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### Committee D02 on PETROLEUM PRODUCTS AND LUBRICANTS

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August 1, 2007

Reply to:

Donald T. Bartlett

The Lubrizol Corporation

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ASTM D02.B0.03 L-37 Surveillance Panel

Members and Guests:

Attached for your review and comment are the unconfirmed minutes of the:

- o July 24, 2007 L-37 Surveillance Panel Teleconference Meeting

Please direct any corrections or comments to my attention.

Sincerely,

Donald T. Bartlett, Chairman

L-37 Surveillance Panel

Attachments

**Report of Meeting**  
**L-37 Surveillance Panel Teleconference**  
July 24, 2007

**I. Attendees:**

ASTM TMC:	Don Lind	Ethyl Corp:	Cory Koglin
Lubrizol Corp:	Don Bartlett	Lubrizol Corp:	Jerry Gropp
Dana Corp:	Don Kreinbring	SwRI:	Brian Koehler
PARC:	Dale Smith	Dana Corp:	Steve Bird
Lubrizol Corp:	Chris Prengaman	Dana:	Joe Guzikowski

**II. Agenda:**

- Review of progress and preparation for August 8, 2007 Surveillance Panel Meeting

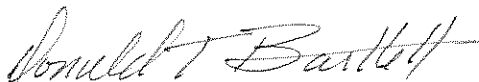
**III. Summary of Panel Discussion, Consensus Actions, and Motions:**

The below action items were discussed.

1. **June 27 meeting:** Mr. Fett kept Lubrizol sets CMIR 058195 and CMIR 058292 to perform further metallurgical analysis. The reports are included as Attachments # 1 and # 2. Especially note comments from the Pitting Analysis and Conclusions (they are \*).
2. **June 27 meeting:** The labs to send lubrited ring and pinion hardware only to Maumee facility for metallurgical analysis:
  - Lubrizol sent end of test ring and pinions from gear batches T758A/L245; P4L626A/V1L686, and P4L514A/V1L303.
  - Afton looking to find/send end of test ring and pinions from gear batch P4L309R/C1L308 and/or P4L404A/C1I426.
  - Parc is unable to send end of test ring and pinions from either gear batch P4L404A/C1I426 or P4L309R/C1L308.
  - Dana to provide metallurgical report to the August Surveillance Panel meeting.
3. **June 27 meeting:** The labs did express continued support for experimenting with a modified test procedure to allow the axle batch to be approved for use. Focus will be on both gear conditioning and gear test phase conditions.
4. **July 3 meeting:** The four labs did send two complete axle assemblies from the non-lubrited hardware gear batch P4L792/V1L417 to the attention of Joe Guzikowski at the Maumee facility.
  - All 8 axles were disassembled and all parts kept together as a unit. One lab sent in two axles that were lubrited from the B6L566 lubrited batch. Therefore, only three ring and pinions had the Ft. Wayne lubriting process and 3 axles had the alternate lubriting process.

- The axles were all reassembled and built to specification (proper position and preload) after the gears were phosphated. As long as you have gear sets with the correct phosphate coating it should make no difference whose original axle components were used as they are all the same part number.
  - The axle tubes will be marked appropriately.
  - The labs, upon receipt, will conduct two tests on TMC 153 as soon as possible and report the results to the TMC for panel review.
  - The labs agreed to save/send the End of Test ring and pinion back to Dana for further destructive analysis.
5. **July 24 meeting:** Dana to have internal discussions and report back to the August Surveillance panel meeting:
1. Cost and timing of providing a new batch.
  2. Quote a price for a new ring and pinion set. Let's evaluate an option of acquiring an outside source to rebuild the axle in a controlled environment since it appear that Dana is unable to perform this specific task at this time.

Respectfully submitted:



Donald T. Bartlett  
L-37 Surveillance Panel Chairman



**DANA SHARED SERVICES  
A.S.G. TECH CENTER  
3939 TECHNOLOGY DRIVE, MAUMEE, OH 43537  
MATERIAL SCIENCE DEPARTMENT REPORT**

*THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE CONSENT OF THE MATERIALS ENGINEERING DEPARTMENT.*

ASG LAB NO.	: 2007-0412	PART NO.	: 060GP104
PART NAME	: PINION – HYPOID DRIVE FIN	PRINT REV.	:
REP. TITLE	: GEAR, PINION	MODEL	:
MARKINGS	: #2 0 DANA 05 060GP104 41 7 PM3216 #5 0 DANA 05 060GP104 41 7 3206TG	HEAT CODE	: #2 B6L566 #5 B6L566
MATERIAL	: STEEL, SAE 8625, OPTIONAL GROUP C	MFG. DATE	:
VENDOR	: DANA – FORT WAYNE	SAMP. REQ.	: NA
CUSTOMER	: ASTM (L-37 COMMITTEE)	VIN	: NA
TAR NO.	:	MAR NO.	: 2772
TEST ENG.	:	REC'D DATE	: 6/27/2007
REQ. BY	: JOE GUZIKOWSKI	REP. DATE	: 7/6/2007
REP. BY	: TOM WOODARD	PAGES	: 7
TRP LAB NO.	: 907142		
ADD. COMMENTS	: THIS GEARSET HAS NOT BEEN ABLE TO DISTINGUISH BETWEEN ACCEPTABLE AND UNACCEPTABLE REFERENCE OILS.		
COPIES	: GREG FETT, JOE GUZIKOWSKI, DANA COMBS		
REQUEST	: EVALUATE GEAR SET THAT WAS L-37 DYNO TESTED BY THE ASTM SUB-COMMITTEE SAMPLES FROM A HEAT CODE BATCH OF GEARSETS THAT ARE TO BE USED AS THE OFFICIAL HARDWARE FOR TESTING AND APPROVING NEW LUBRICANT CANDIDATES TO SAE AND MIL STANDARDS. THE GEARS ARE EXPERIENCING WEAR, RIDGING AND TOOTH BREAKAGE.		
REASON	:		

**VISUAL INSPECTION**

GEAR #2 HAD NO BROKEN OR CRACKED TEETH. THE DRIVE SIDE TEETH HAD A POLISHED CONTACT PATTERN THAT STARTED APPROXIMATELY 3/16" FROM THE HEEL AND ENDED FLUSH WITH THE TOE.

GEAR #5 HAD TWO BROKEN TEETH. THE CONTACT PATTERN ON THE DRIVE SIDE STARTED APPROXIMATELY 3/16" FROM THE HEEL AND ENDED FLUSH WITH THE TOE. EXAMINATION AT LOW MAGNIFICATION SHOWED PITTING ALONG THE ROOT LINE ON THE DRIVE SIDE. BOTH GEARS HAD RIDGING AND WEAR ON THE TEETH.

**MAGNAGLOW INSPECTION:**

#2 – NO INDICATIONS

#5 - THERE WERE SLIGHT INDICATIONS ALONG THE ROOT ON THE DRIVE SIDE. (FOLLOWED THE PITTING)

**MICROHARDNESS MEASUREMENTS**

ASTM E384-05

500G VICKERS CONVERTED TO HRC

DEPTH (IN)	PITCH LINE		ROOT LINE	
	#2	#5	#2	#5
0.002	64	61	63	62
0.004	63	61	63	61
0.006	61	61	60	61
0.008	61	61	60	60
0.010	61	61	59	60
0.020	59	60	57	53
0.030	58	58	47	52
0.040	56	56	39	37
0.050	52	54	32	43
0.060	51	50	30	29
0.070	47	49	30	31
0.080	44	47	31	28

Attachment	1
Page	1062
Reference	L-37

**EFFECTIVE CASE DEPTH MEASURED AT 50 HRC**

SAE J423 FEB. 1998

LOCATION	#2	#5	SPECIFICATION
PITCH	0.062"	*0.066"	0.050" – 0.065" (0.76-1.65mm)
ROOT	0.025"	0.036"	0.025" – 0.065" (0.38-1.65mm)

THE CASE DEPTH VALUES WERE OBTAINED BY INTERPOLATING THE MICROHARDNESS MEASUREMENT DATA TO 50 HRC.

\* ABOVE SPECIFICATION

**SURFACE HARDNESS OF GEAR TEETH**

ASTM E384-05

500g VICKERS 0.004" AND 0.006" BELOW THE SURFACE CONVERTED TO HRC.

LOCATION	#2	#5	SPECIFICATION
PITCH	63, 61	61	61 – 63
ROOT	63, 61	61	61 – 63

**SURFACE HARDNESS OF BEARING DIAMETER**

ASTM E18-05

DIRECT HRC ON BEARING DIAMETER SURFACE.

#2	#5	SPECIFICATION
61	62	61 – 63

**CORE HARDNESS**

ASTM E18-05

DIRECT HRC ON MOUNTED SAMPLES

LOCATION	#2	#5	SPECIFICATION
PITCH	41	37	--
ROOT	31	31	25-43 HRC
1/8" BELOW ROOT	28	27	--
OUTBOARD BEARING 1/2 RADIUS	23	24	--

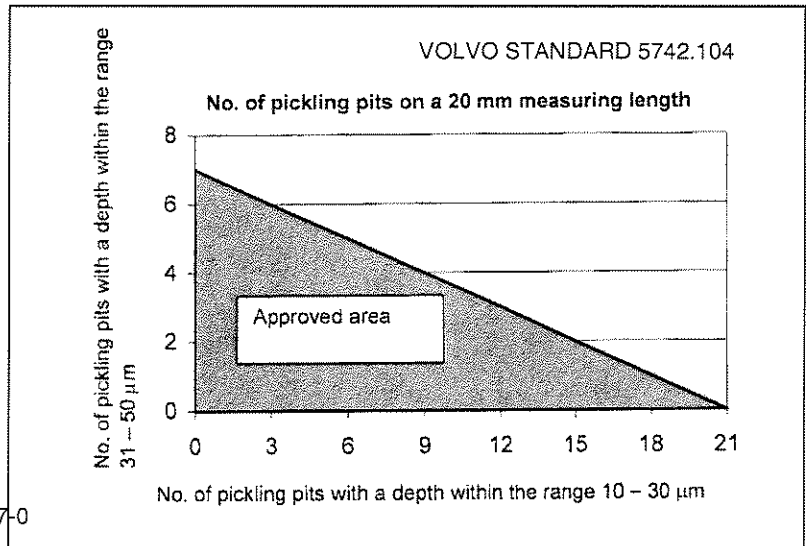
**PITTING ANALYSIS:** PER VOLVO STANDARD 5742.104

NUMBER OF PITS PER 20 MM OF SURFACE LENGTH

SIZE 10µM – 30µM	#2 *100+	#5 *100+
SIZE 31µM – 50µM	NONE	NONE
SIZE > 50µM	NONE	NONE

\*EXCEEDS SPECIFICATION

Attachment 1  
 Page 2 of 8  
 Reference 6-37



PITS WERE MEASURED AT 1000X MAGNIFICATION ON THE UNWORN COAST SIDE AND THE ROOT.

**CHEMICAL ANALYSIS**

ASTM E415-99 (2005)

ELEMENT	#2	#5	SAE 8625	ES-PM-FW0001
C	0.28	0.24	0.23-0.28	
Mn	0.81	0.82	0.70-0.90	
P	0.009	0.010	0.030 max	
S	0.027	0.029	0.040 max	
Si	0.21	0.21	0.15-0.35	
Ni	0.43	0.43	0.40-0.70	
Cr	0.47	0.48	0.40-0.60	
Mo	0.15	0.16	0.15-0.25	
Cu	0.19	0.19	--	0.35 MAX
Al	0.027	0.026	--	0.015 MAX
Sn	0.009	0.009	--	0.025 MAX
V	0.005	0.005	--	0.020 MAX
Nb	0.001	0.001	--	0.010 MAX
Zr	0.001	0.001	--	0.010 MAX
B	0.0002	0.002	--	0.0005 MAX
Ti	0.001	0.001	--	0.010 MAX
Pb	0.000	0.000	--	0.010 MAX
Ca	0.001	0.001	--	0.0030 MAX
N	0.008	0.011	--	0.015 MAX
As	0.005	0.006	--	0.010 MAX
Zn	0.003	0.003	--	0.030 MAX
Sb	0.000	0.000	--	0.010 MAX
*D.I.	2.33	2.08		2-10-2.60

\*FOR REFERENCE ONLY

**MICROSTRUCTURE:**

CASE: TEMPERED MARTENSITE WITH 5 – 10% RETAINED AUSTENITE

CORE: TRANSFORMATION PRODUCTS

IGO: 0.0005" – 0.0015"

NMTP 0.0008" – 0.0012"

**CONCLUSION**

: THE PARTS MEET PRINT SPECIFICATIONS EXCEPT FOR THE CASE BEING SLIGHTLY DEEP. THE PITTING IS EXCESSIVE, PER THE VOLVO SPECIFICATION, WITH PITS TOO NUMEROUS TO COUNT. THE FRACTURED TEETH ON GEAR #5 WERE LIKELY A RESULT OF THIS SEVERELY PITTED SURFACE BEING TESTED AT THE L-37 LOADS. SEVERE PITTING CAN CAUSE ABNORMAL WEAR AND RIDGING WHICH CAN IN TURN LEAD TO PITTING, SPALLING, AND TOOTH BREAKAGE. THE SURFACE HARDNESS SPECIFICATION OF 61 – 63 HRC IS NOT REASONABLE. LONG TERM A RANGE OF 6 OR 7 POINTS HRC IS NECESSARY.

Attachment	<u>1</u>
Page	<u>3 of 8</u>
Reference	<u>L-37</u>

PHOTOS

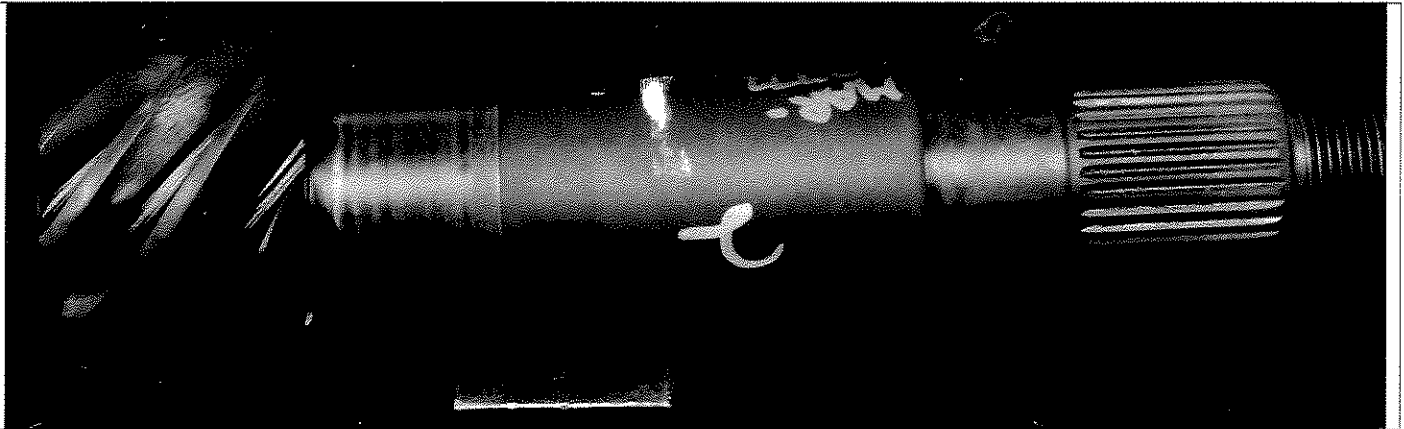


PHOTO 1. PINION #2 AS RECEIVED

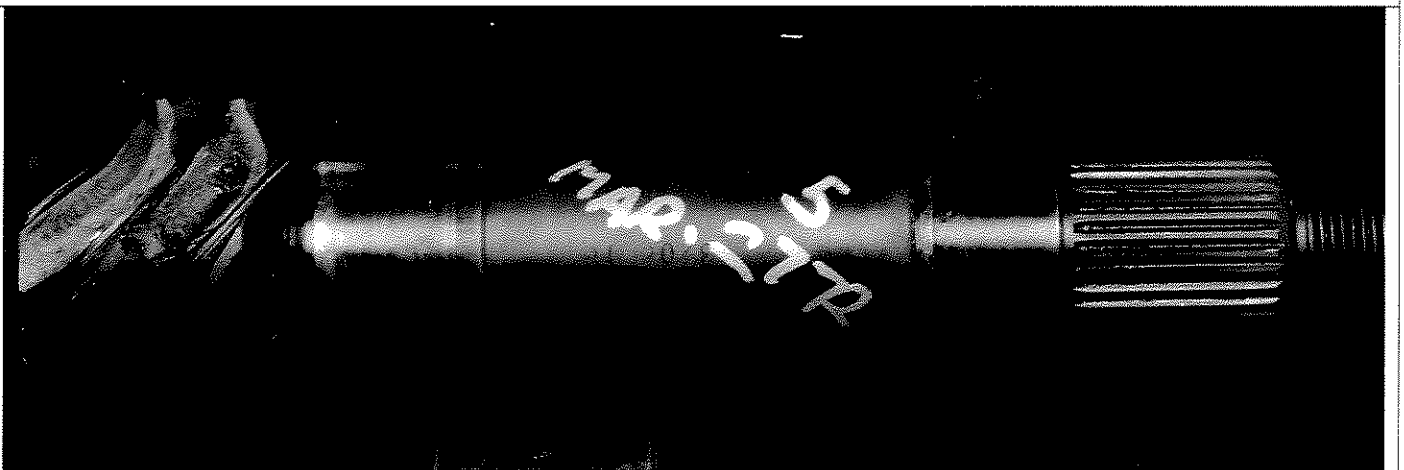


PHOTO 2. PINION #5 AS RECEIVED

Attachment	<u>1</u>
Page	<u>488</u>
Reference	<u>237</u>

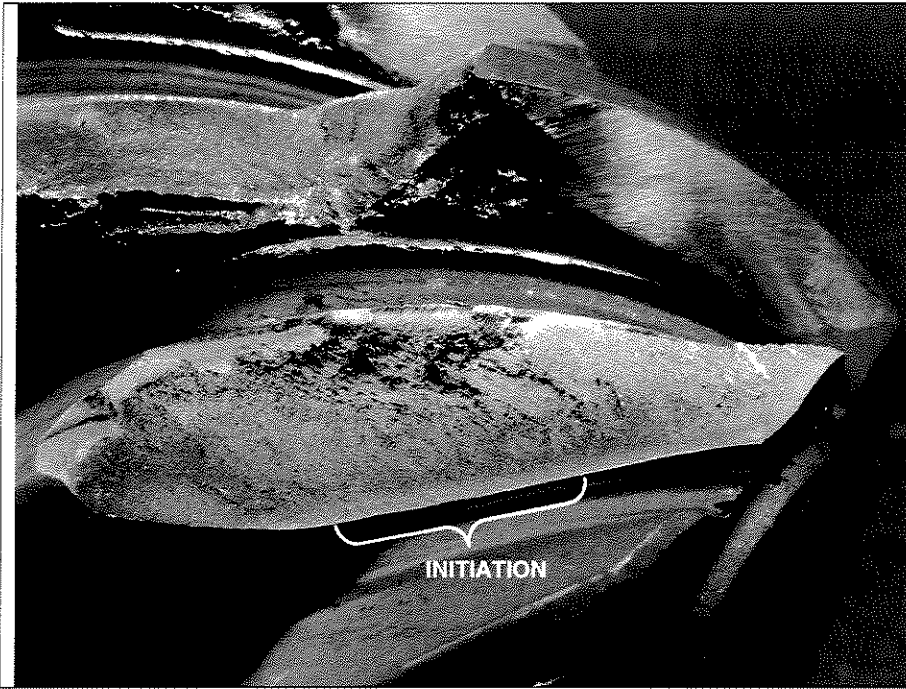


PHOTO 3.  
CLOSE UP OF THE FRACTURED TEETH. THE LOWER TOOTH FAILED FIRST AND THE OTHER TOOTH DAMAGE WAS SECONDARY.

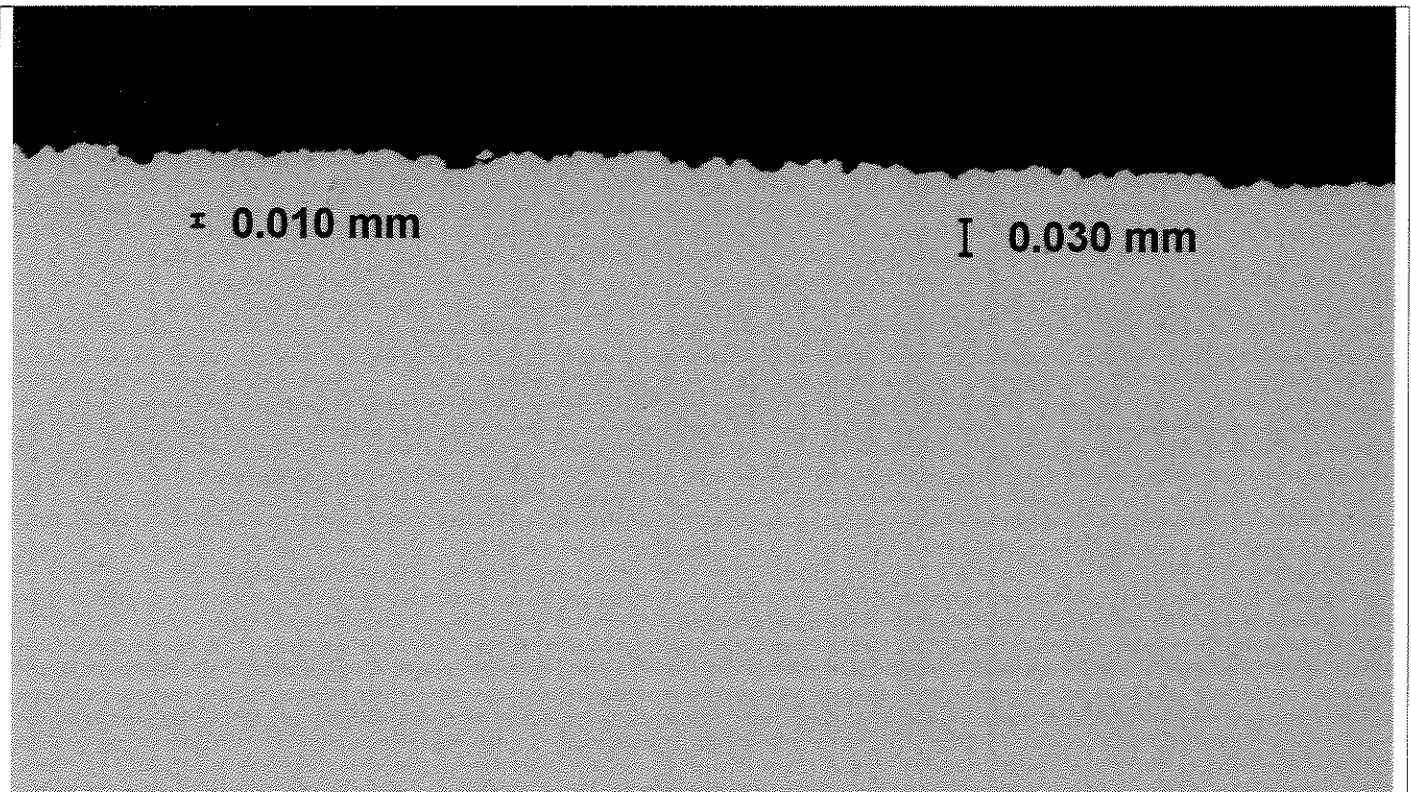


PHOTO 4. PICKLING PITS FROM THE PHOSPHATING PROCESS PINION GEAR #2 100X NO ETCH

Attachment	<u>1</u>
Page	<u>5 of 8</u>
Reference	<u>L-37</u>



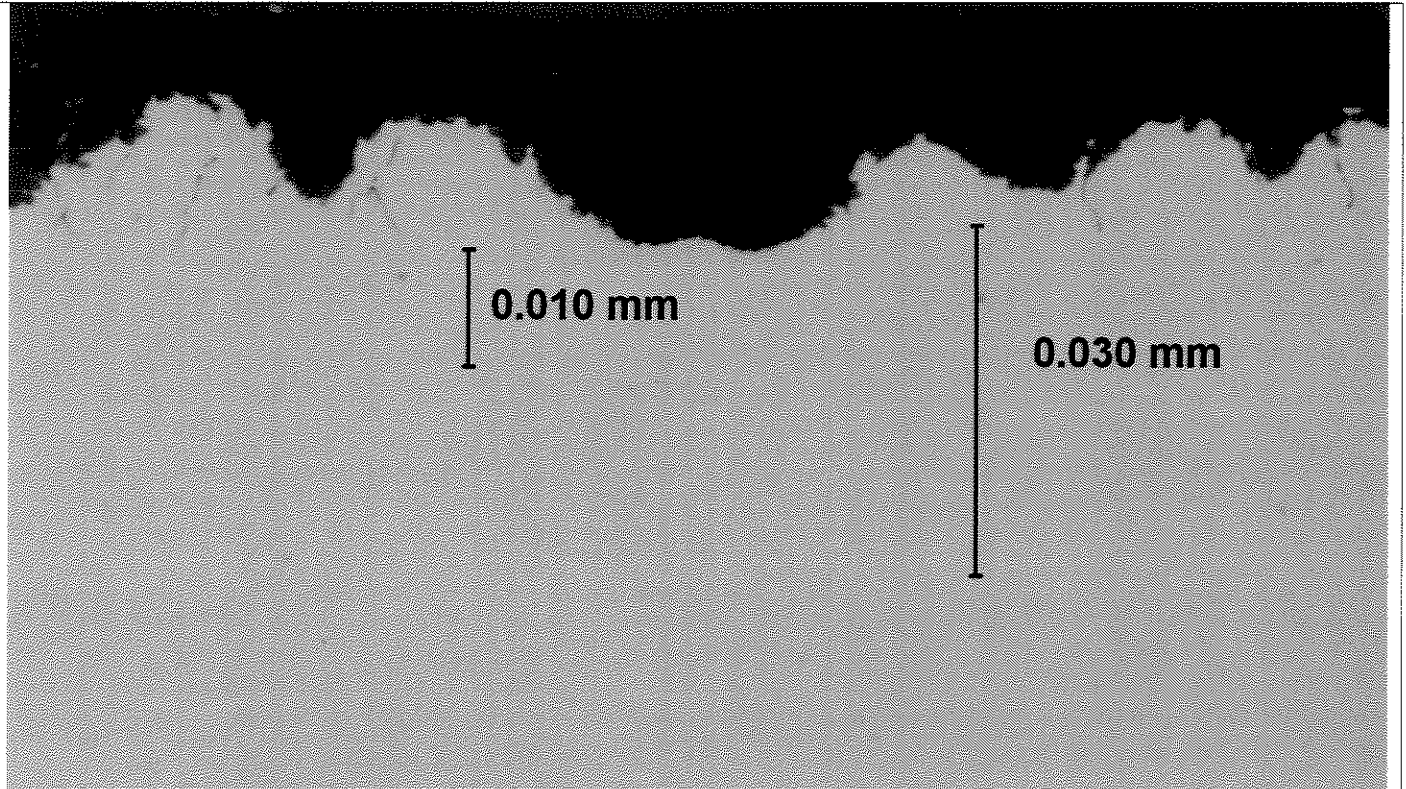


PHOTO 5. SAME AS PHOTO 4 BUT AT HIGHER MAGNIFICATION

PINION GEAR #2

1000X NO ETCH

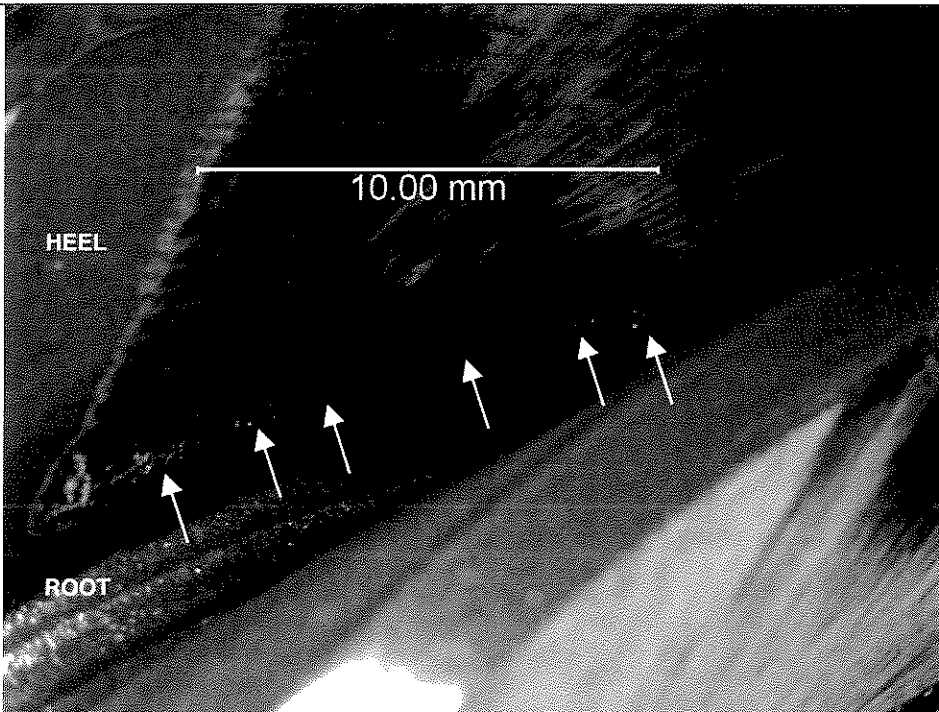


PHOTO 6.

EXAMPLE OF THE PITTING SEEN AT THE ROOT ON THE DRIVE SIDE OF GEAR #5.

7.1X MAGNIFICATION

Attachment	<u>1</u>
Page	<u>6 of 8</u>
Reference	<u>4-37</u>

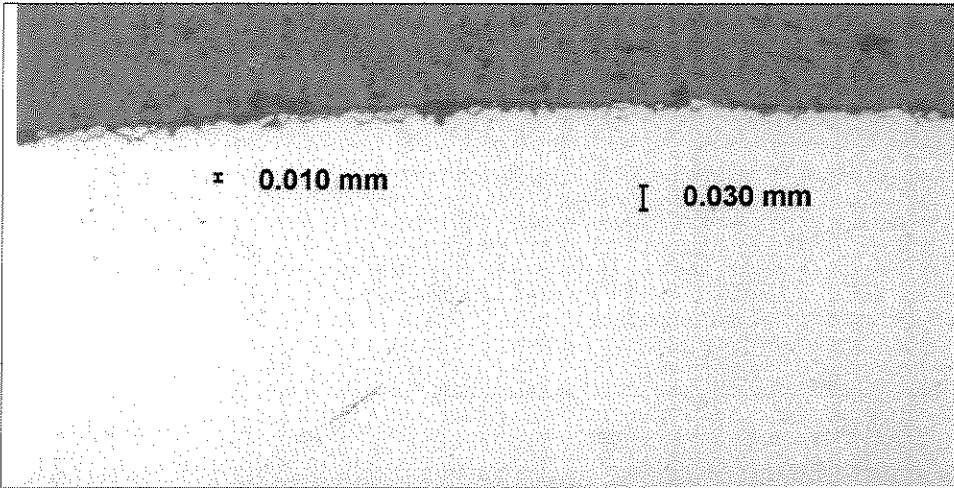


PHOTO 7.  
PICKLING PITS FROM THE  
PHOSPHATING PROCESS.

GEAR #5  
100X MAGNIFICATION  
NO ETCH

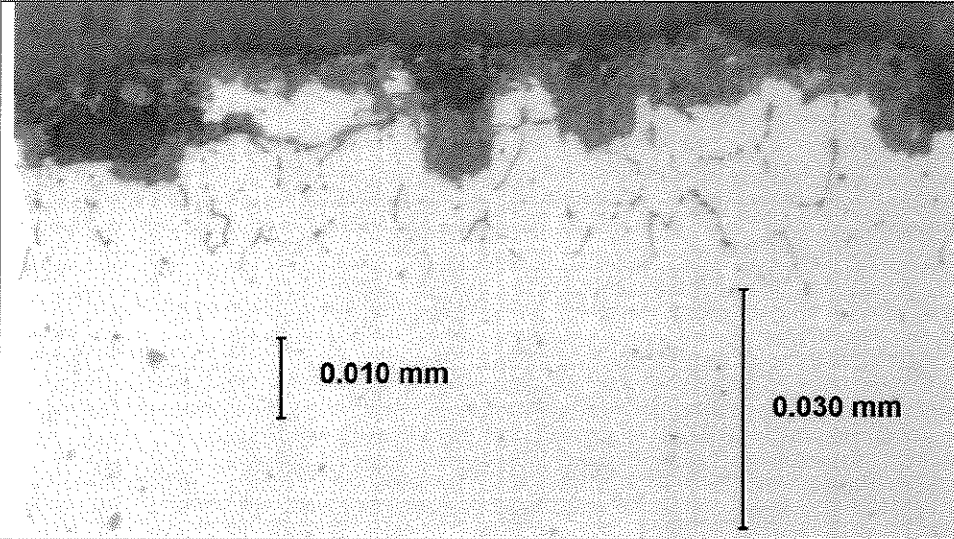


PHOTO 8.  
SAME AS PHOTO 7, BUT AT HIGHER  
MAGNIFICATION.

GEAR #5  
1000X MAGNIFICATION  
NO ETCH

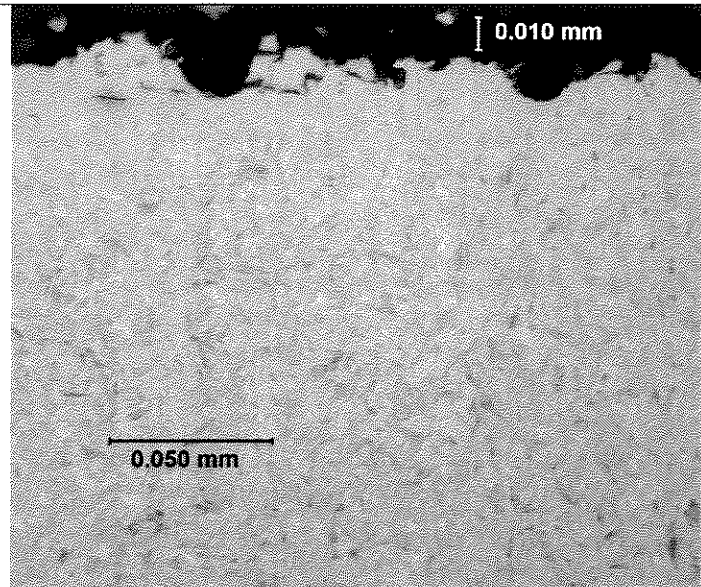


PHOTO 6. TYPICAL CASE MICROSTRUCTURE.  
500X 2% NITAL ETCH

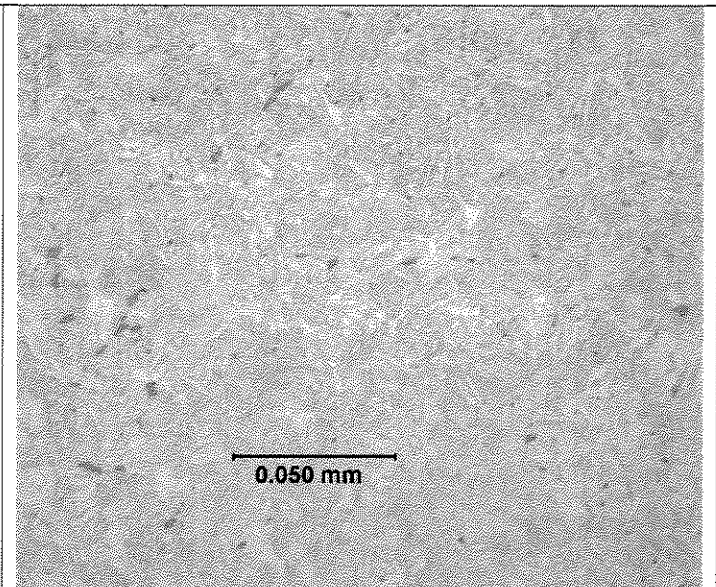


PHOTO 7. TYPICAL CORE MICROSTRUCTURE.  
500X 2% NITAL ETCH

Attachment	1
Page	7 of 8
Reference	1-37

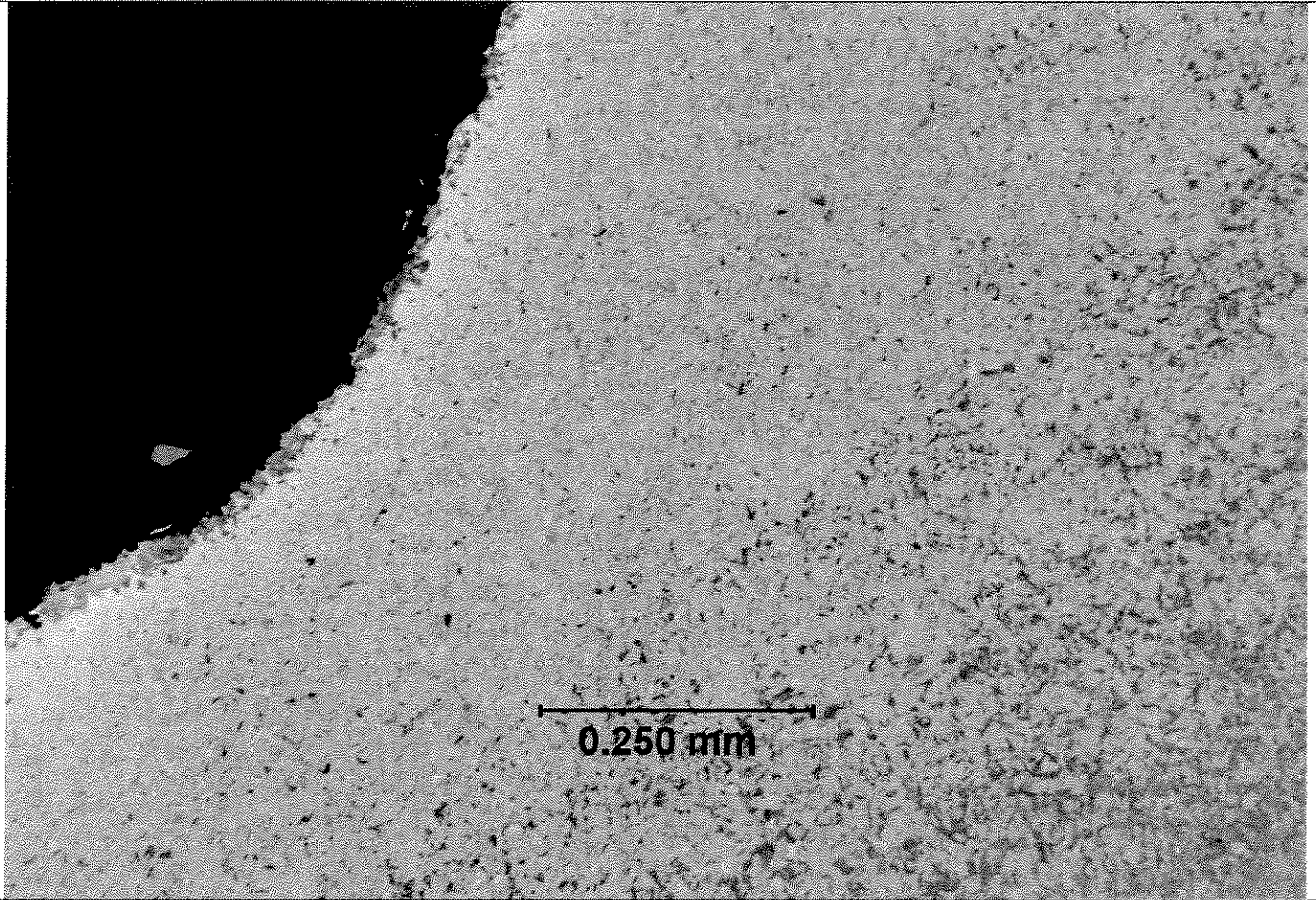


PHOTO 8. TYPICAL CASE / CORE MICROSTRUCTURE.

100X 2% NITAL ETCH

Attachment	<u>1</u>
Page	<u>8 of 8</u>
Reference	<u>L-37</u>



**DANA SHARED SERVICES**  
**A.S.G. TECH CENTER**  
 3939 TECHNOLOGY DRIVE, MAUMEE, OH 43537  
**MATERIAL SCIENCE DEPARTMENT REPORT**

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE CONSENT OF THE MATERIALS ENGINEERING DEPARTMENT.

ASG LAB NO.	: 2007-0411	PART NO.	: 060GR104
PART NAME	: RING GEAR	PRINT REV.	:
REP. TITLE	: GEAR – HYPOID DRIVE	MODEL	:
MARKINGS	: #2 – DANA D 060GR104 41 7 7P #5 - DANA D 060GR104 41 7 5G	HEAT CODE	: P4L816
MATERIAL	: STEEL, SAE 8620, OPTIONAL GROUP C	MFG. DATE	: #2 – 011607 #5 - 011707
VENDOR	: DANA – FORT WAYNE	SAMP. REQ.	: NA
CUSTOMER	: ASTM L-37 COMMITTEE	VIN	: NA
TAR NO.	:	MAR NO.	: 2772
TEST ENG.	:	REC'D DATE	: 6/27/2007
REQ. BY	: JOE GUZIKOWSKI	REP. DATE	: 7/6/2007
REP. BY	: TOM WOODARD	PAGES	: 8
TRP LAB NO.	: 907143		
ADD. COMMENTS	: THIS GEARSET HAS NOT BEEN ABLE TO DISTINGUISH BETWEEN ACCEPTABLE AND UNACCEPTABLE REFERENCE OILS.		
COPIES	: GREG FETT, JOE GUZIKOWSKI, DANA COMBS		
REQUEST	: EVALUATE GEAR SET THAT WAS L-37 DYNO TESTED BY THE ASTM SUB-COMMITTEE SAMPLES FROM A HEAT CODE BATCH OF GEARSETS THAT ARE TO BE USED AS THE OFFICIAL HARDWARE FOR TESTING AND APPROVING NEW LUBRICANT CANDIDATES TO SAE AND MIL STANDARDS		
REASON	: SAE AND MIL STANDARDS		

**VISUAL INSPECTION**

#2 – THE TOOTH CONTACT PATTERN RAN FROM THE HEEL TO JUST SHORT OF THE TOE WITH EVEN WEAR FROM ROOT TO TIP.

#5 -THE CONTACT PATTERN ON THE GEARS WAS POLISHED AT THE HEEL AND TOE WITH HEAVY RIDGING AT THE HEEL. THERE WERE NO BROKEN TEETH.

**MAGNAGLOW INSPECTION:**

THERE WERE NO INDICATIONS.

**MICROHARDNESS MEASUREMENTS**

ASTM E384-05

500G VICKERS CONVERTED TO HRC

DEPTH (IN)	PITCH LINE		ROOT LINE	
	#2	#5	#2	#5
0.002	63	61	64	63
0.004	61	61	62	61
0.006	62	60	61	62
0.008	62	60	60	60
0.010	61	60	60	60
0.020	59	60	56	57
0.030	57	57	49	54
0.040	53	55	38	45
0.050	50	51	38	38
0.060	45	50	31	34
0.070	44	49	30	33
0.080	40	47	21	28

Attachment 2  
 Page 1 of 9  
 Reference L-37

**EFFECTIVE CASE DEPTH MEASURED AT 50 HRC**

SAE J423 FEB. 1998

THE CASE DEPTH VALUES WERE OBTAINED BY INTERPOLATING THE MICROHARDNESS MEASUREMENT DATA TO 50 HRC.

LOCATION	#2	#5	SPECIFICATION
PITCH	0.048"	*0.060"	0.040" – 0.055" (0.76-1.65mm)
ROOT	0.029"	0.033"	0.020" – 0.055" (0.38-1.65mm)

\* ABOVE SPECIFICATION

**SURFACE HARDNESS OF GEAR TEETH**

ASTM E384-05

500g VICKERS 0.004" AND 0.006" BELOW THE SURFACE CONVERTED TO HRC.

LOCATION	#2	#5	SPECIFICATION
PITCH	*61, *62	*61, *60	58 – 60
ROOT	*62, *61	*61, *62	58 – 60

\* ABOVE SPECIFICATION

**CORE HARDNESS**

ASTM E18-05

DIRECT HRC ON MOUNTED SAMPLES

LOCATION	#2	#5	SPECIFICATION
PITCH	45	46	--
ROOT	39	40	25-43 HRC
1/8" BELOW ROOT	31	34	--

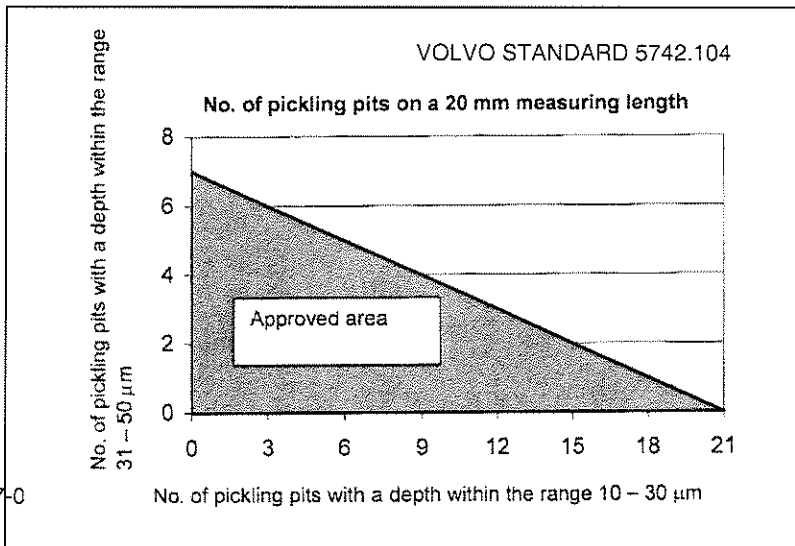
**PITTING ANALYSIS:** PER VOLVO STANDARD 5742.104

NUMBER OF PITS PER 20 MM OF SURFACE LENGTH

SIZE 10µM – 30µM	#2 *100+	#5 *100+
SIZE 31µM – 50µM	NONE	NONE
SIZE > 50µM	NONE	NONE

\*EXCEEDS SPECIFICATION

Attachment	2
Page	20/9
Reference	L-37



PITS WERE MEASURED AT 1000X MAGNIFICATION ON THE UNWORN COAST SIDE AND THE ROOT.

**CHEMICAL ANALYSIS**

ASTM E415-99 (2005)

ELEMENT	#2	#5	SAE 8620	ES-PM-FW0001
C	0.21	0.21	0.18-0.23	
Mn	0.84	0.82	0.70-0.90	
P	0.010	0.009	0.030 max	
S	0.033	0.031	0.040 max	
Si	0.18	0.17	0.15-0.35	
Ni	0.45	0.44	0.40-0.70	
Cr	0.52	0.52	0.40-0.60	
Mo	0.17	0.16	0.15-0.25	
Cu	0.17	0.17	--	0.35 MAX
Al	0.02	0.02	--	0.015 MAX
Sn	0.009	0.008	--	0.025 MAX
V	0.003	0.003	--	0.020 MAX
Nb	0.001	0.001	--	0.010 MAX
Zr	0.001	0.001	--	0.010 MAX
B	0.0002	0.0002	--	0.0005 MAX
Ti	0.001	0.001	--	0.010 MAX
Pb	0.000	0.000	--	0.010 MAX
Ca	0.001	0.001	--	0.0030 MAX
N	0.006	0.005	--	0.015 MAX
As	0.006	0.006	--	0.010 MAX
Zn	0.002	0.002	--	0.030 MAX
Sb	0.000	0.000	--	0.010 MAX
*D.I.	1.93	1.84		2-10-2.60

\*FOR REFERENCE ONLY

**MICROSTRUCTURE:**

CASE: TEMPERED MARTENSITE WITH 5 – 10% RETAINED AUSTENITE

CORE: TRANSFORMATION PRODUCTS

IGO: 0.0005" – 0.0010"

NMTP 0.0005" – 0.0010"

**CONCLUSION:**

THE PARTS EXCEEDED SPECIFICATIONS FOR CASE DEPTH (#5) AND SURFACE HARDNESS. THE PITTING IS EXCESSIVE, PER THE VOLVO SPECIFICATION, WITH PITS TOO NUMEROUS TO COUNT. SEVERE PITTING CAN CAUSE ABNORMAL WEAR AND RIDGING WHICH CAN IN TURN LEAD TO PITTING, SPALLING, AND TOOTH BREAKAGE. THE SURFACE HARDNESS SPECIFICATION OF 58 – 60 HRC IS NOT REASONABLE. LONG TERM A RANGE OF 6 OR 7 POINTS HRC IS NECESSARY.

Attachment	<u>2</u>
Page	<u>38/9</u>
Reference	<u>L-37</u>

PHOTOS



PHOTO 1. RING GEAR #2 AS RECEIVED

Attachment	<u>2</u>
Page	<u>10/9</u>
Reference	<u>L-37</u>

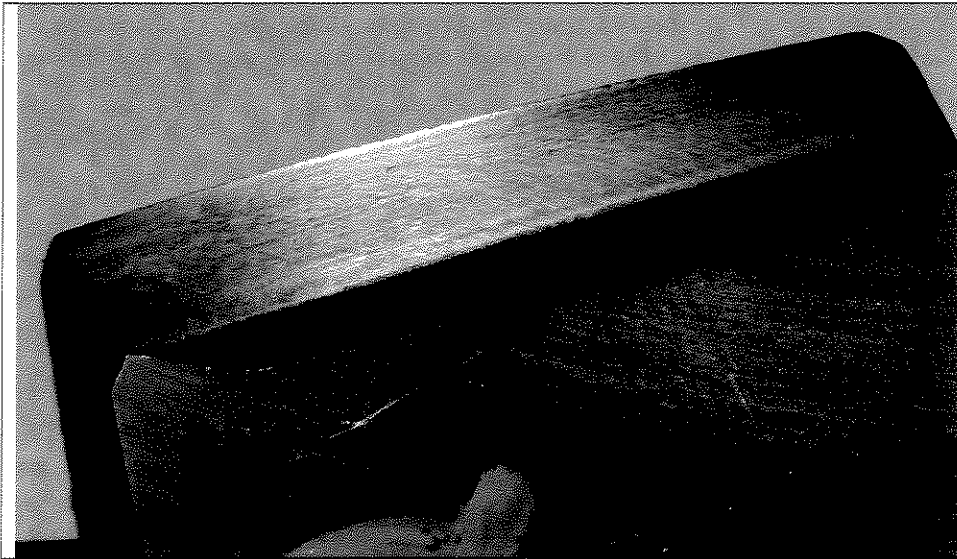


PHOTO 2.

CLOSE UP OF THE CONTACT PATTERN ON THE DRIVE SIDE OF GEAR #2.

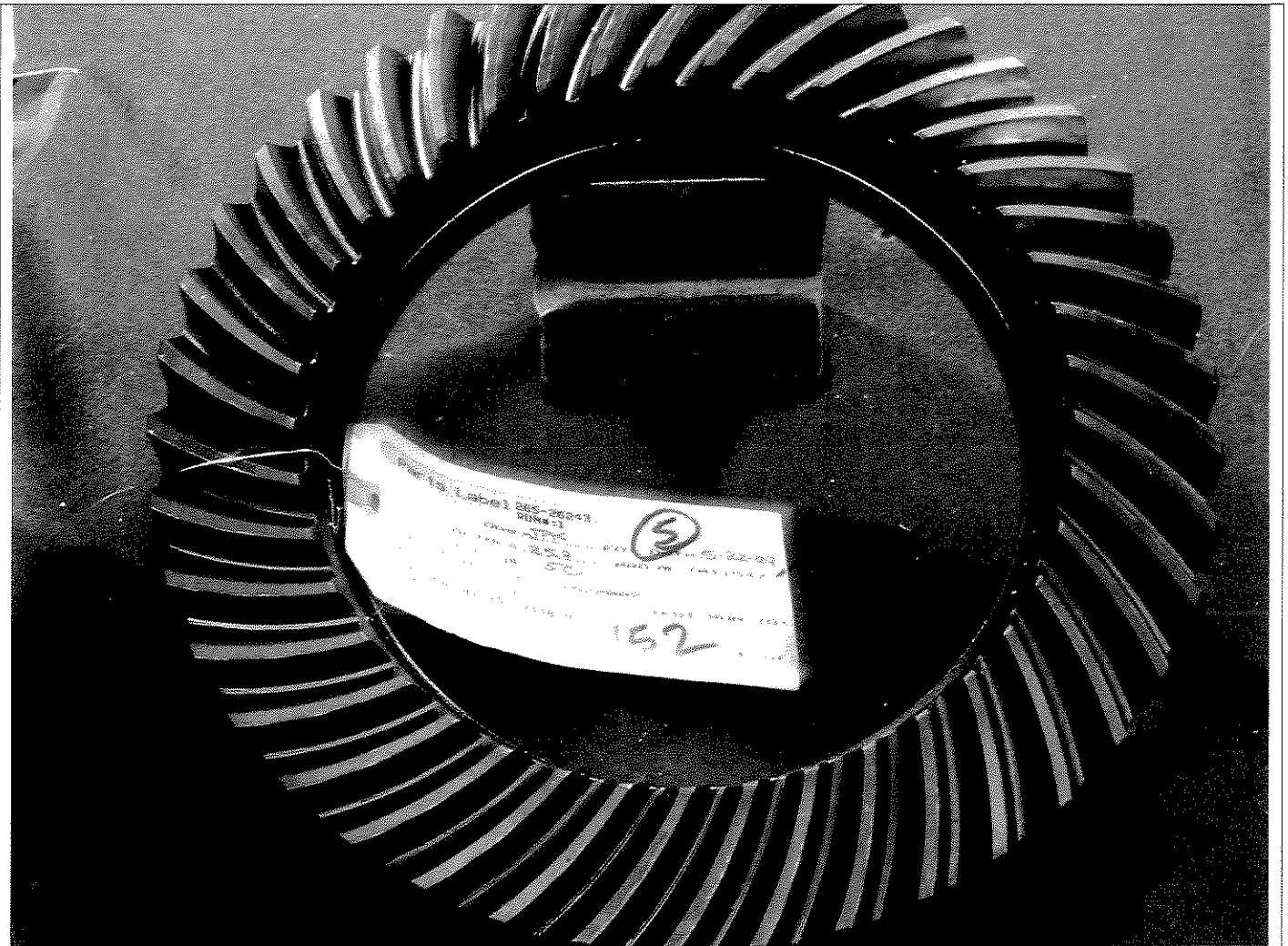




PHOTO 3. RING GEAR #5 AS RECEIVED

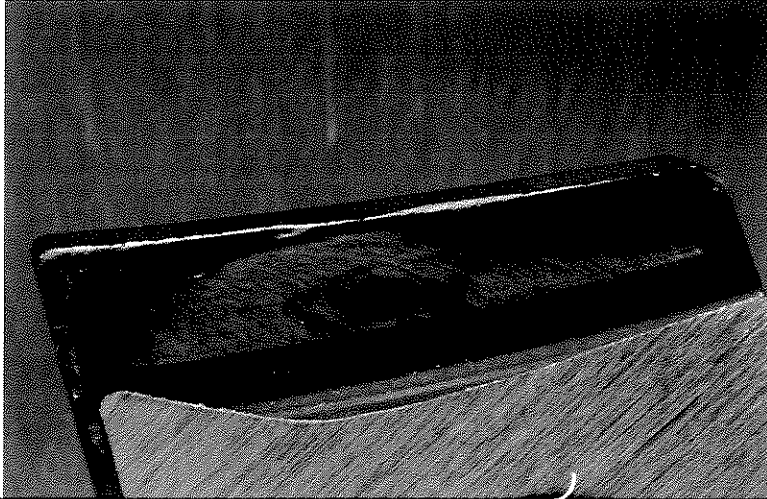


PHOTO 4.

CLOSE UP OF THE CONTACT PATTERN ON THE DRIVE SIDE.

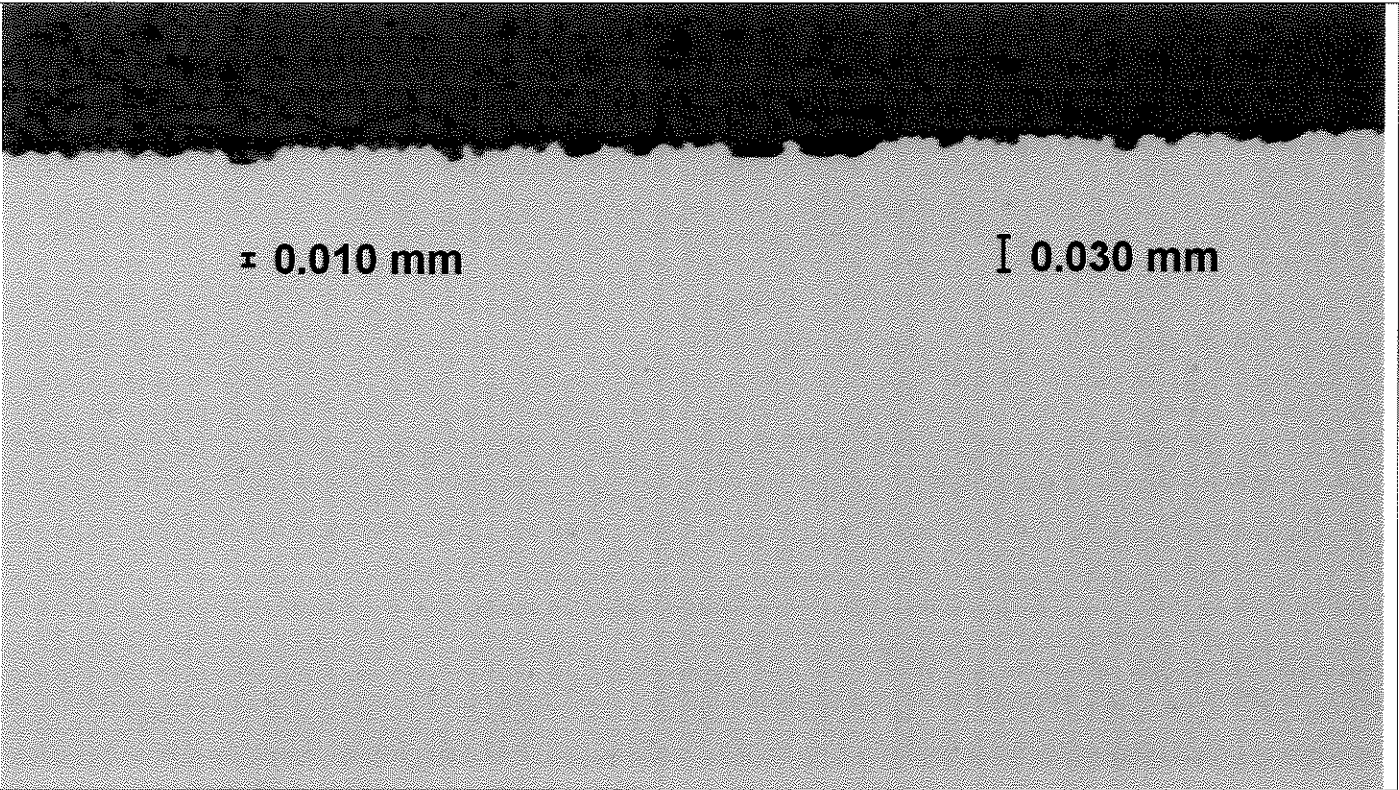


PHOTO 5. PICKLING PITS FROM THE PHOSPHATING PROCESS, GEAR #2.

100X MAGNIFICATION

NO ETCH

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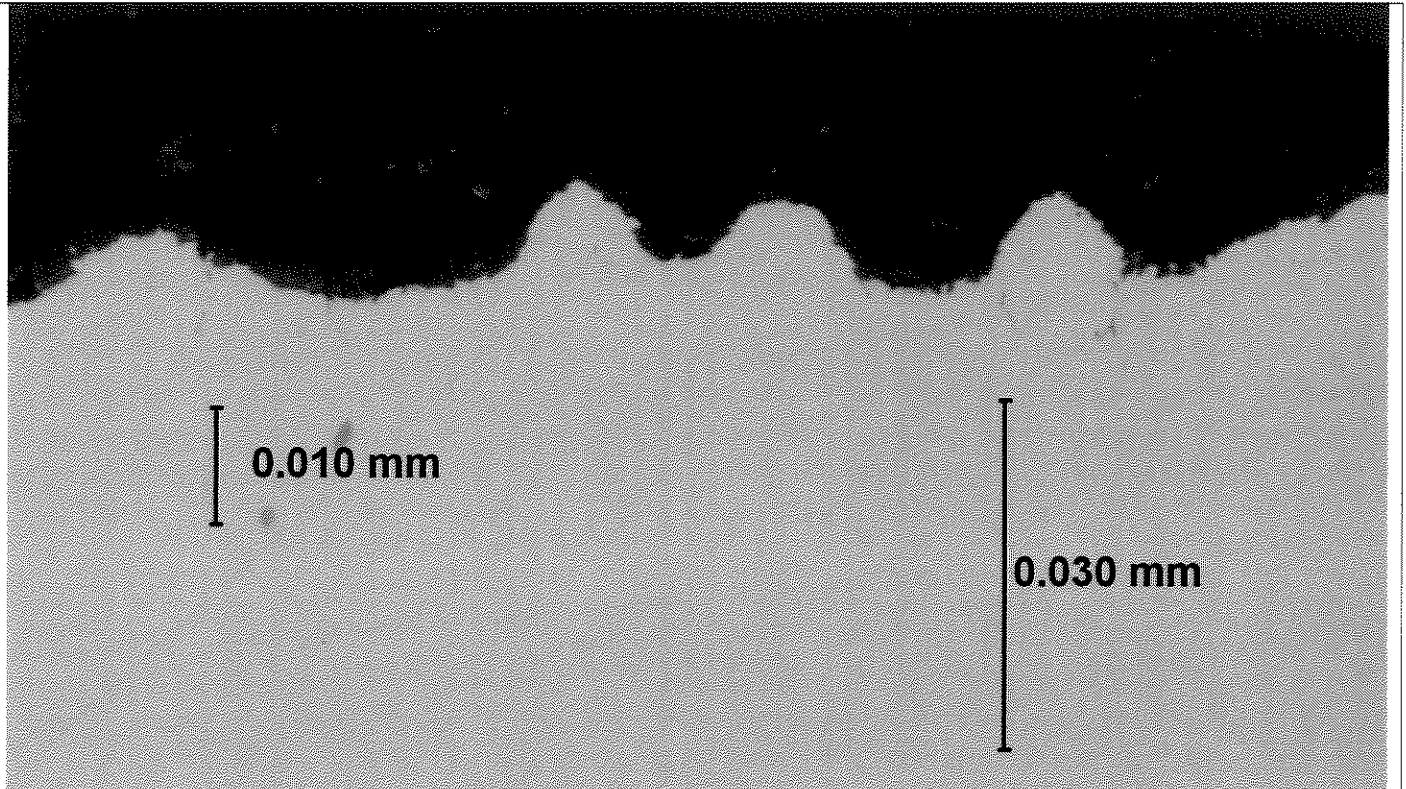


PHOTO 6. SAME AS PHOTO 5, BUT AT HIGHER MAGNIFICATION.

100X MAGNIFICATION

NO ETCH

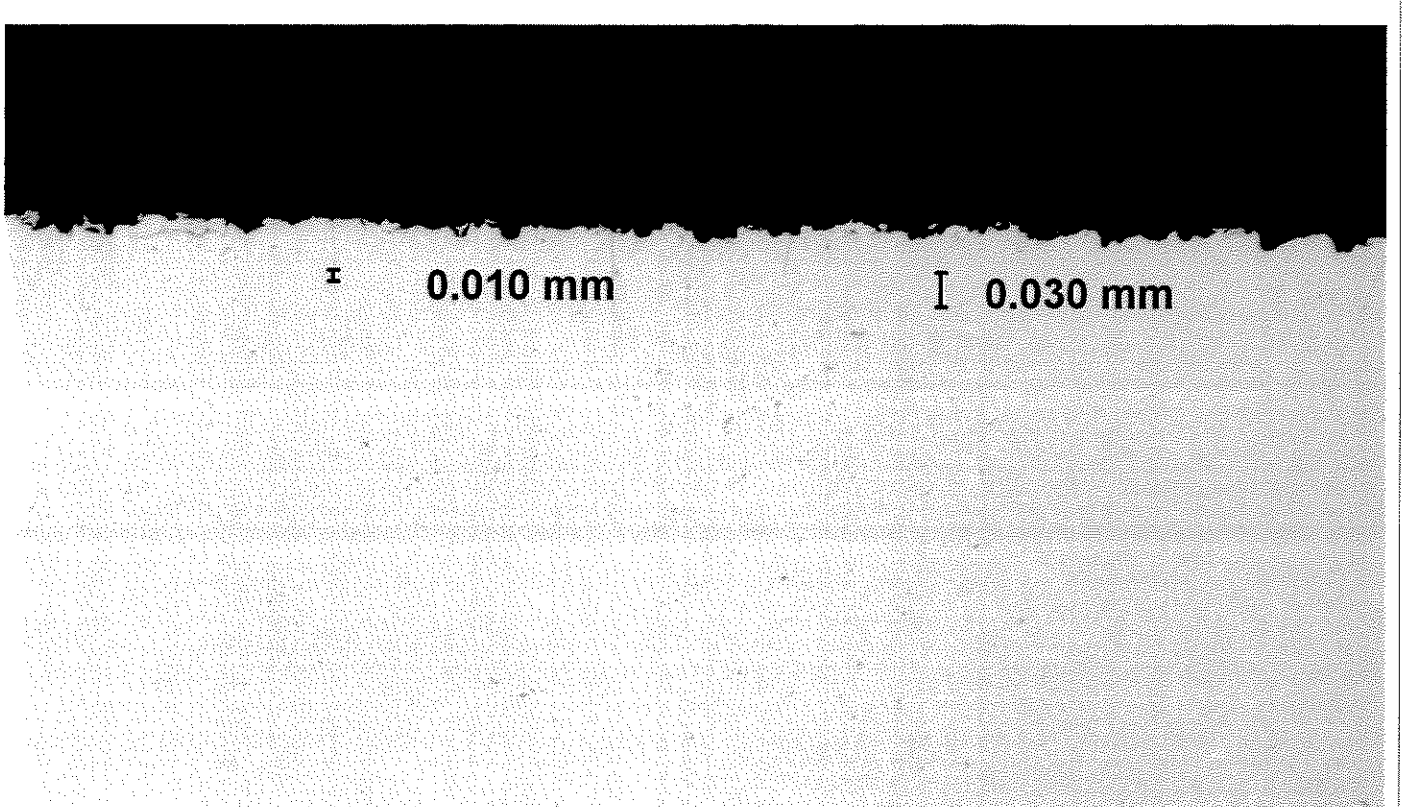


PHOTO 7. PICKLING PITS FROM THE PHOSPHATING PROCESS.

100X MAGNIFICATION

NO ETCH

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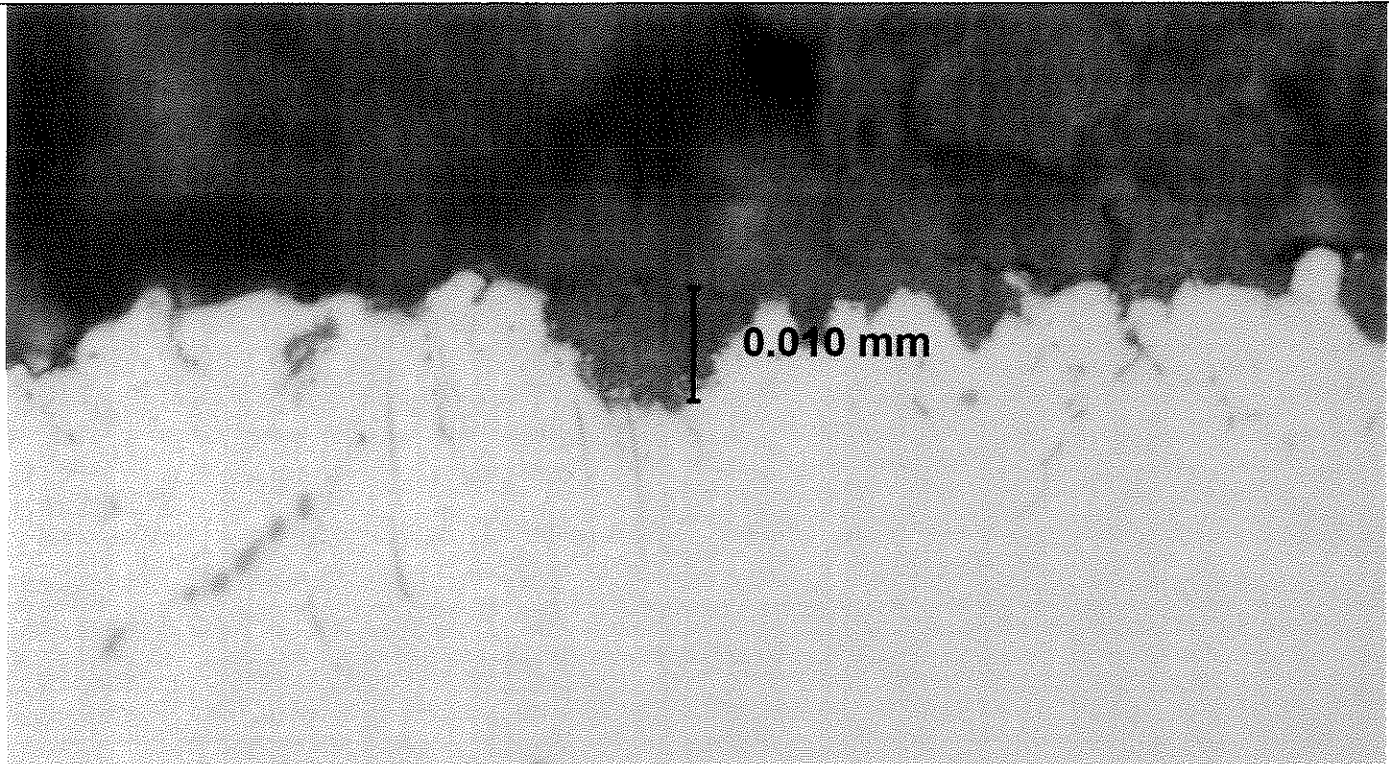


PHOTO 8. SAME AS PHOTO 7, BUT AT HIGHER MAGNIFICATION.

1000X MAGNIFICATION

NO ETCH

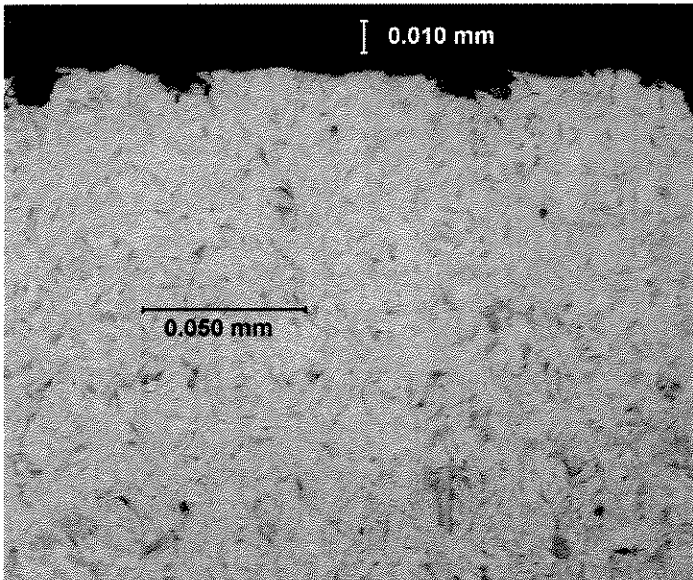


PHOTO 9. TYPICAL CASE MICROSTRUCTURE.

500X 2% NITAL ETCH

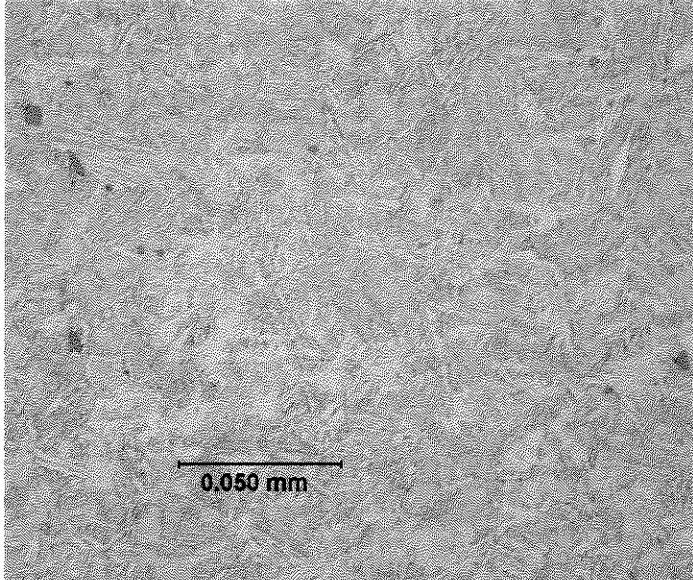


PHOTO 10. TYPICAL CORE MICROSTRUCTURE.

500X 2% NITAL ETCH

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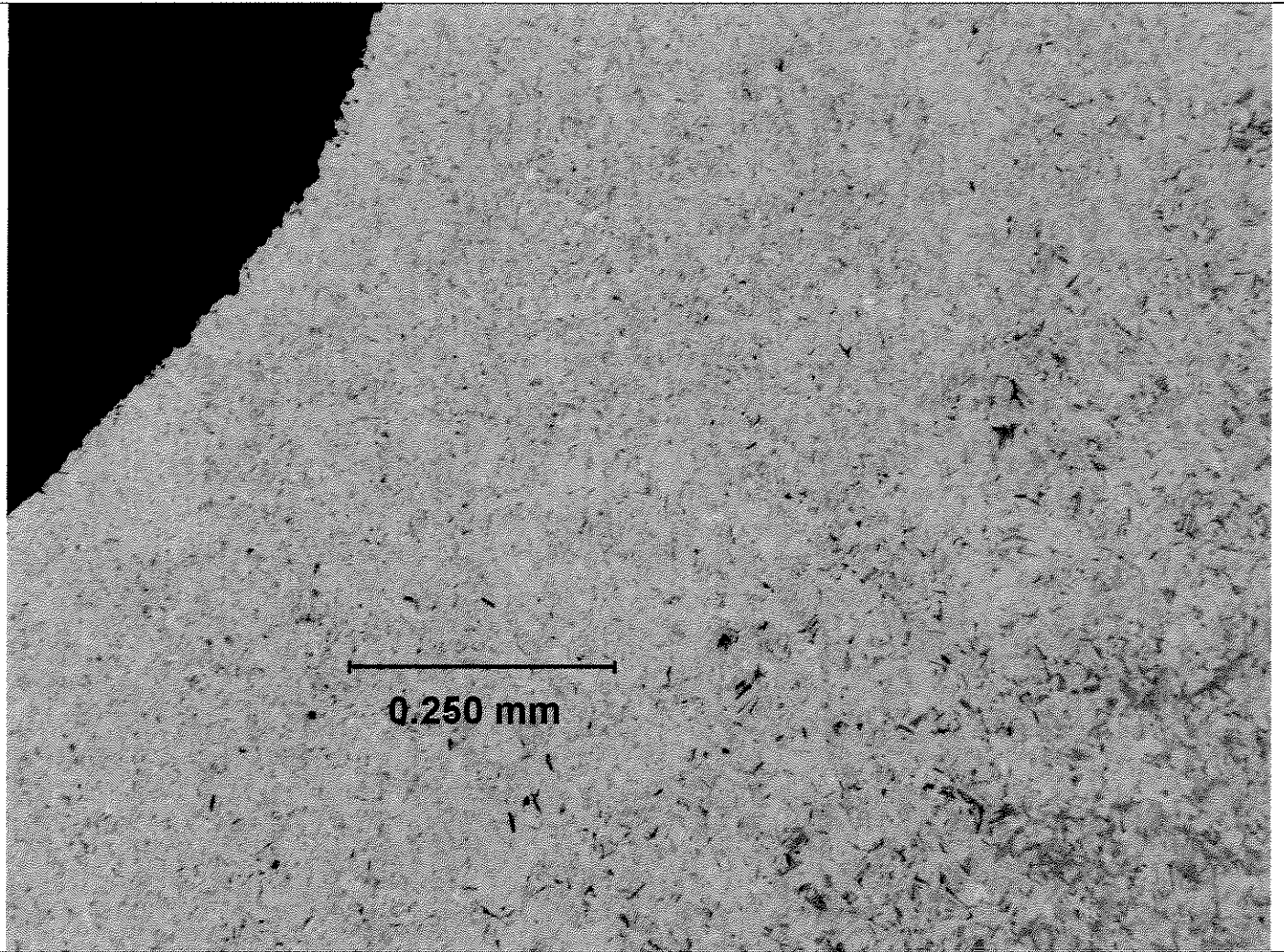


PHOTO 11. TYPICAL CASE / CORE MICROSTRUCTURE.

100X 2% NITAL ETCH

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