

EA11003EN-01122[0]

From: Non-responsive content removed
To: [Redacted]
CC: [Redacted]
Date: 8/25/2011 11:52:00 AM
Subject: ANS: HP from endurance run for diagnosis
Attachments: [VW361MECM015-0S_19808_mls_18.06.2011mit_Motor_aus.txt](#)
[Tankkarte VW361MECM015-0S.PDF](#)

Hello [Redacted]

INFORMATION Redacted PURSUANT TO THE FREEDOM OF INFORMATION ACT (FOIA), 5 U.S.C. 552(B)(6)

Here is the additional information:

-Vehicle number: [VW361MECM015-0S](#)
- Mileage: 31,874 km

Regards

[Redacted]

From: Non-responsive content removed
Sent: Thursday, August 25, 2011 12:18 PM
To: Non-responsive content removed
Cc: [Redacted]
Subject: ANS: HP from endurance run for diagnosis

Hello [Redacted]

I can't give you any information about the project!

[Redacted] can you please place this in the proper channels?

Regards,

[Redacted]

From: Non-responsive content removed
Sent: Thursday, August 25, 2011 12:09 PM
To: Non-responsive content removed
Cc: Non-responsive content removed
Subject: ANS: HP from endurance run for diagnosis

Hello [Redacted]

ASAP for diagnosis

@ [Redacted]
Please carry out diagnosis ASAP. Unfortunately, pump has been neglected due to lack of information.

Note: Contrary to the information in the mail, this is not a pump from N MS, but rather from N CS.

After speaking with [Redacted]
I have the following data:

EA11003EN-01122[1]

- Driving profile: Public roads
- WHERE: USA
- Fueling: At local public gas stations
- Vehicle: NCS (Jetta)
- Vehicle number: Information will be provided by [Redacted] Non-responsive content removed
- Mileage: Information will be provided by [Redacted]

The diagnosis must be booked to [Redacted] activity => Gain in findings, because [Redacted] project has long been closed

Best regards / mit freundlichen Grüßen

Non-responsive content removed

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

Tel. Non-responsive content removed
 Fax removed
 PC fax Non-responsive content removed
 Mobile removed
 Non-responsive content removed

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
 Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
 Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-Henning Scheider, Peter Tyroller



From: Non-responsive content removed
Sent: Thursday, August 25, 2011 7:52 AM
To: Non-responsive content removed
Subject: RE: HP from endurance run for diagnosis

Hello [Redacted]

The pump mentioned below BPT0451 is with me.
 It has not been registered because I do not have any information on it.

What is supposed to happen to it?
 Mit freundlichen Grüßen / Best regards

Non-responsive content removed

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

EA11003EN-01122[2]

Tel. [Redacted]

Fax -

PC fax [Redacted]

Mobile -

[Redacted]

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-
Henning Scheider, Peter Tyroller



From: [Redacted]

Sent: Wednesday, August 24, 2011 10:53 AM

To: [Redacted]

Subject: Re: HP from endurance run for diagnosis

Hello [Redacted]

Do you know anything about the parts?

I'm looking for the US HPP.

Mit freundlichen Grüßen / Best regards

[Redacted]

Robert Bosch GmbH

[Redacted]

www.bosch.com

Tel. [Redacted]

Fax [Redacted]

PC [Redacted]

Mobile [Redacted]

[Redacted]

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-
Henning Scheider, Peter Tyroller



From: [Redacted]

Sent: Wednesday, August 24, 2011 9:22 AM

To: [Redacted]

Subject: Re: HP from endurance run for diagnosis

Hello [Redacted]

EA11003EN-01122[3]

I'm looking for the US HPP.
03L 130 755 A no info on the HP ;-(
08 081210
BPT 0451

Is the pump in your database?

If so, what is the diagnosis status?

Regards

Best regards / mit freundlichen Grüßen

Non-responsive content removed

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

Tel. Non-responsive content removed

Fax

PC fax Non-responsive content removed

Mobile moved

Non-responsive content removed

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-
Henning Scheider, Peter Tyroller



From: Non-responsive content removed

Sent: Tuesday, August 23, 2011 5:24 PM

To: Non-responsive content removed

Subject: Re: HP from endurance run for diagnosis

Here is some info on the US pump

From: Non-responsive content removed

Sent: Friday, July 22, 2011 3:25 PM

To: Non-responsive content removed

Cc:

Subject: ANS: HP from endurance run for diagnosis

Hello Non-responsive content removed

Here is the story of the HPP from MNS (Q verification run, failure at 31,874 km)

During a shift trip yesterday (Friday, 6/17/2011), motorway with approx. 120 km/h, the engine suffered a drop in power.

EA11003EN-01122[4]

No more gas was accepted, the preheat light started blinking in instrument cluster; when the vehicle came to a stop, the engine died.
The vehicle could no longer be started and had to be towed to the station.

3 static error memory entries in CU01:
"P0087 Fuel rail / system pressure too low
0110 0001 Upper threshold exceeded"
Diagra extract from the engine and transmission MVB attached.

A fuel sample was taken from the vehicle and examined with "fuel identification device DMP 02".
(Unfortunately, this device only makes statements on the fuel type, not the quality.)
Result: 100% diesel (see attached photo "diesel sample")

The HPP was analyzed in an initial approach, and several shavings were found (see photos).
HPP part data:
805 010 511 0, Bosch 1000, 1027, 02/53R/1S4PC/RC, A557 031 L30, 01 21 80 80, 1540TPB.

Crafter and RPU HPP ran with [redacted] inspection fuel. Low-pressure circuit in both series.

We are trying to obtain the additional information (questionnaire) you requested; when we get it, we will let you know in a diagnosis meeting.

Please send me and [redacted] the results of the [redacted] HPP analysis in advance. I will not be able to find out the results in PM 117 due to the plant holiday.

Thank you

Best regards
[redacted]
VOLKSWAGEN AG
[redacted]
Tel. [redacted]
IHC
[redacted]

From [redacted]
Sent: Friday, July 22, 2011 1:57 PM
To [redacted]

Subject: Re: HP from endurance run for diagnosis

Hello [redacted]

Here are the questions from [redacted]

Best regards.
[redacted]

EA11003EN-01122[5]

Volkswagen AG

Non-responsive content removed

Tel. Non-responsive content removed

Mobile Non-responsive content removed

From: Non-responsive content removed**Sent:** Thursday, July 21, 2011 4:53 PM**To:** Non-responsive content removed**Subject:** ANS: HP from endurance run for diagnosis

Hi all,

If I see it correctly, the lower two are the failures? Please provide answers to my questions as best you can, thanks.

It would be very helpful in the diagnosis. Thank you.

Mit freundlichen Grüßen / Best regards

Non-responsive content removed

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

Tel. Non-responsive content removed

Fax

Non-responsive content removed

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-Henning Scheider, Peter Tyroller

Description:

cid:b28ce4b8-b627-448e-aecd-19b7a229ed22

**From:** Non-responsive content removed**Sent:** Thursday, July 21, 2011 3:16 PM**To:** Non-responsive content removed**Cc:** Non-responsive content removed**Subject:** HP from endurance run for diagnosis

Hello

I received the three high-pressure fuel pumps. They will be sent with an application vehicle tomorrow towards

We've received the following information on the HP:

- 1.) 03L 130 755 A no info on the HP ;-(
08 081210
BPT 0451
- 2.) 03L 130 755 AB from VN 817 1 0360 with 89,297km
02 211010
BPT 0249
- 2.) 03L 130 755 AB from VN 831 9 0143 with 143,821km (EVT)
08 100810
BPT 0022


Can you please let us know the missing information about HP number 1?

please enter the HPs in the diagnosis list. The HPs are in a Passat (NMS) that will be sent from to tomorrow.

Please take the parts from the trunk on Monday and give them to

Thanks for your efforts!

EA11003EN-01122[6]

Regards, 

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

Non-responsive content re
Mobile moved

Non-responsive content removed

Domicile: Stuttgart, Court of Registry: Local District Court Stuttgart, Commercial Register No. 14000;
Chairman of the Supervisory Board: Hermann Scholl; Management: Franz Fehrenbach, Siegfried Dais;
Stefan Asenkerschbaumer, Bernd Bohr, Rudolf Colm, Volkmar Denner, Wolfgang Malchow, Peter Marks, Uwe Raschke, Wolf-
Henning Scheider, Peter Tyroller

< OLE object: Picture (Enhanced Metafile) >>

Non-responsive content removed

Non-responsive content removed



Non-responsive content removed

Non-responsive content removed

CP4.1 - Complaint [redacted] as of 10/20/06

Status of pumps

- Conspicuous due to engine noise after 2-30 minutes at [redacted]
 - No. 1: 1508060018 drivetrain parts received at RB
 - No. 2: 1508060017 received at RB
 - No. 3: 689 4067 pictures received at RB
 - No. 4 6894255 received at RB (10/20/06)

In all probability, subsequent defect due to heavy particle contamination from no. 3
- Failure of drivetrain through standing roller (no. 1-4), tappet assembly also turned 90° in no. 2 and 3
- In addition, 2 further OK pumps (each 5h LT-TR) received for assessment (10/20/06), diagnosis underway
- Previously delivered (same batches) for order 2_ 36 pcs. AHM,
- 100 pcs. VW [redacted]

CP4.1 - Complaint [redacted] as of 10/20/06

Measures implemented to date

- Research pump history, outbound delivery status OK
- Result of comparison in insertion procedure [redacted]
 - [redacted] hot test:
 - 20s LP venting, n= 0, ca. 4 bar _ rel
 - 10s pulling, n= 1000 rpm, PRail = 0 bar
 - Actual situation (measured) 3s - 5 0s
 - Engine start with C U
 - LT-TR [redacted]
 - 30s LP venting, n= 0, ca. 4 bar _ rel
 - 30s pulling, n= 4 5 0 rpm, PRail = 0 bar
 - Engine start with C U
 - [redacted]
 - 20s LP venting, n= 0
 - 10s pulling, n= 1000 rpm, PRail = 0 bar
 - Engine start with C U
 - Commissioning rule Bosch:
 - 10s-20s LP venting
 - 5s - max. 10s pulling, min. 300 - max. 1000 rpm
 - Normal operation with CU (i.e., rail pressure far >0)

* ... verbal statement, not confirmed yet

[redacted] | 10/25/2006 | All rights reserved by Robert Bosch GmbH, also with regards to industrial property rights.

All usage rights, including copying and distribution, reserved.

[redacted] 25.10.2006 | © Alle Rechte bei Robert Bosch GmbH, auch für den Fall von Schutzrechtsanmeldungen. Jede Verfügungsbefugnis, wie Kopier- und Weitergaberecht, bei uns.

CP4.1 - Complaint Non-responsive content removed as of 10/20/06

Research of pump history

	Pump 1	Pump 2	Pump 3	Pump 4
Audi identifier				
Pump identifier	150806 0018	150806 0017	689 4067	689 4255
Assembly	8/16/06 06:33 am	8/16/06 06:33 am	9/20/06 9:40 am	10/04/06 8:48 am
Inspection series	8/16/06 12:55 pm	8/16/06 12:51 pm	9/21/06 8:52 am	10/04/06 10:24 am
Inspection COS	8/18/06 4:46 am	8/19/06 1:25 am	9/22/06 10:22 pm	10/06/06 3:10 am
Delivery	8/18/06	8/23/06	9/29/06	10/06/06
Failure at customer	WK 38	WK 39	WK 41	WK 41
Backflow temperature (COS)	normal	normal	normal	normal
Friction coefficient RS/LR	OK	OK	OK	OK
Right angle of tappet assembly	OK	OK	OK	OK
Customer error symptoms	Noise	Noise	Noise	Noise
Runtime at failure in min.	2	2	3	30
Failure location	<small>Non-responsive content removed</small>	<small>Non-responsive content removed</small>	<small>Non-responsive content removed</small>	<small>Non-responsive content removed</small>
Ser. no. engine	1	2	3	3
				Consequential damage (confirmed by customer), contaminated system through failure of pump 3 on same engine

Confidential level 2

CP4.1 - Complaint Non-responsive content removed as of 10/20/06**“Sluggish roller” test program****Results so far**

Test: Impression from hard test on roller with 2 series test cycles

- Result: Sluggish roller could not be reproduced

Test: Impression from hard test on camshaft with 18h ER

- Result: Sluggish roller could not be reproduced

Strong influence from particles confirmed (see failed pump no. 4)

Open tests

- Influence of rail pressure and low pump pressure on roller support (analytical) | 10/27/06
- Further examinations to optimize venting procedure | 10/27/06
- Roller support with C layer gaps in running surface | M 11/06
- Roller with contact surface | E 11/06

Confidential level 2

CP4.1 - Complaint [redacted] as of 10/20/06

Summary

- Delivery status of complaint pumps is OK
- Failure of pump 1-3 during commissioning
 - Deviation in commissioning procedure: [redacted] differs from [redacted] and Bosch rule
 - Failure hypothesis: Pulling duration without rail pressure too long (low speed more critical than high speed)
 - Consequence: Start of roller not ensured if speed is too low, excessively long pull duration results in roller damage
- Failure of pump 4 after 30 min (LT-TR)
 - Subsequent failure due to particle contamination (confirmed by Audi-[redacted]) in system due to failure of pump no. 3

CP4.1 - Complaint [redacted] as of 10/20/06

Further steps

- Completion of pump history 10/20/06 done
- Query of run-in program in [redacted] 10/18/06 done
Verbal statement received, written confirmation still pending
- Inspection of run-in program / handling / evolution after order 1 at AHM by Bosch employees on site from ~~10/17/06~~ done 1.
- Compare with [redacted] 10/24/06
- Test program to reproduce failure symptoms on test rig See slide 4
- Analysis of remaining 2 OK pumps 10/27/06
- Commissioning at Audi [redacted] according to Bosch rules [redacted] asap

Proposal:

- Measure run-in procedure in [redacted] WK 45

Diesel Systems

**BOSCH**

From

Processor

Tel

Fax

Non-responsive content removed

Non-responsive content removed

Non-responsive content removed

7/29/2008

No. [REDACTED] 887-014/01

Log

Recipients: see e-mail

For info: see e-mail

Host: [REDACTED]

Participants **AUDI:** Non-responsive content removed

Non-responsive content removed

BOSCH: Non-responsive content removed

Head Non-responsive content removed

Minutes

Organiz.

Date/Location **7/2/2008, 3:00 – 5:00 pm**Topic **CP4 pump technical meeting****1.) 2. Failure USA ER (attachments 1, 2)**

- Failure after 60tkm, damage symptoms analog 1. Failure (capital drivetrain damage, both tappets seized in TDC), Failure hypothesis: sluggish roller (cause unclear).
- Fuel from failed pump was analyzed internally at Audi, result did not show any striking features.
- No lateral roller start-up.
- Seized tappet in TDC has not occurred yet in this defect pattern. Analysis is being carried out, interim status to Audi on both failures.
- Both failed pumps are from the same production period (2 of 7). Bosch recommends replacing and analyzing the pumps to gain further insights. We have agreed to leave the pumps in the vehicles, to avoid losing the mileage for the overall project.
- 1st failure: EFP connector with problem (would result in emergency mode when the fault occurs).
- The 8 pumps delivered as replacements have been installed in 5 0-series vehicles, the pumps will be installed as follows:
 - 1 x engine damage, 2 x replacement failure
 - 1 pump from engine damage to RB.
- Compile history of failure vehicles and check shipping/transport for series. Obtain filters from failure vehicles.
- List of drivetrain damage internal and at customers since start of series, as well as C and D samples.
- AUDI suggests further trials and considerations with regard to water.

Non-responsive content removed

done

ASAP

7/16/2008

Non-responsive content removed

7/16/2008

Non-responsive content removed

7/15/2008



From

[Redacted]

Processor

Non-responsive content removed

Tel

Non-responsive content removed

Fax

Non-responsive content removed

7/29/2008

No. [Redacted] 887-014/01

Log

CP4 pump technical meeting

2.) Failure W24 system endurance run (attachments 3..5)

- 1 failure in system ER after 422h with drivetrain damage, failure hypothesis also sluggish roller.
- No lateral start-up
- DM: 882
- Test rig and external conditions of failure are currently being checked.
- Mechanical anti-turning lock is not being pursued further by Bosch because sluggishness of roller is the original problem.

Non-responsive content removed

7/16/2008

3.) Housing - change of external contour (attachments 6, 7)

- Model for installation examination was provided, installation test was positive.
- AUDI approved the change. Submit change notification for official signature.

Non-responsive content removed

done

4.) Return pressure with Bruss shaft seal (attachment 8)

- Approval of 2.2 bar absolute for 300h made based on executed system ER. The TCDs will be revised accordingly.
- Further qualification for higher pressures and time slices will only be made for future new developments.
- Q5 is over 2.2 bar, however. Clarify implementation dates for vehicle-side measures (TEE, T piece diameter)
- Cold package (Bruss shaft seal, 2 MU O-rings) for EU5 pump (.611) will be presented to internal Audi approval committee and then introduced.
- C layer thicker for USA launch
- Q5: Increase of T piece diameter will be implemented

Non-responsive content removed

8/1/2008

Non-responsive content removed

Non-responsive content removed

done

5.) Turn PIN Clean diesel (attachments 9, 10)

- Check if there is a clear connection between second supplier and turning of PIN.
- Revised offer submitted to Audi, conclusion pending.
- Determine ISIR date and clarify whether the 16 weeks for the introduction can be shortened

Non-responsive content removed

done

Non-responsive content removed

done

Non-responsive content removed

8/15/2008

6.) Change packages

- Clarify when D samples will be available for W24 and which sample versions will be used for the pre-series.

Non-responsive content removed

Non-responsive content removed

done



Fig. 1 071130-0633_Roller_L_01



Fig. 2 071130-0633_Roller_L_05



Fig. 3 071130-0633_TapBod_L_inside_02



Fig. 4 071130-0633_Roller_R_01



Fig. 5 071130-0633_Roller_R_05



Fig. 6 071130-0633_TapBod_R_inside_02

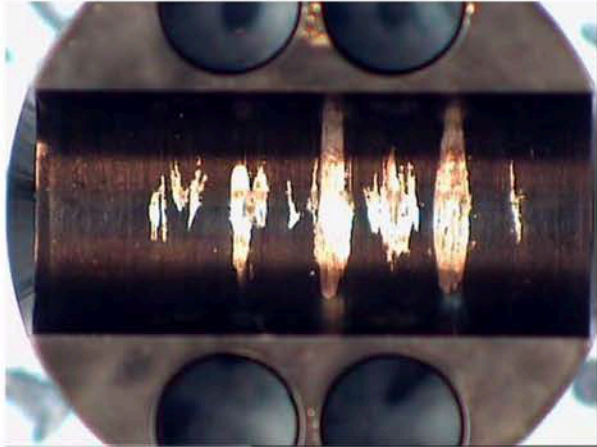


Fig. 7 071130-0633_RS_L_Running surface

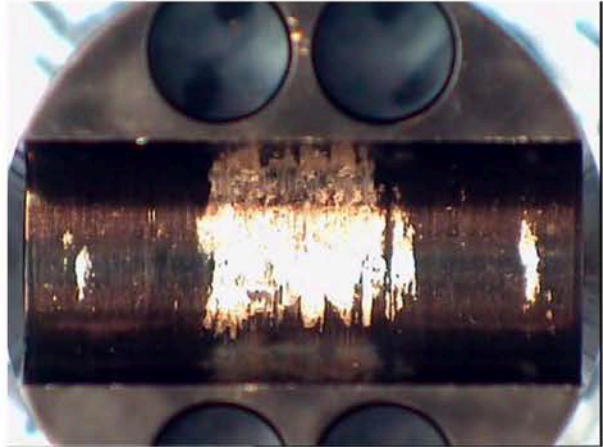


Fig. 8 071130-0633_RS_R_Running surface

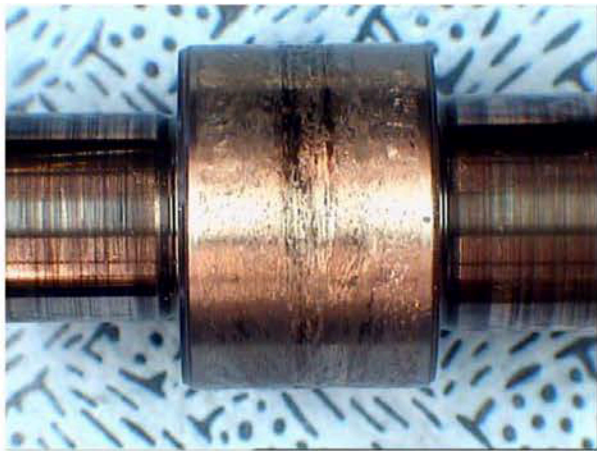


Fig. 9 071130-0633_CS_Running surface_TDC

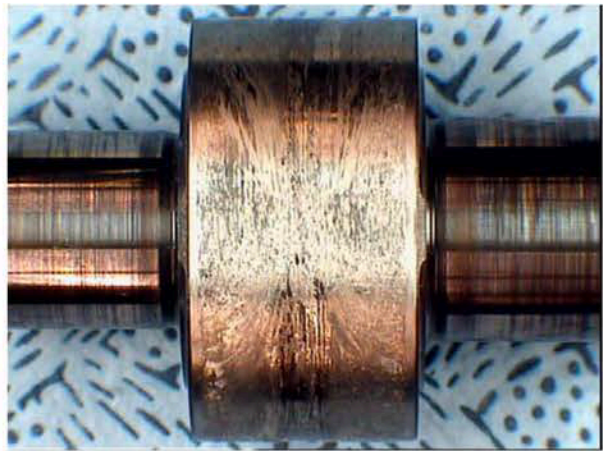


Fig. 10 071130-0633_CS_Running surface_BDC_180°



Fig. 1 882-4934_Roller_L_01

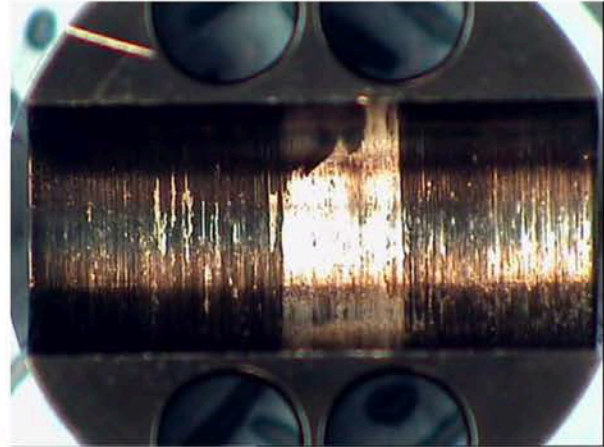


Fig. 2 882-4934_RS_L_Running surface

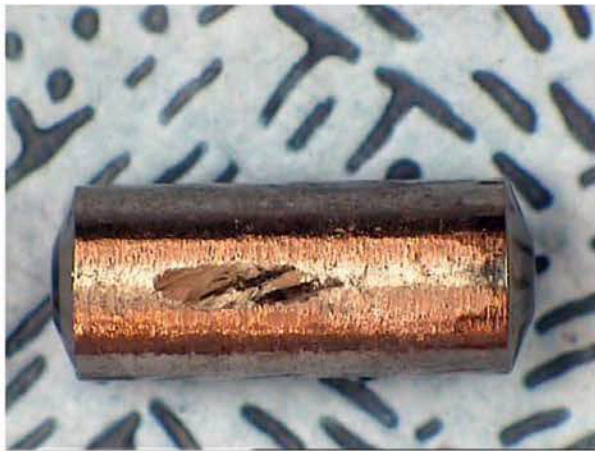


Fig. 3 882-4934_Roller_R_01

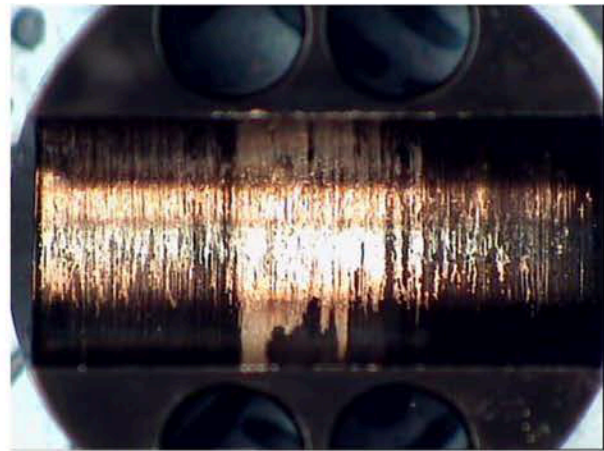


Fig. 4 882-4934_RS_R_Running surface

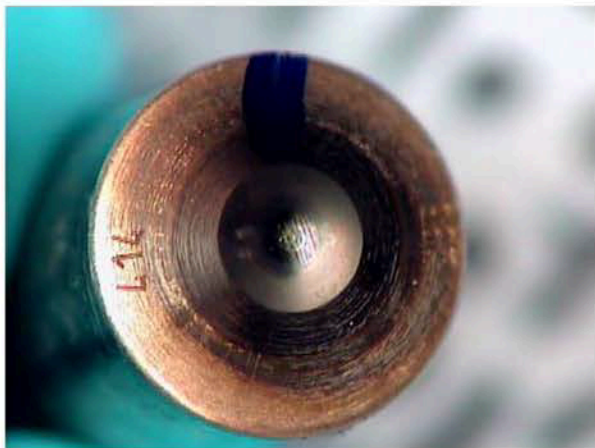


Fig. 5 882-4934_Roller_L_flg



Fig. 6 882-4934_Roller_L_hous

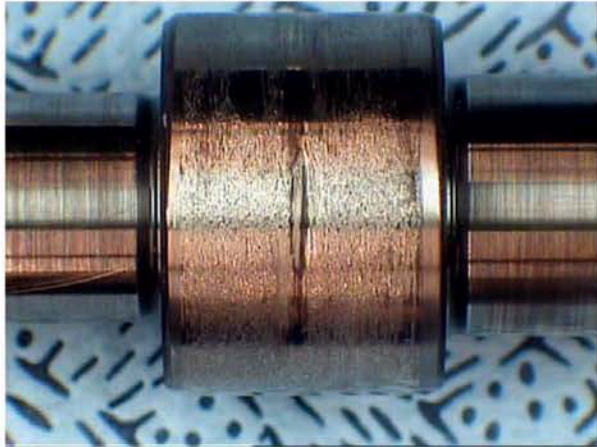


Fig. 7 882-4934_CamShaft_Running surface_TDC

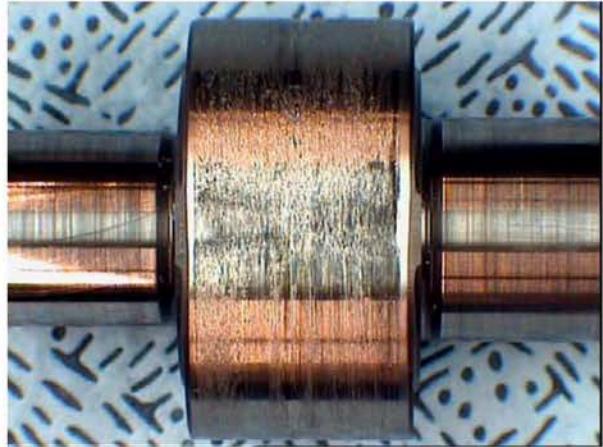


Fig. 8 882-4934_CamShaft_Running surface_BDC



Fig. 9 882-4934_TapBod_L_inside_flg



Fig. 10 882-4934_TapBod_L_inside_hous



Fig. 11 882-4934_Roller_R_hous

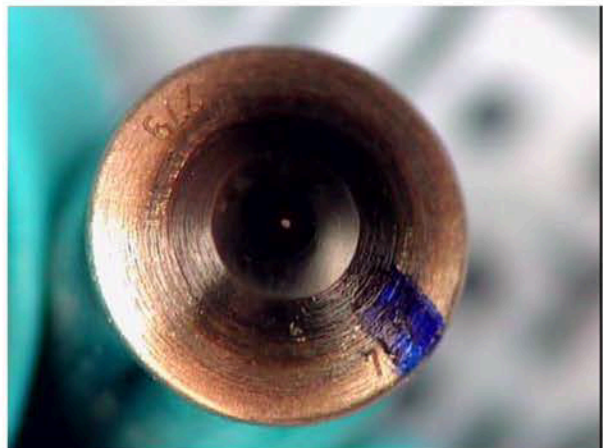


Fig. 12 882-4934_Roller_R_flg

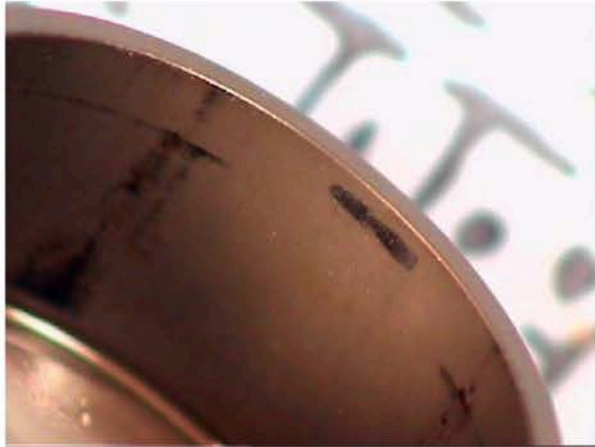


Fig. 13 882-4934_TapBod_R_inside_hous



Fig. 14 882-4934_TapBod_R_inside_flg

Non-responsive content removed

CP4 Audi TM 07/02/2008: New housing blank

Topic

New housing blank for CP4.2 with gear pump

Motivation

Standardize customer & gear pump versions (GP38 & GP40)

- No change of supplier
- No change of material
- No tests needed

Proposal & further work

Create model for installation examinations,
Installation examinations,

Customer approval for use in W24 & W26

done
done, positive
7/2/2008

Note: The new blank will enable future use of GP40, GP38 will not be developed further or pursued.

Attachment
6
for [REDACTED] 887-014

Diesel Systems

1

Confidential [REDACTED] 07/02/2008 [REDACTED] © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, or otherwise for the registration of special industrial property rights.

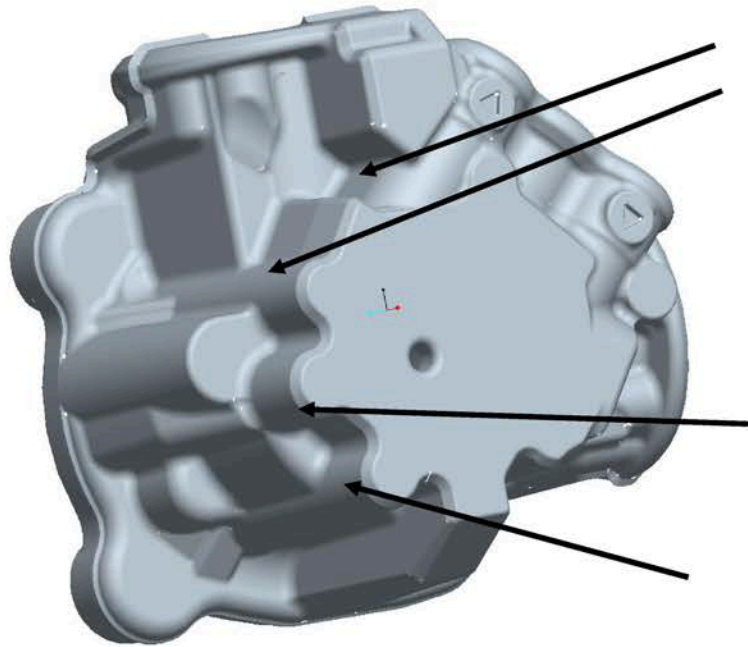


BOSCH

CP4 Audi TM 07/02/2008: New housing blank

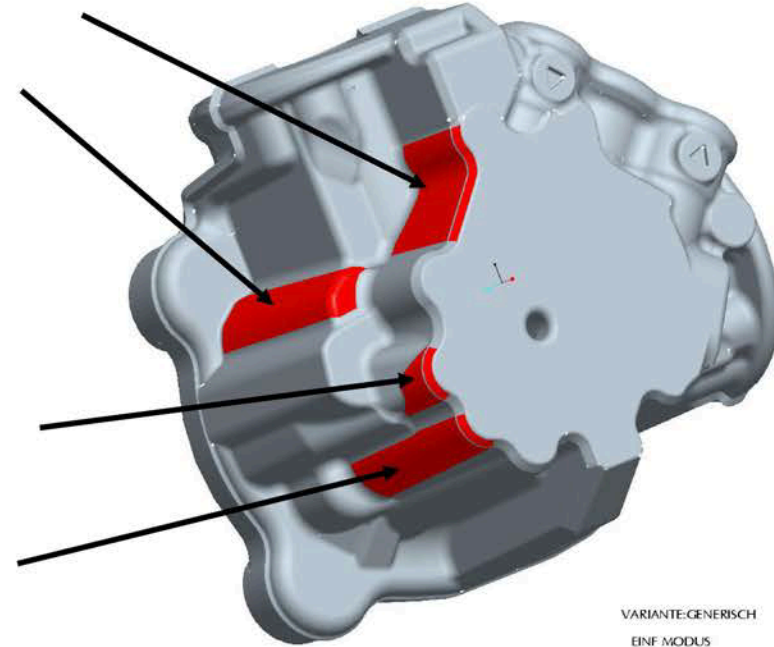
Source: [REDACTED]

Additional material thickening for cast blank CP4.2 GP



VARIANTE:GENERISCH-

Blank 1 465 C04 014



VARIANTE:GENERISCH
EINF. MODUS

Blank 1 465 C04 014 Attachment 7
for [REDACTED] 887-014



CP4 Audi TM 07/02/2008: Increased return pressure

Topic

The permissible return pressure (2.05 bar_abs) is exceeded in W19 BIN5/EU6 by 2.8 % (from load collective measurement; 168h@6000h car service life), target: release 300h@p_return 2.2 bar_abs

Procedure (increase return pressure at end of 2000h system PER)

2 EU6 system ER & 2 BIN5 system ER after 1700h increased to p_return=2.2 bar

2 BIN5 system ER after 1700h increased to p_return=2.2 bar

Pumps must be diagnosed OK with regard to function & leakage (shaft seal) after ER

Results

Non-leakage in function & cold test & wear on shaft seal

OK

Further work

Based on positive diagnosis, 2.2 bar return pressure is approved for a duration of 300h for pump 0 445 020 613 / 059 130 755 AG.

Update & distribution TCD

07/11/2008 / Non-responsive content removed

Note

Pump 0 445 020 611 / 059 130 755 AB also approved for 300h@2.2 bar_abs when switch from KaCo to Bruss shaft seal takes place.

Any additional increase (pressure, time slice) will require successful validation in a future EE project.

Diesel Systems

1

Confidential Non-responsive content removed 7/2/2008 | Non-responsive content removed © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

Attachment
8
for Non-responsive content removed 887-014

CP4 Audi TM 07/02/2008: PIN turned

PIN turned by 81.82° clockwise relative to cam TDC

Motivation

Pump bearing load in CP4.2H after ...613 (W19 BIN5/EU6) with W24 tension roller OK – chain force **not OK** -> turned installation will make chain force OK
(other benefits: simple assembly & identical parts in toothed belt drive)

Status

PIN bore in soft part @ second supplier*

Heat treating, ball peening, hard processing @ Non-responsive content removed

After (approval of) elimination of ball peening, complete camshaft will be obtained from second supplier**

Quotation drawing was sent to customer.

Further work

Customer order

asap

CO

after customer order/in process

* Due to clamping device, soft part cannot be obtained from first supplier.

** 67 pumps (0 445 020 620 / 057 130 755 T) from the second supplier were sent to Audi with complete camshaft processing for testing.

Attachment
9
for XXXXXXXXXX 887-014

Diesel Systems

1

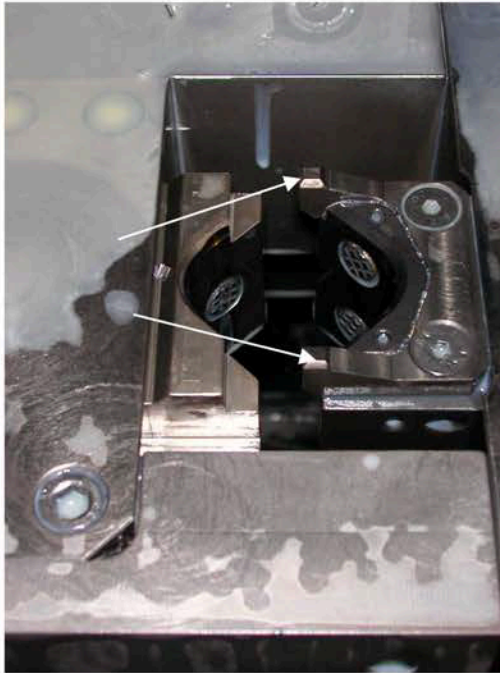
Confidential XXXXXXXXXX | 7/2/2008 | XXXXXXXXXX | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

CP4 Audi TM 07/02/2008: PIN turned

PIN turned by 81.82° clockwise relative to cam TDC



If the turned cam were ground, the contact point would be ground away.

Anlage
10
zu [redacted] 887-014

Audi - CP4 drivetrain damage

US verification with CP4.2 according to 0 445 010 0613/ 059 130 755 AG for V6 BIN5

3 failures in **Q verification** (no failures in test vehicles, page 9)

- 1 x Q7 (40,000km; DM 071130; SN 626)
- 1 x Q7 (62,300km; DM 071130; SN 633)
- 1 x Touareg (2,723km; DM 080122; SN 900)

Analysis

- Cause can no longer be determined due to damage progress on the component
- Both Q7 had tension pulley 059 109 243 P (W19) instead of 0 57 109 243 M (W24)

Preventive replacement performed on 6 vehicles with low mileage.

Analysis

- 1 pump with items of note
 - 1x Q7 (9,845km; DM080122; SN901) with small braking flats on roller & Zigzag trail on camshaft (pages 10,11,12)

Hypothesis (2 x US Q7)

Strong rotary drive oscillations lead to unnaturally intensive slipping between the roller & cam and create braking flats.

Diesel Systems

1

Confidential Non-responsive content removed 8/27/2008 | Non-responsive content removed © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

Audi - CP4 drivetrain damage

Field failures with CP4.x (list from [Non-responsive content removed] excerpt on Page 13)

58 [Non-responsive content removed] Audi/VW field failures (delivery quantity Audi 125,520, without VW)

CP4.2 field failures after 0 445 010 611 / 059 130 755 AB in V6 EU5

34 field failures in [Non-responsive content removed] quantity delivered: 1,885)

- 21 CP4.2 failures in [Non-responsive content removed] Delivery quantity 623
 - 18xAudi, 3xVW Delivery quantity Audi 430 / VW 193
- 13 CP4.2 failures in [Non-responsive content removed] Delivery quantity 1,262
 - 9xAudi, 4xVW Delivery quantity Audi 478 / VW 784

Evaluation

- Failure rate B8 (CP4.1) vs. Q7 (CP4.2) in [Non-responsive content removed] similar
- Failure rate B8 (CP4.2) & Q7 (CP4.2) in [Non-responsive content removed] significantly higher than [Non-responsive content removed]



Audi - CP4 drivetrain damage

Immediate activities

Water in fuel

Unlikely; analysis did not discover any corrosion of pump parts

- Sample test with sloshing water

Done; Non-responsive content removed

Result: Slight start-up tracks in housing (film)

Air in fuel

Vehicle measurements (Leasing Q7) showed indications of air in pump inlet.

- Sample test with high air content

Done; Non-responsive content removed

Result: nothing of note (film)

Further investigations with Audi series EFP & filter planned
(Can Q7 inline EFP draw air through the filter? – how much?)

WK35; Non-responsive content removed

Non-responsive content removed

-> Fuel peculiarities (steroyl glucosides)

Unlikely, because [redacted] does not use biodiesel

Procurement (steroyl glucosides) for basic investigations

Ongoing; Non-responsive content removed

endurance run with fuel incl sg. (100h PER; 3 day standstill; 10 h PER)

Prio C

Start KT analysis

Why is failure rate in Non-responsive content removed much higher than Non-responsive content removed

Ongoing; Non-responsive content removed



Audi - CP4 drivetrain damage

Ongoing & planned activities

- Organization & analysis of fuel in radius of failed pumps ongoing; RB
- Diagnosis of zigzag error symptoms ongoing; RB
- Pump torque measurements on W19 EU5 & W19 BIN5 with max./ min. tension pulley tension WK39
- Pump test rig test with little belt tension
- Air test with glass pump
- Robustness test with min. inlet pressure (OV closed)
- Further water reproduction tests
- Test with Non-responsive content removed fuel with sg
- Investigations with customer EFP & filter (air, pressure loss,...)
- Investigation of deposits on failed pumps

Helpful examinations in case of drivetrain damage

- Determine belt tension strength Audi
- Determine fuel inlet pressure Audi
- Analyze fuel sample, filter, EFP Audi
- RS friction coefficient examinations with fuel from failed pumps RB

Diesel Systems

4

Confidential Non-responsive content removed 8/27/2008 | Non-responsive content removed | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

Audi - CP4 drivetrain damage

Question catalog (KT analysis)

- When were vehicles produced (information on commissioning)
- Do the failures involve rental cars?
- Where are the vehicles registered (map) ?
- How are the vehicles transported to [redacted]
- What is the failure situation & delivery quantities at VW [redacted]
- How high is the EFP failure situation?
- How many pumps were settled in which markets?
- Where does the winter testing take place [redacted]
- What is the status of the EFP from B8 (8-D) ?

[redacted]
[redacted]
(done)
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]
[redacted]



Audi - CP4 drivetrain damage

Backup

Diesel Systems

6

Confidential [REDACTED] 8/27/2008 | [REDACTED] | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

Audi - CP4 drivetrain damage

Field failures with CP4 drivetrain damage - List from Non-responsive content removed

Model	Engine	Market	Failure	Delivery quantity Vehicles	Failure quota per million	Factor above average compared to worldwide	Factor above average compared to [REDACTED]	
Audi Q7	3.0l	Non-responsive content removed	18	19,344	0.9	---		
			1	5,685	0.2			
			5	187	26.7	29	152	
			5	317	15.8	17	90	
Audi A4/A5	2.0l	Non-responsive content removed	7	87660	0.1			
			5	24813	0.2			
			1	1724	0.6	7	3	
			1	1,225	0.8	10	4	
			2.7l	23	18,516	1.2		
				5	5,899	0.8		
13	243	53.5		43	63			
VW Touareg	3.0l	Non-responsive content removed	4	161	24.8	20	29	
			?	?				
			?	?				
			3	193	15.5			
			4	789	5.1			
Grand total			63					
Field total			58					

VW Touareg not as critical as Q7 (vehicle SOP) ?

Situation VW Non-responsive content removed



Audi - CP4 drivetrain damage

Overview of tension pulleys

W19 V6 TDI EU5: Tension pulley 059 109 243 P (280 N +/- 15%)

W19 V6 TDI BIN5/EU6: Tension pulley 057 109 243 M (340N +/- 15%)

W24 V8 TDI EU5: Tension pulley 057 109 243 M (340N +/- 15%)



Audi - CP4 drivetrain damage

Trial experience (ER findings; not relevant for approval)

6 x 500h with BDF 650µm	positive*
*(1 failure after 490h due to piston seizure; cause: lack of C coating on piston)	
2 x 100h with BDF650µm	positive
1 x 750h@2050 bar with kerosene (jet A1 kerosene F35)	positive
1 x 500h@2050 bar with kerosene (jet A1 kerosene F35)	positive
3 x WCF (water contaminated fuel) without AWP	-> HP piston seizure
2 x WCF (water contaminated fuel) with CP4 with AWP	-> Drivetrain damage*

*after pump breakdown not in actual ER. Parts are highly corroded.

Note: WCF results are not applicable to the series (1% water content)



CP4 Audi technical meeting 08/27/2008: GP cap wear

Subject: GP cap wear

Cap wear of up to 15 μm was measured on CP4.2 gear pumps during W26 engine endurance runs. (See overview on Page 3)

The anodized cap layer has a thickness of (16 +/- 8) μm .

Information

- The engine endurance runs were sometimes run **above** the allowed inlet pressure (1.8 bar_abs): (~ 2.0 bar_abs)
- In vehicles, inlet pressures were sometimes measured **above** the allowed inlet pressure (~ 1.9 bar_abs)
- Pumps from W26 vehicles are not available
- Pumps from W24 vehicles are not available

For **risk assessment**, a 250h constant ER, BDF570, inlet pressure 1.8 bar_abs, interim check after 76h (08/25/2008), with a GP that had already run at Audi (from engine ER no. W26 134/1, SN. 4612 with 15 μm cap wear), to assess the response of the GP once the anodized layer was consumed.

Note: Max. cap wear < 8 μm @ during internal RB / customer test



CP4 Audi technical meeting 08/27/2008: GP cap wear

Measures being tested @ Bosch

- Increase anodized layer thickness Done, [redacted]
Statement: not effective, because thicker layer results in rougher surface & therefore to greater initial wear
- Assessment of effectiveness of smaller GP balance choke (if Audi agrees to increase in min. inlet pressure) [redacted]
- Assessment (dates, costs) Ni cap vs. CP40 09/24/2008, [redacted]
- Investigation with cap made of housing material (simulation CP40)

For **potential estimation**, a 250h constant ER was started with BDF570, inlet pressure 1.8 bar_abs, interim check after 76h (08/25/2008) with **nickel cap**.

Measures @ Audi

- Invitation to meeting on reduction of inlet pressure @ W26 Done, [redacted]
- On-board voltage window at min./max. consumer 08/18/2008, [redacted]
- Vehicle low-pressure measurements on [redacted] ER 09/23/2008, [redacted]
Objective: Correlate cap wear to max. inlet pressure
- Check positioning of inlet/return connectors 09/23/2008 [redacted]
- Check change of diameter on JSP 09/23/2008, [redacted]

Diesel Systems



CP4 Audi technical meeting 08/27/2008: GP cap wear

Further work at RB

- Correlation of anodized layer thickness vs. roughness done
- Compare W26 vs. W24 (no parts available yet)
- Compare low-pressure measurements W26 vs. W24

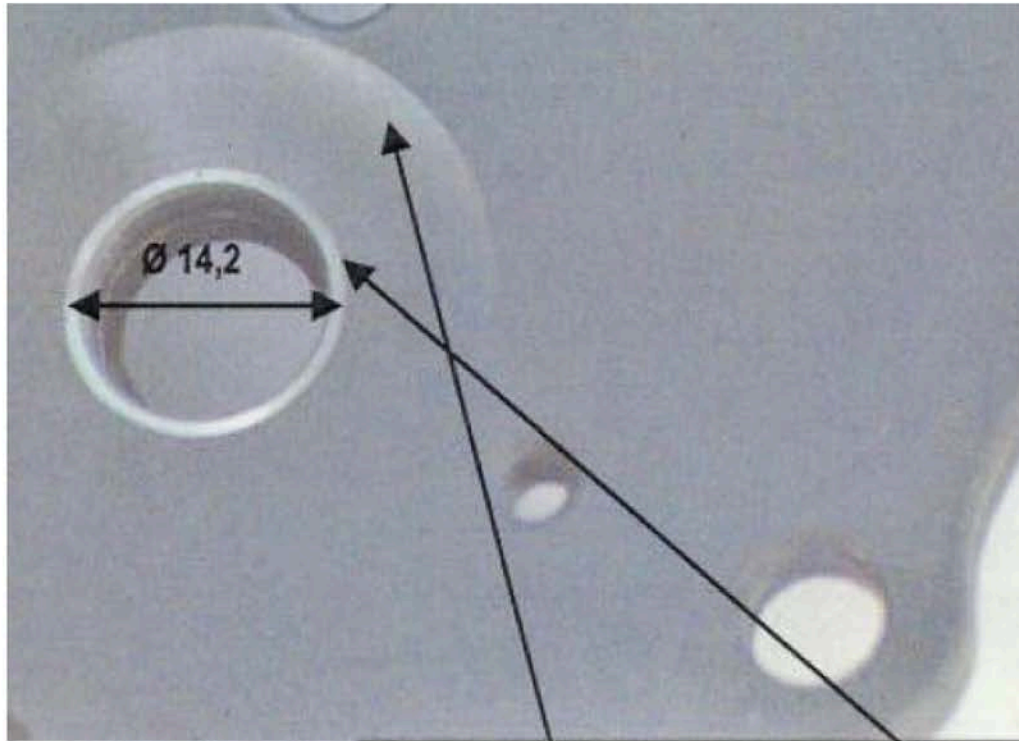
Audi confirmation

- Check inlet pressure engine ER done
- Assign pump / cylinder bank (left, right) done
- Results of low-pressure measurements in W26 vehicles



CP4 Audi technical meeting 08/27/2008: GP cap wear

Cap wear



cover wear at prim. gear 14 μm , wear at coupling 55 μm

Diesel Systems

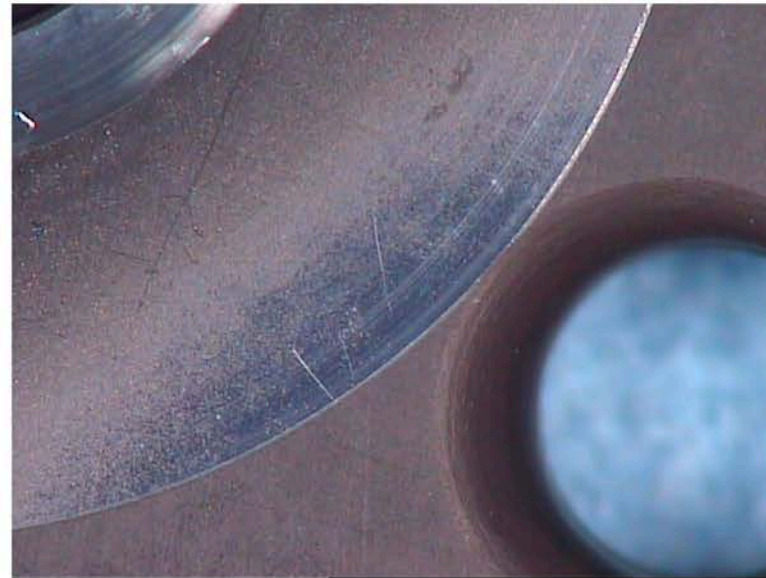
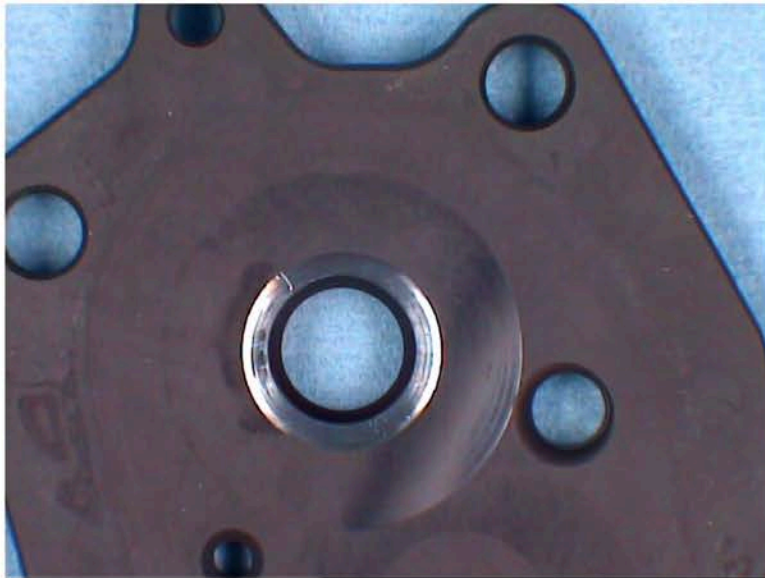


BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Result after 76h constant endurance running (continued run @ R.B. after engine ER)

Anodized cap



Diesel Systems

5

Confidential | [REDACTED] | 8/26/2008 | [REDACTED] © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.

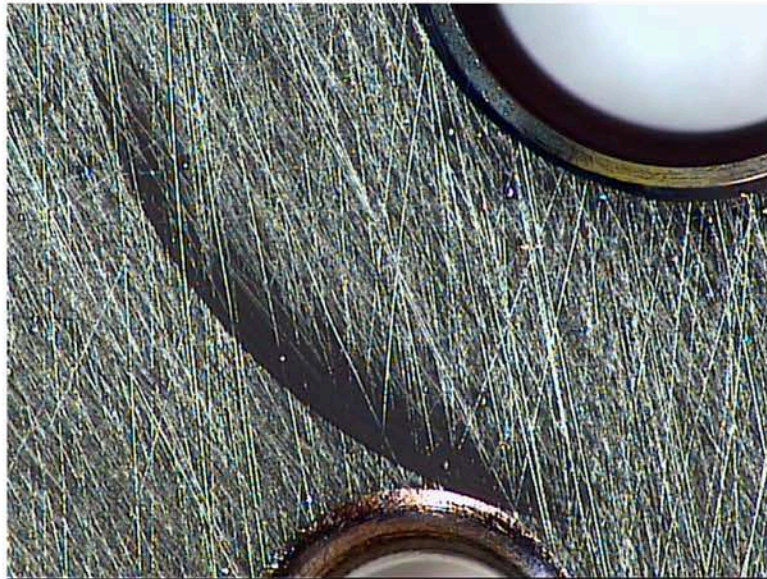


BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Result after 76h constant endurance running (new part)

Nickel cap



Diesel Systems

6

Confidential | [REDACTED] 8/26/2008 | [REDACTED] | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Overview from customer test

Befundung CP4.2 W26										Stand: 27.08.08		ZP: Retam									
Rel. Nr.	Teile Nr.	Exemplar Nr.	FD	Motor Nr.	DL Art	Ablieferung zur Befundung	Bericht CP4.2 SAMOS Nr.	Bericht ZME	Bericht ZP	Bericht durch EDI erstellt am	Ewoks Anfrage vorhanden ? ja / nein	DL Zeit [h]	Ewoks Anfrage genehmigt ? Ja / nein	ZP Kupplungsanlauf Durchmesser [mm] wear at coupling	ZP Kupplungsanlauf Tiefe [mm] wear at coupling	ZP... Eingrabung ZP am Deckel [mm]	ZP nach +76h	Elozschicht am Deckel [µm] (Mittelwert, > 10 µm)	Rz Deckel ohne Verschleiß		
1	05A 130 755 A 0 445 620 200-05	4922	787 (Jul 07)	W26 122	Applikation	KW 1008	2008-CP4_0322 0593765/1	ZVM 615	MAP DS-182311 B2597		nein	917	ja	14,1	54	7		12,5	5,9		
2	05A 130 755 A 0 445 620 200-05	4936	787 (Jul 07)	W26 122	Applikation	KW 1008	2008-CP4_0324 0593765/02	ZVM 616	MAP DS-182312 B2598	22.07.2008	nein (nur erstes Blatt)	917	ja	13,4	25	7		11,5	6,4		
3	05A 130 755 0 445 620 165-02	BPT 4614	781 (Jan 07)	W26 022	Fkt. Mechanik	KW 1708	2008-CP4_0359 0599050	sw im anhalten	enthält	01.07.2008	nein (nur erstes Blatt)	211	ja								
4	05A 130 755 0 445 620 165-02	BPT 4618	781 (Jan 07)	W26 022	Fkt. Mechanik	KW 1708	2008-CP4_0360 0599051	sw im anhalten	enthält	03.07.2008	nein (nur erstes Blatt)	211	ja								
5	05A 130 755 0 445 620 165-02	BPT 4920	782 (Feb 07)	W26 033	Diesels	KW 1708	2008-CP4_0365 0599052	sw im anhalten	enthält	02.07.2008	nein (nur erstes Blatt)	540	ja								
6	05A 130 755 0 445 620 165-02	BPT 4921	782 (Feb 07)	W26 033	Diesels	KW 1708	2008-CP4_0366 0599045	sw im anhalten	enthält	02.07.2008	nein (nur erstes Blatt)	540	ja								
7	05A 130 755 A 0 445 620 200-01	BPT 4463	785 (Ma 07)	W26 056	IR-DL VQ-Fzg. V7	KW 1709	2008-CP4_0363 0599046	sw im anhalten	MAP DS-184341 B2601	01.07.2008	ja	8000km	ja	13,3	37	5		12,5	7,4		
8	05A 130 755 A 0 445 620 200-01	BPT 4484	785 (Ma 07)	W26 056	IR-DL VQ-Fzg. V7	KW 1709	2008-CP4_0364 0599061	sw im anhalten	MAP DS-184357 B2602	01.07.2008	ja	8000km	ja	15,4	120	5		13	7,9		
9	05A 130 755 B 0 445 620 200-07	4611	789 (Sep 07)	W26 134/1	PZD/Raf-Test	KW 1709	2008-CP4_0361 0599052	sw im anhalten	MAP DS-184351 B2599	02.07.2008	ja		ja	13,4	18	5		10,5	5,6		
10	05A 130 755 B 0 445 620 200-07	4612	789 (Sep 07)	W26 134/1	PZD/Raf-Test	KW 1709	2008-CP4_0362 0599054	?	DS-184363 B2600	01.07.2008	ja		ja	14	76	15	17	ZP bei 518			
11	05A 130 755 A 0 445 620 200-05	BPT 4889	787 (Jul 07)	W26 125	Nardo/EWI (Pst.)	KW 1808	2008-CP4_0416 700794.001	ZVM 619 (im Bericht 416)	DS-186625 B2603	29.07.2008	ja	963	ja	13,6	40	10		13	5,9		
12	05A 130 755 A 0 445 620 200-05	BPT 4909	787 (Jul 07)	W26 125	Nardo/EWI (Pst.)	KW 1808	2008-CP4_0417 700794.002	ZVM 620 (im Bericht 417)	DS-186626 B2604	29.07.2008	ja	963	ja	14,2	55	14		12	6,8		
13	05A 130 755 B 0 445 620 200-07	4496	789 (Sep 07)	W26 129	Raf-Test	KW 1808	2008-CP4_0418 700795.001	?	DS-186620 B2605	30.07.2008	ja	265	ja	14	46	12		10,5	5,2		
14	05A 130 755 B 0 445 620 200-07	4577	789 (Sep 07)	W26 129	Raf-Test	KW 1808	2008-CP4_0419 700795.002	?	DS-186621 B2606	30.07.2008	ja	265	ja	14	44	10		10,5	6,3		
15	05A 130 755 B 0 445 620 200-07	4578	789 (Sep 07)	W26 130	Raf-Test	KW 1808	2008-CP4_0420 700791.001	?	DS-186623 B2607	31.07.2008	ja	265	ja	13,4	46	6		10	6,4		
16	05A 130 755 B 0 445 620 200-07	4594	789 (Sep 07)	W26 130	Raf-Test	KW 1808	2008-CP4_0421 700791.002	?	DS-186624 B2608	31.07.2008	ja	265	ja	13,4	30	10		10,5	6,3		
17	05A 130 755 B 0 445 620 200-07	BPT 4736	790 (Okt 07)	W26 155	Diesels	KW 2908	?	?			nein	552									
18	05A 130 755 B 0 445 620 200-07	BPT 4737	790 (Okt 07)	W26 155	Diesels	KW 2908	?	?			nein	552									
19	05A 130 755 B 0 445 620 200-07	BPT 4734	790 (Okt 07)	W26 157	Versottung	KW 2908	?	?			nein	553									
20	05A 130 755 B 0 445 620 200-07	BPT 4731	790 (Okt 07)	W26 157	Versottung	KW 2908	?	?			nein	553									
21	05A 130 755 B 0 445 620 200-07	BPT 4700	790 (Okt 07)	W26 161	Nardo/EWI	KW 2908	?	?			nein										
22	05A 130 755 B 0 445 620 200-07	4613	789 (Sep 07)	W26 161	Nardo/EWI	KW 2908	?	?			nein										
23	05A 130 755 B 0 445 010 619	BPT 0834	080118	W26 168	Raf-Test	KW 2908	?	?			nein										
24	05A 130 755 B 0 445 010 619	BPT 0831	080118	W26 168	Raf-Test	KW 2908	?	?			nein										
25	05A 130 755 B 0 445 620 200_07	BPT 4787	790 (Okt 07)	W26 164	PZD	KW 3008	?	?			nein										
26	05A 130 755 B 0 445 620 200_07	BPT 4786	790 (Okt 07)	W26 164	PZD	KW 3008	?	?			nein										

Diesel Systems



BOSCH

CP4 Audi technical meeting 08/27/2008: First filling

First system filling with fuel $\leq 400 \mu\text{m}$ (HFRR)

The CP4 pump TCD contains system TCD 0 440 D05 000 as an annex.

This system TCD highly recommends the first fueling with fuel $\leq 400 \mu\text{m}$ (HFRR) in accordance with DIN ISO 12156-1.

A first filling with EN590 fuel is allowed for the CP4 high-pressure fuel pump.

Recommendation:

The following recommendations apply to “critical” export markets:

- Fill the vehicle tank with more EN590, to shift the fuel mixture properties towards the EN590 values in case of accidental filling up with “poor” fuel by the consumer.
- Fill fuel without biodiesel content, to keep fuel aging as small as possible, for example, over long shipping distances.



From: Non-responsive content removed
To:
CC:

Date: 8/26/2008 5:21:19 PM
Subject: Opening pressure of overflow valve
Attachments: [20080826101344069.pdf](#)

Hello

There are various limits in the pump TCD

1) Inlet pressure 4.5 bar_abs

2) Differential pressure (dp) via pump > 3 bar

In an isolated examination of this limit, it is correct that the OV can be closed

3) Min. pump return volume (bearing + overflow valve volume 80 l/h @ 80°C)

This is only reached when the overflow valve is open!

(at max. bearing play, the bearings provide 67 l/h, which means the remaining 20 l/h come from the overflow valve)

In addition, the illustration indicates the min. inlet volume of > 187 l/h (at min. on-board voltage!).

Of course, we would prefer to have a higher inlet pressure or dp via the pump, but in a borderline system examination (minimum on-board voltage, average EFP vs. max. on-board voltage, max. EFP), it isn't that simple.

-> For example, the maximum counter-pressure of the EFP could be exceeded, which would cause the internal EFP pressure relief valve to open, & the pressure would then collapse.

I have agreed with [redacted] that [redacted] will explain this connection in the system at the next technical meeting at the latest.

Can you please check the EFP TCD:

Min. delivery volume @ min. voltage

Max. delivery volume @ max. voltage

EFP opening pressure

We could contrast this with our Bosch EFP.

We will measure the EFP to this extent.

Best regards / mit freundlichen Grüßen

[redacted]

Robert Bosch GmbH

Non-responsive content removed

www.bosch.com

Tel. [redacted]

PC-Fax [redacted]

[redacted]

Domicile: Stuttgart

Court of Registry: Local District Court Stuttgart Commercial Register No. 14000

Chairman of the Supervisory Board: Hermann Scholl;
Management: Franz Fehrenbach, Siegfried Dais;
Bernd Bohr, Rudolf Colm, Gerhard Kümmel, Wolfgang Malchow, Peter Marks;
Volkmar Denner, Uwe Raschke, Peter Tyroller

-----Original message-----

From: Non-responsive content removed
Sent: Tuesday, August 26, 2008 12:08 PM
To: Non-responsive content removed
Subject: Re: Your Scan

Hello Non-responsive content removed

- In the last minute, we had a question from Non-responsive content removed that we should handle at the next TM (if possible), or, if the time is not sufficient, should note for the next TM.

- I have already included the question as a further item on the agenda.

- Question on TCD operation of the OV:
Does borderline operation of the TCD result in non-opening of the OV?
(since the OV would close at a minimum differential pressure $Dp = 3.1$ bar)
Non-responsive content removed sent us a sketch for this purpose (see attachment)

- Can we contribute anything to this? Or will we need to handle the topic the next time?
Mit freundlichen Grüßen / Best regards

BeQIK

Non-responsive content removed

Tel. Non-responsive content removed
Fax
Mobile Non-responsive content removed

-----Original message-----

From: Non-responsive content removed
Sent: Tuesday, August 26, 2008 11:17 AM
To: Non-responsive content removed
Subject: Re: Your Scan

Hi all,

As we just discussed.
Yours sincerely,

Non-responsive content removed

Non-responsive content removed

AUDI AG

Non-responsive content removed

Tel.: Non-responsive content removed
Fax: d

EA11003EN-01169[2]

mailto:Non-responsive content removed

www.audi.com

Sitz/Domicile: Ingolstadt

Registergericht/Court of Registry: Local District Court Ingolstadt

HRB Nr./Commercial Register No.: 1

Vorsitzender des Aufsichtsrats/Chairman of the Supervisory Board: Martin Winterkorn

Vorstand/Board of Management: Rupert Stadler (Vorsitzender/Chairman), Ulf Berkenhagen, Michael Dick, Frank Dreves,

Peter Schwarzenbauer, Axel Strotbek, Werner Widuckel

Wichtiger Hinweis: Die vorgenannten Angaben werden jeder E-Mail automatisch hinzugefügt und lassen keine Rückschlüsse auf den Rechtscharakter der E-Mail zu.

Important Notice: The above information is automatically added to this e-mail. This addition does not constitute a representation that the content of this e-mail is legally relevant and/or is intended to be legally binding upon AUDI AG.

-----Original message-----

From: Non-responsive content removed

Sent: Tuesday, August 26, 2008 11:14 AM

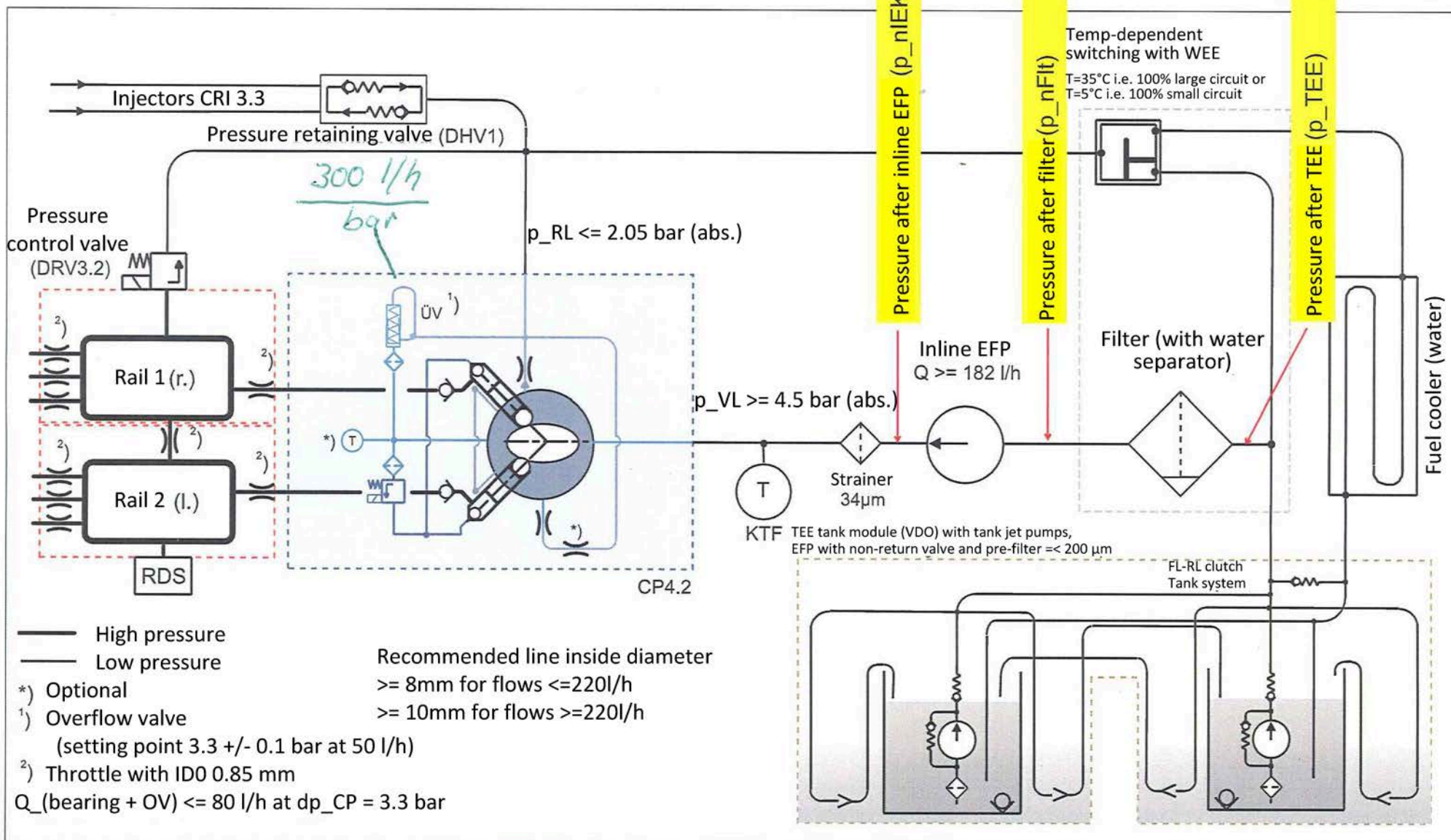
To: Non-responsive content removed

Subject: Your Scan

your scan is attached to this email

Common Rail System (CRS3.3) - 2000 bar AUDI V6 3.0l TDI in Q7 and Touareg BIN 5 Eu6

Vorläufig



— High pressure
— Low pressure

*) Optional

¹⁾ Overflow valve

(setting point 3.3 +/- 0.1 bar at 50 l/h)

²⁾ Throttle with ID0 0.85 mm

Q_(bearing + OV) <= 80 l/h at dp_{CP} = 3.3 bar

Recommended line inside diameter

>= 8mm for flows <= 220l/h

>= 10mm for flows >= 220l/h

BOSCH



Status:

Non-responsive content remove

CP4 Audi technical meeting 08/27/2008: GP cap wear

Subject: GP cap wear

Cap wear of up to 15 μm was measured on CP4.2 gear pumps during W26 engine endurance runs. (See overview on Page 3)

The anodized cap layer has a thickness of (16 +/- 8) μm .

Information

- The engine endurance runs were sometimes run **above** the allowed inlet pressure (1.8 bar_abs): (~ 2.0 bar_abs)
- In vehicles, inlet pressures were sometimes measured **above** the allowed inlet pressure (~ 1.9 bar_abs)
- Pumps from W26 vehicles are not available
- Pumps from W24 vehicles are not available

For **risk assessment**, a 250h constant ER, BDF570, inlet pressure 1.8 bar_abs, interim check after 76h (08/25/2008), with a GP that had already run at Audi (from engine ER no. W26 134/1, SN. 4612 with 15 μm cap wear), to assess the response of the GP once the anodized layer was consumed.

Note: Max. cap wear < 8 μm @ during internal RB / customer test

Diesel Systems

1 Confidential Non responsive content removed | 8/26/2008 | Non responsive content removed | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Measures being tested @ Bosch

- Increase anodized layer thickness Done, [Non-responsive content removed]
Statement: not effective, because thicker layer results in rougher surface & therefore to greater initial wear
- Assessment of effectiveness of smaller GP balance choke (if Audi agrees to increase in min. inlet pressure) [Non-responsive content removed]
- Assessment (dates, costs) Ni cap vs. CP40 09/24/2008, [Non-responsive content removed]
- Investigation with cap made of housing material (simulation CP40)

For **potential estimation**, a 250h constant ER was started with BDF570, inlet pressure 1.8 bar_abs, interim check after 76h (08/25/2008) with **nickel cap**.

Measures @ Audi



- Invitation to meeting on reduction of inlet pressure @ W26 Done, [Non-responsive content removed]
- On-board voltage window at min./max. consumer 08/18/2008, [Non-responsive content removed]
- Vehicle low-pressure measurements on [Non-responsive content removed] 09/23/2008, [Non-responsive content removed]
Objective: Correlate cap wear to max. inlet pressure
- Check positioning of inlet/return connectors 09/23/2008 [Non-responsive content removed]
- Check change of diameter on JSP 09/23/2008, [Non-responsive content removed]

Diesel Systems



CP4 Audi technical meeting 08/27/2008: GP cap wear

Further work at RB

- Correlation of anodized layer thickness vs. roughness done
- Compare W26 vs. W24 (no parts available yet) 
- Compare low-pressure measurements W26 vs. W24 

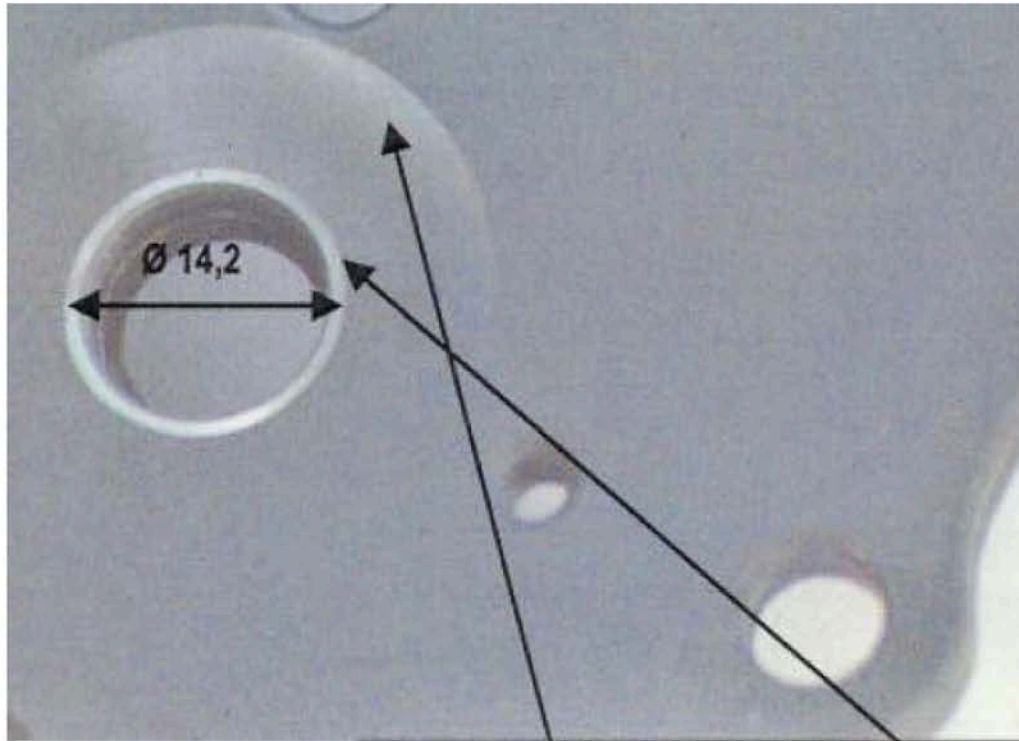
Audi confirmation

- Check inlet pressure engine ER done
- Assign pump / cylinder bank (left, right) done
- Results of low-pressure measurements in W26 vehicles



CP4 Audi technical meeting 08/27/2008: GP cap wear

Cap wear



cover wear at prim. gear 14 μm , wear at coupling 55 μm

Diesel Systems

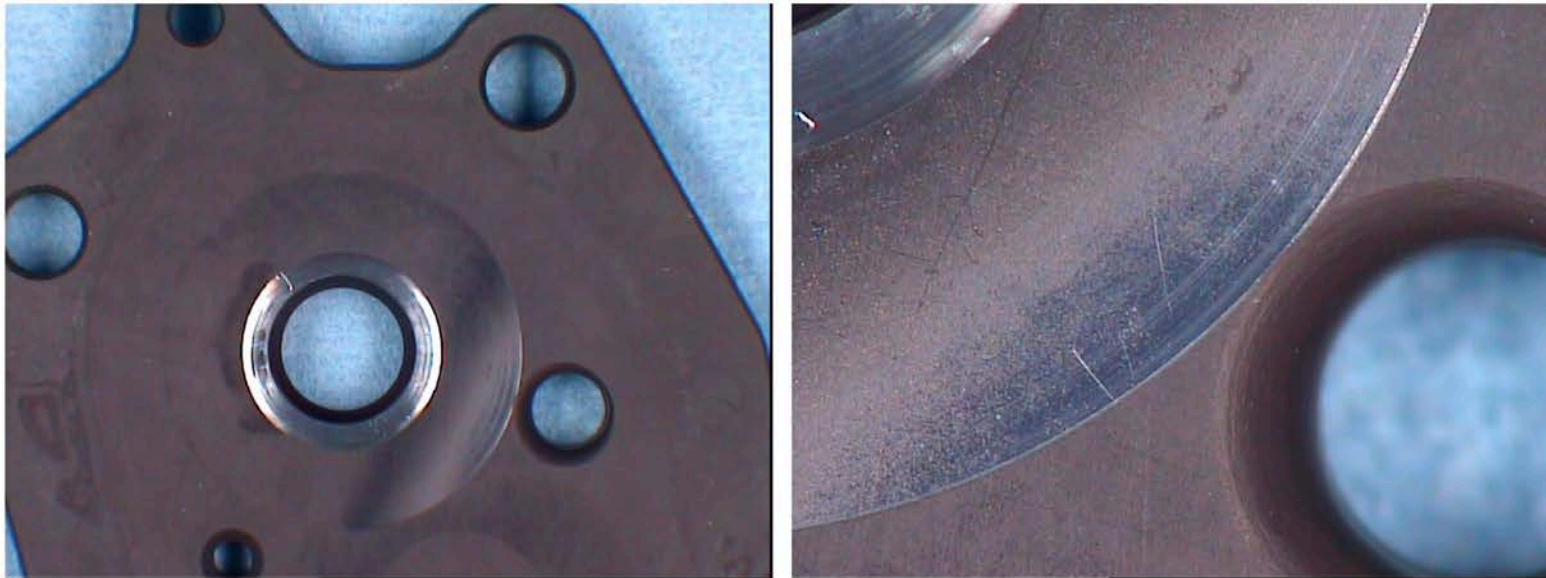


BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Result after 76h constant endurance running (continued run @ R.B. after engine ER)

Anodized cap



Diesel Systems

5

Confidential Non responsive content removed | 8/26/2008 | Non responsive content removed © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.

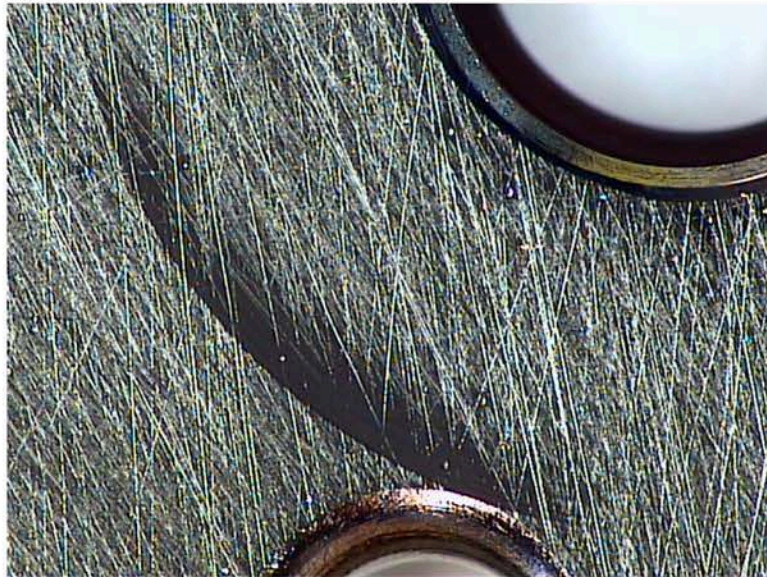


BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Result after 76h constant endurance running (new part)

Nickel cap



Diesel Systems

6

Confidential Non-responsive content removed 8/26/2008 | Non-responsive content removed | © Robert Bosch GmbH 2007. All rights reserved, also regarding any disposal, exploitation, reproduction, processing, distribution, as well as for the registration of special industrial property rights.



BOSCH

CP4 Audi technical meeting 08/27/2008: GP cap wear

Overview from customer test

Befundung CP4.2 W26										Stand: 27.08.08		ZP: Rettsam									
Rel. Nr.	Teile Nr.	Exemplar Nr.	FD	Motor Nr.	DL Art	Ablieferung zur Befundung	Bericht CP4.2 SAMOS Nr.	Bericht ZME	Bericht ZP	Bericht durch EDI erstellt am	Ewoks Anfrage vorhanden ? ja / nein	DL Zeit [h]	Ewoks Anfrage genehmigt ? Ja / nein	ZP Kupplungsanlauf Durchmesser [mm] wear at coupling	ZP Kupplungsanlauf Tiefe [mm] wear at coupling	ZP - Eingrabung ZP am Deckel [mm]	ZP nach +76h	Elozschicht am Deckel [µm] (Mittelwert, > 10 µm)	Rz Deckel ohne Verschleiß		
1	05A 130 755 A 0 445 820 200-05	4922	787 (Jul 07)	W26 122	Applikation	KW 1008	2008-CP4_0322 0593765/1	ZVM 615	MAP DS-182311 B2597		nein	917	ja	14,1	54	7		12,5	5,9		
2	05A 130 755 A 0 445 820 200-05	4936	787 (Jul 07)	W26 122	Applikation	KW 1008	2008-CP4_0324 0593765/02	ZVM 616	MAP DS-182312 B2598	22.07.2008	nein (nur erstes Blatt)	917	ja	13,4	25	7		11,5	6,4		
3	05A 130 755 0 445 820 165-02	BPT 4614	781 (Jan 07)	W26 022	Fkt. Mechanik	KW 1708	2008-CP4_0359 0599050	sw im anhalten	enthält	01.07.2008	nein (nur erstes Blatt)	211	ja								
4	05A 130 755 0 445 820 165-02	BPT 4618	781 (Jan 07)	W26 022	Fkt. Mechanik	KW 1708	2008-CP4_0360 0599051	sw im anhalten	enthält	03.07.2008	nein (nur erstes Blatt)	211	ja								
5	05A 130 755 0 445 820 165-02	BPT 4920	782 (Feb 07)	W26 033	Diesels	KW 1708	2008-CP4_0365 0599052	sw im anhalten	enthält	02.07.2008	nein (nur erstes Blatt)	540	ja								
6	05A 130 755 0 445 820 165-02	BPT 4921	782 (Feb 07)	W26 033	Diesels	KW 1708	2008-CP4_0366 0599045	sw im anhalten	enthält	02.07.2008	nein (nur erstes Blatt)	540	ja								
7	05A 130 755 A 0 445 820 200-01	BPT 4463	785 (Mai 07)	W26 056	JR-DL VQ-Fzg. V7	KW 1709	2008-CP4_0363 0599046	sw im anhalten	MAP DS-184341 B2601	01.07.2008	ja	8000km	ja	13,3	37	5		12,5	7,4		
8	05A 130 755 A 0 445 820 200-01	BPT 4484	785 (Mai 07)	W26 056	JR-DL VQ-Fzg. V7	KW 1709	2008-CP4_0364 0599061	sw im anhalten	MAP DS-184352 B2602	01.07.2008	ja	8000km	ja	15,4	120	5		13	7,9		
9	05A 130 755 B 0 445 820 200-07	4611	789 (Sep 07)	W26 134/1	PZD/Raf-Test	KW 1709	2008-CP4_0361 0599052	sw im anhalten	MAP DS-184351 B2599	02.07.2008	ja		ja	13,4	18	5		10,5	5,6		
10	05A 130 755 B 0 445 820 200-07	4612	789 (Sep 07)	W26 134/1	PZD/Raf-Test	KW 1709	2008-CP4_0362 0599054	?	DS-184363 B2600	01.07.2008	ja		ja	14	76	15	17	ZP bei 518			
11	05A 130 755 A 0 445 820 200-05	BPT 4889	787 (Jul 07)	W26 125	Nardo/EWI (Pst.)	KW 1808	2008-CP4_0416 700794.001	ZVM 619 (im Bericht 416)	DS-186625 B2603	29.07.2008	ja	963	ja	13,6	40	10		13	5,9		
12	05A 130 755 A 0 445 820 200-05	BPT 4909	787 (Jul 07)	W26 125	Nardo/EWI (Pst.)	KW 1808	2008-CP4_0417 700794.002	ZVM 620 (im Bericht 417)	DS-186626 B2604	29.07.2008	ja	963	ja	14,2	55	14		12	6,8		
13	05A 130 755 B 0 445 820 200-07	4496	789 (Sep 07)	W26 129	Raf-Test	KW 1808	2008-CP4_0418 700795.001	?	DS-186620 B2605	30.07.2008	ja	265	ja	14	46	12		10,5	5,2		
14	05A 130 755 B 0 445 820 200-07	4577	789 (Sep 07)	W26 129	Raf-Test	KW 1808	2008-CP4_0419 700795.002	?	DS-186621 B2606	30.07.2008	ja	265	ja	14	44	10		10,5	6,3		
15	05A 130 755 B 0 445 820 200-07	4578	789 (Sep 07)	W26 130	Raf-Test	KW 1808	2008-CP4_0420 700791.001	?	DS-186623 B2607	31.07.2008	ja	265	ja	13,4	46	6		10	6,4		
16	05A 130 755 B 0 445 820 200-07	4594	789 (Sep 07)	W26 130	Raf-Test	KW 1808	2008-CP4_0421 700791.002	?	DS-186624 B2608	31.07.2008	ja	265	ja	13,4	30	10		10,5	6,3		
17	05A 130 755 B 0 445 820 200-07	BPT 4736	790 (Okt 07)	W26 155	Diesels	KW 2908	?	?			nein	552									
18	05A 130 755 B 0 445 820 200-07	BPT 4737	790 (Okt 07)	W26 155	Diesels	KW 2908	?	?			nein	552									
19	05A 130 755 B 0 445 820 200-07	BPT 4734	790 (Okt 07)	W26 157	Versottung	KW 2908	?	?			nein	553									
20	05A 130 755 B 0 445 820 200-07	BPT 4731	790 (Okt 07)	W26 157	Versottung	KW 2908	?	?			nein	553									
21	05A 130 755 B 0 445 820 200-07	BPT 4700	790 (Okt 07)	W26 161	Nardo/EWI	KW 2908	?	?			nein										
22	05A 130 755 B 0 445 820 200-07	4613	789 (Sep 07)	W26 161	Nardo/EWI	KW 2908	?	?			nein										
23	05A 130 755 B 0 445 010 619	BPT 0834	080118	W26 168	Raf-Test	KW 2908	?	?			nein										
24	05A 130 755 B 0 445 010 619	BPT 0831	080118	W26 168	Raf-Test	KW 2908	?	?			nein										
25	05A 130 755 B 0 445 820 200_07	BPT 4787	790 (Okt 07)	W26 164	PZD	KW 3008	?	?			nein										
26	05A 130 755 B 0 445 820 200_07	BPT 4786	790 (Okt 07)	W26 164	PZD	KW 3008	?	?			nein										

Diesel Systems



BOSCH

**BOSCH**

Diesel Systems

From

Non-responsive content removed

Processor

Non-responsive content removed

Phone

Non-responsive content removed

Fax

Non-responsive content removed

12/15/2008

No. [redacted] 892-168/01

Log

Recipients: See e-mail

For Info

Host

Participants

AUDI: Non-responsive content removed

Non-responsive content removed

BOSCH: Non-responsive content removed

Management

Non-responsive content removed

Log

Organiz.

AUDI

Date/Location

11/19/2008, 2:30 – 5:00 pm**[redacted] bldg. B12 middle conference room**

Topic

Pump technical meeting**1.) General:**

- Create and maintain OPL. Uniform layout with [redacted] technical meeting and close tracking.
- Minutes must be distributed by Monday after TM.

Non-responsive content removed

asap

Non-responsive content removed

asap

2.) Endurance run**2.1) V6 Clean diesel**

- 2 ER (2000h) passed with intolerably high wear on roller end, 1 ER failed at 1126h.
- 4 new ERs set up with C2.1 roller end. Completion by 03/2009. AUDI demands that the ER be continued over Christmas and eventual factory holidays, to avoid losing any time. *Note: ERs will be continued to the end.*

Non-responsive content removed

done.

2.2) V8

- 1 drivetrain damage (D4), caused by not-OK parts.
- 1 housing bearing melted, analysis not completed yet.
- 2 Q7 and 4 D4 system ER.

3.) C2.1 layer roller end

- Implemented in VW R4, AUDI V8.
- Previously, Clean diesel pumps were shipped with C3 layer.
- Determination whether and where Bin pumps with C2 layer were delivered

Non-responsive content removed

4.) Strainer in front of intake valve

- Not sensible for CP4.2, because no improvement, not completed yet for CP4.1



Diesel Systems

From [Redacted]
Non-responsive content removed

Processor [Redacted]
Non-responsive content removed

Phone [Redacted]
Non-responsive content removed

Fax [Redacted]
Non-responsive content removed

[Redacted]
12/15/2008
No. [Redacted] 892-168/01

Log
Pump technical meeting

5.) Failure W36 CP4.2

- Roller support worn across entire length. This heavy wear does not match the short running time with starter speed on the test rig.
- Use of C2 layer was agreed upon in preliminary talks.
- C2 layer on roller support was tested for U.S. projects. C2 layer as such cannot be seen as the primary cause of the failure; poor layer adhesion is one possibility, further analysis needed.
- Defective pump was identified in test program at BOSCH
- Assess AUDI idea of a "magnetic screw" as shaving collector.

[Redacted]
Non-responsive content removed

[Redacted]
Non-responsive content removed

6.) W37 volume balance

- A violation currently occurs with 6.75mm at 40°C.
- Data basis (volume requirement AUDI, CRI5.1 and CP4.2 requirements) will be revised to keep stroke as low as possible.
- Stroke definition for initial engines (still with CRS3.3) is already overdue, contact [Redacted] *Remark: 6.75mm necessary, AUDI demands repeat check whether further reduction is possible through application and less reserve (steering committee minutes)*

[Redacted]
Non-responsive content removed

done

[Redacted]
Non-responsive content removed

done

7.) W24 verification inlet pressure

- VB is not affected negatively
- Cavitation ER required for verification, clarify cost question

[Redacted]
Non-responsive content removed

8.) Drivetrain damage

- Intensified inspection point must lie within TCD. Clarify whether intensified inspection point and revision of program sensible.

[Redacted]
Non-responsive content removed

9.) Miscellaneous

- CP4.1 from [Redacted] have "BPT" indicator [Redacted]. Indicator must be corrected to "BPY".

[Redacted]
Non-responsive content removed

[Redacted]
Non-responsive content removed

CP4-18/1 for VW R4 2.0L

(79. PM 9/1/2009)

Contents:

- Complaint Q verification Audi A3
- CP4-18/1 for R4 2.0L EA189 CRS2.5 BIN5
 - Sample status
 - Fuel specification
- CP4 noises



CP4.1 for VW R4 2.0L – 79. PM 9/1/2009**Pump complaint from vehicle endurance run (Q verification USA)****Fact:**

- CP4.1 Part no. 0 445 010 508 DM 290109, SN 0425
- Mileage 83,726 km
- Engine no. CBE000155 BIN5
- Vehicle: AU35308050 Audi A3
- Failure location: USA

Fault pattern:

- Drivetrain damage: Deep wear track in middle of cam track due to perpendicular roller as consequence of sluggish roller, corresponding deep wear track on the roller. Wear track in the middle of the running surface on the roller support. Numerous chips present in the MU strainer, OV strainer, CH intake valve compartment, in the OV and MU bores, as well as in the bearings and on the shaft seal.
- MU fastening screw missing upon delivery -> Probably removed by customer



CP4.1 for VW R4 2.0L – 79. PM 9/1/2009

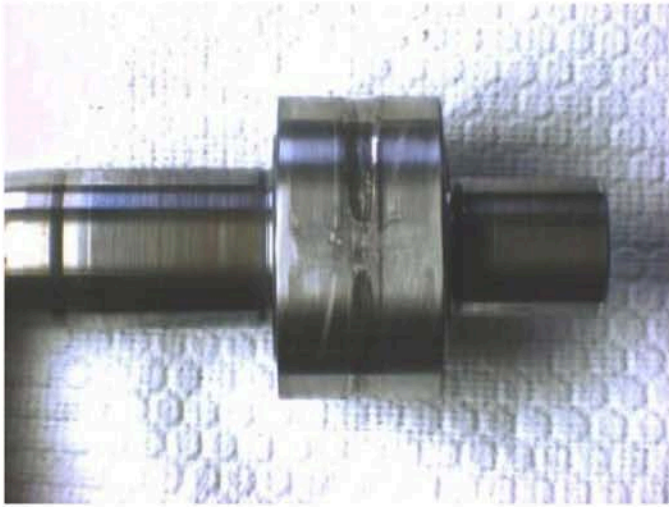
Pump complaint from vehicle endurance run (Q verification USA)

Result:

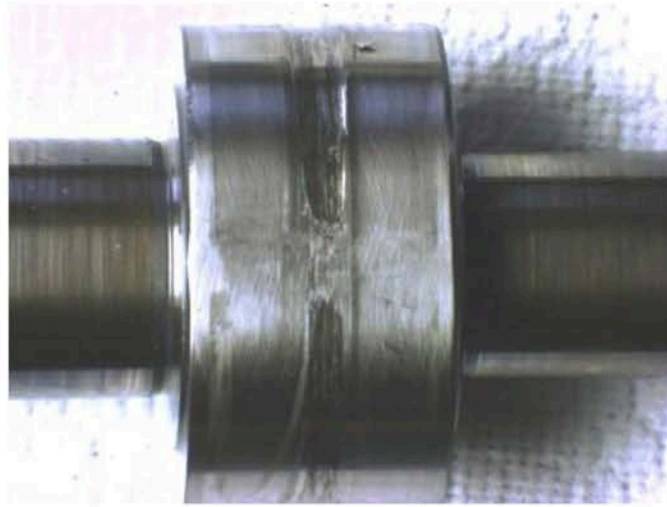
- Based on the SEM pictures of the roller, both adhesion (picture 1) and evidence of fatigue (pictures 2 and 3) can be seen. The roller shows several “braking flats”, which means it came to a temporary stop several times.
- An analysis of the roller support running surface did not show any indications of C layer detachment (adhesion class 1 -> very good) or contamination from previous processes (see set of slides 232_My). The C layer abrasion in the middle is the consequence of the destroyed roller surface (passage of broken-off roller material). No metal spatters or elevations were found.
- Tappet bore and piston base show greater cavitation erosion than usual
- The shaft seal shows greater wear optically; wear measurement to follow | RB
- Flange bushing shows smearing and heavy smoothing, which could be a result of the drivetrain damage.
- The cause of the damage could not be identified uniquely. However, there are indications for operation with a low-viscosity/poor lubricity fuel or increased water content. An analysis of the fuel could provide further indications or evidence.
pending: Fuel analysis | VW



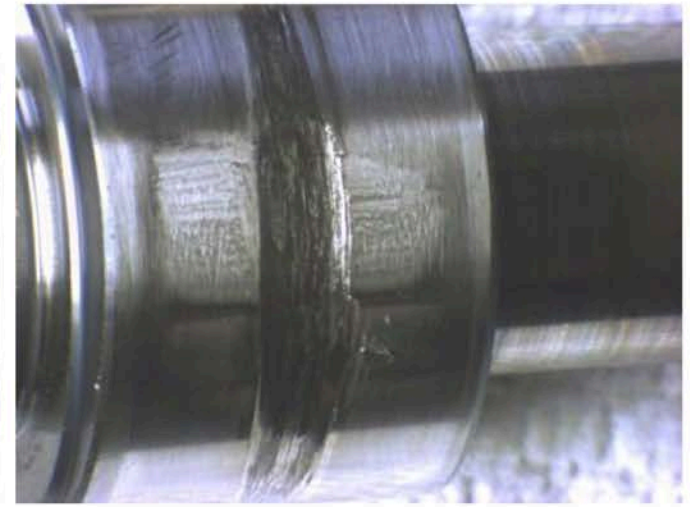
Initial diagnosis VW damage case from Q verification ER USA



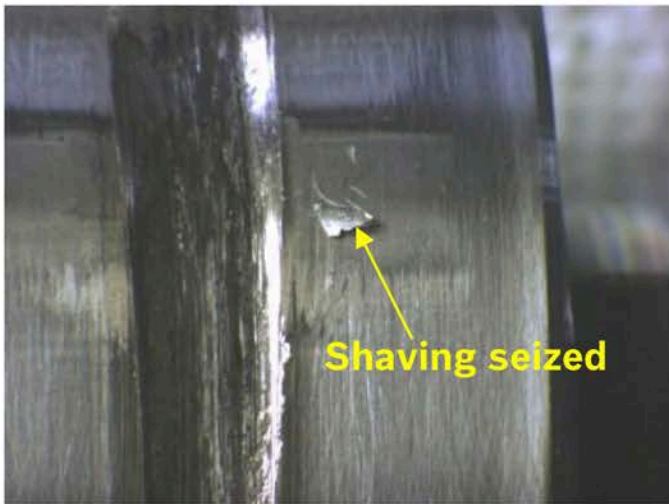
Camshaft



Camshaft BDC



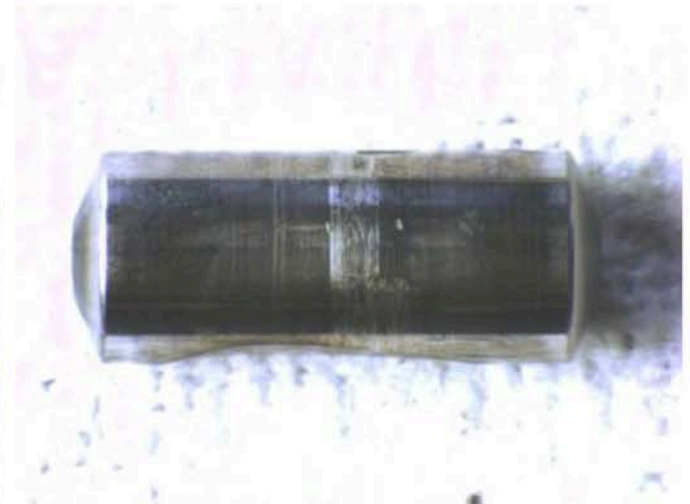
Camshaft TDC



Camshaft TDC



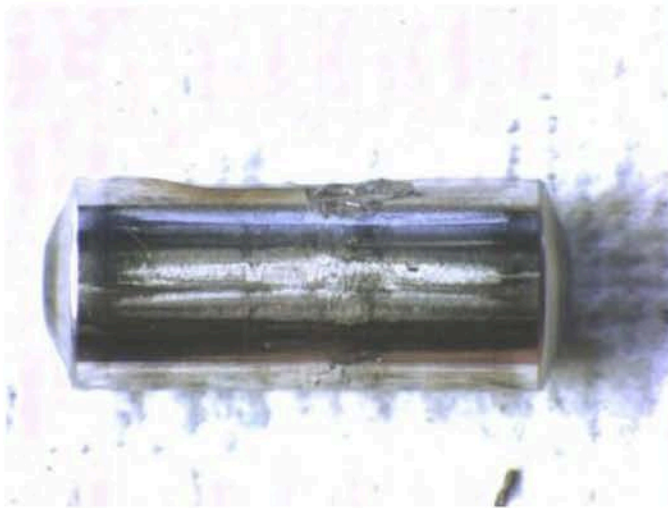
Roller surface



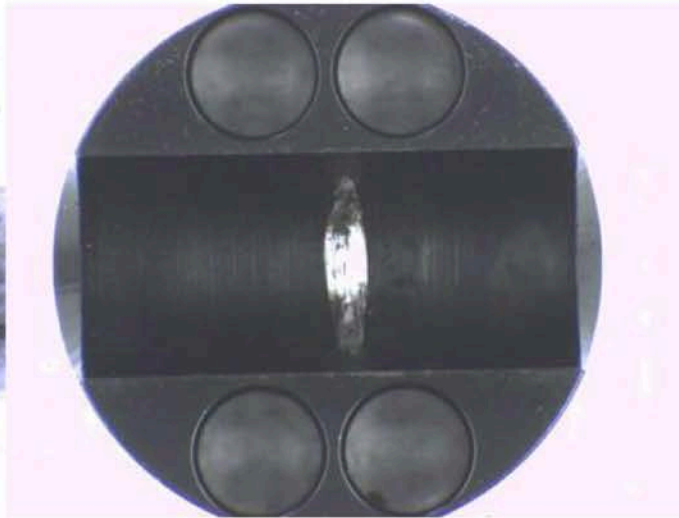
Roller surface turned 180°



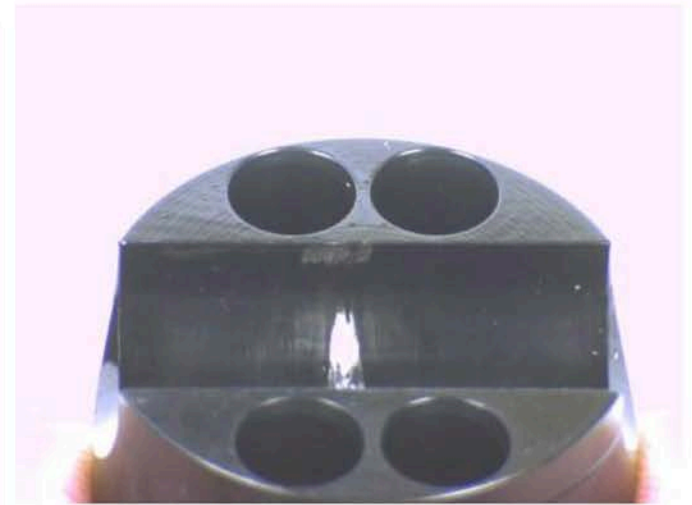
Initial diagnosis VW damage case from Q verification ER USA



Roller running surface



Roller support running surface



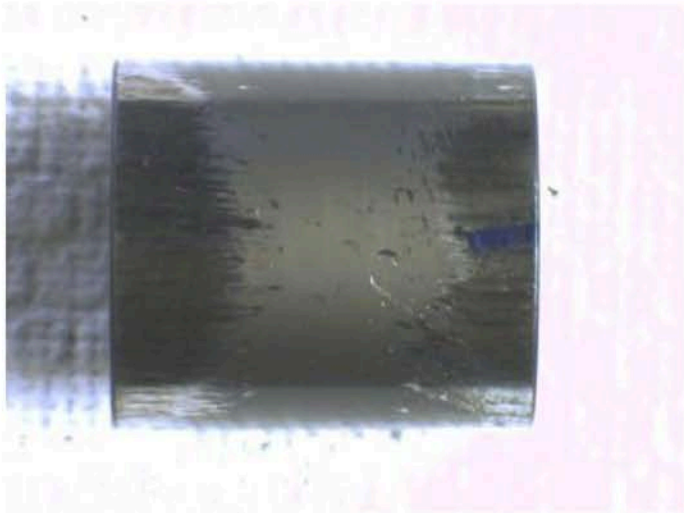
CH intake valve compartment



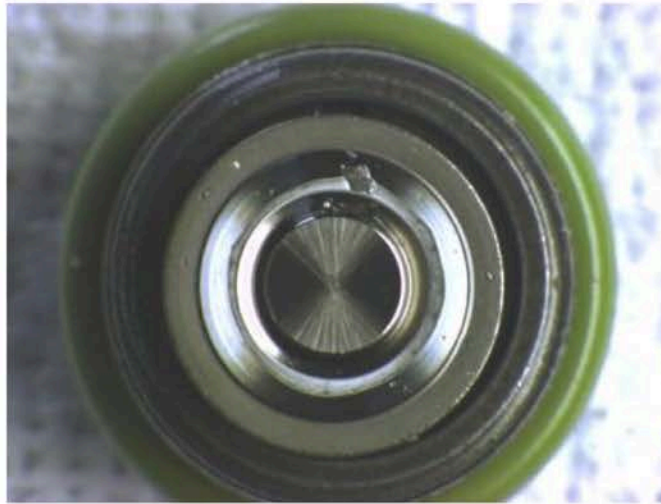
MU strainer



MU bore



Tappet body



Intake valve



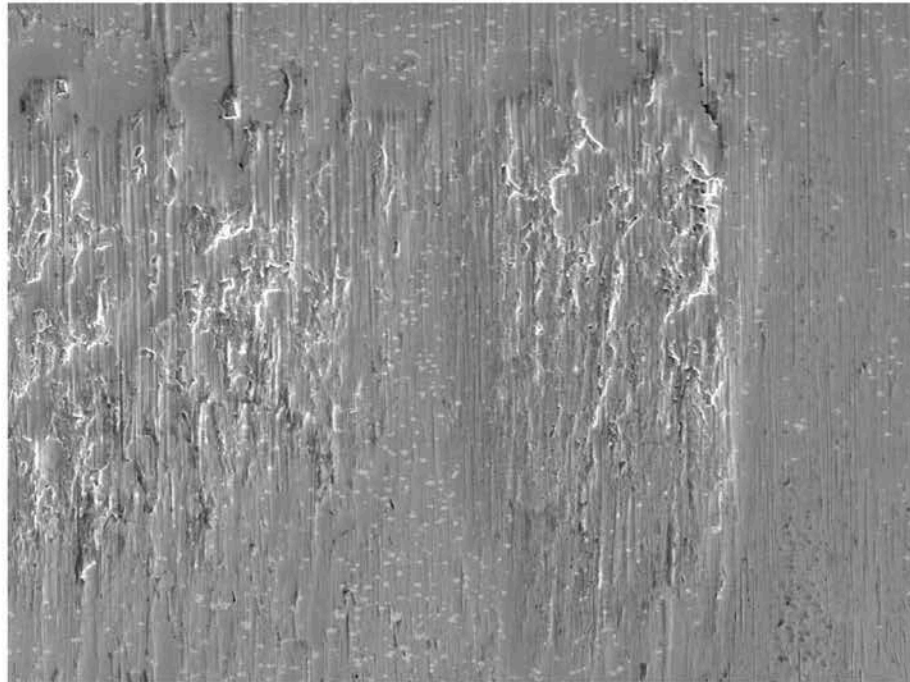
Intake valve gasket



Piston base

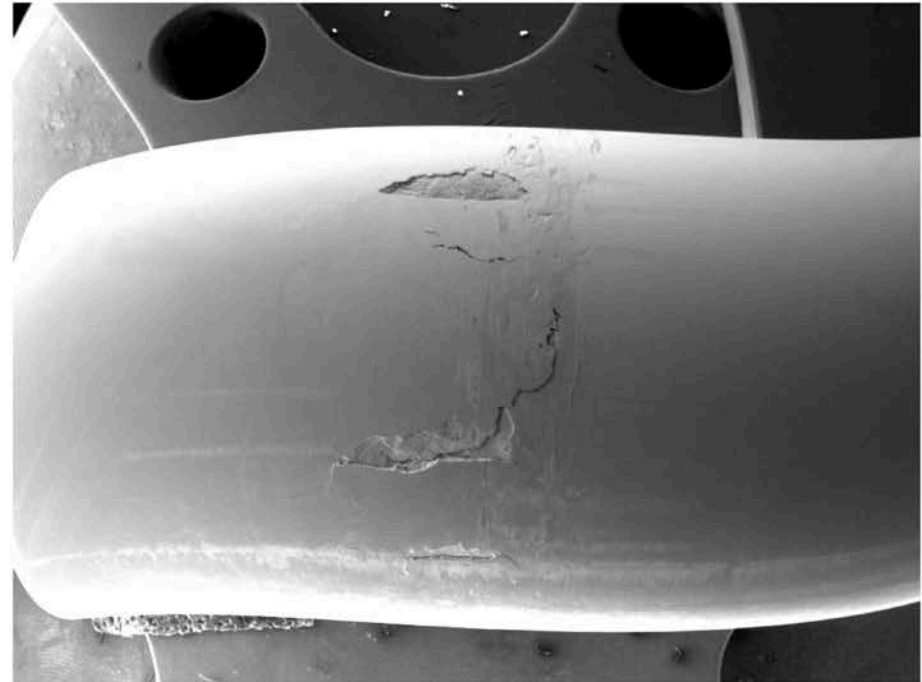
SEM examination of roller:

Fig. 1



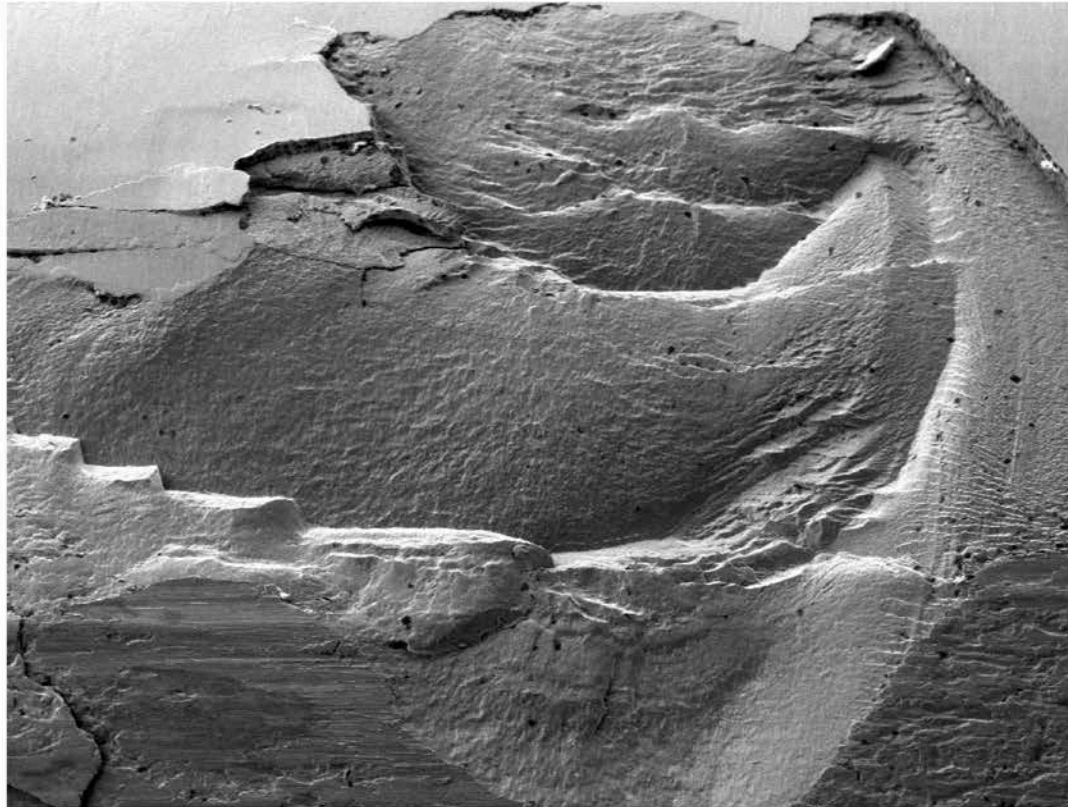
View field: 313.79 um DET: SE Detector
HV: 20.0 kV DATE: 08/12/09 100 um
Vega ©Tescan
Bosch [REDACTED]

Fig. 2



View field: --- DET: SE Detector
HV: 20.0 kV DATE: 08/12/09
Vega ©Tescan
Bosch [REDACTED]

Fig. 3



View field: 3.94 mm

DET: SE Detector



HV: 20.0 kV

DATE: 08/12/09

1 mm

Bosch Vega ©Tescan
Non-responsive content removed



Analysis of CP4 roller support

Subject of analysis

- CP4 roller support after failure, process number 2009-CP4_0410 (Pp 290109-0425, number of roller support: 6007 1585)
- The examined roller support shows damage in the center of the running area.

Goal of analysis

- Assessment of the layer in the running area of the RS at the damage point using SEM/EDX, adhesion impression.
- Determination of cause of damage.



Adhesion measurements of CP4 roller supports

Adhesion measurements on C layer

In running area of a CP4 RS after failure at mileage 83,726 km (2009 CP4 0410)

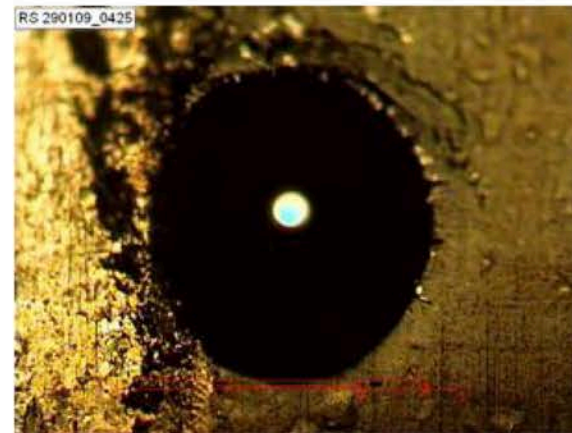
Adhesion measurement close to damage point

→ Pp 290109 - 0425



Right of damage

HF: 1



Left of damage

HF: 1

→ Summary: Layer adhesion in damage area inconspicuous. Cause of damage could not be clarified.

Analysis of CP4 roller support

SEM summary:

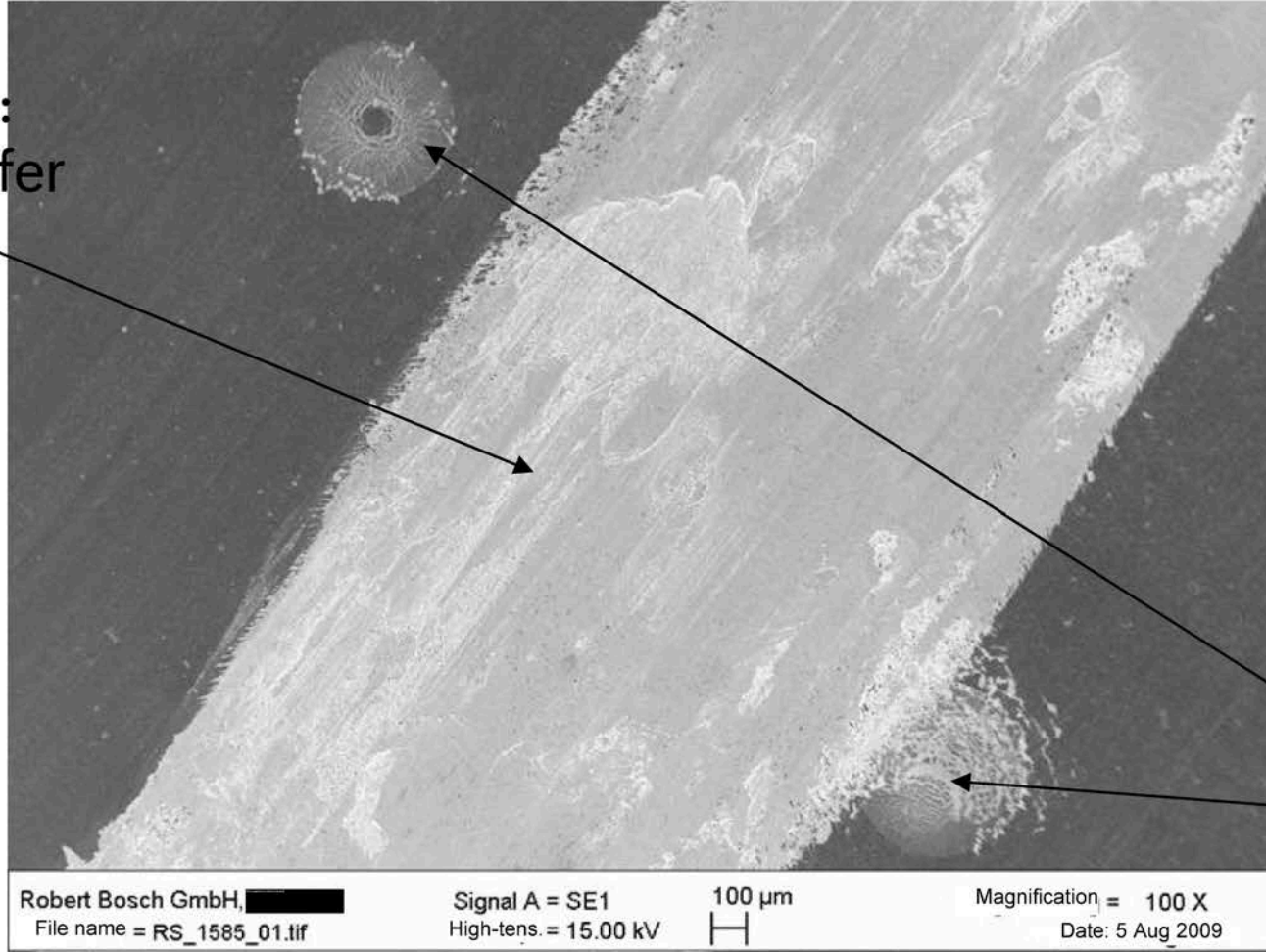
- Main damage point shows
 - areas with material transfer (with/without breakage),
 - areas with C layer detachment from basic material (as a consequence of thermal/mechanical overload) on which no mechanical contact (consequence: seizing) with opposing body has taken place.
- No area of C layer detachment (subsequent damage) shows indications of contamination.
- Damage in roller support does not have any indications of defective C layer quality or contamination from previous processes as cause



Analysis of CP4 roller support

SEM examination of roller support

Main damage:
material transfer



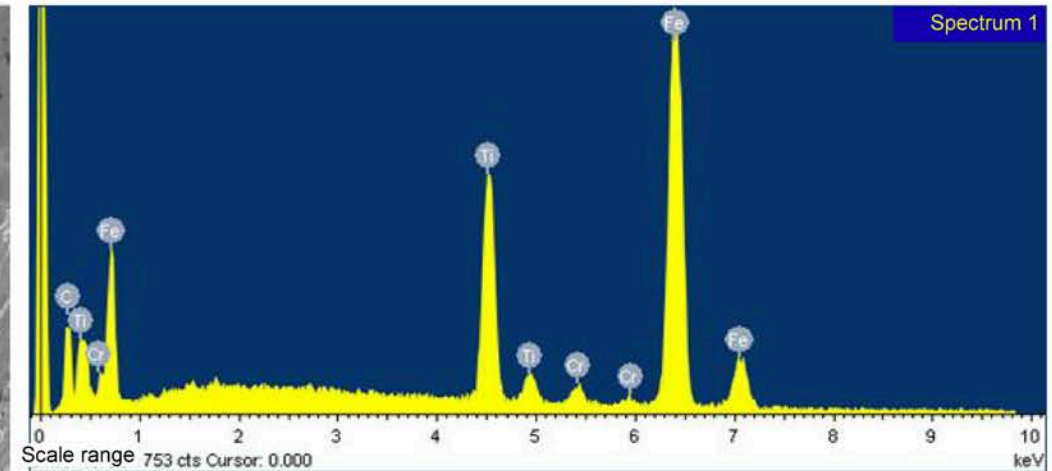
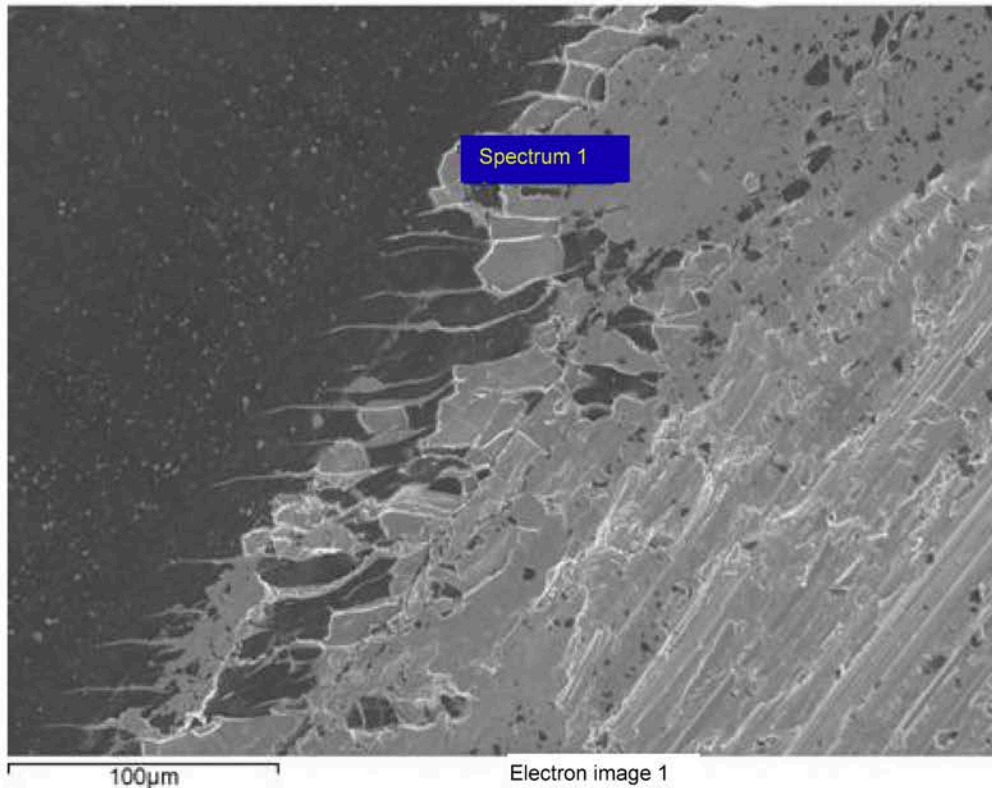
Adhesion
impression

RS: 6007 1585



Analysis of CP4 roller support

SEM EDX examination of roller support

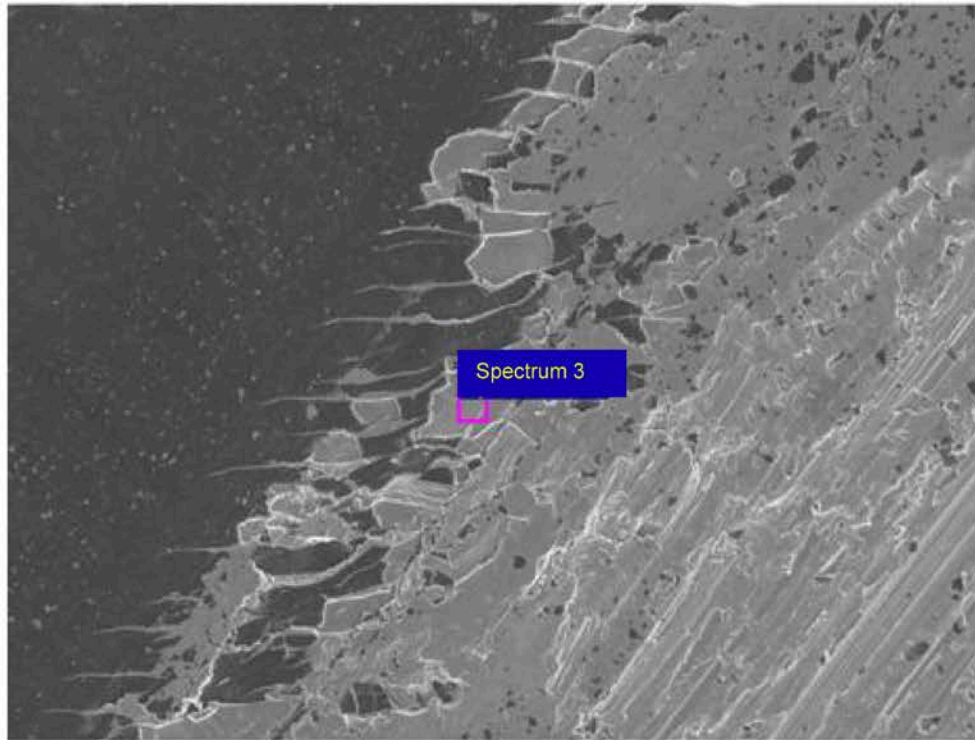


RS: 6007 1585

No contamination found in detached,
non-seized areas

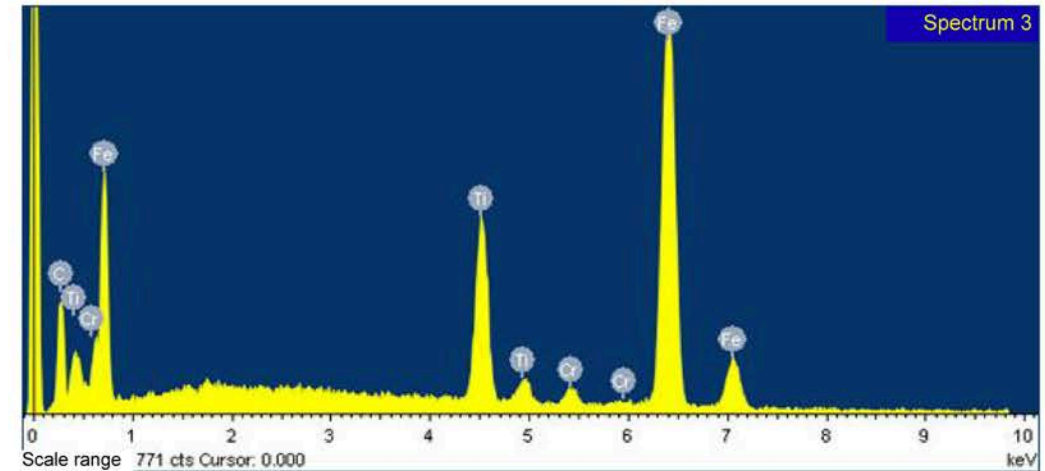
Analysis of CP4 roller support

SEM EDX examination of roller support



100µm

Electron image 1

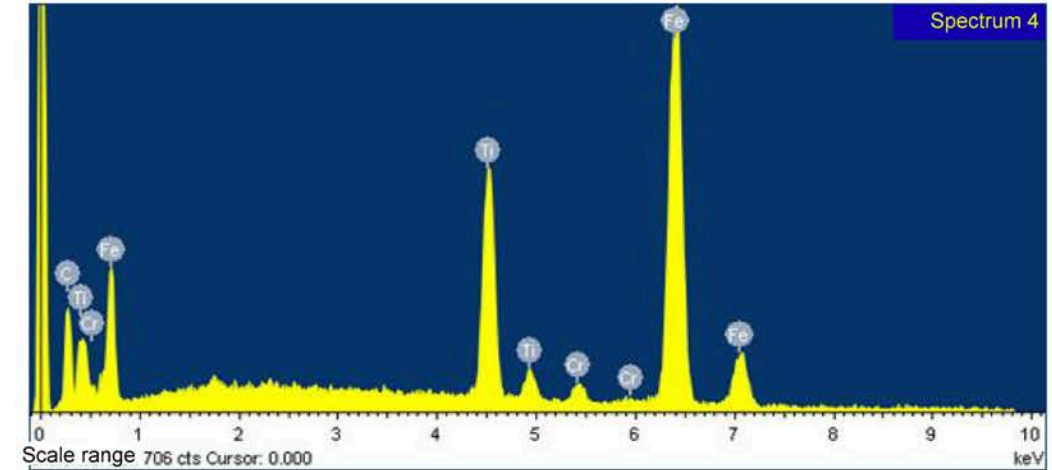
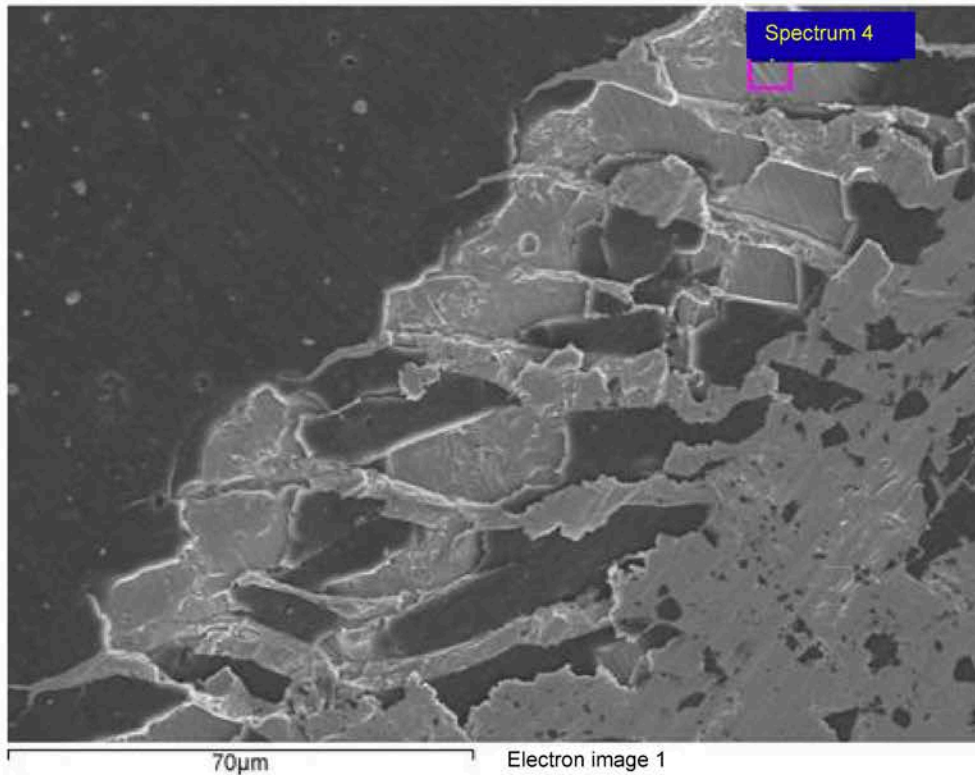


RS: 6007 1585

No contamination found in detached,
non-seized areas

Analysis of CP4 roller support

SEM EDX examination of roller support

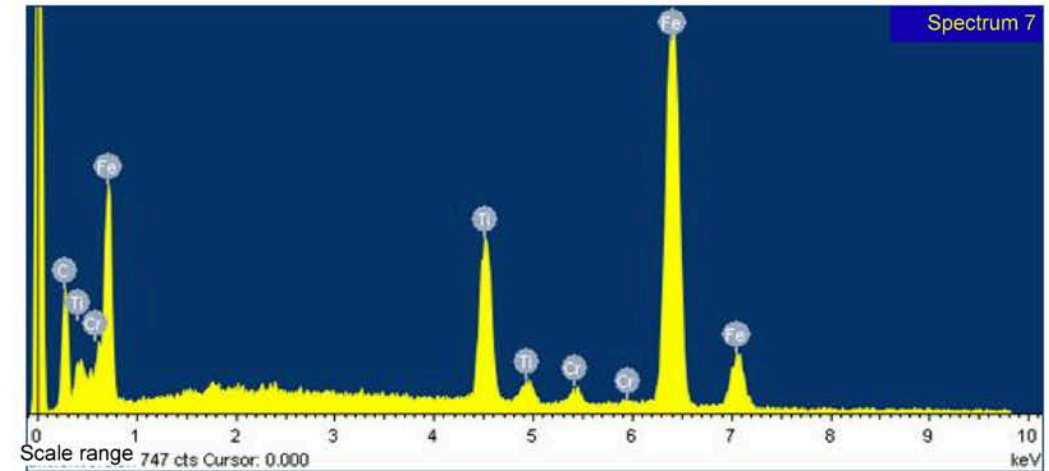
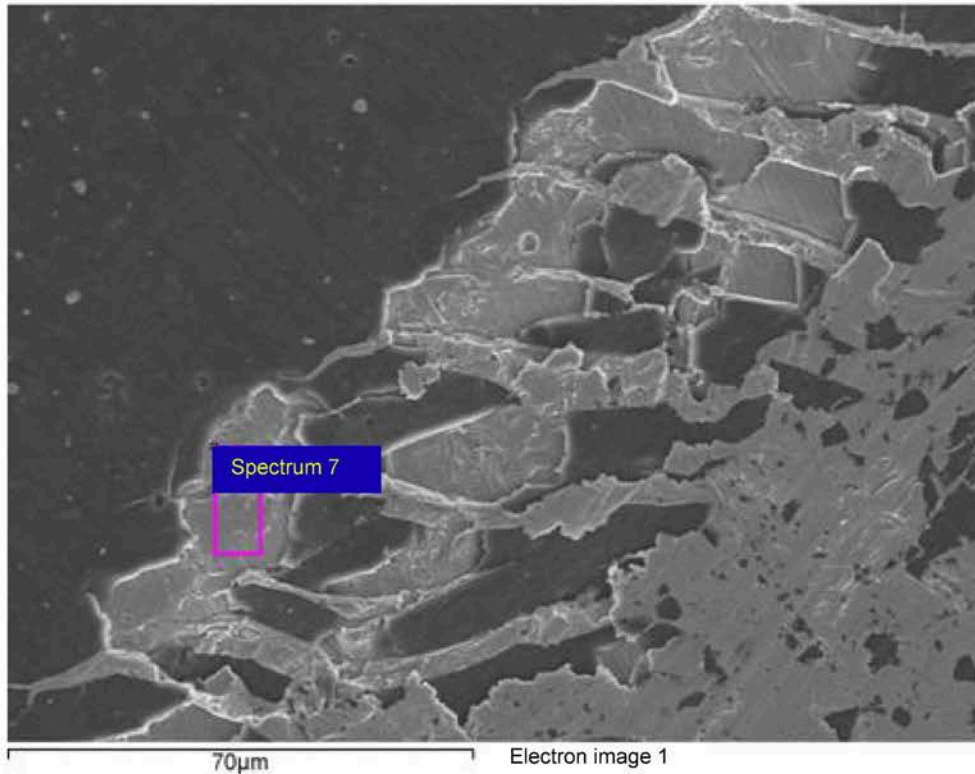


RS: 6007 1585

No contamination found in detached,
non-seized areas

Analysis of CP4 roller support

SEM EDX examination of roller support

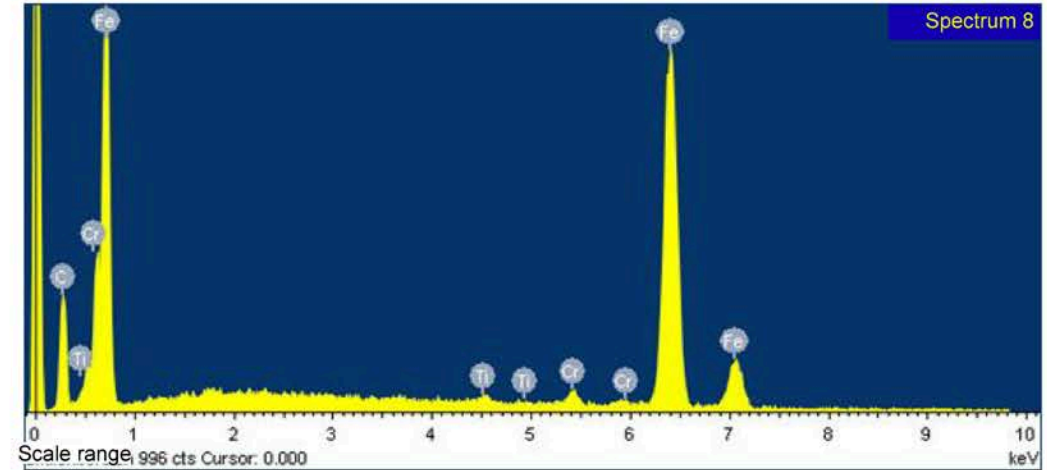
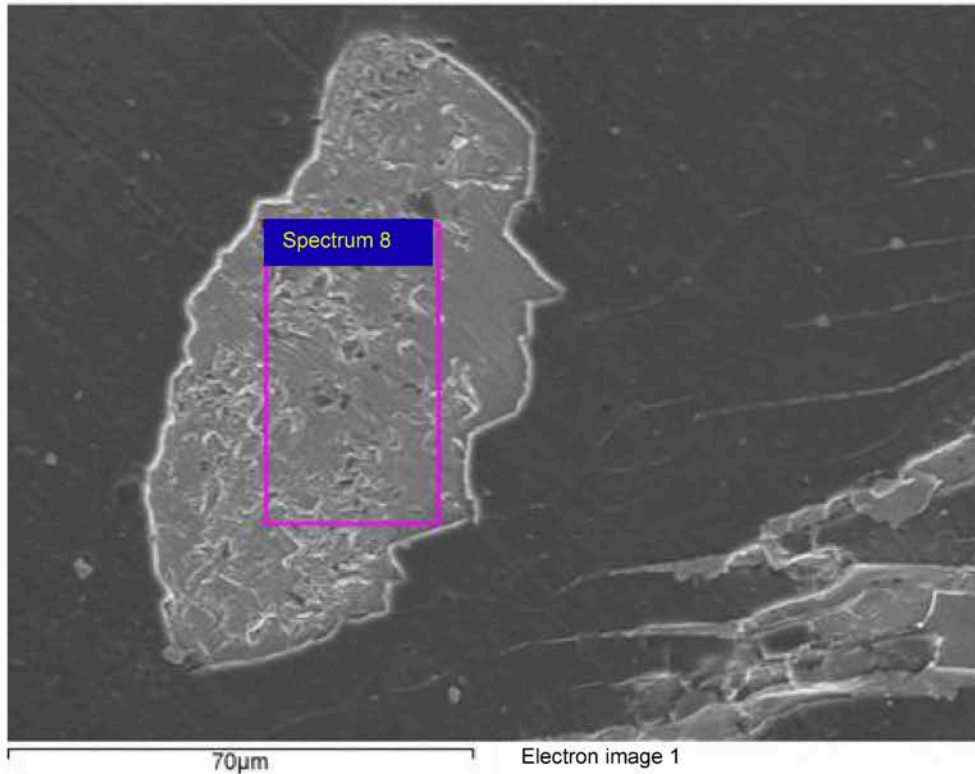


RS: 6007 1585

No contamination found in detached,
non-seized areas

Analysis of CP4 roller support

SEM EDX examination of roller support

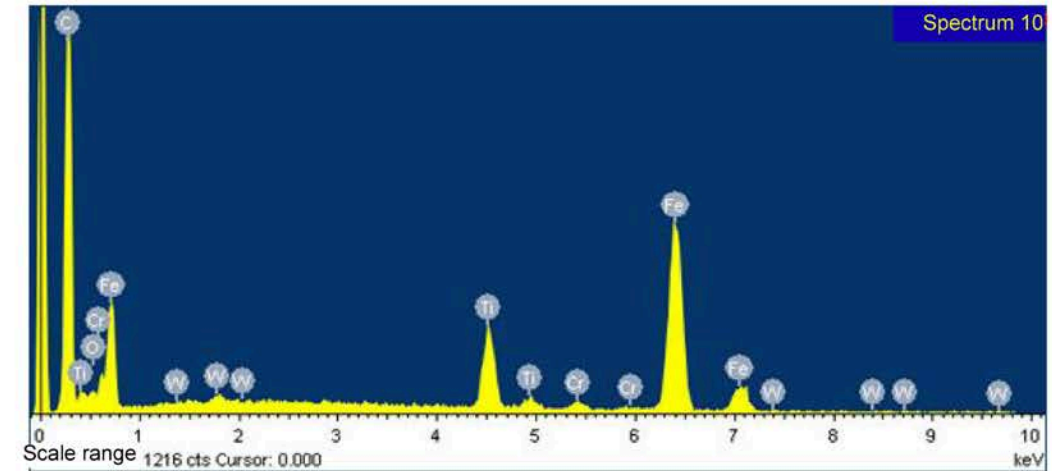
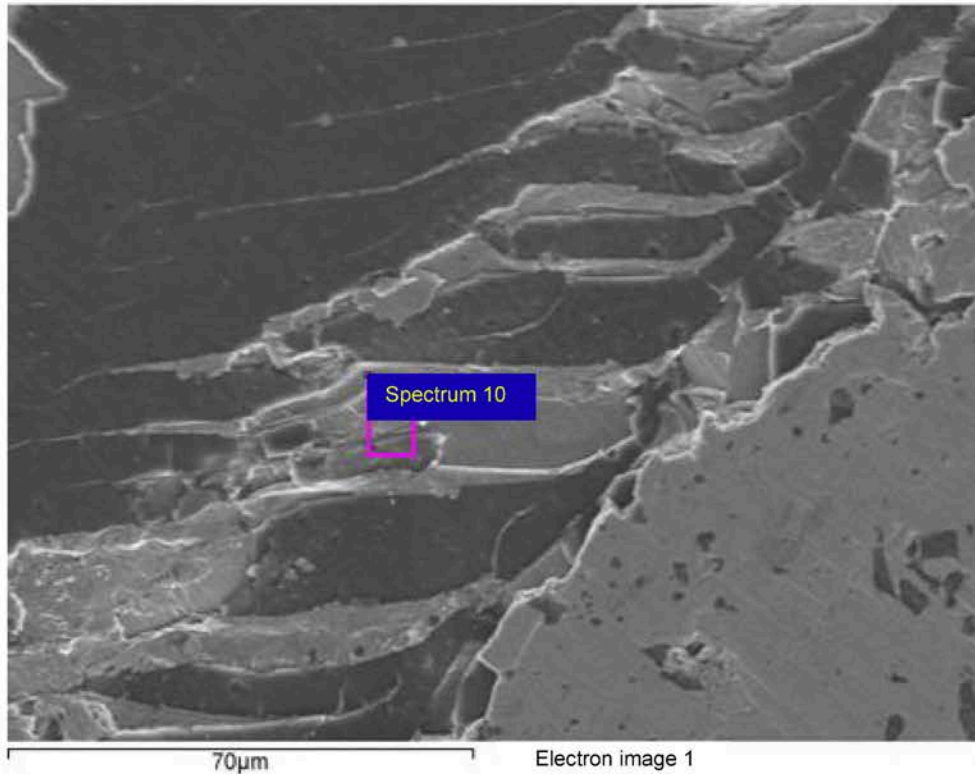


RS: 6007 1585

No contamination found in detached,
non-seized areas

Analysis of CP4 roller support

SEM EDX examination of roller support



RS: 6007 1585

No contamination found in detached,
non-seized areas.

Transfer tracks on roller (W) found.

Sample status 03L 130 755 F

Part no	Category	RS	Second supplier parts
→ 0445B21137-03	B sample	C3	Phase 1
→ 0445B21137-04	C sample	C3.1	Phase 2 (slide 2)
→ 0445B21137-05	C sample	C3.1	Like _04, additional characteristics of phase 3: CH screws supplier 2, connector pieces supplier 2, tappet body supplier 1 with material supplier 2
<u>PPS + zero series:</u>			
→ 0445B21137-06	C sample	C3	like _04



CP4.1 for VW R4 2.0L EA189

Sample order CP4.1 for EA189_2 BIN5

Part no.: **0 445 B21 137-04** (with low lubricity package)

→ New design feature

- Roller support C3.1 layer (instead of previous C3)

→ Verification of second supplier

- | | |
|----------------------------------|-------------------------------------|
| - IV spring plate | Supplier 2 |
| - Flange complete EPP | Supplier 2 |
| - Roller short | Supplier 1 |
| - Calotte NRV | Supplier 3 |
| - Cylinder head, soft | Supplier 2 |
| - O-rings, 4x | Supplier 2 |
| - Spring IV | Supplier 2 |
| - Spring NRV | Supplier 2 |
| - Roller support variant (round) | Supplier 2 with material supplier 2 |



Fuel specification 03L 130 755 F

→ Allowed fuels:

- ASTM D975-05: 1D and 2D
- JIS K 2204:2004
- Diesel fuels such as EN590, but with lubricity (HFRR) <520 µm

→ Water separation in acc. with TCD 0449 D00 005

→ Requirements for filtration TCD 0449 D00 003



CP4 noise measurements

(75. PM 07/07/09)

Impact of piston stroke, speed, fill level

- Determination of strict noise emanating from the CP4
- Variation of piston stroke 5.25 mm / 6 mm
- Speed 0 – 4,500 rpm
- Variation of fill level 400 mA (MU open) / 1,400* mA (partial supply)

*...MU position with loudest subjective noise)



CP4 pump noise measurements

- **task:** measurement of CP4 pump noise in an anechoic chamber.
- **procedure:** pump is running on a special test bench with encapsulated electric motor and rail (minimal background noise)
- **pump:** CP4.1 with different cam lifts (5.25mm, 6mm)

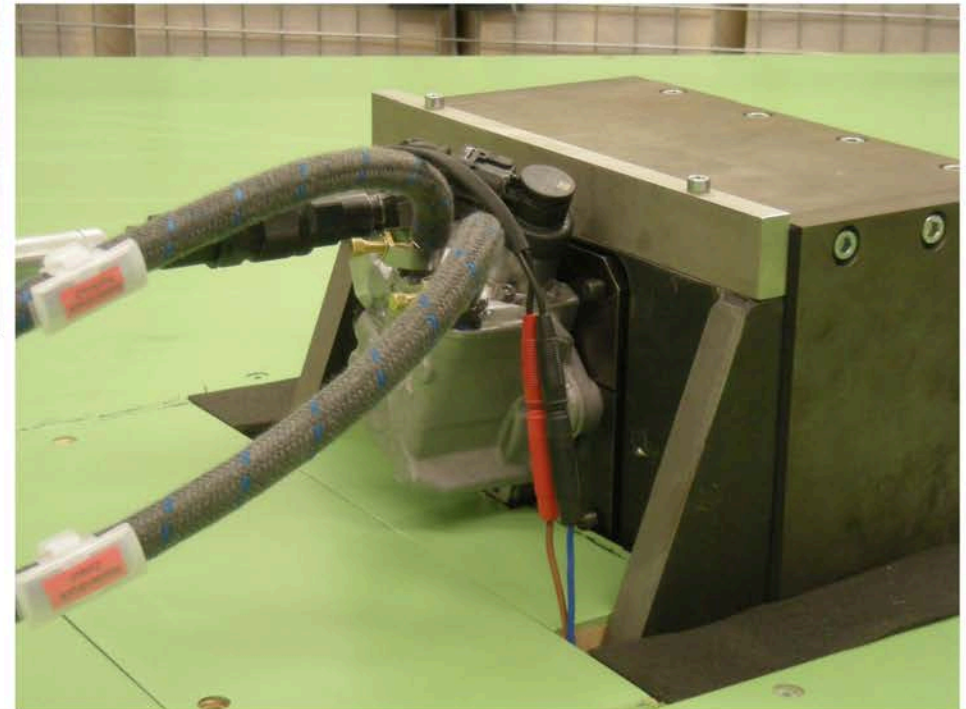


CP4 pump noise measurements

test setup

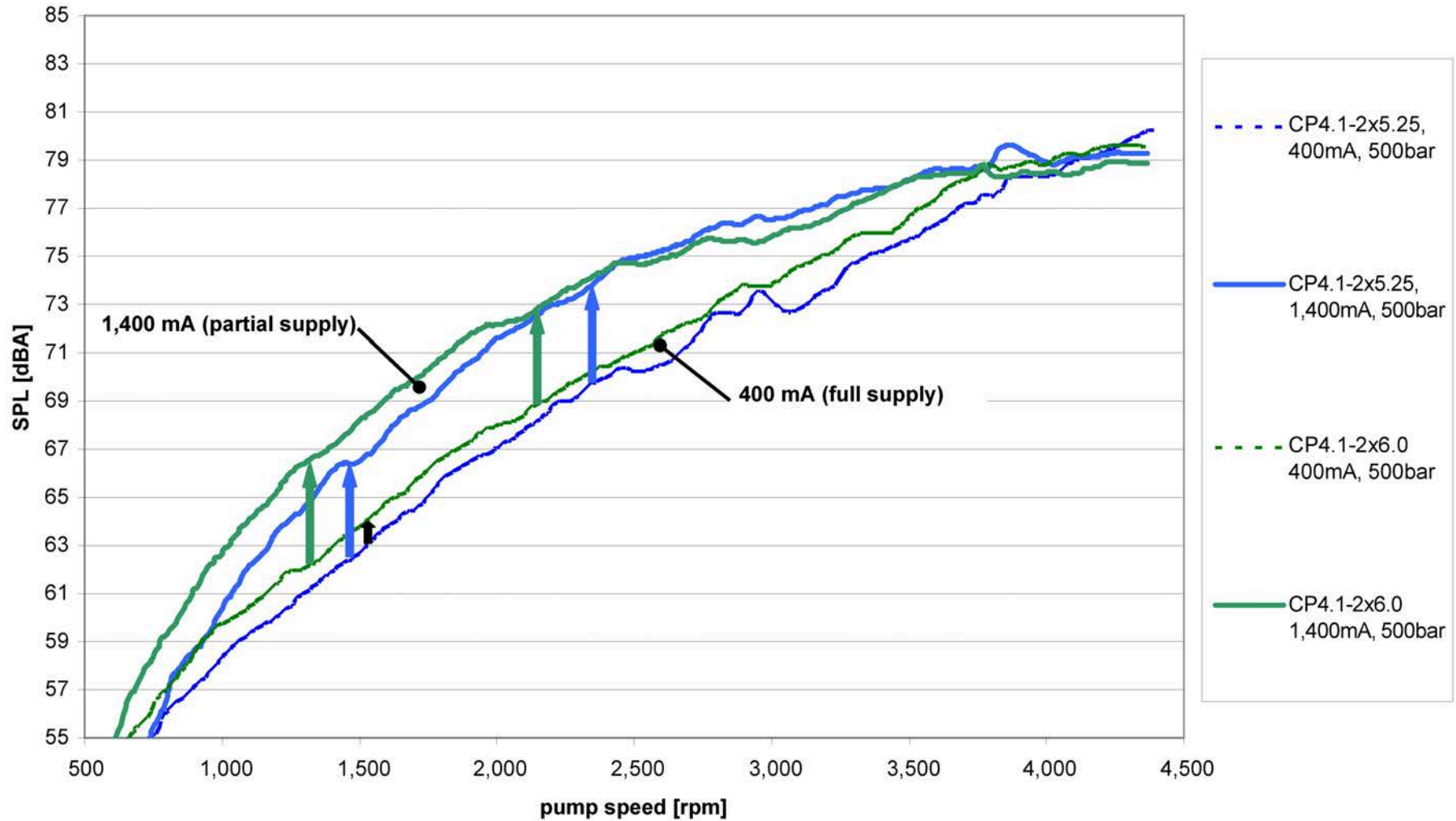


- average sound pressure level (SPL) from 10 microphones (hemispherical)
- sound reflecting surface
- setup similar to setup for acoustic power measurement DIN 45635



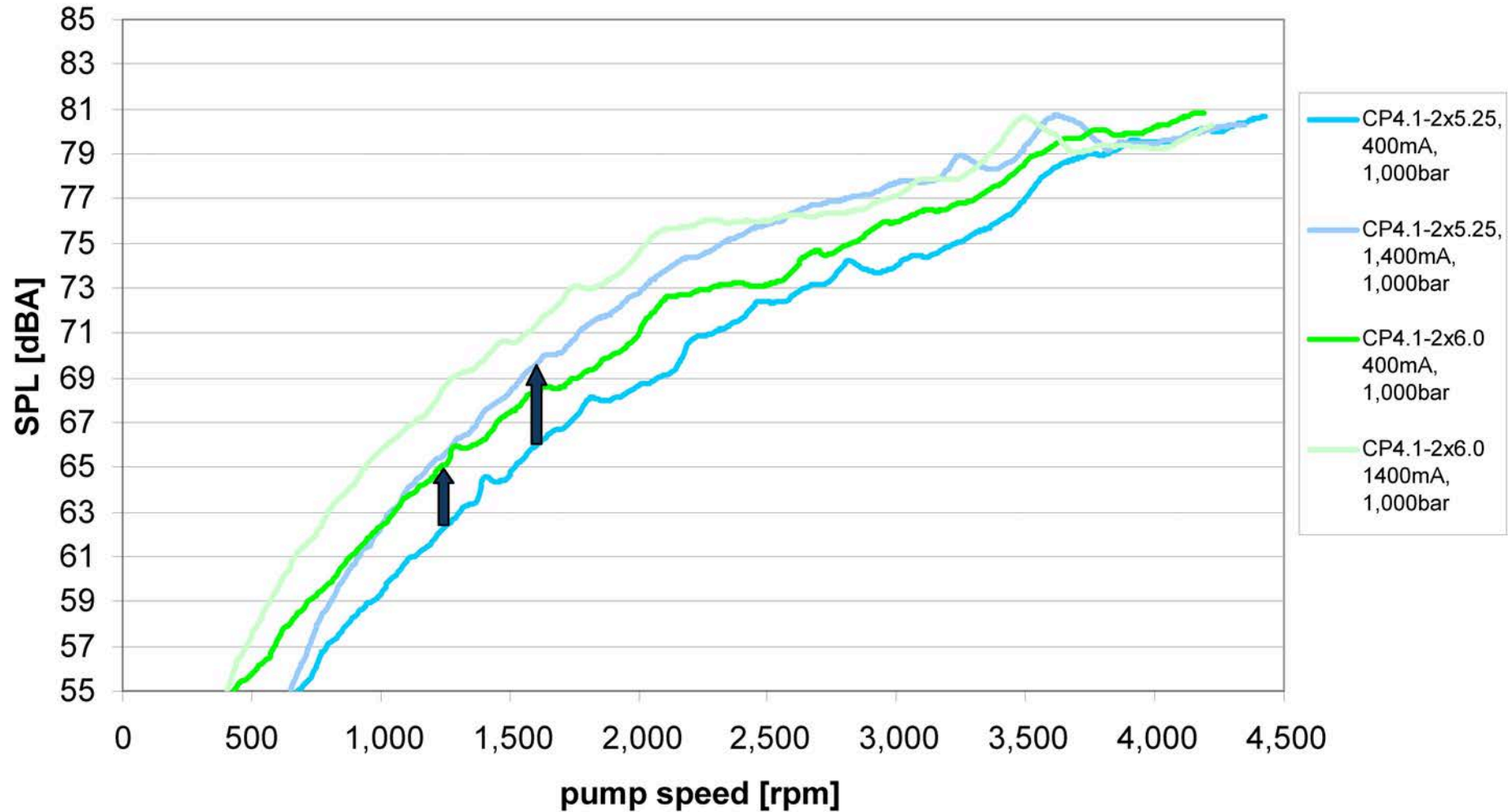
Noise measurement CP4.1 5.25 mm / 6.0 mm

CP4.1 pump noise = f(pump speed)
 $p_{rail}=500\text{bar}$



Noise measurement CP4.1 5.25 mm / 6.0 mm

CP4.1 pump noise = f(pump speed)
 $p_{rail}=1,000\text{bar}$



Noise measurement CP4.1 5.25 mm / 6.0 mm

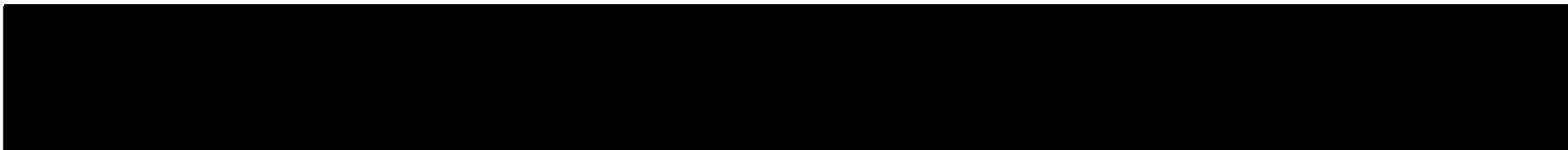
Result:

P_{Rail}	500 bar	1,000 bar
Cam lift 5.25 -> 6.0 mm	1-2 dB	2-3 dB
Fill level 400 mA -> 1,400 mA	4 dB	3-4 dB

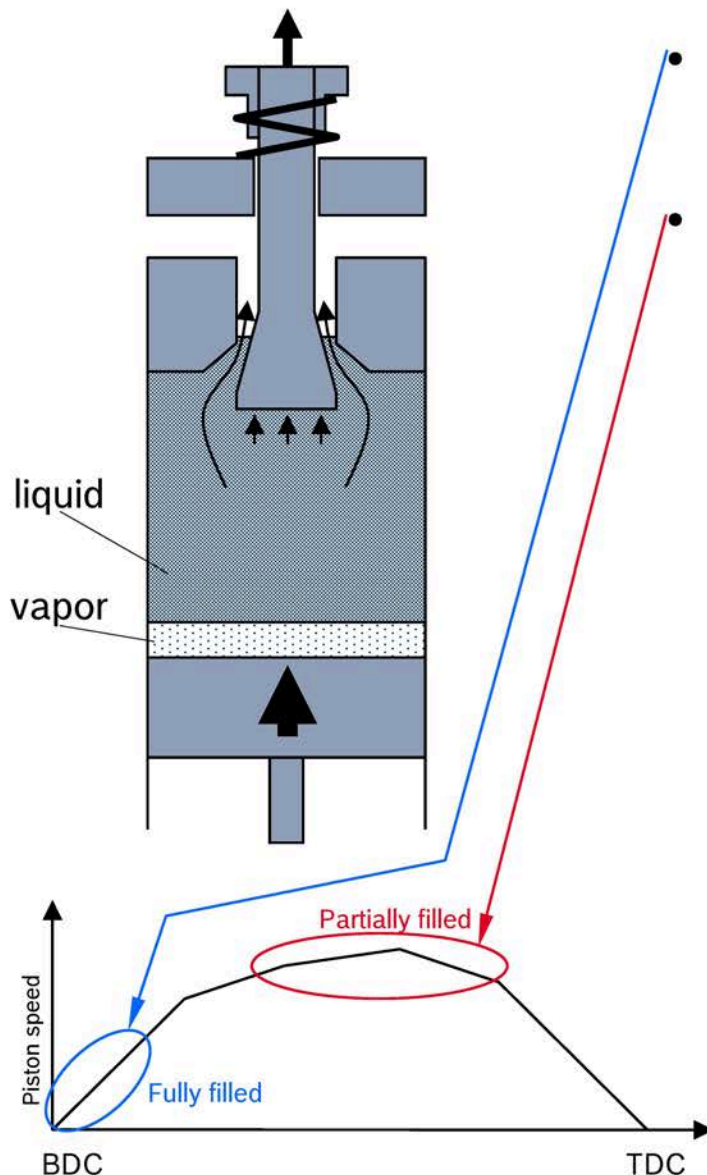
Summary:

- The dominant influencing factor is the pump speed or piston speed
- Influence of fill level can be measured; cause: piston speed = function (start of delivery, speed)

→



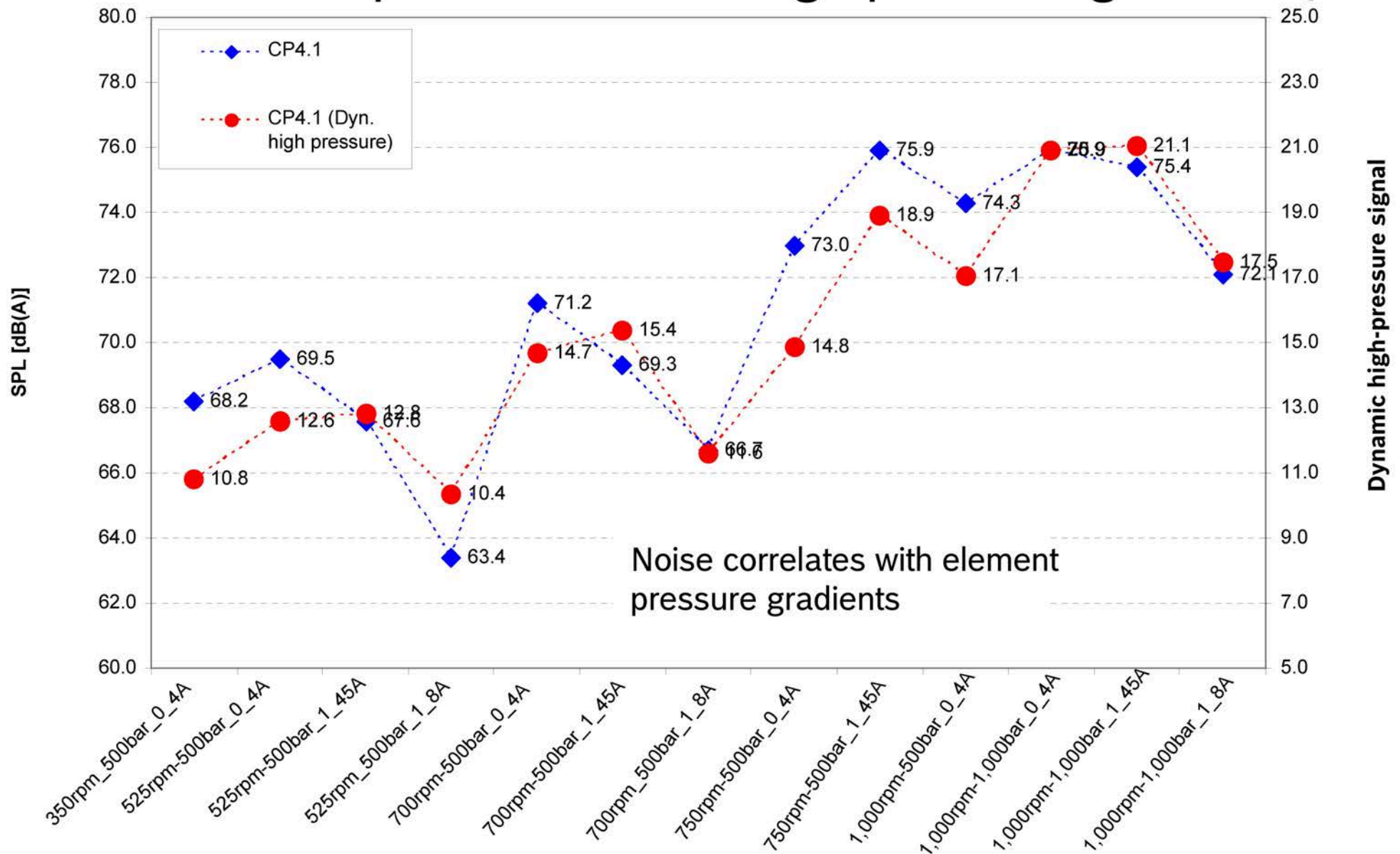
Noise mechanisms



- When filled fully, compression begins from bottom dead center with low piston speeds
- When filled partially, compression does not start until after bottom dead center (previous vapor phase). When the HP piston hits the fluid column, the piston speed is much greater than near bottom dead center (fully filled), the “water impact” has a greater impulse
 - => Piston impacts on the fluid phase (in vapor form, because intake valve is still open)
 - => System becomes hydraulically hard, large pressure gradients, opposing force of piston through plunging into housing
 - => Noise is a function of the piston speed at the time of the start of compression

CP4.1 for VW R4 2.0L EA189 – 79. PM 9/1/2009

Correlation sound pressure level - high pressure gradient (CP4.1)



Noise correlates with element pressure gradients



Assessment of noise reduction measures

Measures	Effect	Feasibility	Costs	Remark / side-effects
Reduce pump speed, lower piston speed	++	++	0	=> Transmission-related, alternative CP4.2 with $i=0.5$
Application higher fill level	+	++	0	=> Possibly greater heat entry => Higher fuel consumption
Sound insulation for engine -> styling cover longer, drawn further down, cover the currently exposed CP4 cylinder head	++	?	?	=> Global insulation possible => Possibly reduced cooling
Change cam shape	0	-	--	=> Cam design based on maximum supply level, minimization of Hertz-ian stress and torque (->Conflict of aims) => Optimization for noise would result in a loss of performance that would have to be compensated through a stroke travel increase <-> Higher piston speed / noise
Sound insulation for pump	?	?	-□	=> Effectiveness only for airborne sound from own emanations => No impact in case of excitation from other engine components => No impact in case of transfer of structure-borne sound through the assembly points => Greater construction compartment => Assembly at customer problematic (adaptation of LP/HP connectors) => Reduced cooling
Seat vapor IV -> Reduction of impact speed	0	--	-	=> Drop in supply level (performance), stroke increase necessary <-> Greater piston speed / noise => Greater wear (unfavorable seat angle difference)
Change spring rate / pre-tension of tappet spring	0	-□ □	-□	=> No detectable influence
Stiffen housing	0	-□ □	-□ □	=> Laser vibrometry shows regular oscillation of the housing surface with the clamping (3D vibration test) => No potential



CP4 noises

Summary:

- CP4.1 has been consistently optimized for cost and effectiveness, at the expense of noise
- Optimization for noise is a conflict of aims with optimization for costs and effectiveness
- CP4 noise is a function of the piston speed; any further active noise optimization will be at the expense of performance and costs
- Alternative with focus on noise optimization:
 - . CP4.2 with lower stroke travel, transmission $i=1$
 - . CP4.2 with same stroke travel, transmission $i=0.5$

