Agenda

Bearing configuration:

- Configuration/basic dimensions
- Bearing material PEEK
- Bearing simulation, bearing force measurements

Bosch trial:

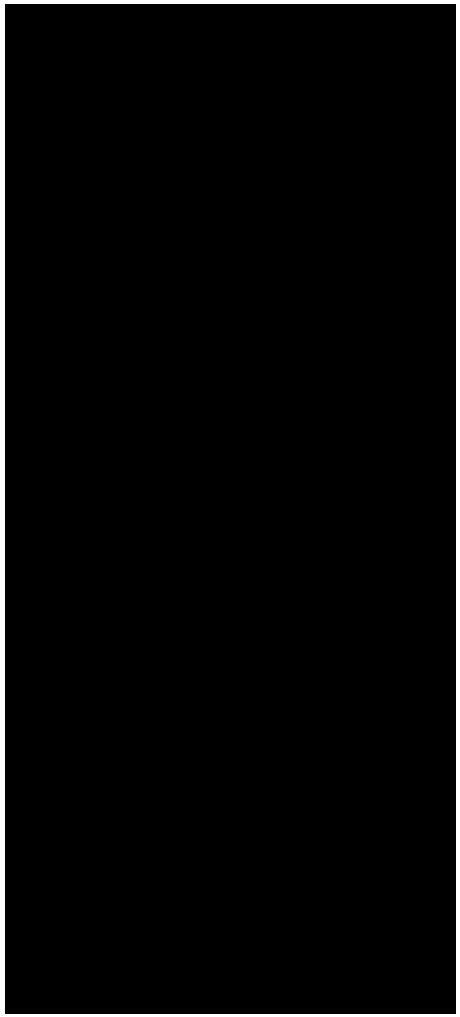
- Schedules
- Trial planning/results
- Analysis results

Audi trial:

- Trial planning/results

Pumps model status:

- Introduction of measures in model phases
- Overview of features Audi model pumps



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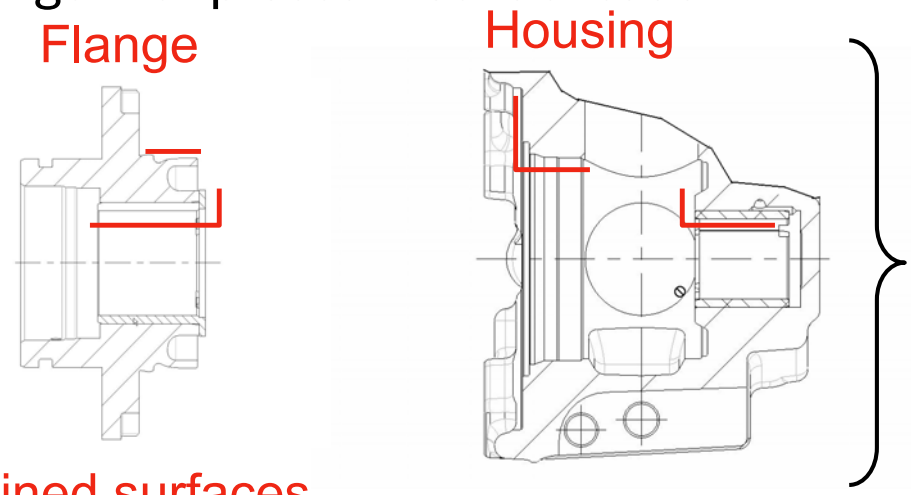
1. Configuration CP4 bearing

- Configuration of the design according to the aspects that are used in distribution pumps.
  - → Minor alignment error of the bearing points in relation to one another, by processing of the components with pressed-in bearing bush in one clamping procedure.
  - → Precise alignment in relation to the main loading direction. Close play tolerance possible.
  - → Minimum axial offset of the bearing points in relation to one another.
  - → Bearings with pressurized lubrication



Fitting diameter and bearing of flange and housing in each case with pressed-in bearings, produced in one clamping procedure

2. Basic dimensions CP4 bearing

Flange bearing:

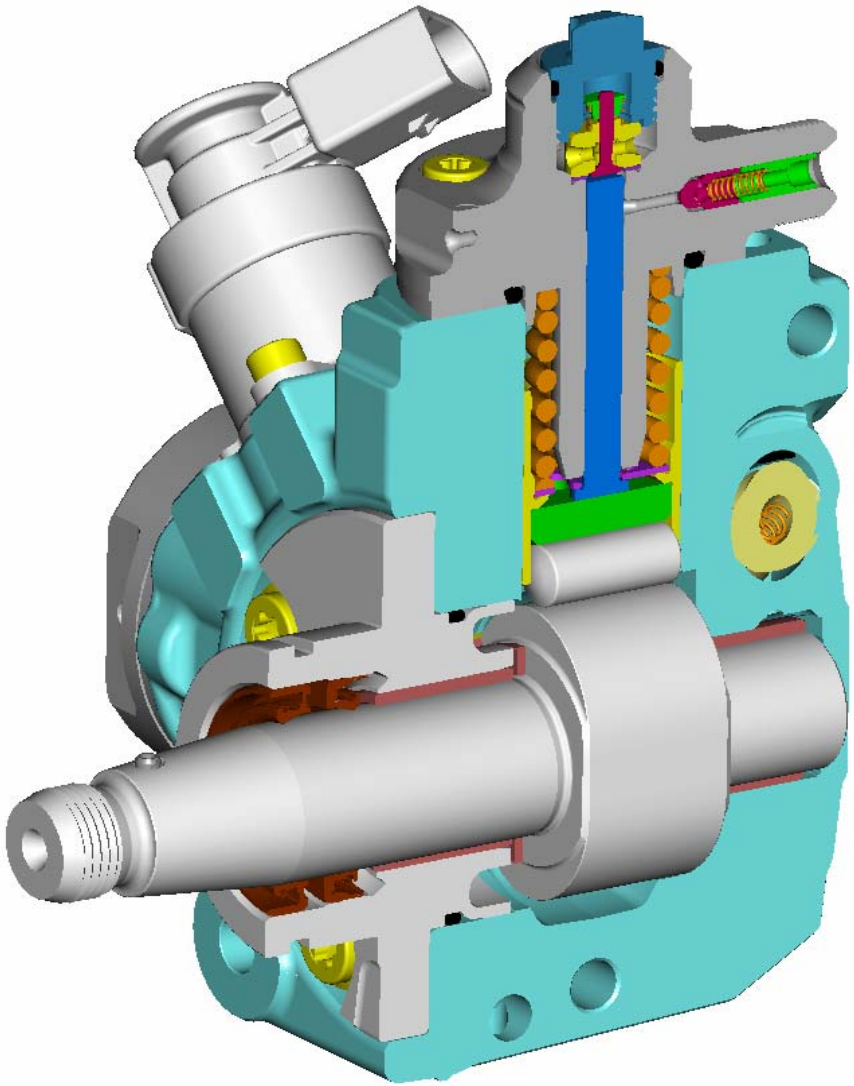
- Effective length: 23mm
- Shaft diameter: 25mm
- Flange hole diameter: 29mm

Housing bearing:

- Effective length: 20mm
- Shaft diameter: 22mm
- Flange hole diameter: 26mm

PEEK bearing:

- Steel back thickness: 1.75mm
- PEEK coating thickness: 0.4mm
- Machined bearing thickness: 2mm



Presentation KS

Bearing force calculation CP4

Procedure static bearing load calculation, conventional method:

- Measurement of the bearing forces with instrumented pump on engine:
  Force vector ***F'***(*t*) in the rotating reference system of the shaft, conversion into resulting force without consideration for the force vector
- Calculation of the piston forces in the pump by element space or rail pressure
- Calculation of bearing forces by the lever arms of the force application points
- Forces as scalable parameters
- Application points of bearing forces assumed to be in middle of bearing
- Result: statically calculated specific bearing load with limit value 14 N/mm²

- Spec. bearing force *F / (D * B)* with bearing width *B*, bearing diameter *D* ➔ does not distinguish between local load distributions!

- Remedy: Elastohydrodynamic plain bearing calculation

Bearing force calculation CP4

Procedure EHD => Elastohydrodynamic plain bearing calculation with EXCITE**:**

- Measurement of the bearing forces with instrumented pump on engine: Force vector ***F‘***(*t*) in the rotating reference system of the shaft
- Transformation into the laboratory system (housing system) with transformation (rotation) matrix **M**(t): ***F***(*t*) = **M**(t) ***F‘***(*t*).
- Amesim calculation (mechanical/hydraulic simulation) for determining the piston force and cam force, for corresponding rotation speed and rail pressure points
- Provision of an FEM model of the housing and an FE bar model for the shaft
- Application of the cam and drive force to the corresponding shaft node in EXCITE, EHD calculation with EXCITE

➔Calculation performed using realistic roughnesses, real bearing plays, fuel viscosities and forces

➔Results: * Specific bearing loads with force vectors
* Pressure distributions in the bearings

BOSCH

Bearing force calculation CP4

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Results of bearing force measurement W19 January 06:

Characteristic parameter	AUDI engine CP4.2 with 6 mm stroke	
Dynamic transverse force (force midpoint of pump cone)	200-2500N (values f. 4.5 mm)	
Specific bearing load peak value on housing bearing	7.9 N/mm²	Limit: 14 N/mm²
Specific bearing load peak value on flange bearing	11.7 N/mm²	Limit: 14 N/mm²

- Calculation of the internal pump forces performed with data for the 6 mm pump
- The forces due to belt tension are calculated with the data of the 4.5 mm pump
- This means the assumption is realistic with regard to external forces, internal forces on the pump at 6 mm stroke are higher than with 4.85 mm
- Values calculated by EHD for cylindrical bearings

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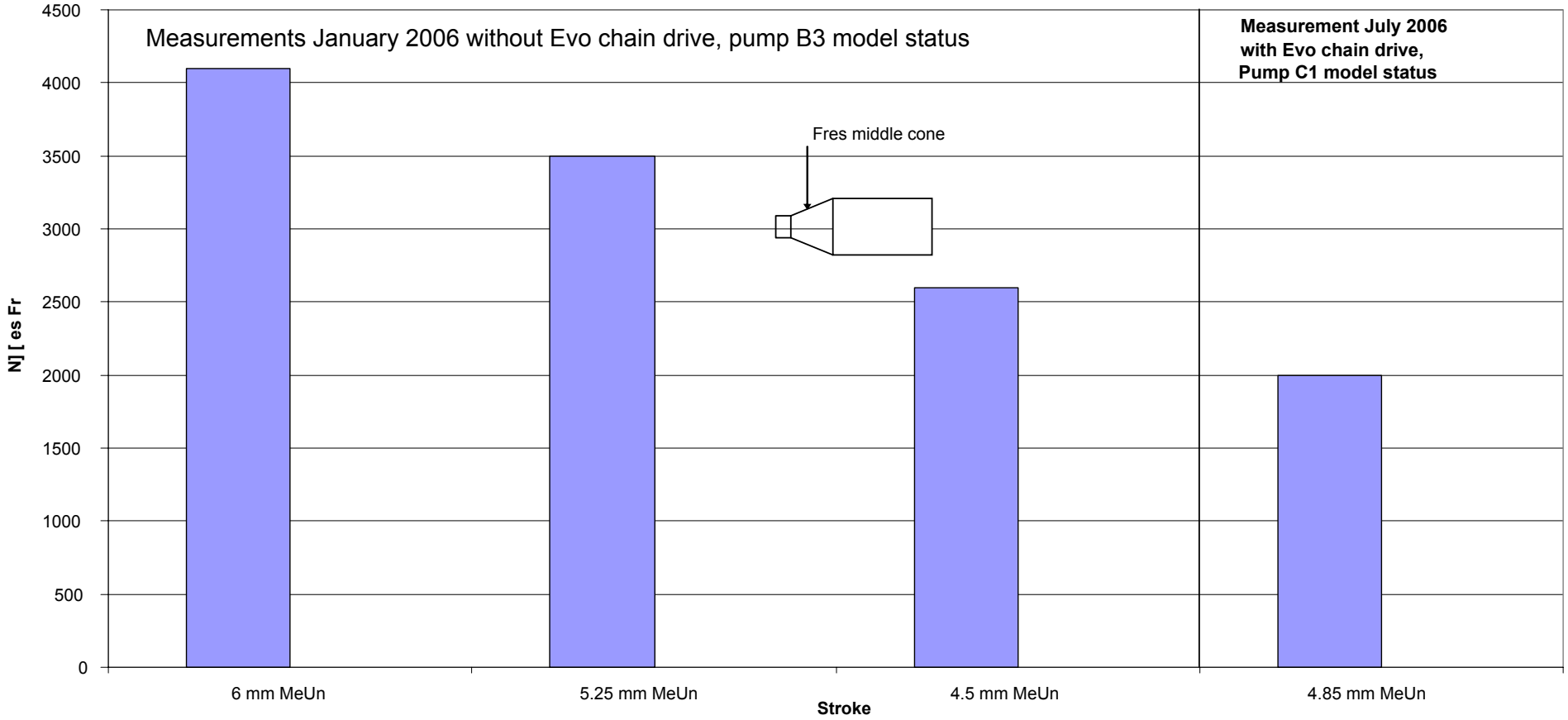
Bearing force calculation CP4

Comparison with current measurement (July 06):

Amounts of the resulting transverse force output from belt tension in relation to middle of cone CP4 are the maximum measured values in MeUn operation



- Internal pump forces due to 4.85 mm stroke lower than 6 mm stroke
- Measured external forces lower due to Evo chain drive

➔ Lower bearing load expected (calculation performed with current values)

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Bearing force calculation CP4

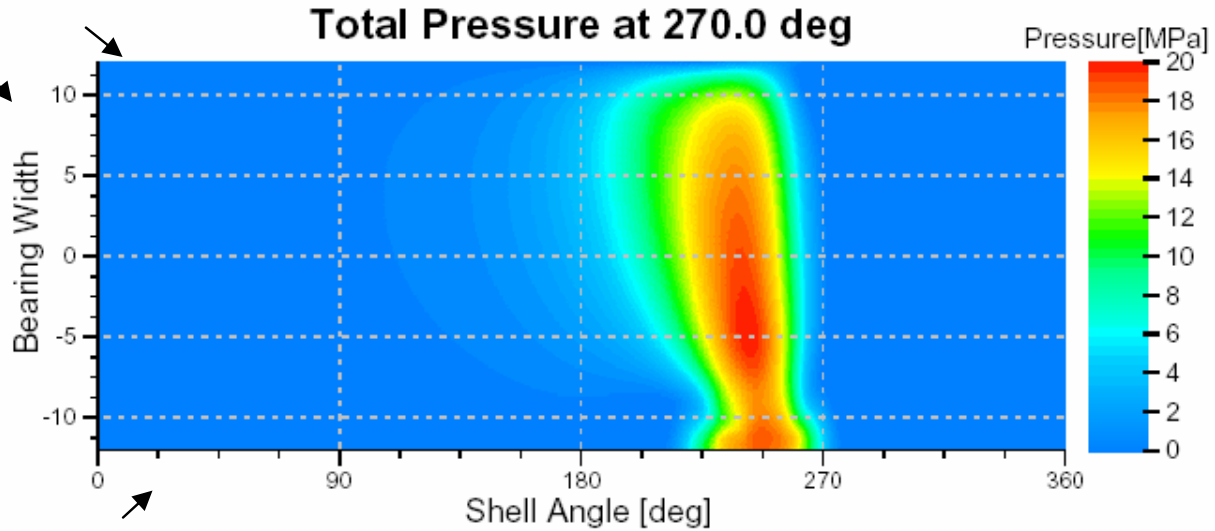
Results EHD: 2D pressure distribution in flange bearing

Definitions

Axial coordinates (Z-direction)

Cam angle

Cam end



Input end

Circumferential φ

0° = metering unit direction

- Pressure distribution in the bearing provides information about zones with high localized loadings
- Basis for parameter variation such as crowned bearing, for example

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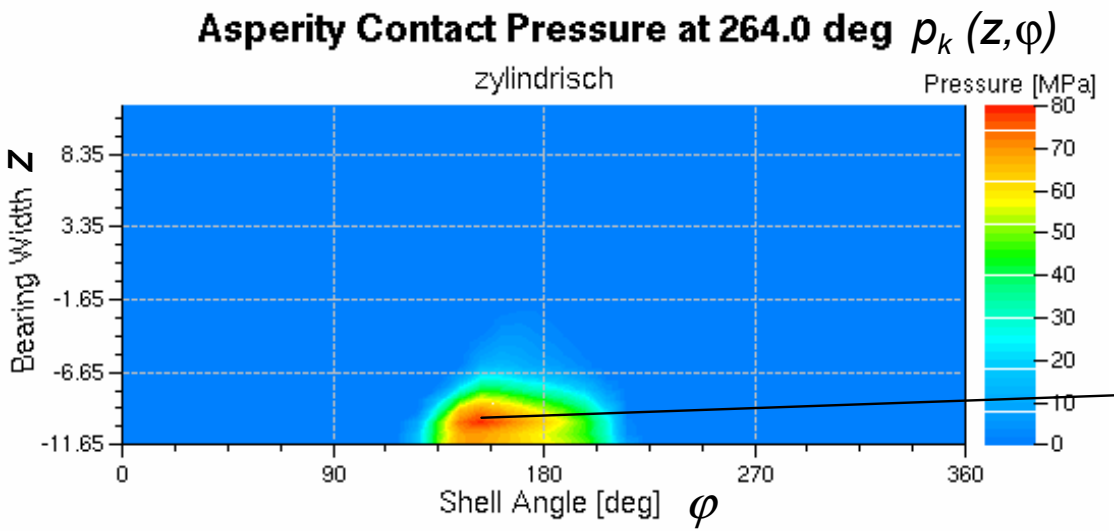
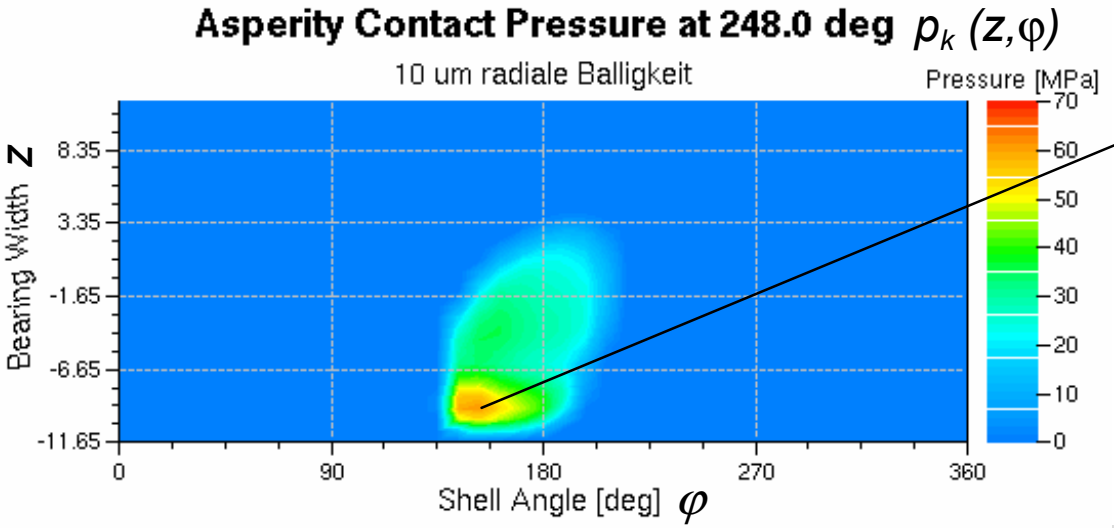
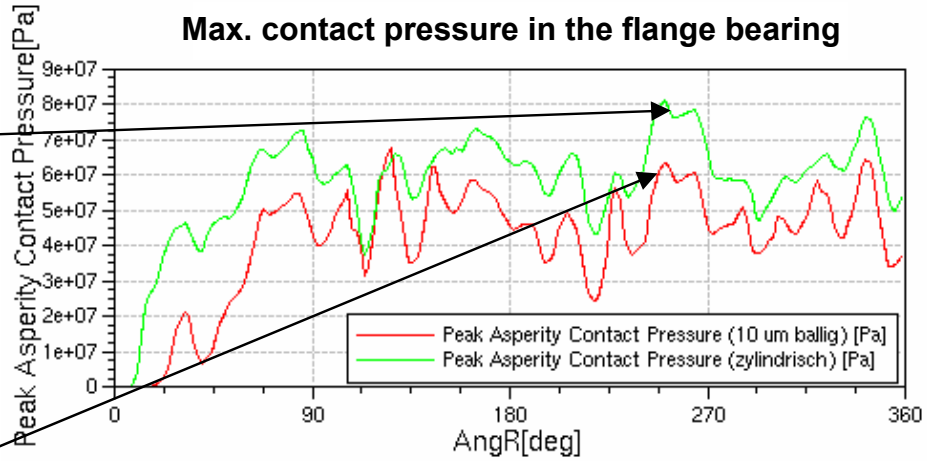
Example of contact pressure in the flange bearing





Cylindrical bearing



Cam angle (→ time *t)*

Crowned bearings

Note:
The values for the contact pressure are comparative values, not absolute values

Bearing force calculation CP4

Further work for Audi V6 TDI EU5:

- Calculation of the bearing load with values from the measurement in July 2006 (V6 with CP4.2 4.85 mm stroke and Evo chain drive)

- Comparison between bearing load for cylindrical and crowned bearing on the flange

Summary:

- Bearing load with Audi V6 TDI minimum

- Further development of crowned bearing with regard to critical applications, e.g. VW VR6

⇒ Results available by WK 37

CP4 technical meeting 8/2/2006

Schedule

	2006												2007												2008												2009											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
CP4.2																																															
V6TDI (EU5), 1800 bar				C			D	E		E					C																																	
EFP, stroke 4.85								E3		E1					2 days prod.																																	
CP4.2H																																															
V6TDI (EU6), 2000 bar			B								C										D		E				C																					
EFP, stroke 5.625																																															
Audi requirement:										WK 40 “C sample”															WK 22 “Release” sample																					
CP4.2H																																															
V6TDI (EU6), 2000 bar											B						C					D		E				C																				
EFP, AWP, stroke 5.625																																															
Audi requirement:									WK 36 “B sample”																	07.07 “Release” sample																					
CP4.2H																																															
V8TDI (EU5), 2000 bar																B						C						D		E		C															
EKP, stroke 5.625																																															
Audi requirement:										WK 40 BST 0.1																																							

A A-sample B B-sample C C-sample D D-sample E ISIR C RB SOP

Comment: **- 4 months delivery time for samples**
- Costs of sample statuses upon agreement with RB Sales

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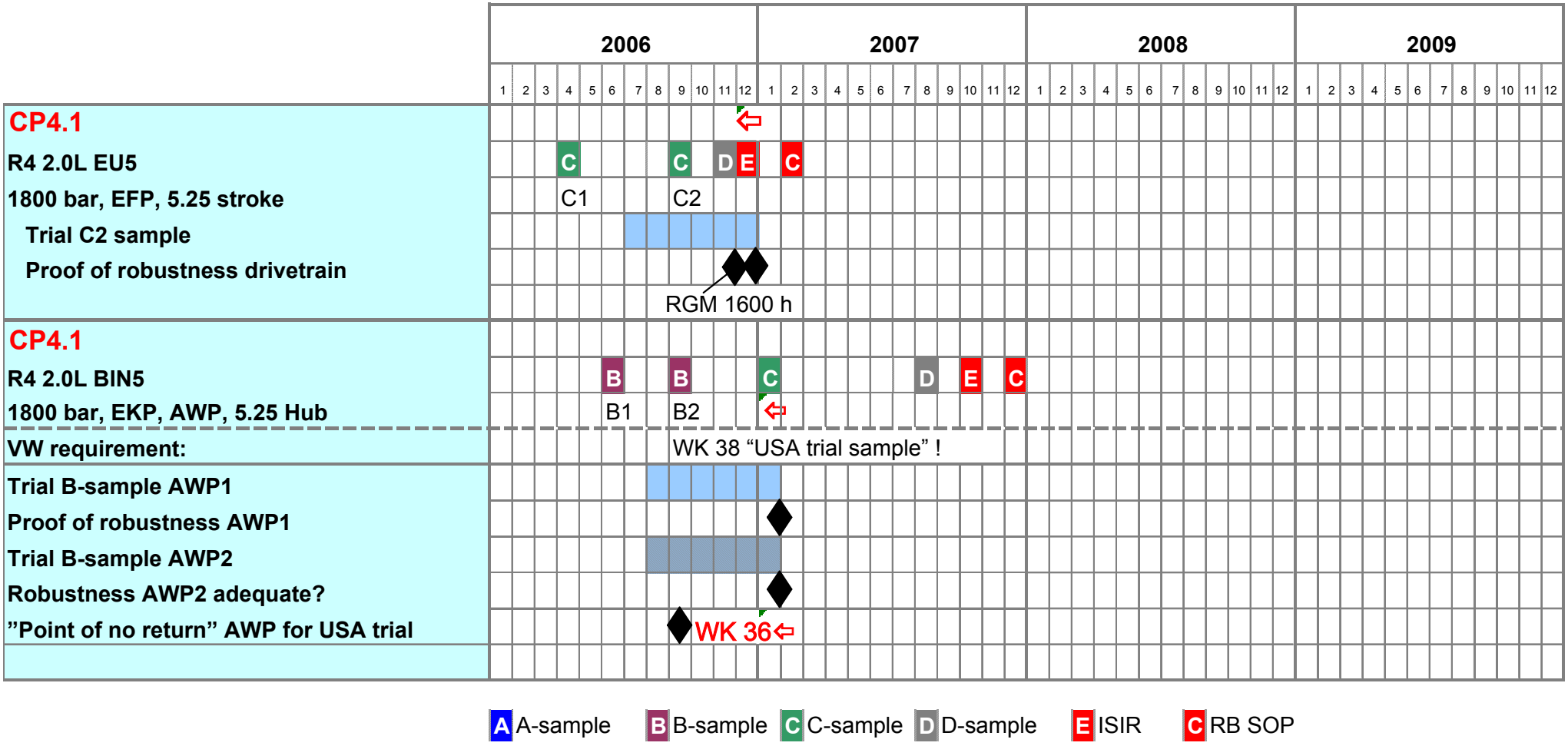
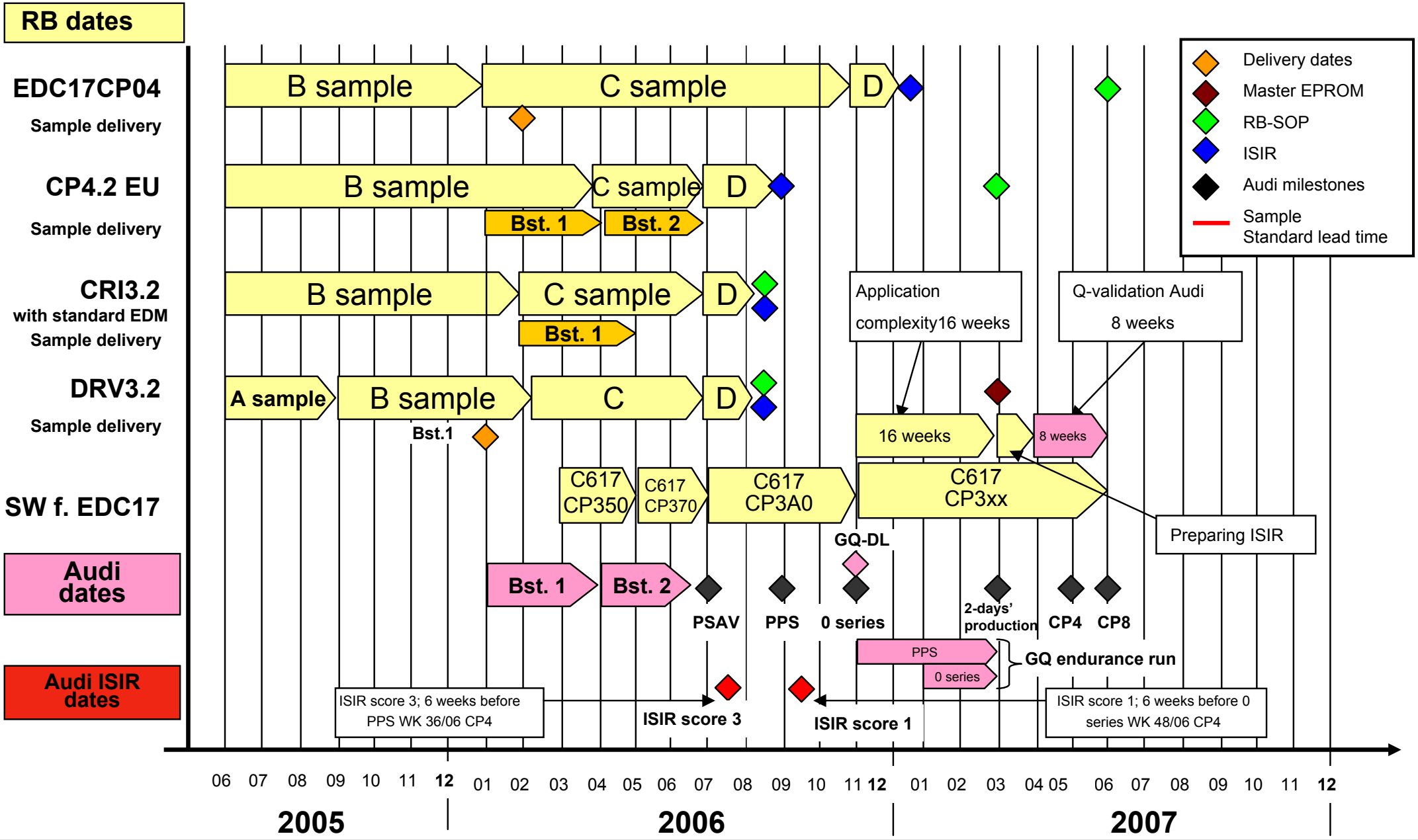
Schedule



Comment: **- 4 months delivery time for samples**
- Costs of sample statuses upon agreement with RB Sales

Deadline situation W19 EUROV SOP WK 22/07



Status: 4/5/2006

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CP4.1S endurance run status

		Nec. ER to achieve B10 target					ER status																															
		Part no	Pump no	M status	Stroke	ER progr	30.1	6.2.	13.2.	20.2.	27.2.	6.3 .	13.3	20.3	27.3	3.4.	10.4	18.4	24.4	1.5.	8.5.	15.5.	22.5.	29.5.	5.6.	12.6.	19.6.	26.6.	3.7.	10.7.	17.7	24.7	31.7	7.8.	14.8.	21.8.	28.8.	4.9.
Platform -1S 4. P C(B sample)		041_11	592-4595	B4	6	PER_2000	528	SB -> OK					635	768	930	1097	1263	1451	1592	1631	Drivetrain damage -> Perpendicularity tappet assembly outside tol.																	
		041_11	592-4596	B4	6	PER_2000	528	Drivetrain damage																														
		037_05	681-4707	B4	6	PER_2000	0	24	190	344	509	674	839	997	1146	1311	1471	1661	1802	1989	2039	ER passed																
		037_05	681-4708	B4	6	PER_2000	0	24	190	344	509	674	839	997	1146	1311	Drivetrain damage																					
		037_05	681-4709	B4	6	CER_1000		0	146	291	457	610	759	917	1080	ER passed																						
		037_05	681-4710	B4	6	CER_1000		0	146	291	457	610	759	917	1080	ER passed																						
Customer E E		050_02	682-4874	C1	5.25	PER_2000				0				498	650	787	951	1037	1175	1208	Drivetrain damage-> Perpendicularity RS + tappet assembly outside tol.																	
		050_02	682-4873	C1	5.25	PER_2000				0				540	627	771	872	1010	1151	1226	SB	1338	1504	1671	1830	1942	2000	ER passed										
		050_02	682-4871	C1	5.25	PER_2000				0				540	627	771	872	1010	1151	1226	SB	1360	1525	1641	1703	SB -> Continued running							1770					
		050_02	682-4872	C1	5.25	PER_2000						0		270	432	599	764	884	1036	1146	SB	1248	1413	1529	Drivetrain damage-> Perpendicularity RS + tappet assembly outside tol.													
		051_12	686-133	C2	5.25	PER_2000																								0	139	300	414					
		051_12	686-134	C2	5.25	PER_2000																								0	139	300	414					
		051_12	686-135	C2	5.25	PER_2000																								0	103	241	325					
		051_12	686-136	C2	5.25	PER_2000																								0	103	241	325					
A customer E A		066_03		C2	5.25	PER_2000																																
		066_03		C2	5.25	PER_2000																																
		066_03		C2	5.25	PER_2000																																
		066_03		C2	5.25	PER_2000																																

ER start: 09/2006
ER end: 12/2006

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CP4.2S endurance run status

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	Nec. ER to achieve B10 target					ER status																																
	Part no.	Pump no.	M status	Stroke	ER progr.	30.1.	6.2.	13.2.	20.2.	27.2.	6.3.	13.3.	20.3	27.3.	3.4.	10.4.	18.4.	24.4.	1.5.	8.5.	15.5.	22.5.	29.5	5.6.	12.6.	19.6.	26.6.	3.7.	10.7.	17.7.	24.7.	31.7.	7.8.	14.8.	21.8.	28.8	4.9.
CP42S-Platform + Platform Segment EE-Kunde	109_08	592-4607	B4	6	PER_2000	384	546	712	877	1043	1210	1369	1467	1606	1730	1893	**2011**	ER passed																				
	109_08	592-4614	B4	6	PER_2000	384	546	712	877	1043	1210	1369	1467	1606	1730	1893	**2011**	ER passed																				
	109_09	681-4730	B4	6	PER_2000		87	251	411	573	739	892	1053	1203	1312	1450	1636	1762	1950	**2017**	ER passed																		
	109_09	681-4731	B4	6	CER_1000	0	22	153	315	482	647	804	965	**1027**	ER passed																							
	109_10	681-4732	B4	6	PER_2000		65	229	389	551	717	870	1031	1181	1290	1428	1614	1740	1928	**1995**	ER passed																		
	109_10	681-4733	B4	6	CER_1000		0	131	293	460	625	782	943	**1005**	ER passed																							
	109_11	683-4336	B5 (C1)	5.25	PER_2000								0	31	142	300	422	569	690	796	SB		833	994	1151	1250	1406	1561	1726	1884	1944	**2000**	ER ended					
	109_11	683-4337	B5 (C1)	5.25	PER_2000								0	51	163	323	422	561	682	803	964	1075	1217	**1350**	Drivetrain damage -> Perpendicularity RS + tappet assembly Outside tol.												
	109_12	683-4446	B5 (C1)	4.85	PER_2000											0	130	179	348	513	583	627	684	835	995	1120	1267	1394	1534	1695	1849	1897						
	109_12	683-4447	B5 (C1)	4.85	PER_2000											0	150	271	405	531	667	811	975	1123	1289	1427	1581	1729	1816	1921	**2069**	ER ended						
	109_12	683-4448	B5 (C1)	4.85	PER_2000											0	130	179	348	513	653	805	960	1111	1271	1396	1543	1670	1810	1971	**2011**	ER ended						
	109_12	683-4449	B5 (C1)	4.85	PER_2000											0	150	271	405	531	667	881	960	1123	1289	1427	1581	1729	1816	1921	**2069**	ER ended						
CP4.2S Platform	133_07	685-..1006	B6 (C1-2)	6	PER_2000																				0	119	233	328	362	429	576	650					
	133_08	686-0140	B7 (C2)	6	PER_2000																								0	116	279	415					
	133_08	686-0143	B7 (C2)	6	PER_2000																									0	88	177					
	133_08	686-0144	B7 (C2)	6	PER_2000																							0	33	141	300	350					
CP42 SE E-Kunde	133_14		C2	4.85	PER_2000																																
	133_14		C2	4.85	PER_2000																																
	133_14		C2	4.85	S-PDL_2000																																
	133_14		C2	4.85	S-PDL_2000																																

ER start: 09/2006
ER end: 01/2007

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CP4 overload endurance run status

Type	Part no.	Mileage	Stroke	ER progr.	Nom. RT	Pump no.	15.5	22.5	29.5	5.6.	12.6	19.6	26.6.	3.7.	10.7	17.7	24.7	31.7.	7.8.	14.8	21.8
CP4.1S (i=1)	051_07	C1.2	6	n-HALT	250h	68511/052..04					0	63	178	**300**	ER completed						
				n-HALT	250h	68511/052..05					0	63	178	**300**	ER completed						
				p-HALT	150h	68511/052..06		0	10	150	SB		200	**250**	ER completed						
				p-HALT	150h	68511/052..07		0	10	150	SB		159	193	228	**250**	ER completed				
				18-stage test	18h	68511/052..010		active	**18h**	Test passed											
				18-stage test	18h	68511/052..011		active	**18h**	Test passed											
	051_09	C2	6	T-HALT	210h	68501…032				0	30	110	163	186	**210**	ER completed					
				HFRR-QALT1	500h	68501…034				0	58	98	215	353	**500**	ER completed					
				HFRR-QALT1	500h	68501…035				0	58	98	215	353	**500**	ER completed					
				18-stage test	18h																
	051_12	C2	5.25	Start/stop	500h	686-131									0	124	280	401			
				Start/stop	500h	686-132									0	124	280	401			
				T-HALT	210h	686-129											0	65			
				HFRR-QALT1	500h	686-130								0	131	291	456	**501**	ER completed		
	051_13	C2	5.25	various									ER start: 08.2006 ER end: 10.2006								
CP4.2S (i=3/4)	133_07	C1.2	6	p-HALT	150h	685/…04	0	50	150	SB		250	**300**	ER completed							
				p-HALT	150h	685/…05	0	50	150	SB		200	**300**	ER completed							
				T-HALT	210h	685/..1001			0	65	201	**210**	ER completed								
				T-HALT	210h	685/..1003			0	65	201	**210**	ER completed								
	133_08	C2	6	n-HALT	250h	686-0141						0	47	100	155	**250**	ER completed				
				n-HALT	250h	686-0142						0	47	100	155	**250**	ER completed				
	133_14	C2	4.85	n-HALT	250h																
					250h								ER start: 08.2006 ER end: 09.2006								
					250h																
					250h																
				various									ER start: 08.2006 ER end: 10.2006								

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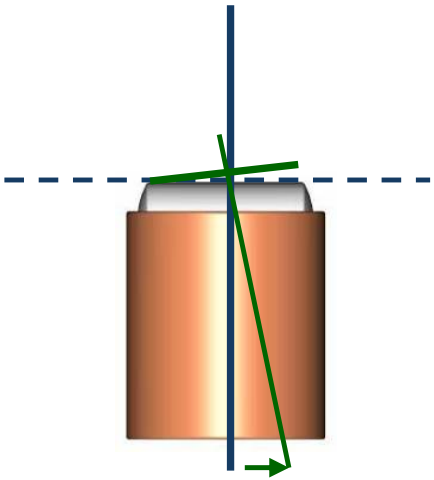
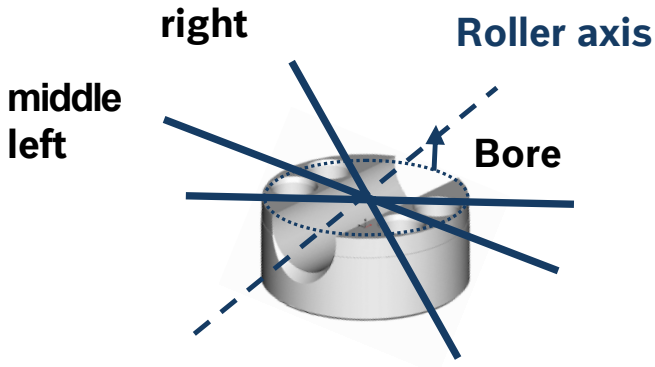
Tolerance compliance tappet assembly and roller support

Pump	90° angle Tappet module	Reference roller support jacket to floor	Roller hole to roller support material
CP4.2:			
➔ 683-4337-1	Actual: 33% *)	Actual: 60/130/180%	Actual: 555%
➔ 683-4337-2	Actual: 11%	Actual: 25/15/20%	Actual: 151%
CP4.1:			
➔ 682-4874	Actual: 85%	Actual: 130/310/20%	Actual: 72%
➔ 682-4872	Actual: 133%	Actual: 155/100/25%	Actual: 61%

*) Actual values in relation to tolerance limit





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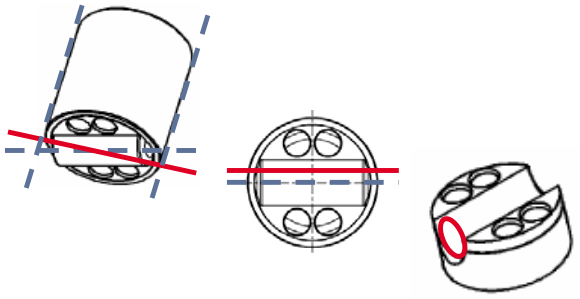
TAT results B5 sample failure #683-4337

Summary (1)

Significant causes for powertrain damage

- Based on a statistical characteristic comparison of failure and endurance run end pumps, the following three geometrical characteristics can mainly be identified as independently acting variables:
  - Perpendicularity of the roller in the tappet assembly
  - Position of the roller bore in the roller support or position of the roller in the tappet assembly
  - Diameter of the roller bore in the roller support (roller play)



- No geometrical value could be observed which had a probability of 100% for successful continuous running as the probability of failure is founded on one of the two other characteristics

Cause of the powertrain damage of pump #683-4337

- The characteristics of the pump do not differ from the 2000h endurance run end pumps

- However, the perpendicularity of the tappet assembly and diameter of the roller bore differ very significantly in the characteristic
  - position of the roller bore

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Summary (2)

Cause of the deviation in the roller position

- Production fault on the roller support jacket (perpendicularity between jacket and back) in conjunction with a roller support back that is not completely upright in the tappet body (roller support became aligned with the jacket during pressing in)

Measures for the features detected

- Perpendicularity of the rollers in the tappet assembly
  - Revised measuring process for perpendicularity
  - Restriction in tolerance to 50% of the previous value (100% testing)
- Position of the roller hole in the roller support in relation to the jacket
  - Process change: Measure of perpendicularity of the jacket in relation to the back is now in the grinding wheel and no longer in the clamping
  - Restriction in tolerance for perpendicularity of jacket in relation to back to 50% of the previous value
  - Temporary 100% visual check for complete contact of the roller support in the tappet body
- Diameter of the roller bore in the roller support
  - Shifting of average value and reduction in the roller play

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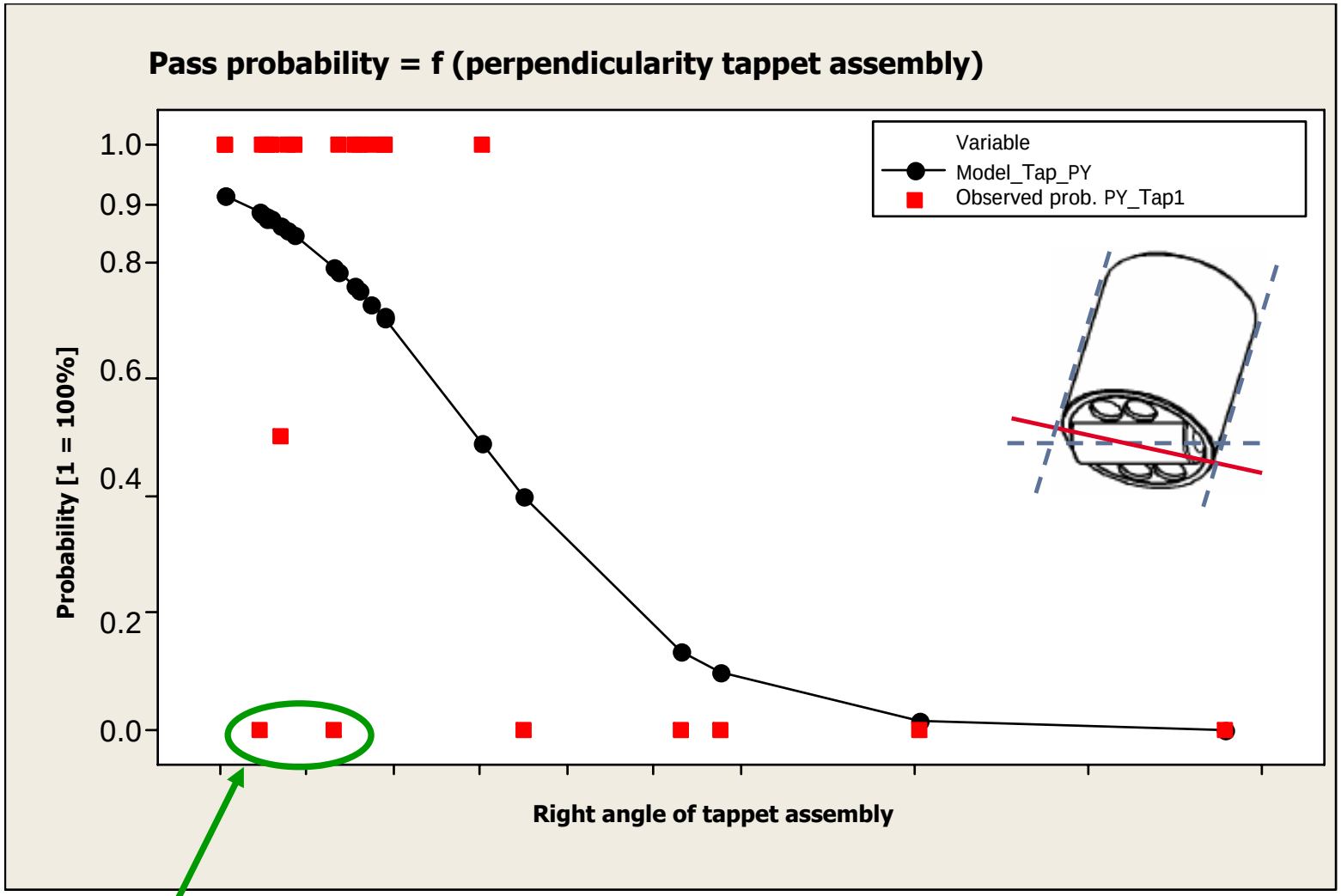
TAT results B5 sample failure #683-4337

Probability for ER end – perpendicularity



Pass

Failures

Perpendicularity values of the pump #683-4337

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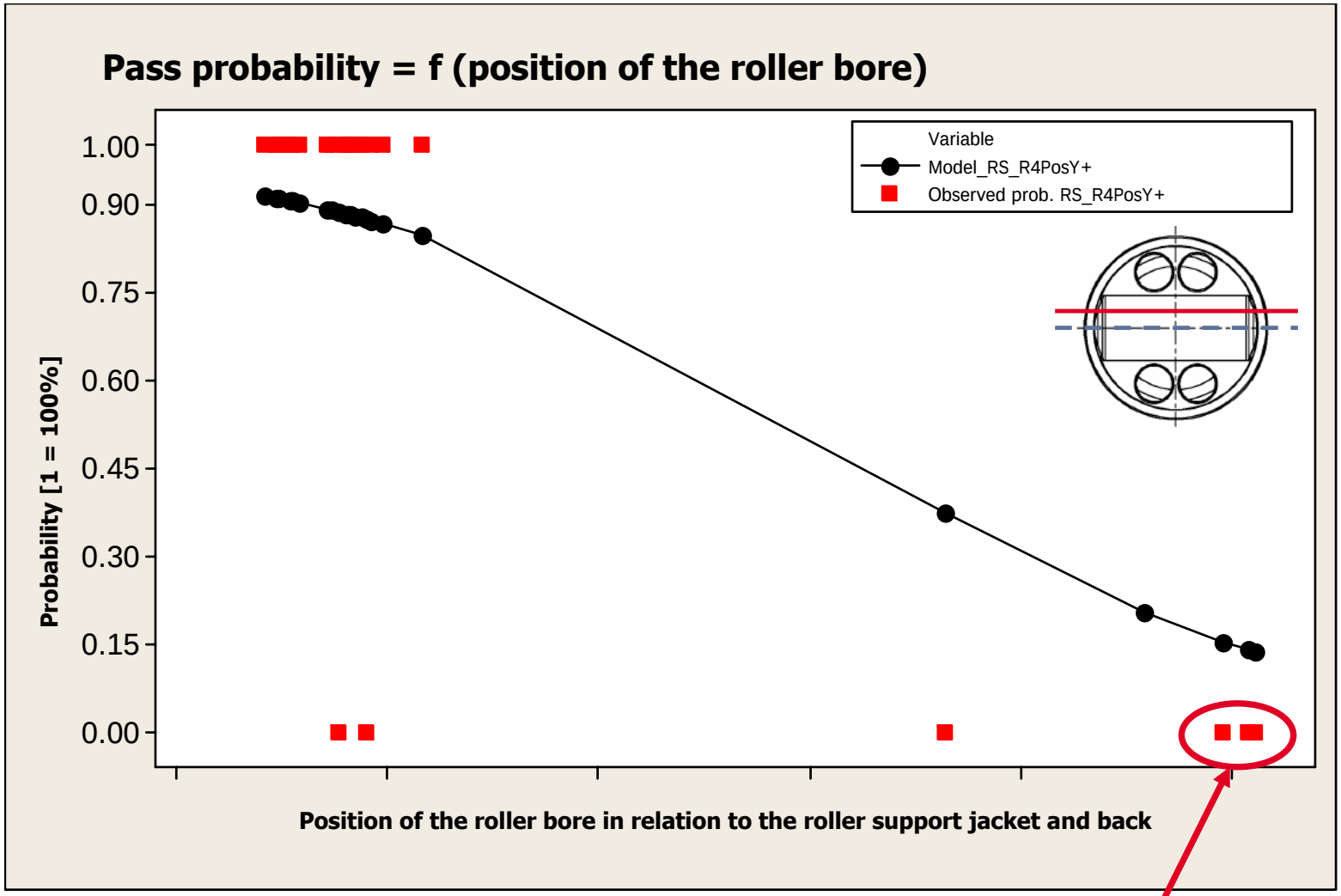
TAT results B5 sample failure #683-4337

Probability for ER end – position



Pass

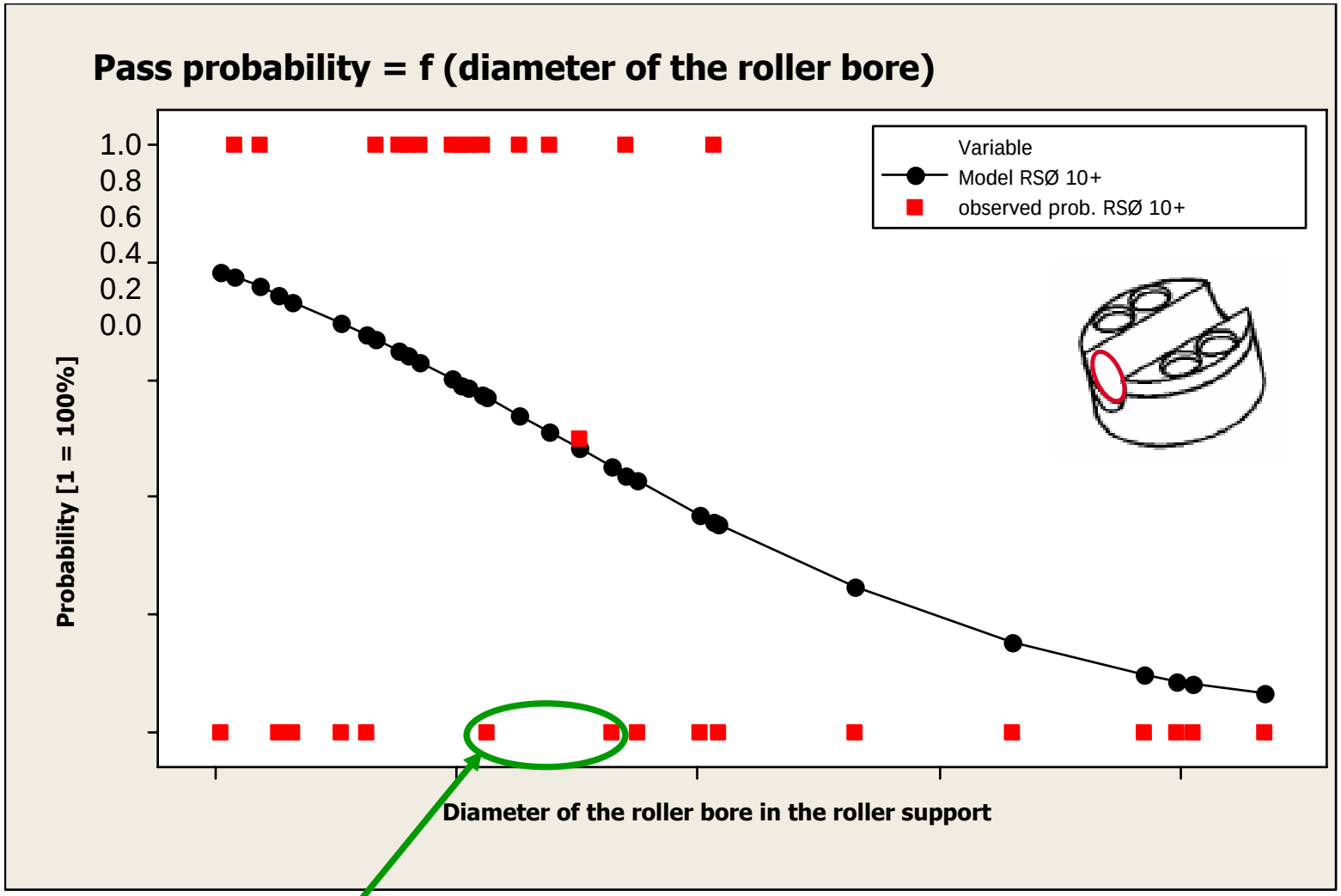
Failures

Position values of the pump #683-4337

BOSCH

TAT results B5 sample failure #683-4337

Probability for ER end – diameter



Pass

Failures

Diameter values of the pump #683-4337

Summary of the trial

- Measurement program B4, C1-sample from 10 “OK” and 10 “poor” ER pumps (PER) reveals the following basic statements:

  1. <500 h primary “sluggish roller”
  2. >1000 h wear / fatigue
  3. Parts in drawing tolerance achieve 2000 h
  4. If the tolerance is exceeded (angularity) then pumps fail due to “sluggish roller” and “fatigue”.

- Measuring program is continued continuously and extends over all special features

Summary:

- C2 sample trial from E 07.06 with parts measured according to the new measuring process
- First endurance runs and C2 samples reveal improvement <500 h.
- Results for wear behavior (>1000 h) | Nov 2006
- Internal endurance runs (accelerated) increase fault type and frequency
  ⇨ Ongoing comparison with customer returns

CP4 EFP AWP platform trial

CP4.x AWP platform trial B sample

Pump	Measure	Sample	Pressure	Trial programm	Running time	Status	Remark	Tol.
CP4.2	No AWP	B3	1800bar	PER (MY04)	88h	Failure	Drivetrain damage	
CP4.2	No AWP	B3	1800bar	PER (MY04)	88h	Failure	Drivetrain damage	
CP4.2	AWP1	B3	1800bar	PER (MY04)	171h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B3	1800bar	PER (MY04)	246h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B3	1800bar	PER (GDK650)	221h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B3	2000bar	PER (GDK650)	283h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B3	1800bar	Speed threshold	246h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B3	2000bar	Speed threshold	143h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B4	1800bar	PER (GDK650)	209h	Failure	Drivetrain damage	Not OK
CP4.2	AWP1	B4	2000bar	PER (GDK650)	500h done	OK		
CP4.1	Ceramic roller	B4	1800bar	PER (GDK650)	523h	Failure	Drivetrain damage (ceramic roller OK)	
CP4.1	Ceramic roller	B0	1800bar	PER (GDK650)	2000h done	OK		
CP4.1	Ceramic roller	B3	1800bar	n-HALT	247h	OK		
CP4.1	Ceramic roller	B0	1850/2050	p-HALT	92h	OK		

1) Components outside tolerance

2) Failures not in range of AWP measures

3) Total AWP trial is repeated in parallel with EN590 trial

Planning CP4.1 with AWP

CP4.1	**AWP2**	B1 (C2) 1800bar PER (MY04)	2000h planned	planned start WK 30/06	**(Rollers geom. B sample)**
CP4.1	**AWP2**	B1 (C2) 1800bar PER (MY04)	2000h planned	planned start WK 30/06	**(Rollers geom. B sample)**
CP4.1	AWP1	B1 (C2) 1800bar PER (MY04)	2000h planned	planned start WK 30/06	
CP4.1	AWP1	B1 (C2) 1800bar PER (MY04)	2000h planned	planned start WK 30/06	
CP4.1	AWP1	B1 (C2) 1800bar speed threshold (MY04)	277h planned	planned start WK 36/06	
CP4.1	AWP1	B1 (C2) 1800bar speed threshold (MY04)	277h planned	planned start WK 36/06	
CP4.1	AWP1	B1 (C2) 1800bar HFRR-QALT1 (PER GDK650)	500h planned	planned start WK 36/06	
CP4.1	AWP1	B1 (C2) 1800bar HFRR-QALT1(PER GDK650)	500h planned	planned start WK 36/06	
CP4.1	AWP1	B1 (C2) 1800bar PER (MY04) with DT	2000h planned	planned start WK 36/06	
CP4.1	AWP1	B1 (C2) 1800bar PER (MY04) with DT	2000h planned	planned start WK 36/06	
CP4.1	**AWP2**	B1 (C2) 1800bar HFRR-QALT1(PER GDK650)	2000h planned	planned start WK 36/06	
CP4.1	**AWP2**	B1 (C2) 1800bar PER (MY04) with DT	2000h planned	planned start WK 36/06	

Planning CP4.2 with AWP

CP4.2	AWP1	B1 (C1) 2000bar speed threshold (MY04)	277h planned	planned start WK 32/2006; then EoL PER
CP4.2	AWP1	B1 (C1) 2000bar speed threshold (MY04)	277h planned	planned start WK 32/2006; then EoL PER
CP4.2	AWP1	B1 (C2) 2000bar T-HALT (MY04)	210h planned	planned start WK 34/2006
CP4.2	AWP1	B1 (C2) 2000bar T-HALT (MY04)	210h planned	planned start WK 34/2006
CP4.2	AWP1	B1 (C2) 2000bar p-HALT (MY04)	150h planned	planned start WK 32/2006; then EoL PER
CP4.2	AWP1	B1 (C2) 2000bar p-HALT (MY04)	150h planned	planned start WK 32/2006; then EoL PER
CP4.2	AWP1	B1 (C2) 2000bar HFRR-QALT1 (PER GDK650)	500h planned	planned start WK 34/2006
CP4.2	AWP1	B1 (C2) 2000bar HFRR-QALT1 (PER GDK650)	500h planned	planned start WK 34/2006
CP4.2	AWP1	B1 (C2) 1800bar PER (MY04) with DT	2000h planned	planned start WK 36/2006
CP4.2	AWP1	B1 (C2) 20000bar PER (MY04) with DT	2000h planned	planned start WK 36/2006
CP4.2	AWP1	B1 (C2) 1800bar PER (MY04) with DT	2000h planned	planned start WK 36/2006
CP4.2	AWP1	B1 (C2) 20000bar PER (MY04) with DT	2000h planned	planned start WK 36/2006
CP4.2	AWP1	B1 (C2) 2000bar HFRR-QALT1 (PER Jet A1)	500h planned	planned start WK 40/2006
CP4.2	AWP1	B1 (C2) 2000bar HFRR-QALT1 (PER Jet A1)	500h planned	planned start WK 40/2006
CP4.2	**AWP2**	B1 (C2) 2000bar wcf test	168h planned	planned start WK 36/2006

Trial CP4-EFP with AWP

- Findings trials with CP4-EFP AWP1 (without ceramic roller) completed
  - Weak points regarding fault patterns identical to EN590, but with amplification factor
  - Robustness previously inadequate
- Brought-forward findings trials with AWP2 (4 pumps with ceramic roller) from 07/2006, but roller geometry and supplier different from the target solution

- Start internal B-sample trial with CP4-EFP and AWP2 (target solution; as customer sample) in WK 35/2006 (target)
- Supply of customer sample with AWP2 WK 38/2006

Measures packages in the individual pattern statuses for increasing robustness

CP4.2, B4:

- Housing mount increased from diameter 20 to 22
- Roller tip C-coated (reduction of friction at the point of contact and increase in wear resistance)
- Spring plate is anti-friction-coated below the tappet spring (reduction of the spring torque on the tappet combination)

CP4.2, C1:

- Stroke reduction + cam profile optimization
- Roller tip radius increased from R10 to R11. 5 (reduction of surface pressure at the contact point)
- Roller support 1 mm thick (reduction of surface pressure on roller support on roller)
- Housing in production version (more ribbing against torsion housing)

CP4.2, C2:

- Roller support finished after C-coat
- Process and measuring process optimization roller support
- Spherical bearing spigot, flange-sided

Stroke overview, differences in features CP4 for Audi/VW

	Audi V6 EU5	Audi V6 EU6/Bin5	Audi V8 EU5	VW R4 EU5/Bin5	VW R5 EU5	VW VR6 EU5
Design	CP4.2 CP4.2H		CP4.2H	CP4.1	CP4.2	CP4.2
Presupply	EFP	EFP	GP38	EFP	GP38	GP38
Rotation direction	right	right	right	right	right	left
Ratio	3/4	3/4	1	1	5/8	3/4
Cam pitch	**4.85**	**5.625**	**5.625(6)**	**5.25**	**5.25**	**5.625(6)**
Customer fitting	ø50mm long	ø50mm long	ø50mm short	ø50mm short	ø50mm short	ø68mm long
Shaft	long, cone DMR25	long, cone DMR25	long, cone DMR25	short, cones DMR25	long, cone DMR25	long, cone 25 short-ened (special type) -> Change refused at RB suggestion
Sealing	1 shaft oil seal	1 shaft oil seal	1 shaft oil seals	1 shaft oil seals	1 shaft oil seal	2 shaft oil seals
Housing connection	3 x M8 and 1 x M8 rear side	3 x M8 and 1 x M8 rear side	3 x M8 and 1x M8 rear side	3 x M8	2 x ø9 => 2 (3?)xM8	3 x D9 and chamfer on third attachment eye
HP output	1 x front, 1 x rear	1 x front, 1 x rear	2 x rear	1 x rear	2 x rear	2 x rear
LP output	2 x different nipples	2 x different nipples	2 x different nipples	2 x different nipples	2 x different nipples	2 x different nipples
MU	R1.8 (110 l/h) AK plug	R1.8 (110 l/h) AK plug	R1.8 (110 l/h) AK plug	MT 4.2 (200 l/h) AK plug	R 1.4 (95 l/h) AK plug	R1.8 (110 l/h) AK plug
Temperature sensor	No	No	No	No	Yes	Yes

CP4.2 for V6TDI EU5, differences in features of sample

		V6 TDI EURO 5						
CP	**Audi part number**	**059 130 755 M**	**n.d.**	**059 130 755 M**	**059 130 755 T**	**059 130 755 T**	**059 130 755 AB**	**059 130 755 AB**
	Audi milestone	**Bst. 1**	**Conversion from 6mm to 4.85mm stroke**	**Bst. 2**	**Bst. 2**	**Bst. 2**	**PSAV**	**PSAV**
	Delivery date (first delivery)	**WK 08/06**	**WK 20/06**	**WK 15/06**	**WK 23/06**	**WK 29/06**	**WK 27/06**	**WK30/06**
	AZ							
	RB part number pump	0 445 B20 127_ 01	0 445 B20 127_02	0 445 B20 133_01	0 445 B20 133_06	0 445 B20 162_01	0 445 B20 162_04	0 445 B20 162_05
	Sample	CP4 2 - B4	CP4.2 - B4	CP4.2 - C1	CP4.2 - C1	CP4.2 - C2	CP4 2 - C2	CP4.2 - C2
Flange / housing	Housing	Die-casting T5	Die-casting T5	Die-casting T5	Die-casting T5	Die-casting T5	Die-casting T5	Die-casting T5
	Pitch circle Ø [mm]	105	105	105	105	105	105	105
	Pitch circle configuration	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)
	Bearing material	PEEK	PEEK	PEEK	PEEK	PEEK	PEEK	PEEK
	Bearing Ø Housing/flange	22 / 25	22 / 25	22 / 25	22 / 25	22 / 25	22 / 25	22 / 25
	Flange	Forged part	Forged part	Forged part	Forged part	Forged part	Forged part	Forged part
	Flange proj. dimension	19 9	19.9	19.9	19.9	19 9	19.9	19.9
	O-ring on customer fitting	No	No	No	No	No	No	No
Camshaft	Cam	not optimized	optimized	optimized	optimized	optimized	optimized	optimized
	Stroke	6	4 85	4.85	4.85	4.85	4 85	4 85
	cylindrical bearing point	X	X	X	X		X	
	crowned bearing point					X		X
	Camshaft driver	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin
Drivetrain	Roller support	C-coated	C-coated	1 mm thickness increase C-coated	1 mm thickness increase C-coated	1 mm thickness increase C-coated	1 mm thickness increase C-coated	1 mm thickness increase C-coated
	Spring plate	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)
	Roller	Dome radius SR10 diameter of the Radius 4 mm C coated	Dome radius SR10 diameter of the Radius 4 mm C coated	Dome radius SR11.5 diameter of the Radius 3.0 mm C coated	Dome radius SR11.5 diameter of the Radius 3 0 mm C coated	Dome radius SR11.5 diameter of the Radius 3 0 mm C coated	Dome radius SR11 5 diameter of the Radius 3.0 mm C coated	Dome radius SR11.5 diameter of the Radius 3.0 mm C coated
LP	LP layout	EFP	EFP	EFP	EFP	EFP	EFP	EFP
	Overflow valve	pö = 3.3 bar	pö = 3.3 bar	pö = 3 3 bar	pö = 3.3 bar	pö = 3.3 bar	pö = 3.3 bar	pö = 3 3 bar
	Inflow pipe I-Ø	8	8	8	8	8	9 5	9.5
	Return pipe I-Ø	8	8	8	8	8	8	8
LP-connection	Supply	0 445 C20 821 AW 7075 T6	0 445 C20 821 AW 7075 T6	0 445 C20 881 AW 7075 T6	0 445 C20 881 AW 7075 T6	1 463 C70 001 AW 7075 T73	0 445 C20 784 AW 7075 T6	0 445 C20 980 AW 7075 T73
	Return	0 445 C20 821 AW 7075 T6	0 445 C20 821 AW 7075 T6	0 445 C20 881 AW 7075 T6	0 445 C20 881 AW 7075 T6	1 463 C70 001 AW 7075 T73	1 463 C70 001 AW 7075 T73	1 463 C70 001 AW 7075 T73
	MU	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)
	MU plug							
misc.	Remark							

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CP4.2 for V6TDI Bin5, differences in features of sample

		WK 02/06			
CP	**Audi part number**	**n.d.**	**059 130 755 R**	**059 130 755 AA**	**n.d.**
	Audi milestone				
	Delivery date (first delivery)	**WK 02/06**	**WK 15/06**	**WK 23/06**	**WK 36/06**
	AZ				
	RB part number pump	0 445 B20 120_01	0 445 B20 128_02	0 445 B20 142_01	0 445 B20 169_01
	Sample	CP4.2 - A	CP4 2 - B3 3	CP4.2 - B4	CP4 2H - A
Housing / flange	Housing	Die-casting	Die-casting T6	Die-casting T6	Die-casting T6
	Pitch circle Ø [mm]	105	105	105	105
	Pitch circle configuration	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)	3-hole (thread M8)
	Bearing material	PEEK	PEEK	PEEK	PEEK
	Bearing Ø Housing/flange	20 / 25	22 / 25	22 / 25	22 / 25
	Flange	Forged part	Forged part	Forged part	Forged part
	Flange proj. dimension	19.9	19.9	19.9	19.9
	O-ring on customer fitting	No	No	No	No
Camshaft	Cam	not optimized	optimized	optimized	optimized
	Stroke	6	4 85	4.85	5.6
	cylindrical bearing point	X	X	X	
	crowned bearing point				X
	Camshaft driver	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin	Cone with clamping pin
Drivetrain	Roller support	C-coated	C-coated	1 mm thickness increase C-coated	1 mm thickness increase C-coated
	Spring plate	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)	Anti-friction coating (SFL 9540)
	Roller	Dome radius SR10 diameter of the Radius 4 mm C coated	Dome radius SR11.5 diameter of the Radius 4 0mm C-coated	Dome radius SR11 5 diameter of the Radius 3 0 mm C coated	Dome radius SR11.5 diameter of the Radius 3.0 mm C coated
LP	LP layout	EFP	EFP	EFP	EFP
	Overflow valve	pö = 3.3 bar	pö = 3 3 bar	pö = 3 3 ba r	pö = 3 3 bar
	Inflow pipe I-Ø	8	8	8	9.5
	Return pipe I-Ø	8	8	8	8
LP-connection	Supply	0 445 C20 595 AW 9002	0 445 C20 821 AW 7075 T6	0 445 C20 881 AW 7075 T6	0 445 C20 980 AW 7075 T73
	Return	0 445 C20 595 AW 9002	0 445 C20 821 AW 7075 T6	0 445 C20 881 AW 7075 T6	1 463 C70 001 AW 7075 T73
	MU	MU 4 (B sample)	MU 4 (B2 sample)	MU 4 (B2 sample)	MU 4 (B2 sample)
	MU plug				
misc.	Remark				

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Trial CP4-Audi:

Project management CP4-VW:

Design CP4-VW:

Function test CP4-VW:

Trial CP4-VW:

[redacted]

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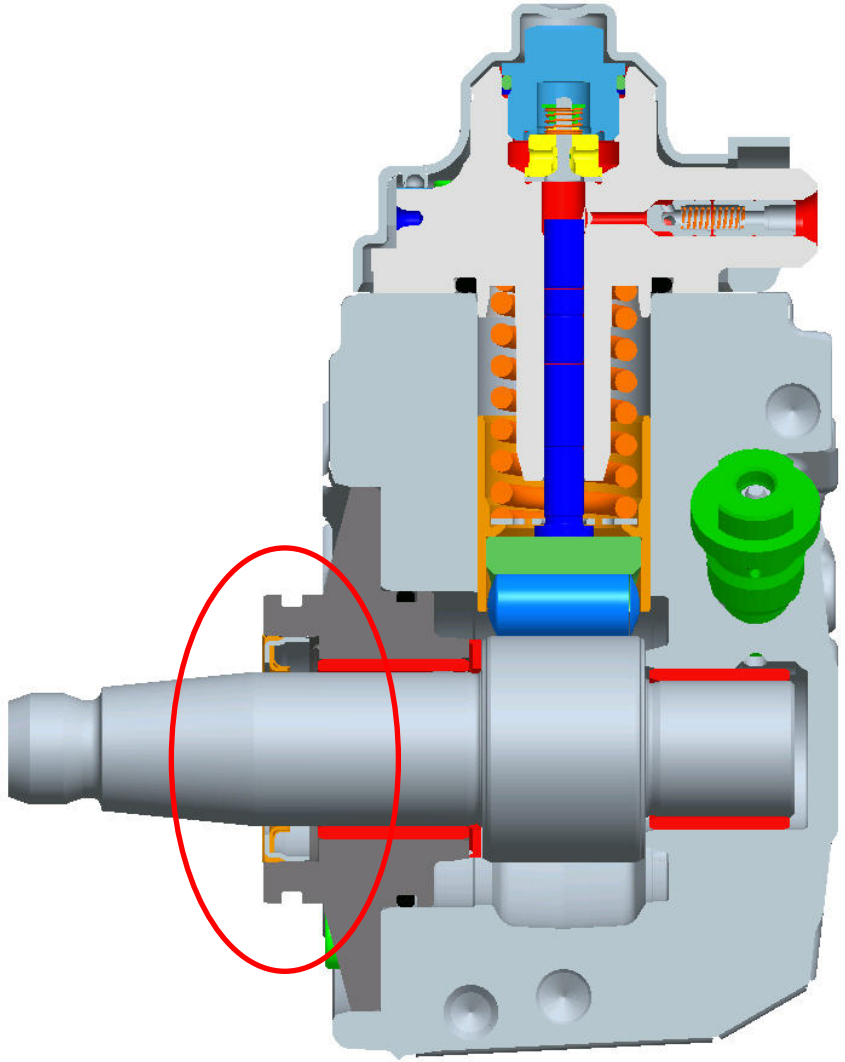
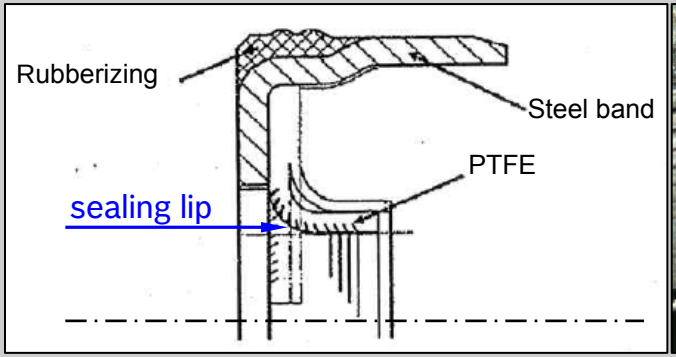
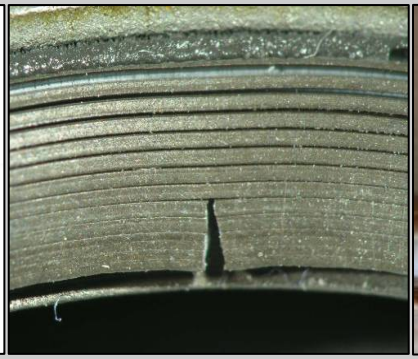
Status problems/measures CP 4

crack in oil seal



Status problems/measures CP 4.1 (4 cylinder) crack in oil seal: **Summary**



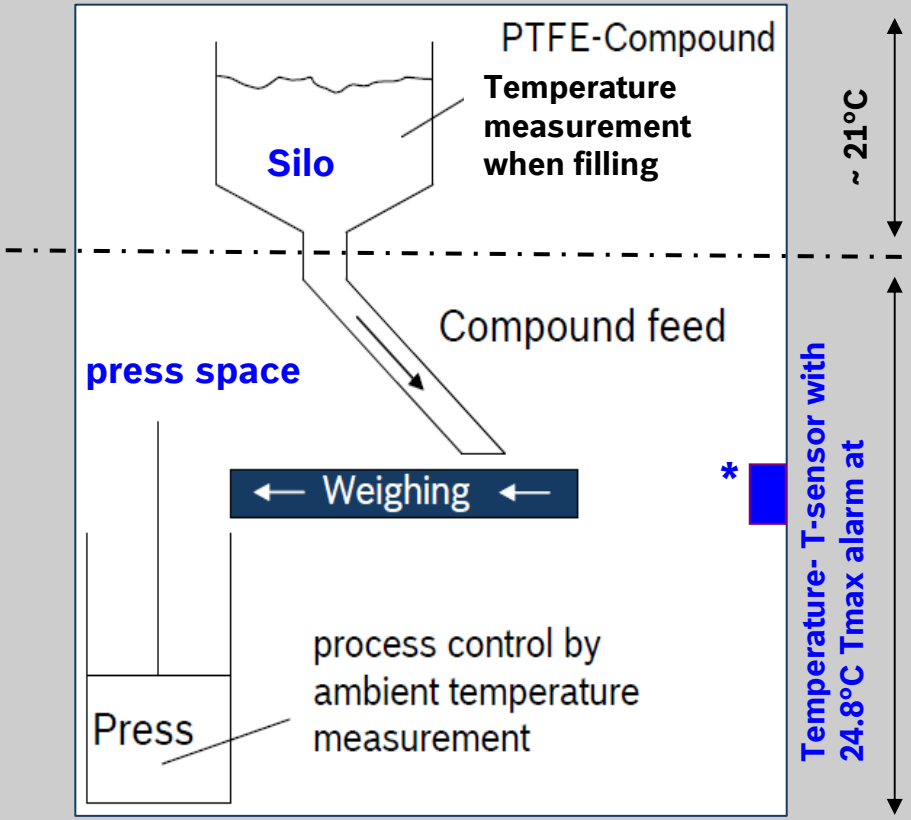


Problem	Leaking CP4 due to crack in oil seal	
Cause	Process temperature exceeded when pressing on the oil seal blanks at the supplier	
Status	27 0 km (12 VW, 15 Audi), 7 (+ 5 not yet confirmed) VW field complaints	
Immediate measure	Pulse bubble test of ongoing series production and warehouse stocks at Bosch and VW Group plants until clean date from	08/18/2010, done.
Corrective measures	Introduction of an additional air-conditioning system in the press space	07/23/2010, done
	Investigation of the temperature and flow profile in the press space by Bosch room climate experts (incl. temperature measurement with 10 sensors and data logger)	09/1-2/2010, done.
	Reduction of the limit temperature of room monitoring	09/20/2010, done.
	Concept for optimizing the room air conditioning	11/26/2010
	Direct, proximity-type temperature measurement of the billet under examination	11/26/2010

Status problems / Measures CP 4.1 (4 cylinder)

Crack in oil seal: **Cause/temperature in the press space**

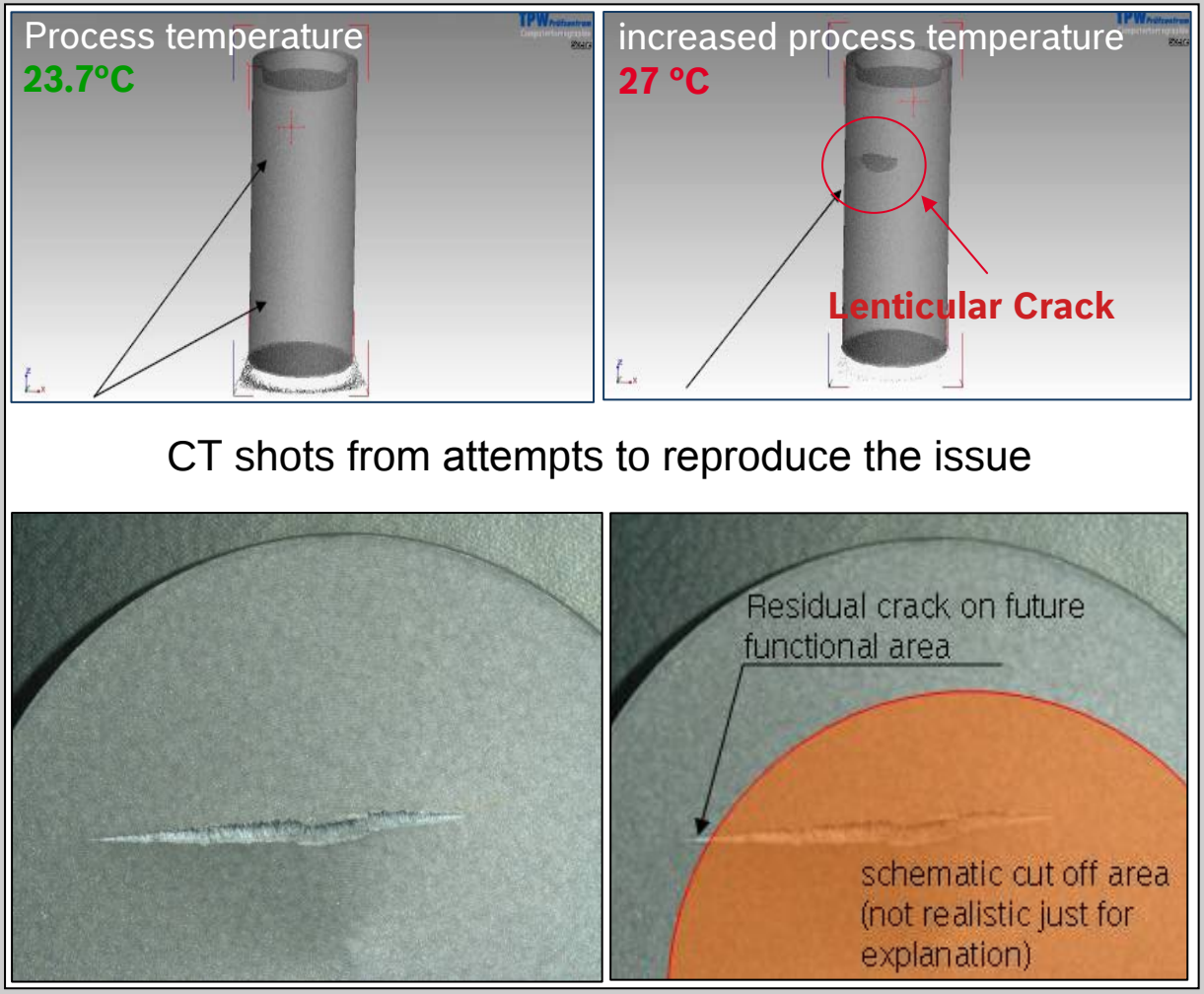
- The room temperature in the press space is set using a an air-conditioning system.
- The PTFE compound in the silo is held at a stable 21°C.
- A temperature sensor* on a wall supplies the control signal.
- The temperature distribution in the press space is not constant.
- A ΔT up to just under +2°C was measured between the sensor and the area above the press (by Bosch room climate experts).
- The press is switched off if the room temperature exceeds 24.8°C as measured on the temperature sensor.



Status problems/measures CP 4.1 (4 cylinder) crack in oil seal: **Cause / Fault mechanism**

If the powder temperature is too high when pressing, the viscosity of the material prevents correct outgassing of the air that is contained, so that the air remains in the blank prior to sinterizing.

Non-escaped air expands during the sinterizing process and can cause the matrix structure to burst
=> lenticular cracks



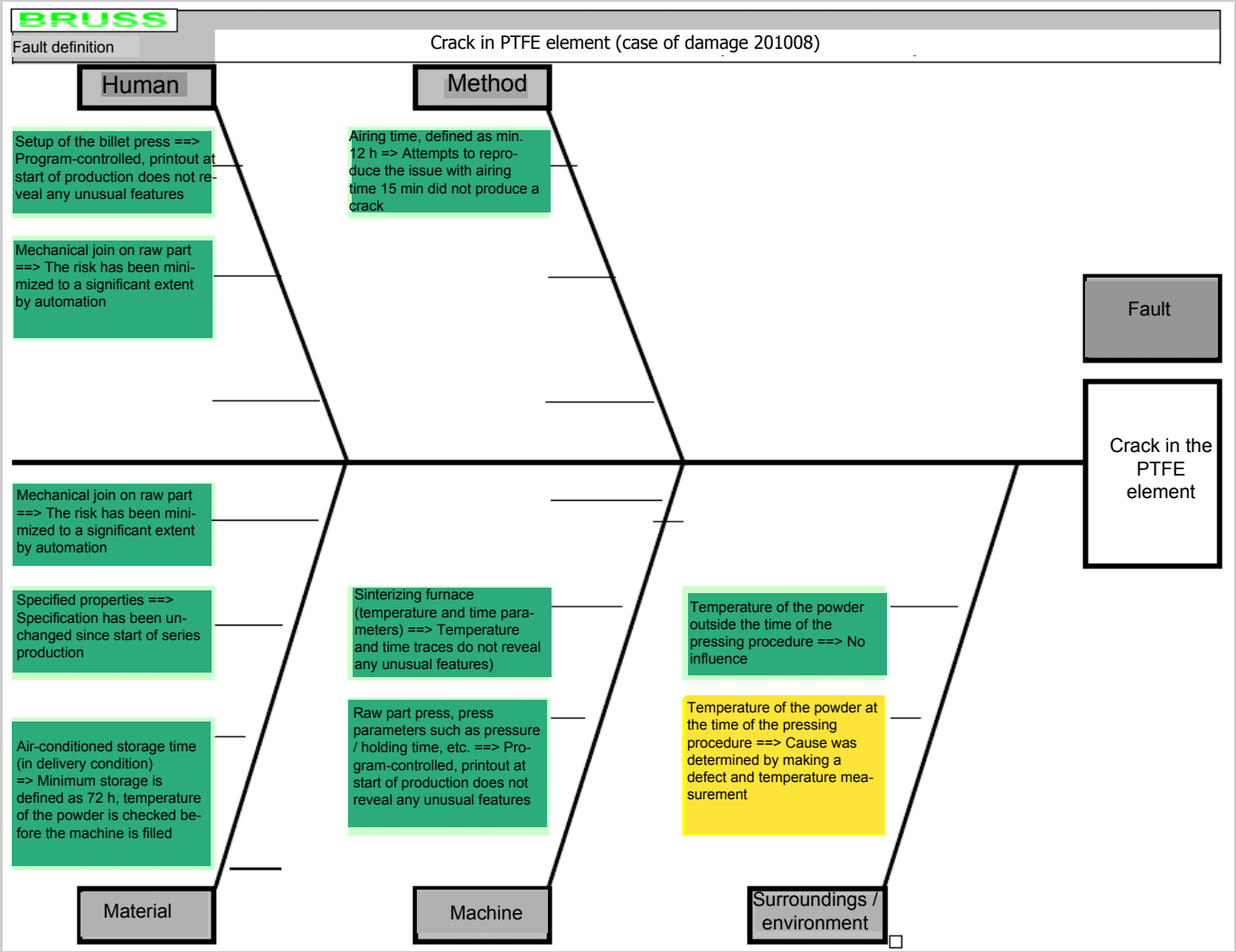
Status problems/measures CP 4.1 (4 cylinder)

Crack in oil seal: **Backup**

Backup

Status problems/measures CP 4.1 (4 cylinder)

Backup crack in oil seal: **Ishikawa**



Status problems/measures CP 4.1 (4 cylinder)

Backup crack in oil seal: **Pulse bubble test**