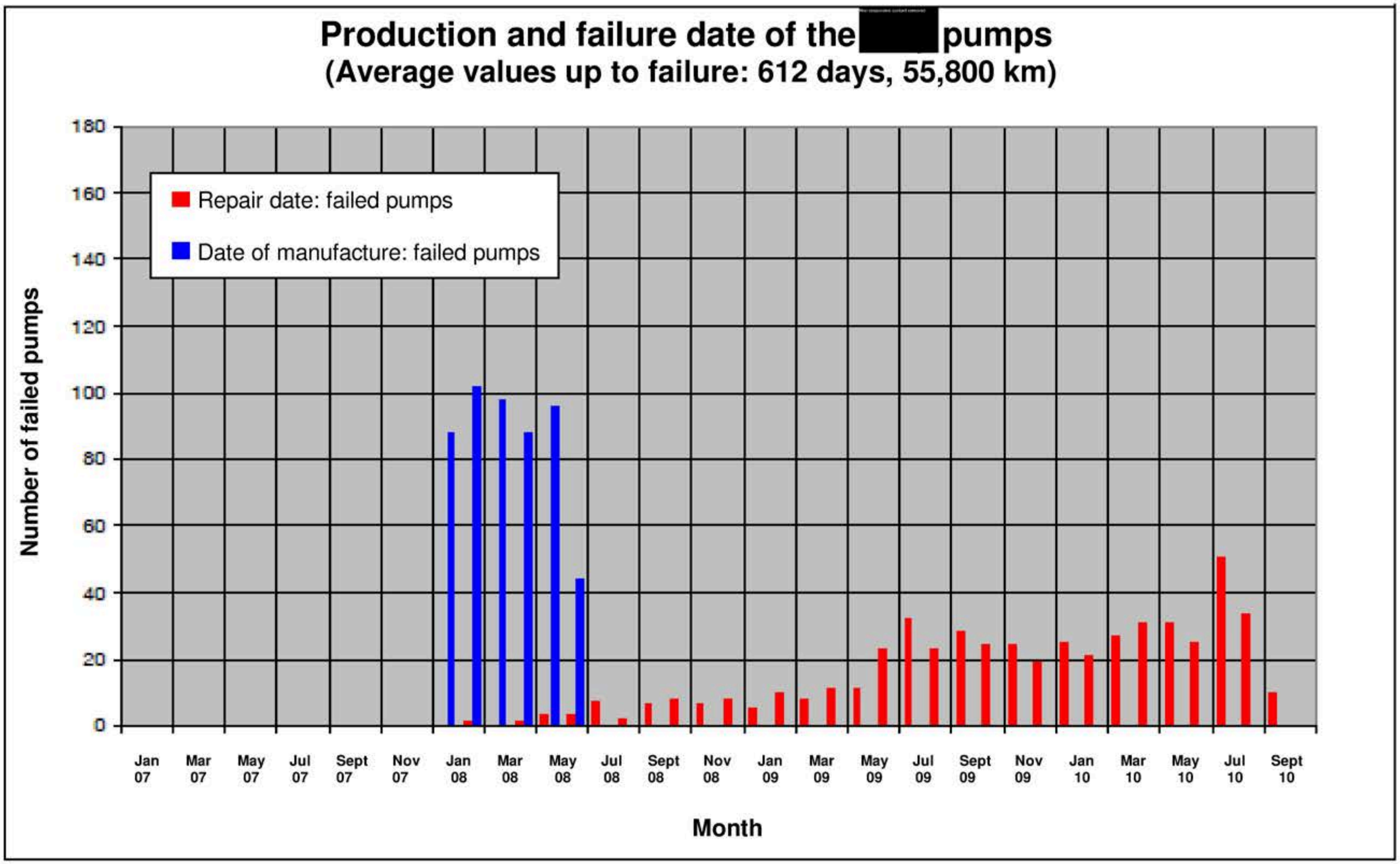
Audi CP4 Task Force, failures [redacted]



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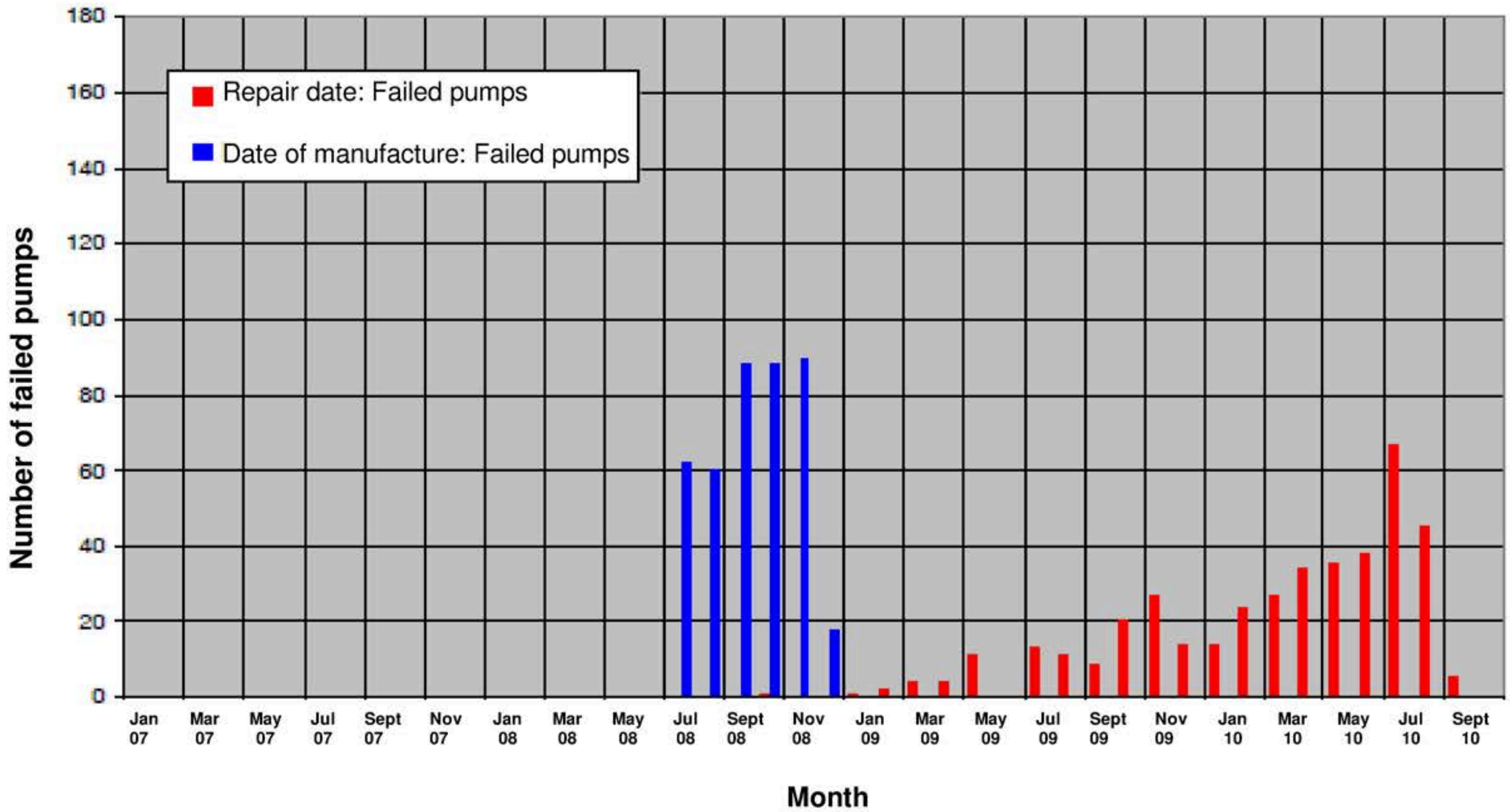
Audi CP4 Task Force, failures Non-responsive content removed [redacted]

Production and failure date of the [redacted] pumps
(Average values up to failure: 534 days, 54,037 km)



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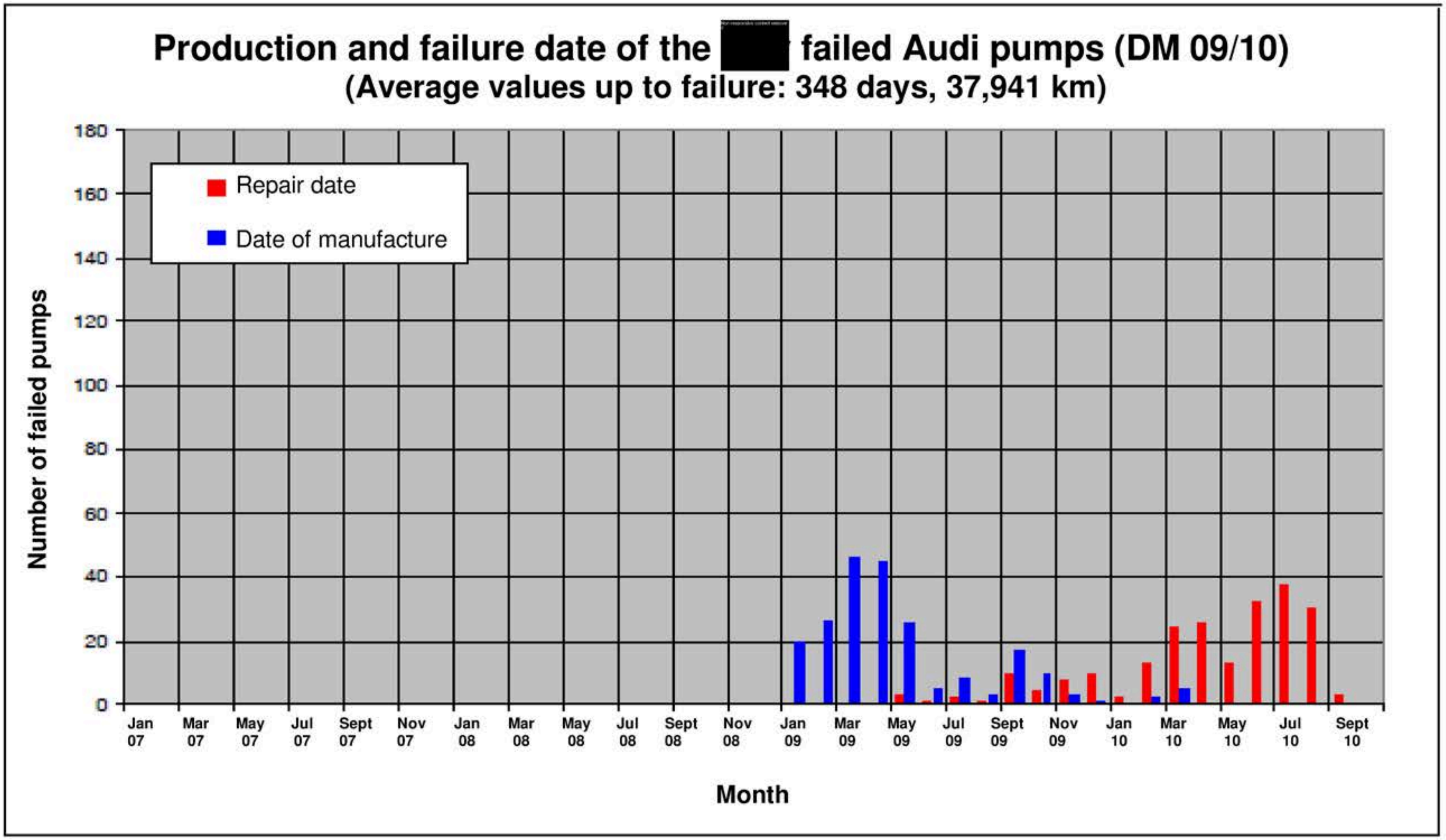
Audi CP4 Task Force, failures [redacted]



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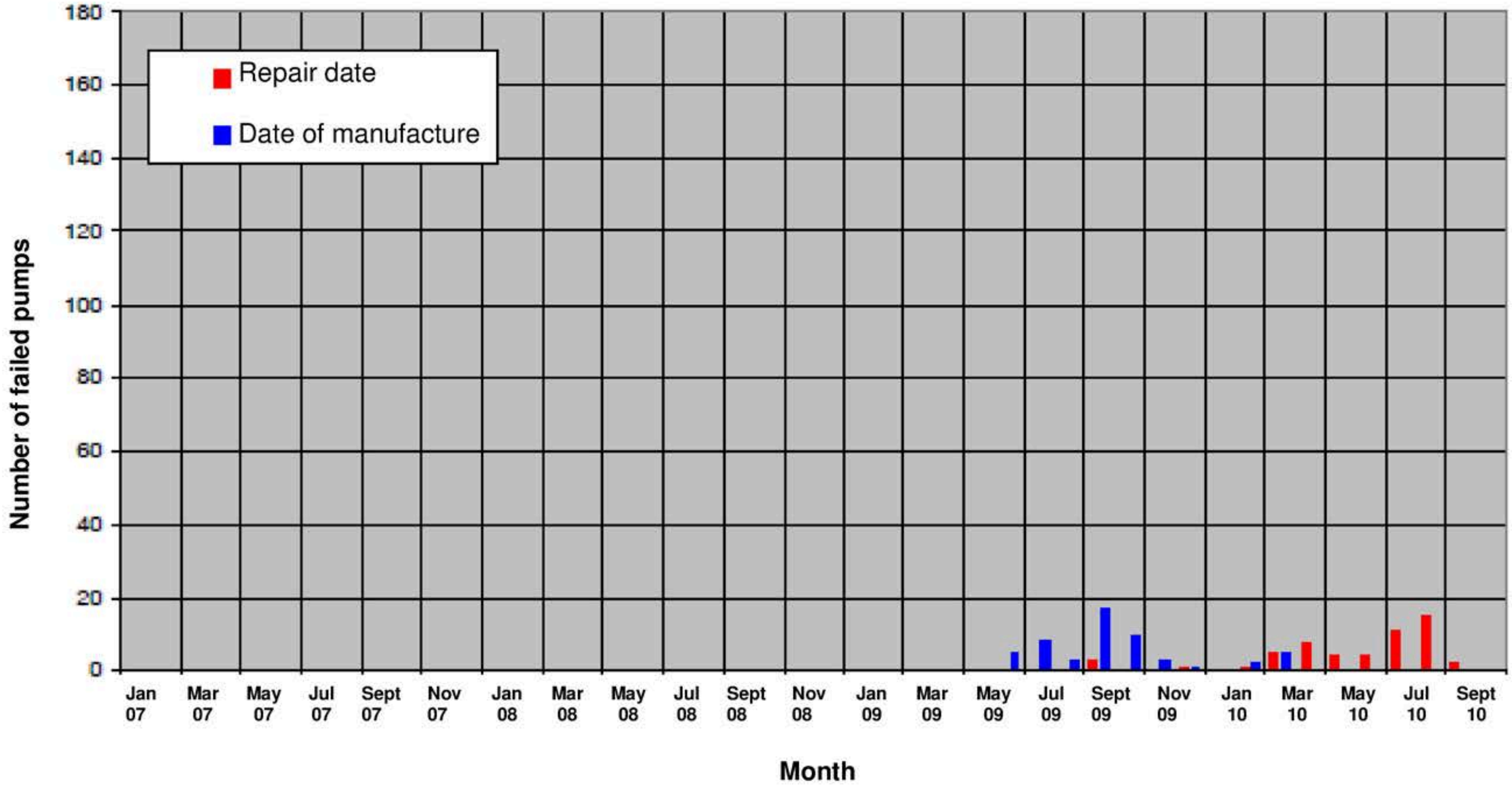
Audi CP4 Task Force, failures [redacted]

Production and failure date of the [redacted] failed Audi pumps (DM)
(Average values up to failure: 247 days, 35,342 km)



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EA11003EN-02137[5]

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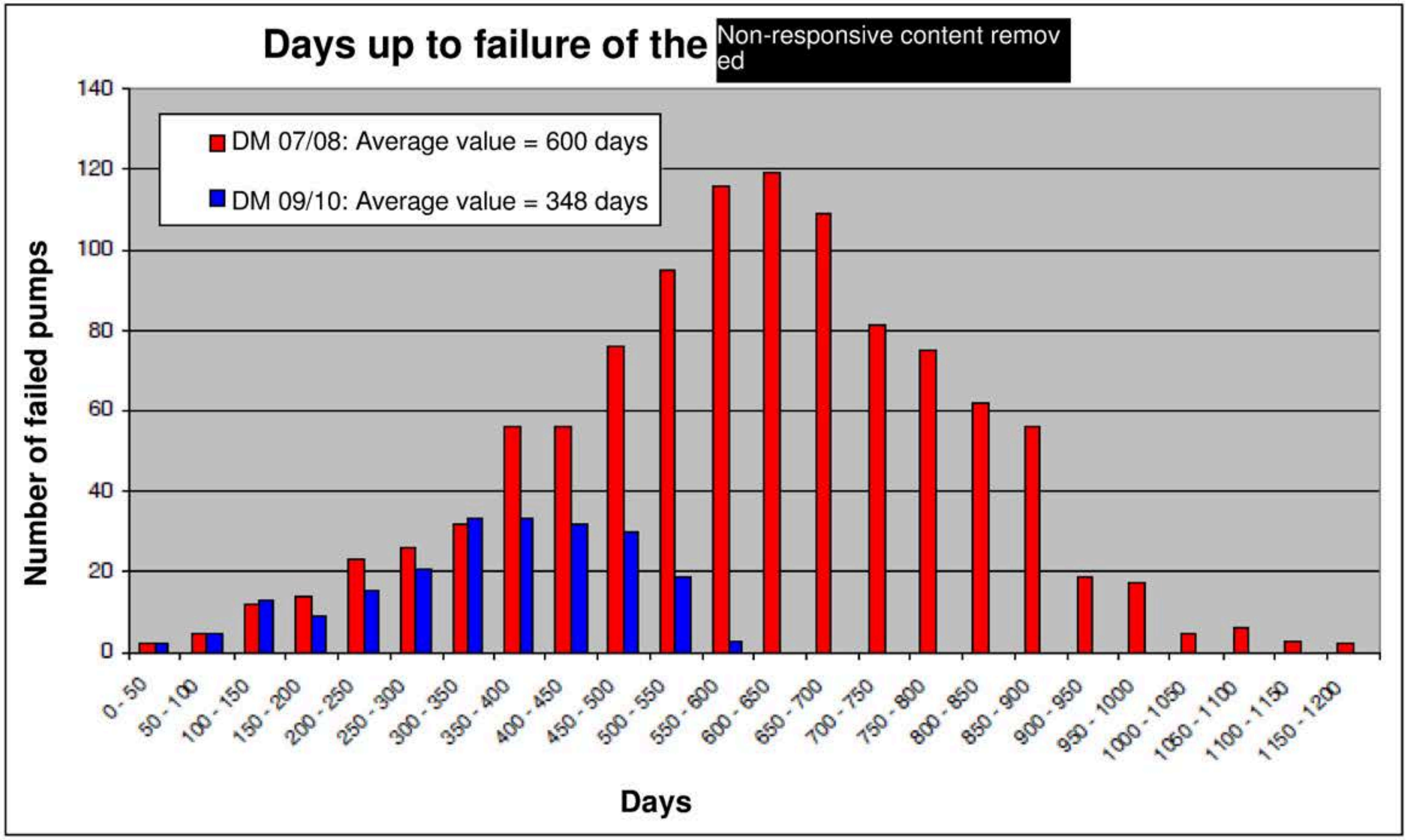

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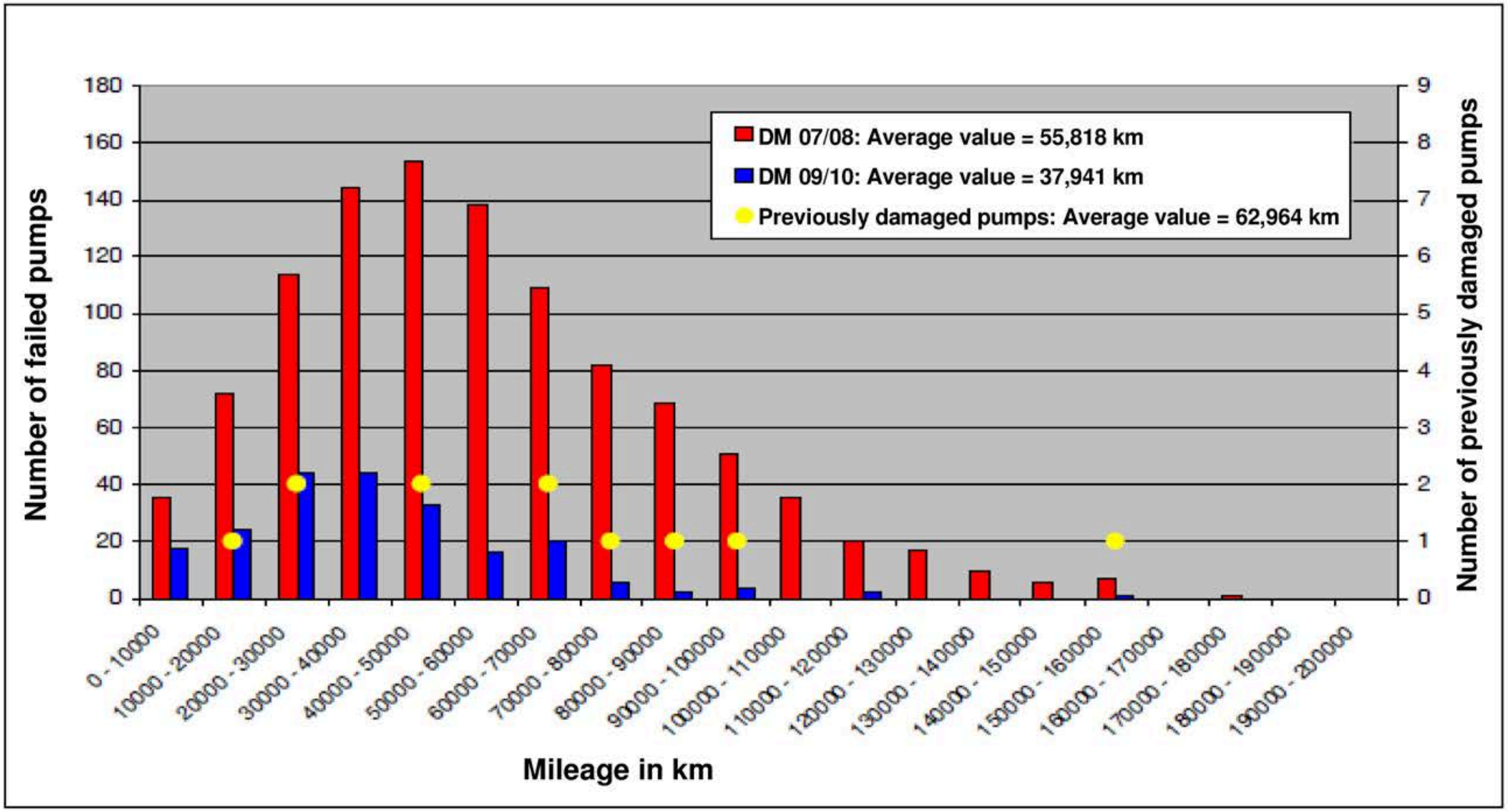
Audi CP4 Task Force, failures [redacted]

Mileage up to failure of the [redacted]



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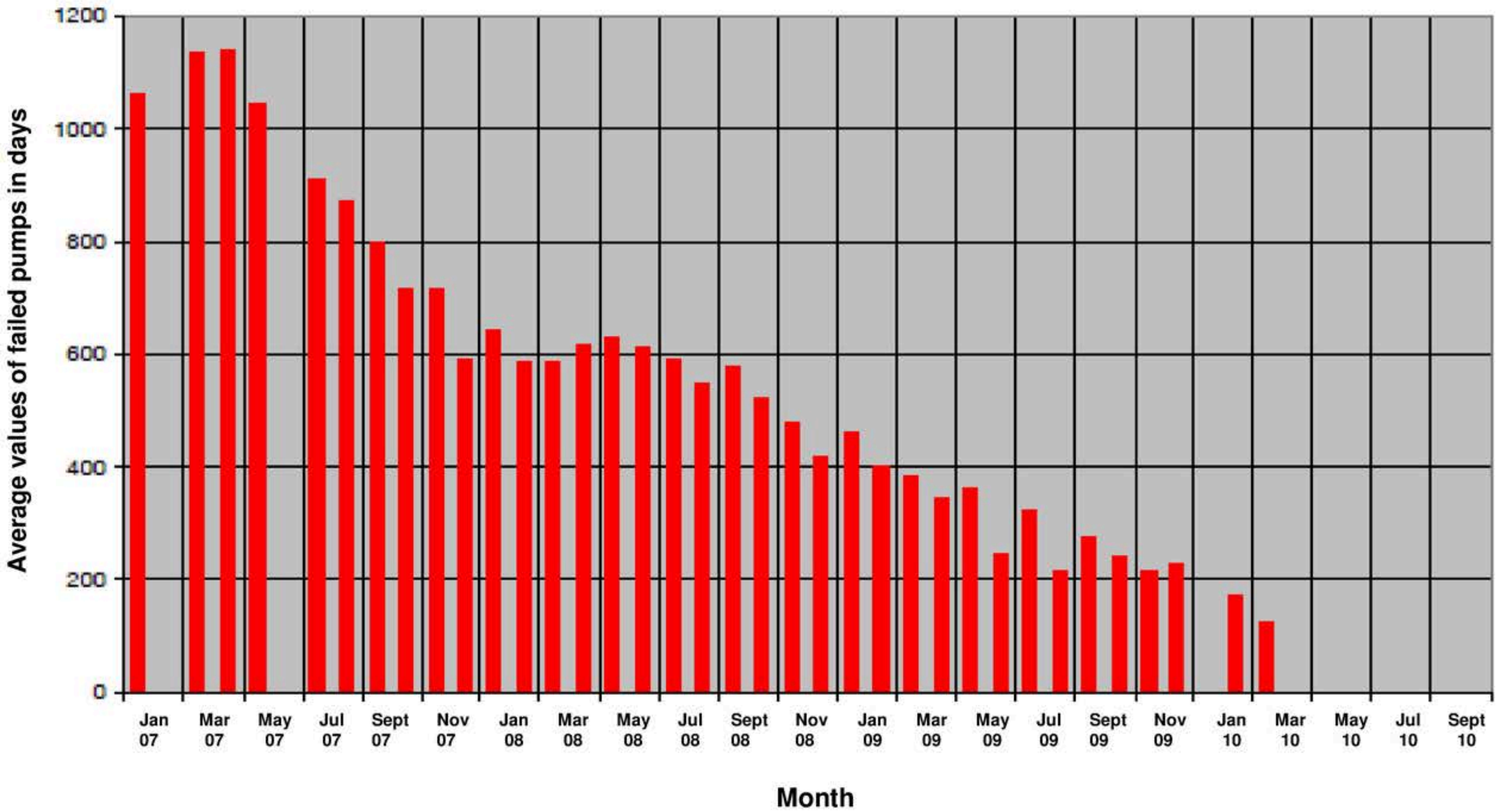
Audi CP4 Task Force, failures Non-responsive content removed

Days up to failure depending on DM for the Non-responsive content removed
(Average values up to failure: 600 days, 55,818 km)



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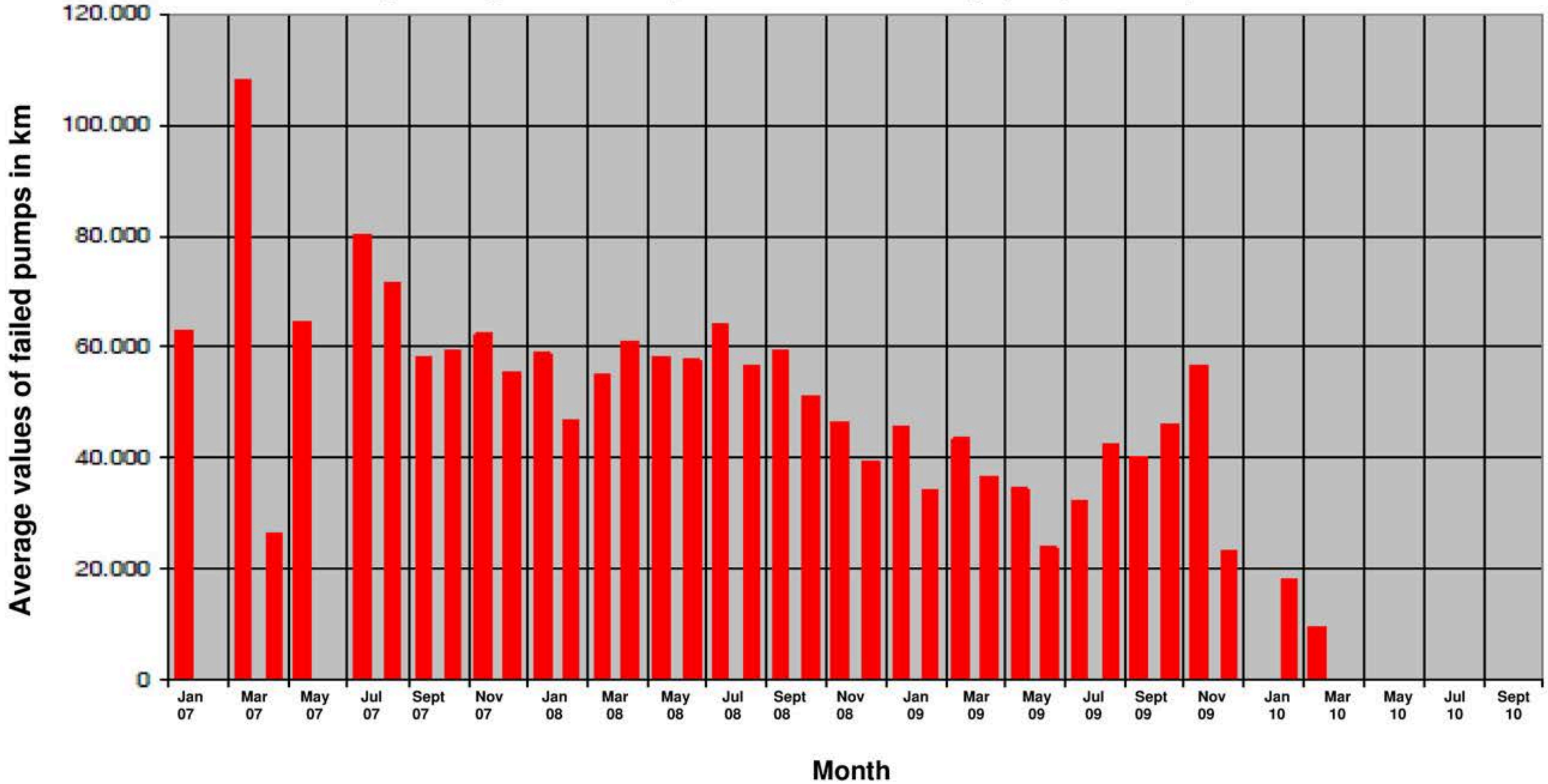
Audi CP4 Task Force, failures [redacted]

Days up to failure depending on DM for the [redacted]
(Average values up to failure: 600 days, 55,818 km)



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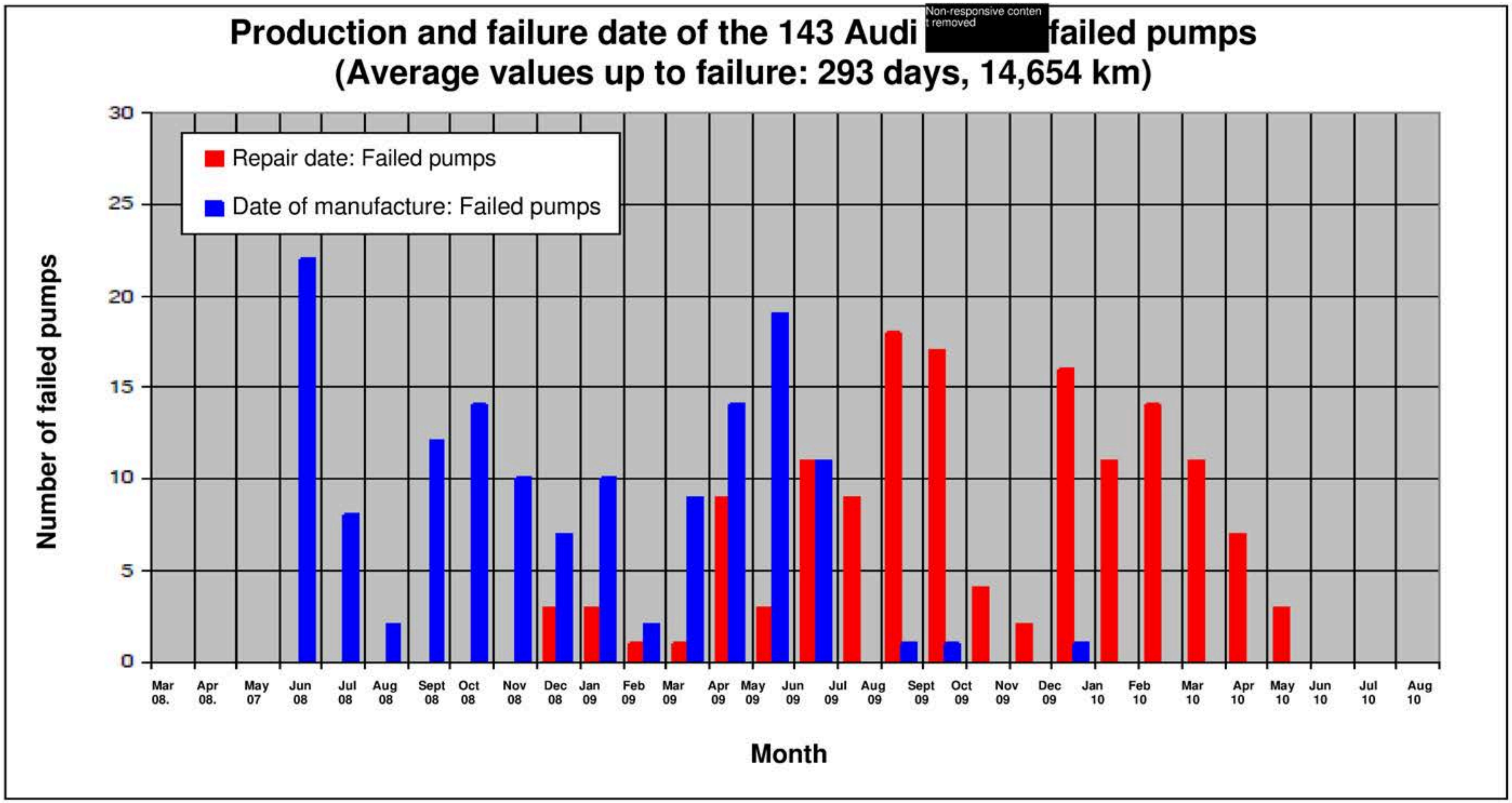
Audi CP4 Task Force, failures [redacted]



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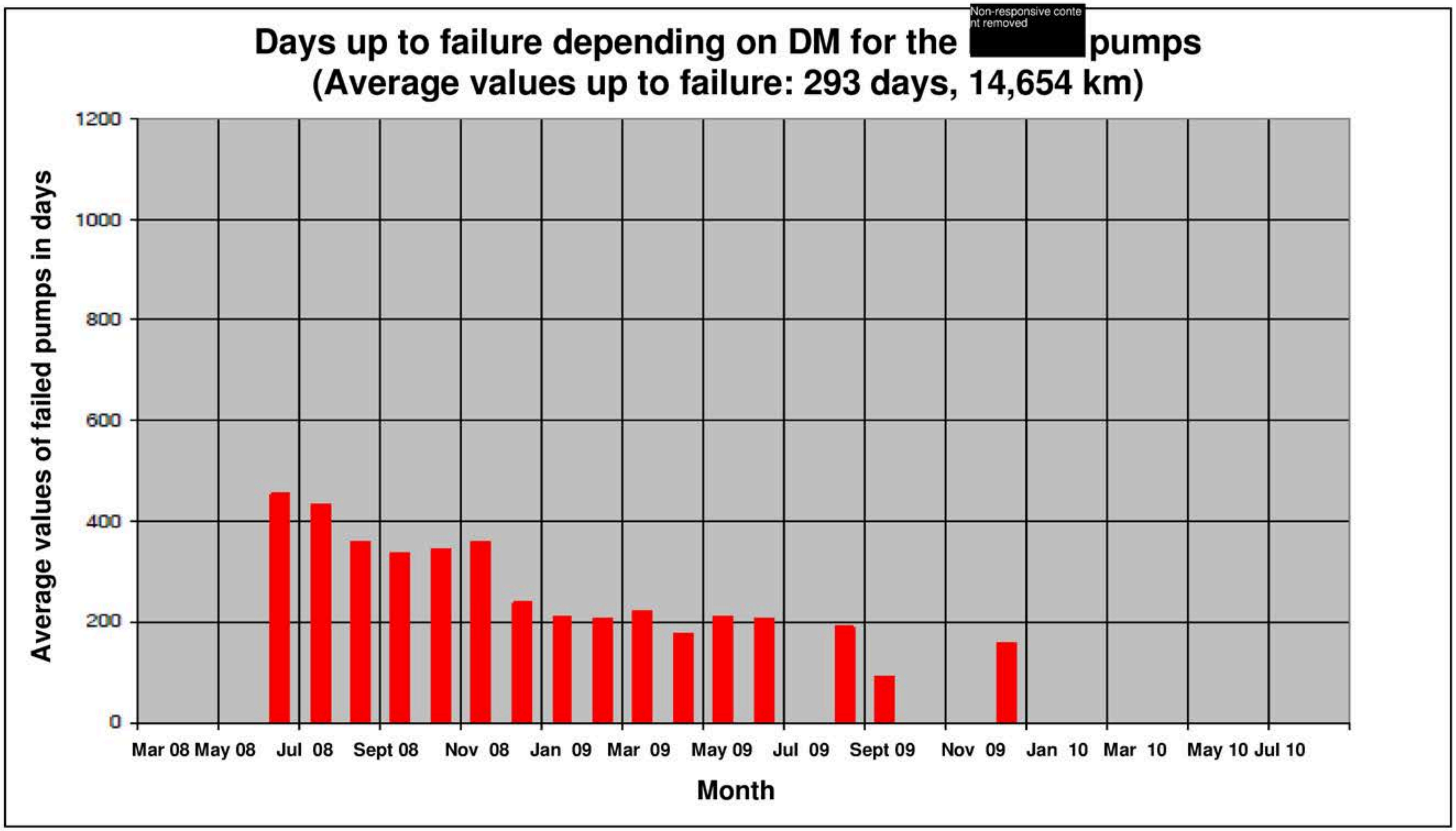
Audi CP4 Task Force, failures [redacted]



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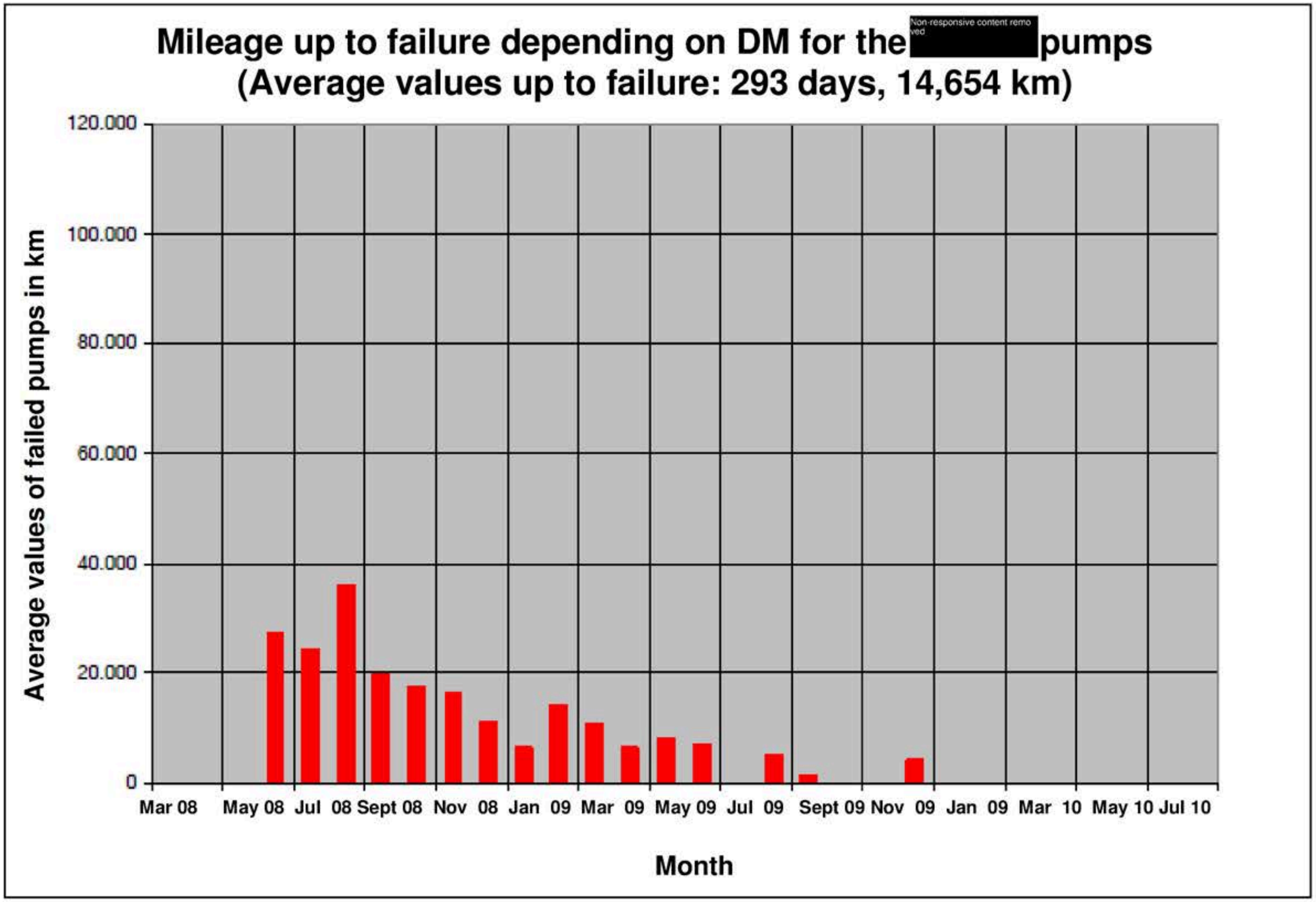
Audi CP4 Task Force, failures [redacted]



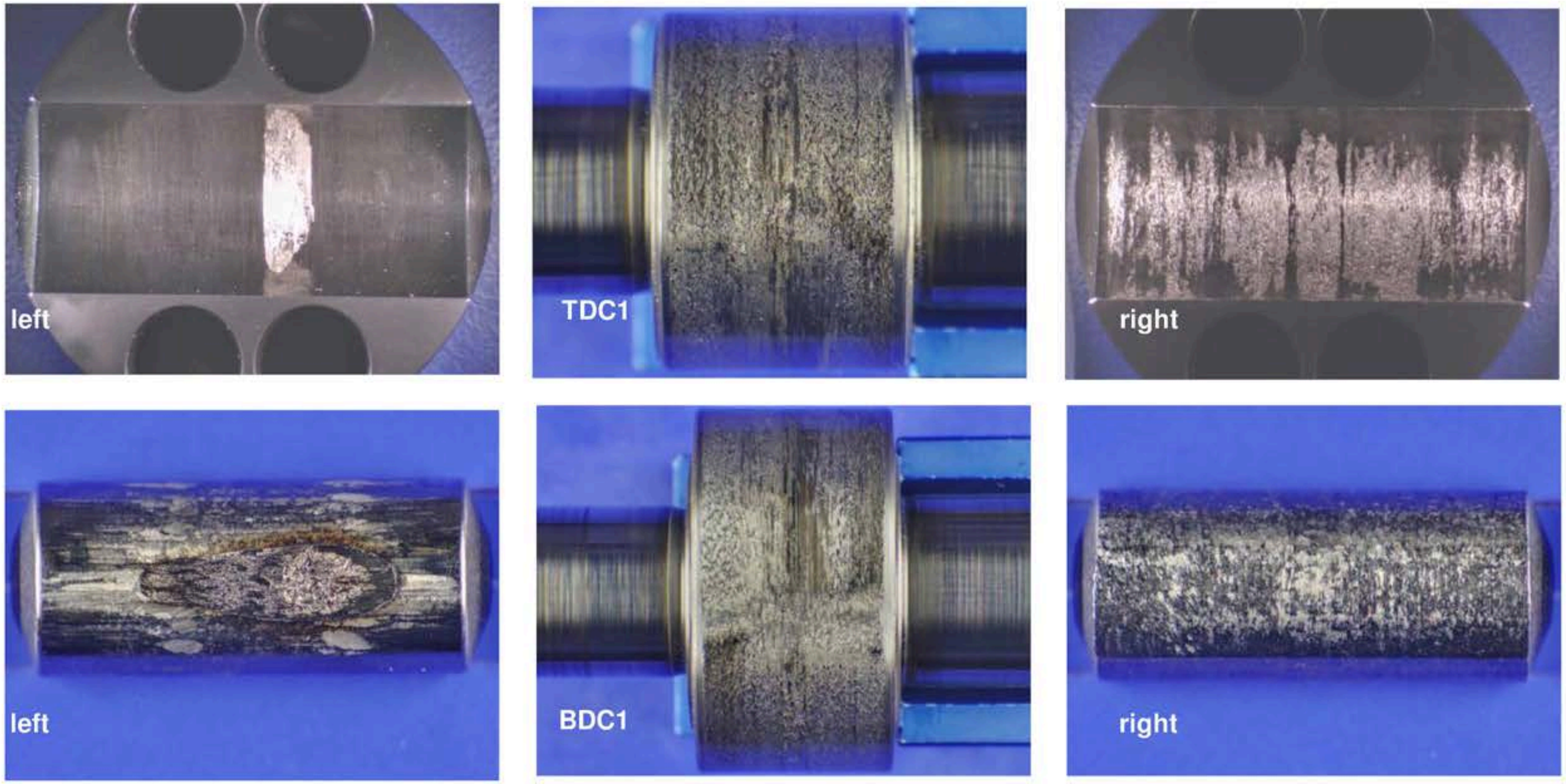
BOSCH

CP4.2 Audi Non-responsive content removed

2010-CP4_0644

Failed pump field Non-responsive content removed RT unknown

0 445 010 611; DM: 100121 BPT 1190; C-Index 05; 059 130 755 AH



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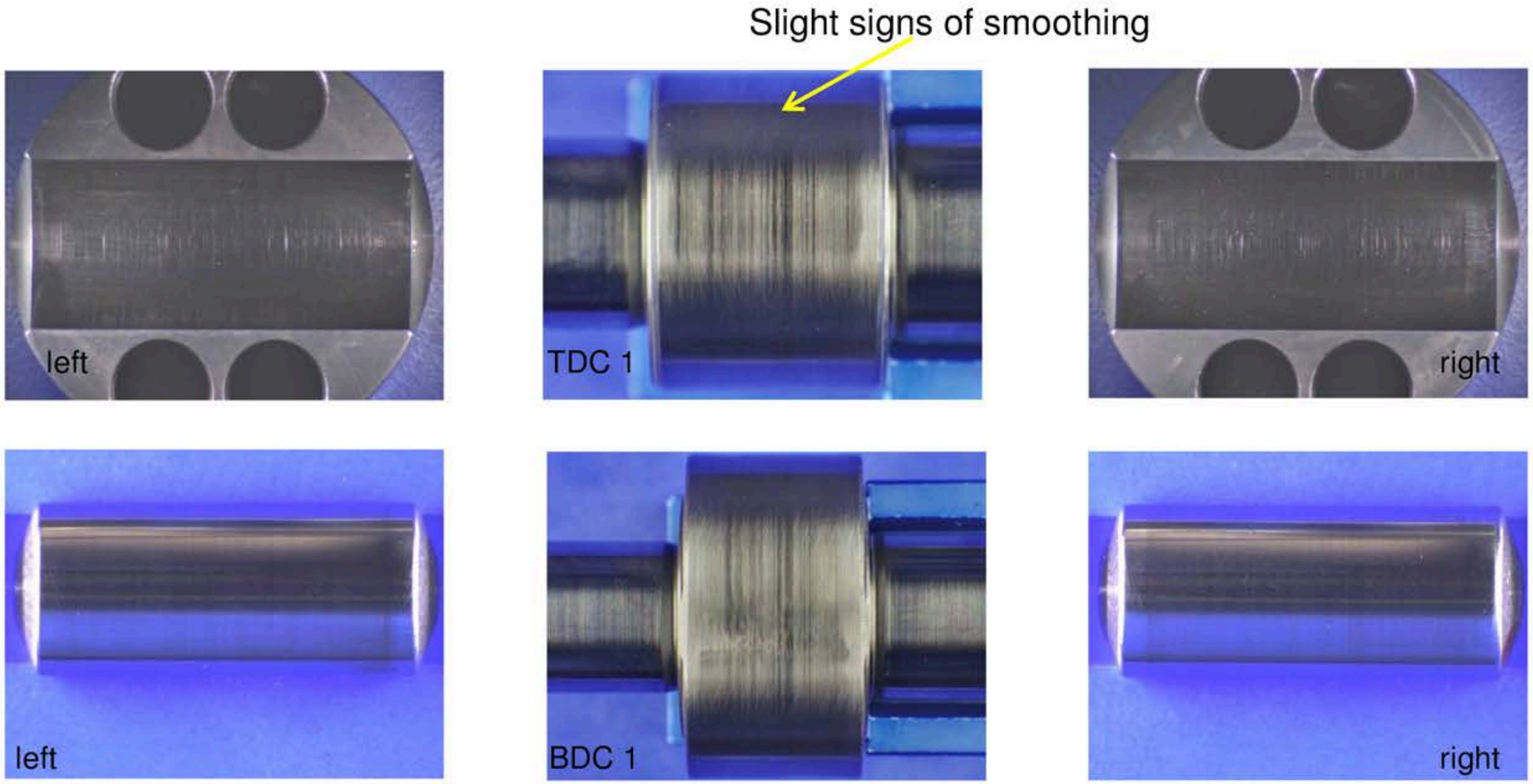
CP4.2 Audi

2010-CP4_0643[redacted] **Road Test RP2** with 43,189km
W36 0445 B20 321_01; 000005 BPT 4000; draft 301 181 KL



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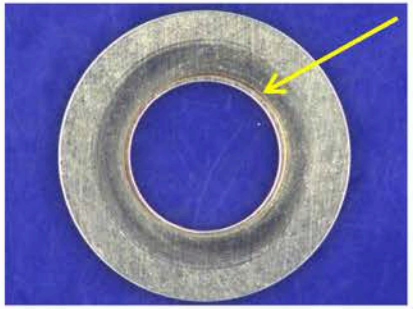
CP4.2 Audi

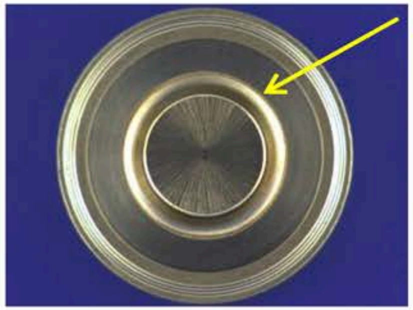
2010-CP4_0643 Non-responsive content removed [redacted] **Road Test RP2** with 43,189km
W36 0445 B20 321_01; 000005 BPT 4000; draft 301 181 KL

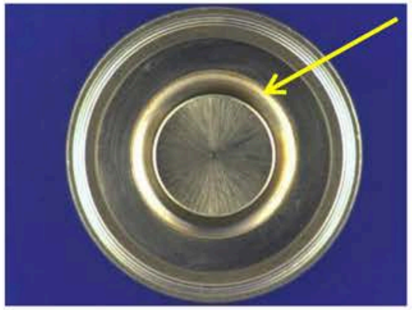
left

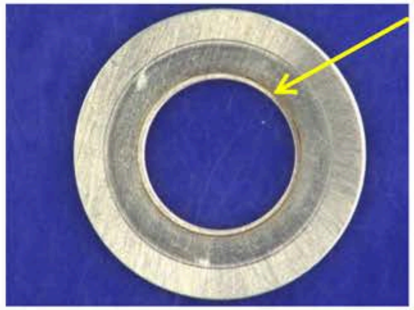
Slight coating

right









BOSCH

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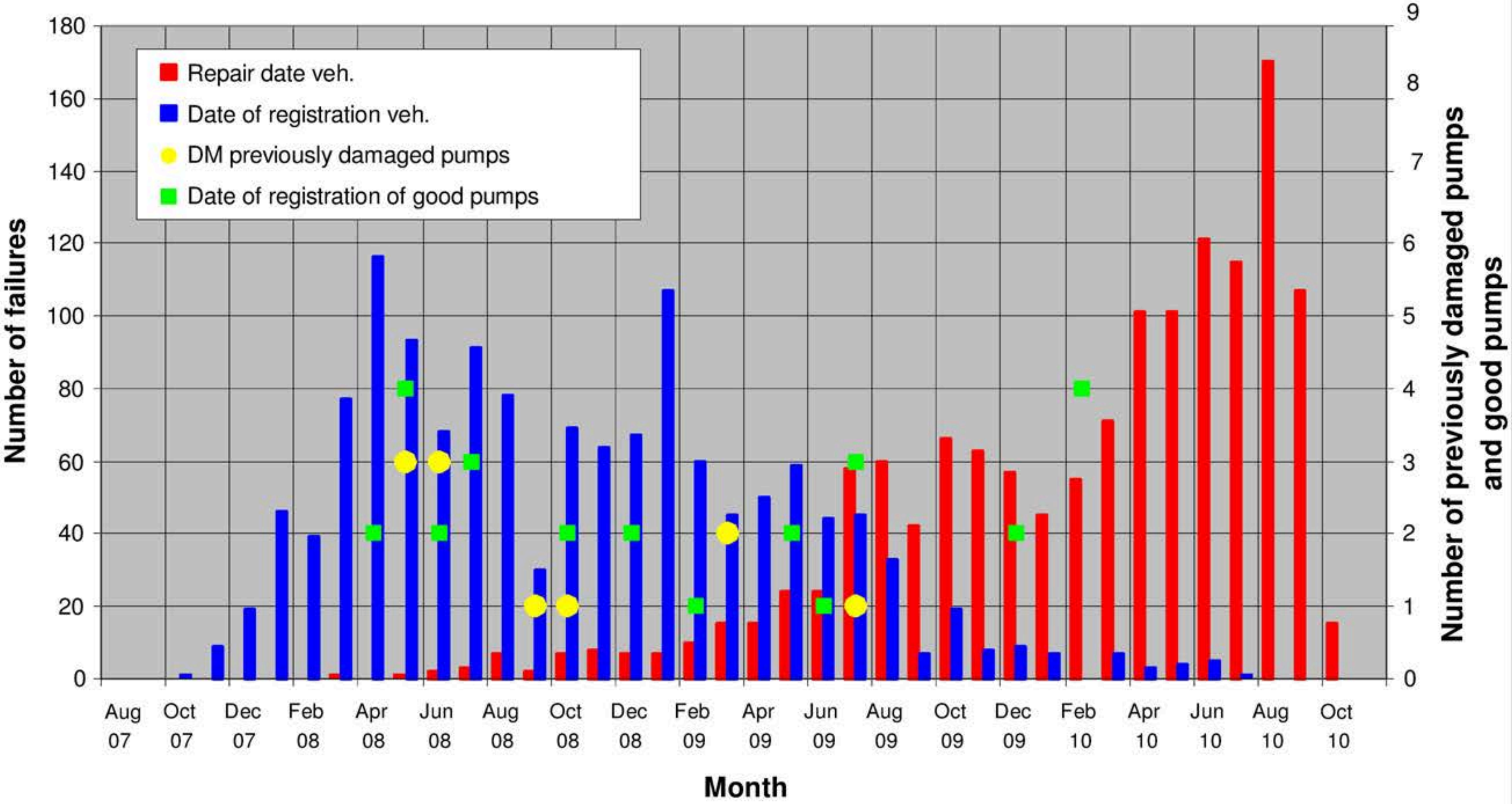
Audi CP4 Task Force, failures [redacted]

Statistics for the 1,380 [redacted] failures Audi
(Average values up to failure: 484 days, 51,366 km)

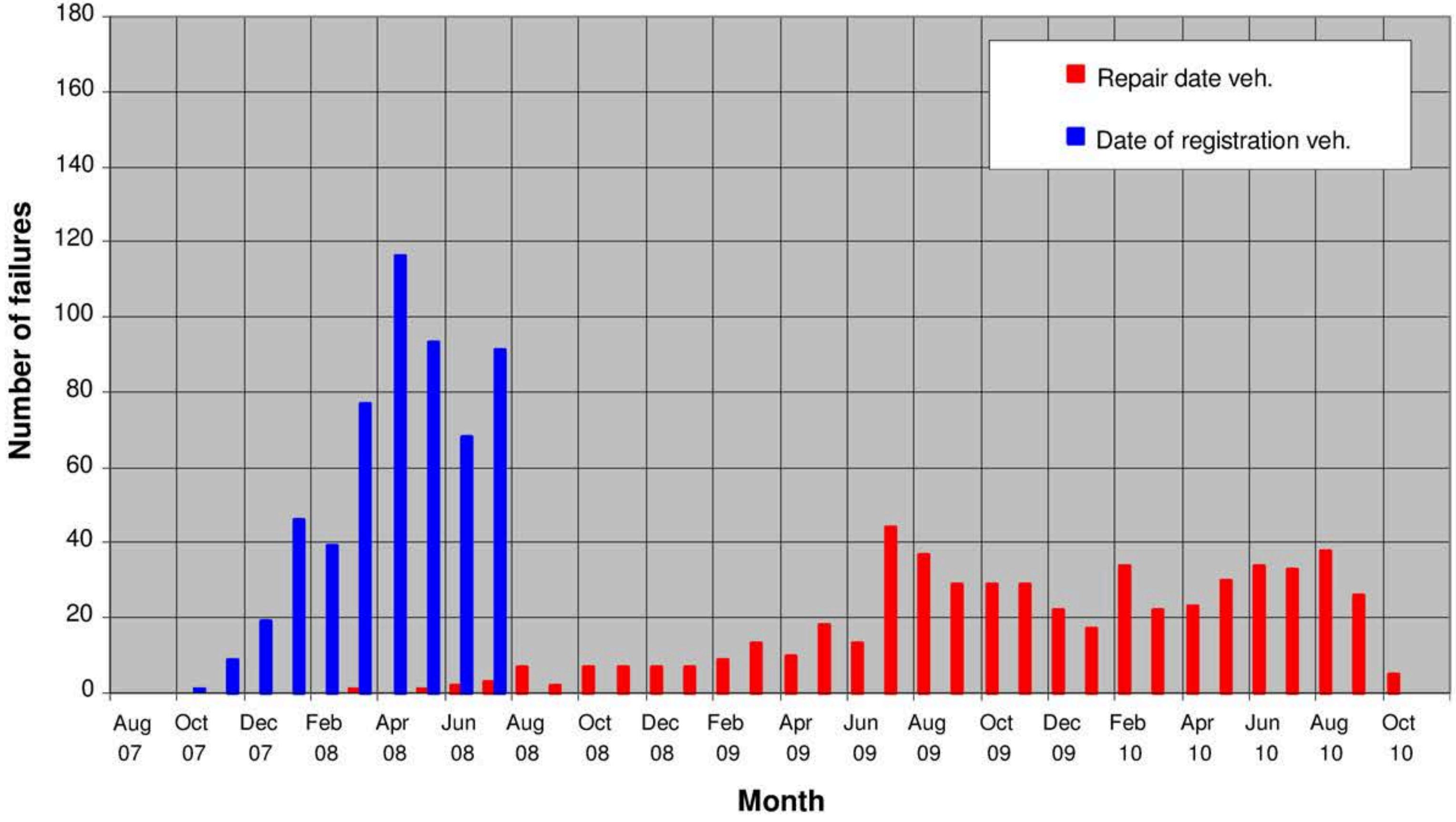


ENTIRE PAGE CONFIDENTIAL

Audi CP4 Task Force, failures [redacted]

Statistics for the 1,380 [redacted] failures Audi

(Average values up to failure: 484 days, 51,366 km)



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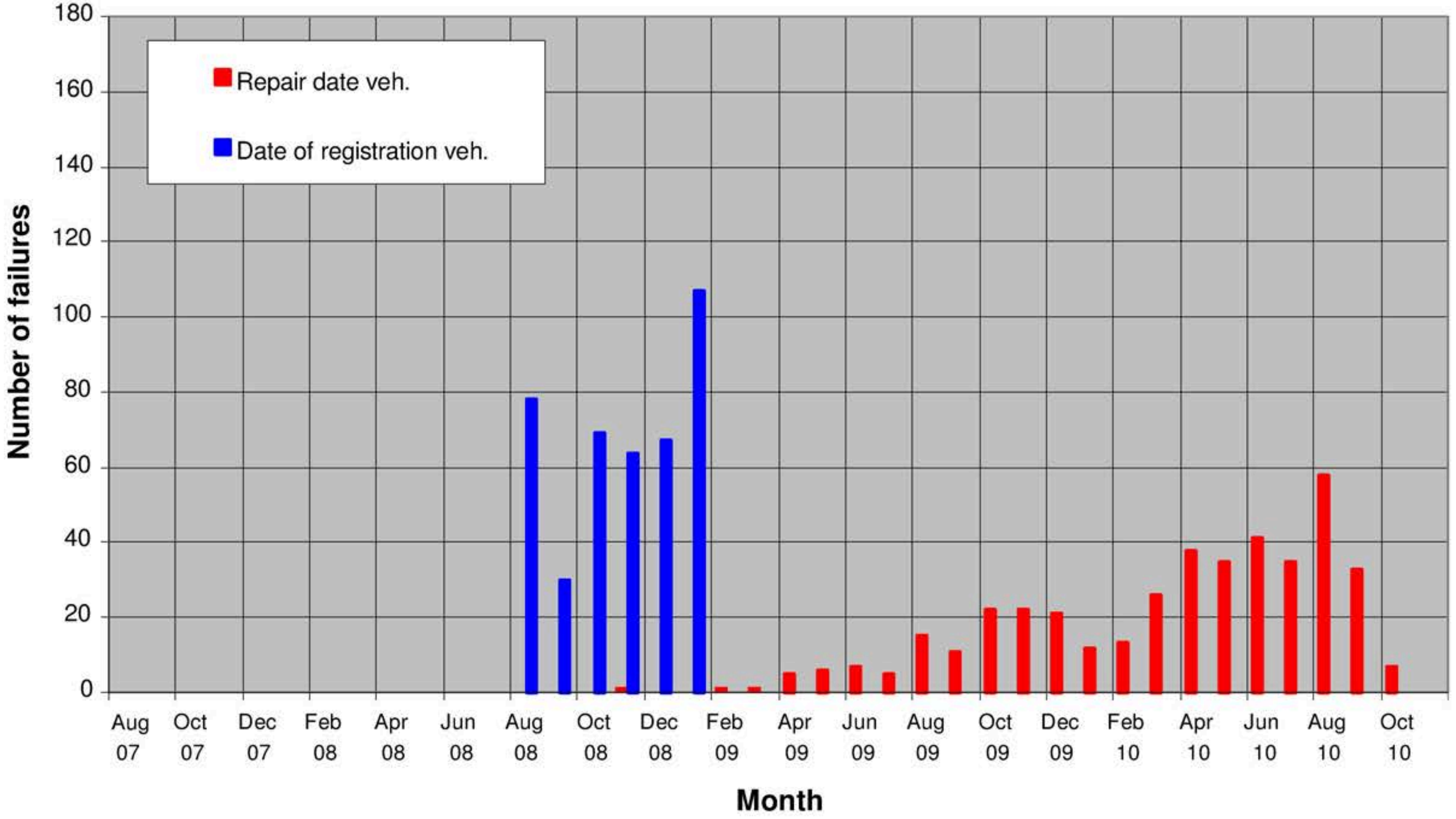
Audi CP4 Task Force, failures [redacted]

Statistics for the 1,380 [redacted] failures Audi
(Average values up to failure: 484 days, 51,366 km)



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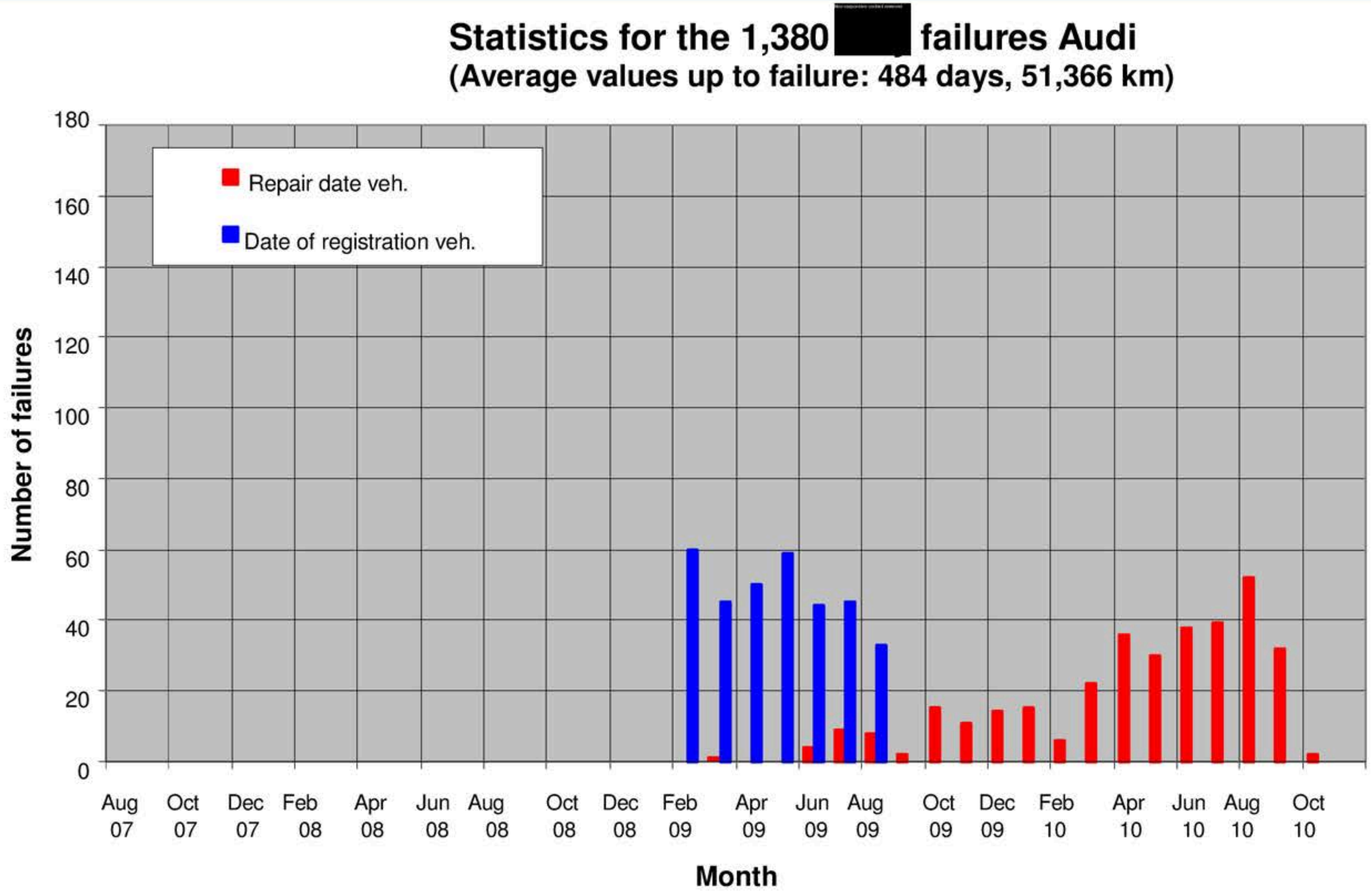
Audi CP4 Task Force, failures [redacted]



BOSCH

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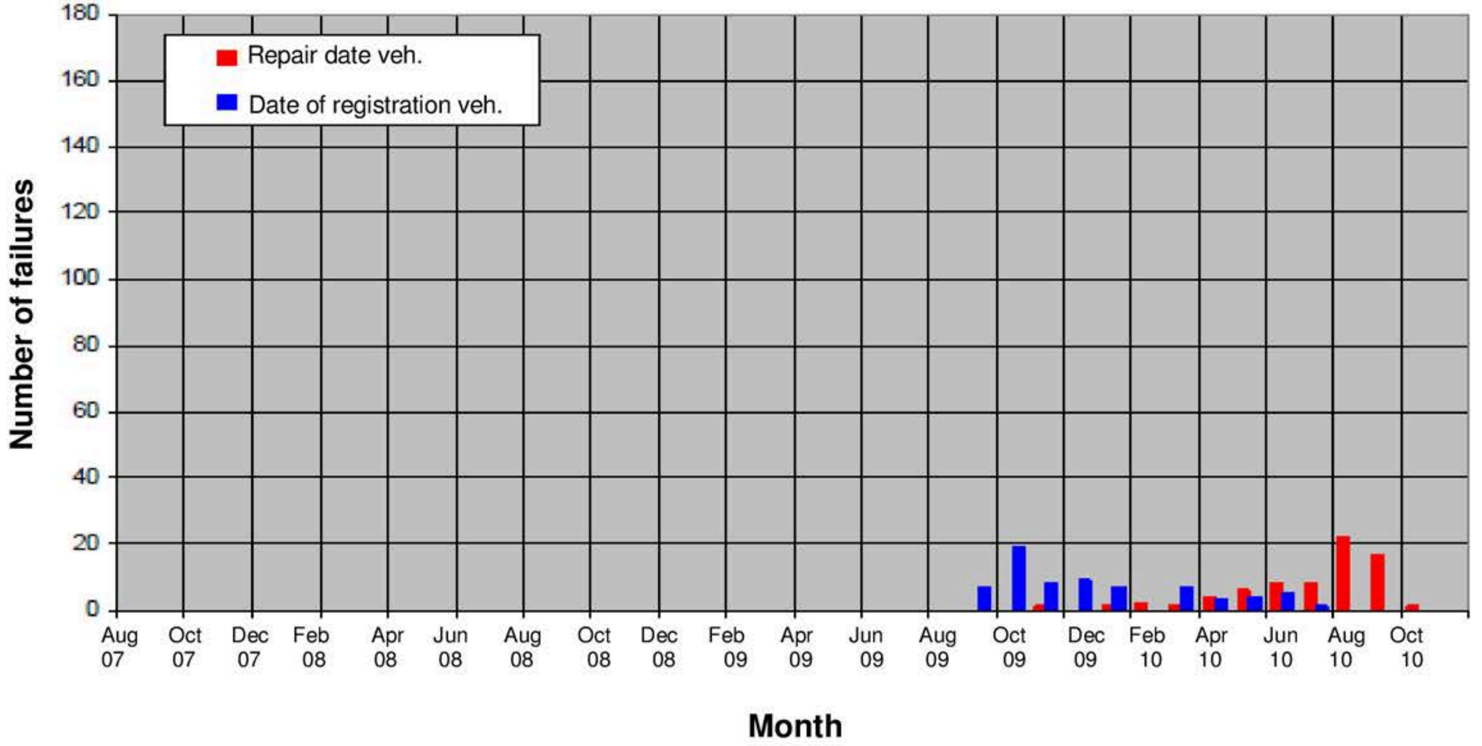
CP4 Task Force Audi, failures in [redacted]

Statistics for the [redacted] failures Audi (date of registration from 08/09
(Average values up to failure: 484 days, 51,366 km)



BOSCH

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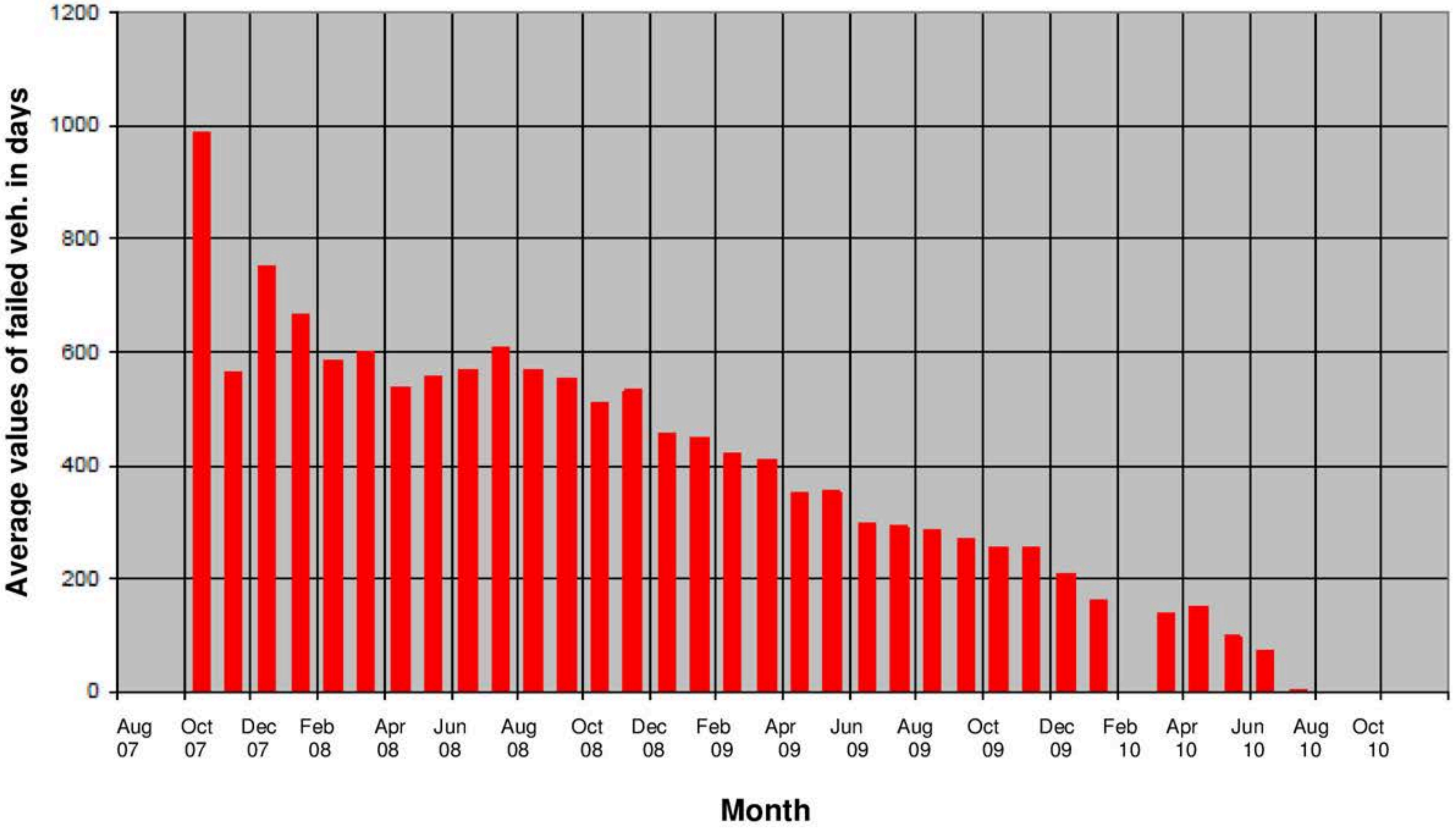
Audi CP4 Task Force, failures [redacted]

Days up to failures = f (date of registration veh.) [redacted]
(Average values up to failure: 484 days, 51,336km)



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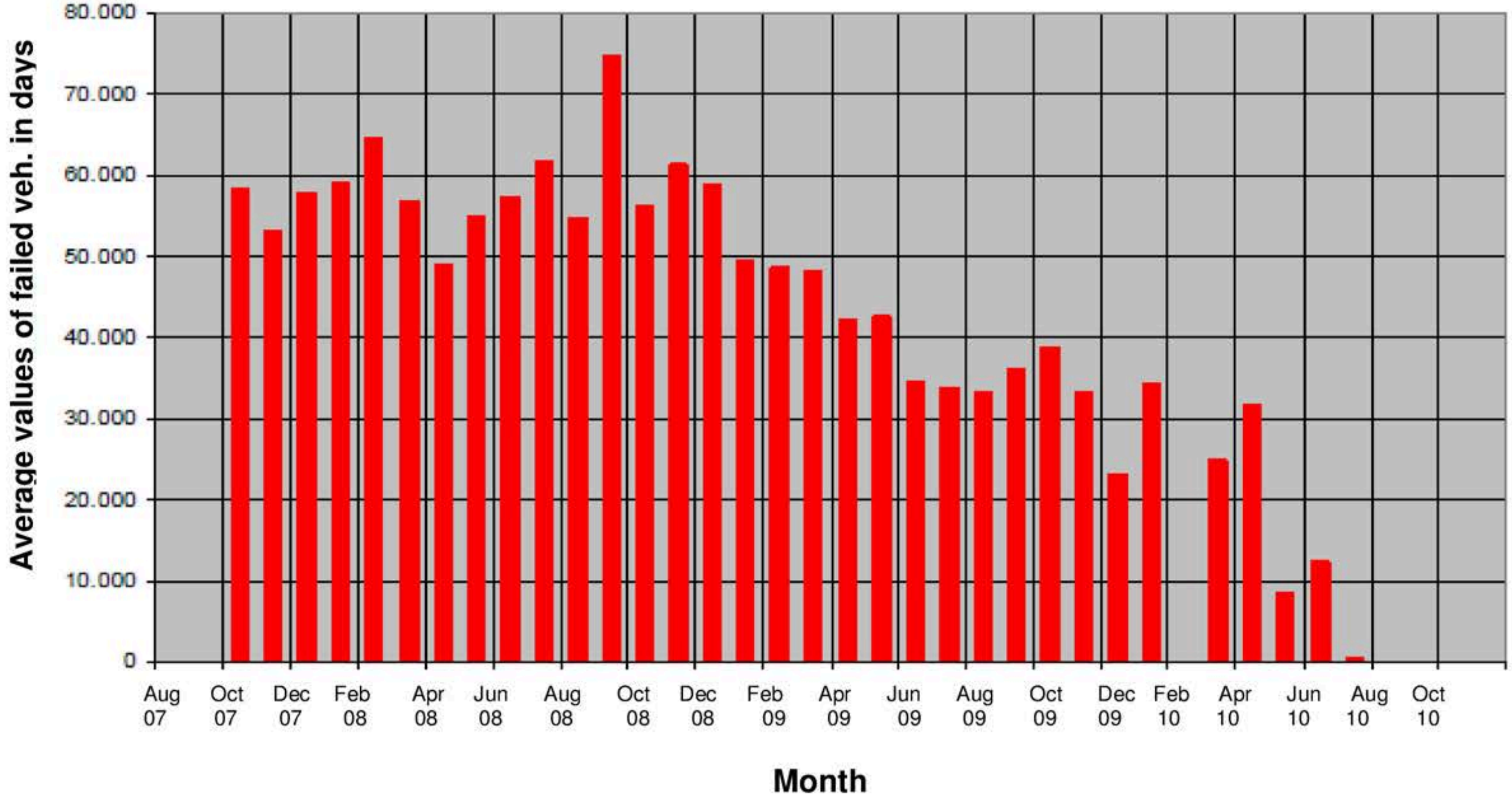
Audi CP4 Task Force, failures [redacted]

Days up to failures = f (date of registration veh.) [redacted]
(Average values up to failure: 484 days, 51,336km)



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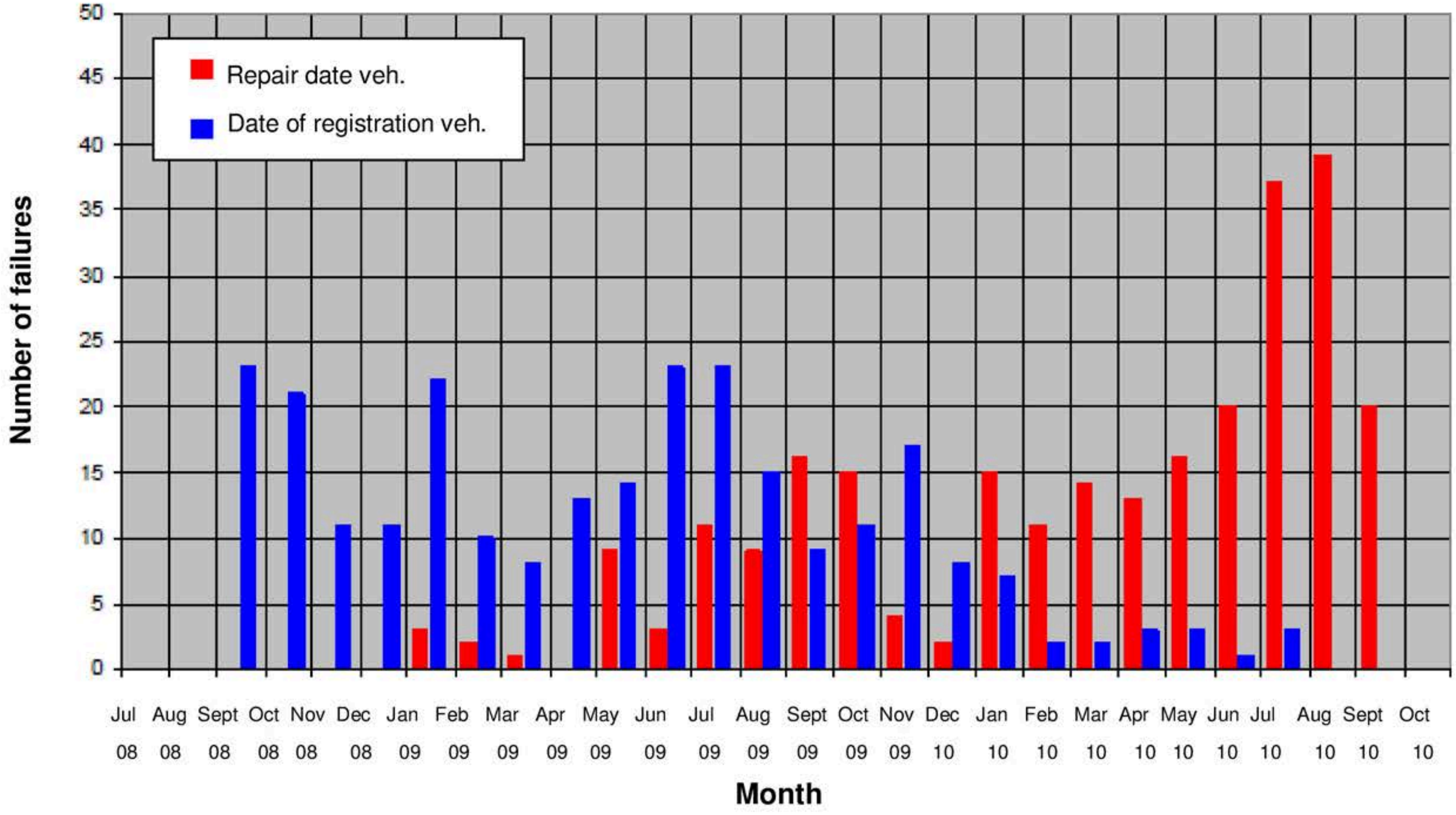
Audi CP4 Task Force, failures [redacted]

Statistics for the 262 [redacted] failures Audi
(Average values up to failure: 300 days, 21,916 km)



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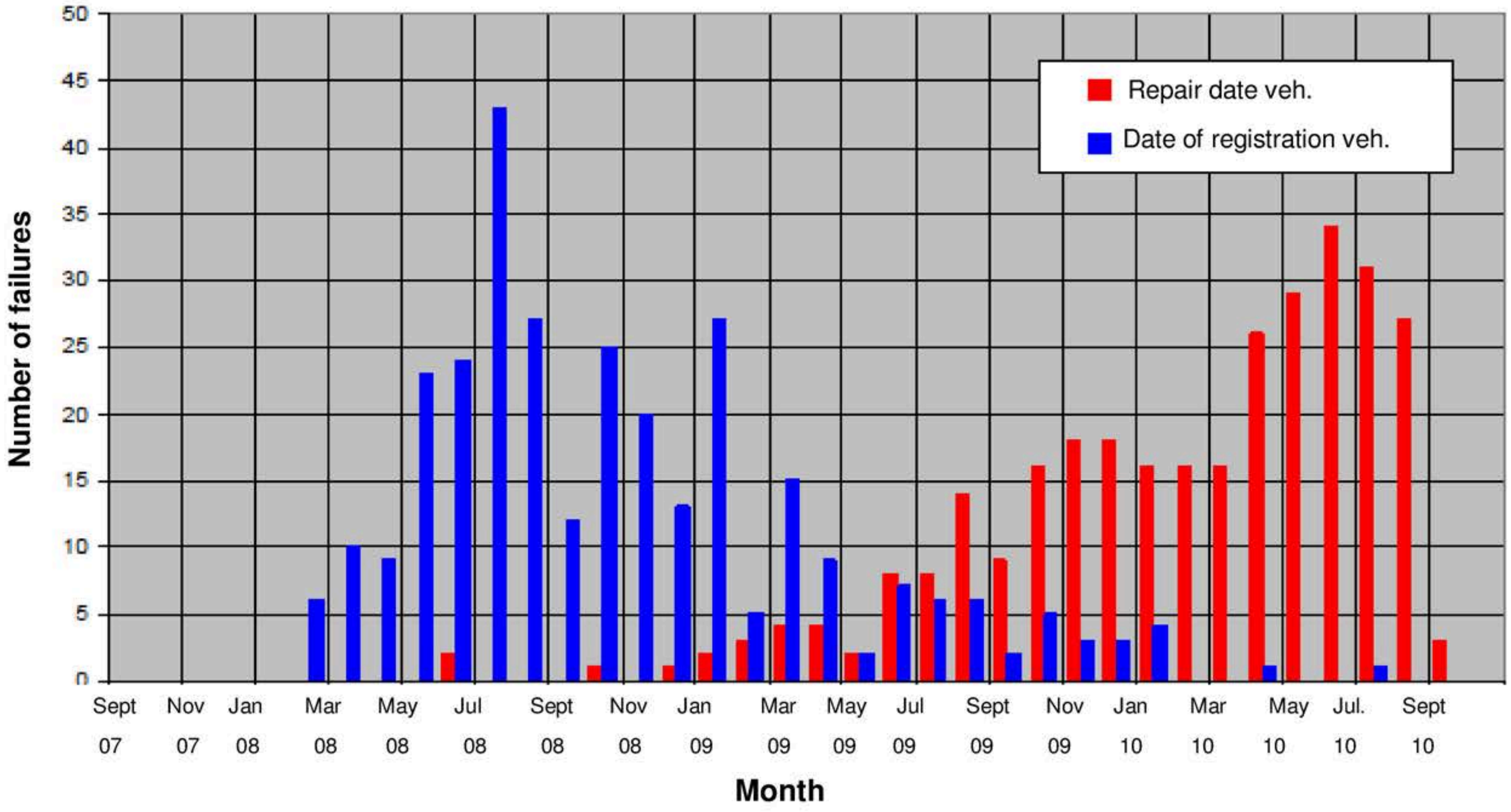
Audi CP4 Task Force, failures [redacted] CP4.1 Audi

Statistics for the 308 [redacted] failures CP4.1 Audi
(Average values up to failure: 464 days, 50,471 km)



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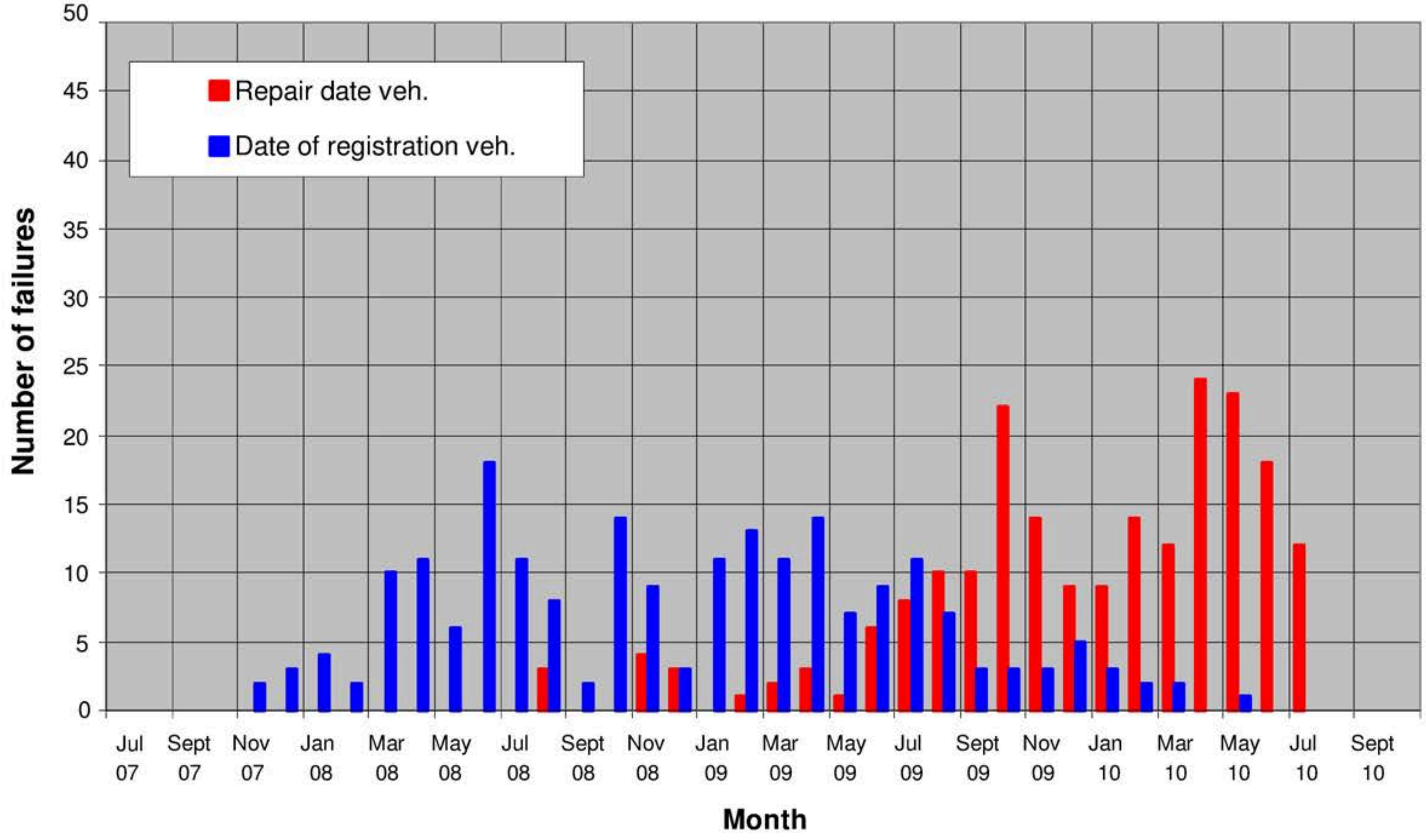
Audi CP4 Task Force, failures [redacted] CP4.1 VW

Statistics for the 208 [redacted] failures CP4.1 VW

(Average values up to failure: 369 days, 39,777 km)



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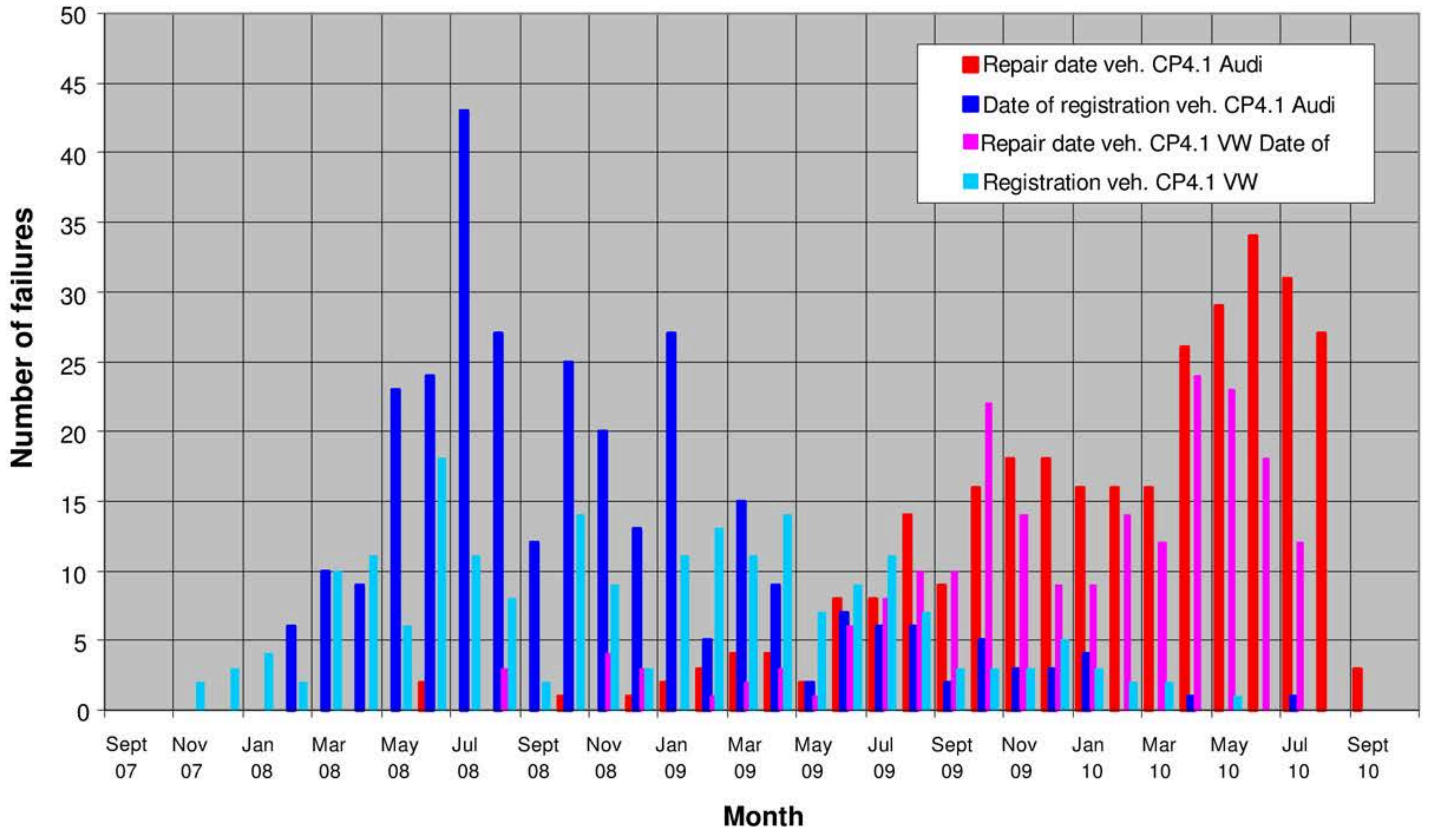
Audi CP4 Task Force, failures [redacted] CP4.1 Audi VW

Statistics for the [redacted] failures CP4.1 Audi, CP4.1 VW



BOSCH

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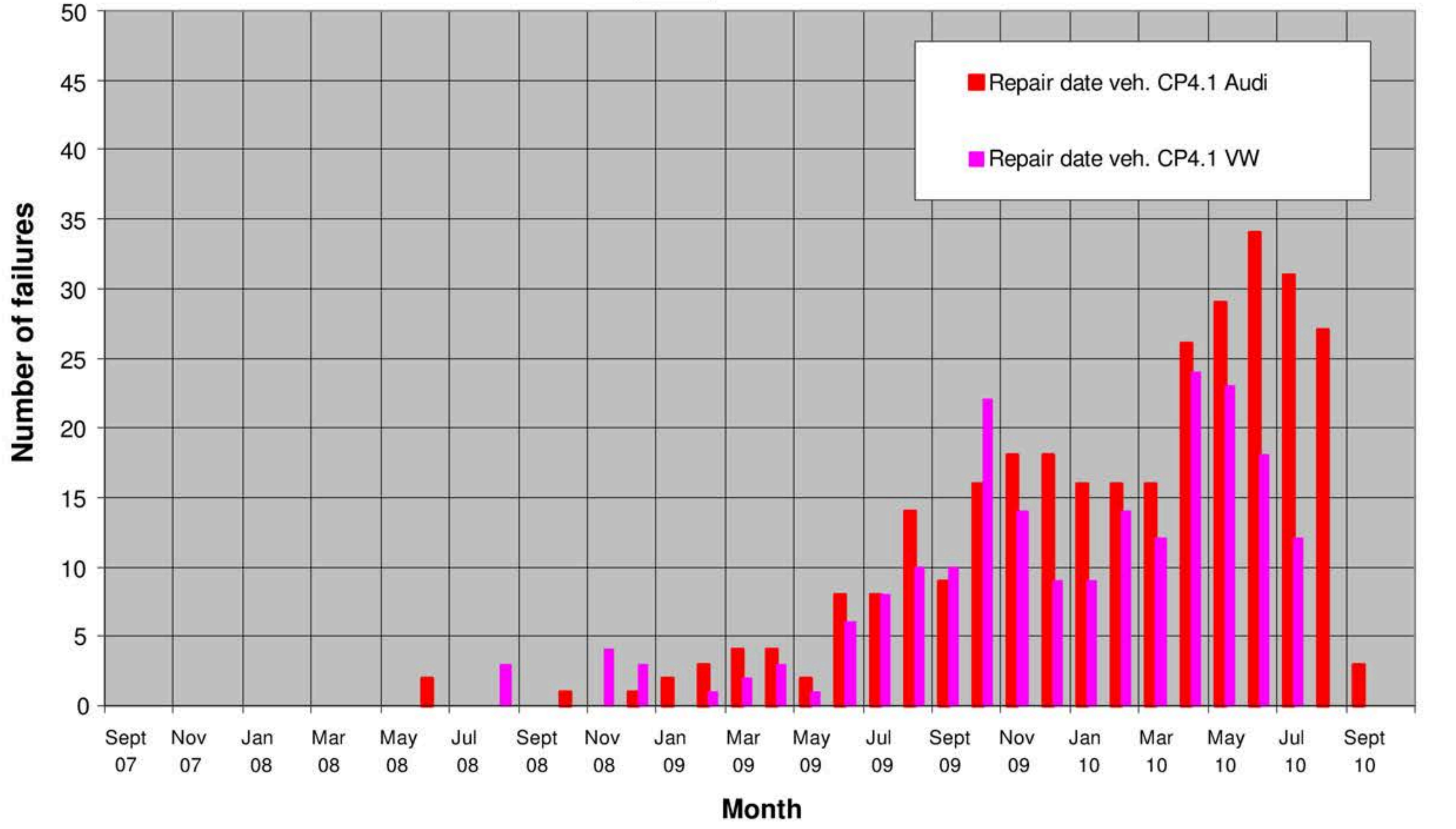
Audi CP4 Task Force, failures [redacted] CP4.1 Audi VW

Statistics for the [redacted] failures CP4.1 Audi, CP4.1 VW



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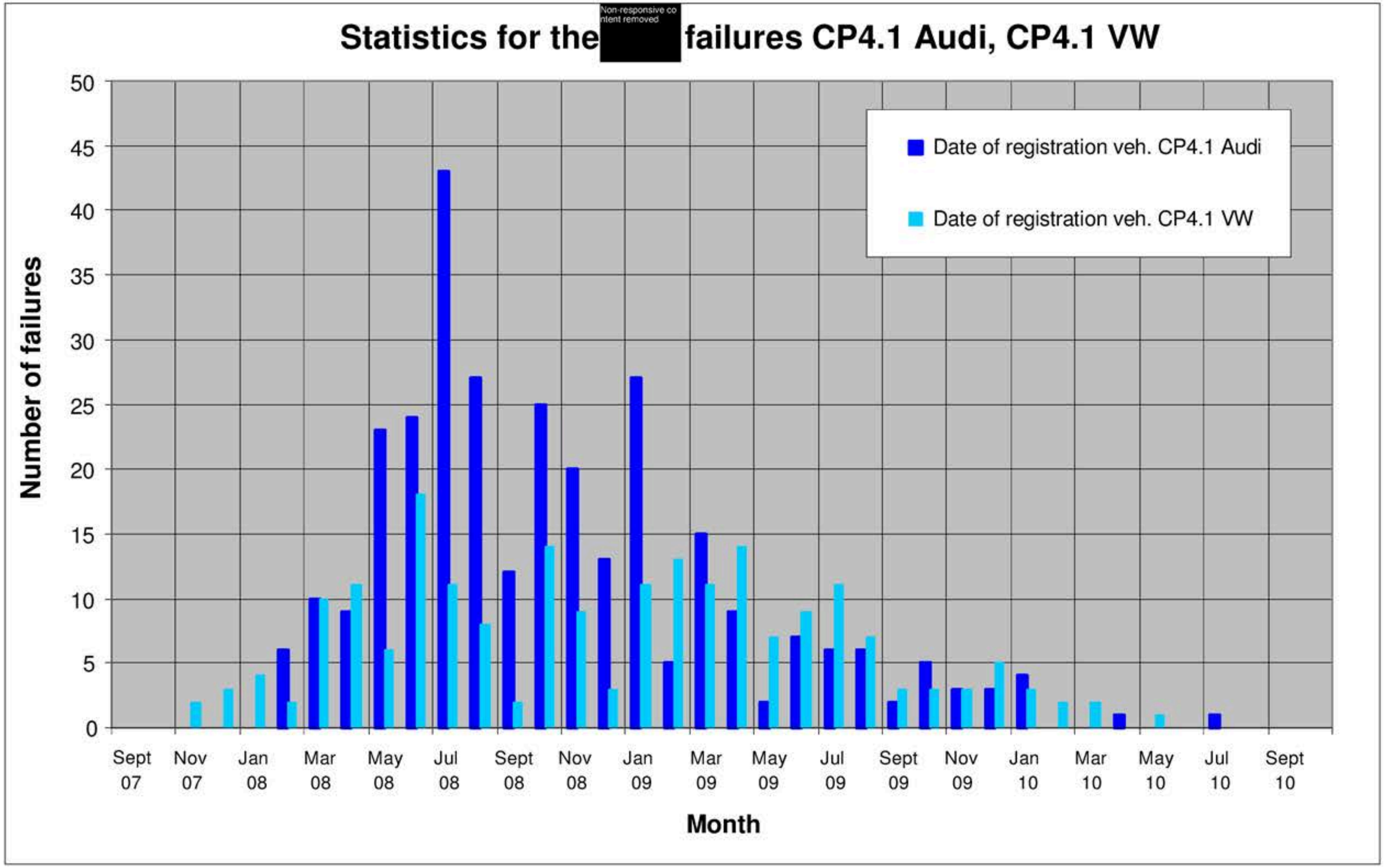
Audi CP4 Task Force, failures [redacted] CP4.1 Audi VW



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TM: Audi overload tests

Status of verification of CP4.2 with series / RP1 / RP2

Audi IAV GmbH KW36

Pump test rig testing CP4.2

Pump type	Test type	ER start TARGET	Fuel type	Actual run time	Target run time	0 – 25 – 50 – 75 – 100 – 125 – 150 – 175 – 200 – 225 – 250	
Series (C3)	QHALT	15/10	EU3	150	150	2,200 bar *	
Series (C3)	QHALT	15/10	EU3	68	150	2,200 bar	* Failure due to drivetrain damage
Series (C3)	QHALT	16/10	EU3	150	150	2,200 bar *	*Parts on 07.28.2010 to BOSCH
Series (C3)	QHALT	18/10	EU3	150	150	2,200 bar **	
RP1 (C2)	QHALT	19/10	EU3	150	150	2,300 bar **	
RP1 (C2)	QHALT	20/10	EU3	150	150	2,300 bar **	
							** Parts on 07.28.2010 to BOSCH
RP2 (C2)	QHALT	29/10	EU3	150	150	2,300 bar BPT4325 on 07.23.10 completed ***	
RP2 (C2)	QHALT	30/10	EU3	150	150	2,300 bar BPT4324 on 08.08.10 completed ***	Inlet pressure reduced from 6 bar to 4.5 bar
RP2 (C2)	QHALT	31/10	EU3	150	150	2300 bar BPT4322 on 08.22.10 completed ***	Inlet pressure reduced from 6 bar to 4.5 bar
RP2 (C2)	QHALT	??/10	EU3	150	150	2300 bar BPT4388 on 09.02.10 completed ***	***Parts on 09.08.2010 to BOSCH

Notes:

Full pressure (rel.)	3.5 bar	4.0 bar	4.5 bar	5.0 bar
Ml/15s	600	940	1280	1550
l/h	144	225.6	307.2	372

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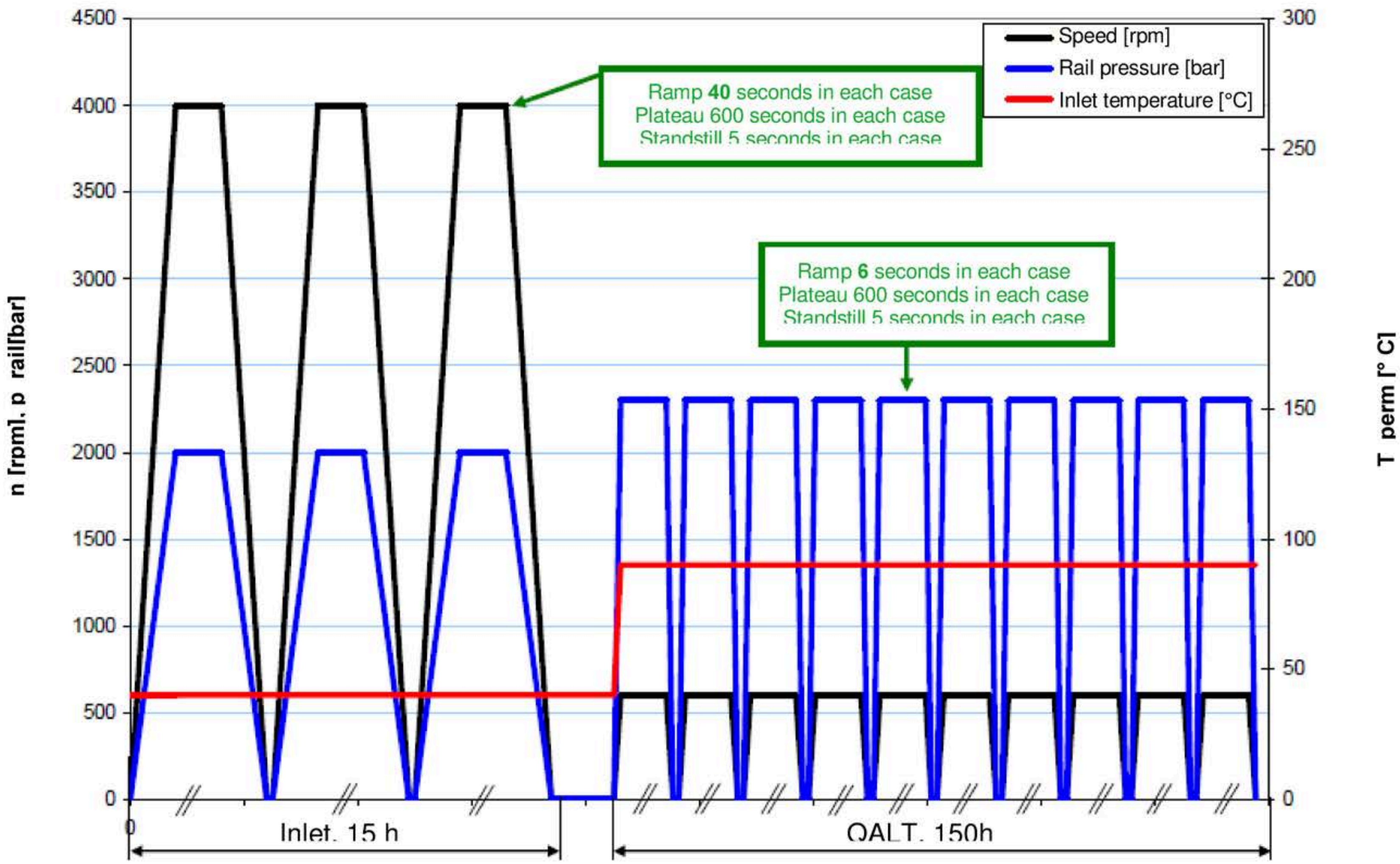
TM: Audi overload tests

Testing conditions

Overload test of drivetrain CP4 LR / RS-QOLD

➔ Version 1: Mixed friction at low engine speed

- Start-up program (15 h, 4,000 rpm, 2,000 bar, 40 °C, Arctic diesel Cl. 4.)
- Endurance run program (150 h, 600 rpm, 2,300 bar, 90 °C, Arctic diesel Cl. 4.)



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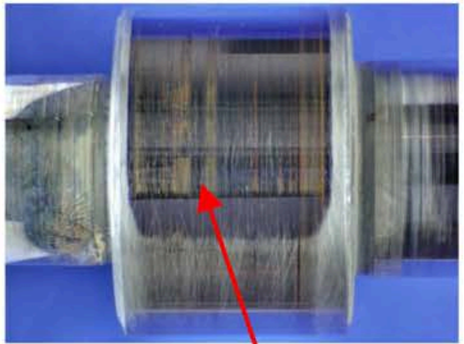
TM: Audi overload tests

2010-CP4_0576; Series; 0445010611; 05 100205 BPT 0604 AH; RT: 150h

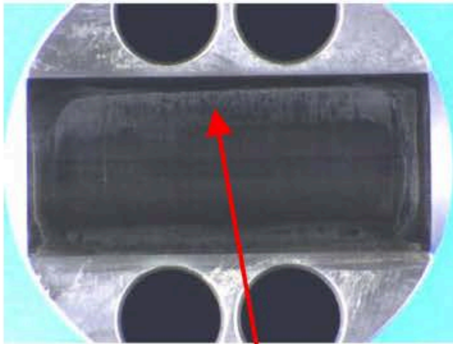
Series (C3)

TDC



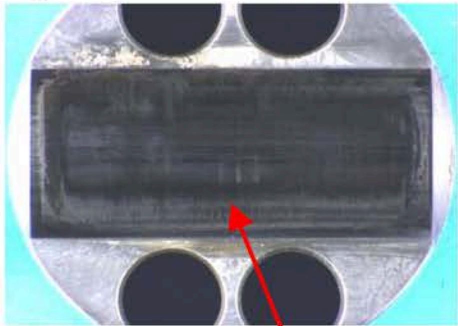
Chatter marks

Cyl.1



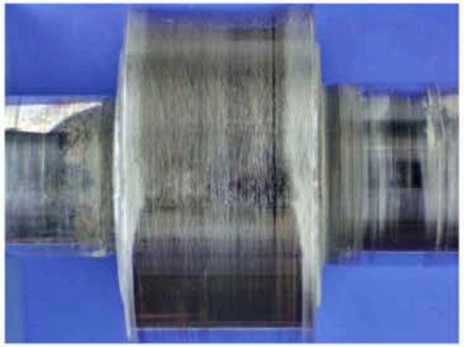
Heavy deposits

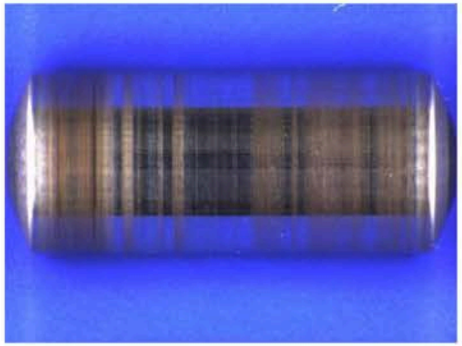
Cyl.2

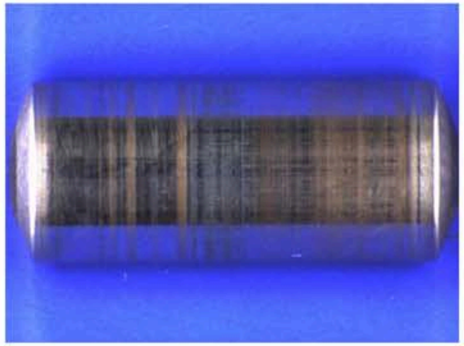


Heavy deposits

BDC







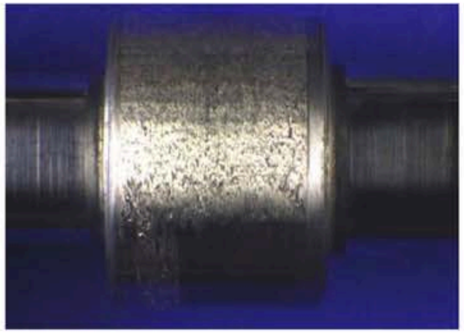
BOSCH

TM: Audi overload tests

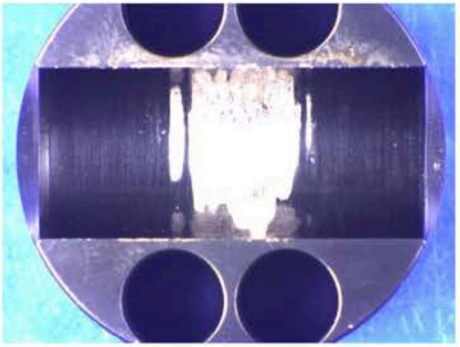
2010-CP4_0577; Series; 0445010611; 05 100205 BPT 0607 AH; RT: 68 h

Series (C3)

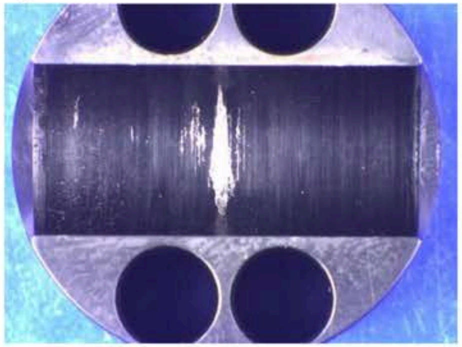
TDC



Cyl.1



Cyl.2



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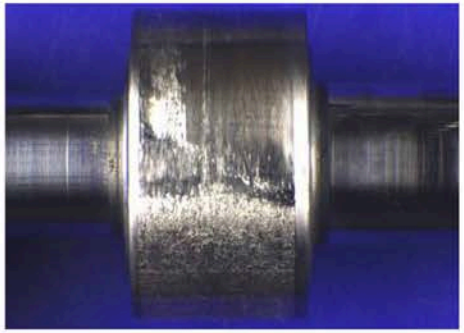

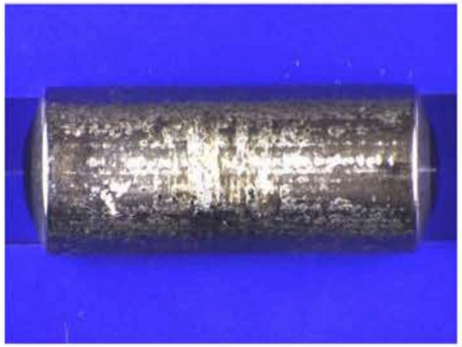

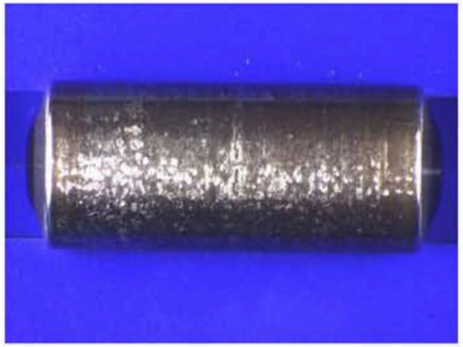

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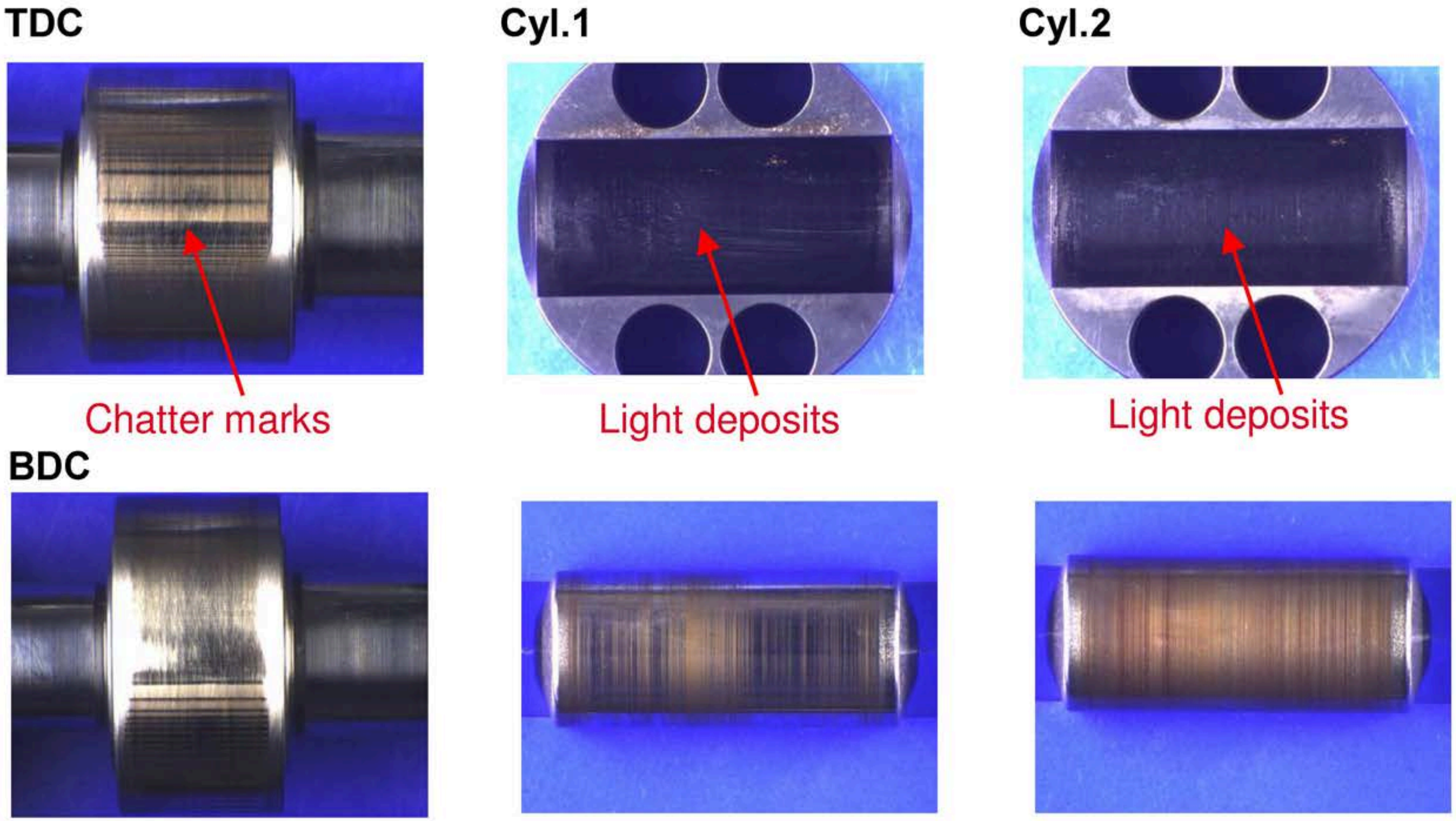
TM: Audi overload tests

2010-CP4_0575; Series; 0445010611; 05 100205 BPT 0608 AH; RT: 150h

Series (C3)



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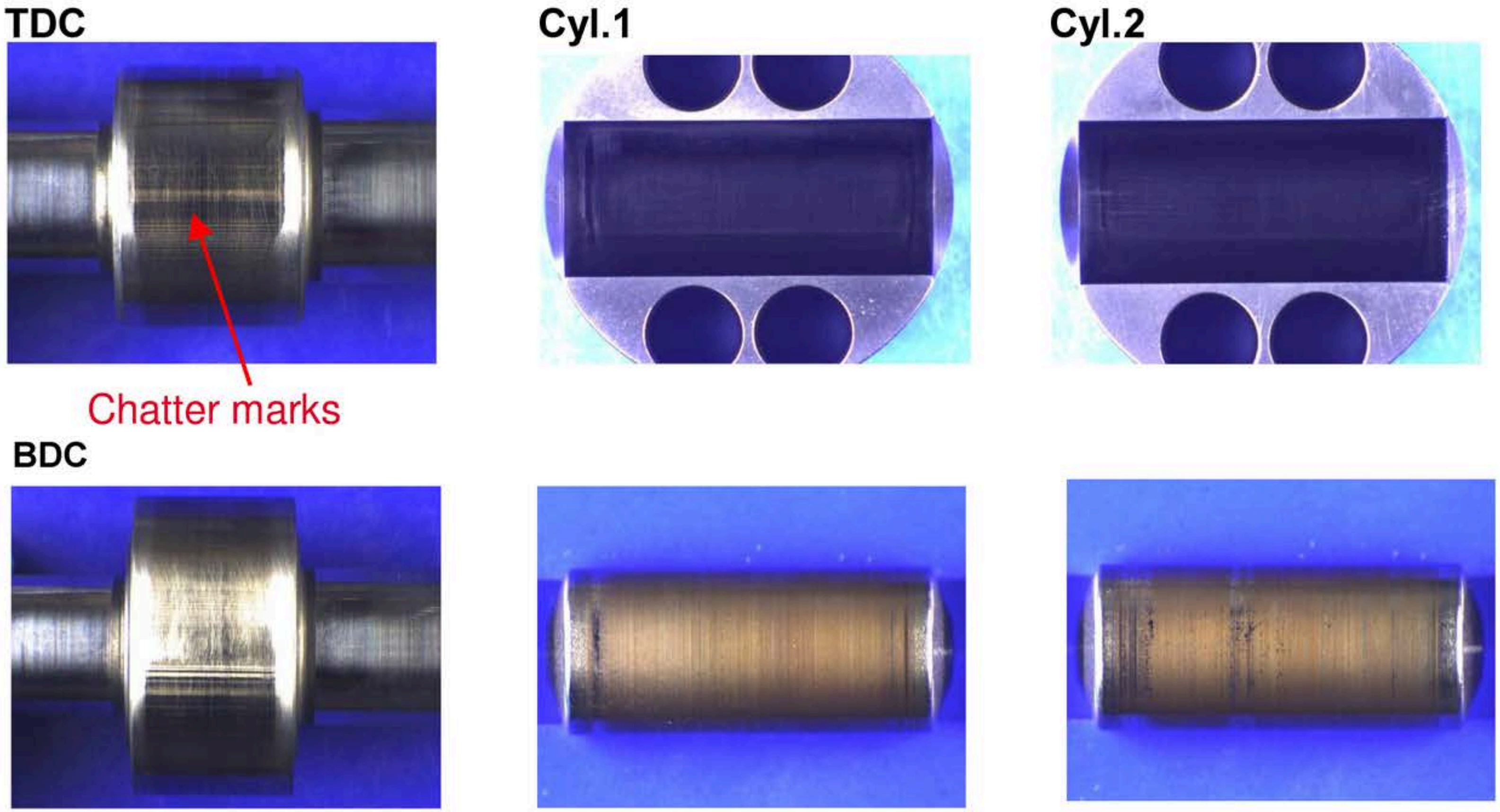
TM: Audi overload tests

2010-CP4_0579; Series; 0445010611; 05 100205 BPT 0603 AH; RT: 150h

Series (C3)

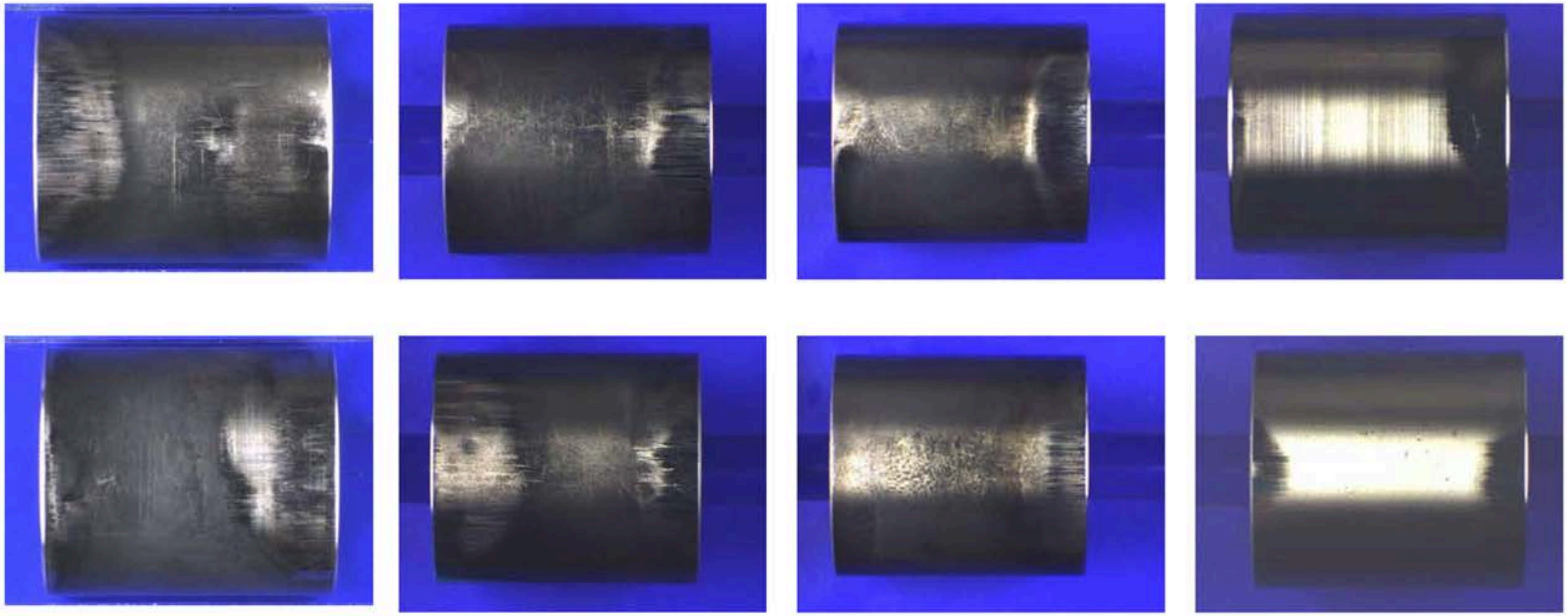


TM: Audi overload tests

2010-CP4_0576; Series; 0445010611; 05 100205 BPT 0604 AH; RT: 150h

Series (C3)

	_0576 (150 h)	_0577 (68 h)	_0575 (150 h)	_0579 (150 h)
Cyl.1				
Cyl.2				



Heavy aluminum oxide formation (black) as an indicator of high temperatures

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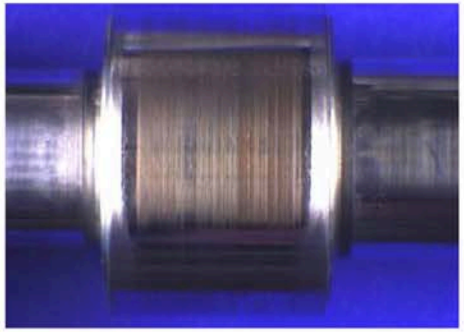
TM: Audi overload tests

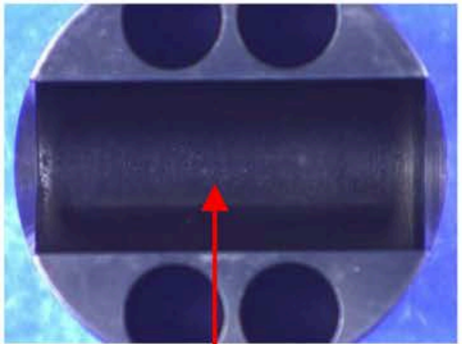
2010-CP4_0578; Series; 0445010611; 05 100402 BPT 1142 BB; RT: 150h

RP1

TDC

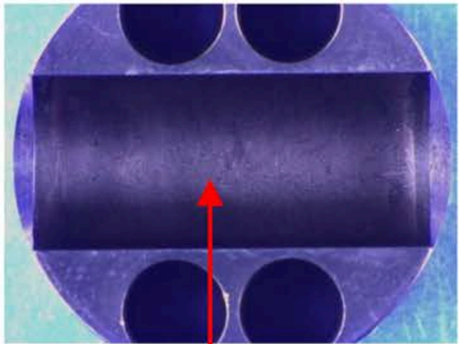


Cyl.1



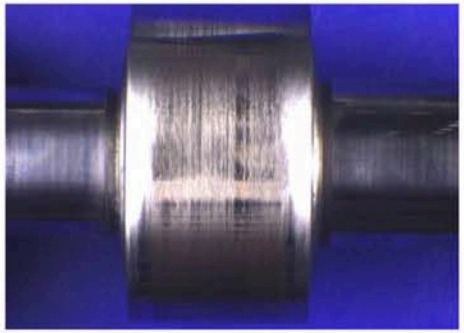
No deposits

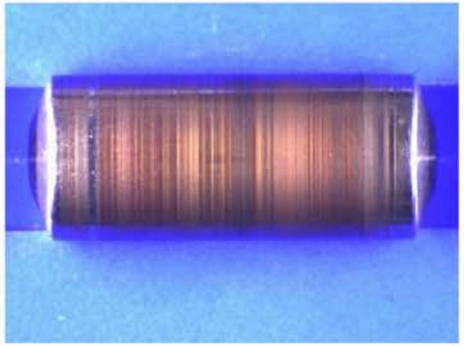
Cyl.2

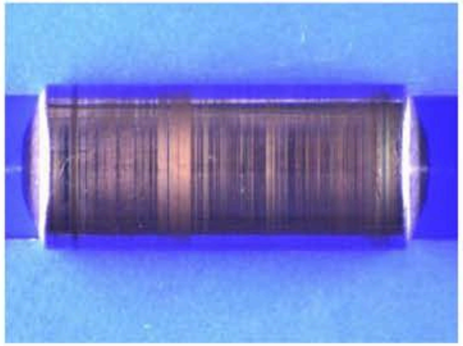


No deposits

BDC







BOSCH

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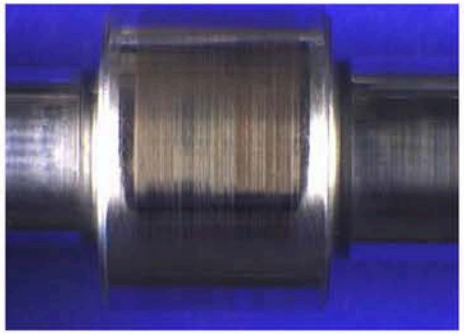
TM: Audi overload tests

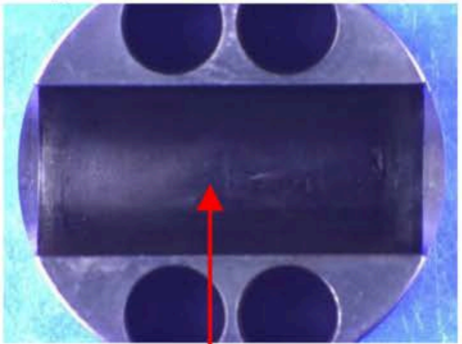
2010-CP4_0580; Series; 0445010611; 05 100402 BPT 1138 BB; RT: 150h

RP1

TDC

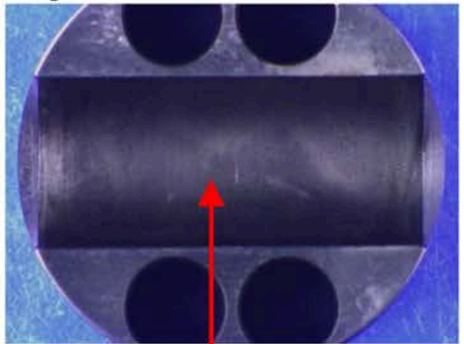


Cyl.1



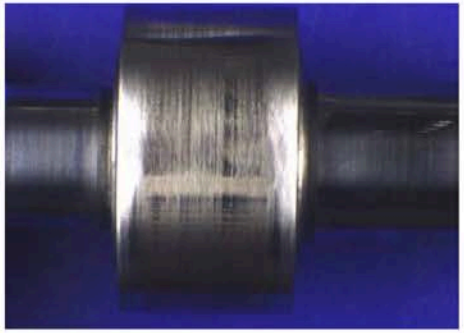
Thin deposits

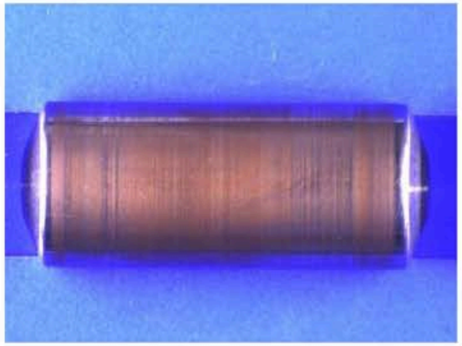
Cyl.2

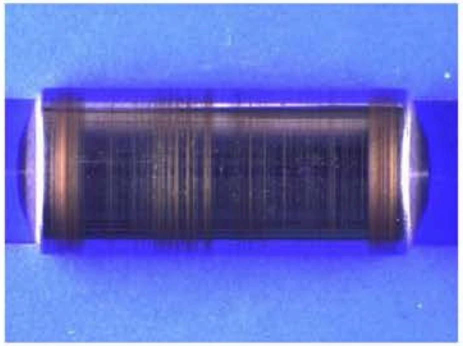


Small deposits

BDC





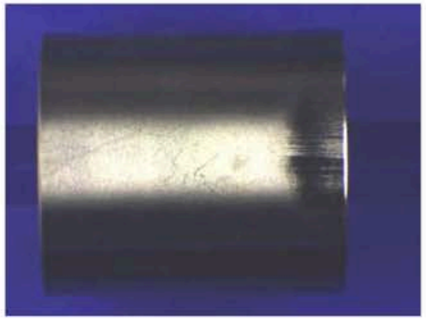
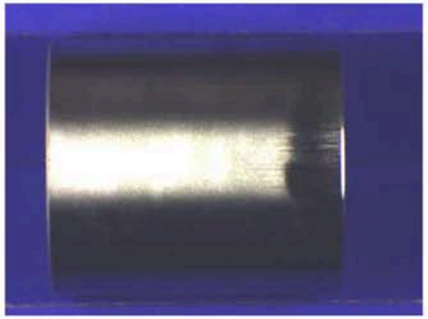
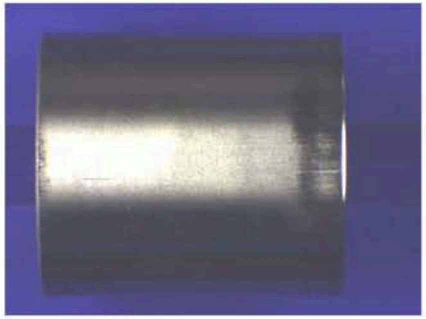


BOSCH

TM: Audi overload tests

2010-CP4_0576; Series; 0445010611; 05 100205 BPT 0604 AH; RT: 150h

RP1

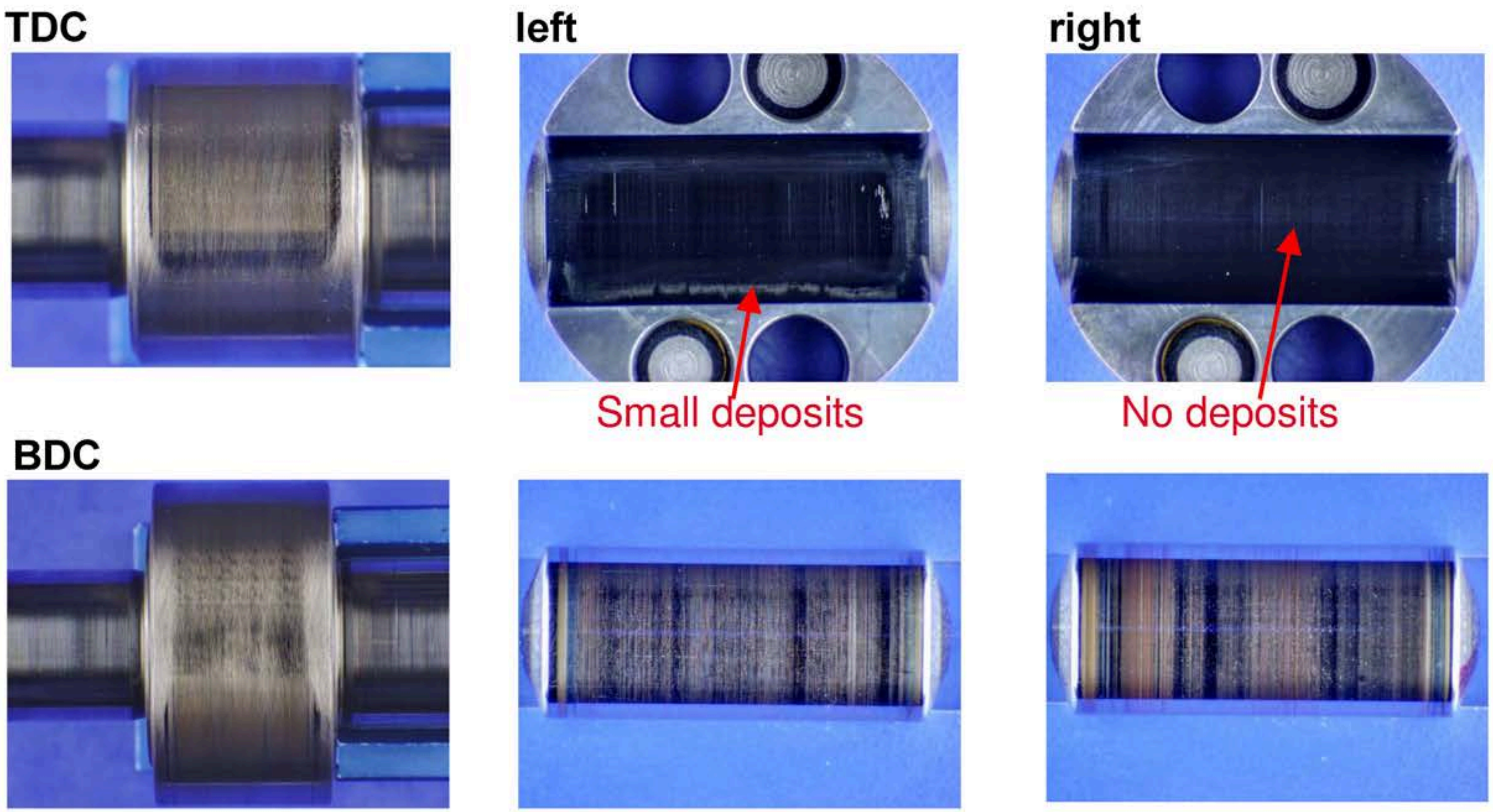
	_0578 (150 h)	_0580 (150 h)
Cyl.1		
Cyl.2		

Aluminum oxide formation (black) as an indicator of elevated temperatures

TM: Audi overload tests

2010-CP4_0633; Series; 0445B20318; 007-4325 (W19 EU5) RT: 150h

RP2



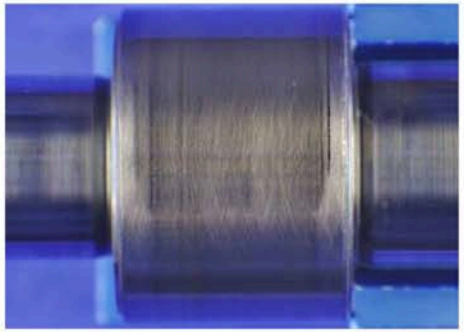
BOSCH

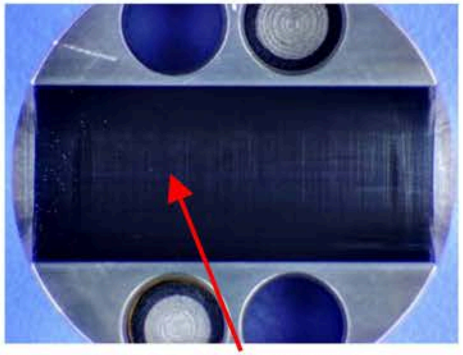
TM: Audi overload tests

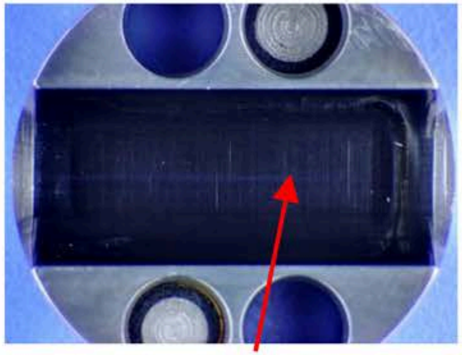
2010-CP4_0631; Series; 0445B20318; 007-4324 (W19 EU5) RT: 150h

RP2

TDC | **left** | **right**



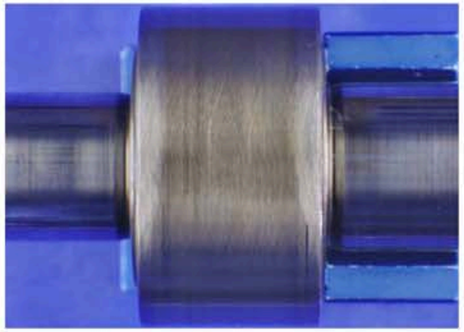


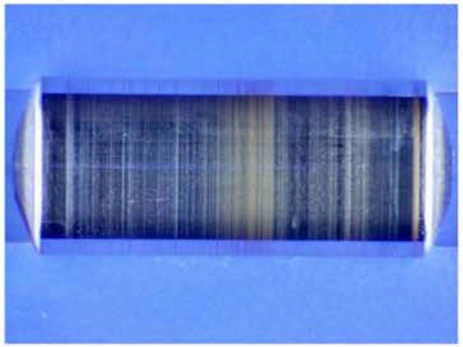


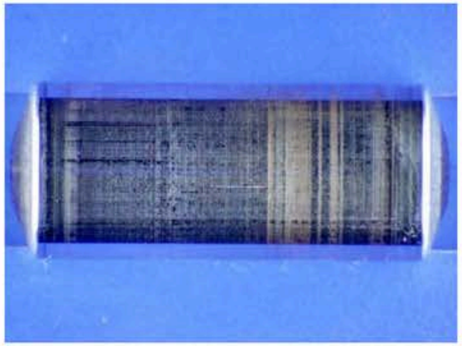
No deposits

No deposits

BDC





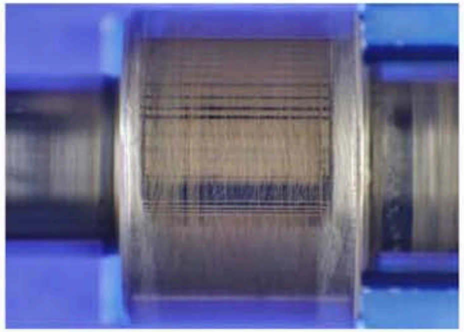


TM: Audi overload tests

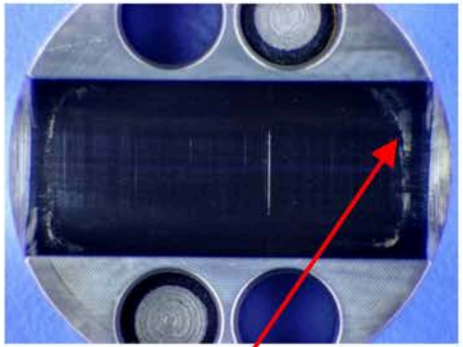
2010-CP4_0632; Series; 0445B20318; 007-4322 (W19 EU5) RT: 150h

RP2

TDC

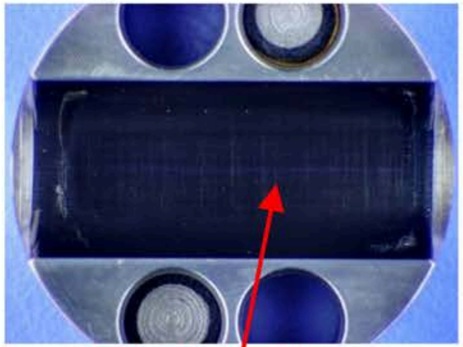


Cyl.1



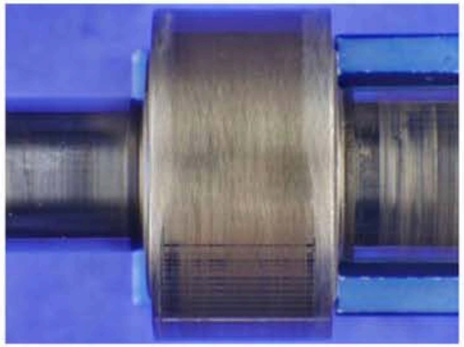
Few deposits

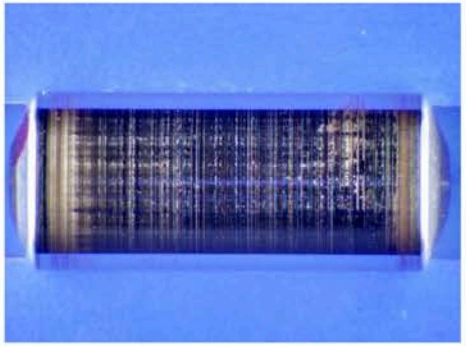
Cyl.2

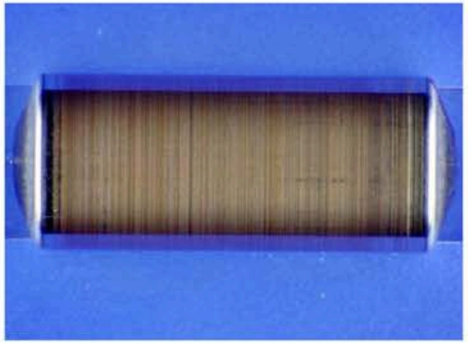


No deposits

BDC







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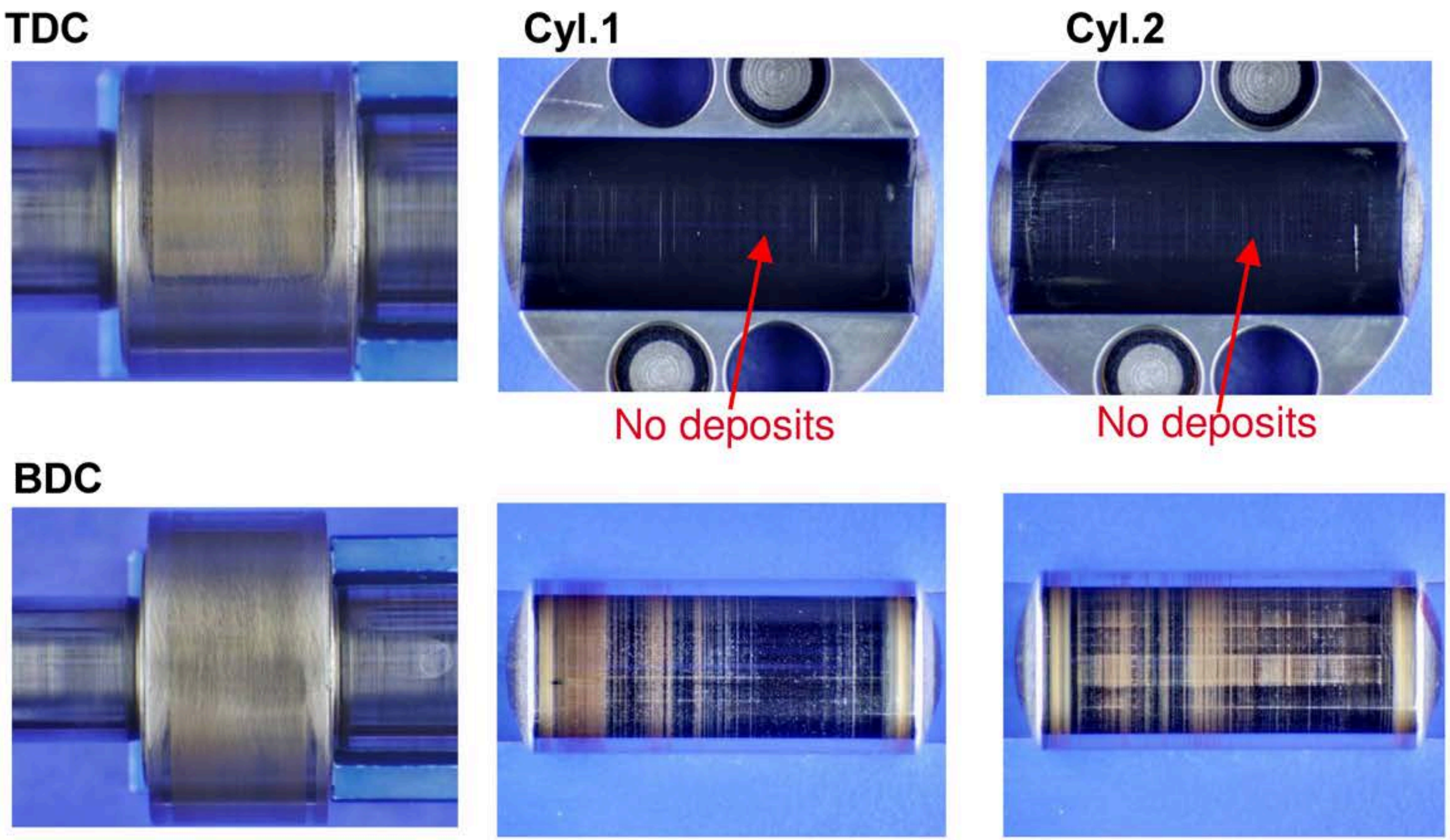
TM: Audi overload tests

2010-CP4_0630; Series; 0445B20318; 007-4388 (W19 EU5) RT: 150h

RP2



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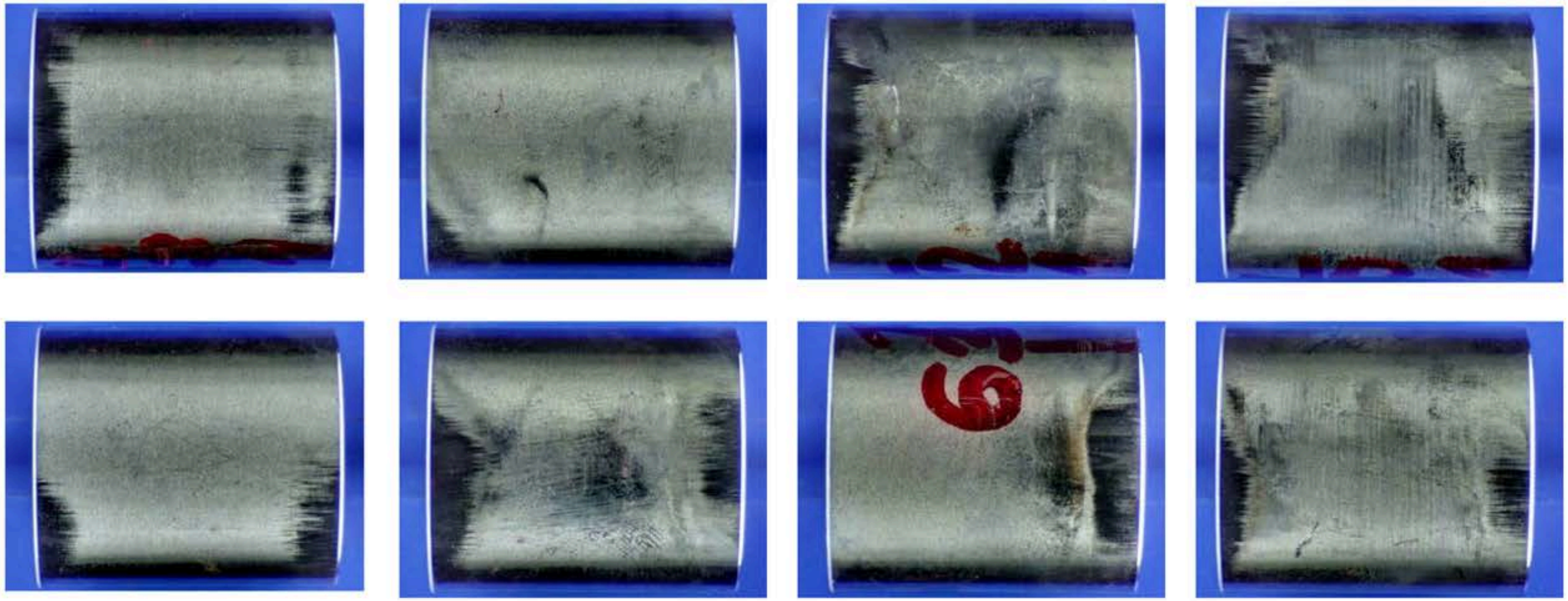
TM: Audi overload tests

2010-CP4_0576; Series; 0445010611; 05 100205 BPT 0604 AH; RT: 150h

RP2

	_0633 (150 h)	_0631 (150 h)	_0632 (150 h)	_0630 (150 h)
Cyl.1				
Cyl.2				



Low aluminum oxide formation (black) as an indicator of low temperatures

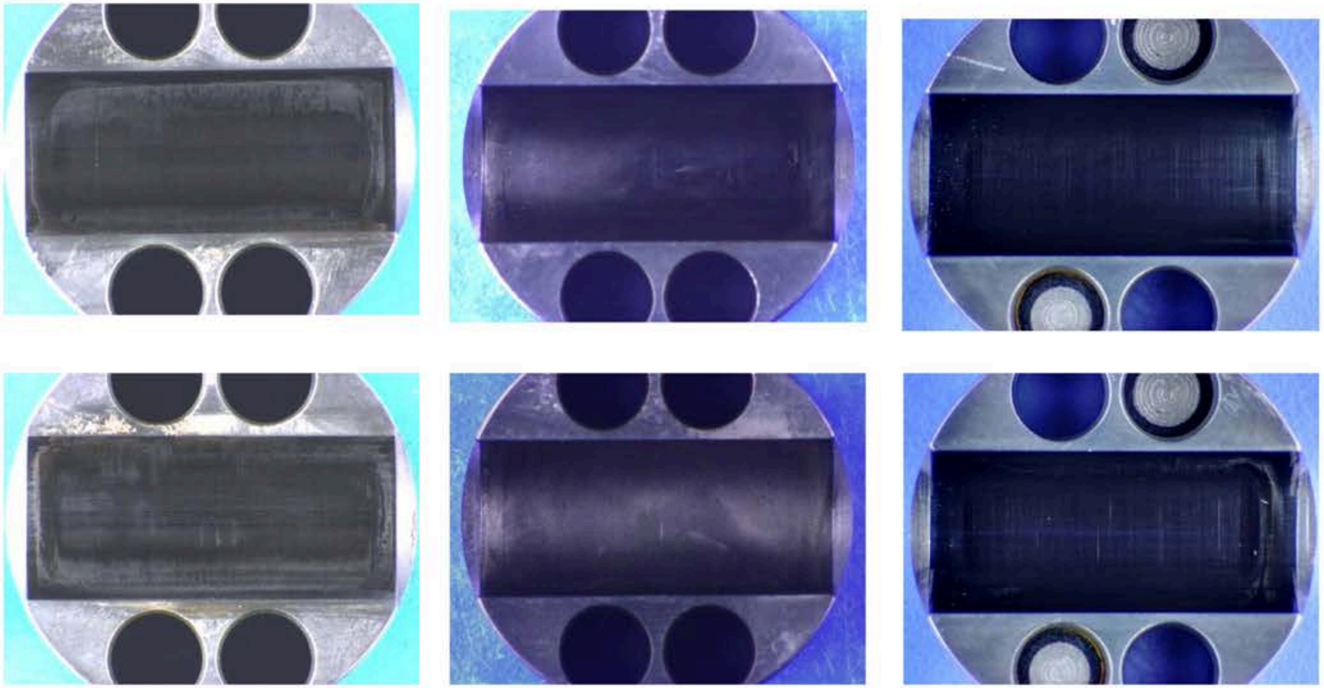
TM: Audi overload tests

Summary of visual findings

	_0576 (150 h)	_0580 (150 h)	_0631 (150 h)

Cyl.1

Cyl.2



C3 Series — RP1 — RP2

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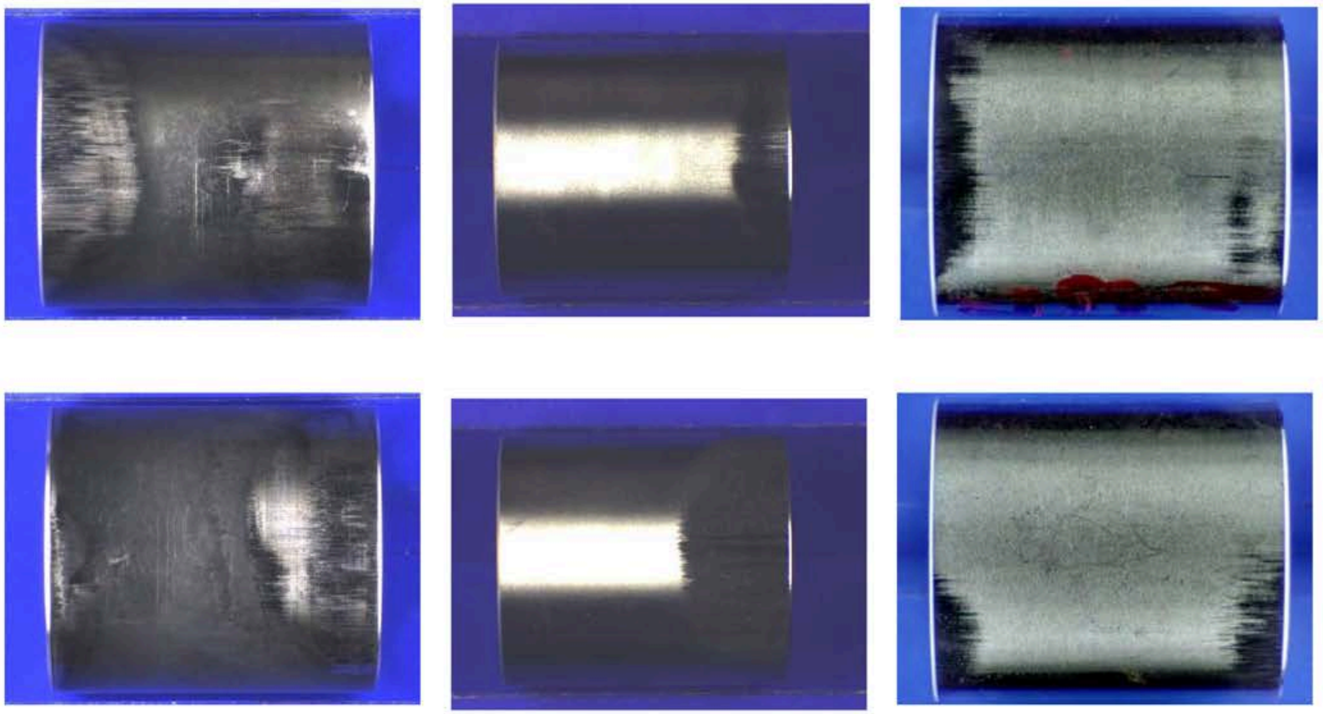
TM: Audi overload tests

Summary of visual findings

	_0576 (150 h)	_0580 (150 h)	_0633 (150 h)
Cyl.1			
Cyl.2			
	C3 Series	RP1	RP2



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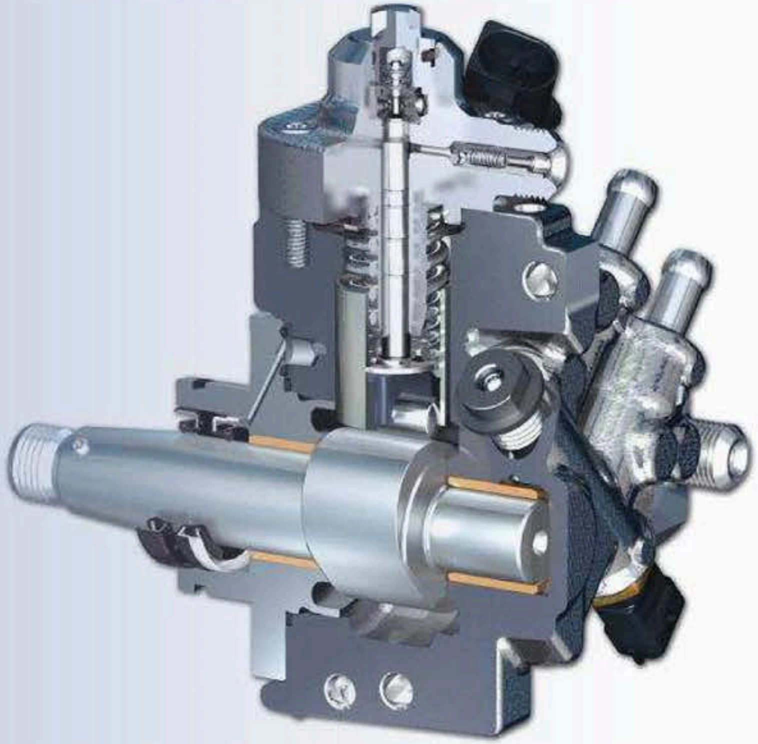
Task Force – Anti-wear packages @ CP4

[redacted]

1) **Anti-wear package 1 (RP1)**
2) **Anti-wear package 2 (RP2)**
3) **Blasted camshaft**

[redacted]



1) Anti-wear package 1 (RP1)

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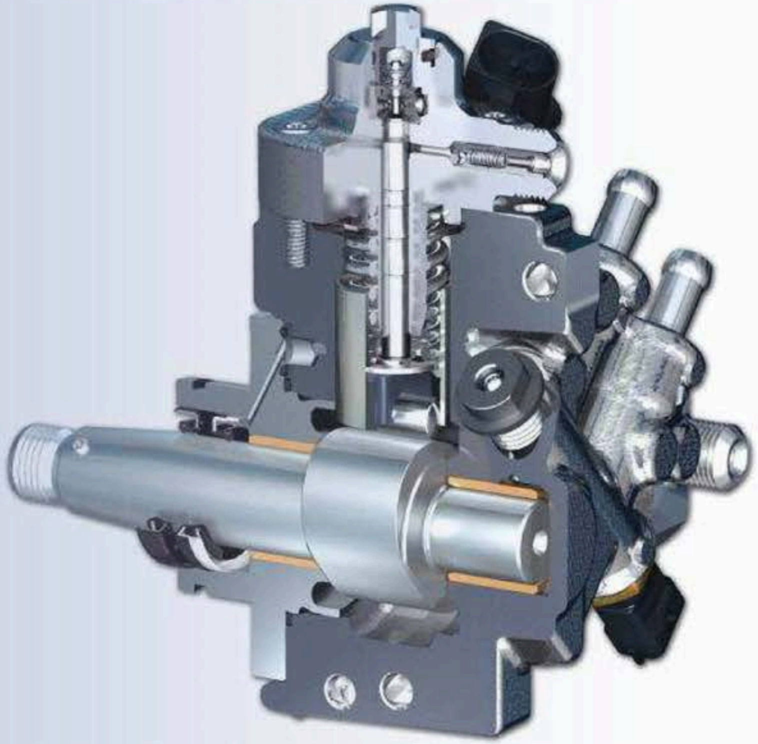

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Task Force – Anti-wear packages @ CP4

Anti-wear package 1

Task

Increasing the lubrication film between the roller support and the roller for fuels with lower viscosity (reduction of mixed friction fraction & temperatures)

Measures

- Reduction in roughness in the roller support due to changeover to C2 coating
- Prevention of metal splashes (for process reasons there are no metal splashes with C2)
- Reduction of play between roller and roller support (smaller roller support bore)
- Reduction in roughness of roller
- Optimization of edge slope on the roller (slackening)

Result

- AWP1 increases the lubrication film by the factor 2 (derived from findings)
- AWP1 has been in series at Audi for all CP4.2 since WK15

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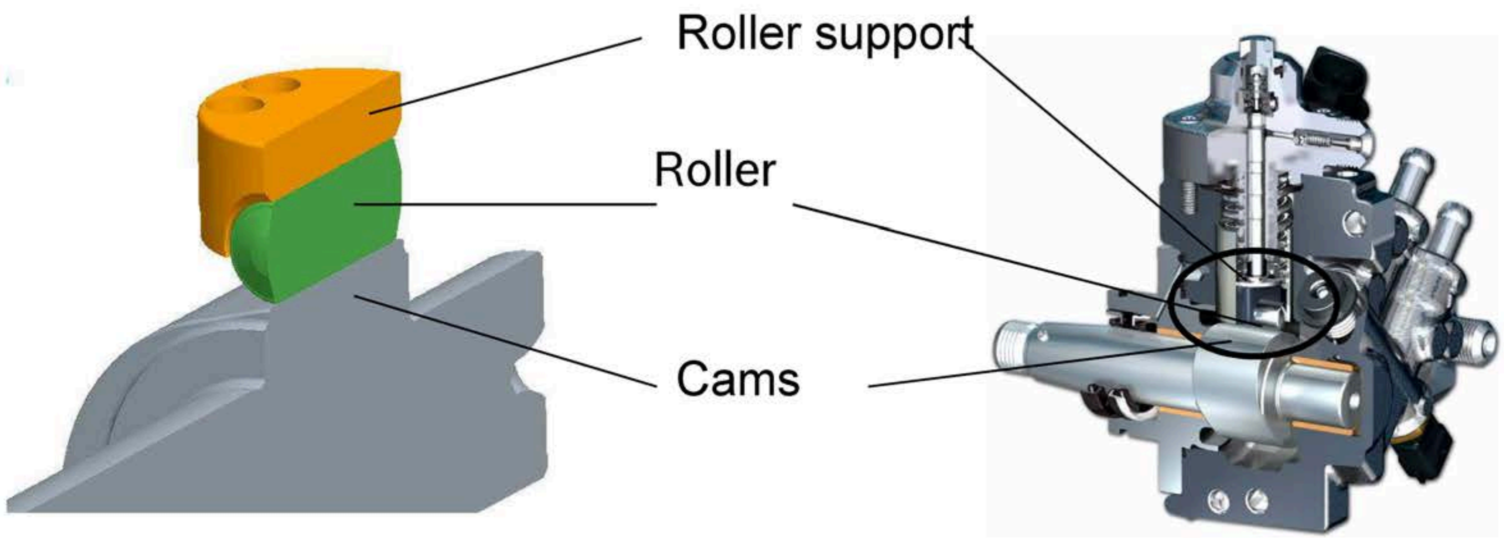
Task Force – Anti-wear packages @ CP4

Anti-wear package 1



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Task Force – Anti-wear packages @ CP4

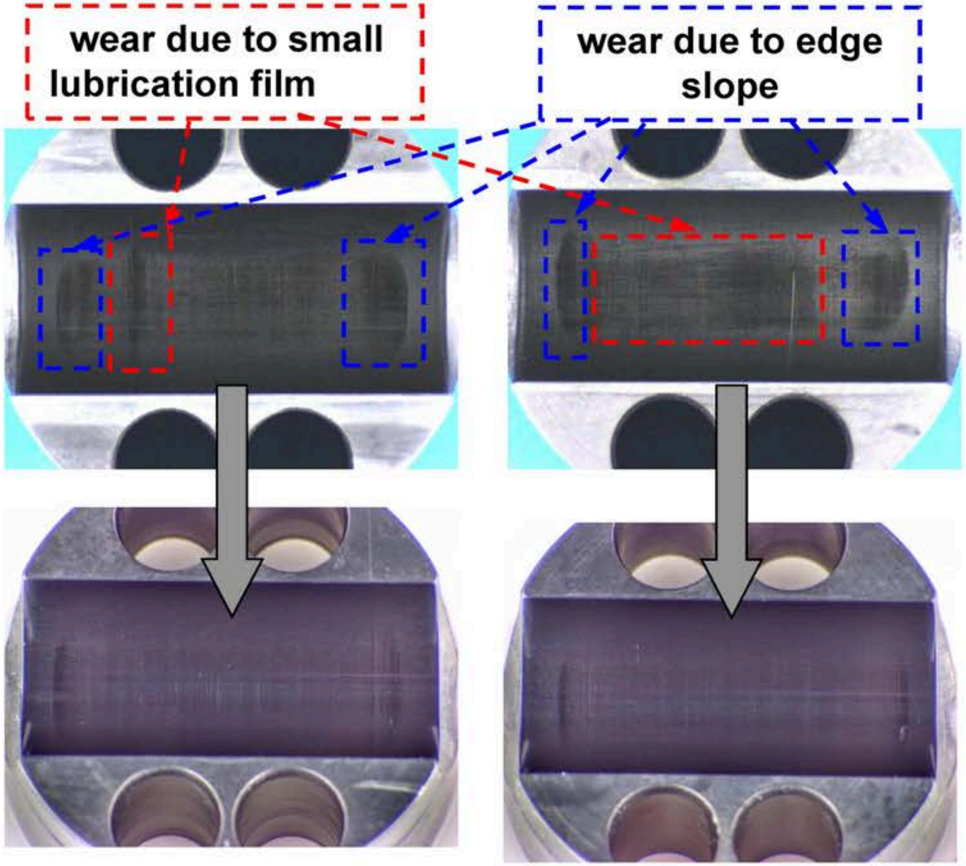
Anti-wear package AWP1

Verification of effectiveness by overload test (150 h with low viscosity)

Initial status of series with C3

Increase of lubrication film thicknesse

AWP1



Roller supports from test 2009-CP4_0728 **cleaned**

Roller supports from test 2010-CP4_0054 **cleaned**

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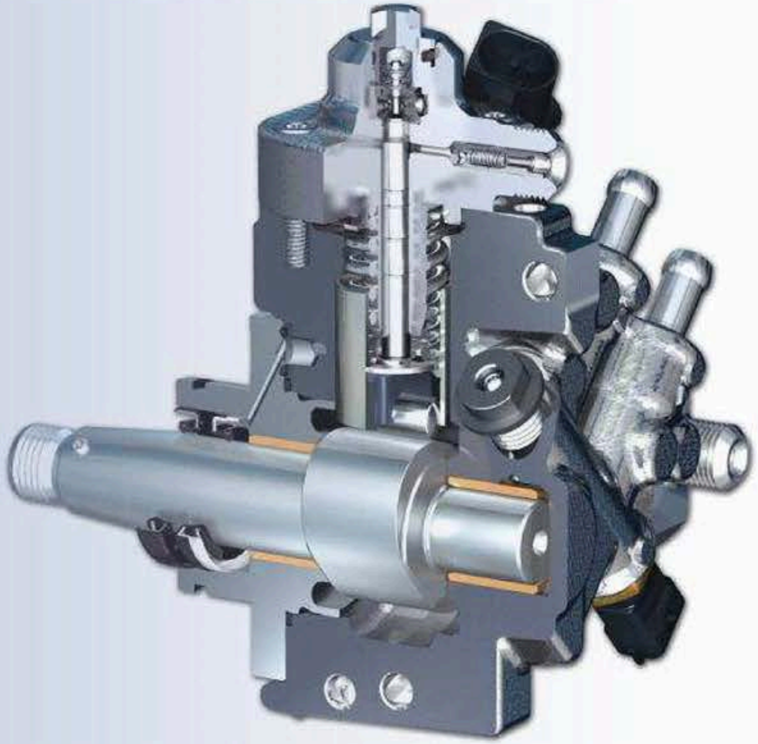
Anti-wear package 2 (RP2)

[redacted]



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Anti-wear package 2

Task

Reduction of local temperature in the right roller support to the level of CP4.1

Measures

- Opt. arrangement of supply & return position (swapping of the supply / return connections)
- Introduction of a robust flange (large overflow cross-sections)

Result

Reduction of temperature in the lubrication gap by 24°C (from 136°C to 111°C @ 80l/h @ 70°C supply)

The level is thus the same as CP4.1

Qalt2 test endurance tests at R.B. passed

Pumps sent to Audi for testing

Series startup

starting WK34 possible

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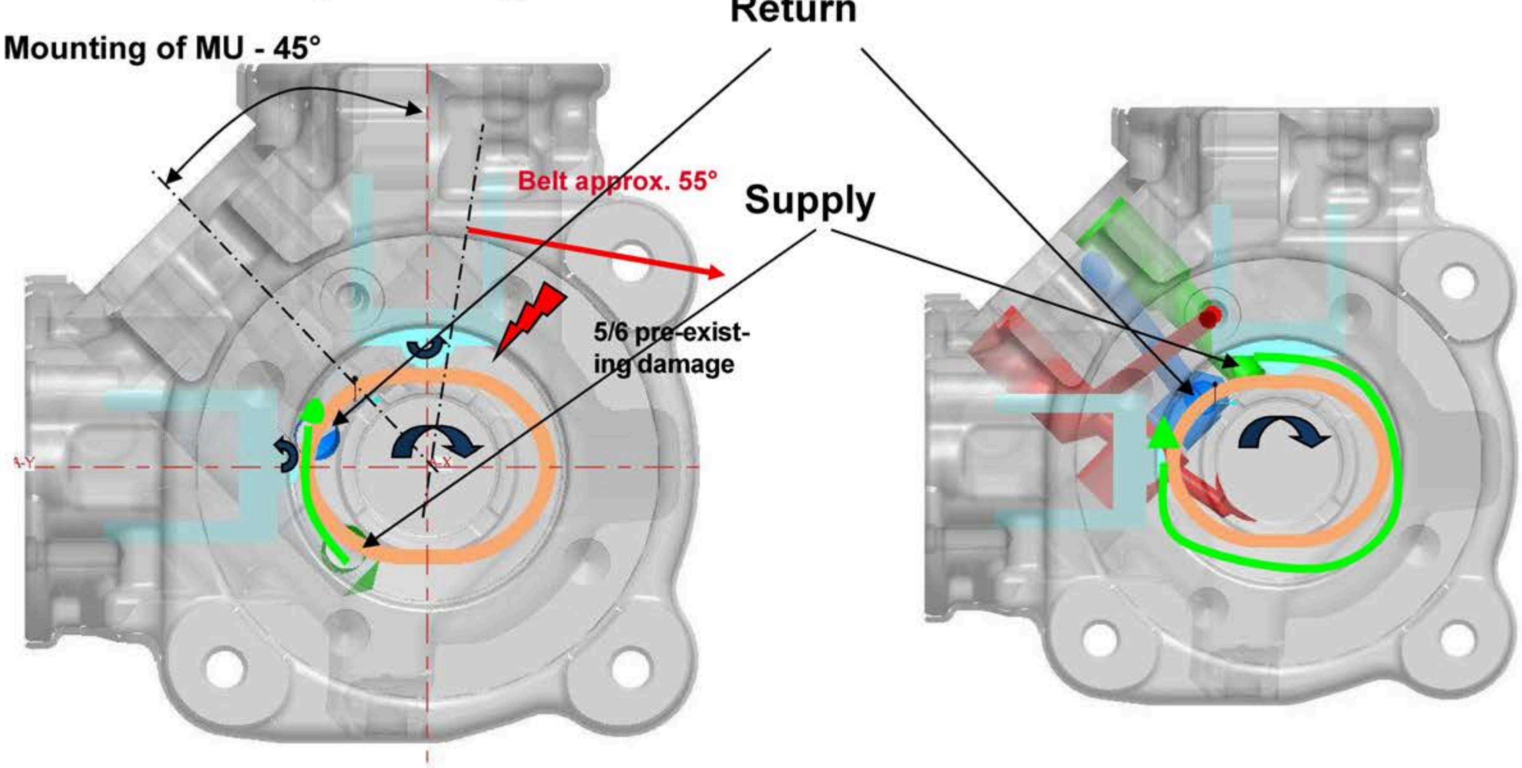
Task Force – Anti-wear packages @ CP4

Anti-wear package 2



Fuel goes direct to return

CP4.2 electric fuel pump cw Audi W19

Fuel is pumped around once

CP4.2 electric fuel pump cw **RP2** for Audi W19

Diesel Systems

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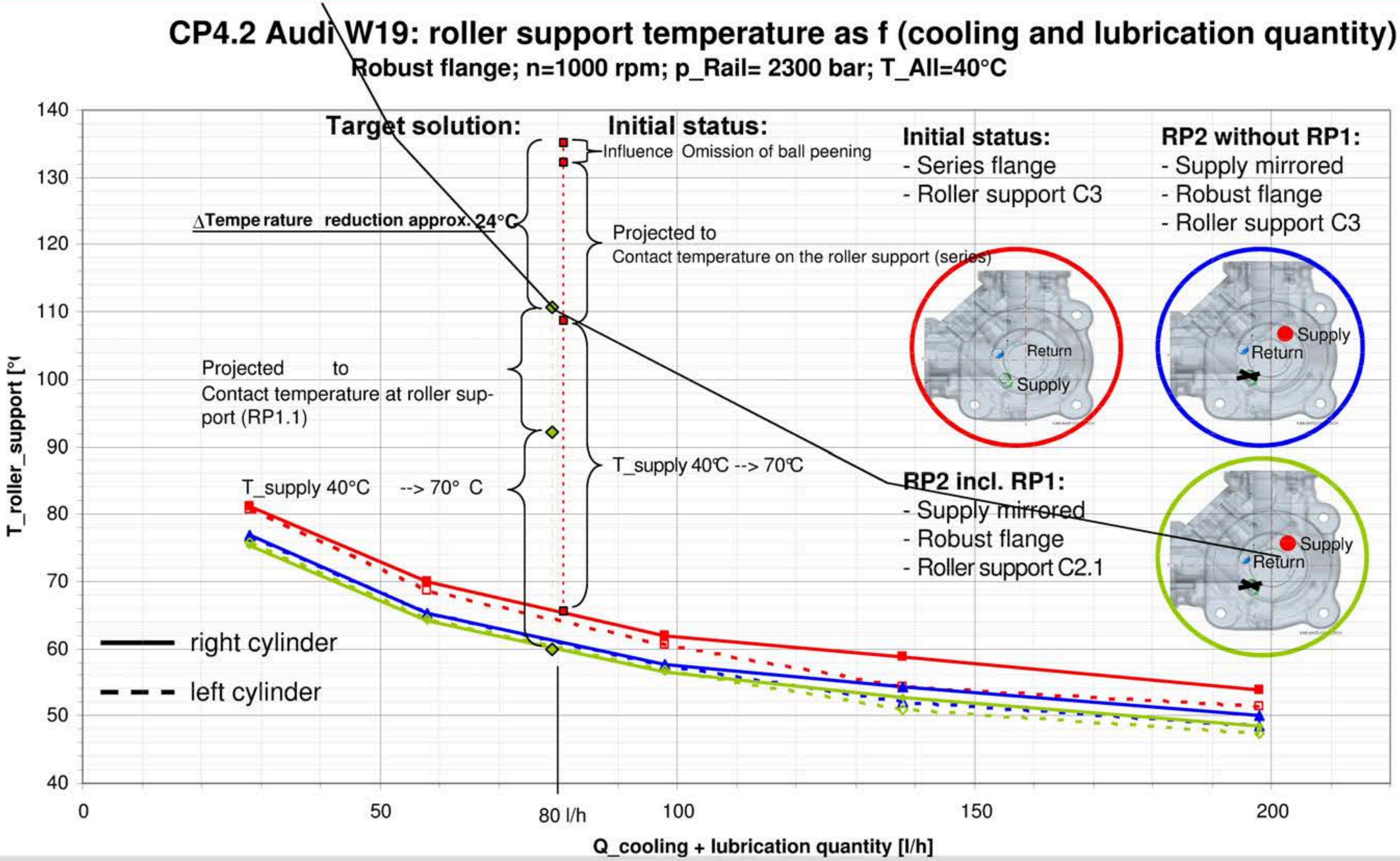
Task Force – Anti-wear packages @ CP4



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Task Force – Anti-wear packages @ CP4

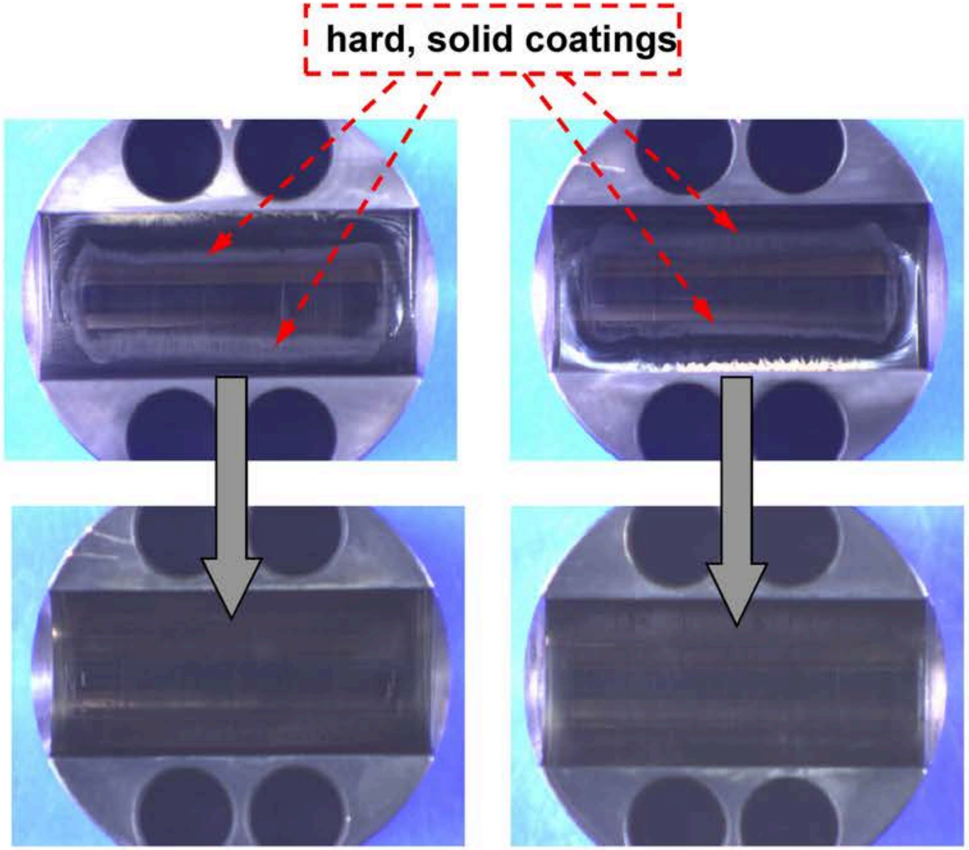
Anti-wear package RP2

Verification of effectiveness by overload test (150 h with low viscosity)

Initial status of series with C3 coating

Reduction in formation of coating

RP2



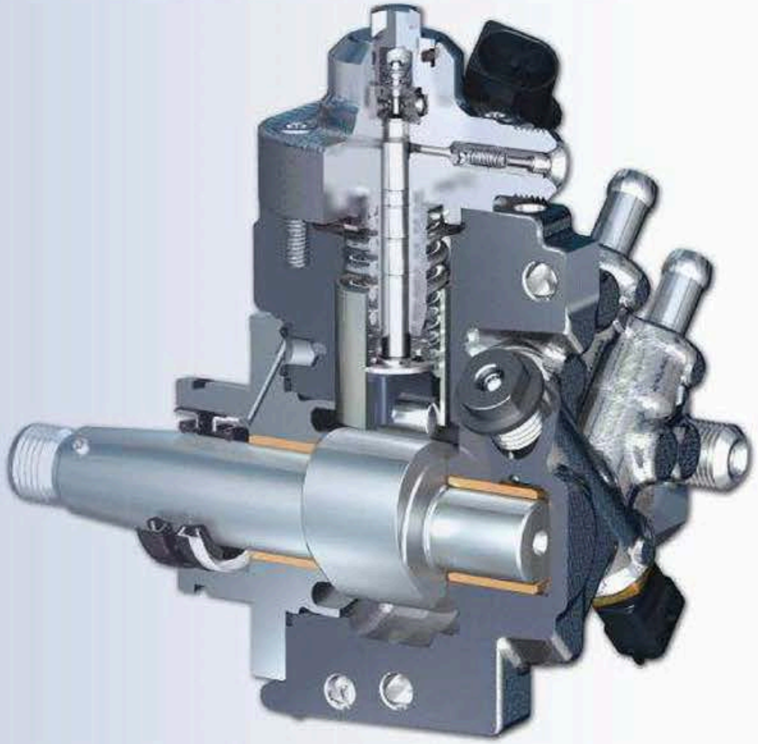
Roller supports from test 2009-CP4_0728 **uncleaned**

Roller supports from test 2010-CP4_304/305 **uncleaned**

ENTIRE PAGE CONFIDENTIAL

3) Blasted camshaft

[redacted]



Diesel Systems

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Task Force – Anti-wear packages @ CP4

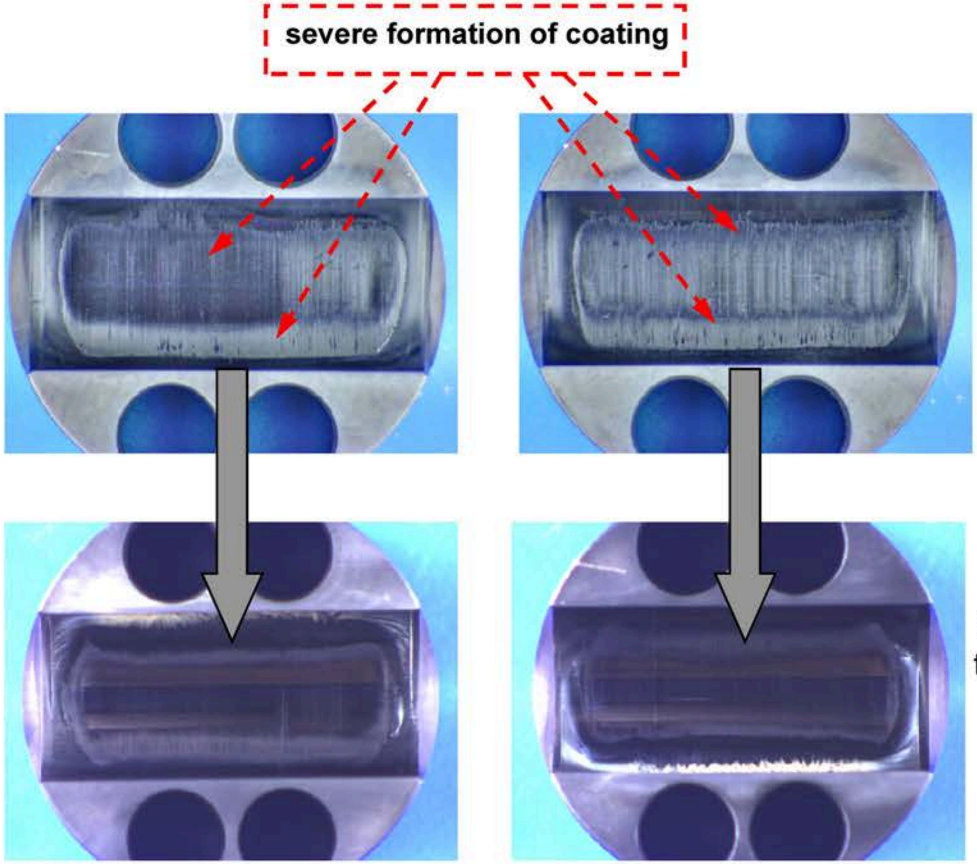
Ball peening of camshafte

Verification of effectiveness by overload test (150 h with low viscosity)

Series up to 05.09 C3 coating and shot blasted camshafte

Reduction in formation of coating

Series after 09.06 C3 coating and unblasted cam shafte



Roller supports from test 2010-CP4_365/366 **uncleaned**

Roller supports from test 2009-CP4_0728 **uncleaned**

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[redacted]

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[redacted]

Backup

Development activities - outlook

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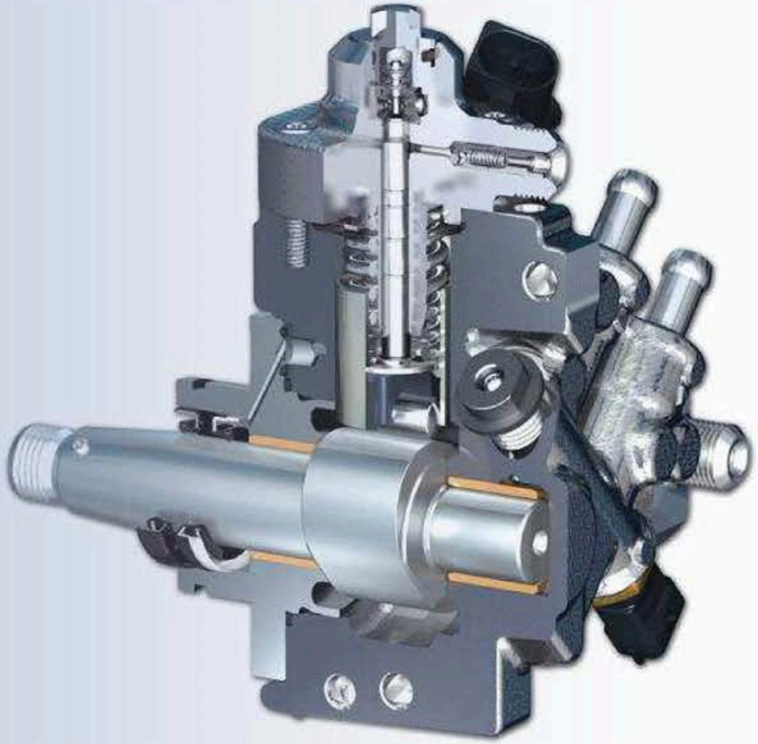

Diesel Systems

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Task Force – Anti-wear packages @ CP4

Increase in robustness for Word Wide Usage (WWU)

1) Optimized C coating in the roller support (C3.1)

- Reduction in roughness peaks (Rp)
- Better adhesion through titanium coating
- Higher resistance to wear

2) Optimized supply geometry at the roller support

- Optimized shape of the roller support bore

3) Reduction of drivetrain temperature

- Efficient heat removal from the housing (increase in coolant quantity, optimized
- Flow through the housing -> new housing !)
- Increase in average drivetrain pressure (reduction of pressure peaks, raising of the overflow valve setting point)

4) Optimized cam surface

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Analysis of CP4.1 from Non-responsive con tent removed

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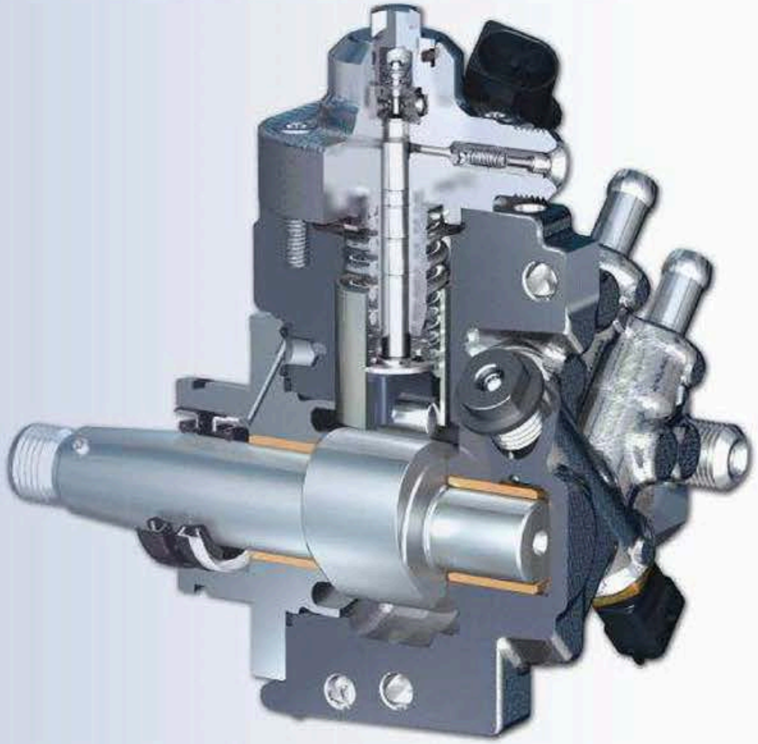

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Task Force – Anti-wear packages @ CP4

Summary of findings 33 CP4.1 pumps from [redacted]

Task

→ Findings overview & Statistics regarding **33 CP4.1 complaints** from Audi vehicles in [redacted]

Result

→ 25 of 33 pumps have drivetrain damage:

I Complete wear of	3 pumps
II Wear band	1 Pumpe
III **Material breakage** Cams	8 pumps
IV **Material breakage** roller	9 pumps
V Central “flattening”	4 pumps

→ 22 of 25 cases of drivetrain damage have a final turned tappet

→ The frequency of coatings in the roller support on CP4.1 is less than on CP4.2

→ The frequency of signs of corrosion on CP4.1 is similar to that on CP4.2

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Task Force – Anti-wear packages @ CP4

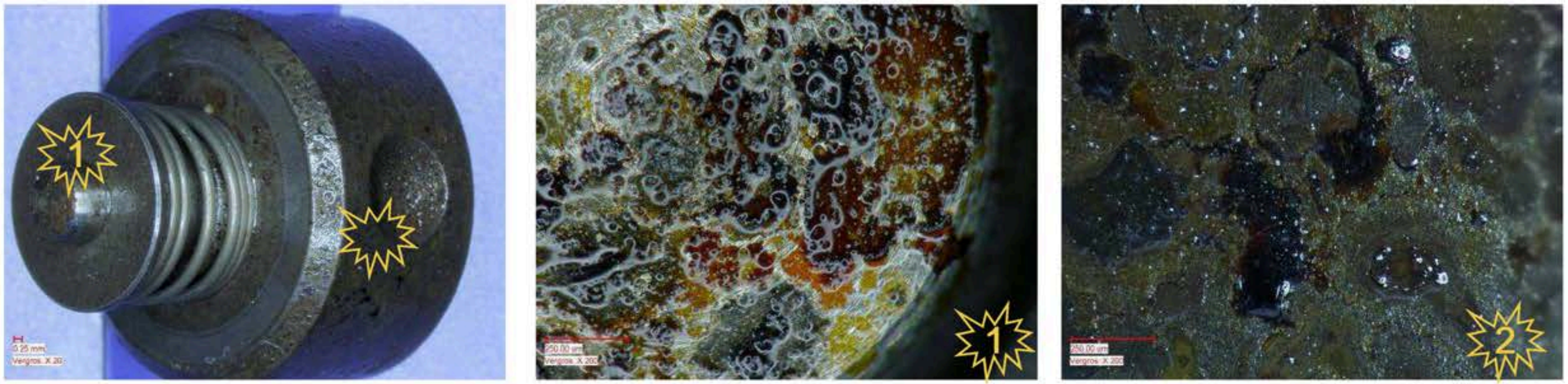
Examples of **fuel aging** at the intake valve (CP4.1 Non-responsive content removed

4VW372 DM Mar 08 35,010 km

without drivetrain damage

4VW354 DM Sept 09 5,358 km

with drivetrain damage



Diesel Systems

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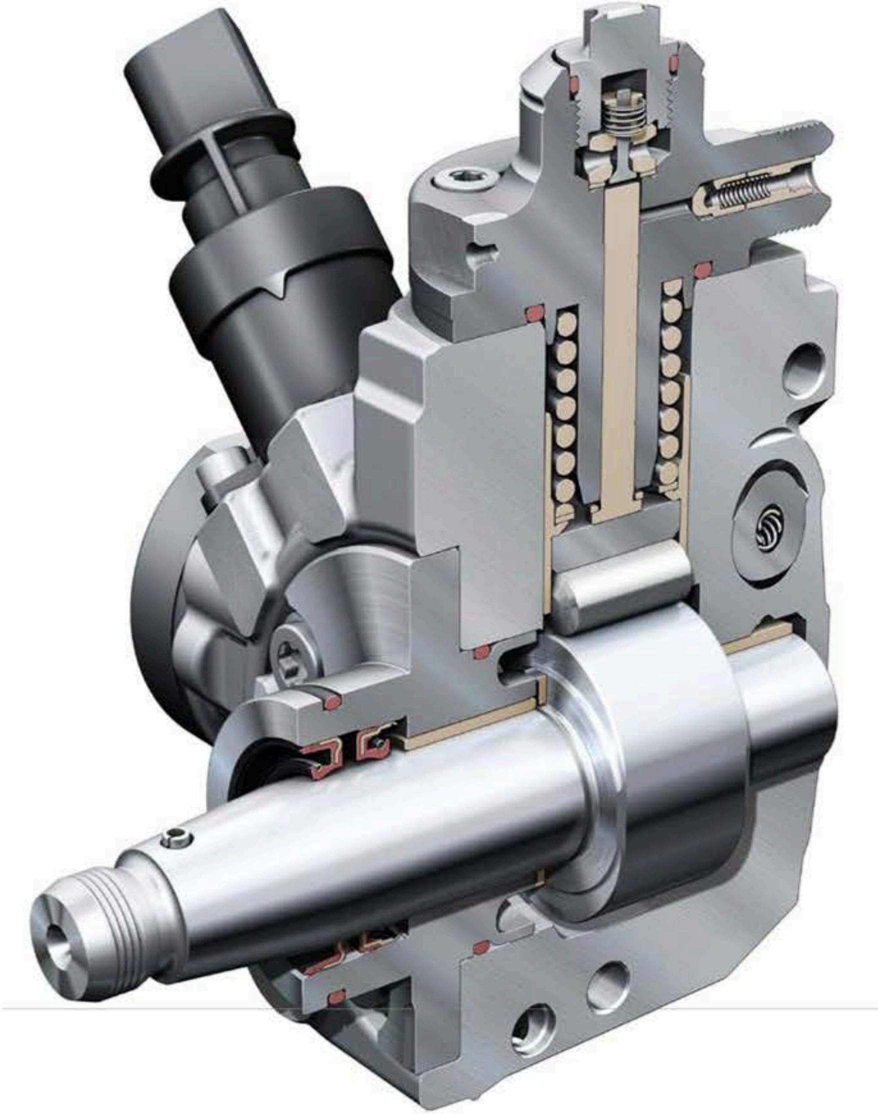
CP4.2 failures V6TDI VW/Audi, Status 09.30.2010

Failures

Damage hypothesis

Root cause analysis

Measures



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CP4.2 failures V6TDI VW/Audi, Status 09.30.2010

Failures

Audi Status as on 09.05.10:

worldwide 2,135 V6 TDI failures (MY 08 to MY 11, CP4.2).

High abnormality [redacted] (1,150 failures, failure rate factor 10 as compared to [redacted]) and CP4.2 as compared to CP4.1 (Factor 10 as compared to CP4.1 in [redacted].

Failure rate greatly decreasing since vehicle DM 08/2009; since vehicle DM 06/2009 no failure V6TDI in Q7 and Touareg in [redacted] Audi failures in the USA at the level of [redacted]

Sharp increase in [redacted],284 failures.

VW (Audi Information from 09.29.10):

worldwide 1210 Touareg failures,

of which 750 [redacted] 235 [redacted], 9 USA, 216 other markets)

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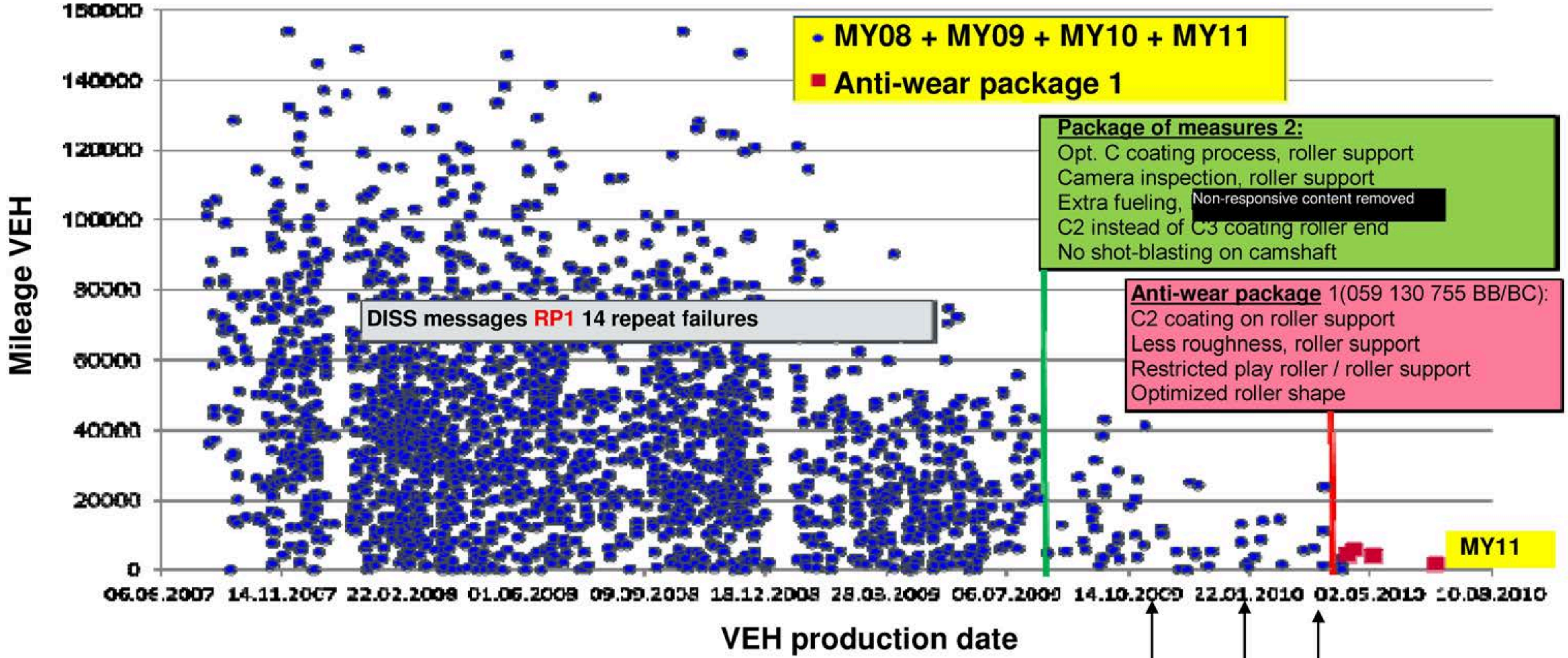
CP4.2 failures V6TDI VW/Audi, Status 09.30.2010

Worldwide failures in the field involving high-pressure fuel pump CP4.2
Effectiveness of measures
All Audi V6-TDI / SAGA 059A_/B_



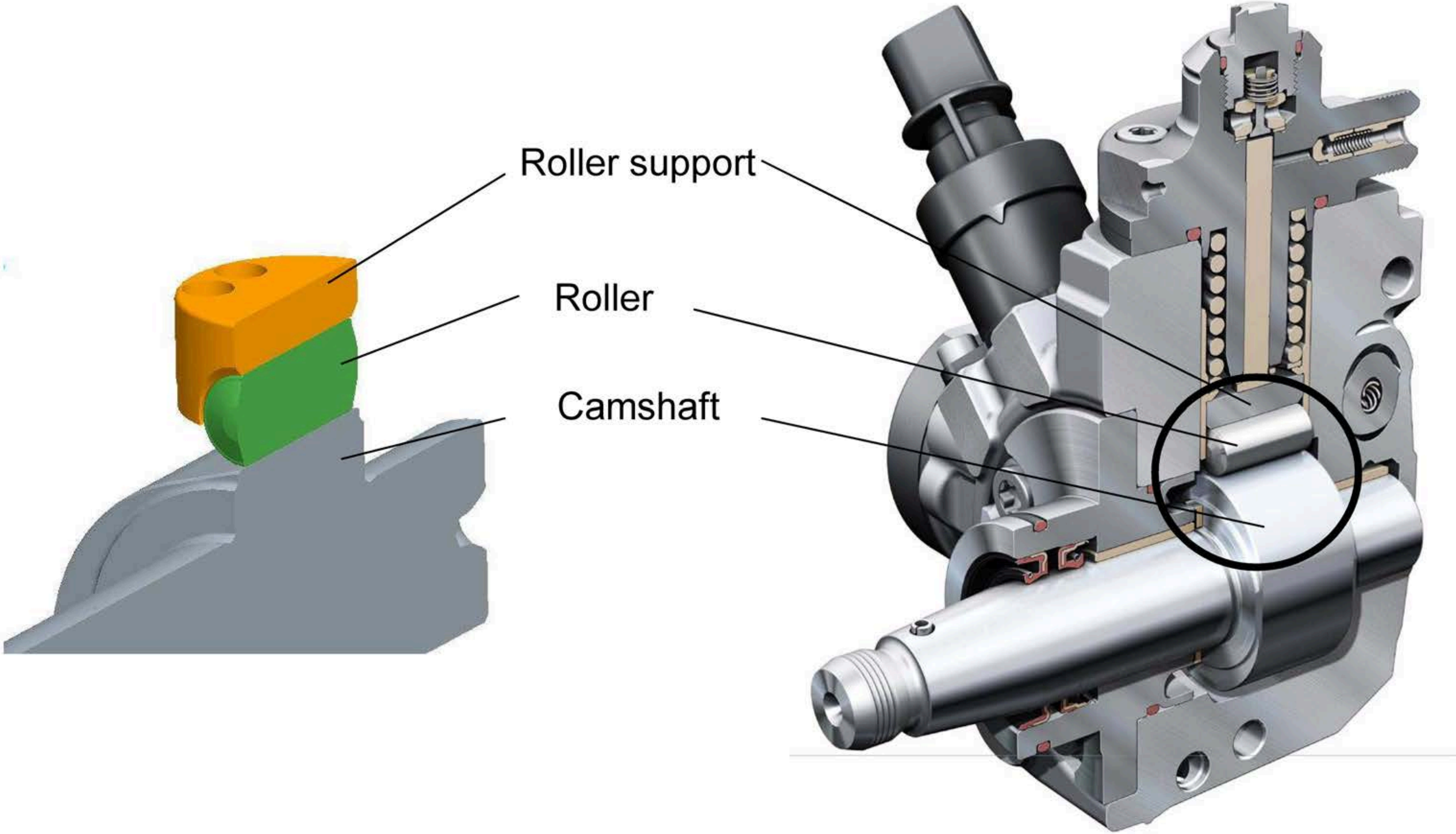
11.04.09 Start Task Force with Focus [redacted]

02.12.10 start quarterly Reviews with [redacted]

4/16/2010
Focus extended
[redacted]
Report about 131 failures RUS

BOSCH

CP4 drivetrain



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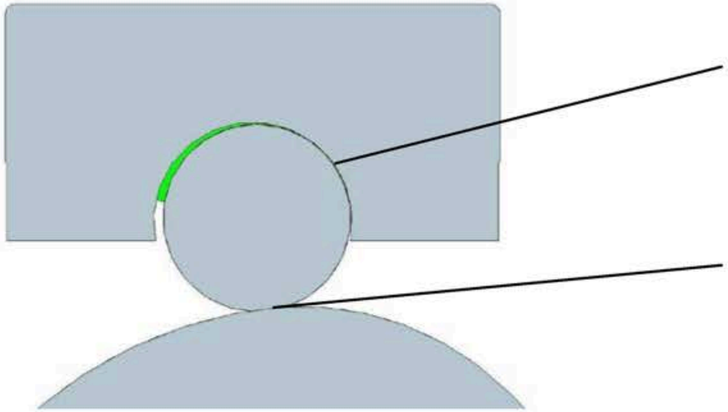
CP4 drivetrain function



Roll function of the roller on the cam is met when the friction coefficient roller / cam is higher than the friction coefficient roller / roller support.

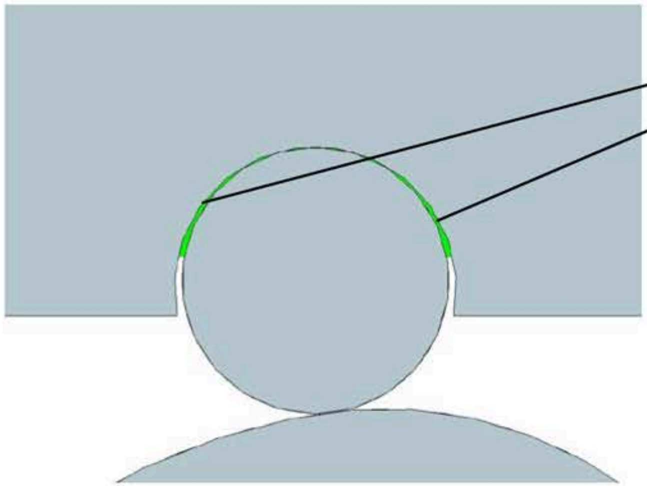
Condition: μ_roller-cam > μ_roller-roller support

Typical values: μ_roller-cam: 0.11
μ_roller-roller support: 0.035

It can be concluded:

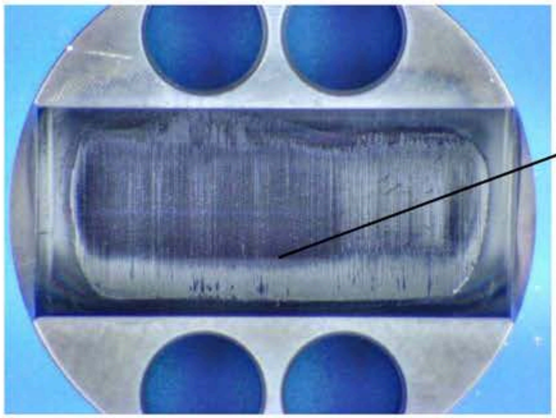
➔ Roller support surface is very smooth at each condition
➔ Camshaft is rough at each condition

Immobilizer by deposits



Deposit in the roller support prevents starting of running of the roller.

Subsequent pump failure due to
- Turned tapper
- Abrasive wear
- Roller fatigue
  (For very wide flat spots)



Deposit in the roller support

Flat spots on roller

Emergence of braking flats

Deposits in the roller support prevent the rocking of the roller in the roller support -> no buildup of hydrodynamics -> stationary / stiff roller -> Roller slides on the cam -> preliminary damage (braking flat on the roller).
Deposits are formed through deposition of biofuels / additives at temperatures > 140°C.

Fuel with low viscosity and low boiling temperature leads with high temperatures in the roller support (~ 200°C) to evaporation of the fuel in the gap -> no build-up of hydrodynamics -> standing/stiff roller -> roller slides on cam -> preliminary damage (braking flat on the roller).

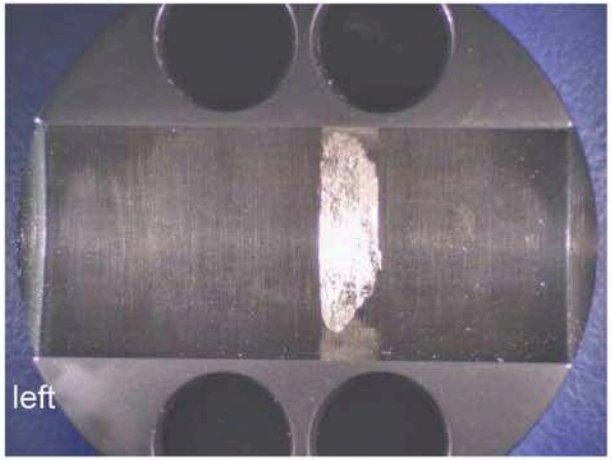
Low viscosity and low-boiling fuels with high proportion of additives (e.g. kerosene) combine both types.

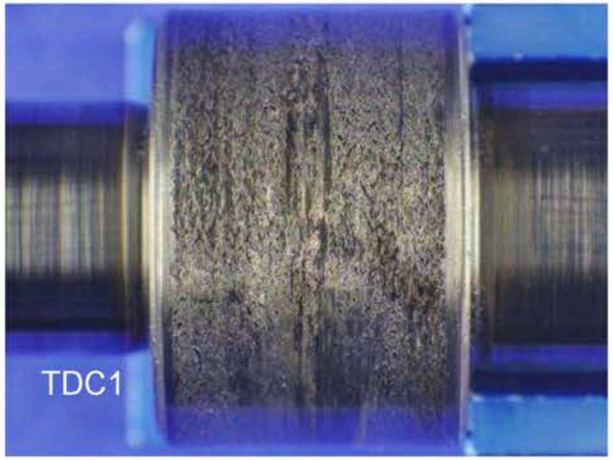
CP4.2 failures V6TDI VW/Audi, Status 09.30.2010

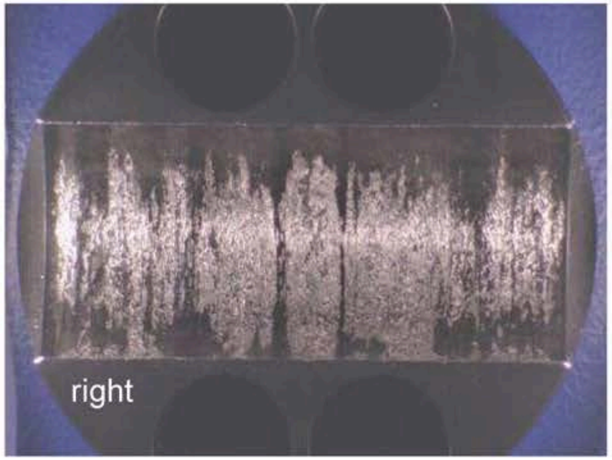
2010-CP4_0644

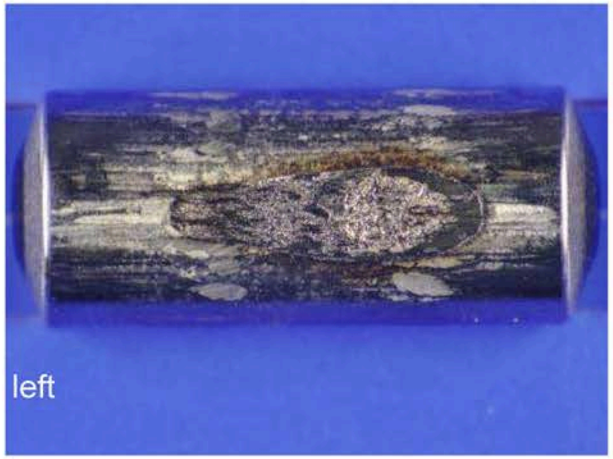
Failed pump field [redacted] RT not known

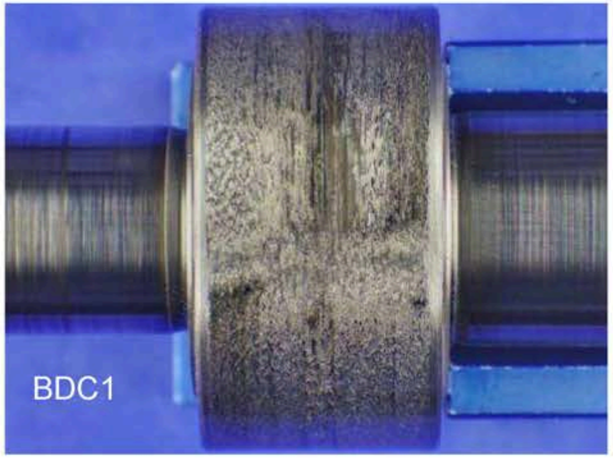
0 445 010 611; DM: 100121 BPT 1190; C-Index 05; 059 130 755 AH

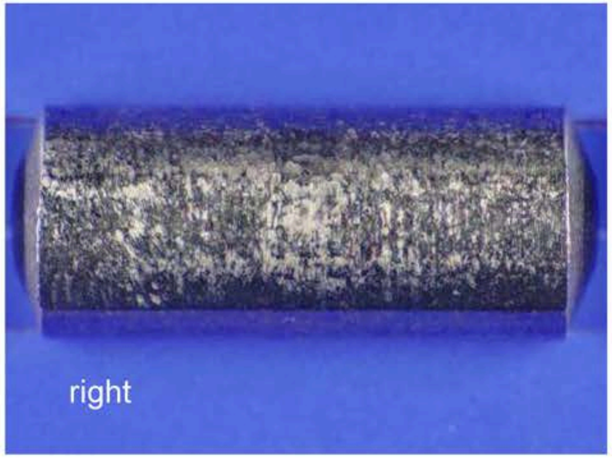












Diesel Systems

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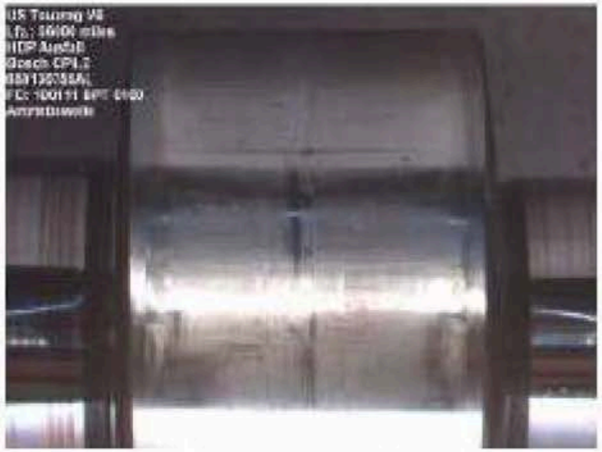
CP4.2 failures V6TDI VW/Audi, Status as on 09.30.2010

Breakdown Touareg NF USA (90,000km)

Roller cyl. 1

Roller cyl. 1



Camshaft

Roller cyl. 2

Roller cyl. 2

Roller fatigue

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Analysis results

Non-responsive content removed [redacted] 39 Good pumps

Deposition products (aged biofuel / additives / water) disallow the start-up of the roller on start. This leads to preliminary damage (braking flat) and later failure through turned tappet.

Non-responsive content removed [redacted] 12 good pumps, partial deposits

Abrasive wear of roller and cam caused by poor quality fuel (low viscosity, low vapor pressure, kerosene, water).

Non-responsive content removed [redacted] 13 good pumps, partial deposits

Good pumps from veh. plant show in 3 of 5 cases preliminary damage (braking flats) after 20 km run-in.

CP4.2:

Increase in temperature of roller cyl. 2 by 20-25°C compared with cyl. 1 due to poorer interior flushing

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CP4.2 failures V6TDI VW/Audi, Status as on 09.30.2010

Measures

1. Optimization of production processes:

SOP 05.2008 package of measures 1

SOP 06.2009 package of measures 2

Quality of previous pump has been achieved with regard to fuels according to specification

2. Increase of robustness against fuels ex spec.:

SOP WK15.2010 anti-wear package 1

(RP1) Impact on CP4.1 and CP4.2

SOP WK45.2010 anti-wear package 2 (RP2)

Impact on CP4.2: no critical temperature rise at roller support 2

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CP4.2 failures V6TDI VW/Audi, Status as on 09.30.2010

Anti-wear package 1 (RP1), SOP WK10.2010

Task

Increasing the lubrication film between the roller support and the roller for fuels with lower viscosity (reduction of mixed friction fraction and temperatures)

Measures

- Changeover of C3 coating (sputtering) of the roller support on C2.1 coating (plasma):
- Reduction of roughness Rv from 1.3um to 0.8um
- Avoidance of fusing and metal spatter (process-related)
- Reduction of play between roller and roller support (smaller roller support hole)
- Reducing the roughness of the roller
- Optimization of edge taper on the roller (slender taper)

Result

RP1 raises the lubricant film by a factor of 2 (derived from diagnosis results). Effectiveness proven via RB test rig stress test.

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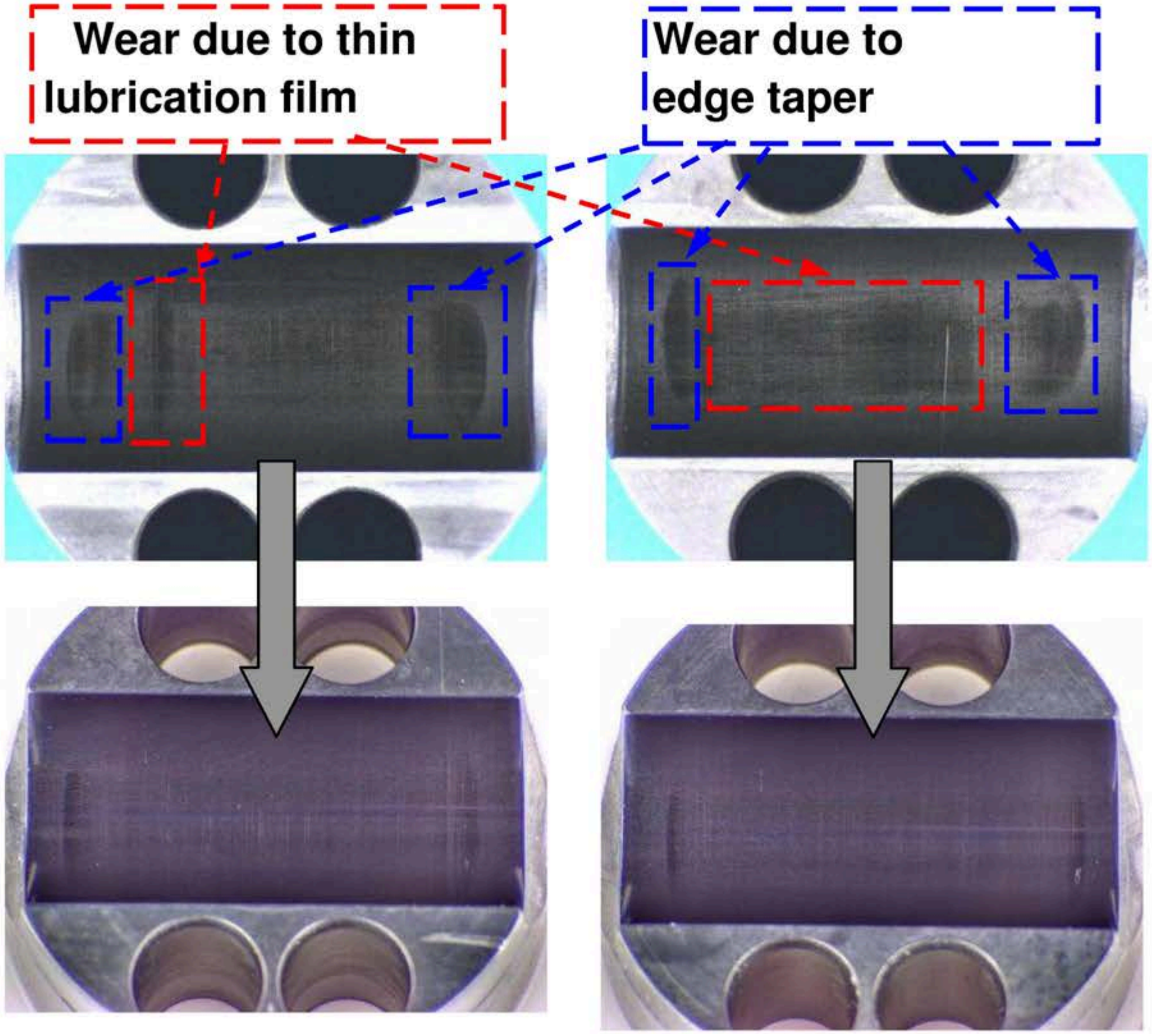
Anti-wear package RP1

Proof of effectiveness by overload test (150 h with low viscosity)

Initial status of series with C3

Increasing lubricant film thickness

RP1



Roller supports from test 2009-CP4_0728 **cleaned**

Roller supports from test 2010-CP4_0054 **cleaned**

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Anti-wear package 2 (RP2), SOP WK 45.2010

Task

Reduction of the local temperature in the right roller support of CP4.2 at the level of CP4.1

Measures

Opt. Arrangement of inflow and return position (replacement of inflow / return connections), introduction of a robust flange (increase of overflow cross-section)

Result

Temperature reduction in the lubrication gap by 24 °C (**from 136°C to 111°C @ 80l/h @ 70°C supply**). The level is thus the same as CP4.1

Significant increase in the lubrication gap and prevention of deposit formation.

Effectiveness proven via RB / IAV test rig stress test.

80 pumps delivered to Audi for testing and use/replacement in failed vehicles in [redacted] 20 additional pumps on 10/01/10 First two vehicle results [redacted] positive.

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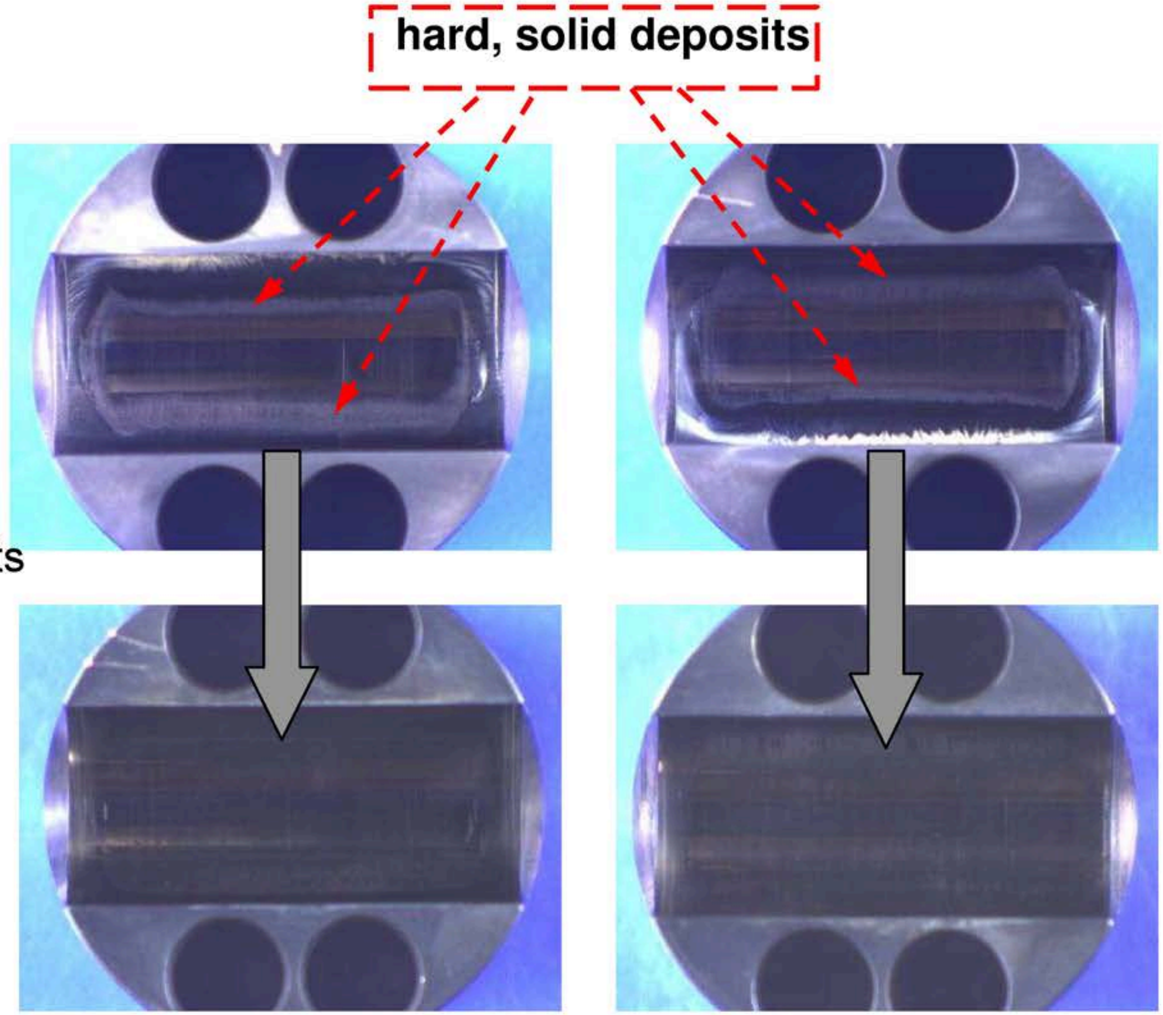
Anti-wear package RP2

Proof of effectiveness by overload test (150 h with low viscosity)

Initial status
Series with C3 coating

Reduction
Formation of deposits

RP2



Roller supports
from test
2009-CP4_0728
uncleaned

Roller supports
from test
2010-CP4_304/305
uncleaned

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Further measures

1. Exclusion of further design-related influences in comparison with CP4.2 at third-party OEM (finish direction of the camshaft different from rotation direction) RB T.: E10.10

2. Exclusion of preliminary damages in delivery chain:

Pumps from the complete delivery chain [redacted] (pump / engine / vehicle), are disassembled and analyzed for preliminary damages.
Action plan agreed with Audi on 09.29.10. Date: E10.10

On-site analysis in [redacted] by joint Audi / RB team Date: E10.10

3. Exclusion of poor lubrication of the pump due to insufficient presupply quantity from the low pressure circuit in connection with poor quality fuels. Audi/ RB T.: E10.10

4. Endurance runs with jointly defined RoW fuel as basis for worldwide approval RB E12.2010 first results

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From: Non-responsive content removed
To:
CC:
Date: 11.02.2010 07:10:57 PM
Subject: List of TOP5 countries
Attachments: TOP 5 Länder-2010-08-02-CP4.1.pdf

Hello Non-responsive content removed

As discussed today, the list of TOP5 countries of CP4.1 as of 08.02.2010.
The updating additionally still includes the error "Non-starter".

Best regards

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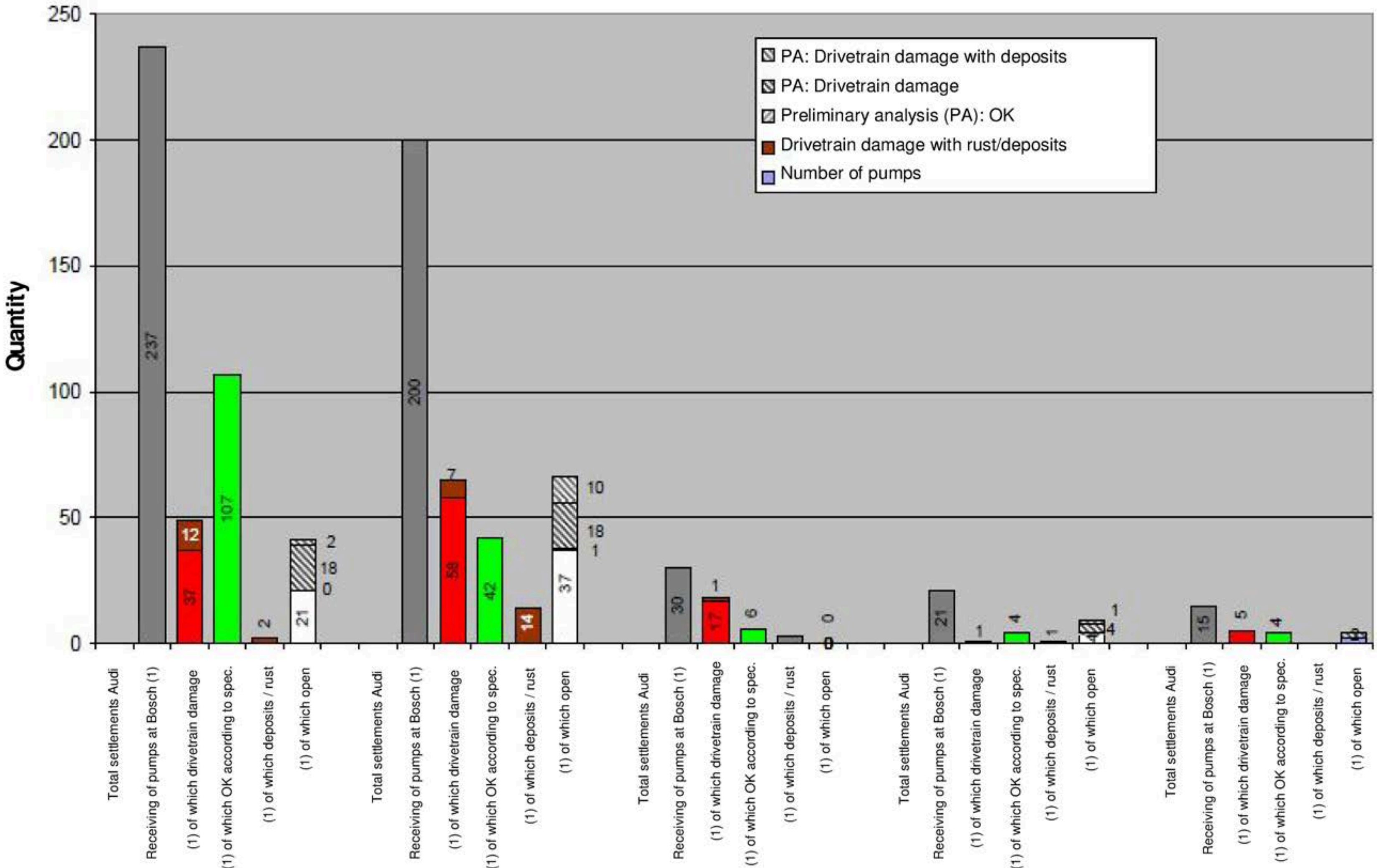
VW/Audi CP4.1 field failures

TOP 5 countries

Base: Bosch: [redacted] as of 08.02.2010



[redacted] | USA | [redacted]

Diesel Systems

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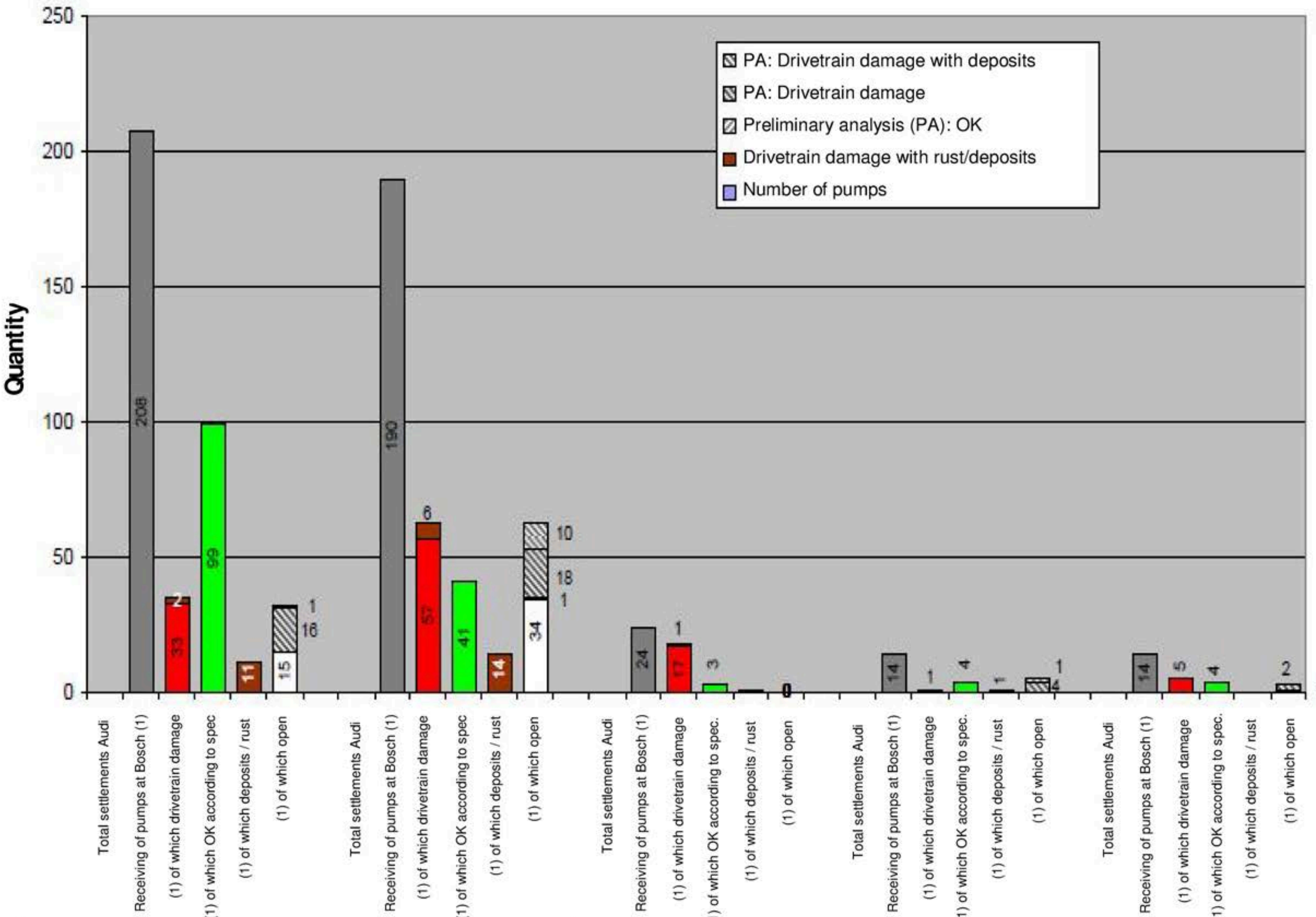
VW/Audi CP4.1 field failures

Base: Bosch[redacted] as of 08.02.2010

TOP 5 countries (DM of pump **before** 06.01.2009)



[redacted] USA [redacted]

Diesel Systems

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VW/Audi CP4.1 field failures

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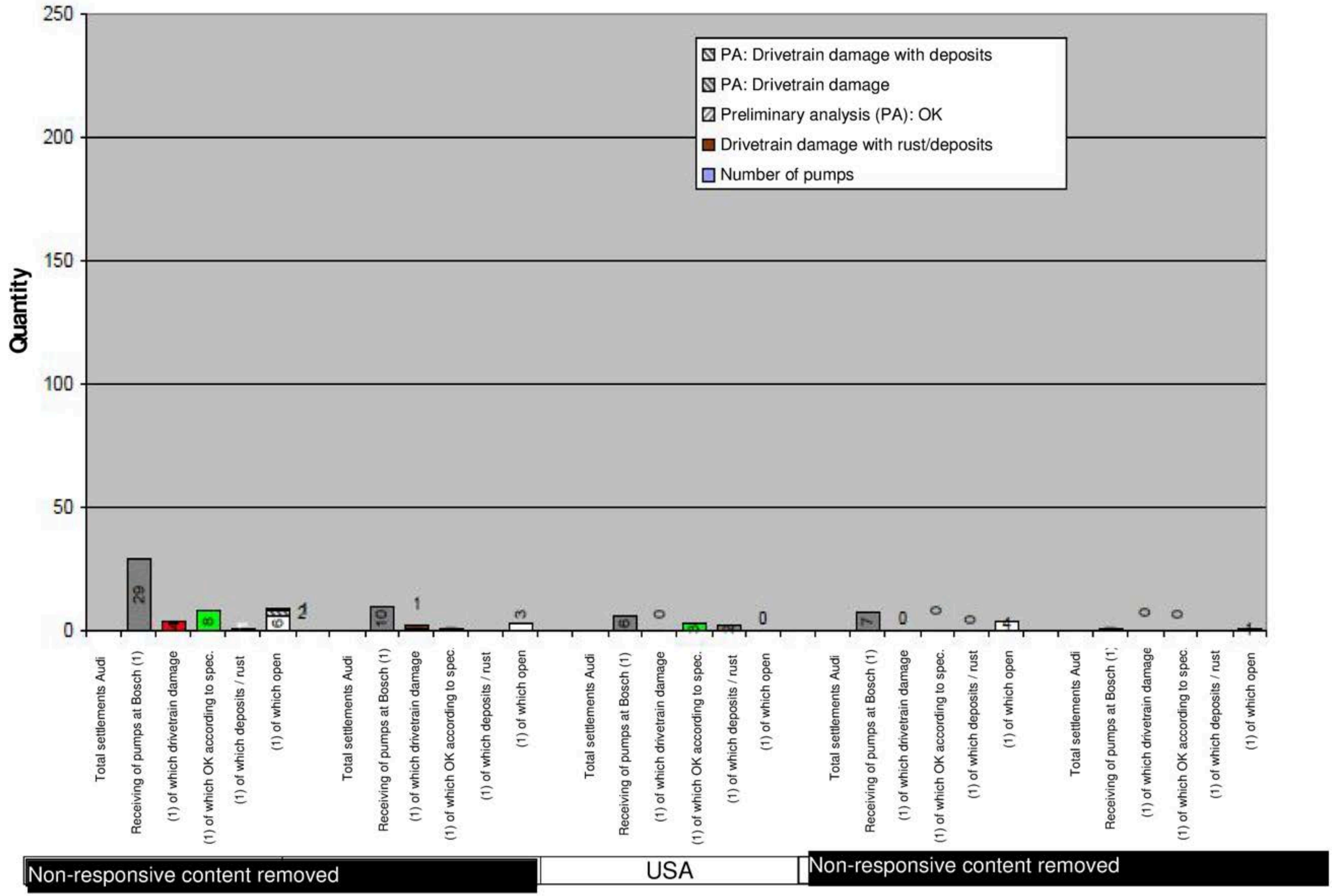
Base: Bosch: [redacted] as of 08.02.2010

TOP 5 countries (DM of pump starting **from** 06.01.2009)



Diesel Systems

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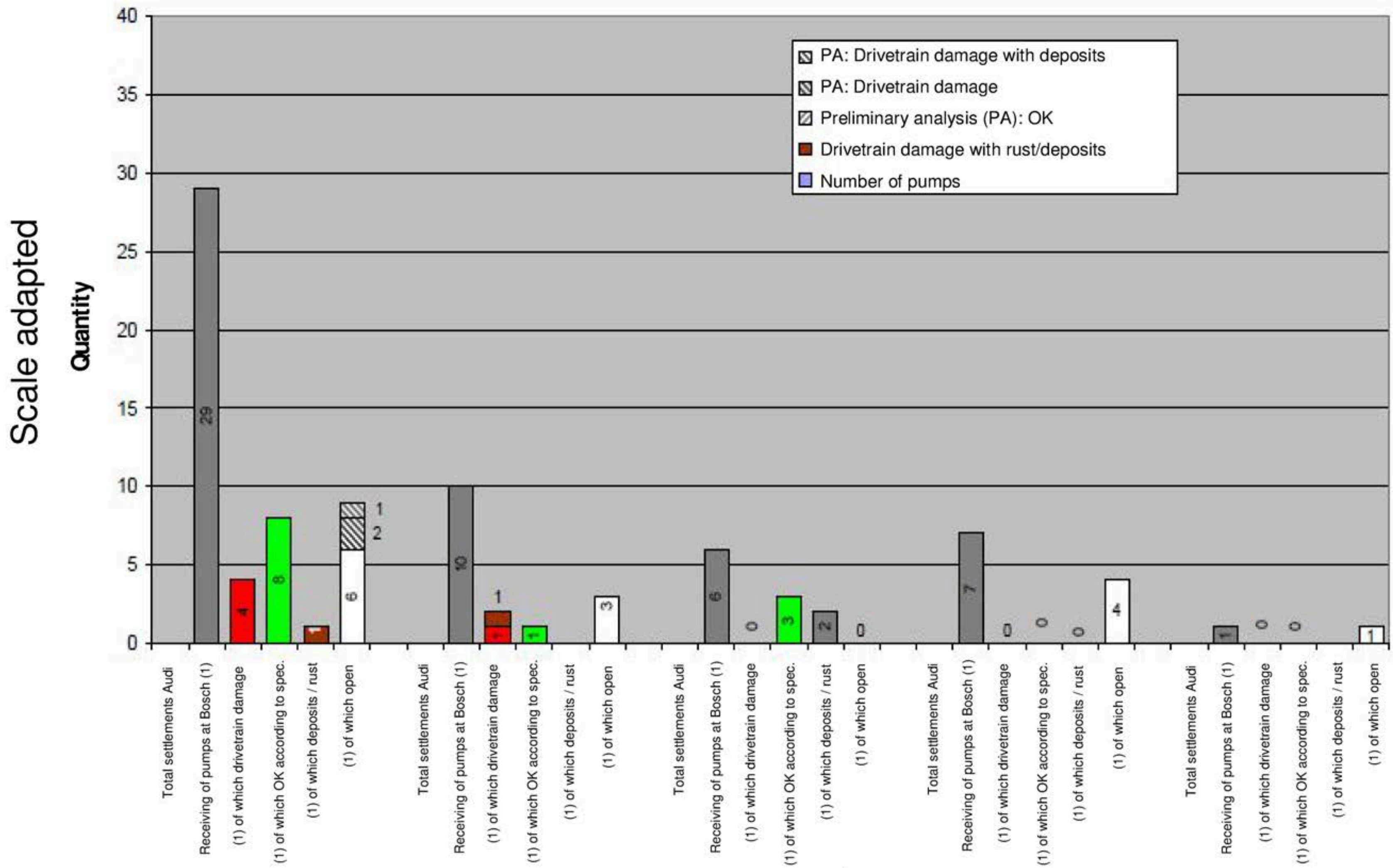
Base: Bosch: [redacted] as of 08.02.2010

TOP 5 countries (DM of pump starting **from** 06.01.2009)



Non-responsive content removed | USA | Non-responsive content removed

Diesel Systems

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