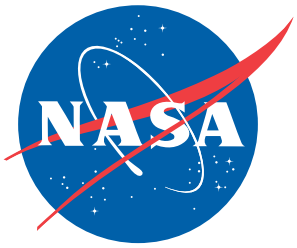
NASA/TM-2011-217072/Volume II
NESC-RP-09-00506



Space Shuttle Program (SSP) Orbiter Main Propulsion System (MPS) Gaseous Hydrogen (GH_2) Flow Control Valve (FCV) Poppet Eddy Current (EC) Inspection Probability of Detection (POD) Study

Appendices

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Langley Research Center, Hampton, Virginia

March 2011

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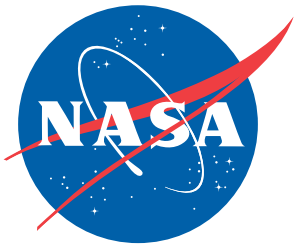

Space Shuttle Program (SSP) Orbiter Main Propulsion System (MPS) Gaseous Hydrogen (GH_2) Flow Control Valve (FCV) Poppet Eddy Current (EC) Inspection Probability of Detection (POD) Study

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National Aeronautics and
Space Administration

Langley Research Center
Hampton, Virginia 23681-2199

March 2011

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Space Shuttle Program (SSP) Orbiter Main Propulsion System (MPS) Gaseous Hydrogen (GH_2) Flow Control Valve Poppet Eddy Current (EC) Inspection Probability of Detection (POD) Study

March 3, 2011

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Appendix A. Poppet Specimens Data

Poppet #1

Surface crack sizes and locations

Poppet #1		
Crack Number	Size (inch)	Angle (degrees)
1	0.007	330
2	0.001	330
3	0.007	330
4	0.002	330
5	0.002	330
6	0.008	150
7	0.002	150
8	0.005	150
9	0.008	150

Boeing Eddy Current Findings

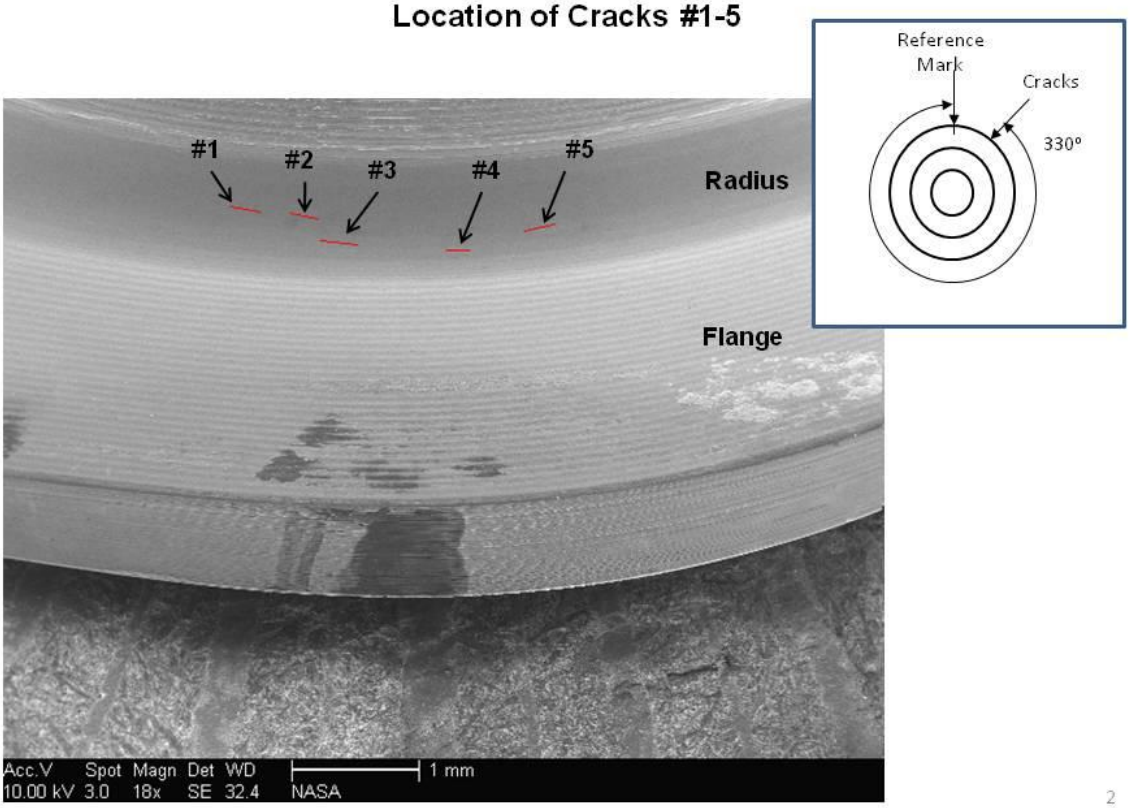
Poppet #1									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.157	0.146	0.147	0.178	0.152	0.163	0.157	Yes	140
J. Engel	-	-	-	-	-	-	-	No	330
B. Devries	-	-	-	-	-	-	-	No	330
B. Devries	0.151	0.158	0.126	0.147	0.154	0.153	0.148	Yes	140

Note: Cracks at the 330° location were not detected by eddy current inspections

1

Poppet #1

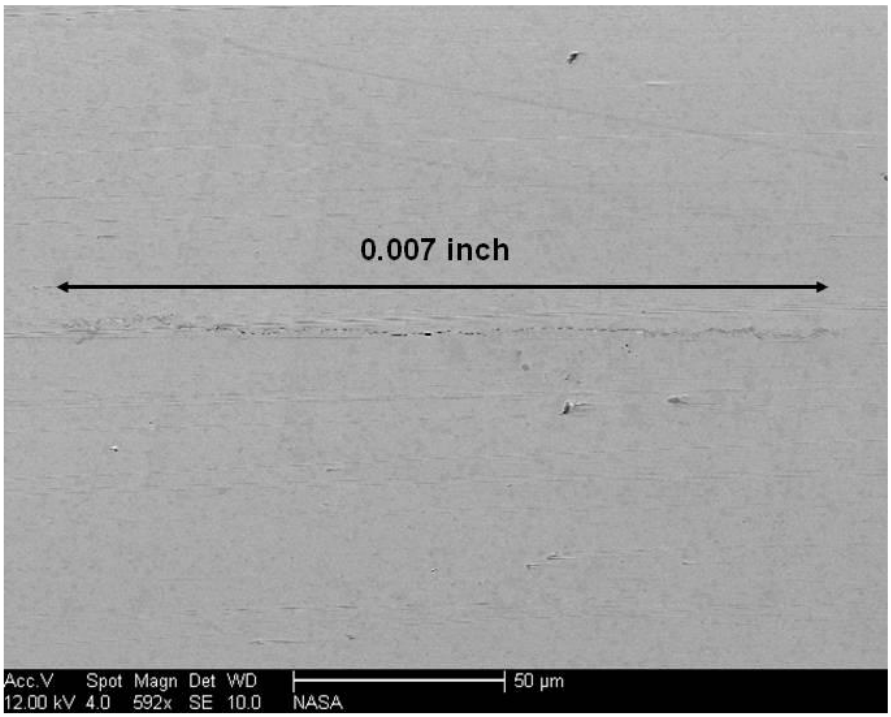
Location of Cracks #1-5



2

Poppet #1

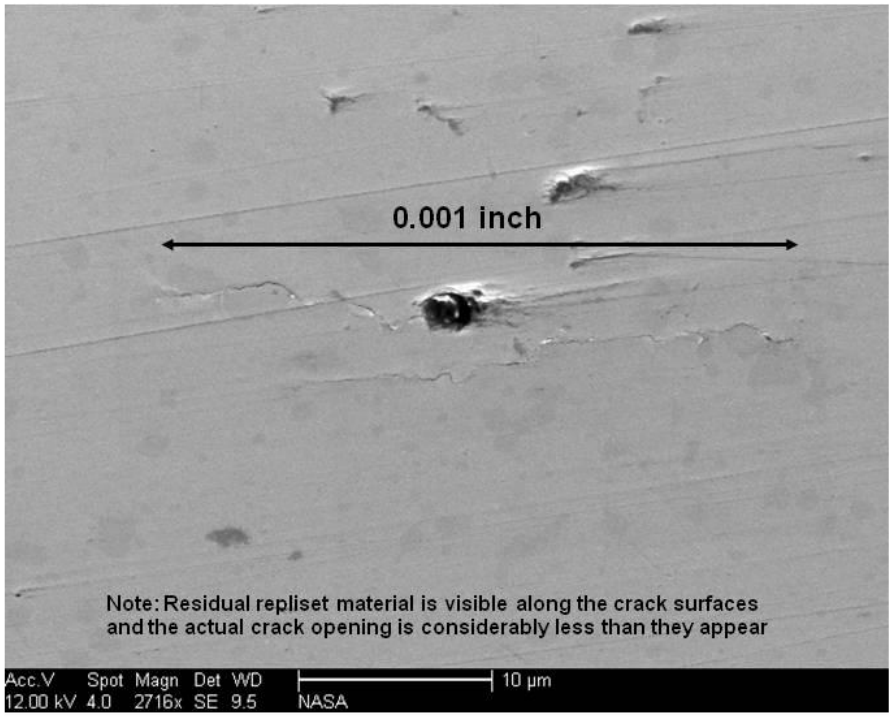
Size of Crack #1



3

Poppet #1

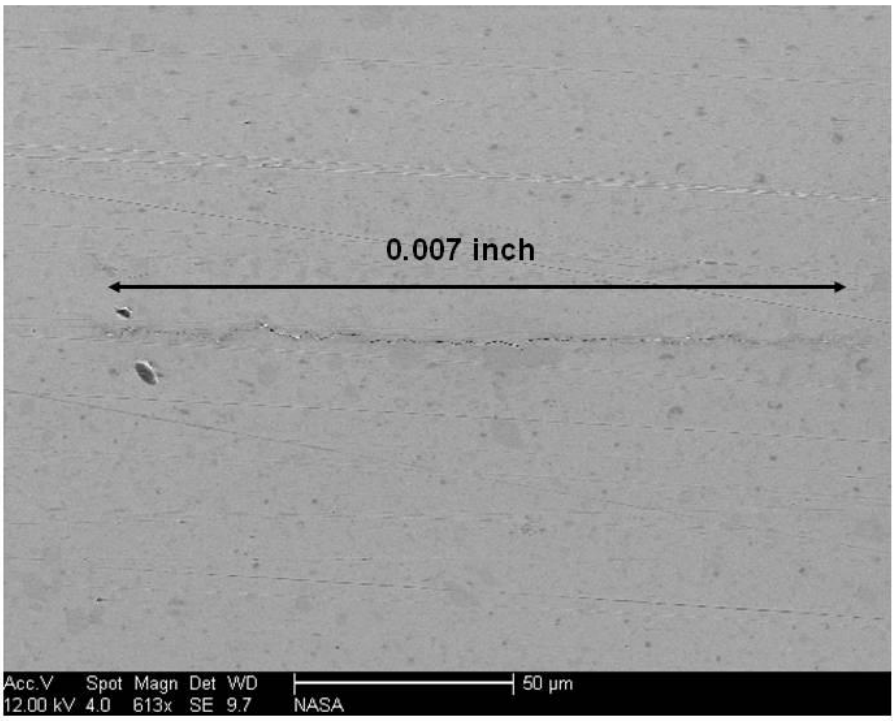
Size of Crack #2



4

Poppet #1

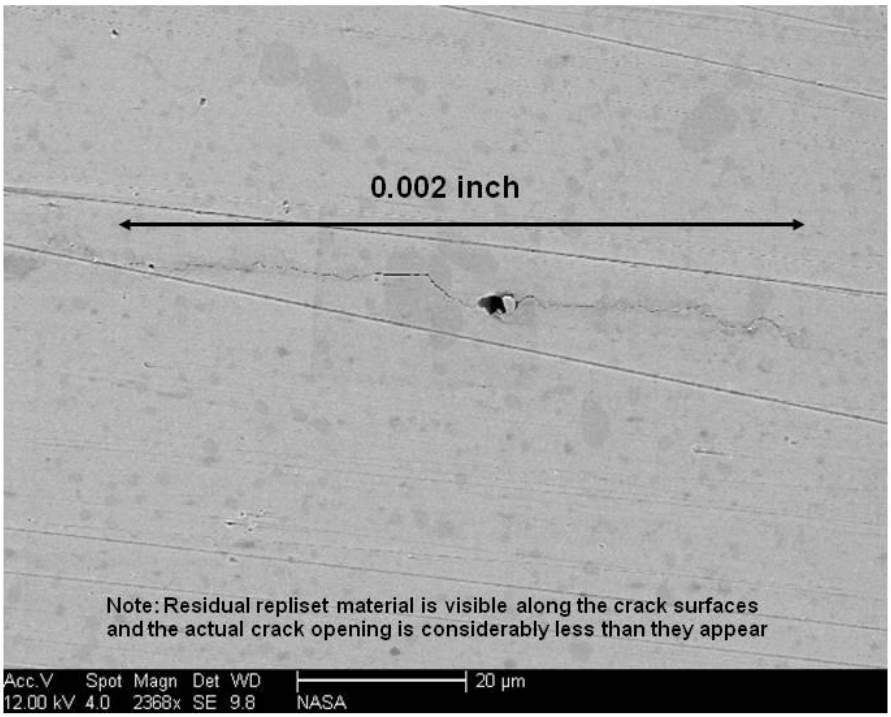
Size of Crack #3



5

Poppet #1

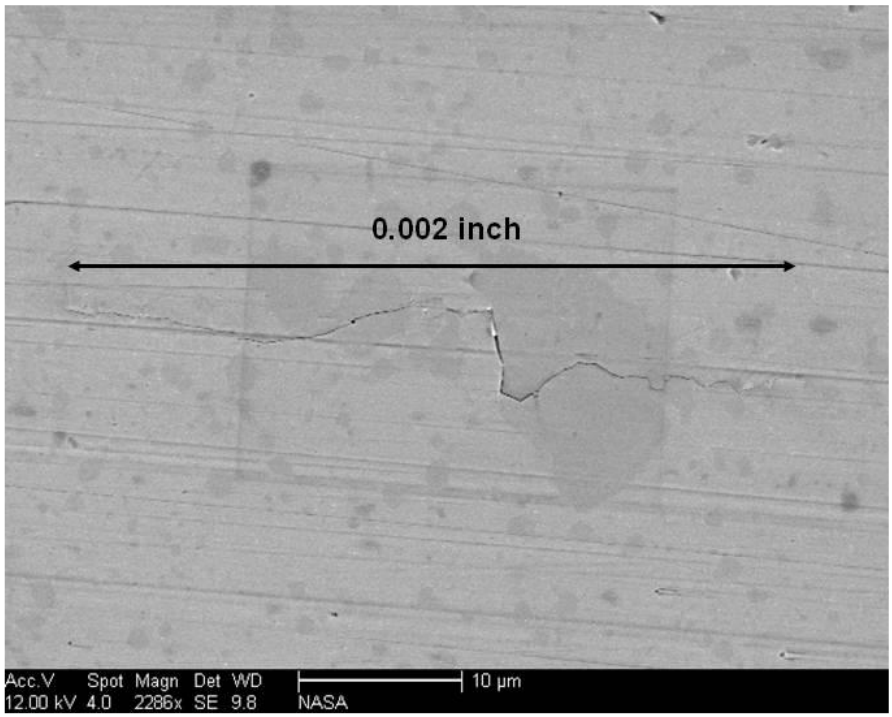
Size of Crack #4



6

Poppet #1

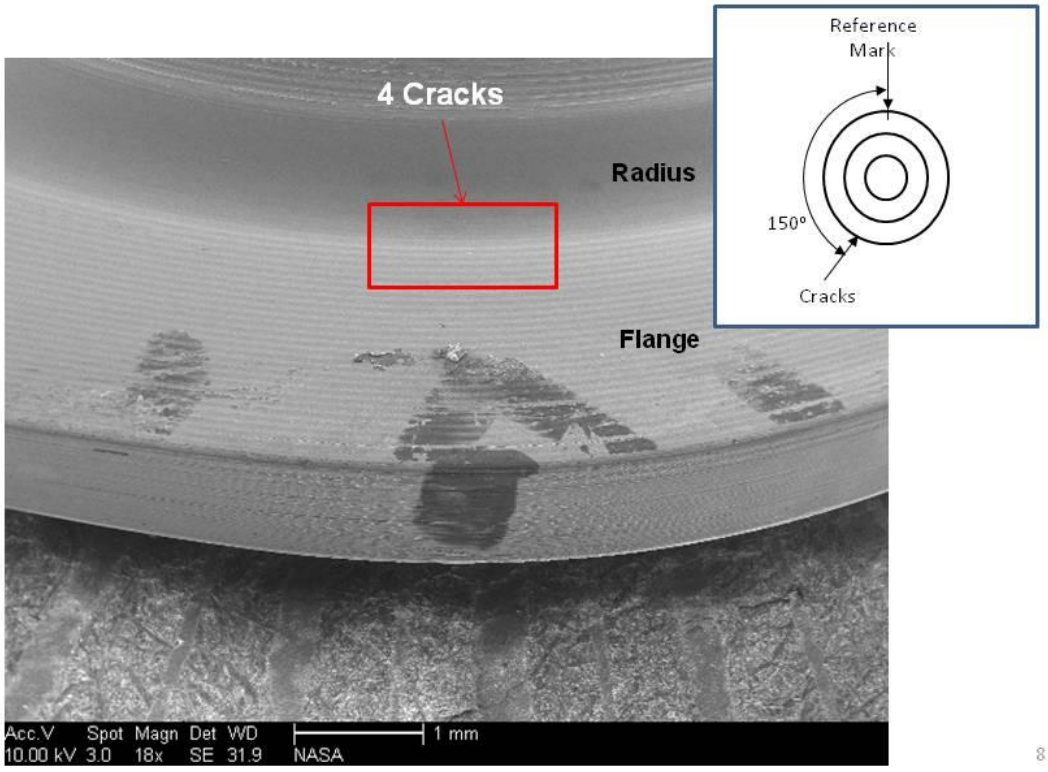
Size of Crack #5



7

Poppet #1

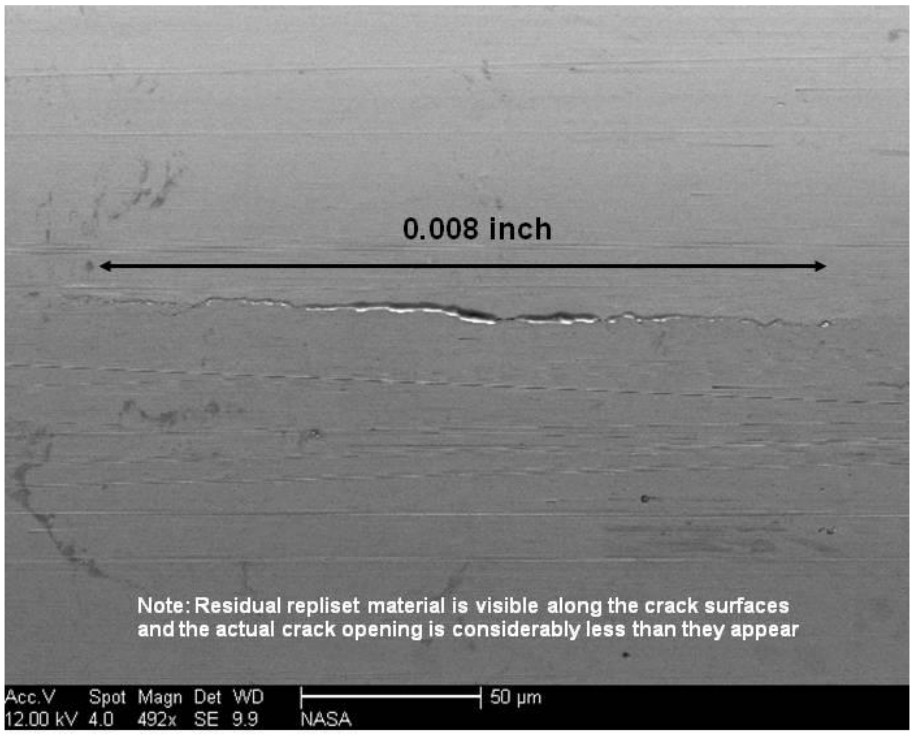
Location of Cracks #6-9



8

Poppet #1

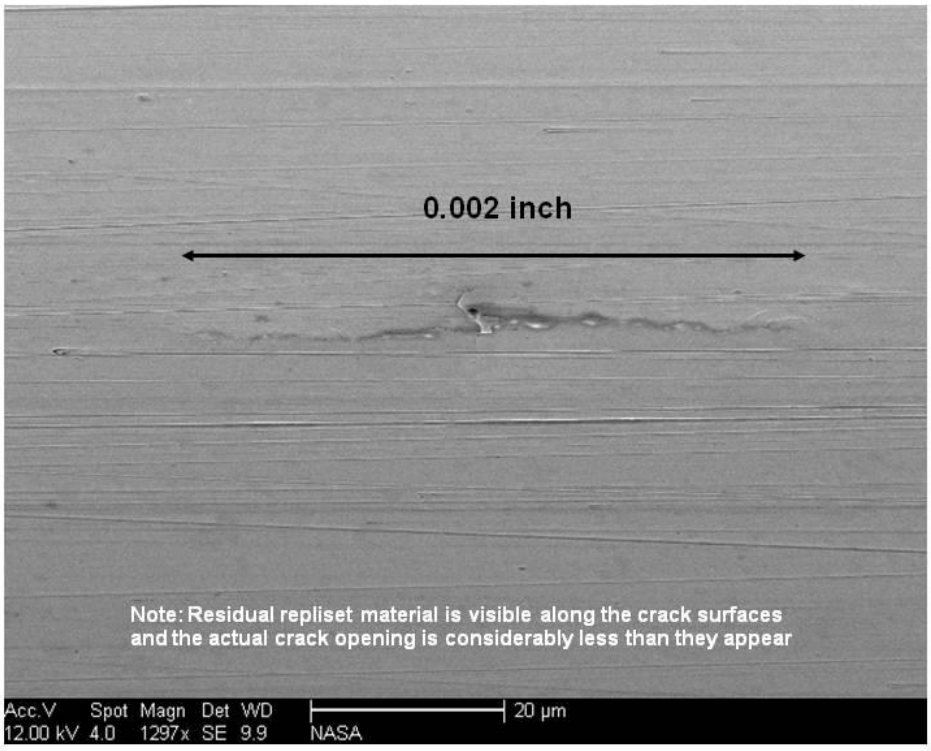
Size of Crack #6



9

Poppet #1

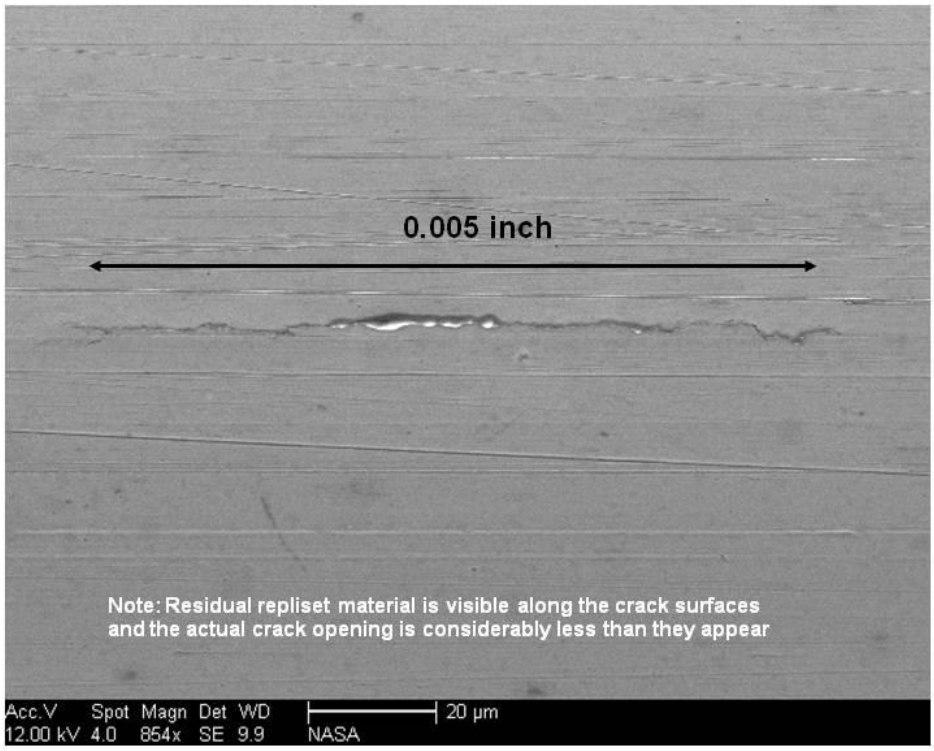
Size of Crack #7



10

Poppet #1

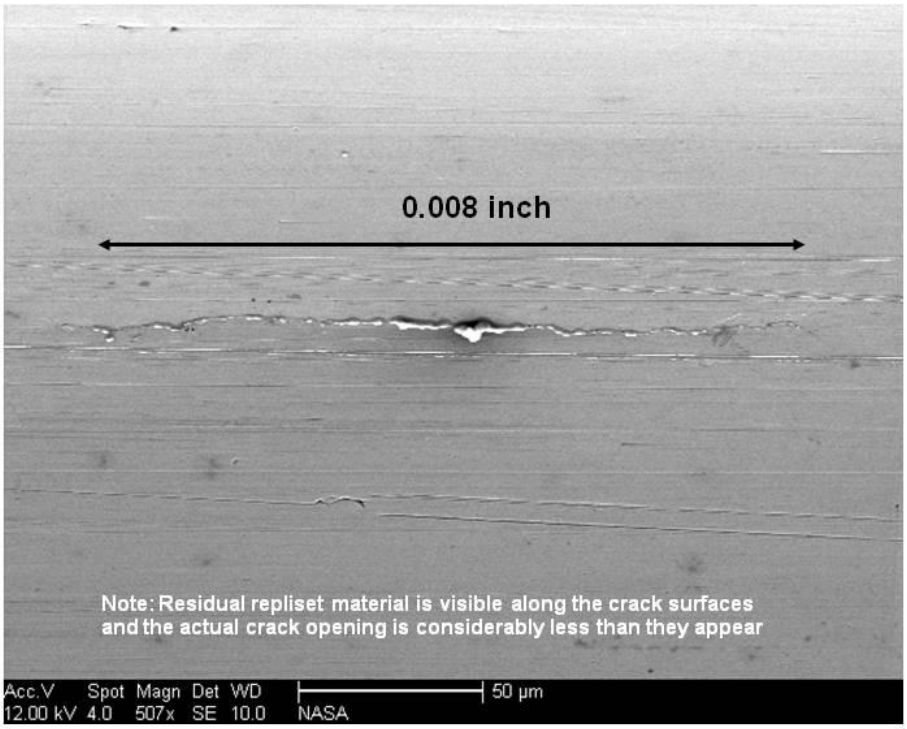
Size of Crack #8



11

Poppet #1

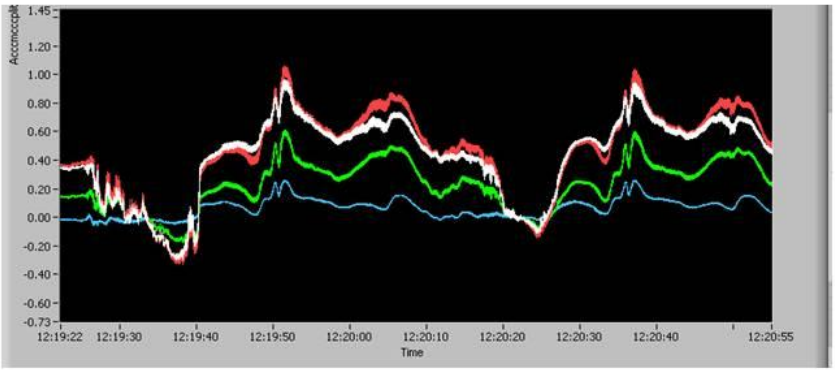
Size of Crack #9



12

Poppet #1

LaRC eddy current findings, the colors indicate ???



13

Poppet #7

Surface crack sizes and locations

Poppet #7		
Crack Number	Size (inch)	Angle (degrees)
1	0.027	125
2	0.024	335

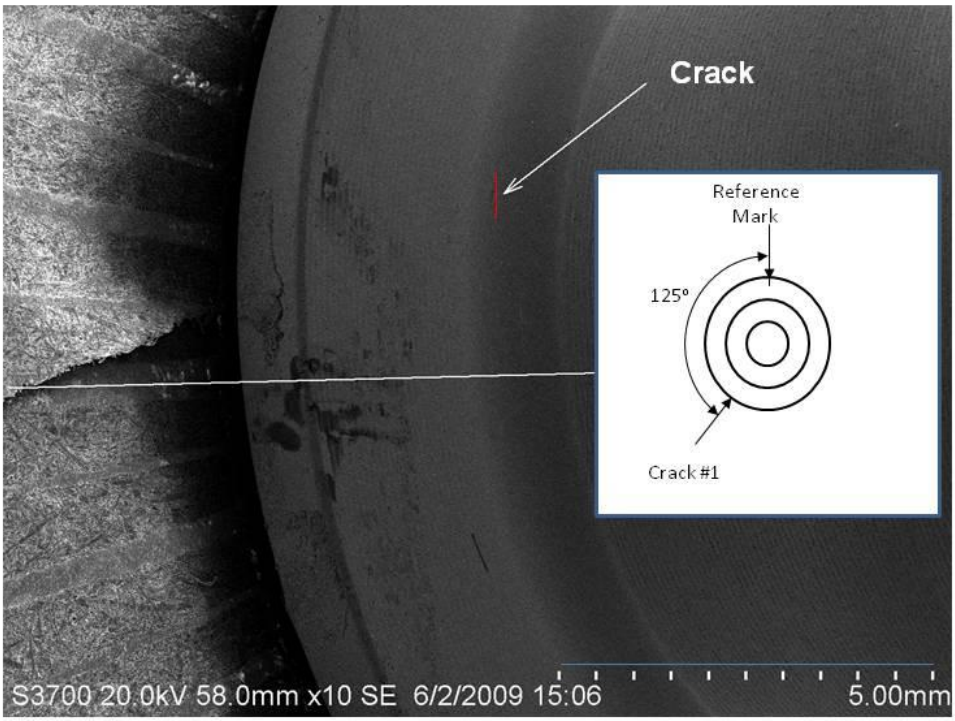
Boeing Eddy Current Findings

Poppet #7									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.246	0.240	0.233	0.250	0.249	0.268	0.248	Yes	290
J. Engel	0.120	0.130	0.149	0.156	0.134	0.132	0.137	Yes	135
B. Devries	0.235	0.226	0.239	0.244	0.247	0.226	0.236	Yes	285
B. Devries	0.132	0.127	0.132	0.133	0.139	0.145	0.135	False	190
B. Devries	0.199	0.199	0.193	0.197	0.199	0.192	0.197	Yes	140

14

Poppet #7

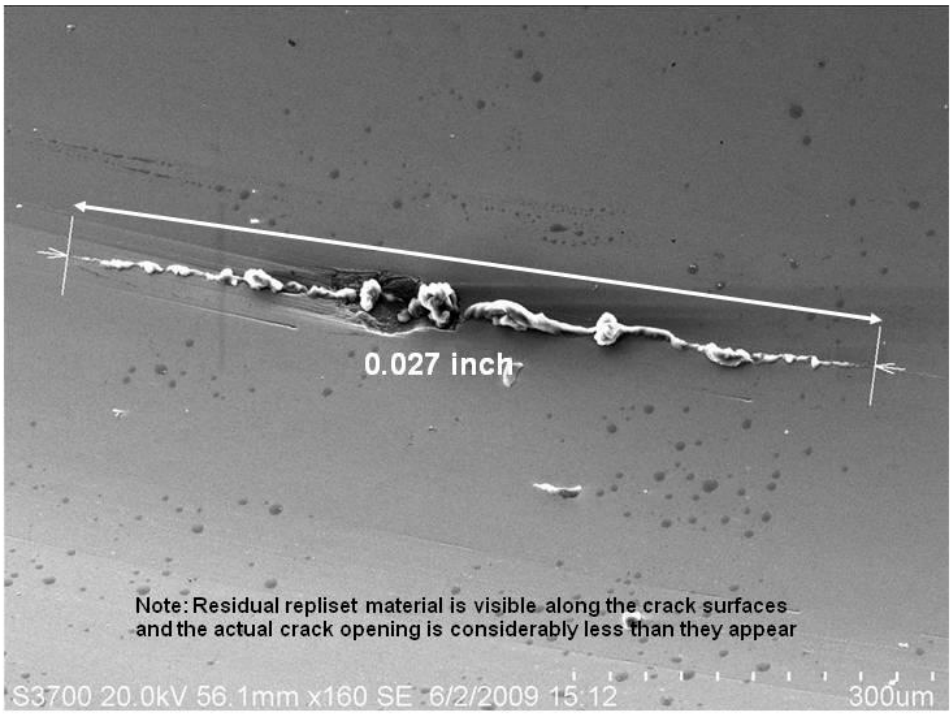
Location of Crack #1



15

Poppet #7

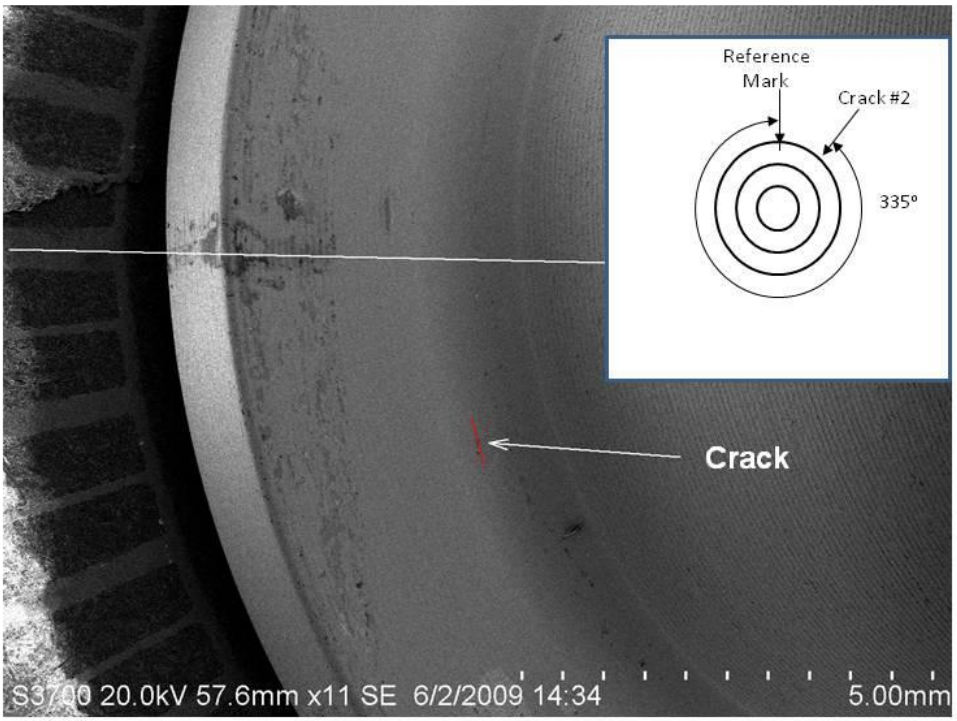
Size of Crack #1



16

Poppet #7

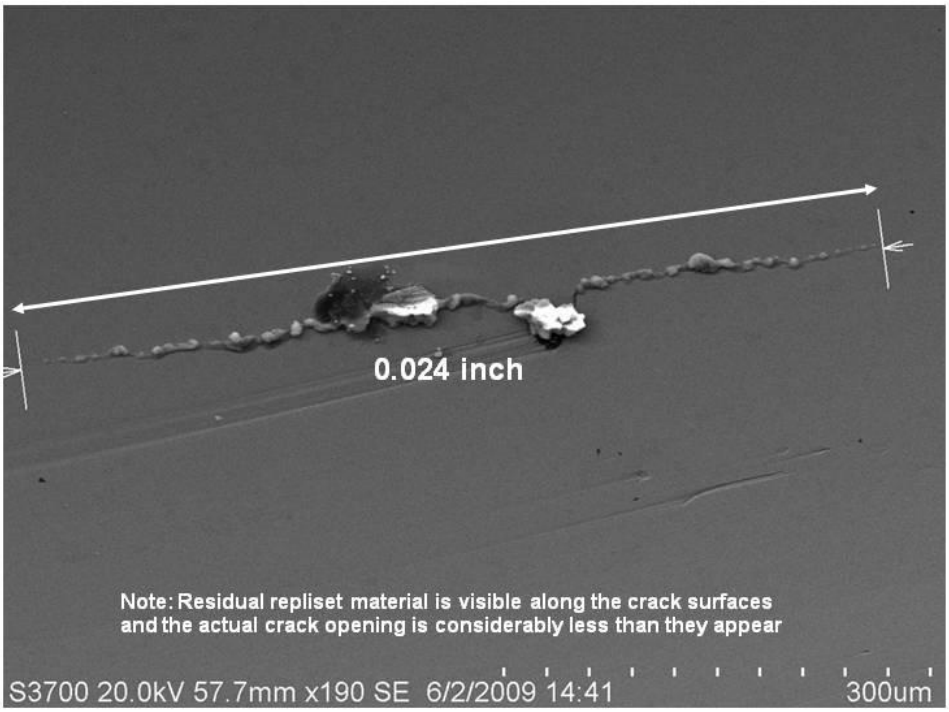
Location of Crack #2



17

Poppet #7

Size of Crack #2



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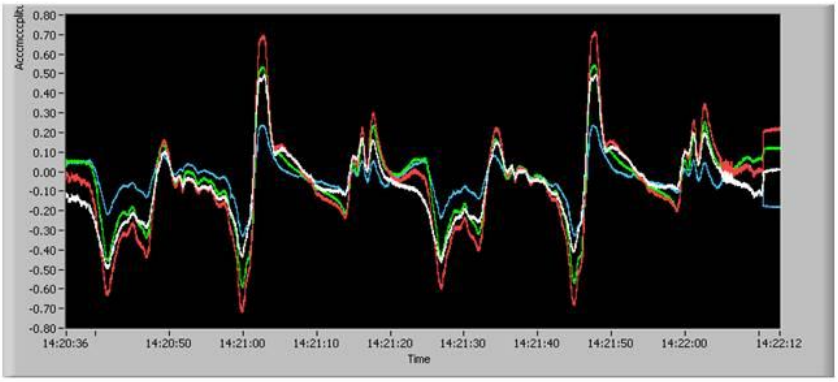
Poppet #7

LaRC eddy current findings, the colors indicate ???



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Poppet #11

Surface crack sizes and locations

Poppet #11		
Crack Number	Size (inch)	Angle (degrees)
1	0.075	90

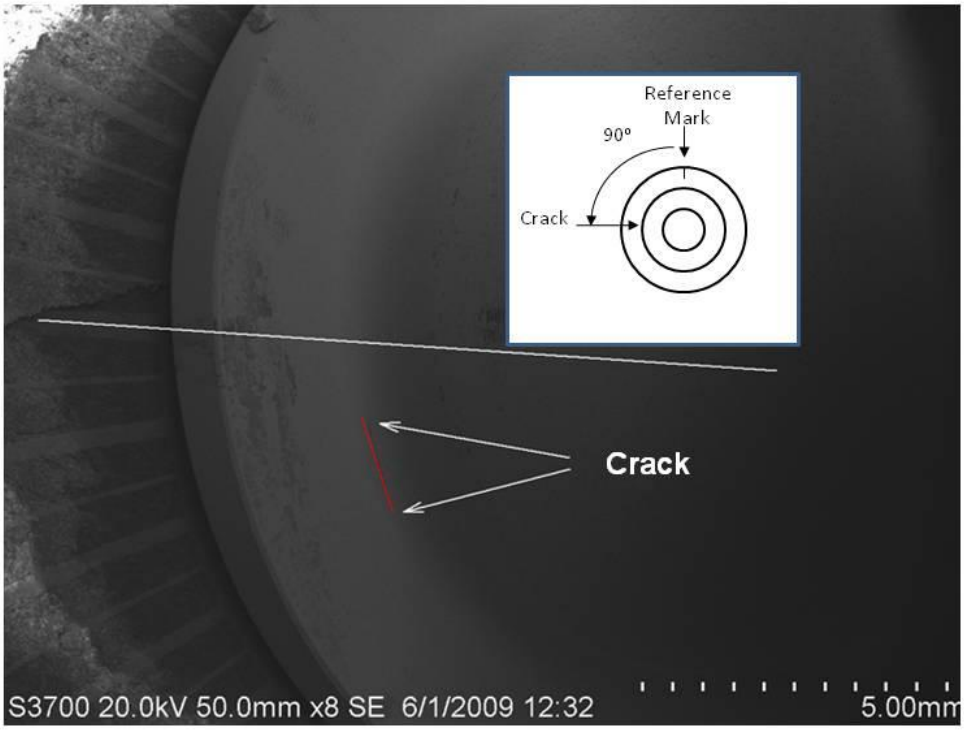
Boeing Eddy Current Findings

Poppet #11									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	-	-	-	-	-	-	-	NA	-
B. Devries	1.041	1.064	1.063	1.054	1.113	1.122	1.076	Yes	70

20

Poppet #11

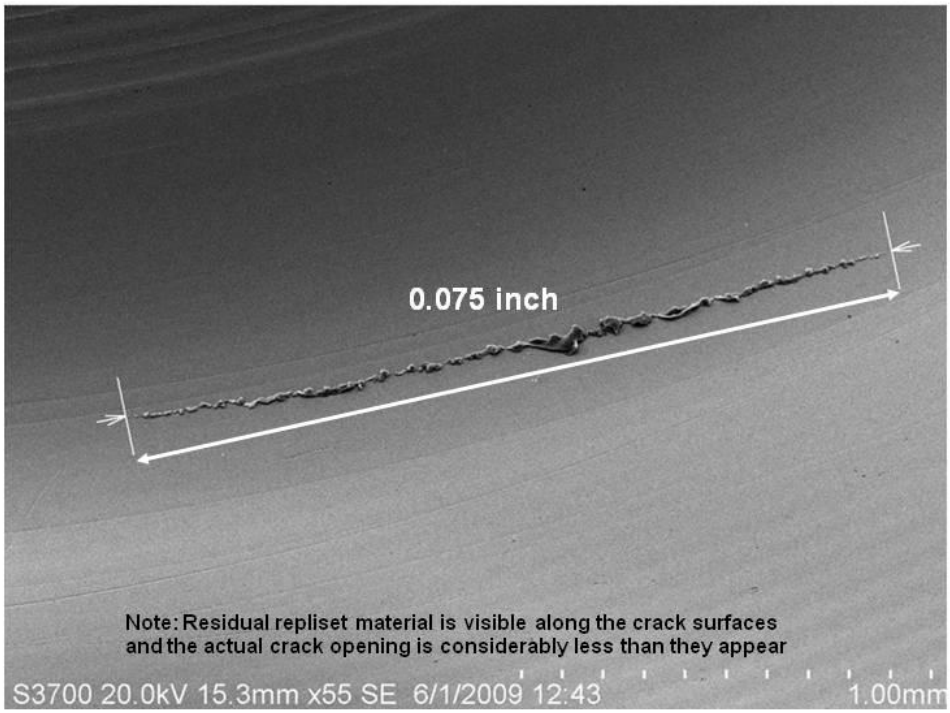
Location of Crack #1



21

Poppet #11

Size of Crack #1

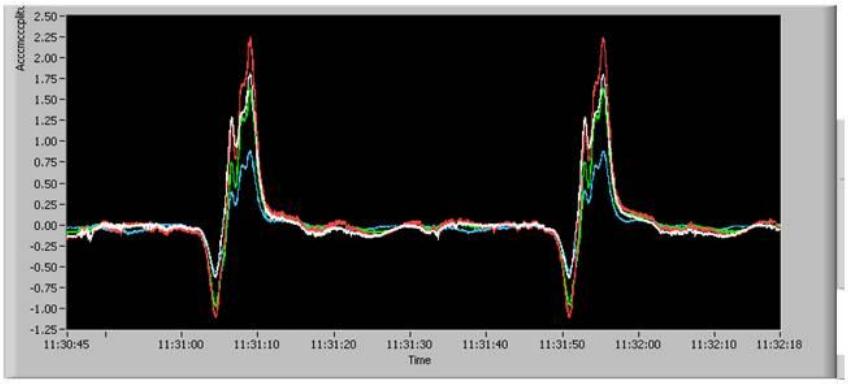


Note: SEM photograph of Poppet Crack with repliset residue highlighting the Crack

22

Poppet #11

LaRC eddy current findings, the colors indicate ???



Note: The time trace accounts for 2 complete revolutions of the Poppet relative to the sensor

23

Poppet #12

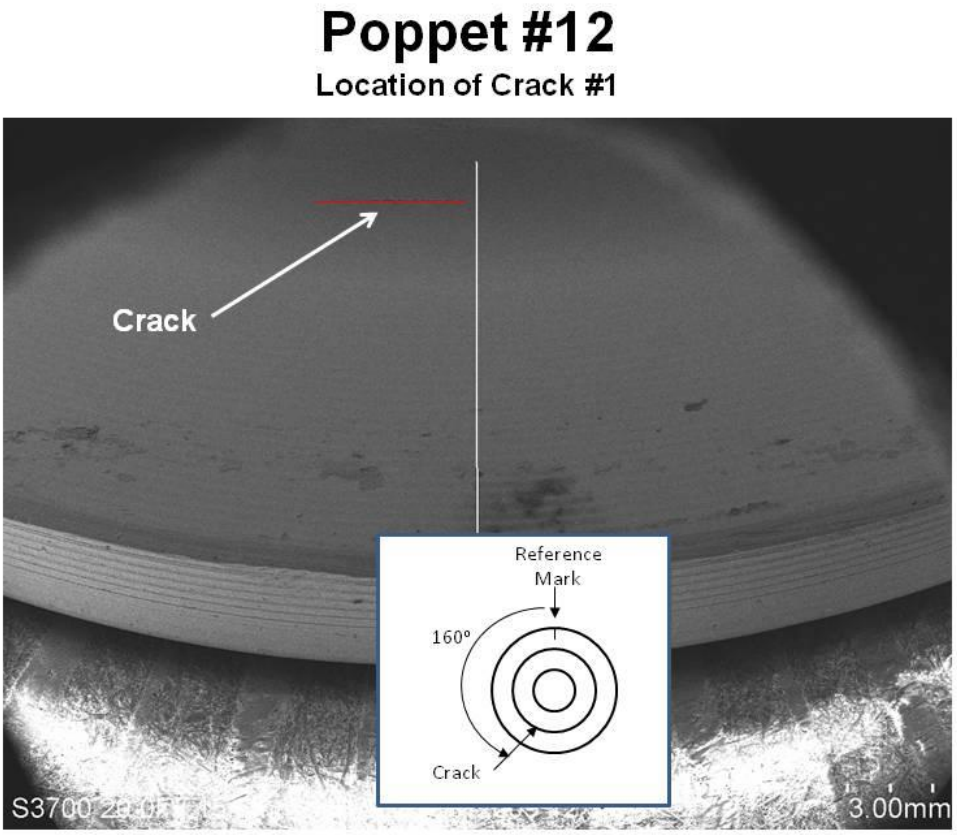
Surface crack sizes and locations

Poppet #12		
Crack Number	Size (inch)	Angle (degrees)
1	0.041	160

Boeing Eddy Current Findings

Poppet #12									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.664	0.677	0.694	0.642	0.485	0.368	0.588	Yes	170
B. Devries	0.658	0.655	0.654	0.666	0.658	0.675	0.661	Yes	170

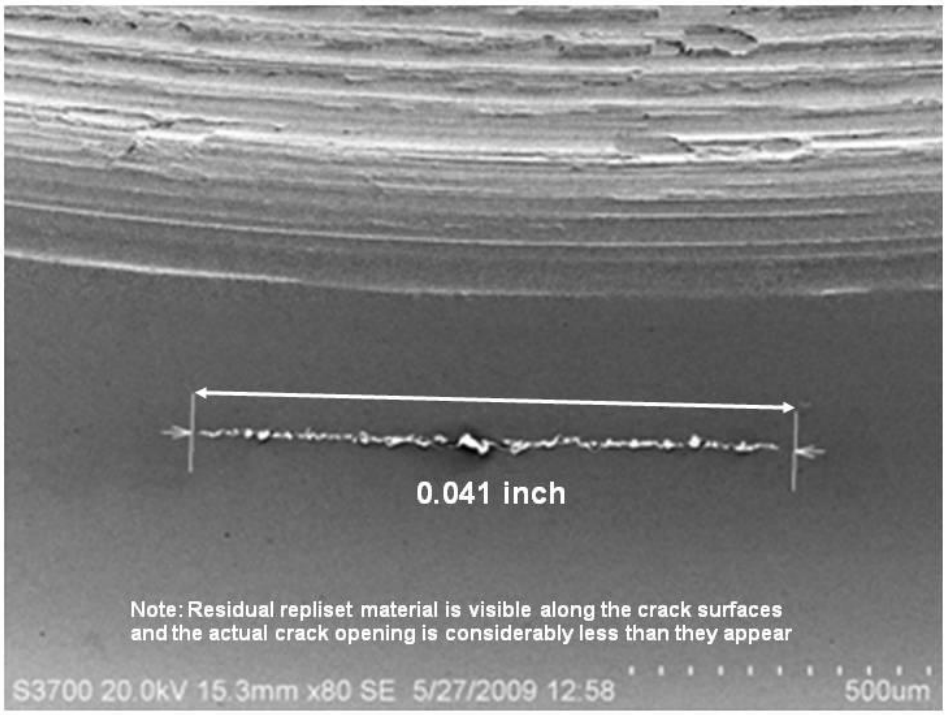
24


Poppet #12
Location of Crack #1
Crack
Reference Mark
160°
Crack
3.00mm

25

Poppet #12

Size of Crack #1



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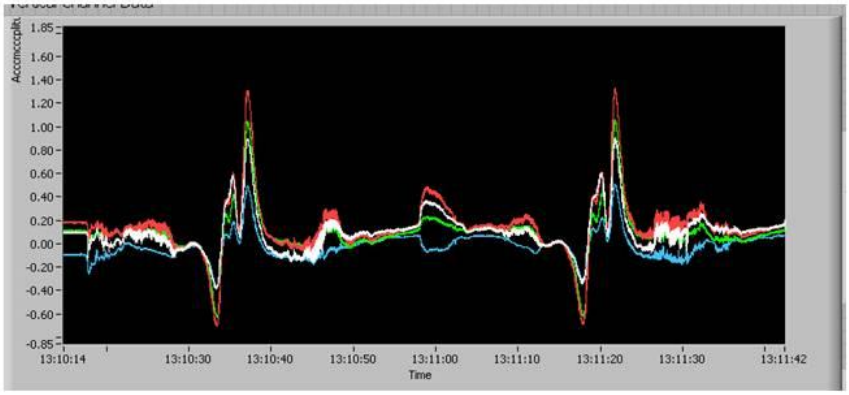
Poppet #12

LaRC eddy current findings, the colors indicate ???



Note: The time trace accounts for 2 complete revolutions of the Poppet relative to the sensor

27

Poppet #13

Surface crack sizes and locations

Poppet #13		
Crack Number	Size (inch)	Angle (degrees)
1	0.014	110
2	0.014	110

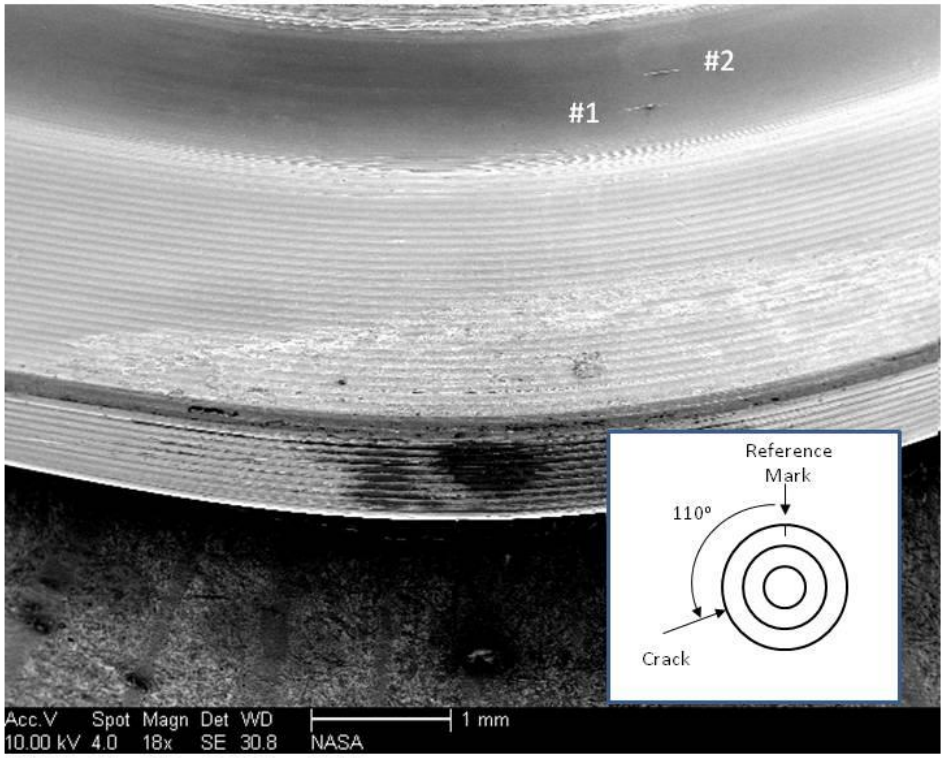
Boeing Eddy Current Findings

Poppet #13									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.185	0.192	0.196	0.202	0.202	0.213	0.198	Yes	120 (Small indication opposite)
B. Devries	0.190	0.187	0.185	0.186	0.192	0.192	0.189	Yes	110

28

Poppet #13

Location of Cracks 1 &2



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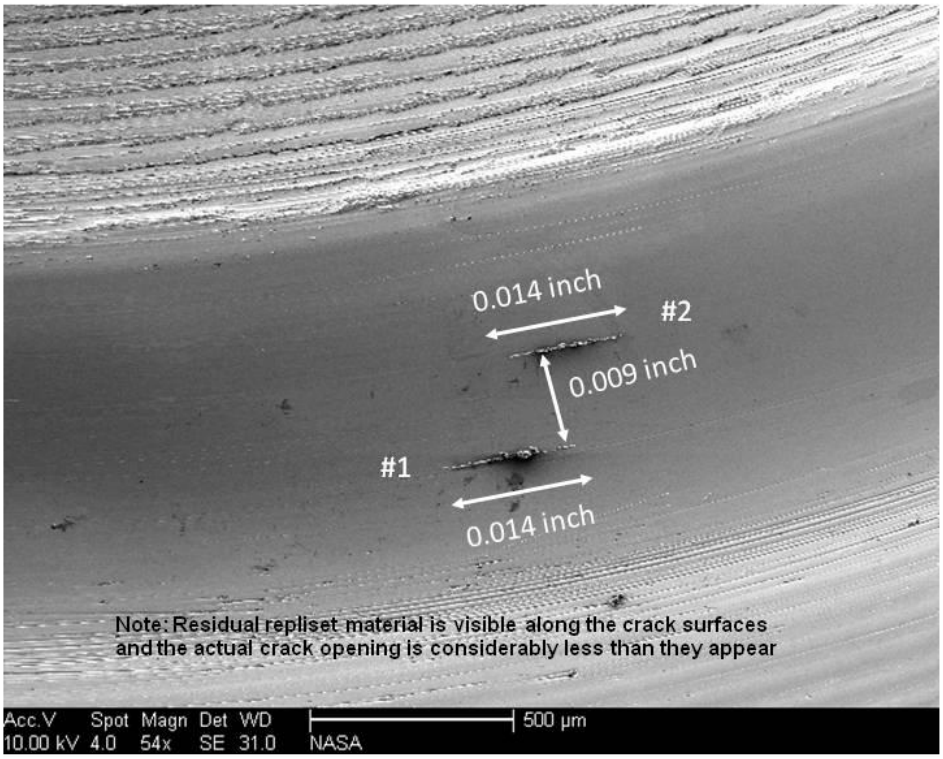
Poppet #13

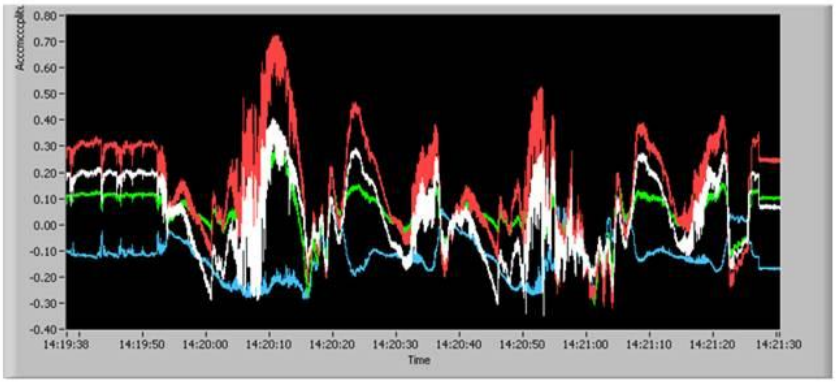
Location and size of Cracks #1 and #2



30

Poppet #13

LaRC eddy current findings, the colors indicate ???



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Poppet #14

Surface crack sizes and locations

Poppet #14		
Crack Number	Size (inch)	Angle (degrees)
1	0.033	310

Boeing Eddy Current Findings

Poppet #14									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.414	0.412	0.420	0.420	0.430	0.426	0.420	Yes	320
J. Engel	0.042	0.039	0.037	0.040	0.039	0.039	0.039	False	145 (Not 3:1 S/N ratio)
B. Devries	0.415	0.419	0.429	0.448	0.455	0.461	0.438	Yes	315

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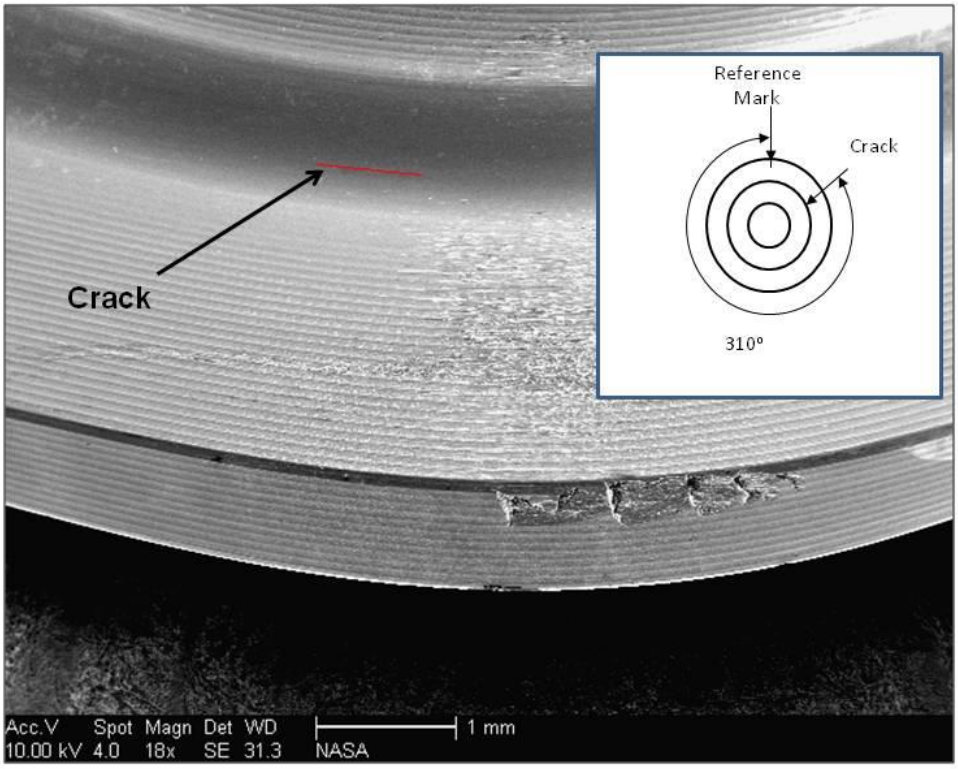
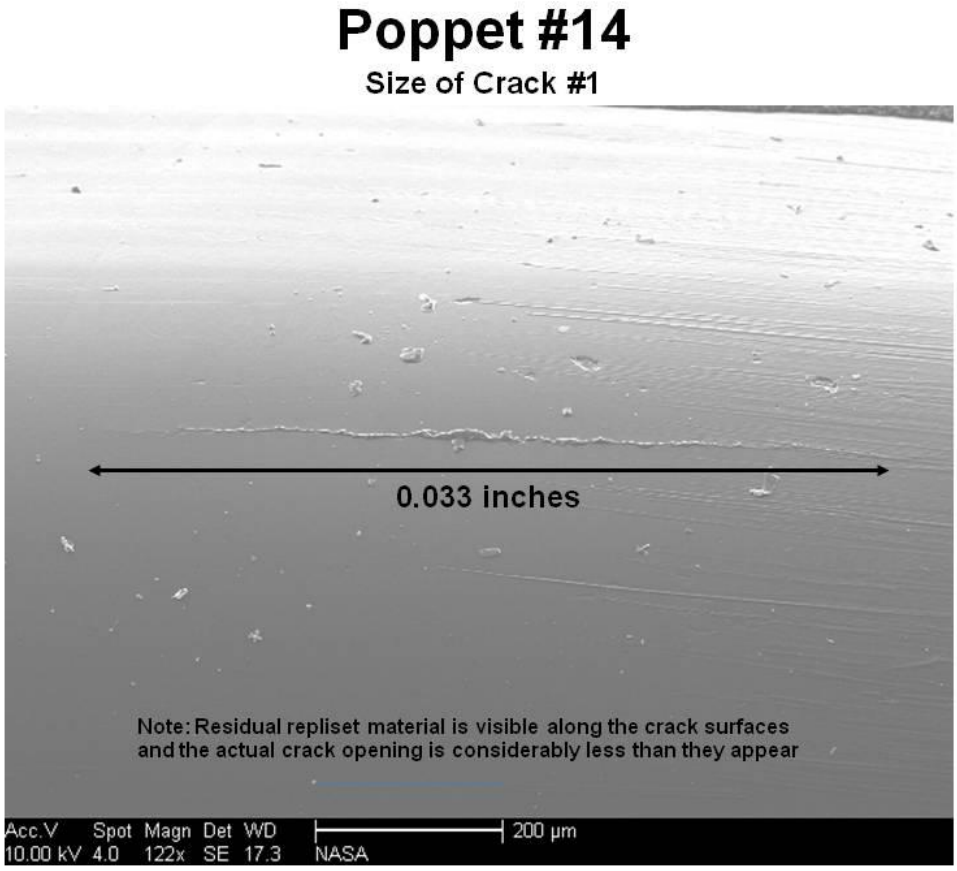
Poppet #14

Location of Crack #1

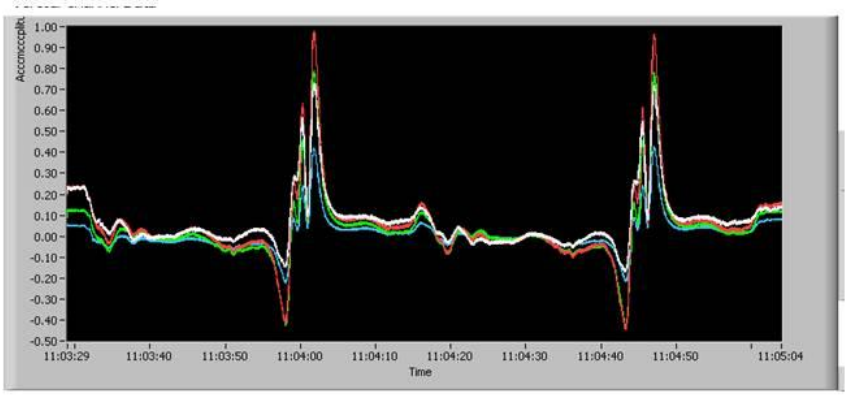


33


Poppet #14
Size of Crack #1
0.033 inches
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
Acc.V Spot Magn Det WD
10.00 kV 4.0 122x SE 17.3
200 µm
NASA
34

Poppet #14

LaRC eddy current findings, the colors indicate ???



Note: The time trace accounts for 2 complete revolutions of the Poppet relative to the sensor

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Poppet #17

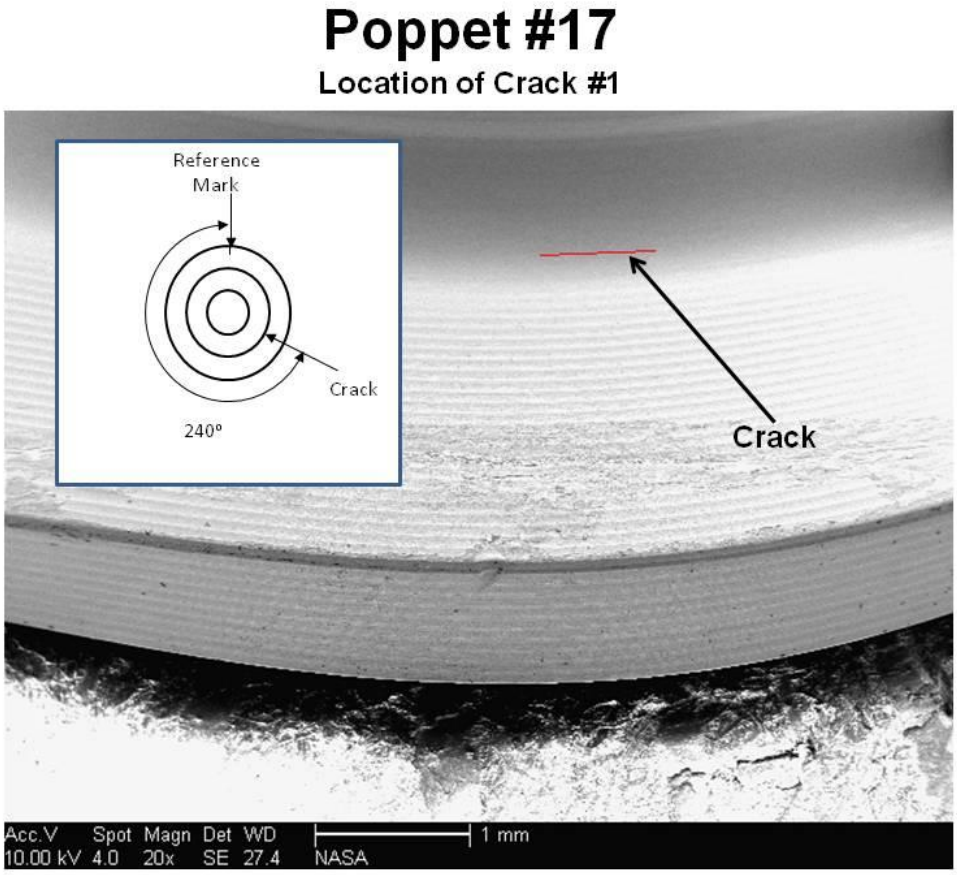
Surface crack sizes and locations

Poppet #17		
Crack Number	Size (inch)	Angle (degrees)
1	0.026	240

Boeing Eddy Current Findings

Poppet #17									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.269	0.275	0.275	0.275	0.276	0.277	0.275	Yes	245
B. Devries	0.257	0.264	0.268	0.269	0.251	0.271	0.263	Yes	255

36


Poppet #17
Location of Crack #1
Reference Mark
Crack
240°
Crack
Acc.V Spot Magn Det WD
10.00 kV 4.0 20x SE 27.4
1 mm
NASA

37

Poppet #17

Size of Crack #1

Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

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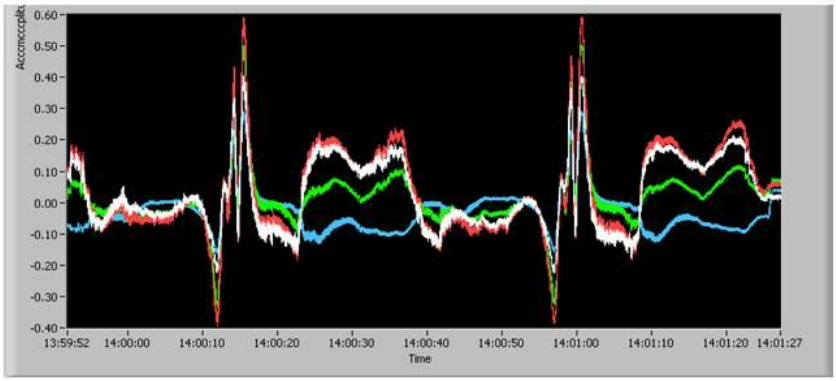
Poppet #17

LaRC eddy current findings, the colors indicate ???



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Poppet #18

Surface crack sizes and locations

Poppet #18		
Crack Number	Size (inch)	Angle (degrees)
1	0.078	140
2	0.025	330

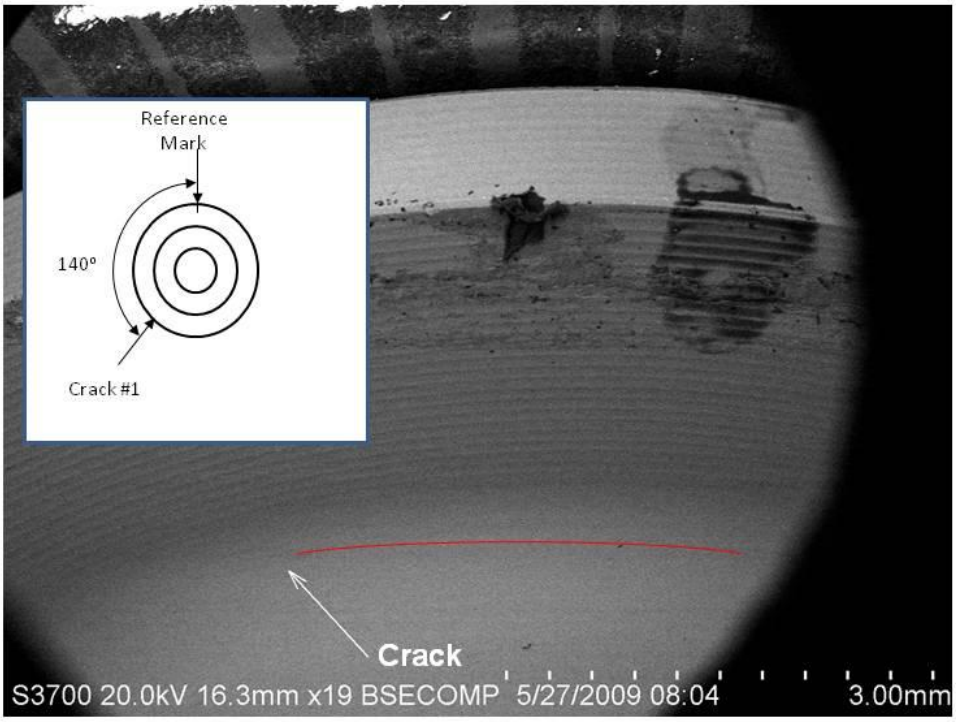
Boeing Eddy Current Findings

Poppet #18									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	1.026	1.028	1.066	1.077	1.088	1.091	1.063	Yes	120
J. Engel	0.231	0.234	0.238	0.234	0.237	0.248	0.237	Yes	320
B. Devries	1.028	1.061	1.041	1.051	1.051	1.096	1.055	Yes	120
B. Devries	0.247	0.250	0.250	0.252	0.255	0.259	0.252	Yes	305

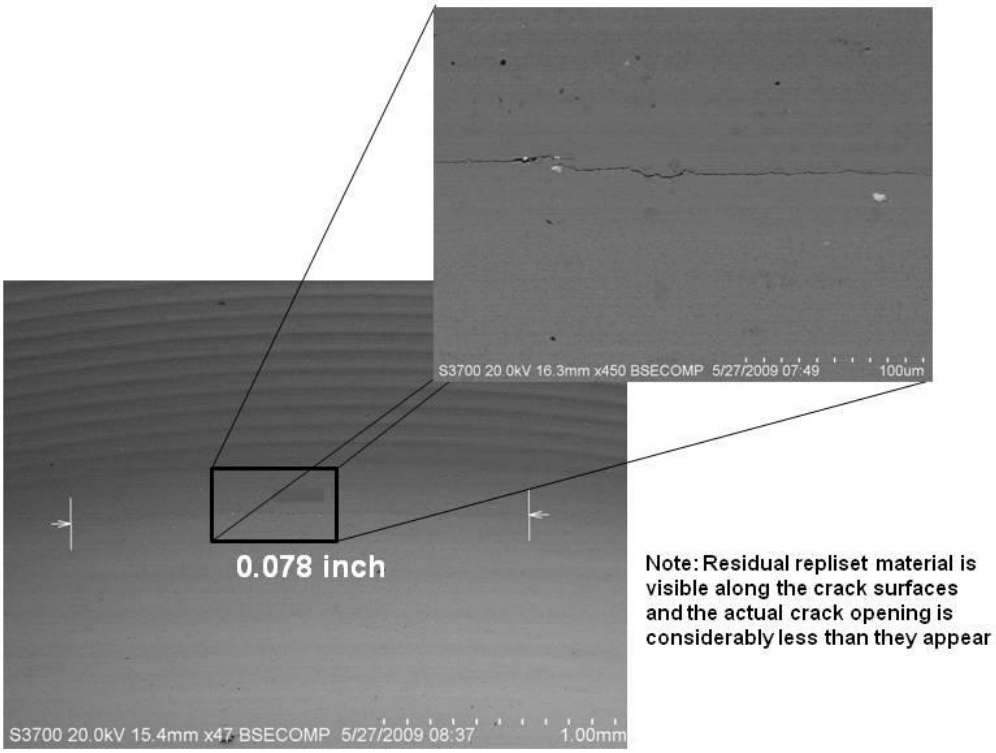
40

Poppet #18

Location of Crack #1

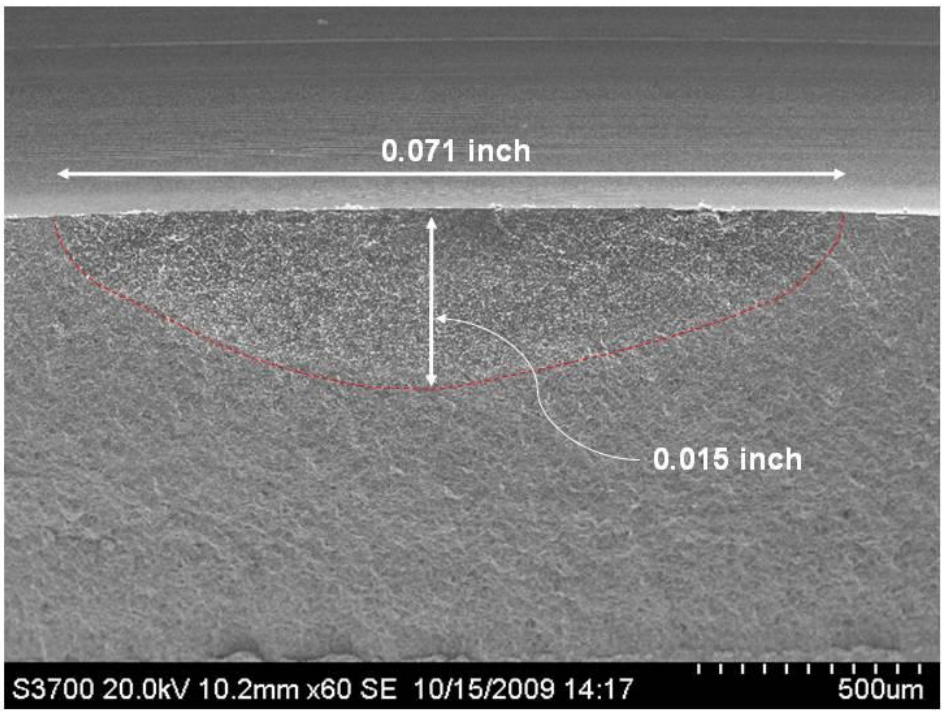


41


Poppet #18
Location and size of Crack #1
S3700 20.0kV 16.3mm x450 BSECOMP 5/27/2009 07:49 100um
0.078 inch
S3700 20.0kV 15.4mm x47 BSECOMP 5/27/2009 08:37 1.00mm
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
42

Poppet #18

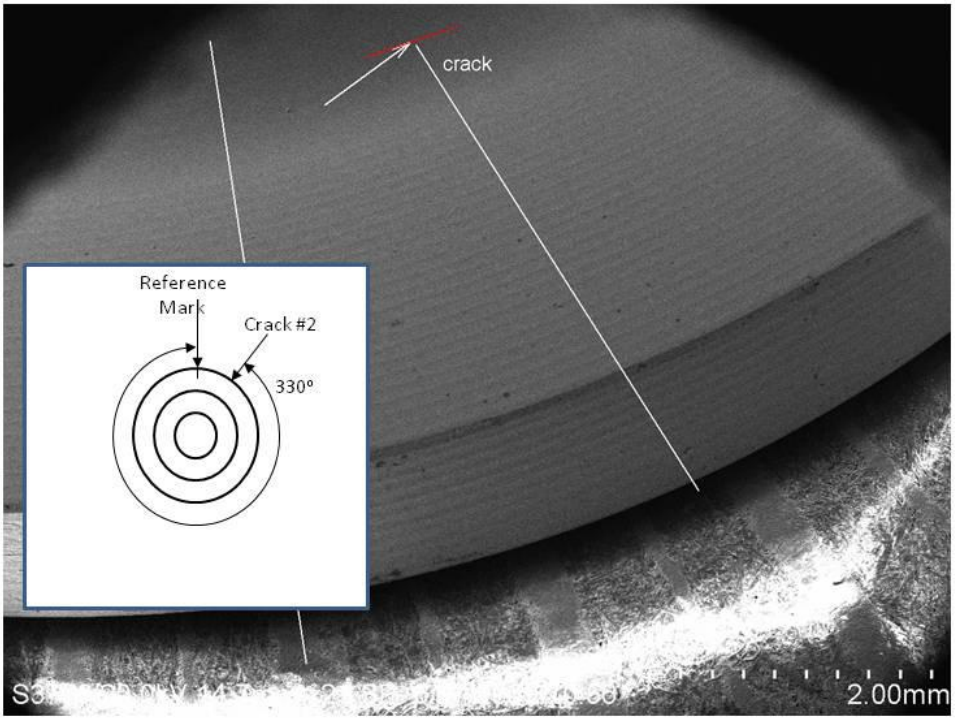
Crack depth and correlation with surface measurements for Crack #1



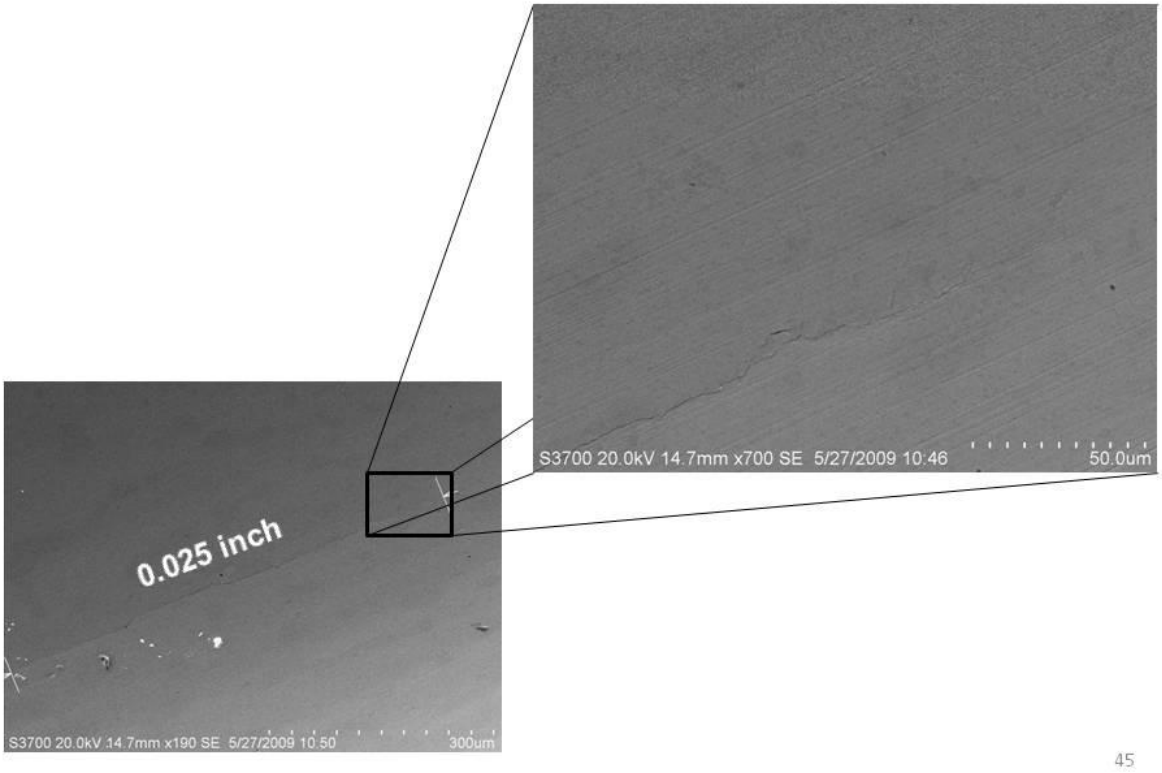
43

Poppet #18

Location of Crack #2

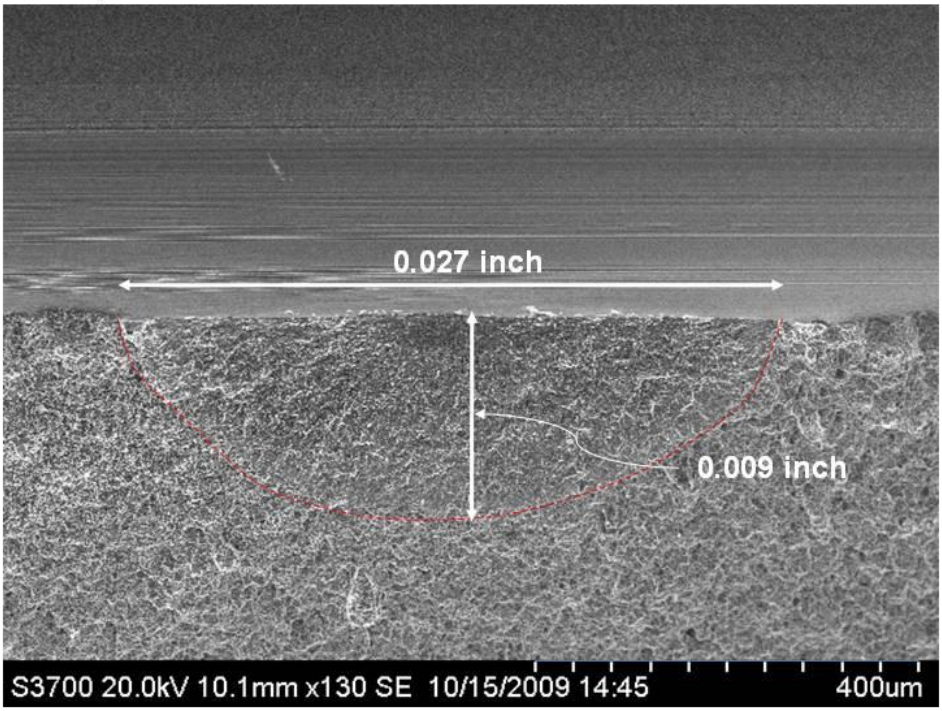


44


Poppet #18
Location and size Crack #2
S3700 20.0kV 14.7mm x700 SE 5/27/2009 10:46
50.0um
0.025 inch
S3700 20.0kV 14.7mm x190 SE 5/27/2009 10:50
300um
45

Poppet #18

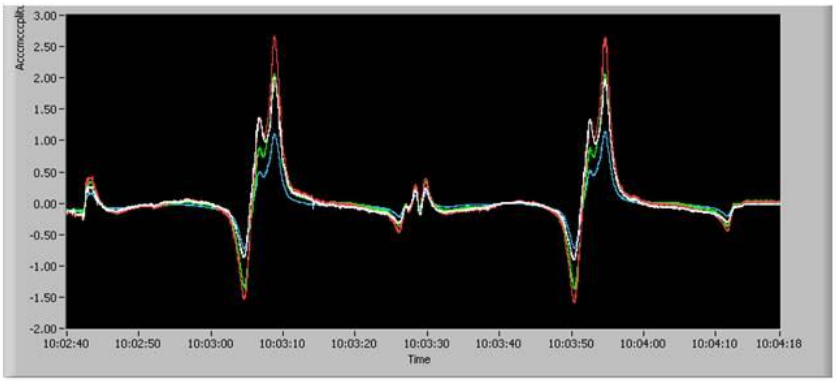
Crack depth and correlation with surface measurements for Crack #2



46

Poppet #1

LaRC eddy current findings, the colors indicate ???



47

Poppet #19

Surface crack sizes and locations

Poppet #19		
Crack Number	Size (inch)	Angle (degrees)
1	0.037	230
2	0.005	230
3	0.004	230
4	0.003	230
5	0.001	230

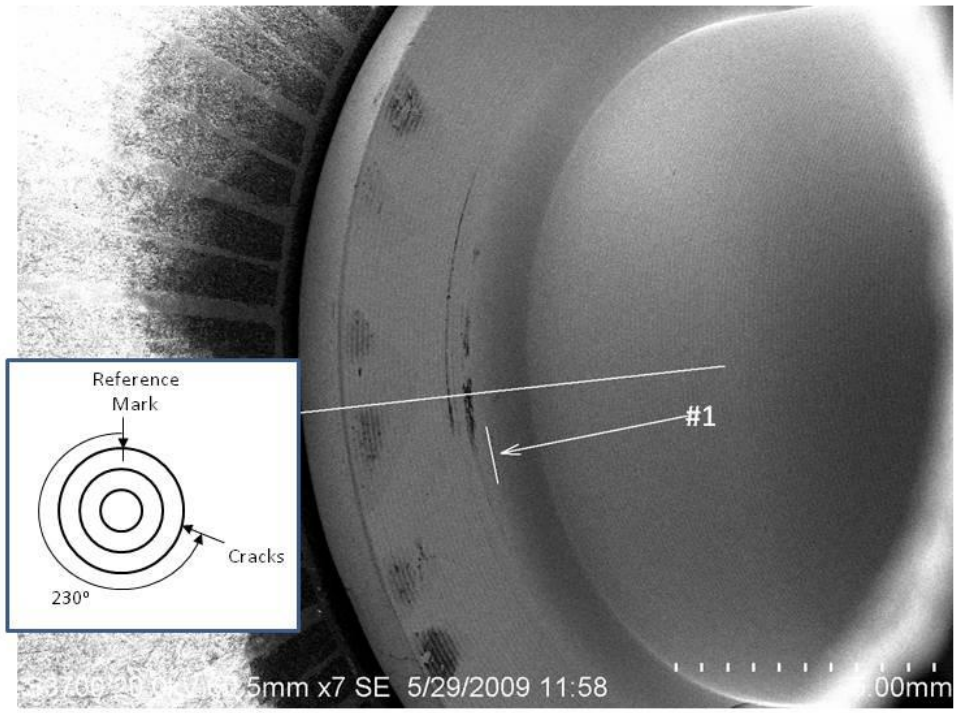
Boeing Eddy Current Findings

Poppet #19									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.495	0.496	0.510	0.520	0.520	0.528	0.512	Yes	210
B. Devries	0.501	0.504	0.523	0.516	0.516	0.493	0.509	Yes	215

48

Poppet #19

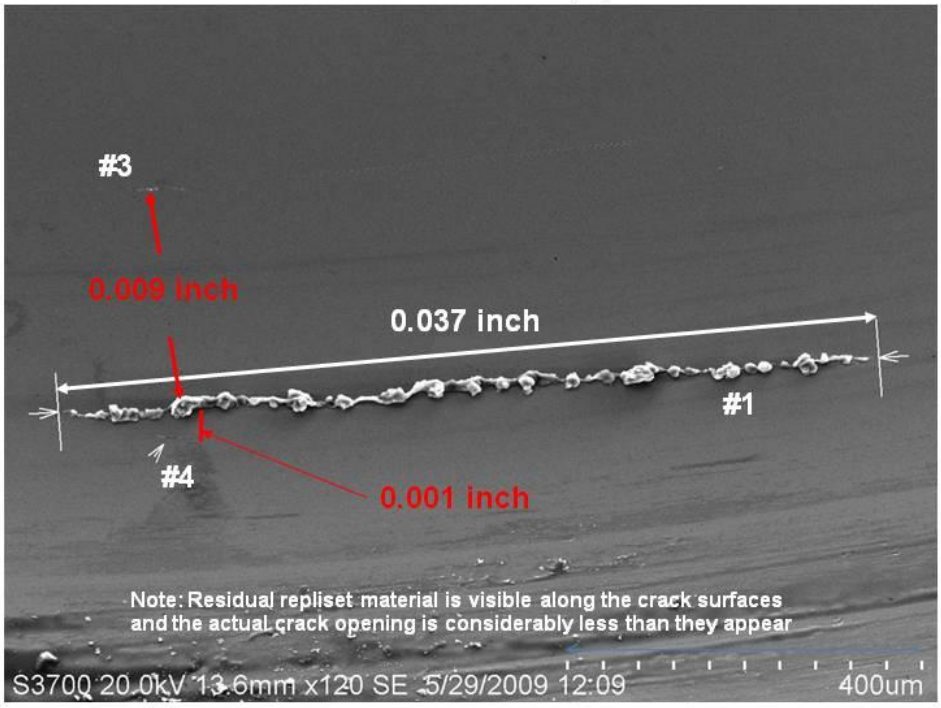
Location of Crack #1



49

Poppet #19

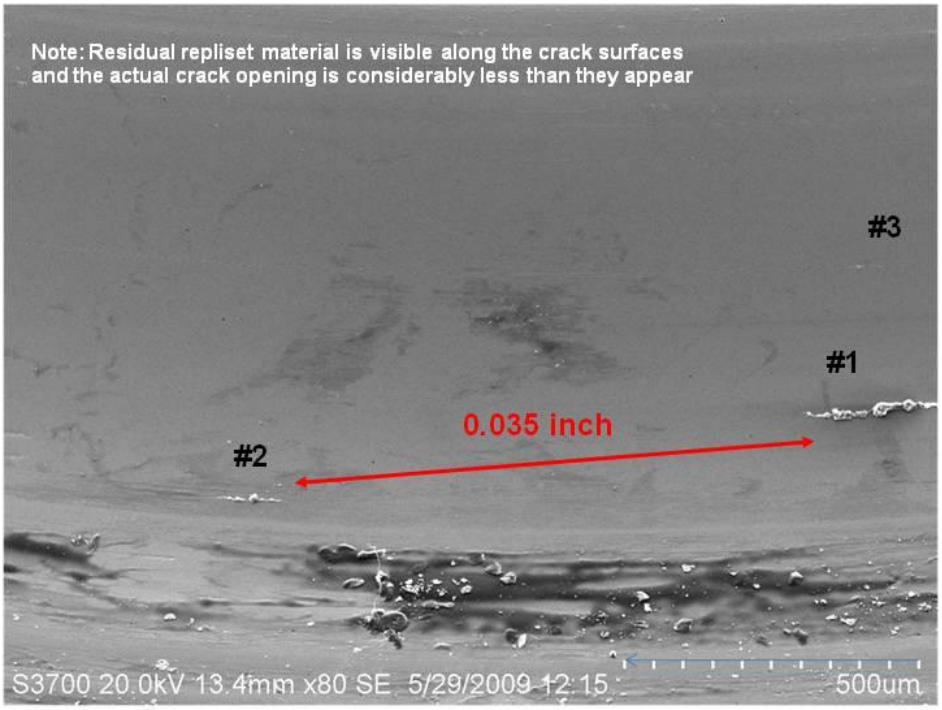
Location of Cracks #1, 3, and 4



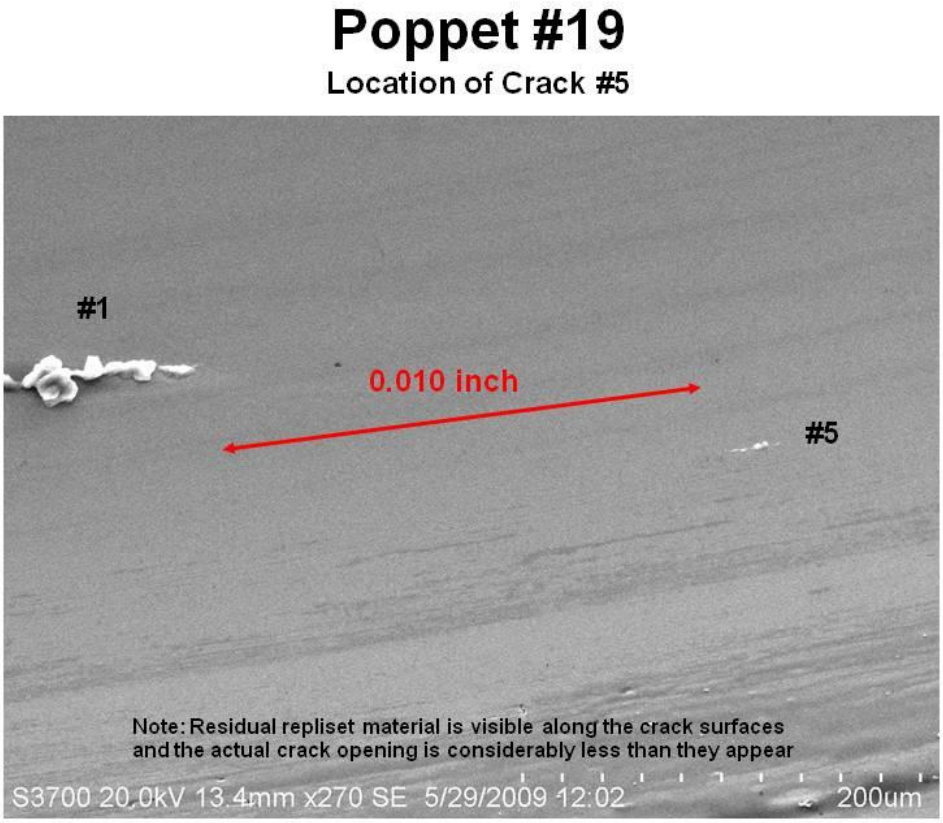
50

Poppet #19

Location of Crack #2



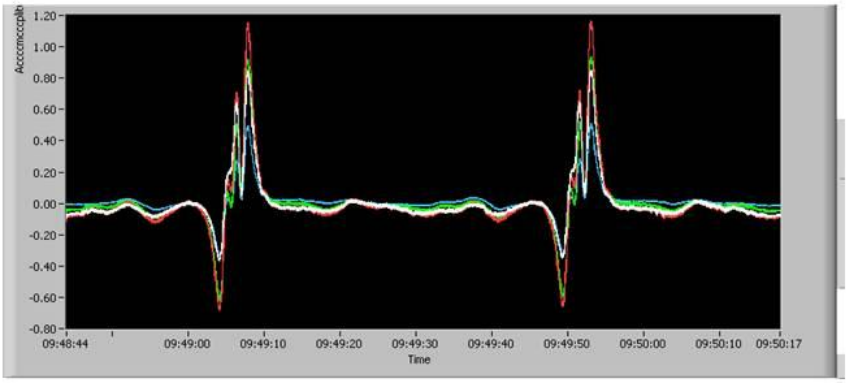
51


Poppet #19
Location of Crack #5
#1
0.010 inch
#5
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 13.4mm x270 SE 5/29/2009 12:02
200um

52

Poppet #19

LaRC eddy current findings, the colors indicate ???



53

Poppet #20

Surface crack sizes and locations

Poppet #20		
Crack Number	Size (inch)	Angle (degrees)
1	0.017	110
2	0.003	110
3	0.003	110

Boeing Eddy Current Findings

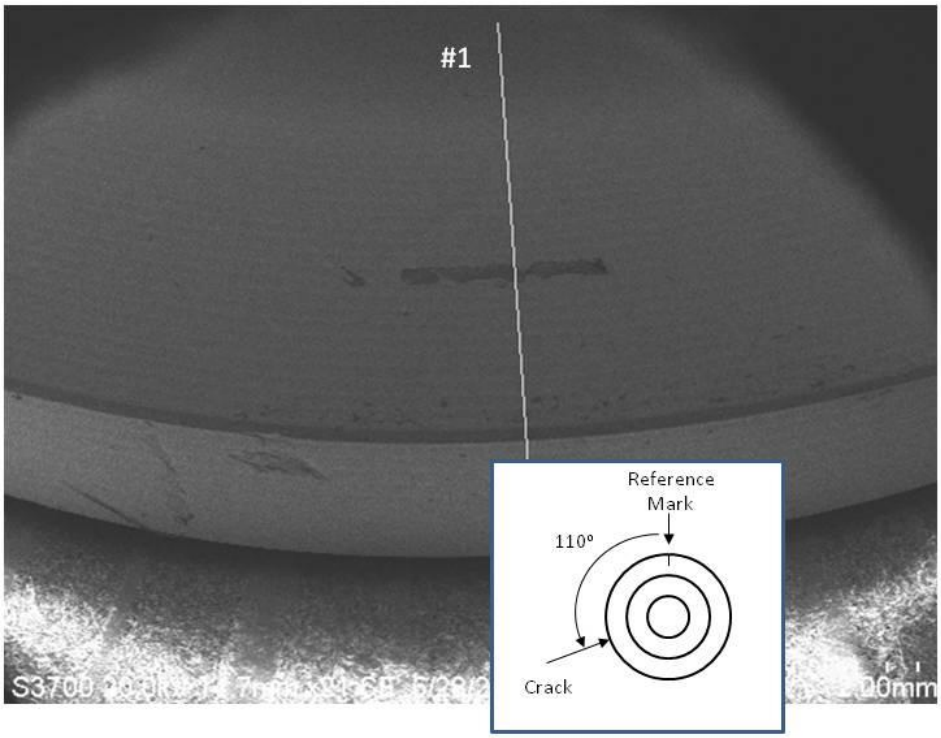
Poppet #20									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.147	0.150	0.154	0.154	0.155	0.145	0.151	Yes	265
B. Devries	0.150	0.165	0.144	0.143	0.144	0.141	0.148	Yes	255

Note: It appears that both Engel and DeVries used a machining mark on the flange as the reference rather than the mark that we put on the specimen. The difference between the two marks was about 160°

54

Poppet #20

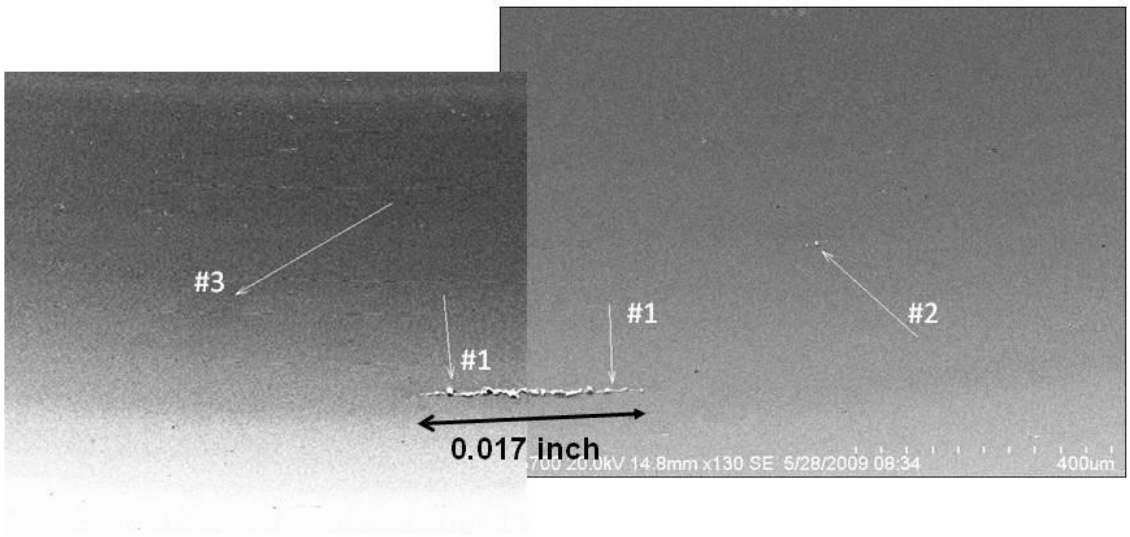
Location of Crack #1



55

Poppet #20

Location of Cracks #1, 2, and 3

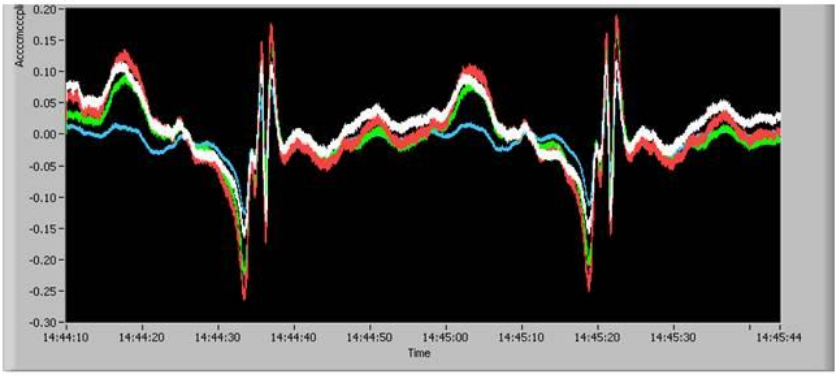


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

56

Poppet #20

LaRC eddy current findings, the colors indicate ???



57

Poppet #21

Surface crack sizes and locations

Poppet #21		
Crack Number	Size (inch)	Angle (degrees)
1	0.017	300
2	0.015	300
3	0.009	300
4	0.008	300

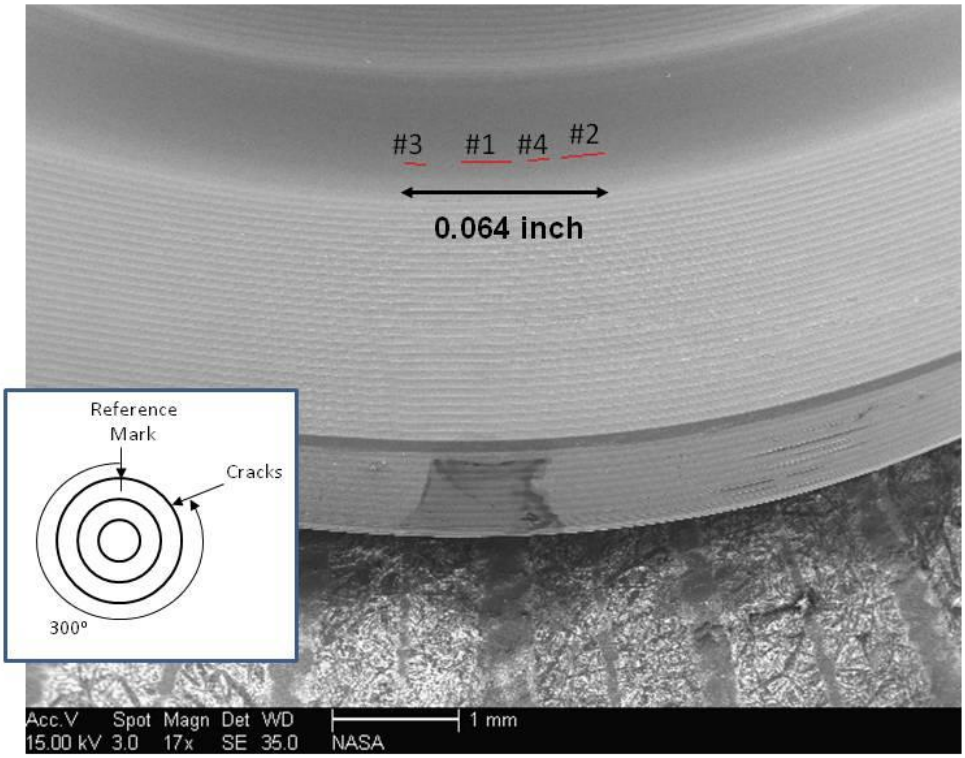
Boeing Eddy Current Findings

Poppet #21									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.143	0.137	0.130	0.143	0.153	0.145	0.142	Yes	300
B. Devries	0.133	0.139	0.137	0.126	0.149	0.128	0.135	Yes	295

58

Poppet #21

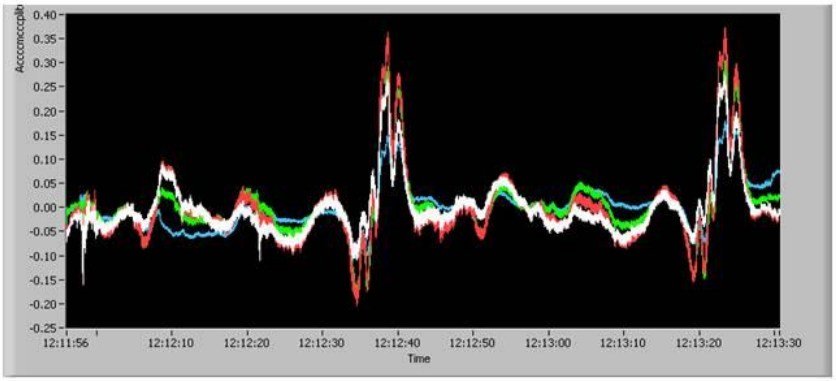
Location of Cracks #1-4



59

Poppet #21

LaRC eddy current findings, the colors indicate ???



60

Poppet #22

Surface crack sizes and locations

Poppet #22		
Crack Number	Size (inch)	Angle (degrees)
1	0.022	135
2	0.009	135
3	0.004	135

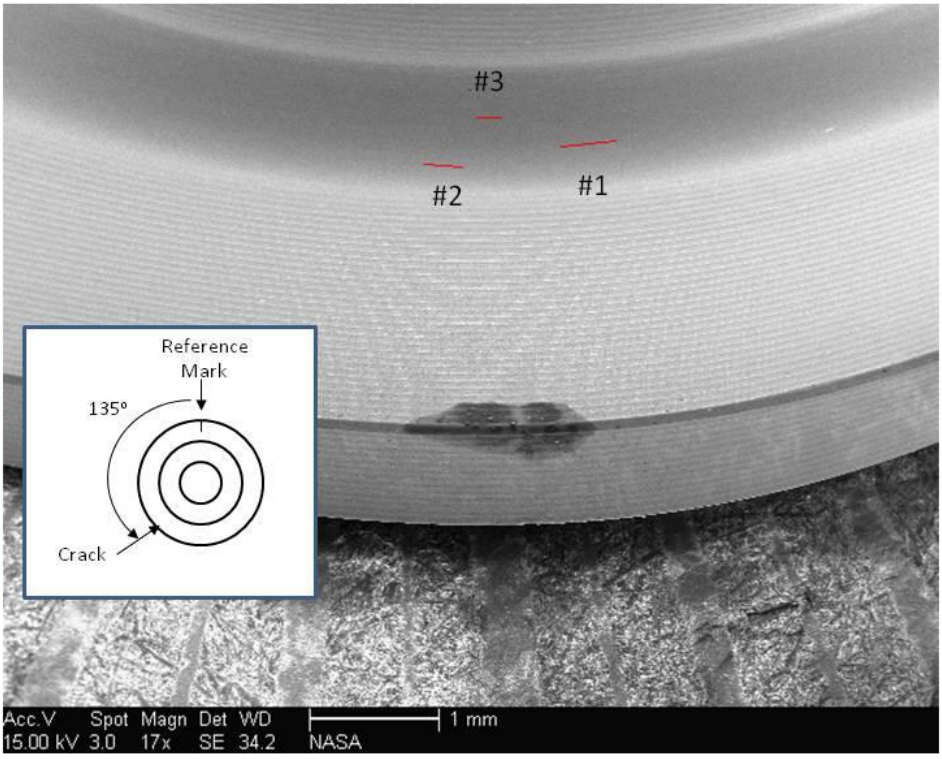
Boeing Eddy Current Findings

Poppet #22									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.223	0.215	0.234	0.224	0.233	0.230	0.227	Yes	140
B. Devries	0.220	0.225	0.223	0.226	0.225	0.229	0.225	Yes	120

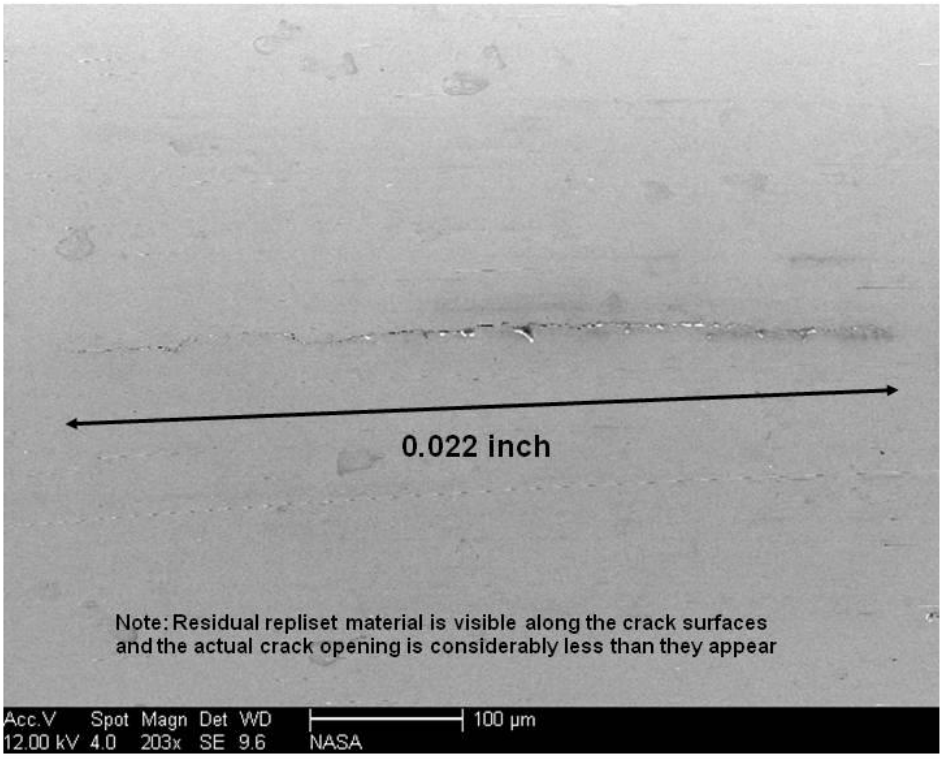
61

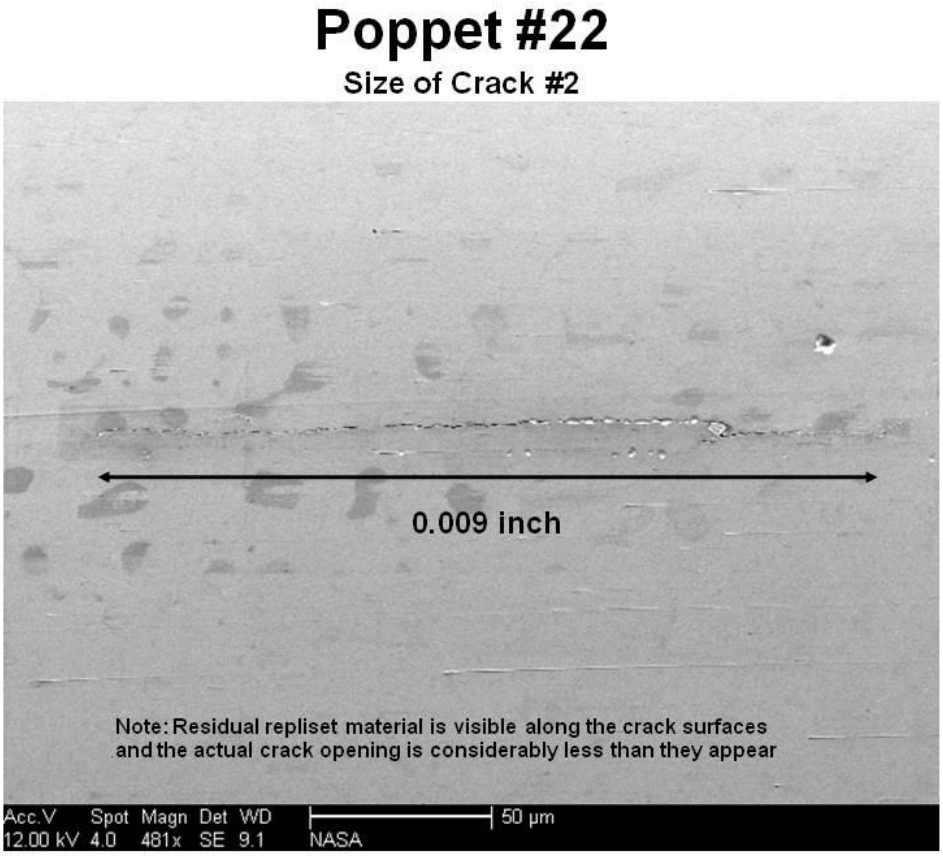
Poppet #22

Location of Cracks #1, 2, and 3



62

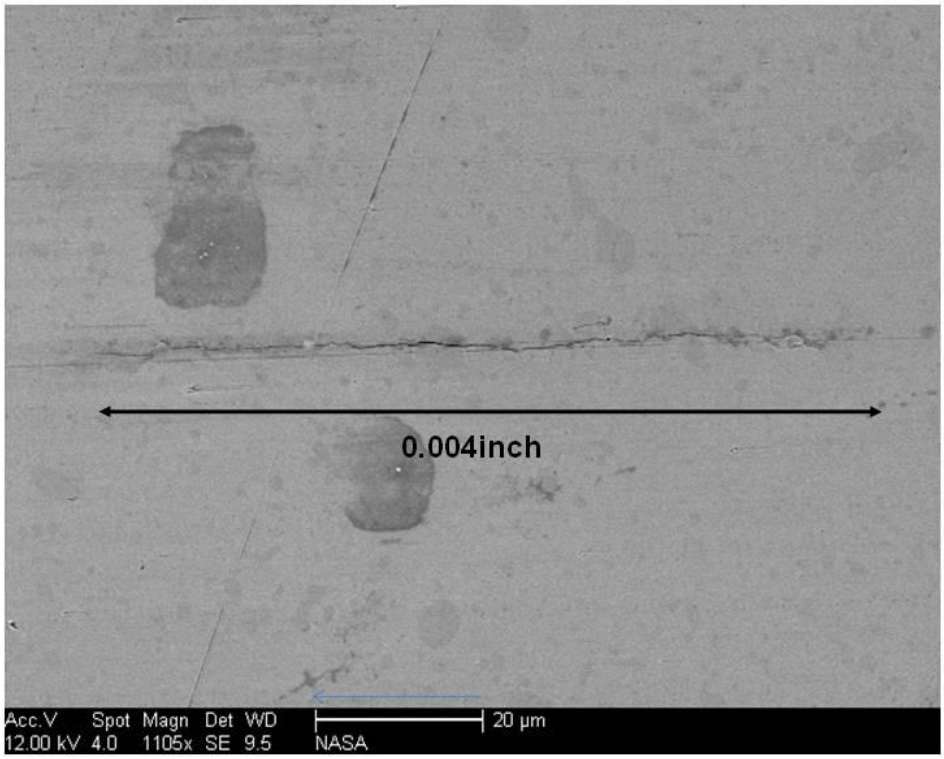

Poppet #22
Size of Crack #1
0.022 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
Acc.V Spot Magn Det WD
12.00 kV 4.0 203x SE 9.6
100 µm
NASA
63


Poppet #22
Size of Crack #2
0.009 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
Acc.V Spot Magn Det WD
12.00 kV 4.0 481x SE 9.1
50 µm
NASA

64

Poppet #22

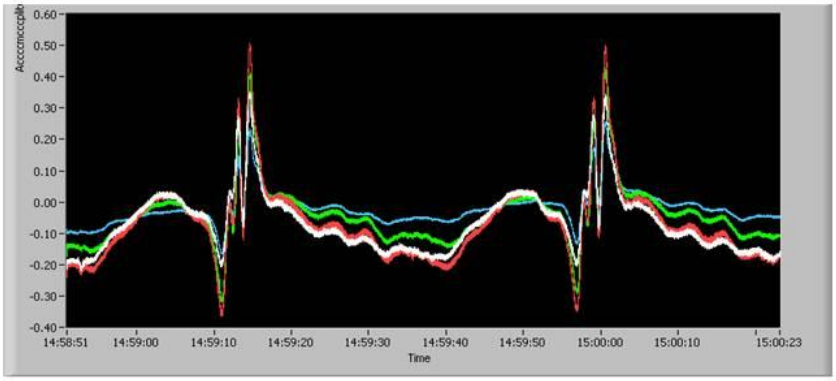
Size of Crack #3



65

Poppet #22

LaRC eddy current findings, the colors indicate ???



66

Poppet #23

Surface crack sizes and locations

Poppet #23		
Crack Number	Size (inch)	Angle (degrees)
1	0.026	85

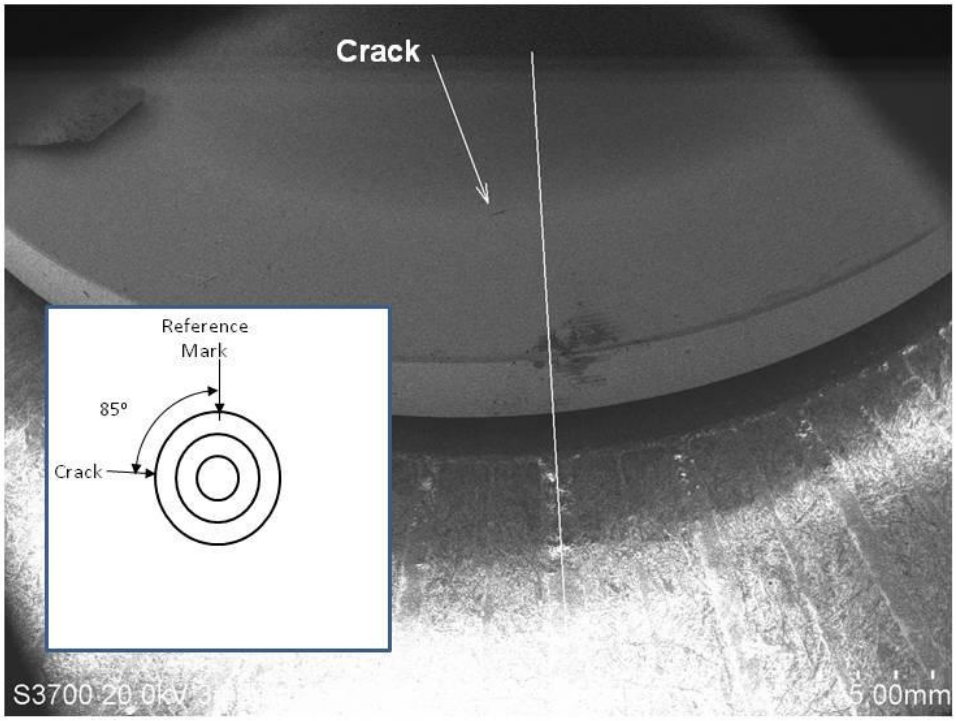
Boeing Eddy Current Findings

Poppet #23									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	-	-	-	-	-	-	-	NA	-
B. Devries	0.180	0.193	0.180	0.180	0.178	0.184	0.183	Yes	75

67

Poppet #23

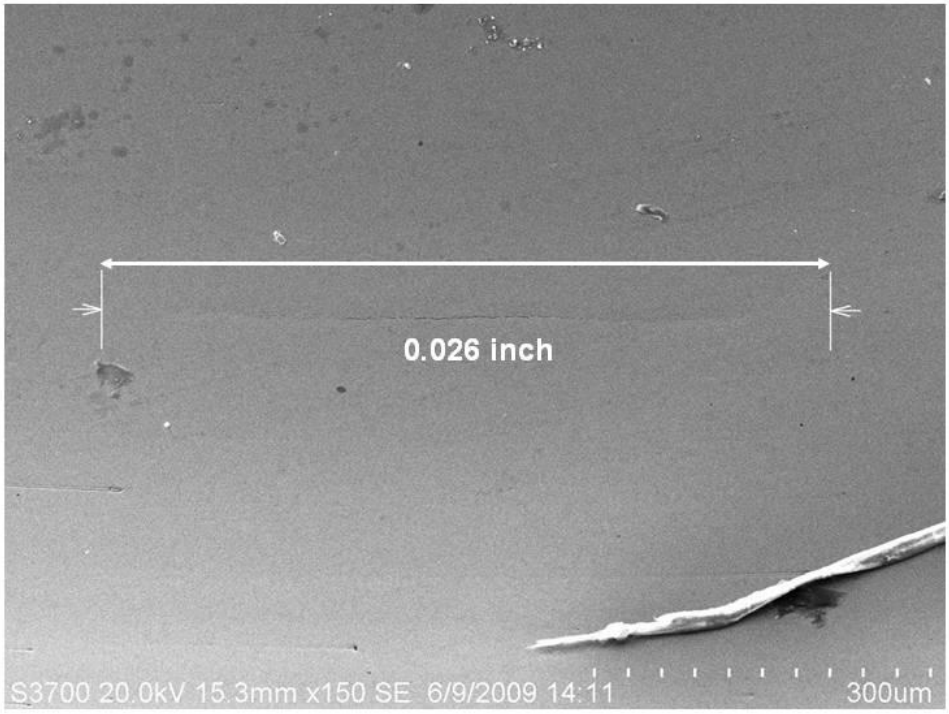
Location of Crack #1



68

Poppet #23

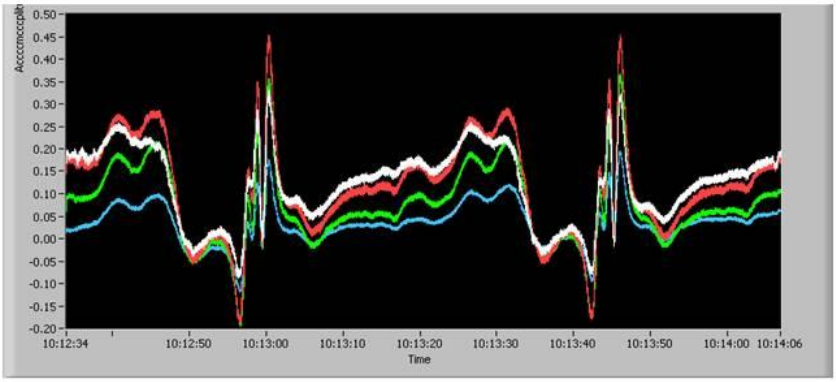
Size of Crack #1



69

Poppet #23

LaRC eddy current findings, the colors indicate ???



70

Poppet #24

Surface crack sizes and locations

Poppet #24		
Crack Number	Size (inch)	Angle (degrees)
1	0.012	50

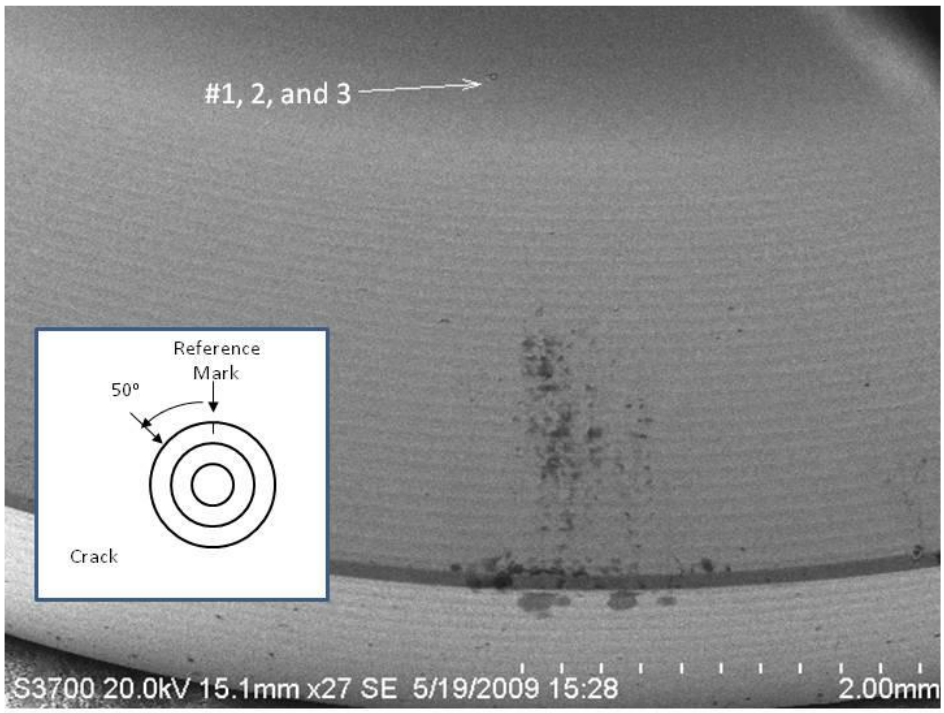
Boeing Eddy Current Findings

Poppet #24									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.078	0.096	0.089	0.077	0.090	0.089	0.087	Yes	45 (Not 3:1 S/N ratio)
B. Devries	0.084	0.101	0.084	0.086	0.092	0.096	0.091	Yes	30

71

Poppet #24

Location of Cracks #1, 2, and 3



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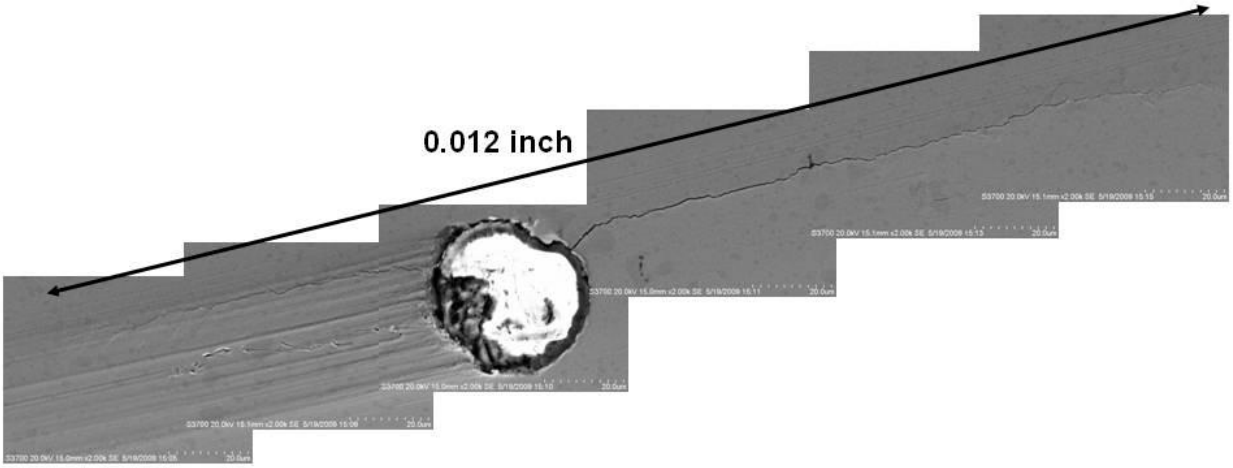
Poppet #24

Size of Crack #1

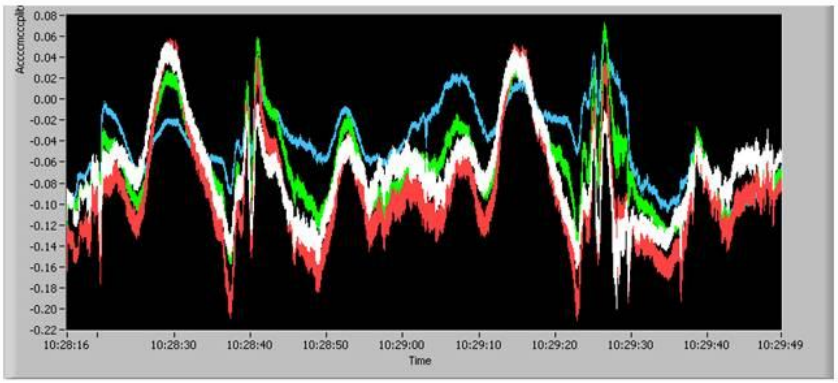


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

73

Poppet #24

LaRC eddy current findings, the colors indicate ???



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Poppet #26

Surface crack sizes and locations

Poppet #26		
Crack Number	Size (inch)	Angle (degrees)
1	0.034	20
2	0.005	210

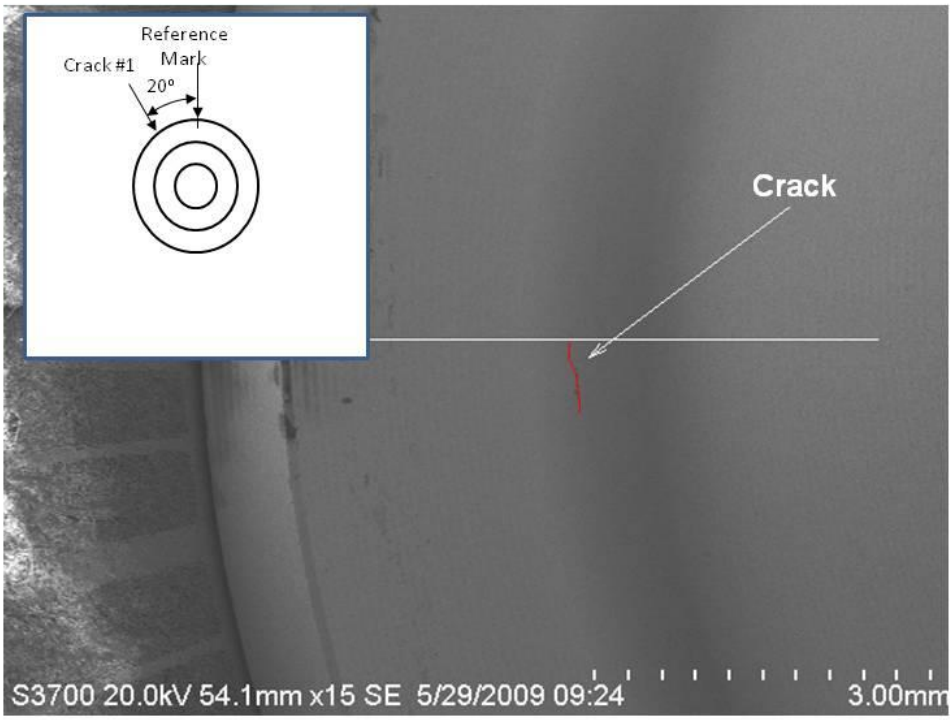
Boeing Eddy Current Findings

Poppet #26									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	-	-	-	-	-	-	-	No	210
J. Engel	0.363	0.348	0.361	0.356	0.353	0.363	0.357	Yes	65
B. Devries	-	-	-	-	-	-	-	No	210
B. Devries	0.348	0.349	0.362	0.365	0.363	0.367	0.359	Yes	75

75

Poppet #26

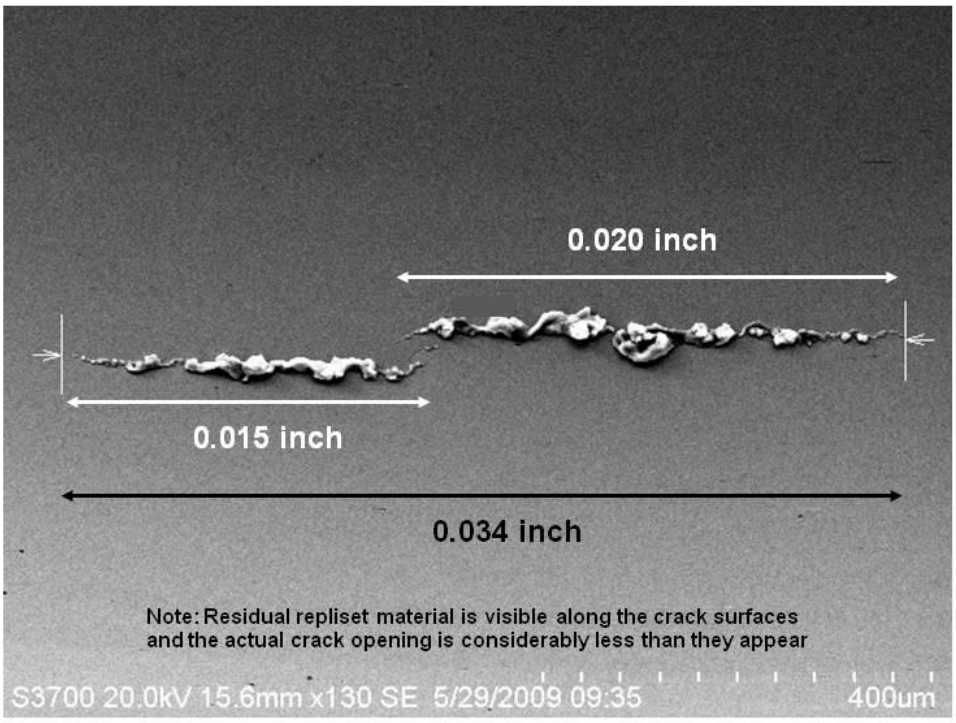
Location of Crack #1



76

Poppet #26

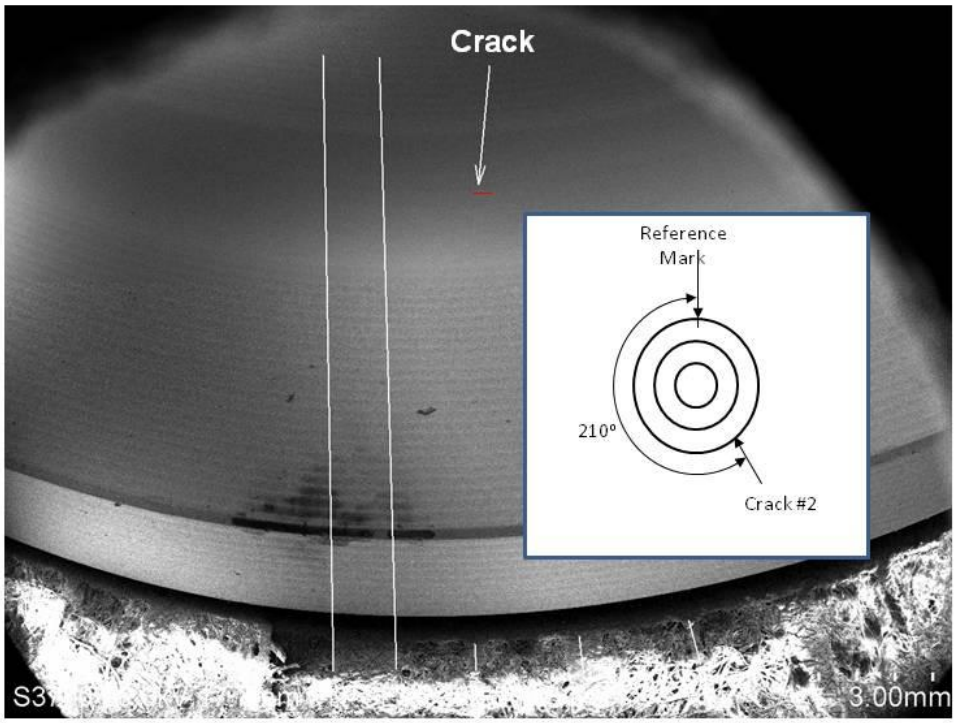
Size of Crack #1



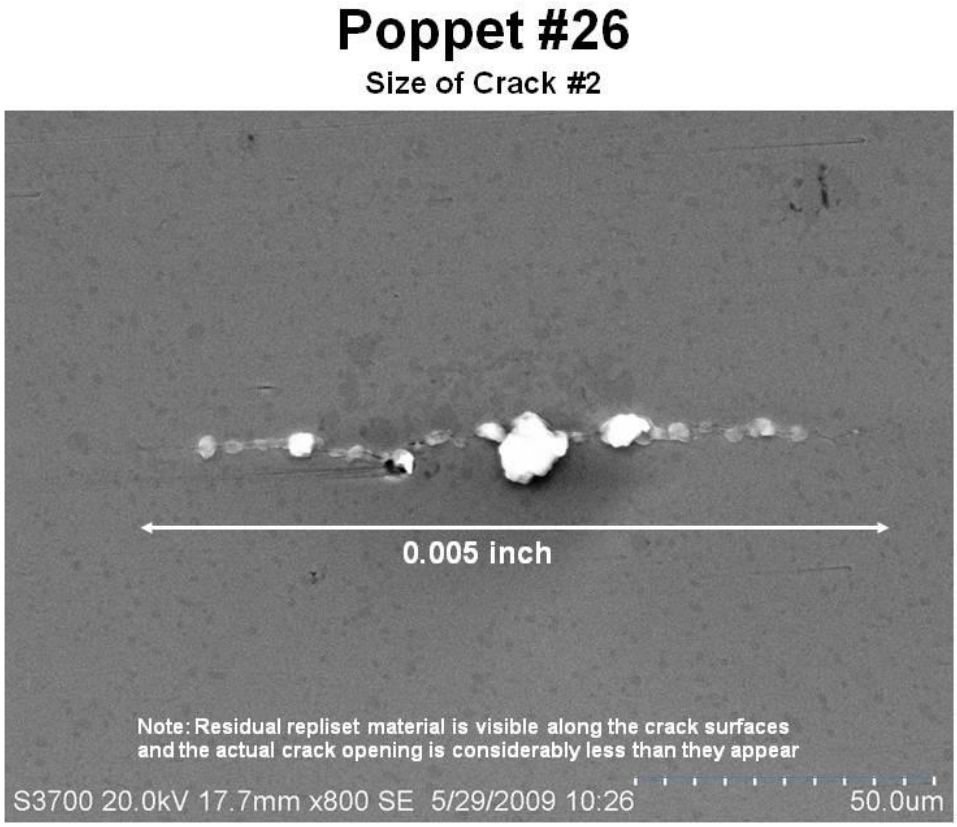
77

Poppet #26

Location of Crack #2



78


Poppet #26
Size of Crack #2
0.005 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 17.7mm x800 SE 5/29/2009 10:26
50.0um

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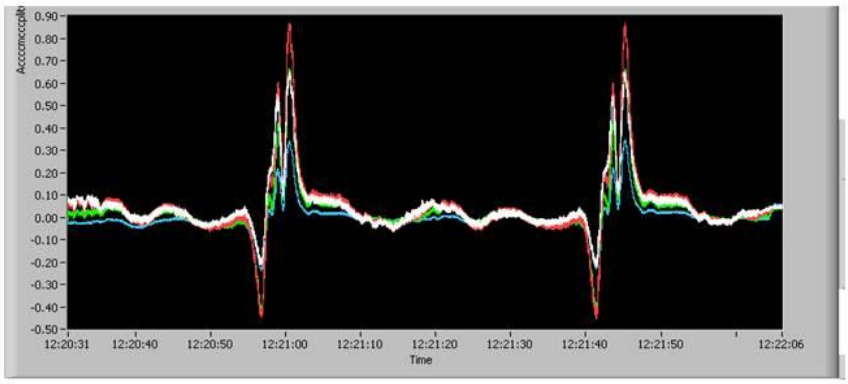
Poppet #26

LaRC eddy current findings, the colors indicate ???



80

Poppet #27

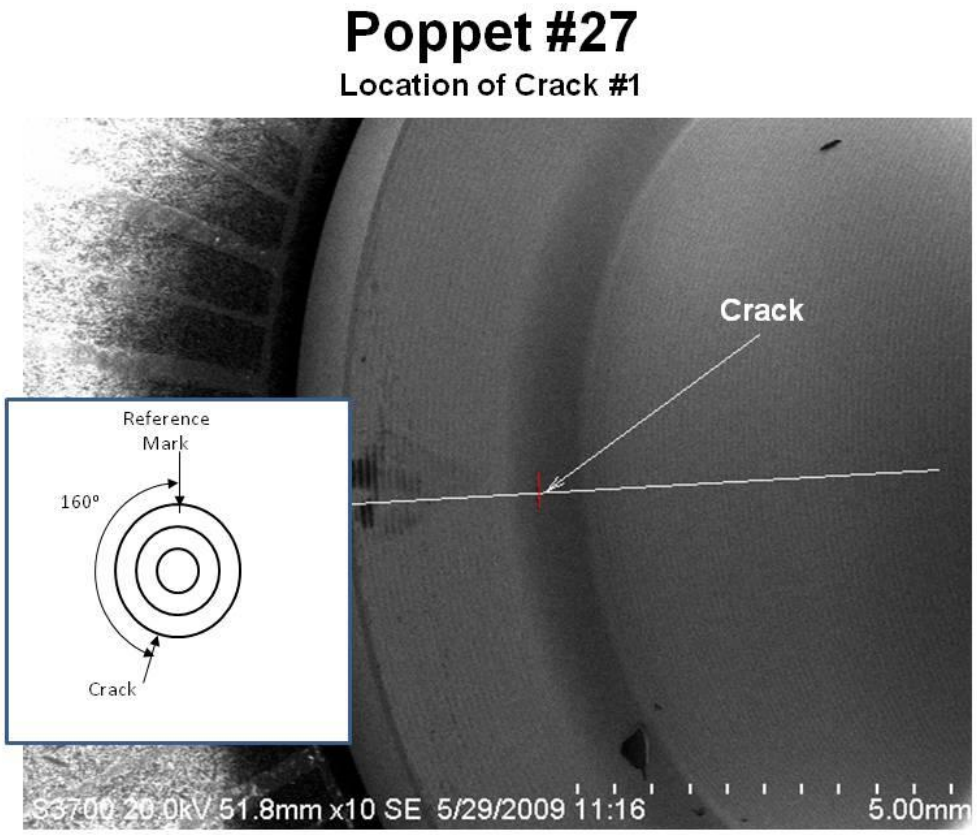
Surface crack sizes and locations

Poppet #27		
Crack Number	Size (inch)	Angle (degrees)
1	0.032	160

Boeing Eddy Current Findings

Poppet #27									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.423	0.441	0.437	0.449	0.456	0.456	0.444	Yes	155
B. Devries	0.449	0.460	0.463	0.464	0.471	0.467	0.462	Yes	145

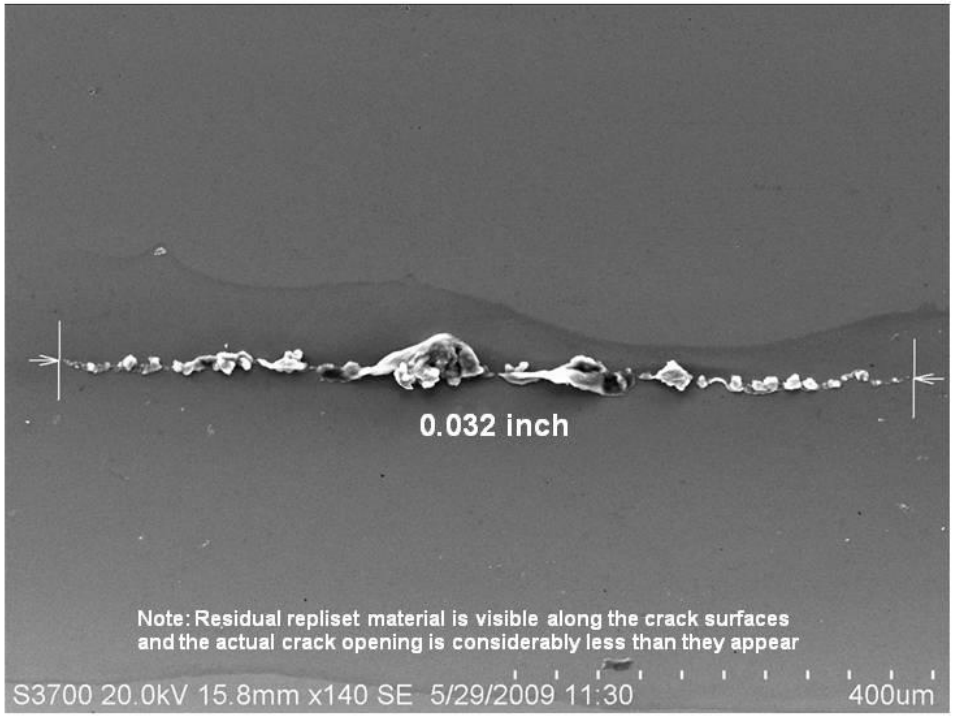
81


Poppet #27
Location of Crack #1
Crack
Reference Mark
160°
Crack
S3700 20.0kV 51.8mm x10 SE 5/29/2009 11:16
5.00mm

82

Poppet #27

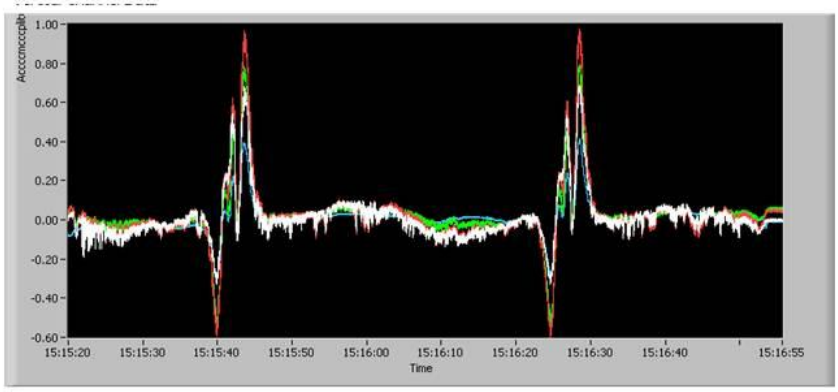
Size of Crack #1



83

Poppet #27

LaRC eddy current findings, the colors indicate ???



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Poppet #29

Surface crack sizes and locations

Poppet #29		
Crack Number	Size (inch)	Angle (degrees)
1	0.038	30
2	0.010	30
3	0.008	30
4	0.006	30

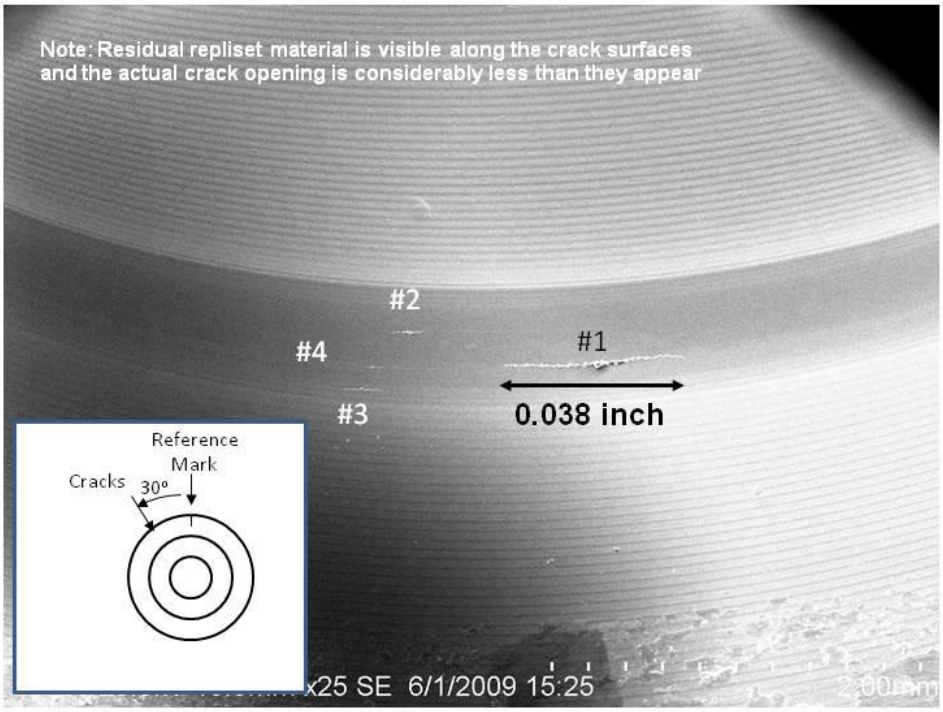
Boeing Eddy Current Findings

Poppet #29									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.531	0.538	0.535	0.538	0.539	0.558	0.540	Yes	30
B. Devries	0.549	0.559	0.558	0.570	0.567	0.568	0.562	Yes	35

85

Poppet #29

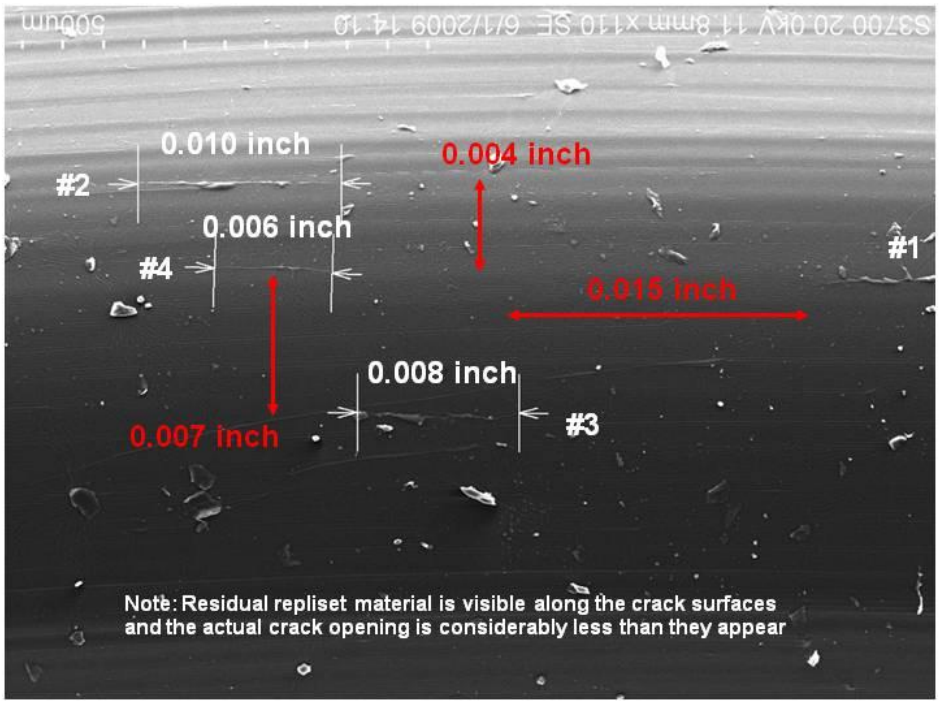
Location of Cracks 1-4



86

Poppet #29

Location and size of Cracks #1-4



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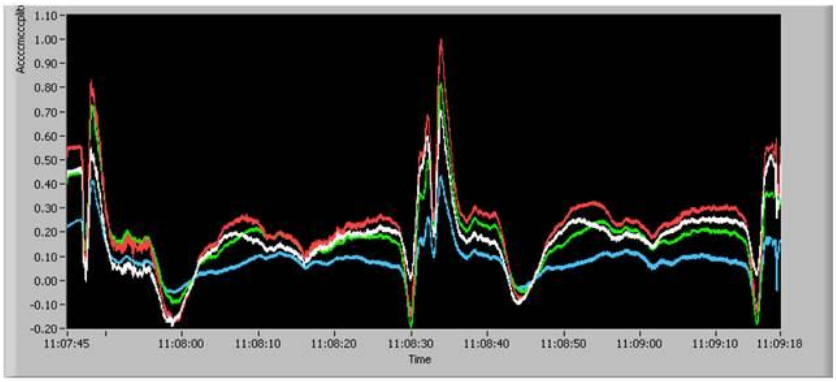
Poppet #29

LaRC eddy current findings, the colors indicate ???



88

Poppet #31

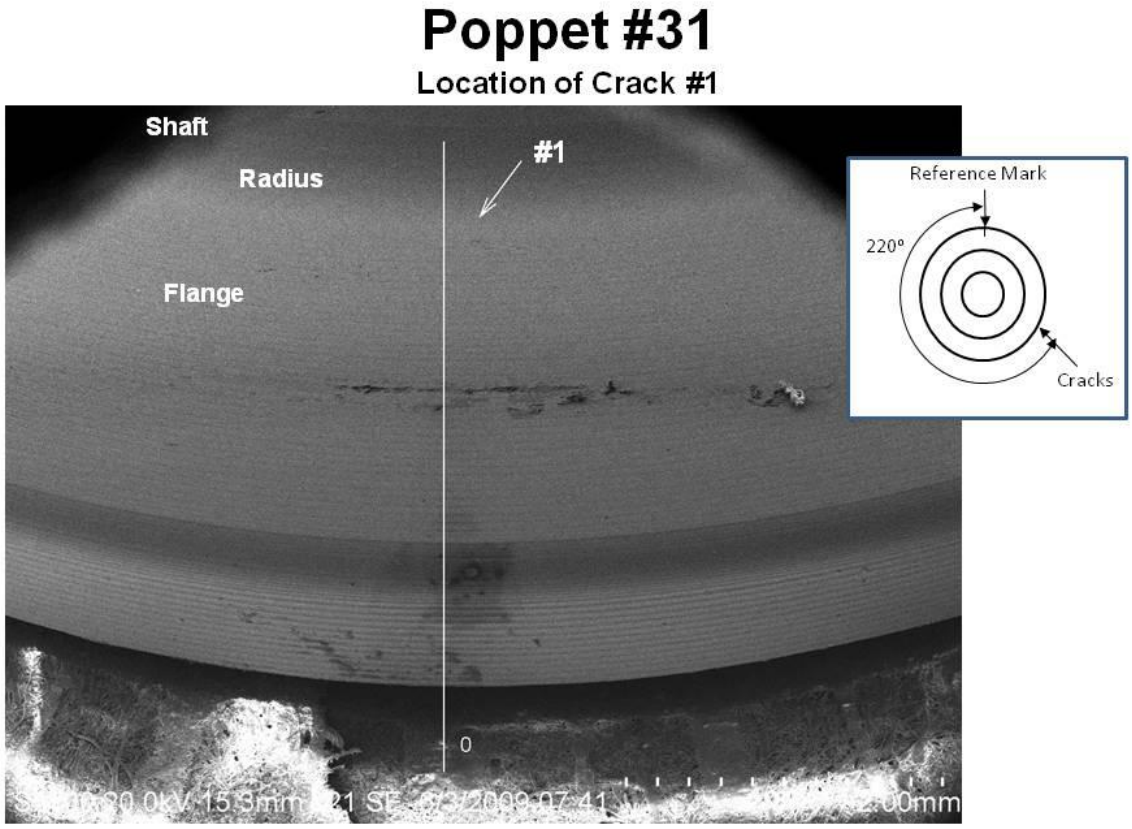
Surface crack sizes and locations

Poppet #31		
Crack Number	Size (inch)	Angle (degrees)
1	0.003	220
2	0.014	40
3	0.007	40
4	0.004	40
5	0.015	40
6	0.004	40
7	0.006	40
8	0.012	40
9	0.010	40
10	0.006	40
11	0.004	40
12	0.002	40

Boeing Eddy Current Findings

Poppet #31									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.233	0.233	0.230	0.230	0.231	0.230	0.231	Yes	40
J. Engel	-	-	-	-	-	-	-	No	220
B. Devries	-	-	-	-	-	-	-	No	220
B. Devries	0.221	0.226	0.222	0.215	0.221	0.226	0.222	Yes	45

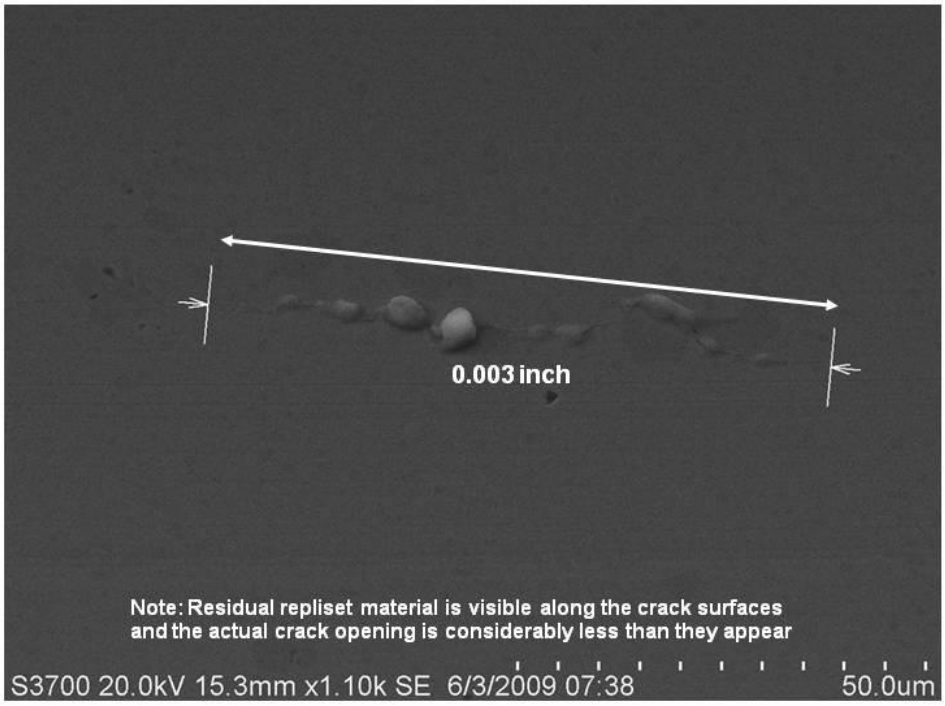
89


Poppet #31
Location of Crack #1
Shaft
Radius
Flange
#1
0
Reference Mark
220°
Cracks

90

Poppet #31

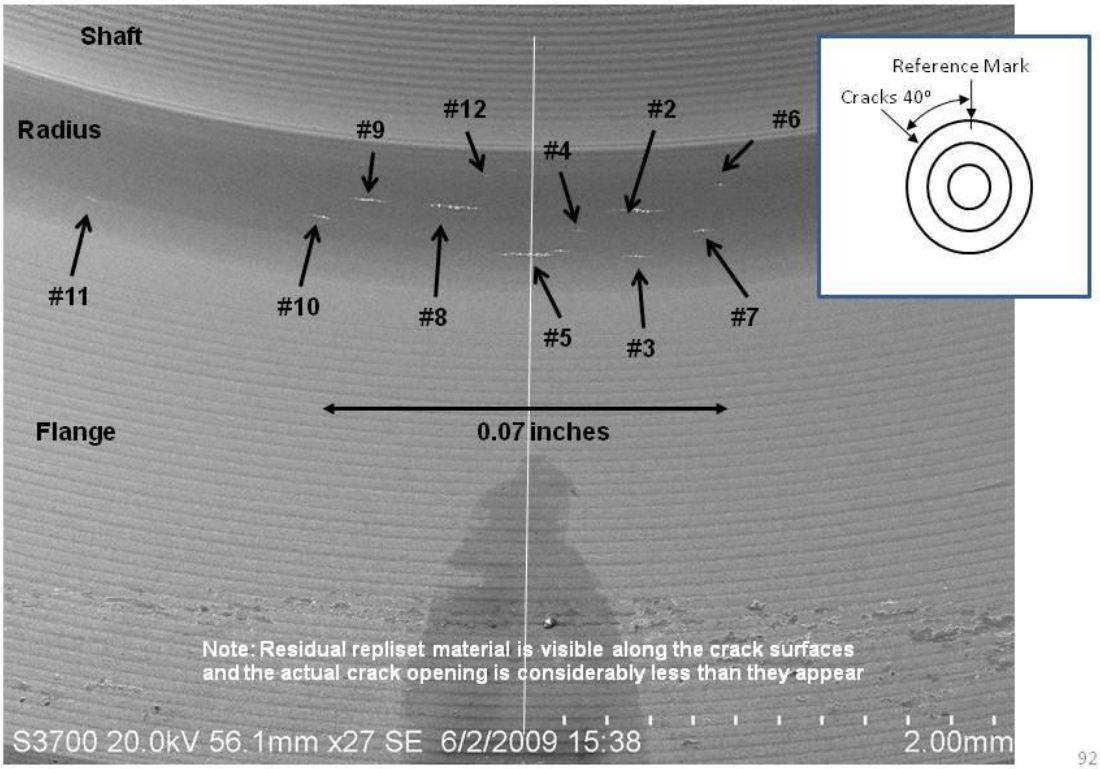
Size of Crack #1



91

Poppet #31

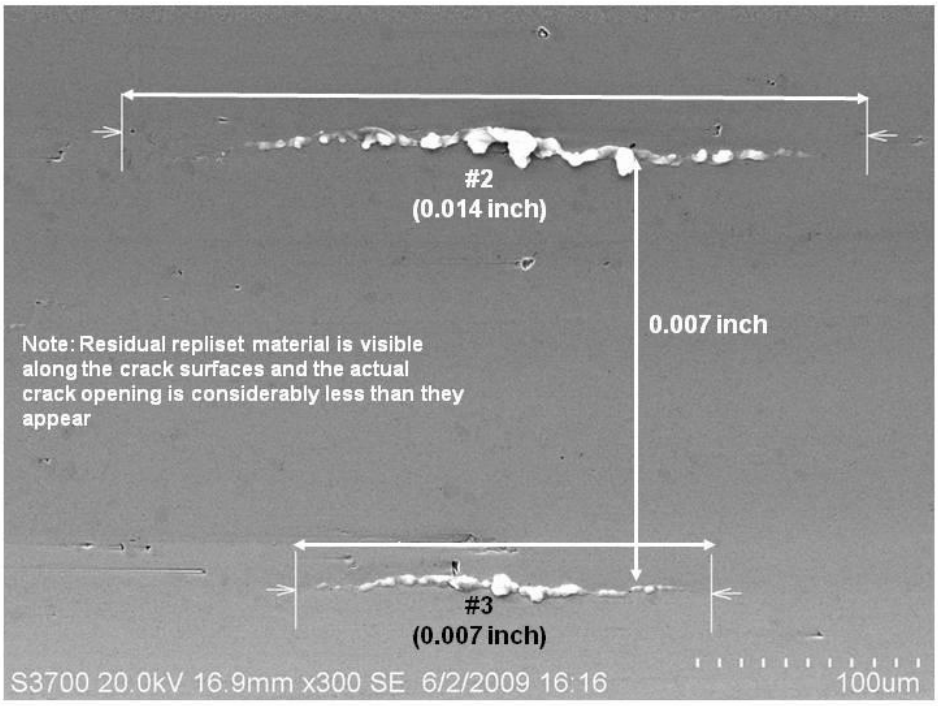
Location of Cracks #2-12



92

Poppet #31

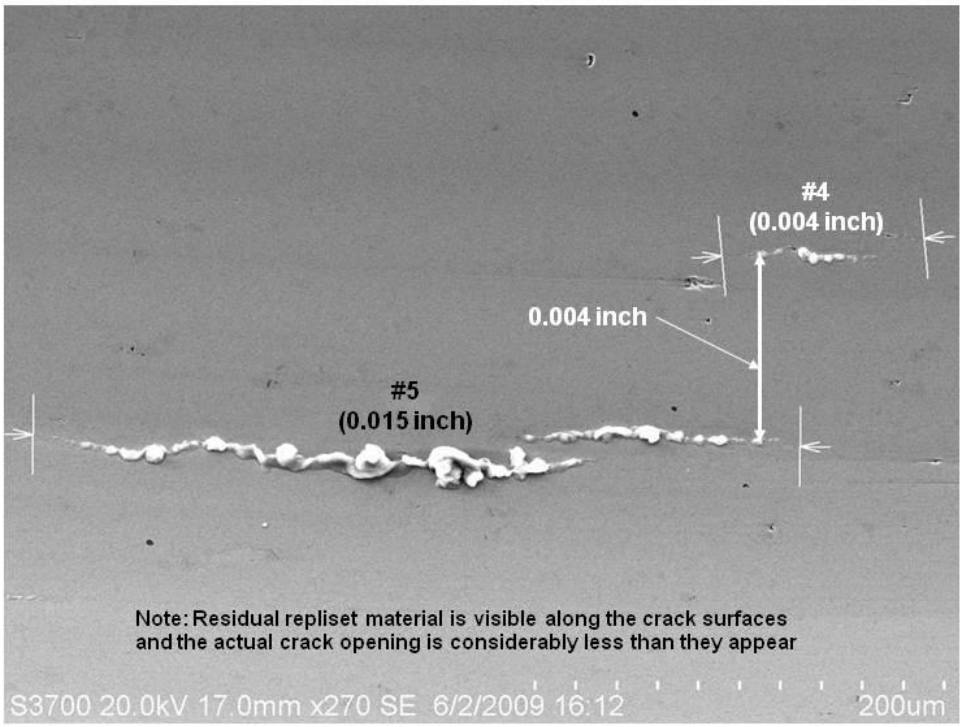
Size of Cracks #2 and 3



93

Poppet #31

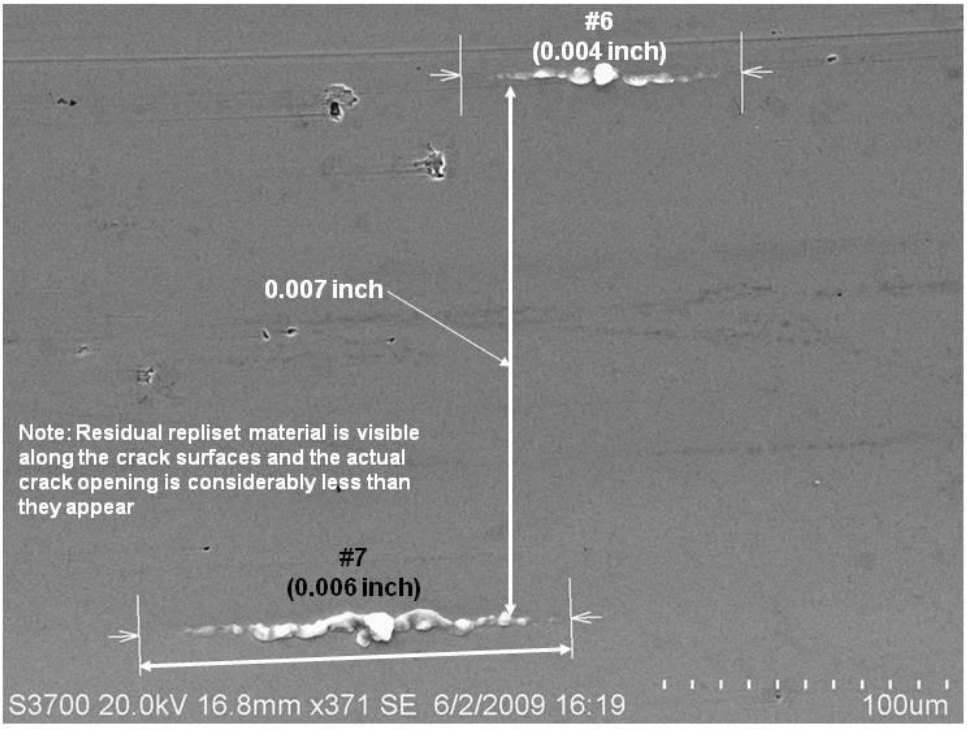
Location and size of Cracks #4 and 5



94

Poppet #31

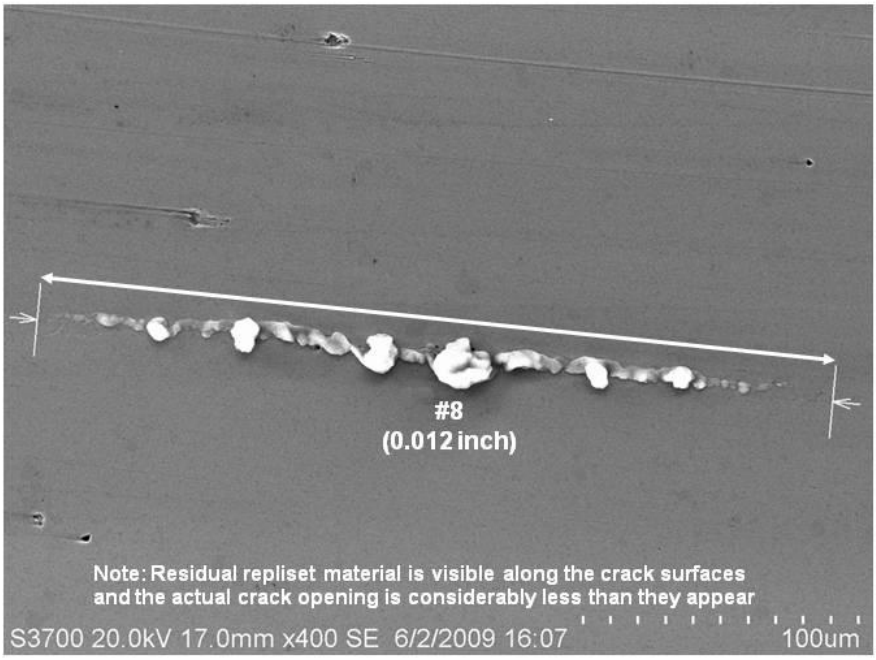
Location and size of Cracks #6 and 7



95

Poppet #31

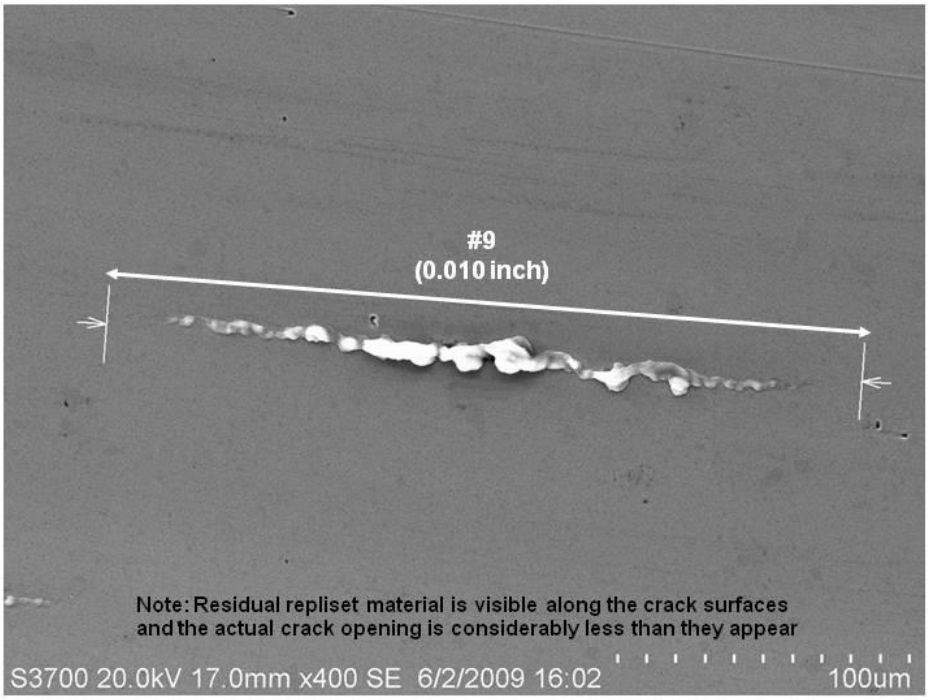
Size of Crack #8



96

Poppet #31

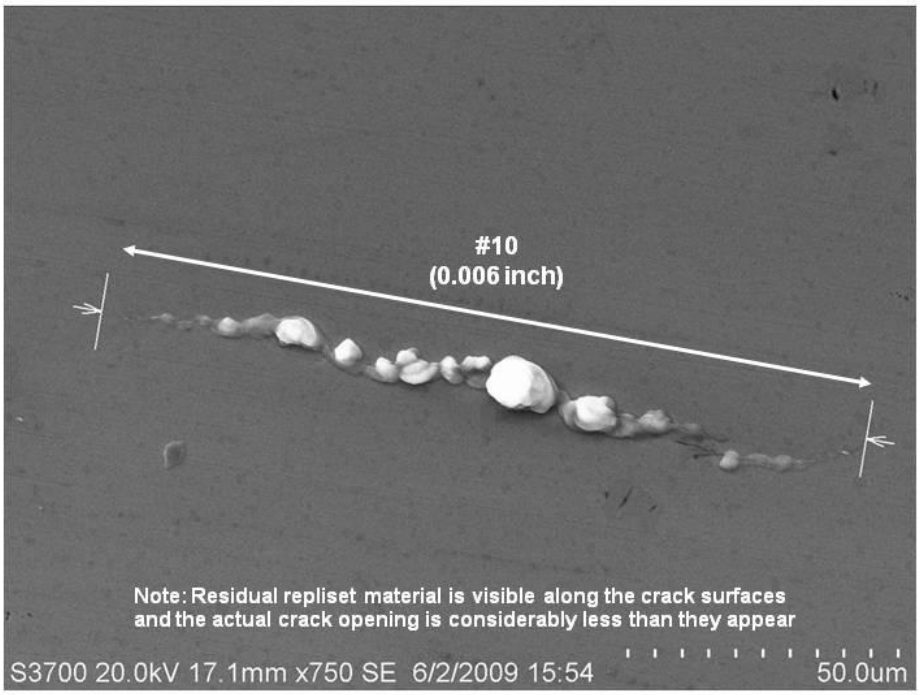
Size of Crack #9



97

Poppet #31

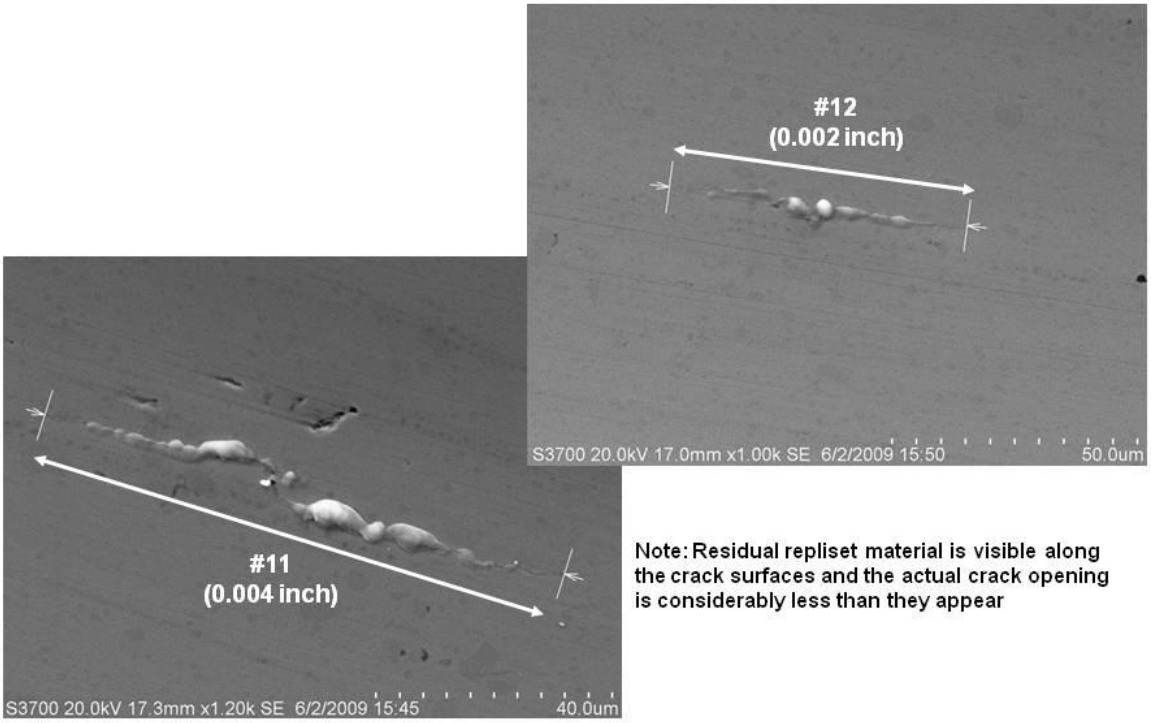
Size of Crack #10



98

Poppet #31

Size of Cracks #11 and 12

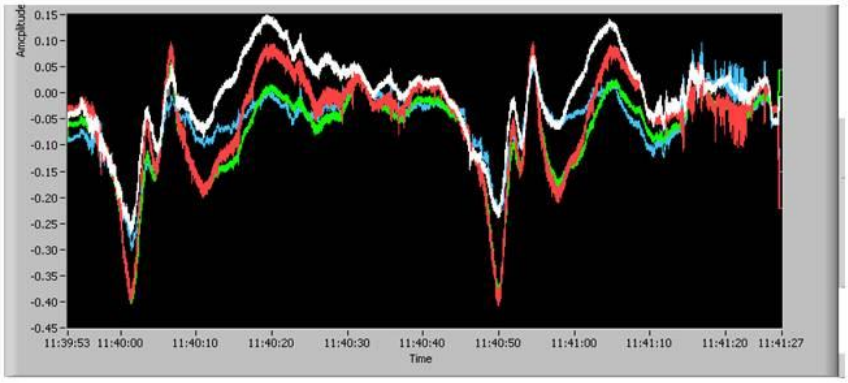


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

99

Poppet #31

LaRC eddy current findings, the colors indicate ???



100

Poppet #32

Surface crack sizes and locations

Poppet #32		
Crack Number	Size (inch)	Angle (degrees)
1	0.025	260
2	0.015	260
3	0.013	260
4	0.011	260
5	0.006	260
6	0.005	260
7	0.012	80
8	0.010	80
9	0.005	80

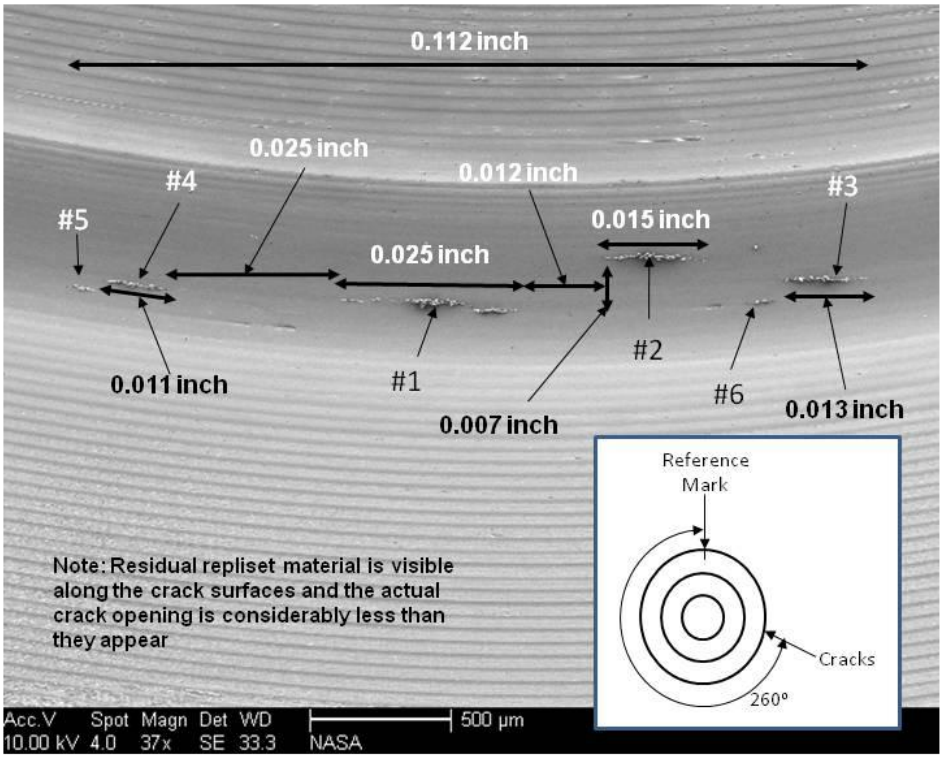
Boeing Eddy Current Findings

Poppet #32									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.248	0.241	0.241	0.249	0.250	0.250	0.247	Yes	75
J. Engel	0.077	0.075	0.076	0.081	0.084	0.086	0.080	Yes	255 (Marginal 3:1 S/N)
B. Devries	0.074	0.073	0.067	0.072	0.067	0.070	0.071	Yes	255
B. Devries	0.244	0.246	0.243	0.244	0.251	0.244	0.245	Yes	75

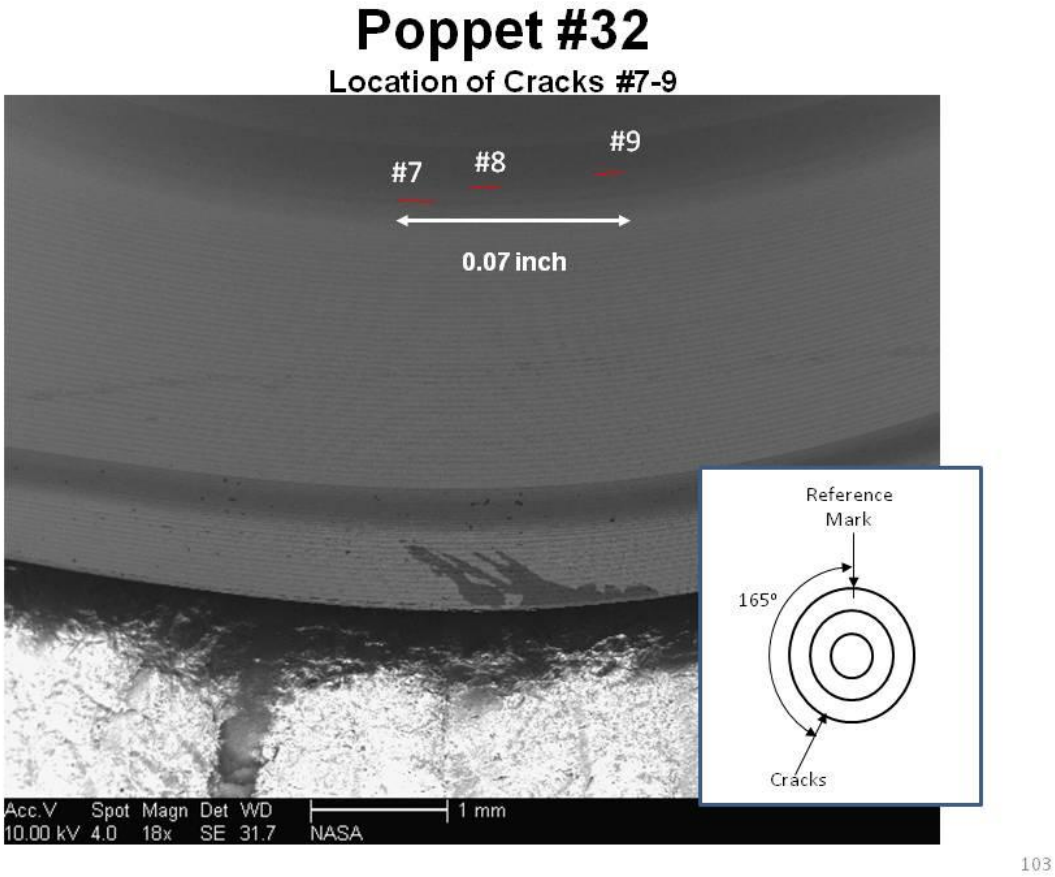
101

Poppet #32

Location and size of Cracks #1-6

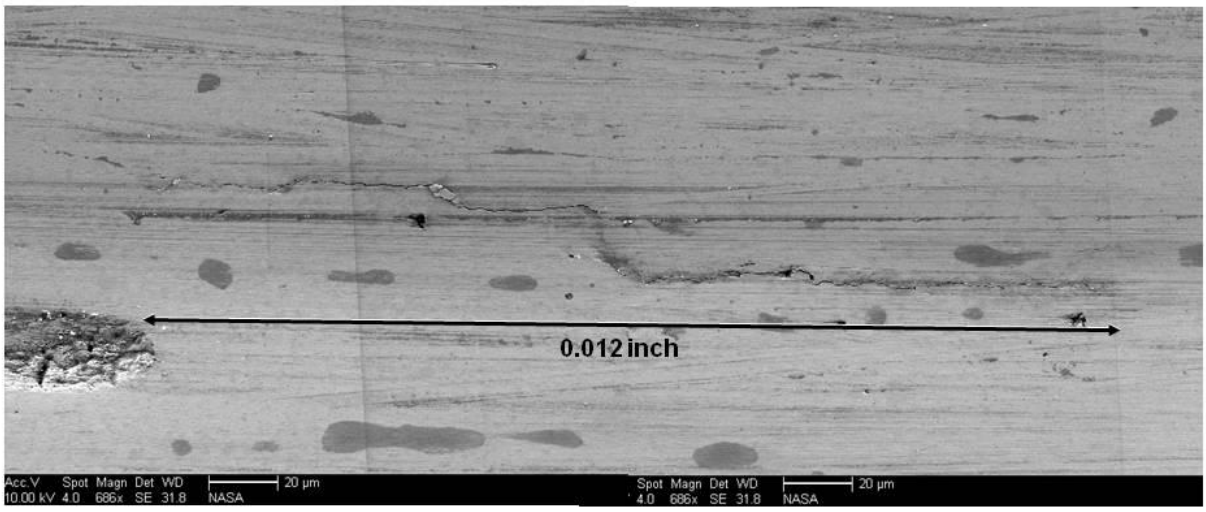


102


Poppet #32
Location of Cracks #7-9
#7
#8
#9
0.07 inch
Reference Mark
165°
Cracks
Acc.V Spot Magn Det WD
10.00 kV 4.0 18x SE 31.7
1 mm
NASA
103

Poppet #32

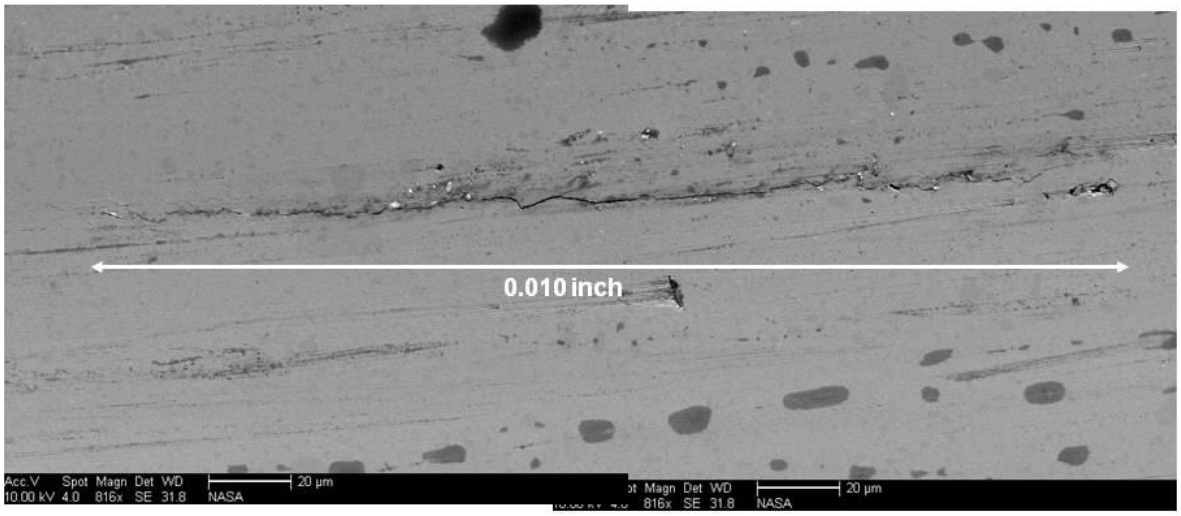
Size of Crack #7



104

Poppet #32

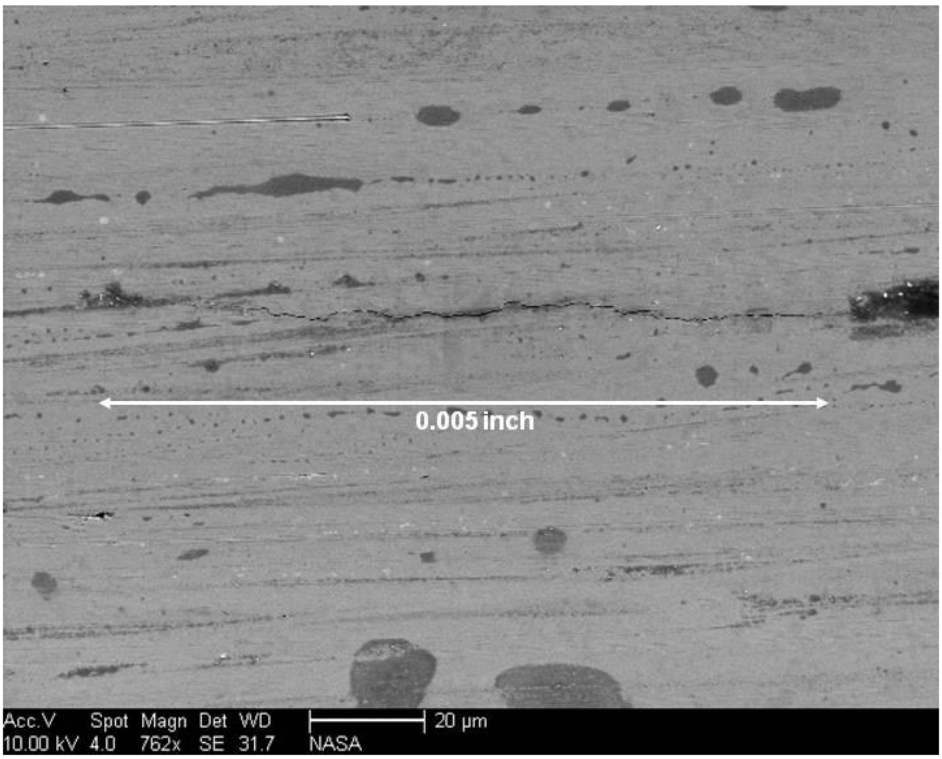
Size of Crack #8



105

Poppet #32

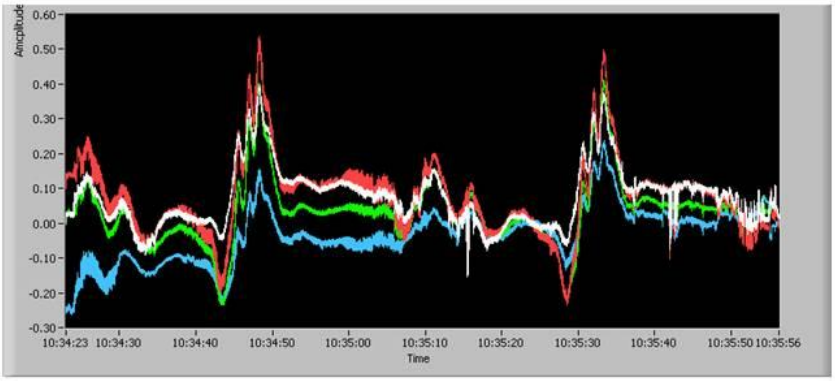
Size of Crack #9



106

Poppet #32

LaRC eddy current findings, the colors indicate ???



107

Poppet #33

Surface crack sizes and locations

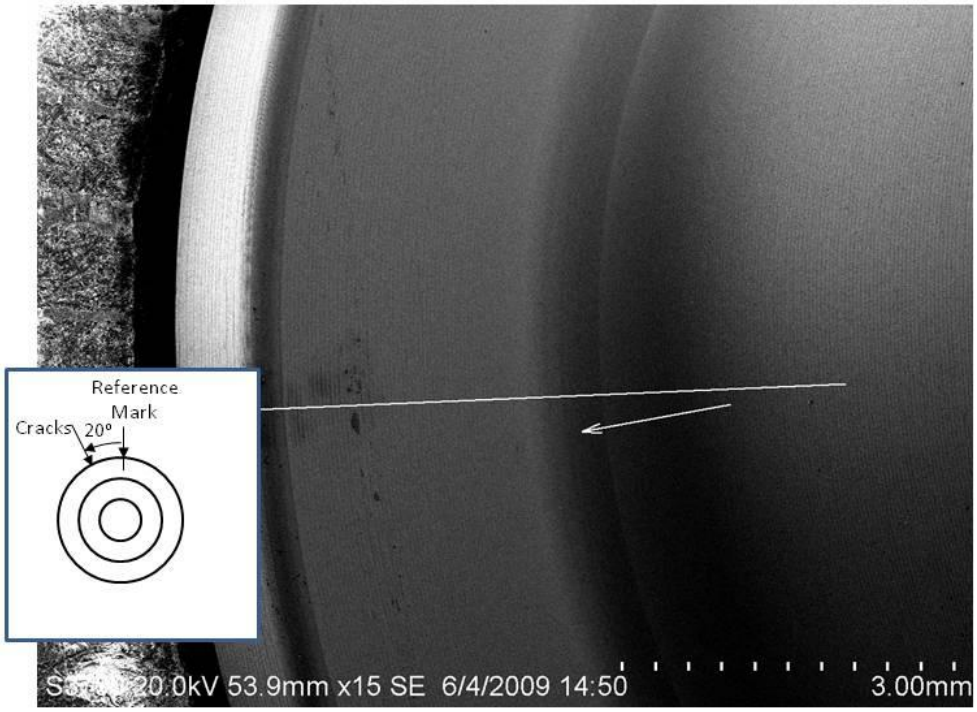
Poppet #33		
Crack Number	Size (inch)	Angle (degrees)
1	0.026	20
2	0.014	20
3	0.002	20
4	0.003	200

Boeing Eddy Current Findings

Poppet #33									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	-	-	-	-	-	-	-	No	200
J. Engel	0.220	0.221	0.223	0.223	0.227	0.218	0.222	Yes	10
B. Devries	-	-	-	-	-	-	-	No	200
B. Devries	0.211	0.216	0.216	0.215	0.209	0.218	0.214	Yes	15

Poppet #33

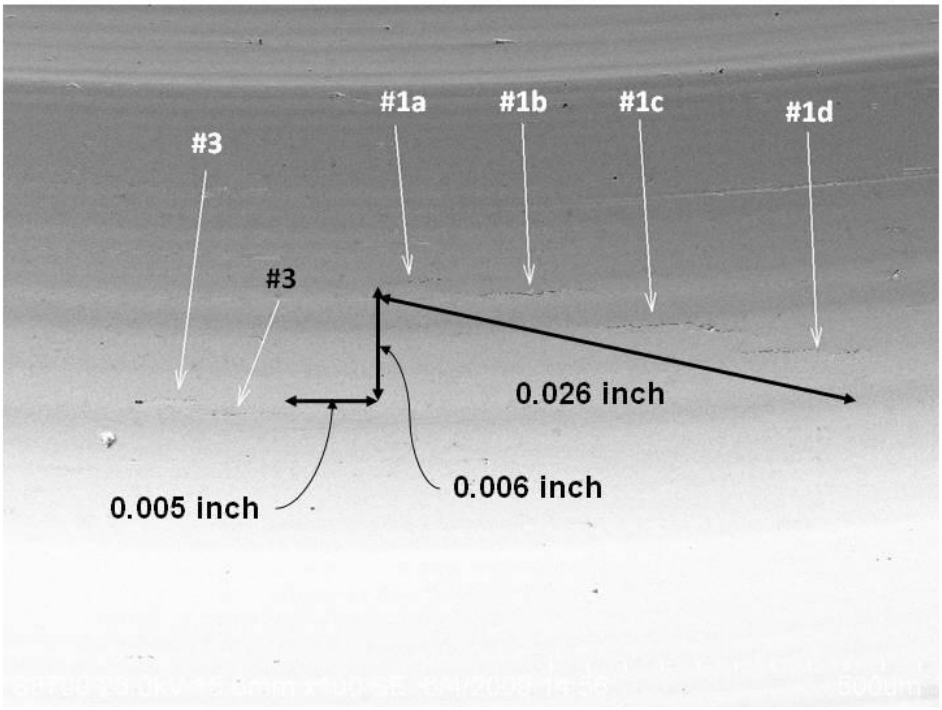
Location of Cracks #1-3



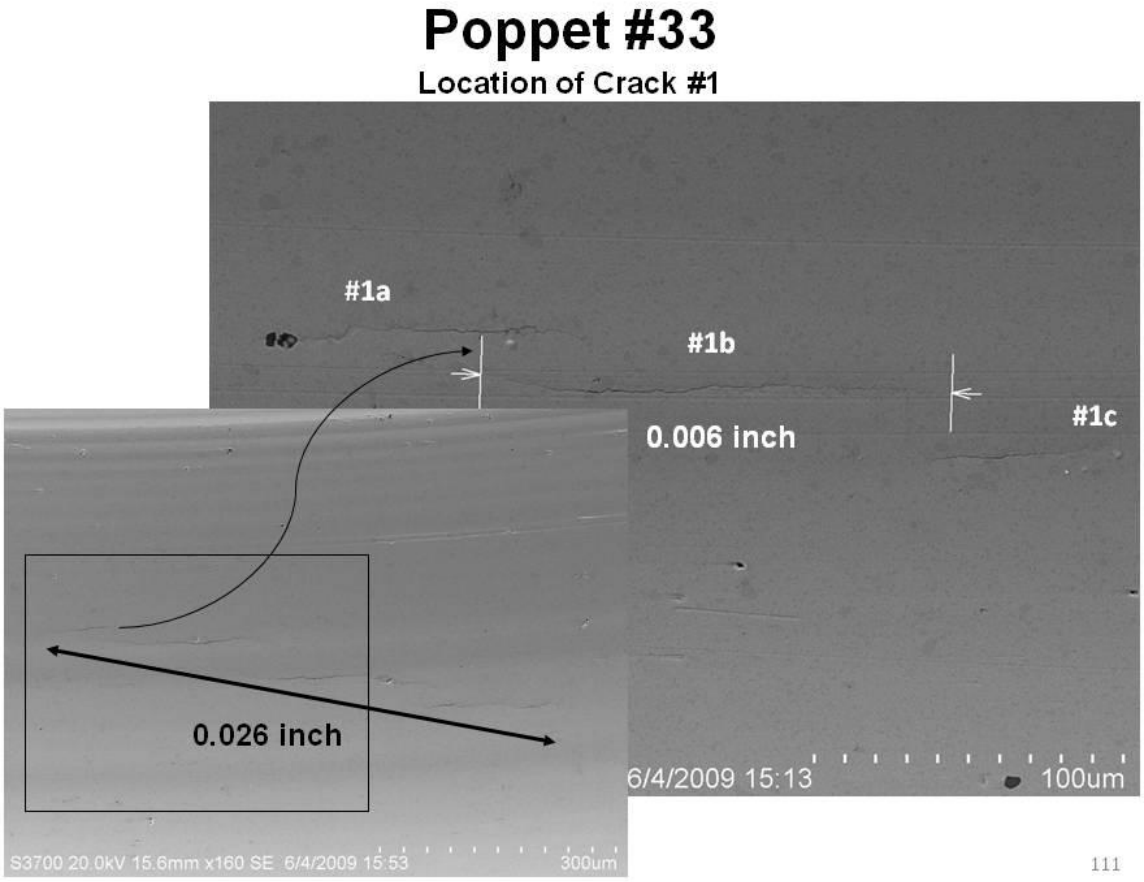
109

Poppet #33

Location and size of Cracks #1, 2, and 3

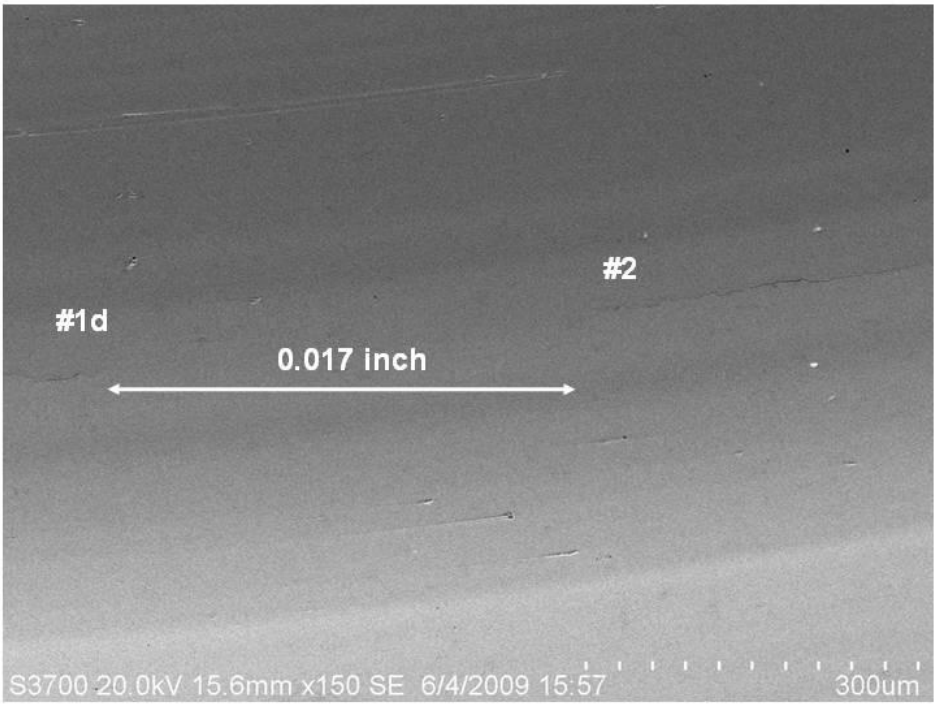


110


Poppet #33
Location of Crack #1
#1a
#1b
#1c
0.006 inch
0.026 inch
6/4/2009 15:13
100um
S3700 20.0kV 15.6mm x160 SE 6/4/2009 15:53
300um
111

Poppet #33

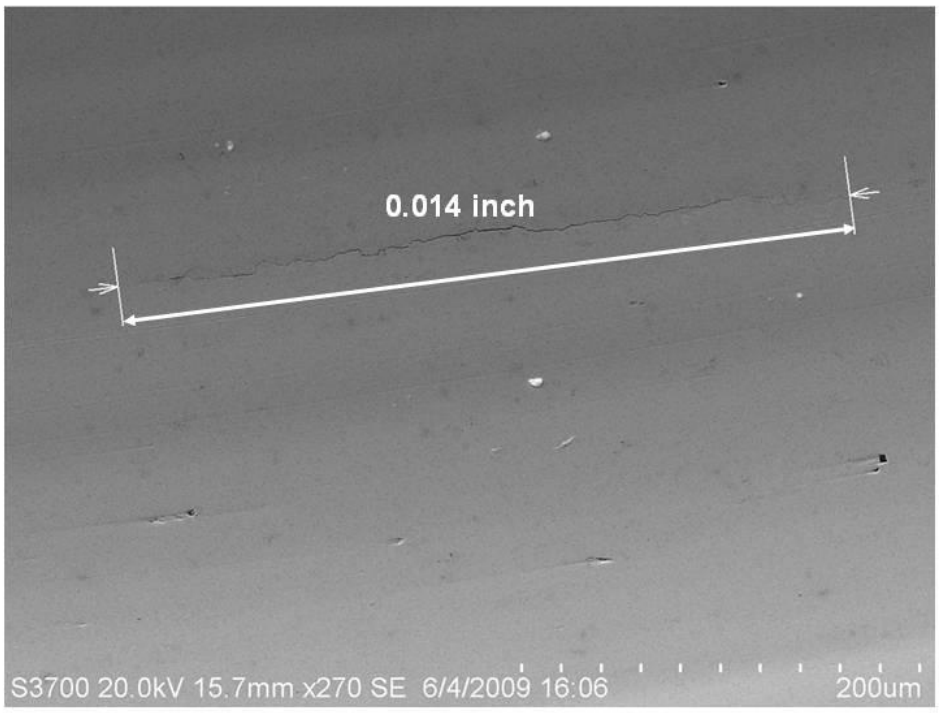
Location of Crack #2



112

Poppet #33

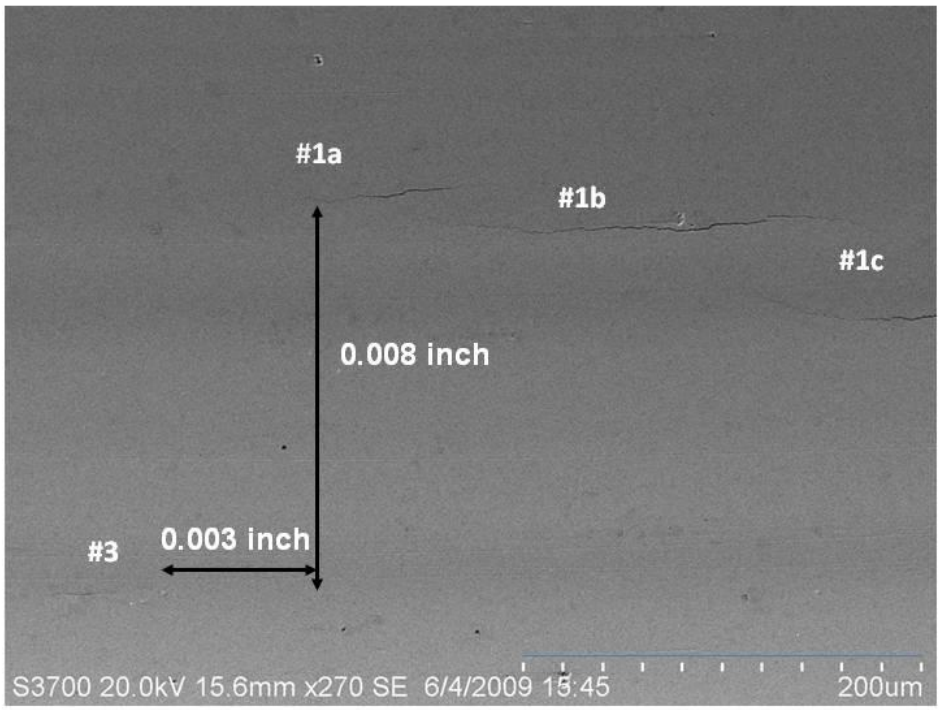
Size of Crack #2



113

Poppet #33

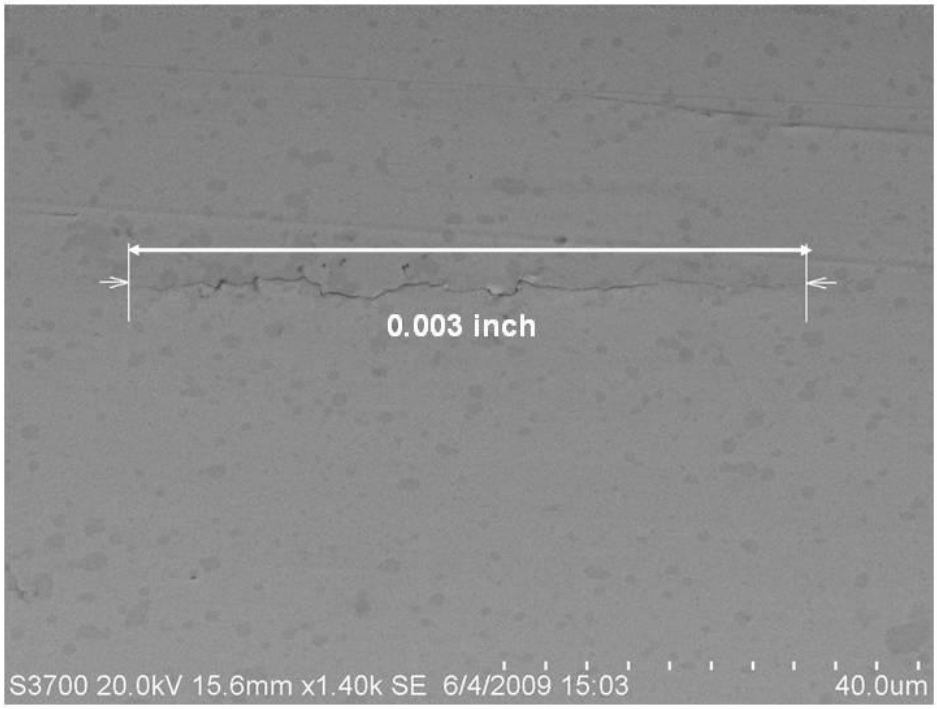
Location of Crack #3



114

Poppet #33

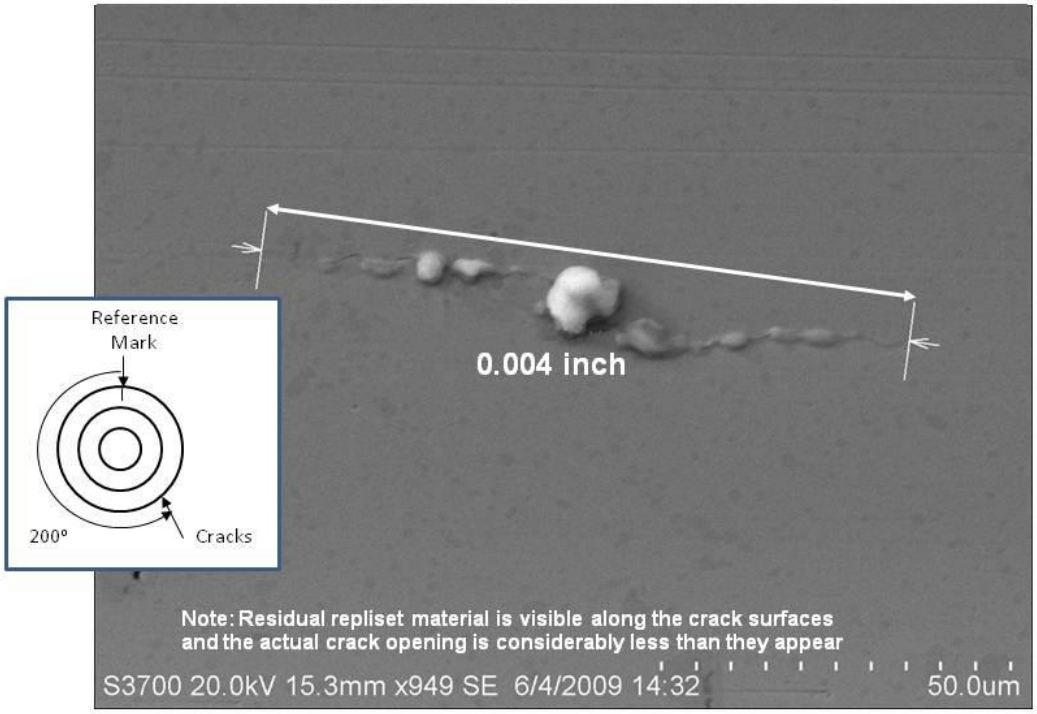
Size of Crack #3



115

Poppet #33

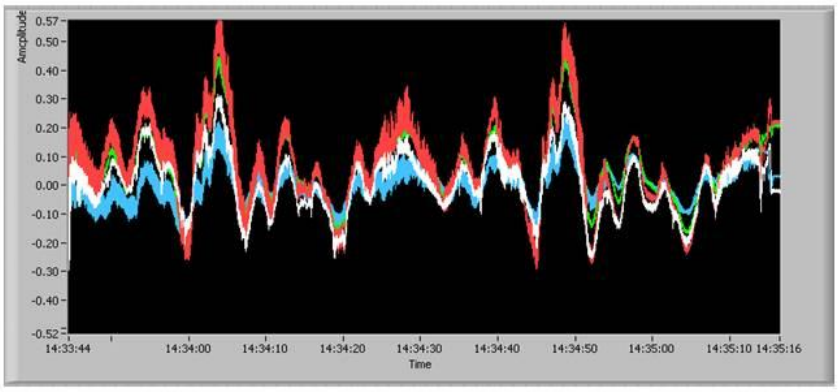
Size of Crack #4



116

Poppet #33

LaRC eddy current findings, the colors indicate ???



117

Poppet #34

Surface crack sizes and locations

Poppet #34		
Crack Number	Size (inch)	Angle (degrees)
1	0.134	180
2	0.027	0
3	0.010	0
4	0.021	0
5	0.009	0
6	0.004	0
7	0.005	0
8	0.005	0

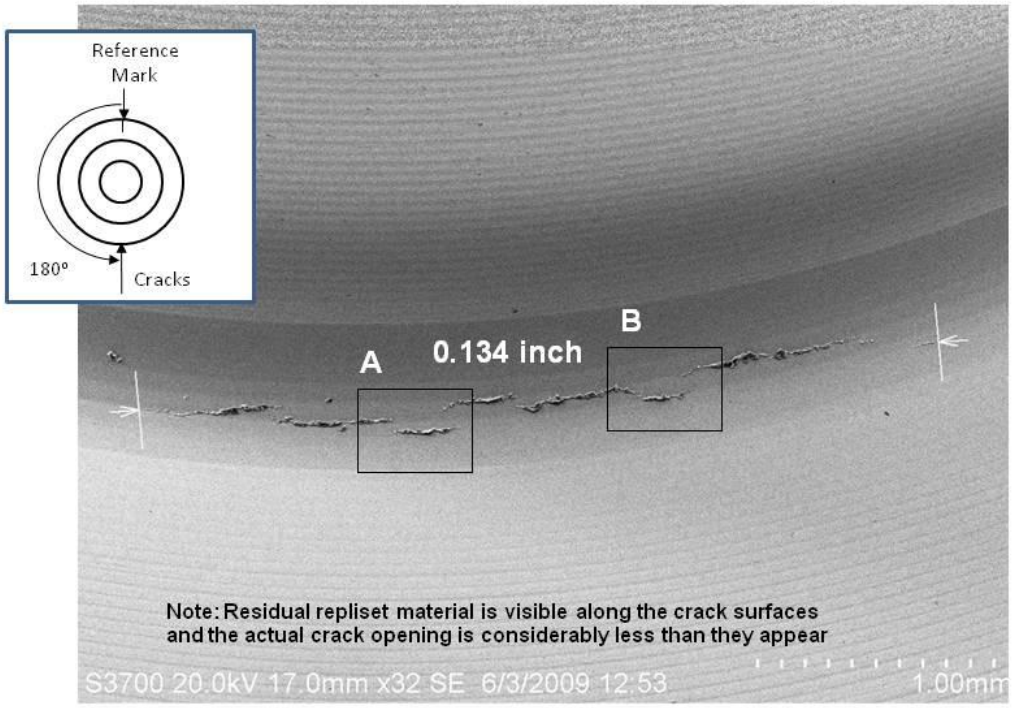
Boeing Eddy Current Findings

Poppet #34									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.681	0.688	0.683	0.690	0.693	0.671	0.684	Yes	180
J. Engel	0.233	0.230	0.235	0.231	0.233	0.233	0.233	Yes	355
B. Devries	0.215	0.218	0.213	0.218	0.217	0.219	0.217	Yes	0
B. Devries	0.648	0.659	0.649	0.654	0.653	0.670	0.656	Yes	180

118

Poppet #34

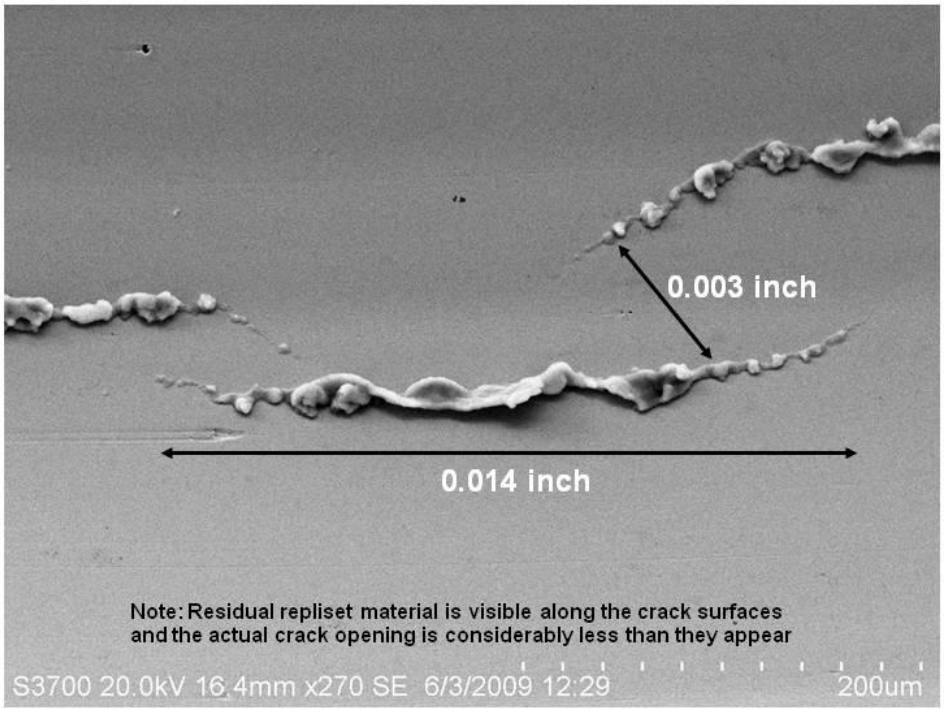
Location and size of Crack #1



119

Poppet #34

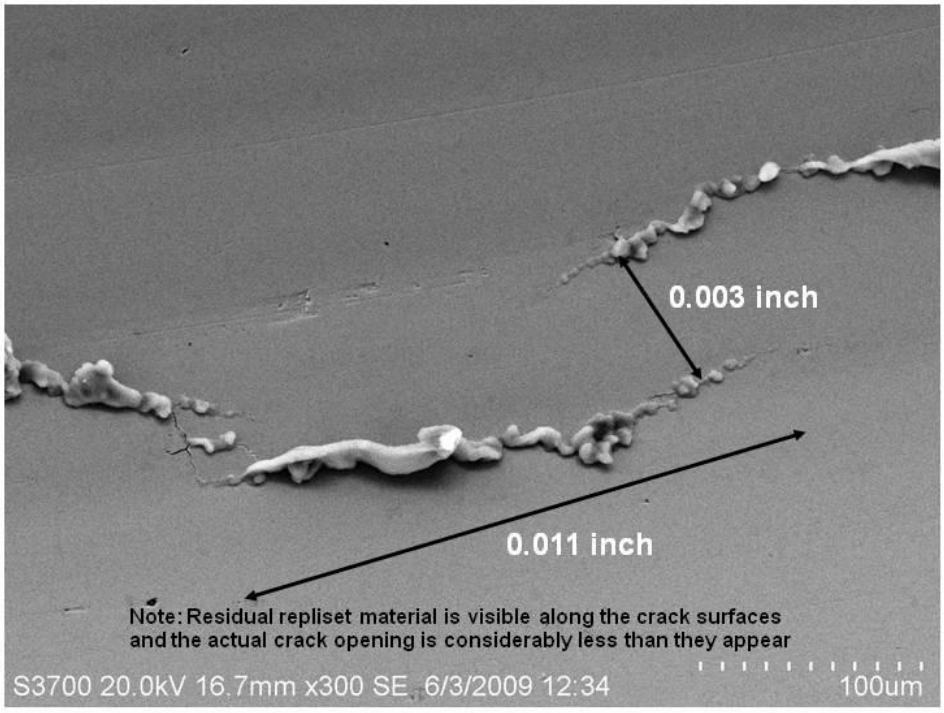
Location A



120

Poppet #34

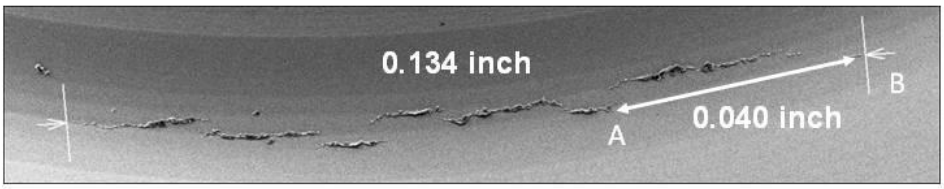
Location B



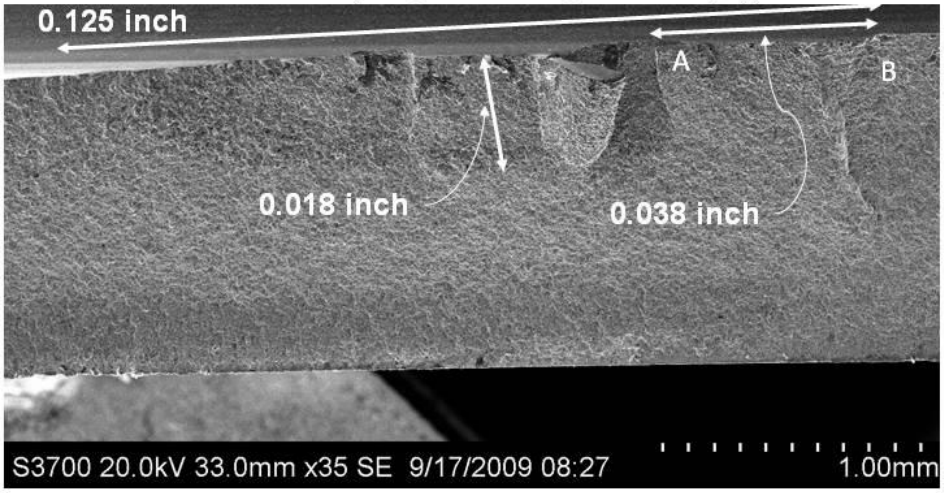
121

Poppet #34

Crack depth and correlation with surface measurements for Crack #1



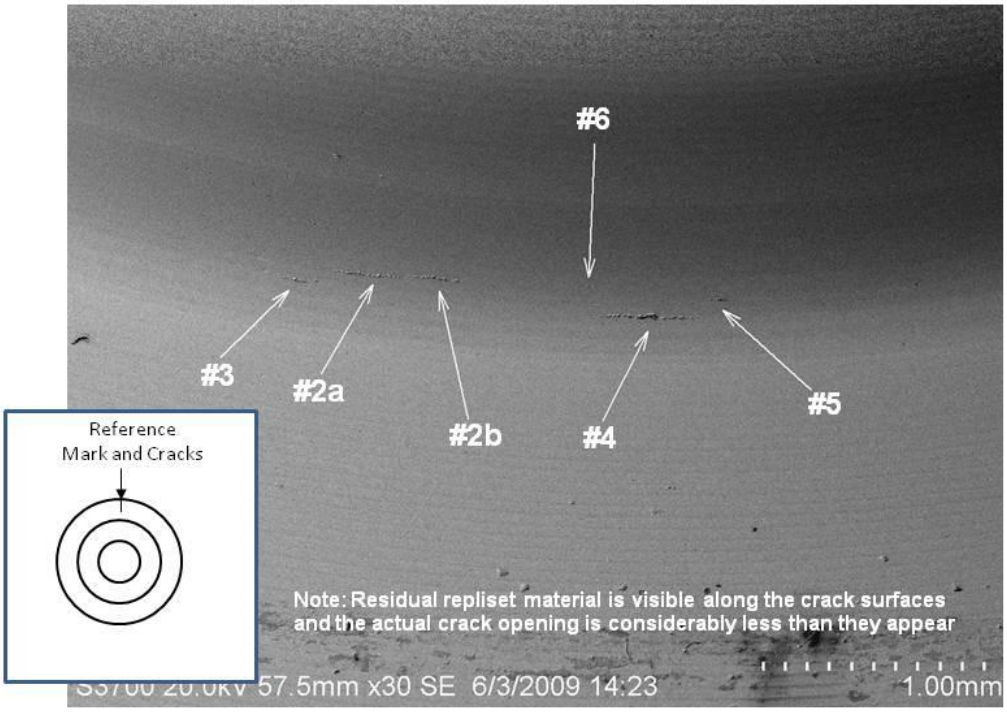
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear



122

Poppet #34

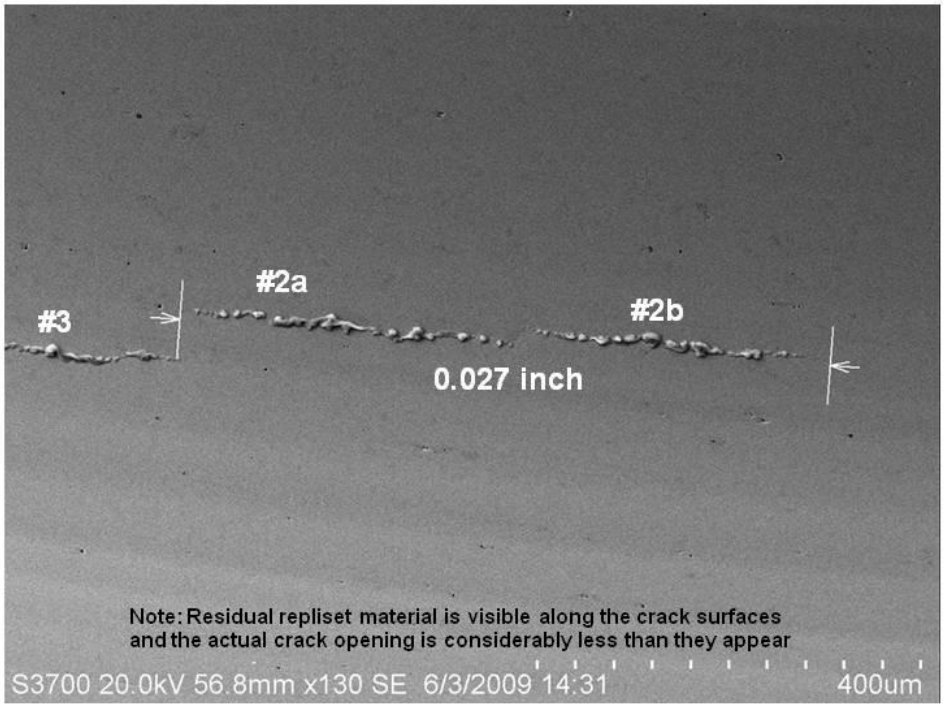
Location of Cracks #2-4



123

Poppet #34

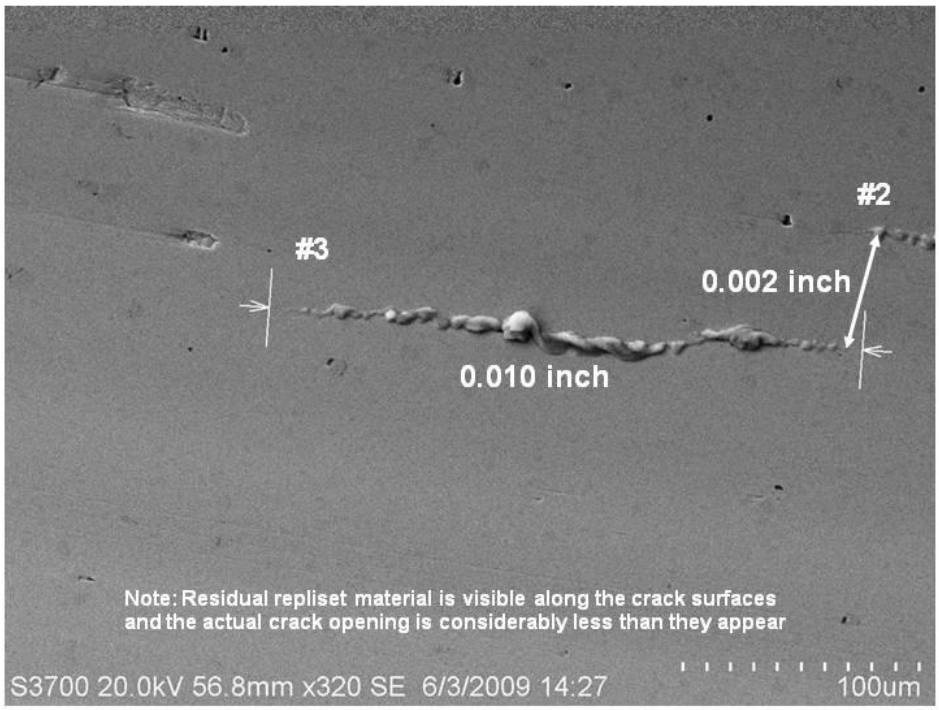
Location and size of Crack #2



124

Poppet #34

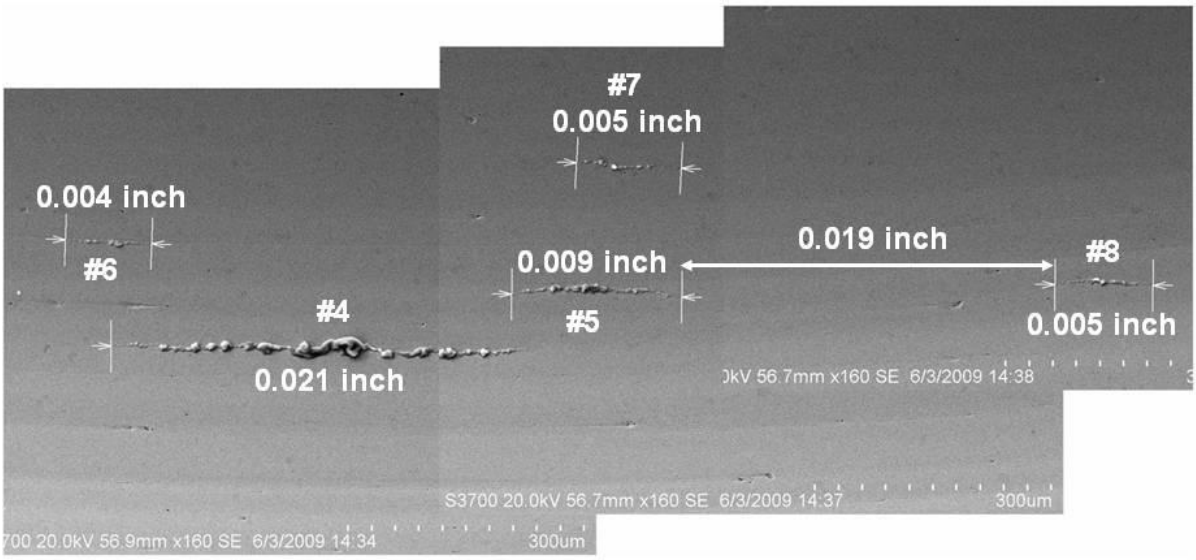
Location and size of Crack #3



125

Poppet #34

Location and size of Cracks #4 - 8

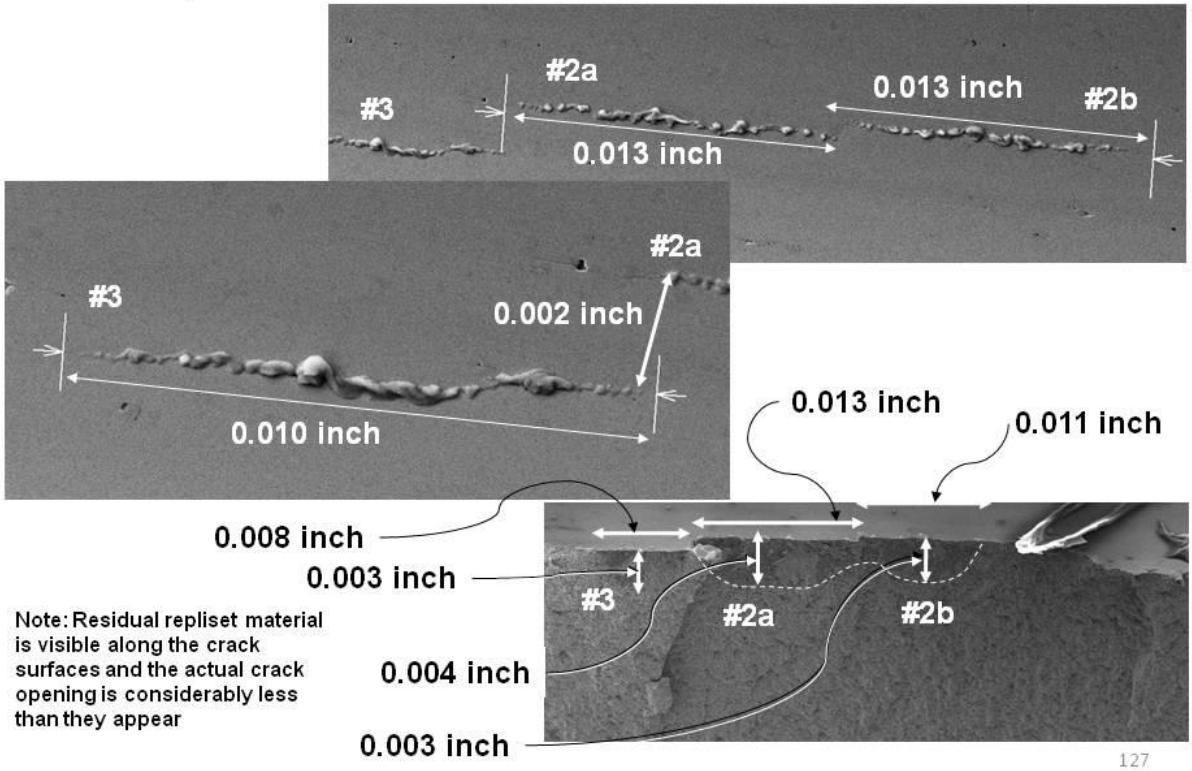


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

126

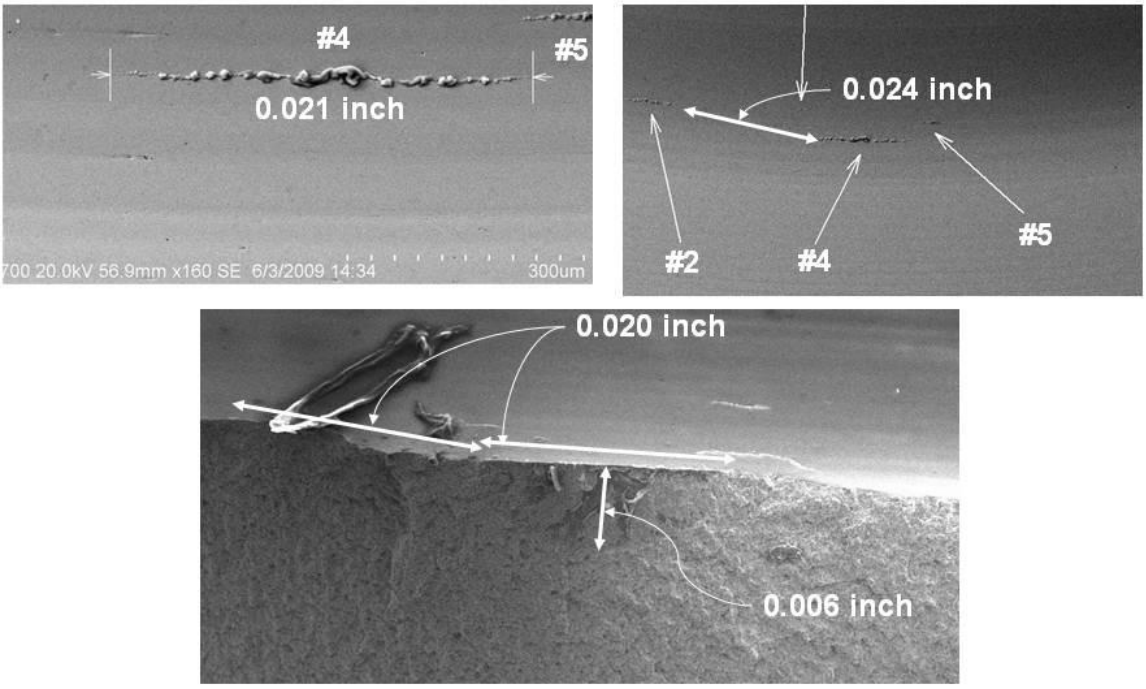
Poppet #34

Crack depth and correlation with surface measurements for Cracks #2 & 3



Poppet #34

Crack depth and correlation with surface measurements for Crack #4

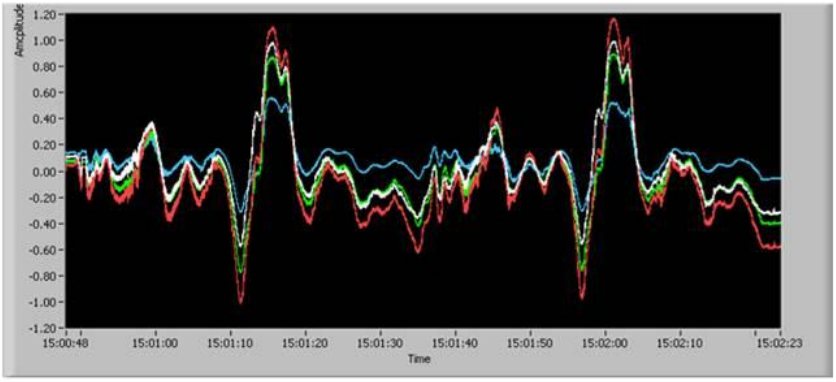


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

128

Poppet #34

LaRC eddy current findings, the colors indicate ???



129

Poppet #35

Surface crack sizes and locations

Poppet #35		
Crack Number	Size (inch)	Angle (degrees)
1	0.044	20
2	0.021	20
3	0.018	20
4	0.006	200
5	0.005	200
6	0.004	200

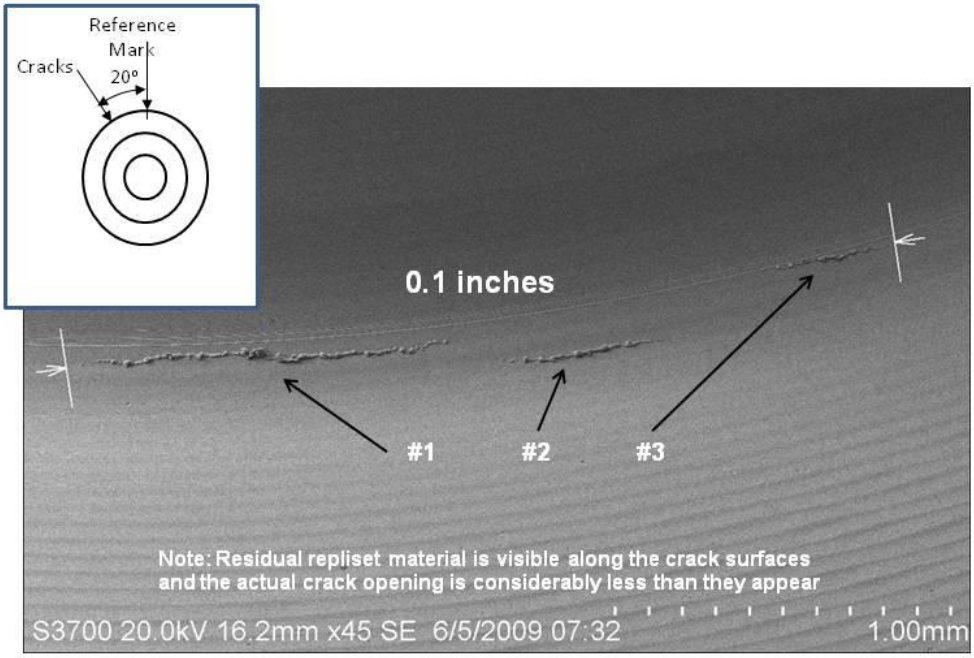
Boeing Eddy Current Findings

Poppet #35									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.564	0.585	0.597	0.596	0.604	0.595	0.590	Yes	10
J. Engel	0.065	0.074	0.055	0.074	0.082	0.068	0.070	Yes	195 (Not 3:1 S/N ratio)
B. Devries	0.573	0.580	0.584	0.577	0.574	0.564	0.575	Yes	15
B. Devries	-	-	-	-	-	-	-	No	200

130

Poppet #35

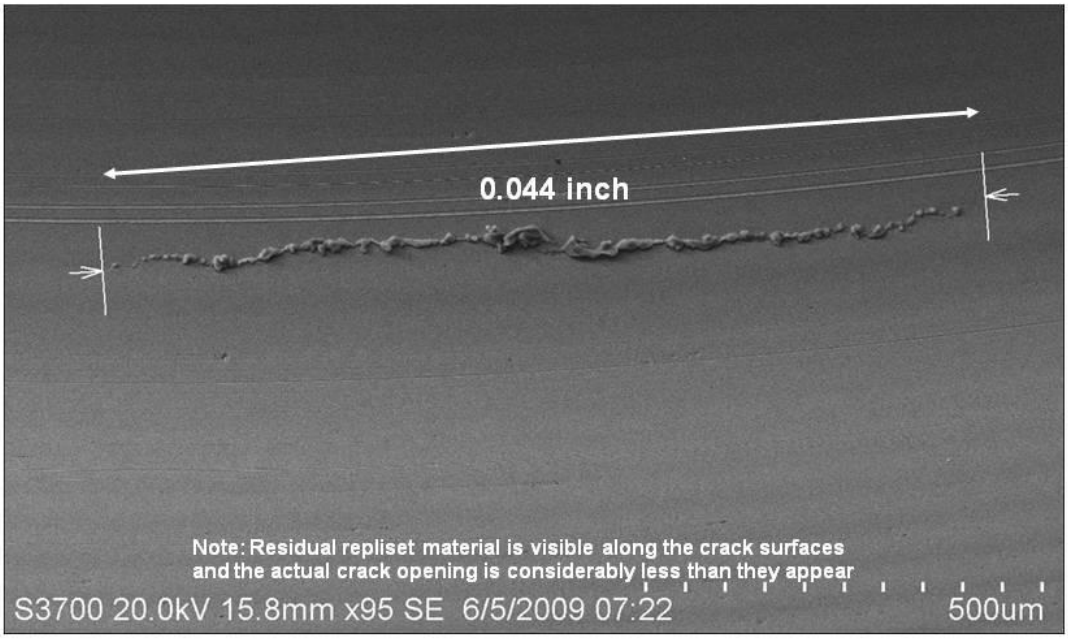
Location of Cracks #1-3



131

Poppet #35

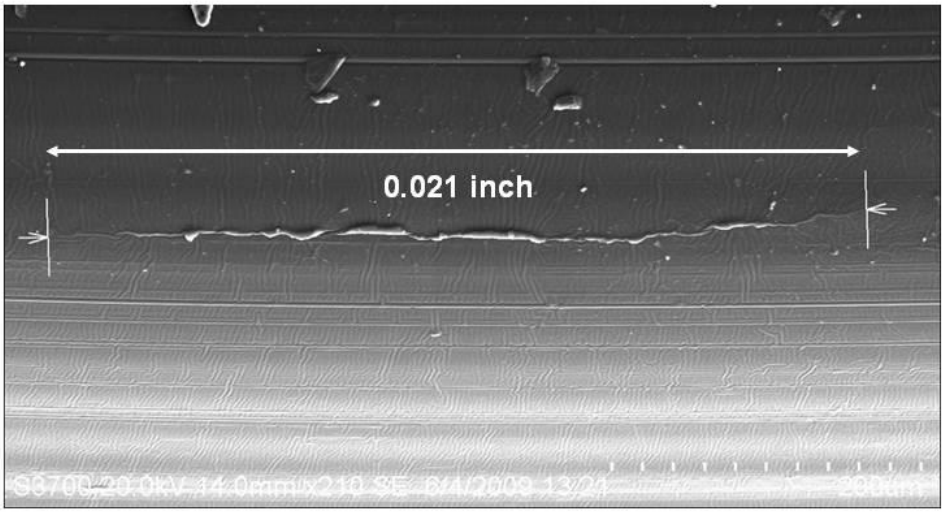
Size of Crack #1



132

Poppet #35

Size of Crack #2

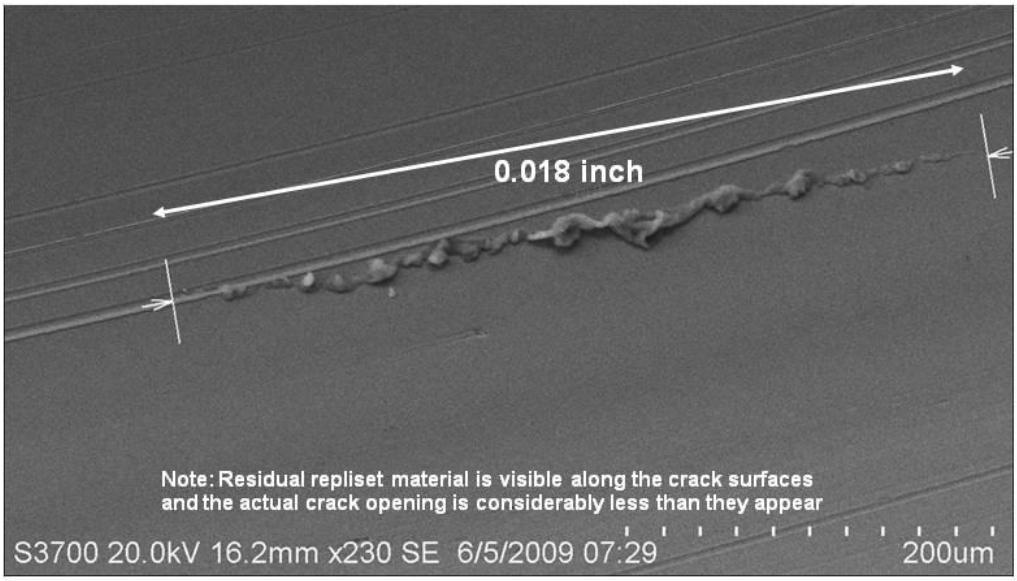


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

133

Poppet #35

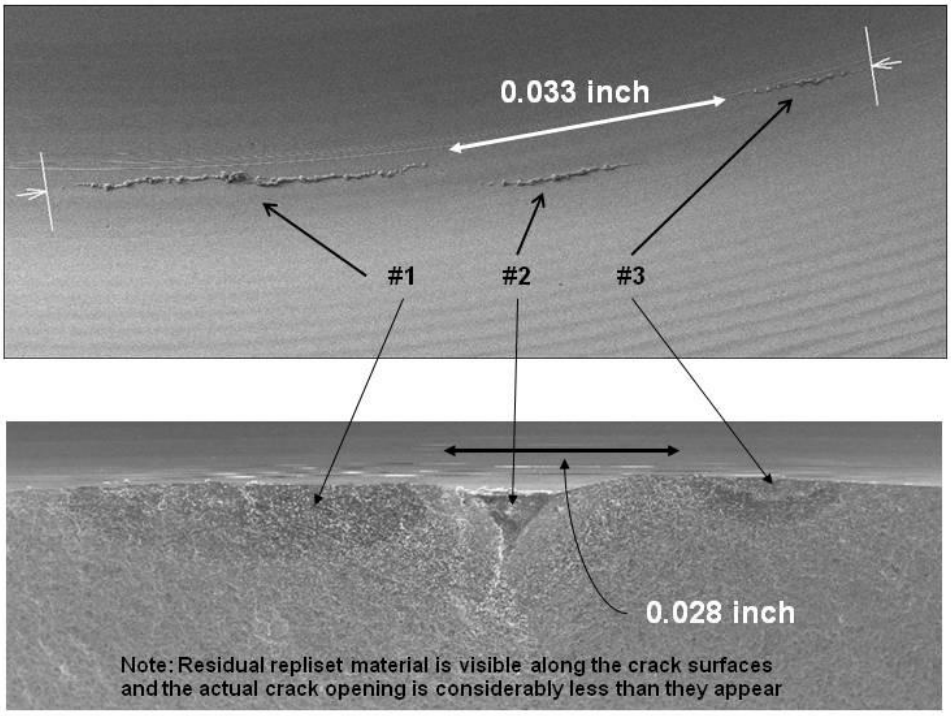
Size of Crack #3



134

Poppet #35

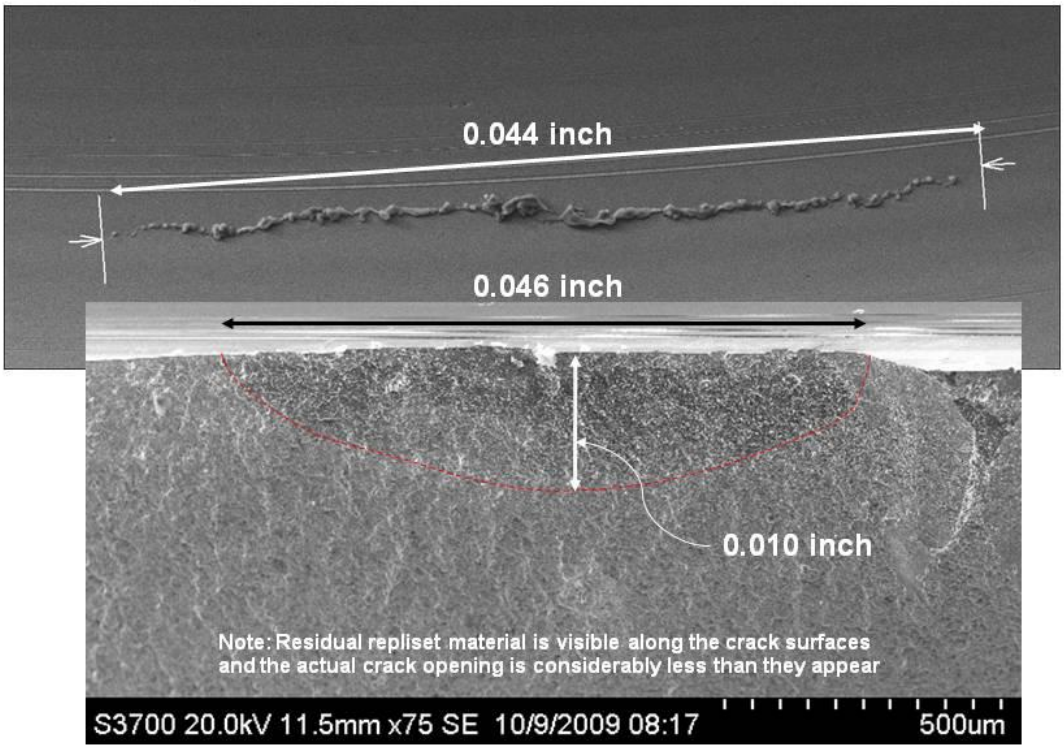
Crack depth and correlation with surface measurements for Cracks #1, 2, and 3



135

Poppet #35

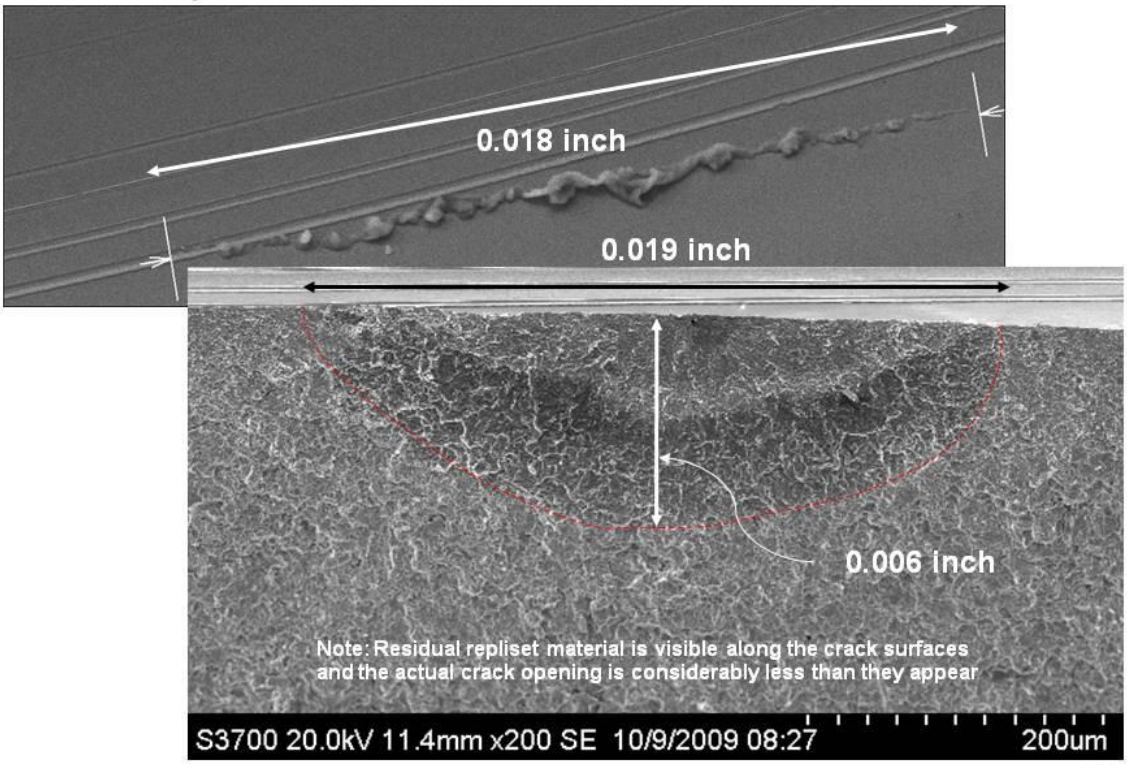
Crack depth and correlation with surface measurements for Crack #1



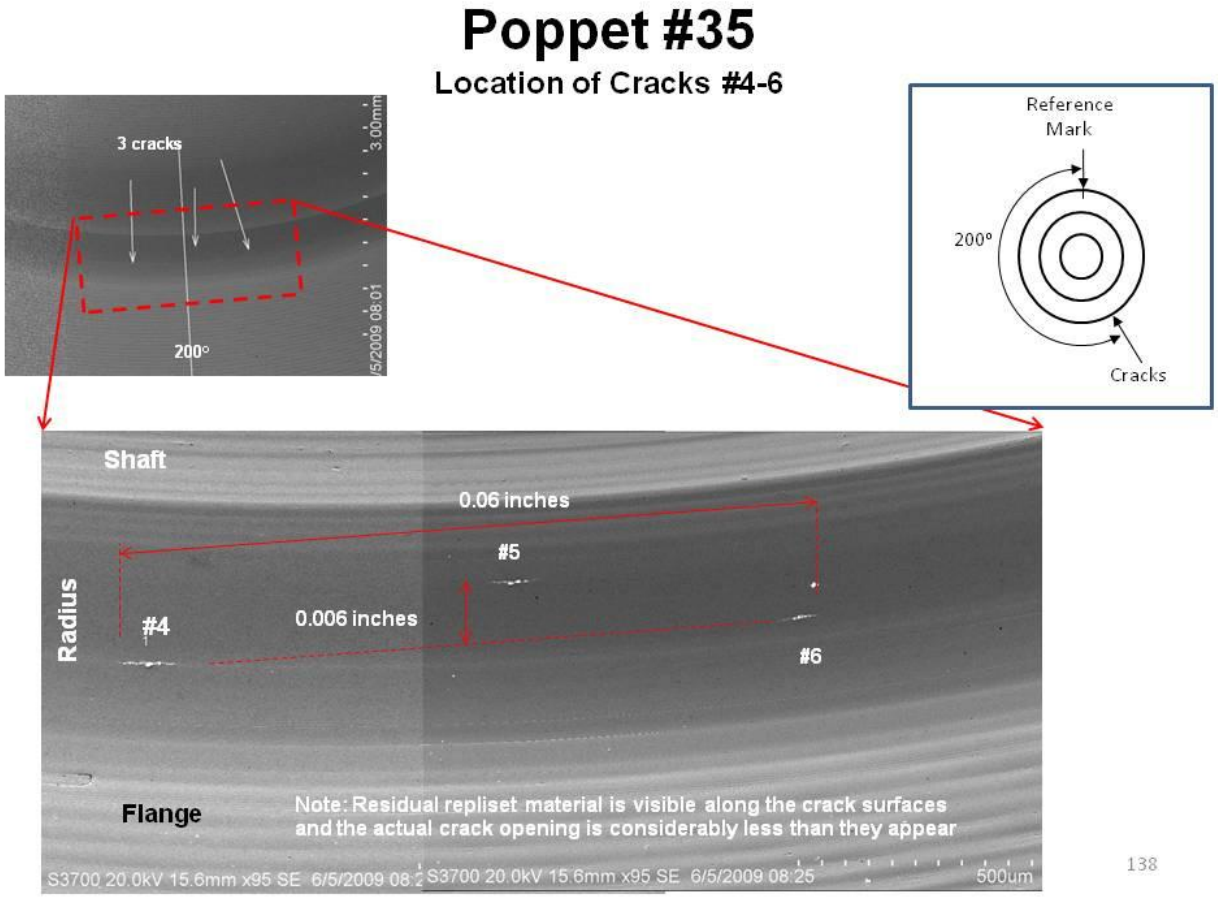
136

Poppet #35

Crack depth and correlation with surface measurements for Crack #3

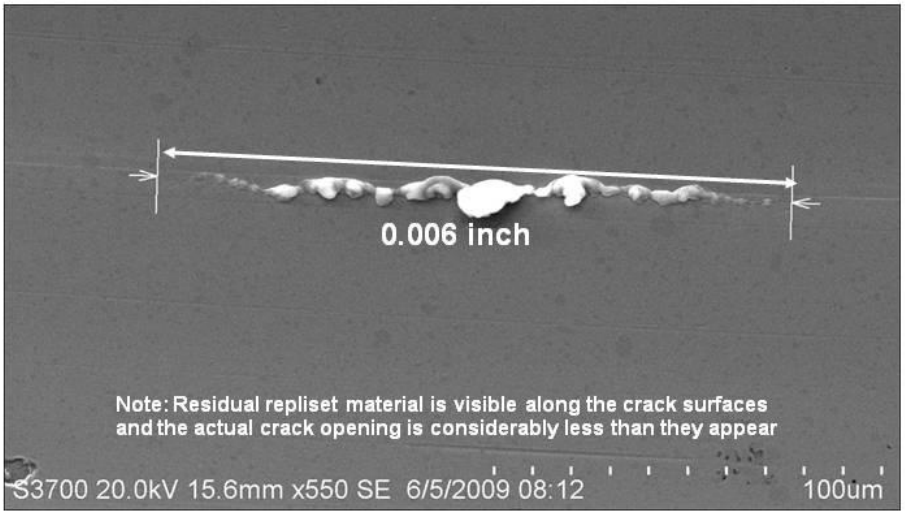


137


Poppet #35
Location of Cracks #4-6
3 cracks
200°
Reference Mark
200°
Cracks
Shaft
0.06 inches
#5
#4
0.006 inches
#6
Radius
Flange
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 15.6mm x95 SE 6/5/2009 08:25
500um
138

Poppet #35

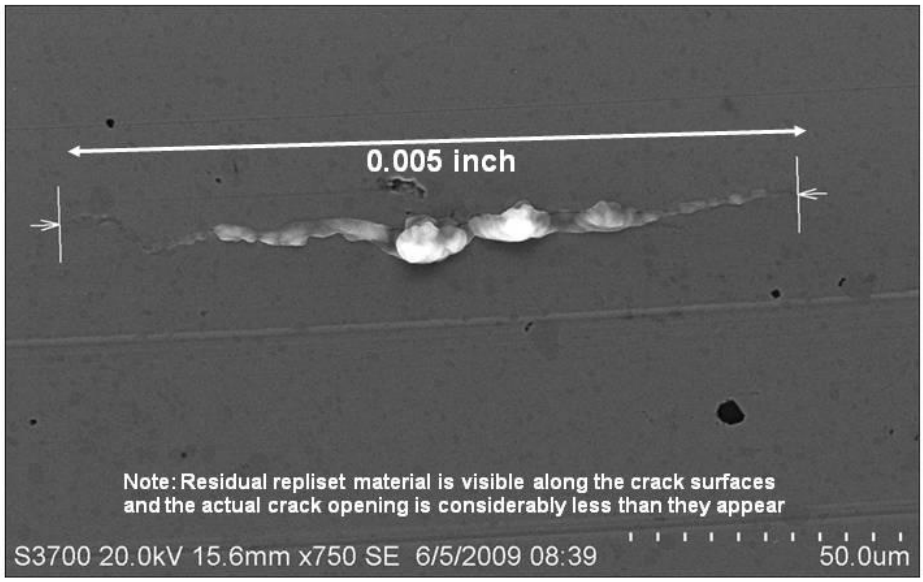
Size of Crack #4



139

Poppet #35

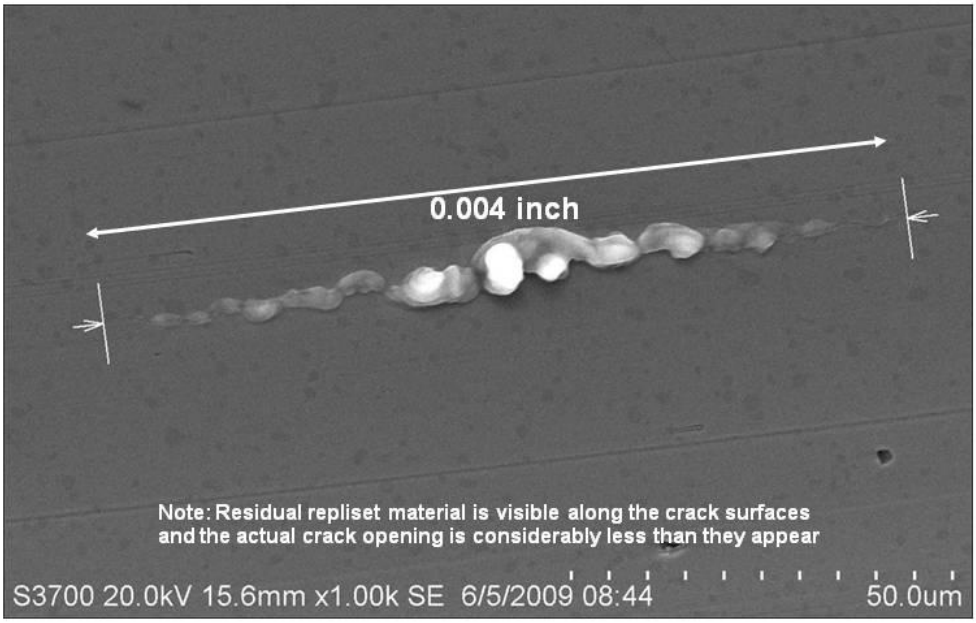
Size of Crack #5



140

Poppet #35

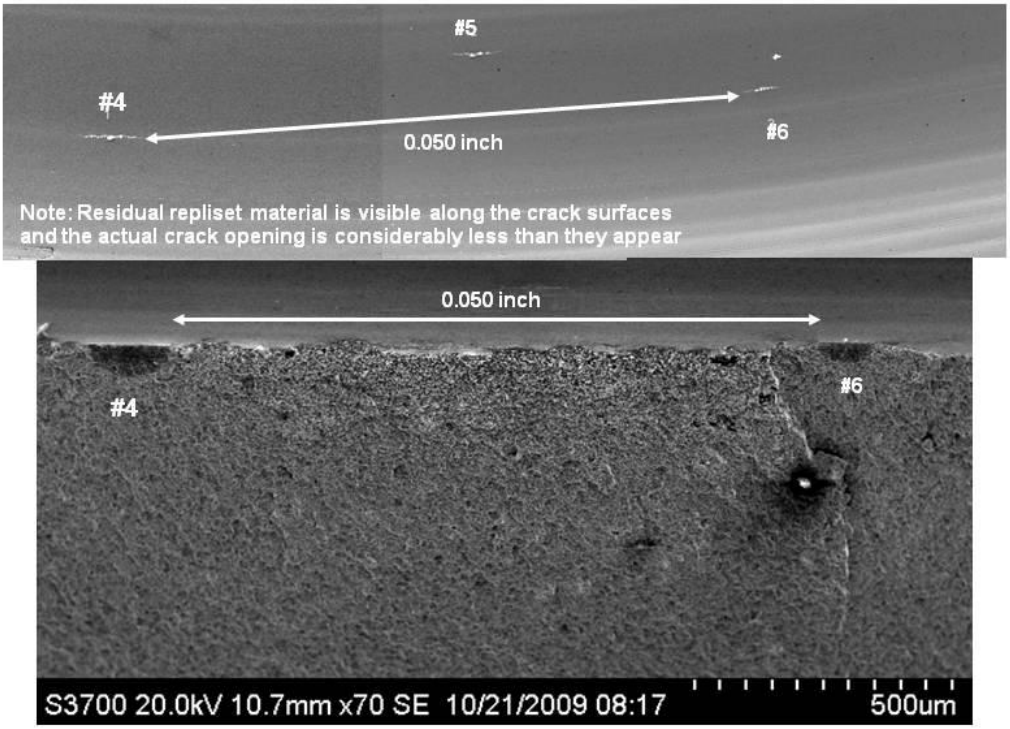
Size of Crack #6



141

Poppet #35

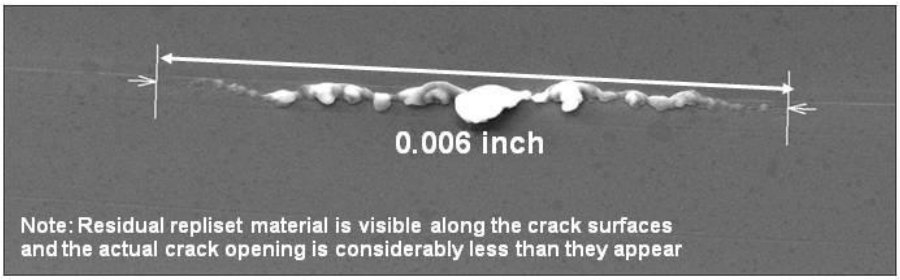
Crack depth and correlation with surface measurements for Cracks #4 and 6

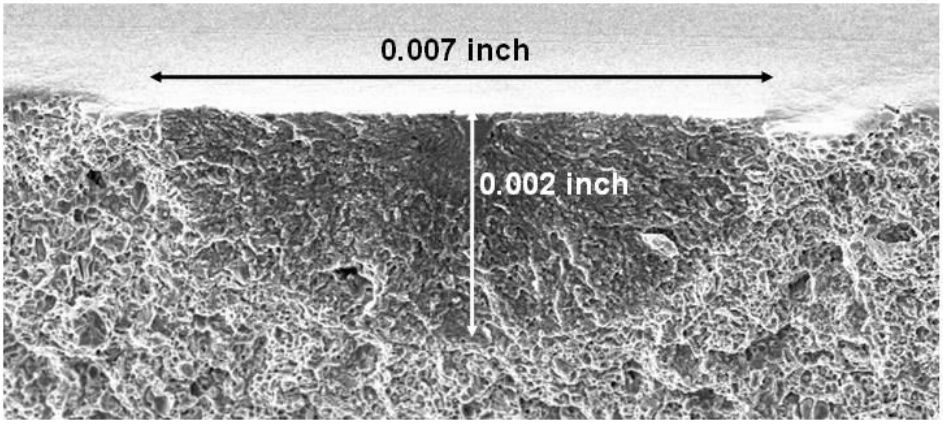


142

Poppet #35

Crack depth and correlation with surface measurements for Crack #4

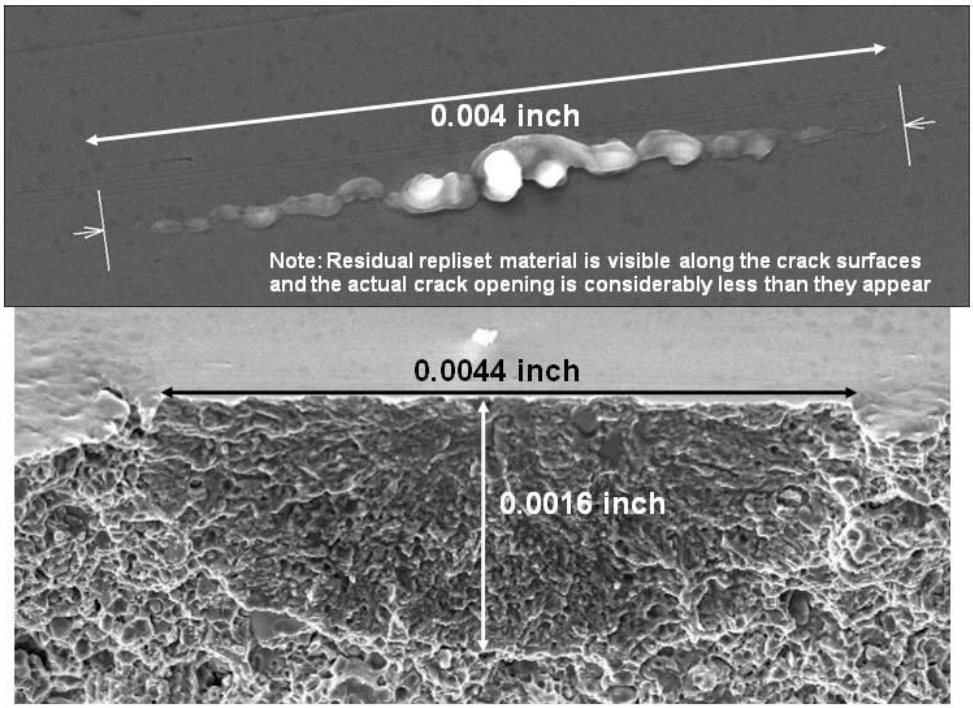




143

Poppet #35

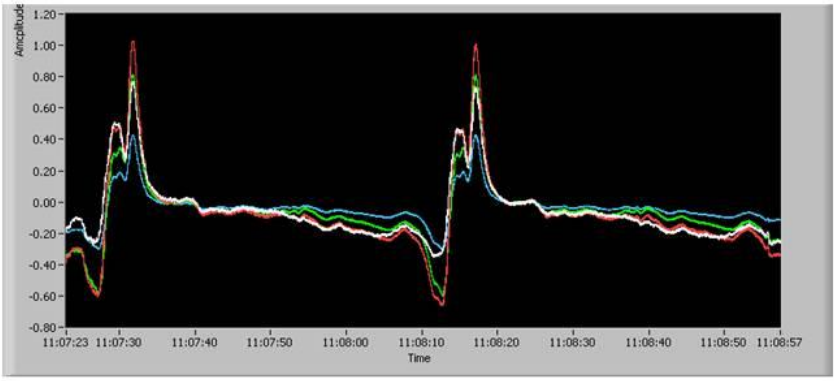
Crack depth and correlation with surface measurements for Crack #6



144

Poppet #35

LaRC eddy current findings, the colors indicate ???



145

Poppet #36

Surface crack sizes and locations

Poppet #36		
Crack Number	Size (inch)	Angle (degrees)
1	0.005	140
2	0.001	140
3	0.001	140
4	0.006	140
5	0.002	140
6	0.014	140
7	0.006	140
8	0.004	140
9	0.002	140
10	0.005	140
11	0.003	140
12	0.013	140
13	0.008	140
14	0.002	140
15	0.002	140
16	0.004	140
17	0.009	310
18	0.004	310
19	0.002	310

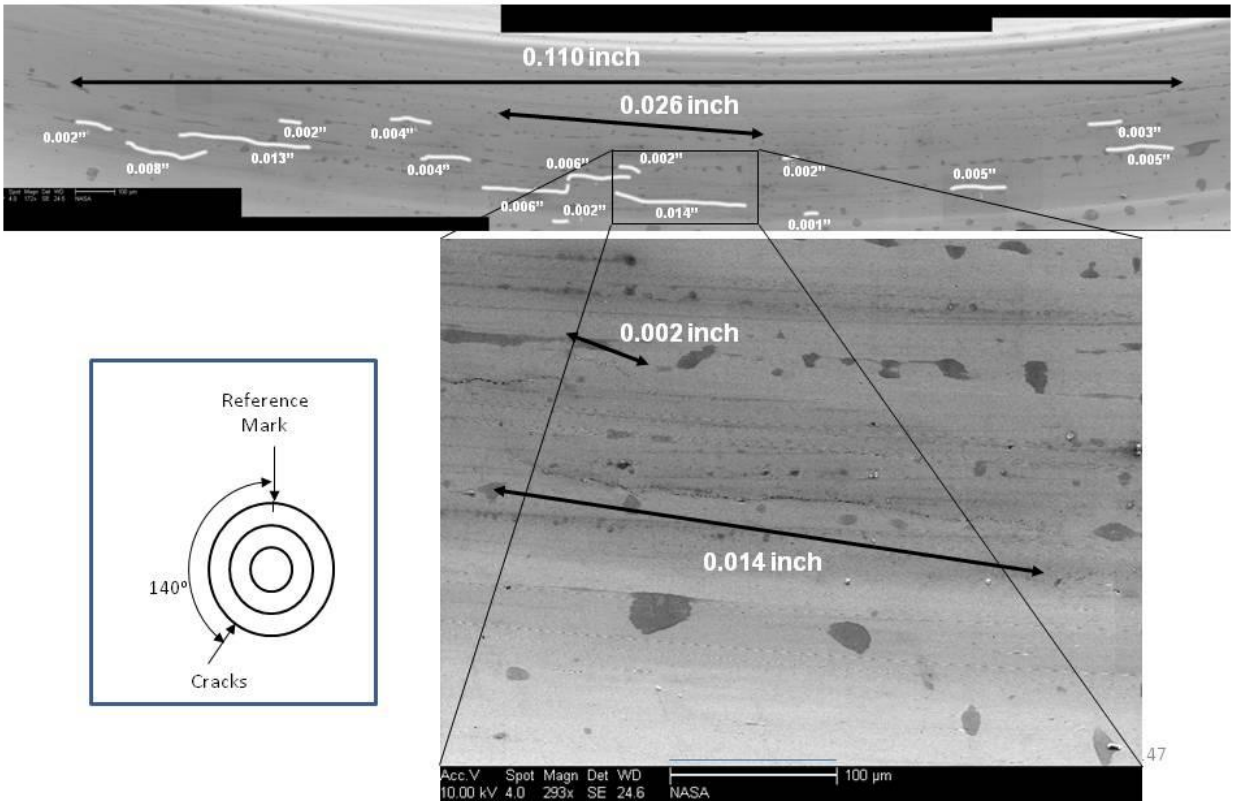
Boeing Eddy Current Findings

Poppet #36									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.157	0.160	0.163	0.168	0.150	0.160	0.160	Yes	135 (Wobble in poppet)
J. Engel	0.099	0.096	0.096	0.096	0.092	0.093	0.095	Yes	310 (Wobble in poppet)
B. Devries	0.175	0.169	0.181	0.171	0.161	0.158	0.169	Yes	130
B. Devries	0.086	0.084	0.087	0.084	0.090	0.076	0.085	Yes	310

146

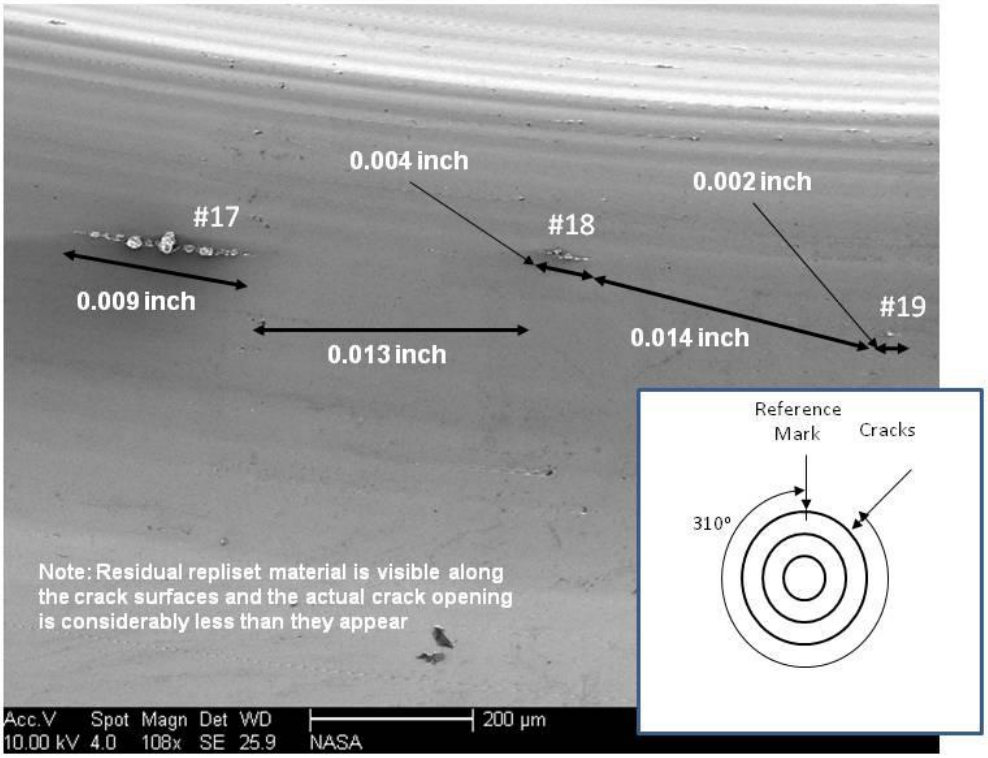
Poppet #36

Location and size of Cracks #1-16



Poppet #36

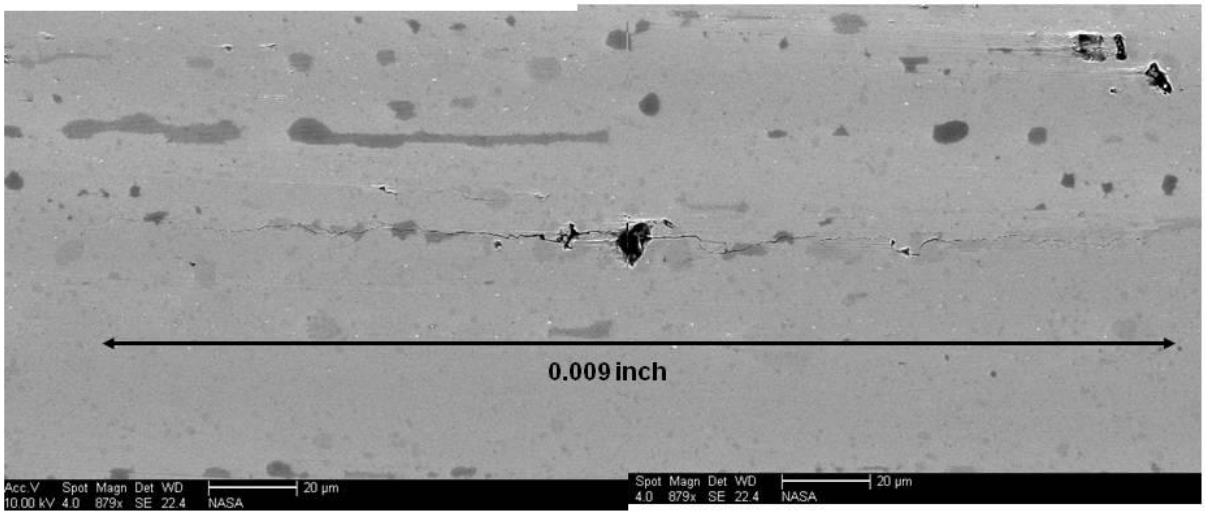
Location and size of Cracks #17-19



148

Poppet #36

Size of Crack #17

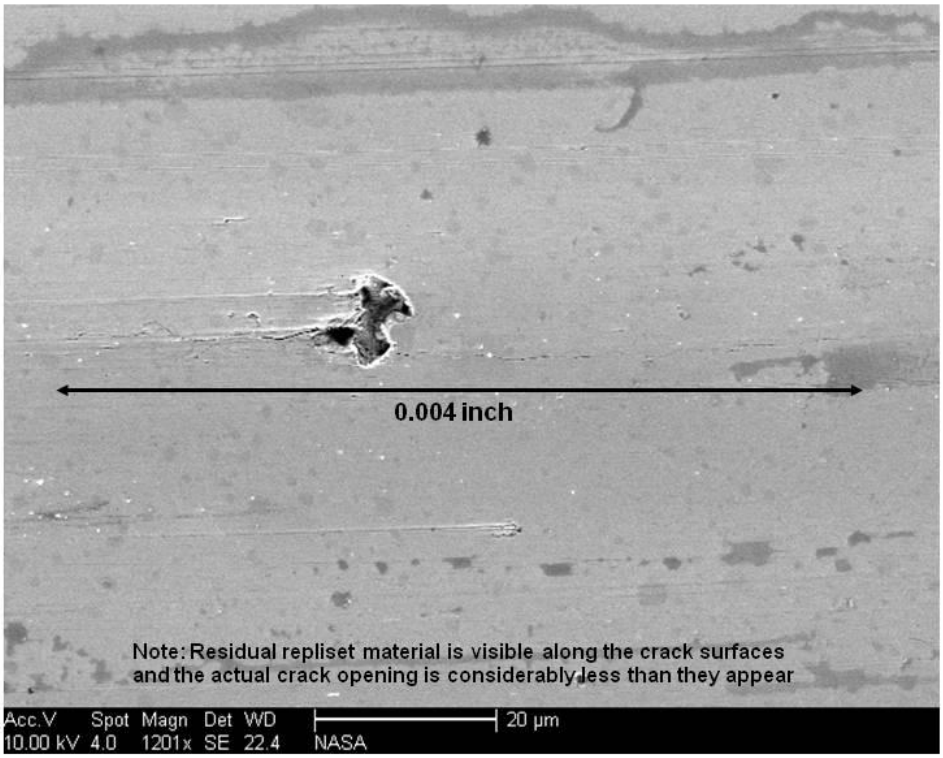


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

149

Poppet #36

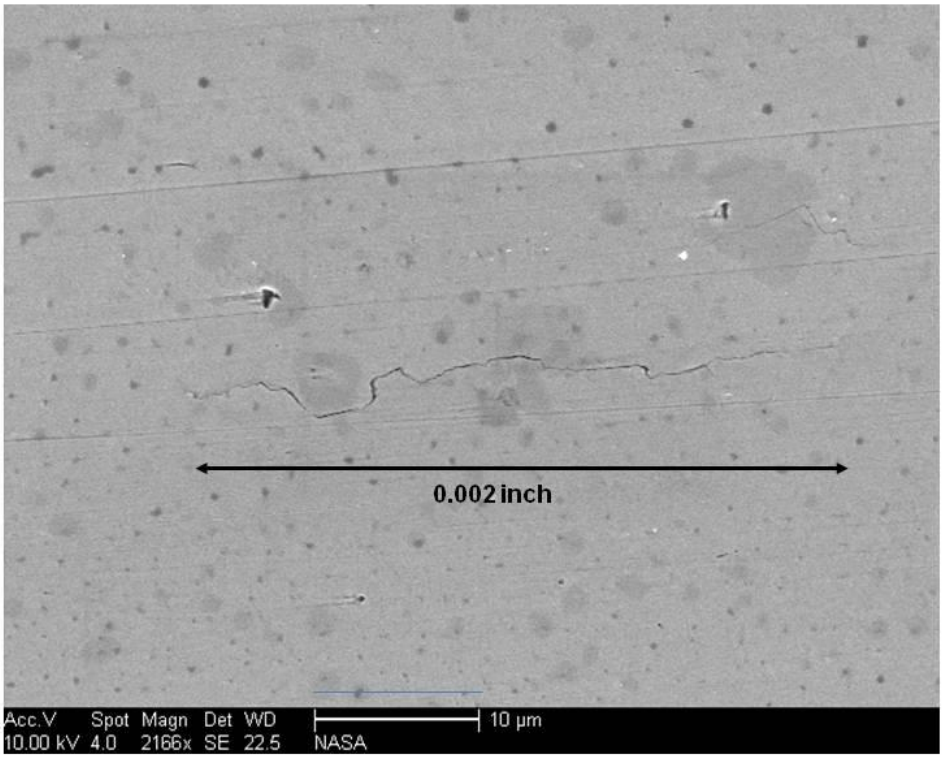
Size of Crack #18



150

Poppet #36

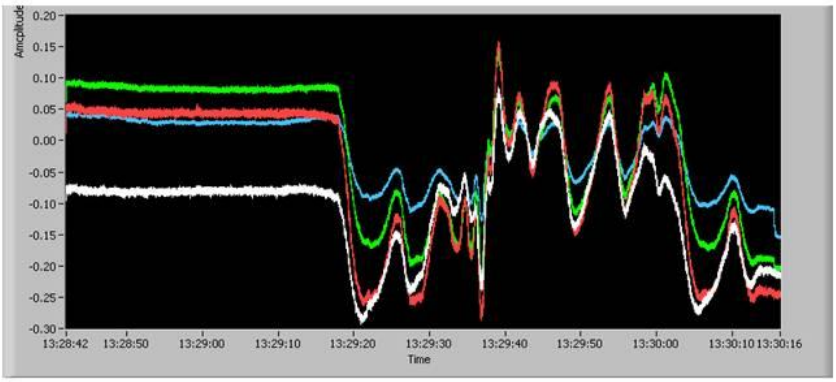
Size of Crack #19



151

Poppet #36

LaRC eddy current findings, the colors indicate ???



152

Poppet #37

Surface crack sizes and locations

Poppet #37		
Crack Number	Size (inch)	Angle (degrees)
1	0.022	280
2	0.002	280
3	0.004	280
4	0.002	280
5	0.001	280
6	0.004	280
7	0.002	110
8	0.002	110
9	0.002	110
10	0.002	110

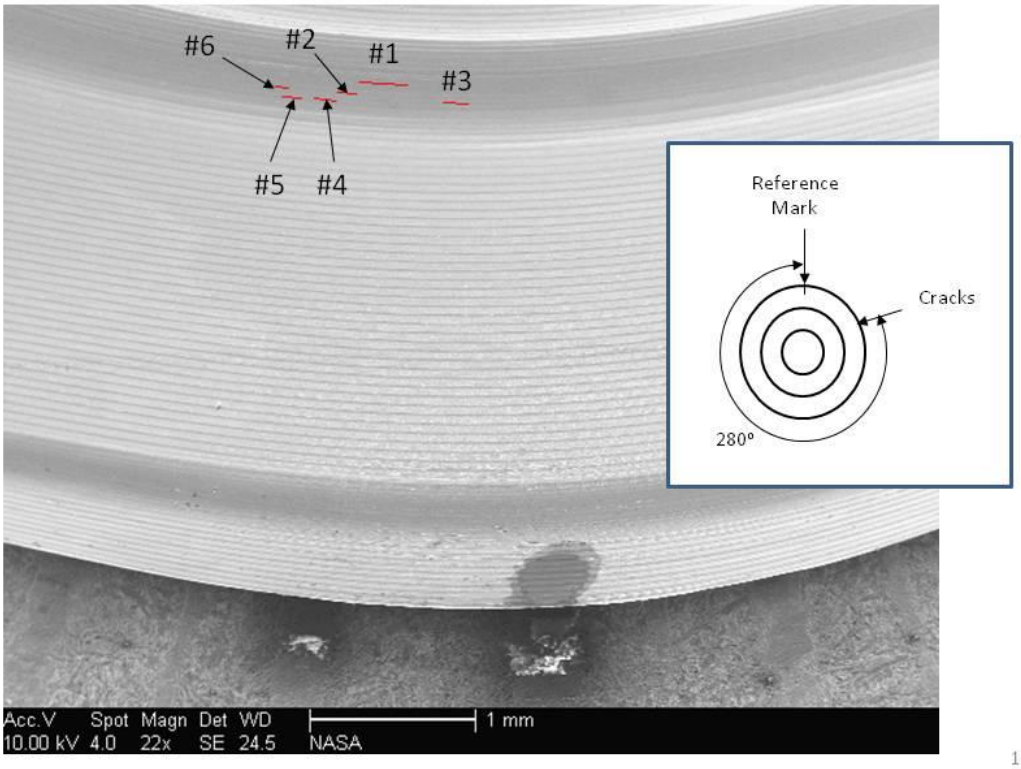
Boeing Eddy Current Findings

Poppet #37									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.243	0.251	0.248	0.254	0.247	0.251	0.249	Crack	290
J. Engel	-	-	-	-	-	-	-	No	110
J. Engel	0.053	0.050	0.050	0.052	0.054	0.071	0.055	False	45 (Not 3:1 S/N ratio)
B. Devries	-	-	-	-	-	-	-	No	110
B. Devries	0.259	0.258	0.258	0.260	0.262	0.257	0.259	Crack	280

153

Poppet #37

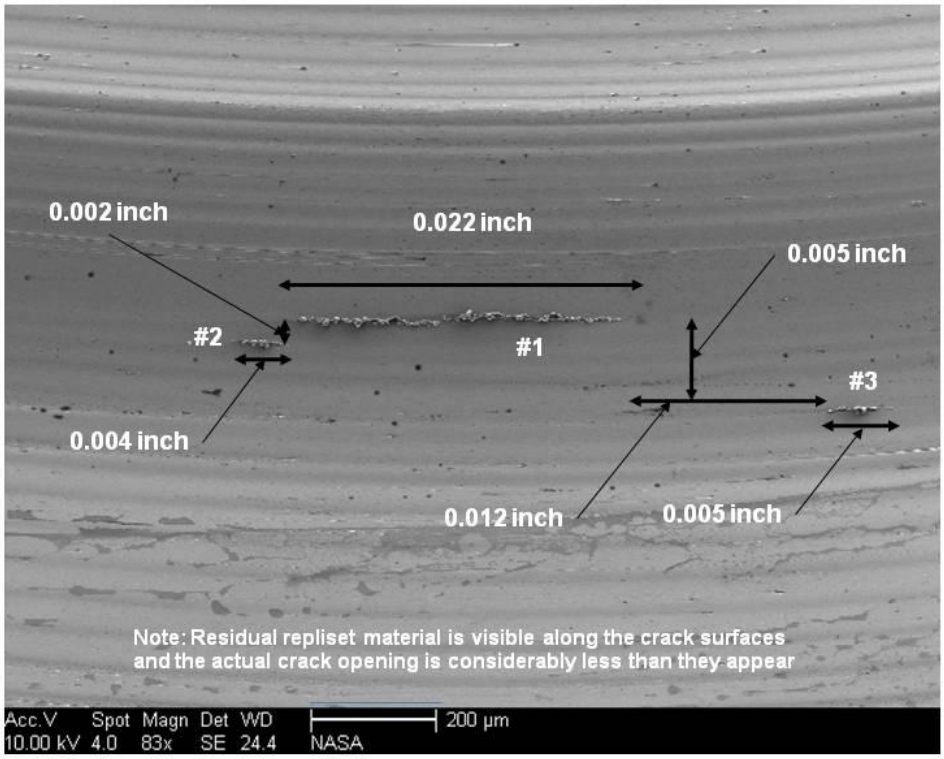
Location of Cracks #1-6



154

Poppet #37

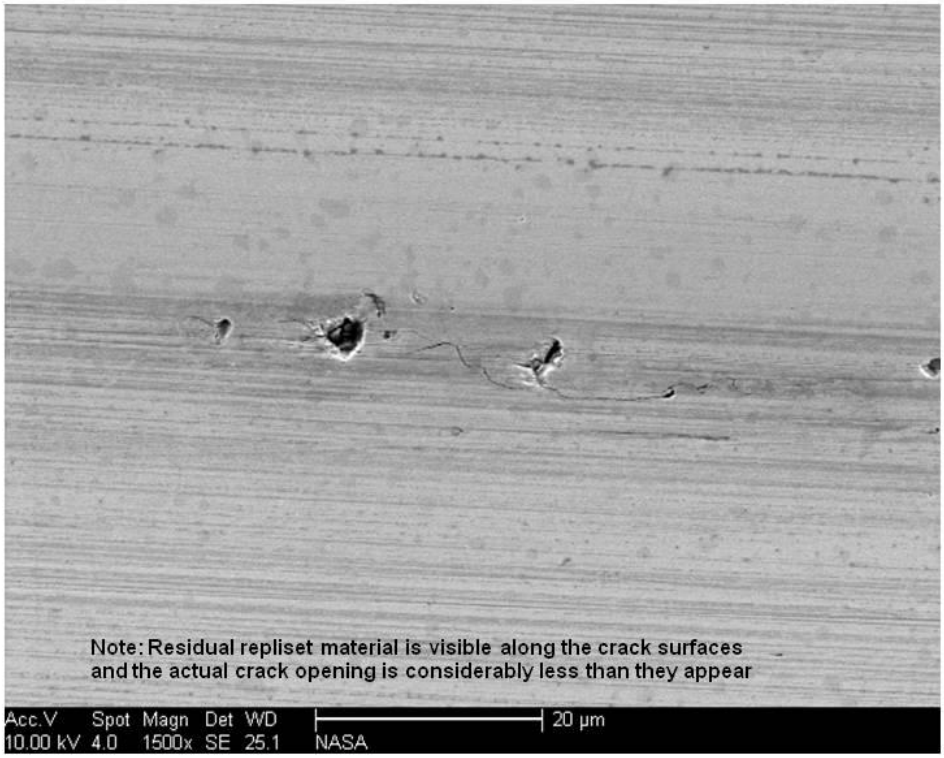
Location and size of Cracks #1-3



155

Poppet #37

Crack #4



156

Poppet #37

Crack #5

157

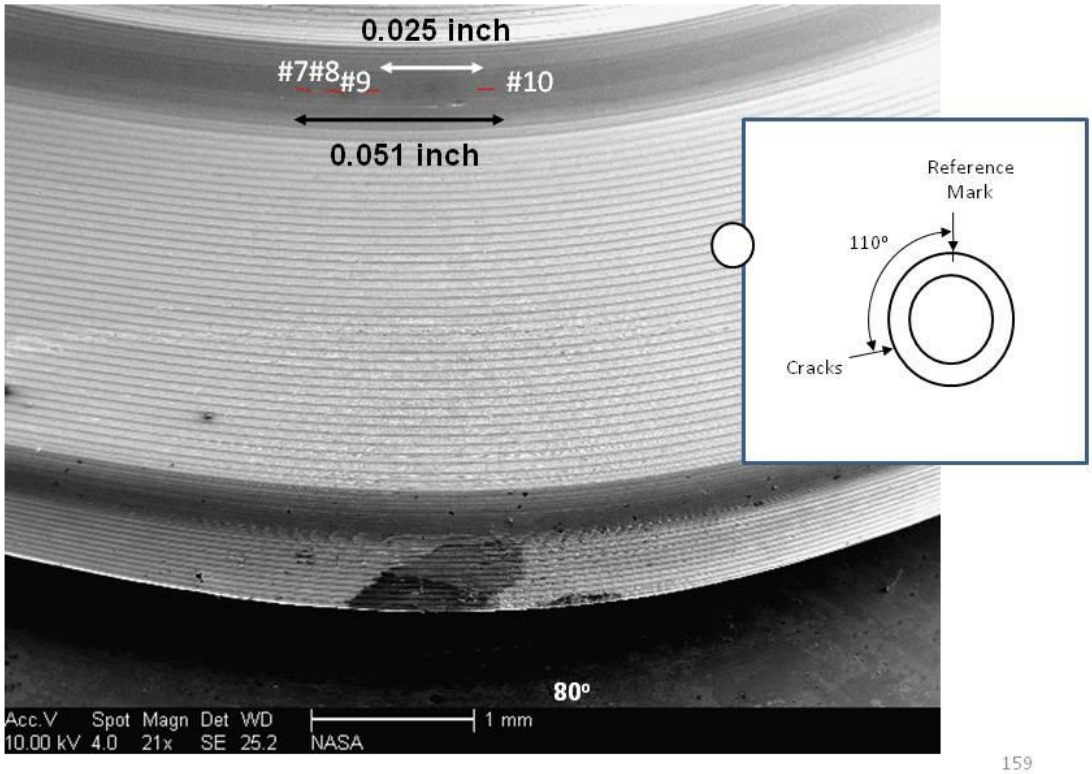
Poppet #37

Crack #6

158

Poppet #37

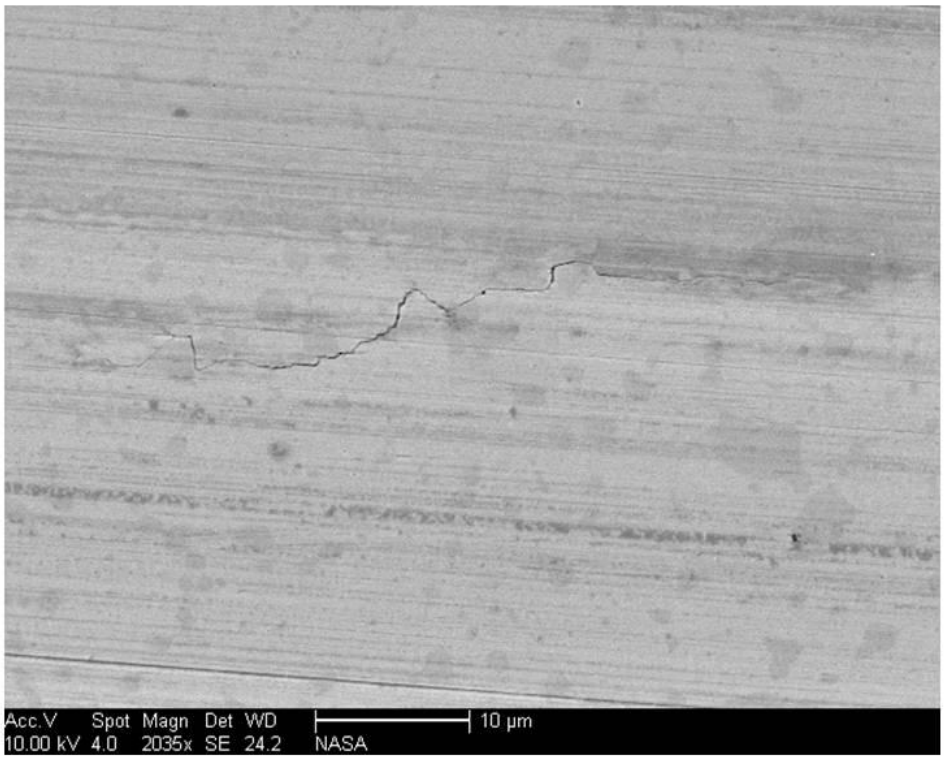
Location of Cracks #7-10



159

Poppet #37

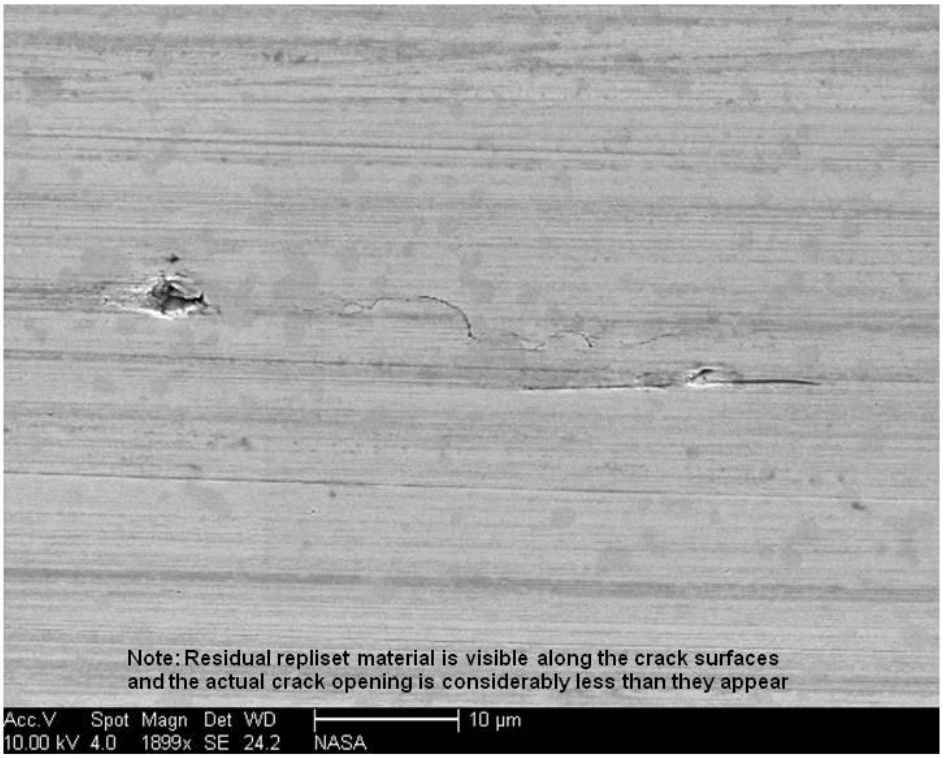
Crack #7



160

Poppet #37

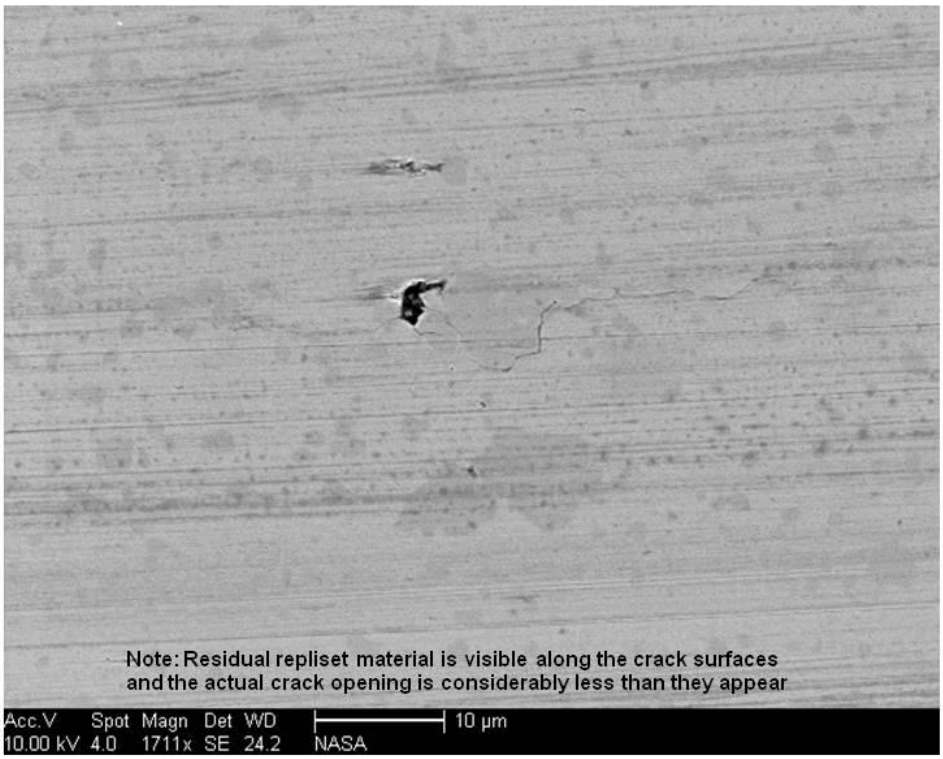
Crack #8



161

Poppet #37

Crack #9



162

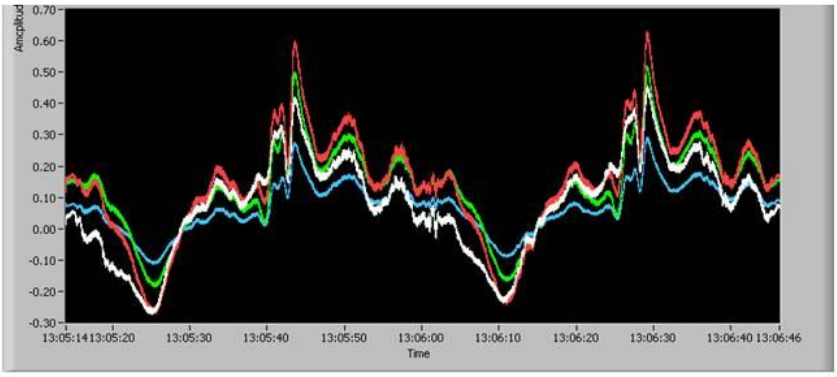
Poppet #37

Crack #10

163

Poppet #37

LaRC eddy current findings, the colors indicate ???



164

Poppet #38

Surface crack sizes and locations

Poppet #38		
Crack Number	Size (inch)	Angle (degrees)
1	0.074	260
2	0.025	80
3	0.011	80
4	0.007	80

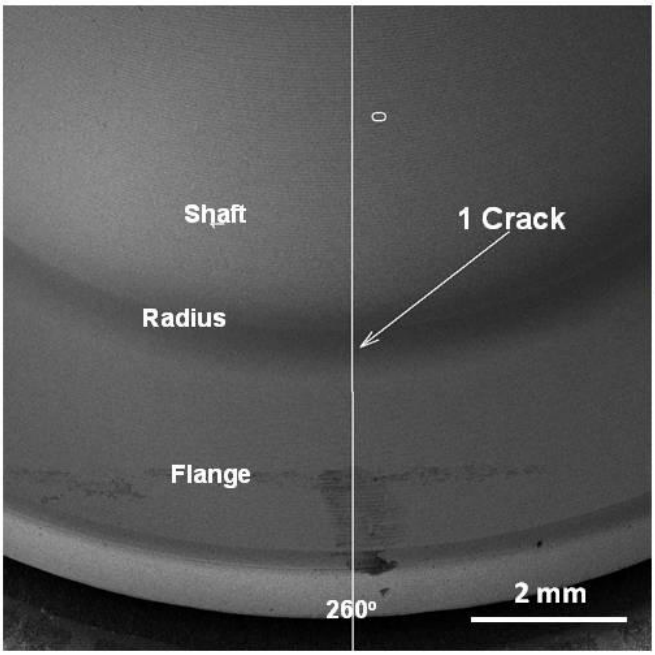
Boeing Eddy Current Findings

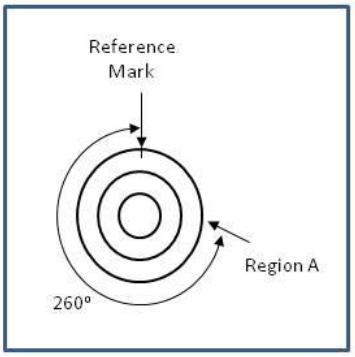
Poppet #38									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.901	0.885	0.891	0.902	0.911	0.912	0.900	Yes	95
J. Engel	0.078	0.075	0.075	0.078	0.076	0.080	0.077	Yes	265 (Not 3:1 S/N ratio)
B. Devries	0.080	0.075	0.093	0.082	0.079	0.079	0.081	Yes	275
B. Devries	0.875	0.866	0.898	0.908	0.913	0.911	0.895	Yes	95

165

Poppet #38

Location of Region A

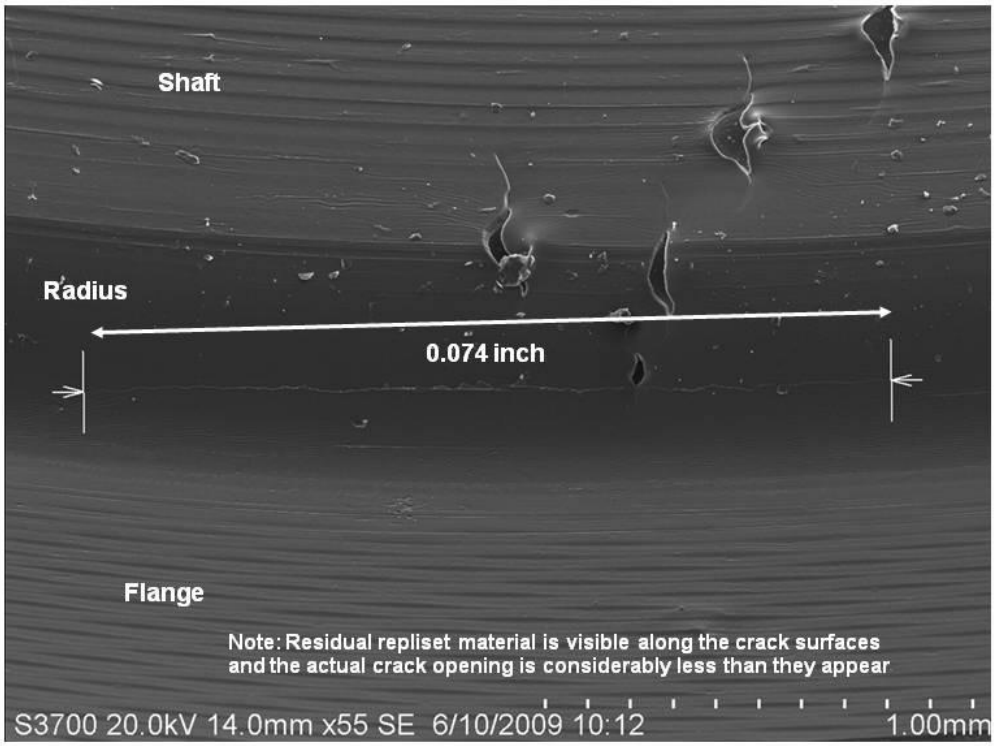




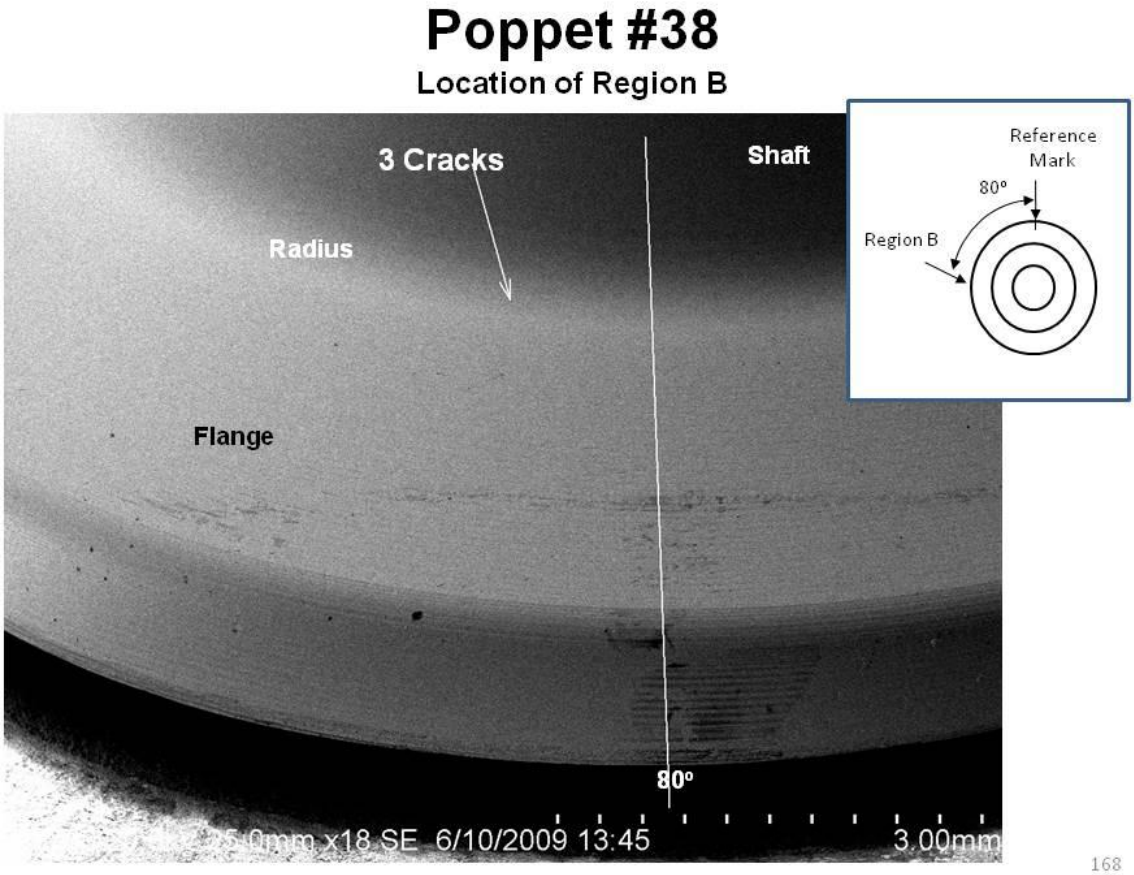
166

Poppet #38

Size of Region A Cracks #1-3

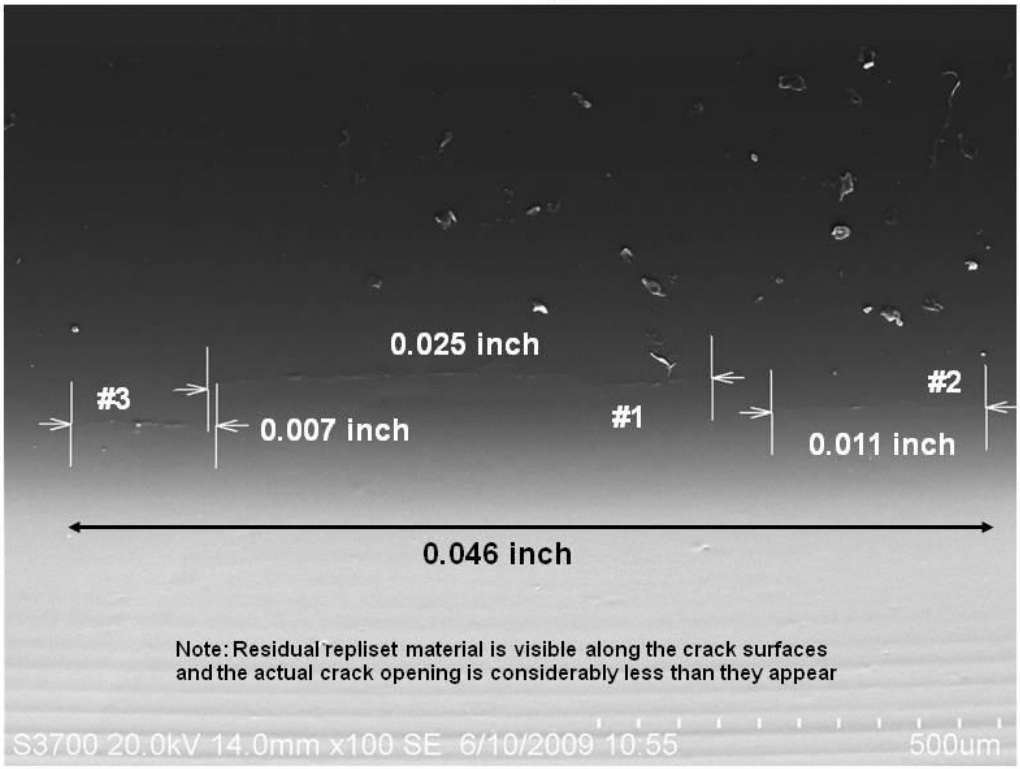


167


Poppet #38
Location of Region B
3 Cracks
Shaft
Radius
Flange
80°
Reference Mark
80°
Region B
25.0mm x18 SE 6/10/2009 13:45
3.00mm
168

Poppet #38

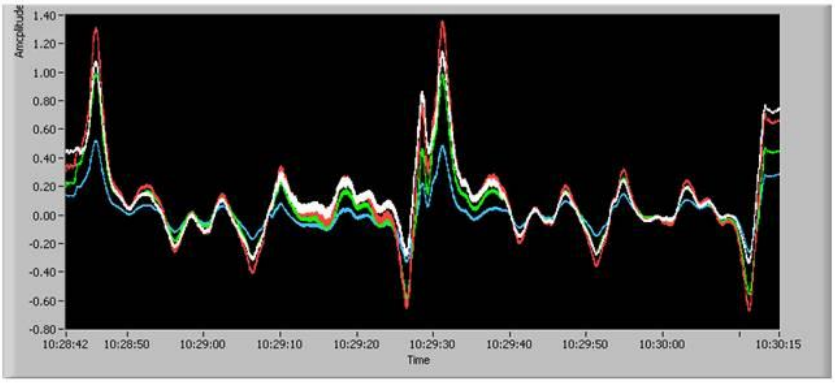
Location and size of Region B Cracks #1-3



169

Poppet #38

LaRC eddy current findings, the colors indicate ???



170

Poppet #39

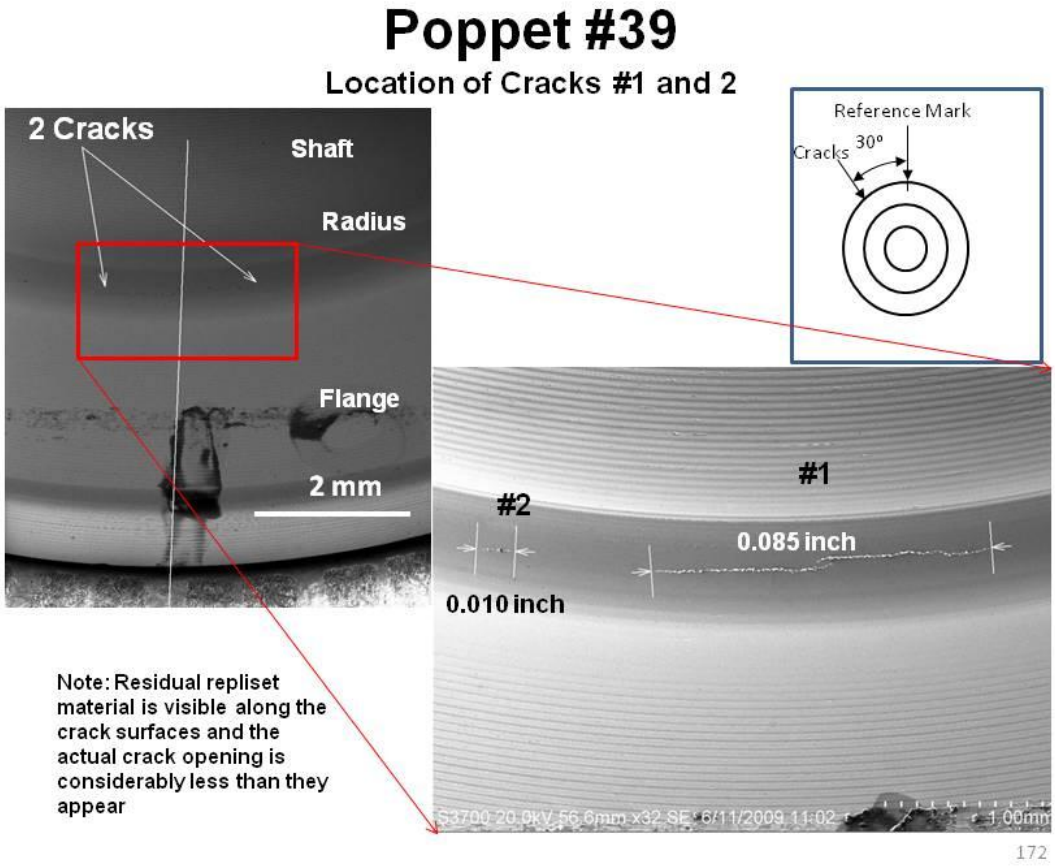
Surface crack sizes and locations

Poppet #39		
Crack Number	Size (inch)	Angle (degrees)
1	0.005	30
2	0.010	30
3	0.056	210

Boeing Eddy Current Findings

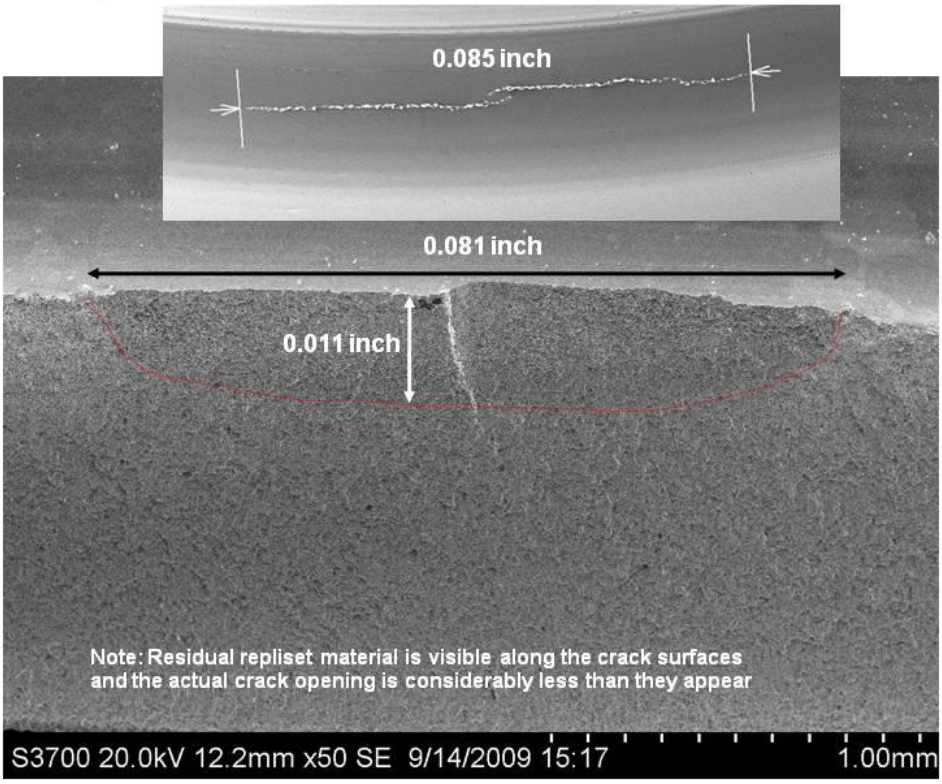
Poppet #39									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.983	0.993	1.010	1.015	1.014	1.012	1.005	Yes	25
J. Engel	0.652	0.649	0.679	0.691	0.662	0.668	0.667	Yes	200
B. Devries	0.963	0.968	0.963	0.968	0.970	0.974	0.968	Yes	30
B. Devries	0.646	0.633	0.647	0.631	0.631	0.659	0.641	Yes	210

171


Poppet #39
Location of Cracks #1 and 2
2 Cracks
Shaft
Radius
Flange
2 mm
Reference Mark
Cracks
30°
#1
#2
0.085 inch
0.010 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
172

Poppet #39

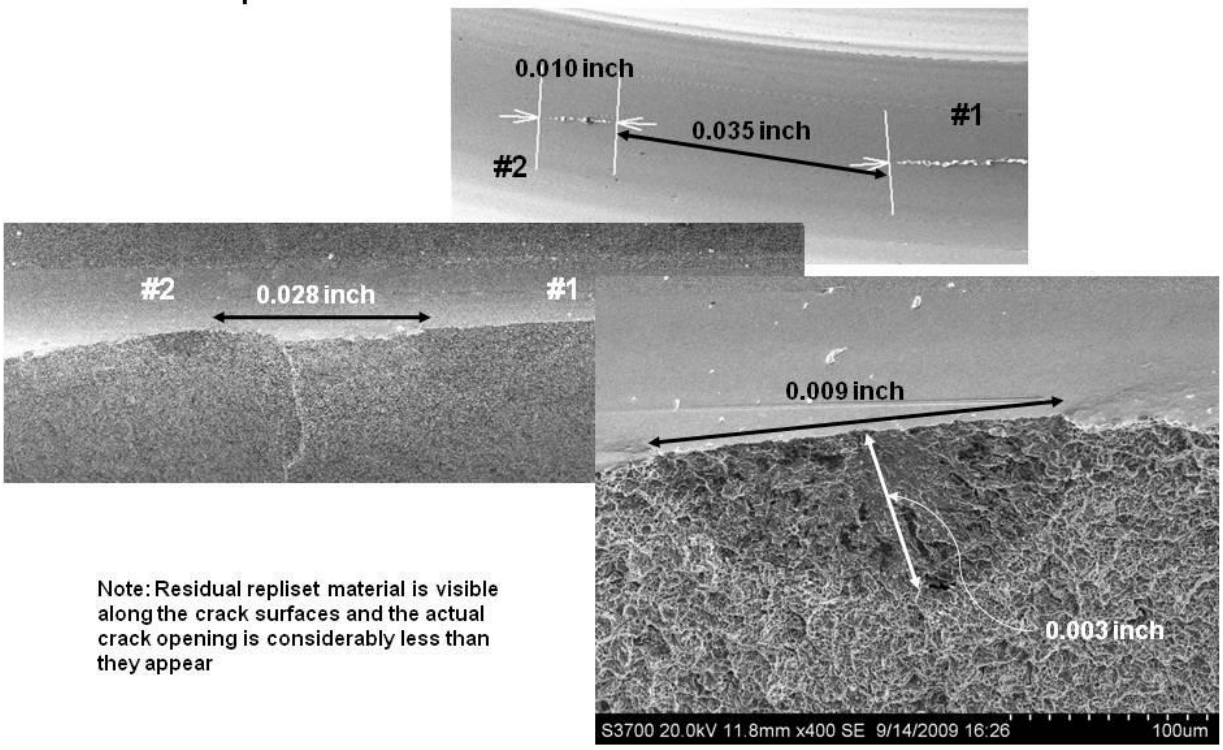
Crack depth and correlation with surface measurements for Crack #1



173

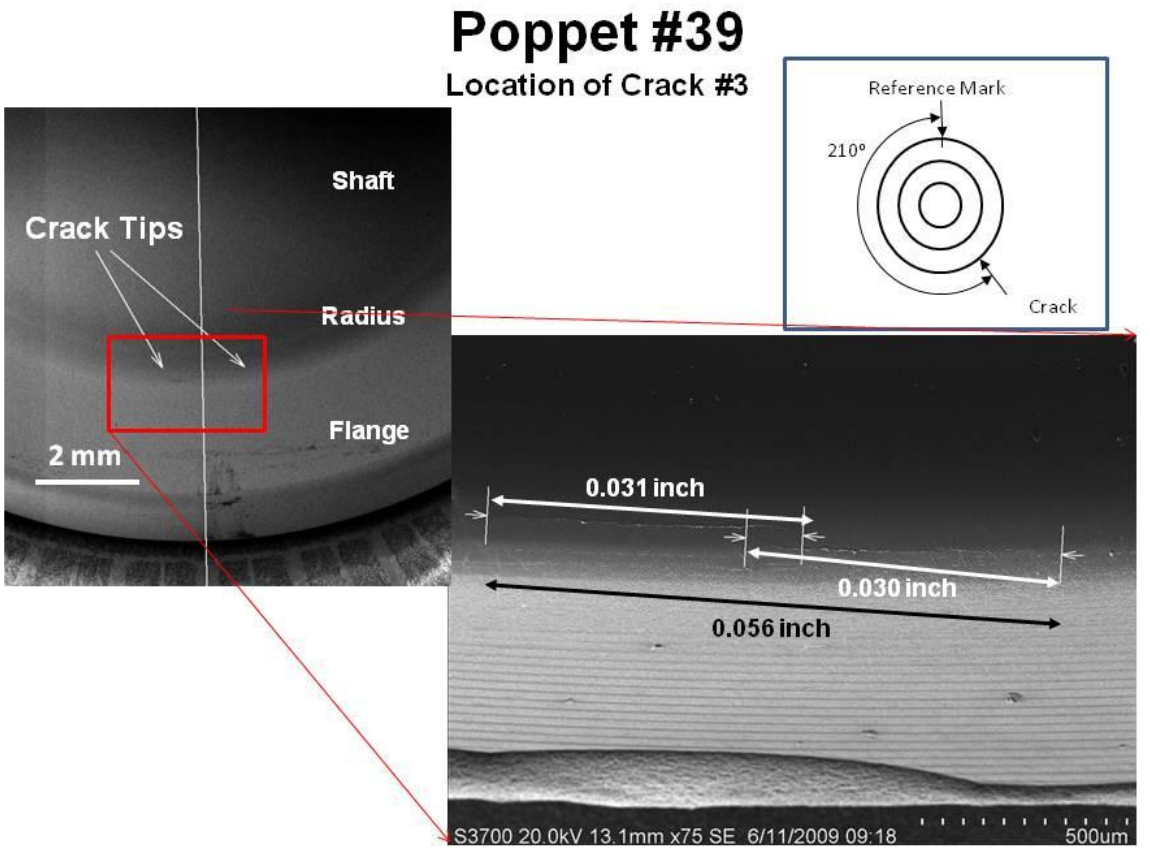
Poppet #39

Crack depth and correlation with surface measurements for Crack #2



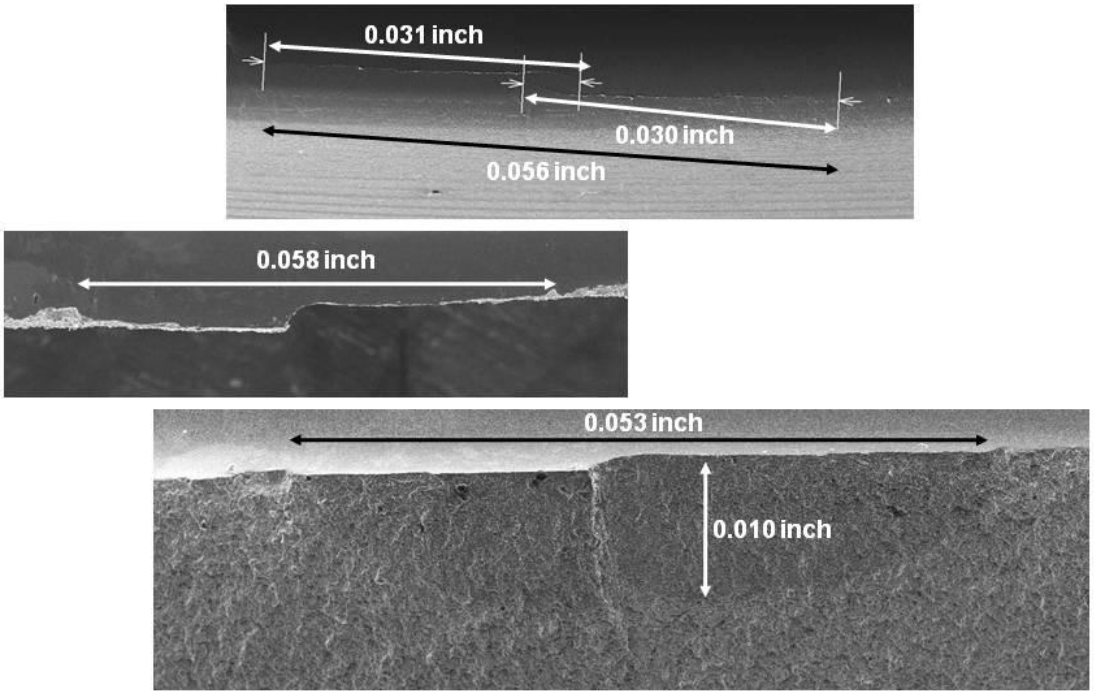
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

174


Poppet #39
Location of Crack #3
Reference Mark
210°
Crack
Shaft
Crack Tips
Radius
Flange
2 mm
0.031 inch
0.030 inch
0.056 inch
S3700 20.0kV 13.1mm x75 SE 6/11/2009 09:18
500um
175

Poppet #39

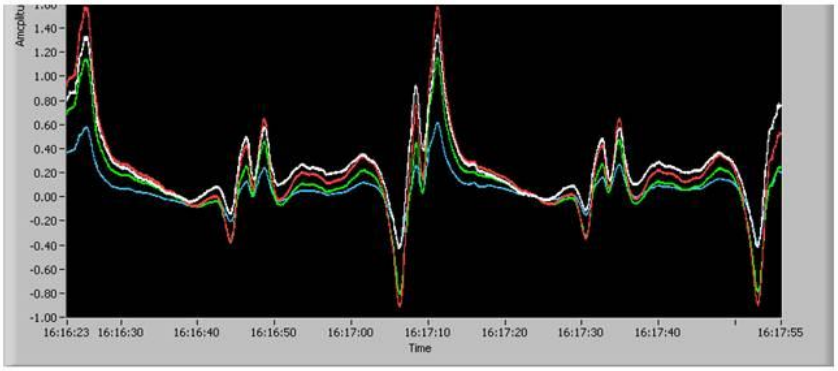
Crack depth and correlation with surface measurements for Crack #3



176

Poppet #39

LaRC eddy current findings, the colors indicate ???



177

Poppet #40

Surface crack sizes and locations

Poppet #40		
Crack Number	Size (inch)	Angle (degrees)
1	0.010	240

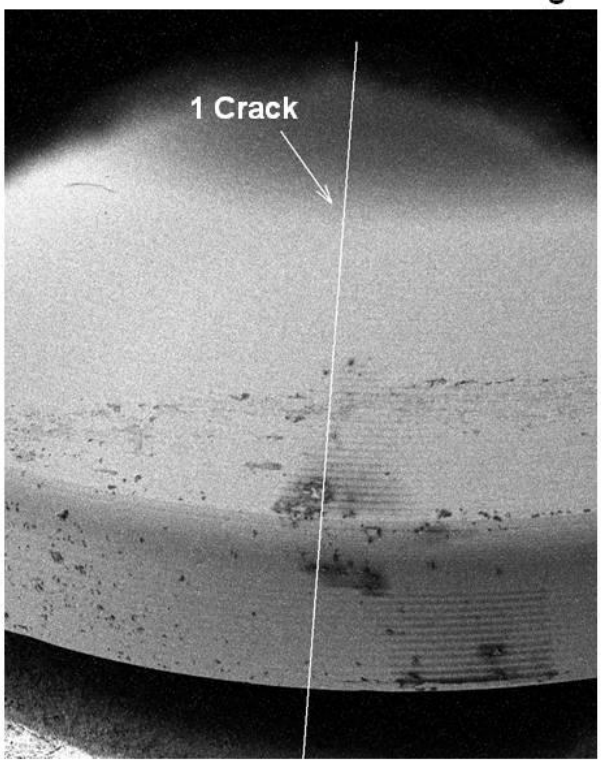
Boeing Eddy Current Findings

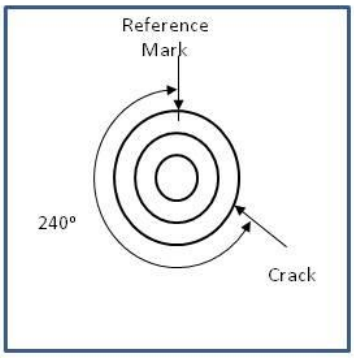
Poppet #40									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.082	0.077	0.079	0.081	0.078	0.081	0.080	Yes	230 (Small indication opposite)
B. Devries	0.772	0.772	0.769	0.791	0.820	0.818	0.790	False	135
B. Devries	-	-	-	-	-	-	-	No	240

178

Poppet #40

Location of Region A

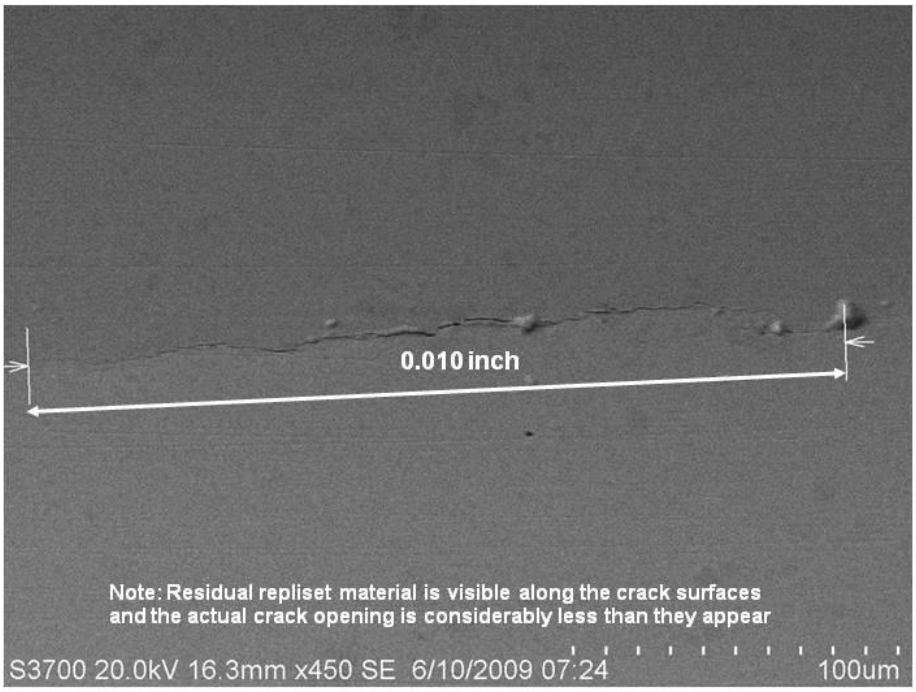




179

Poppet #40

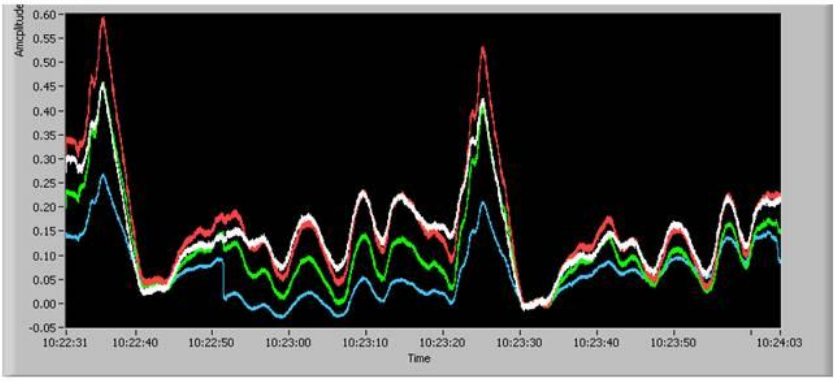
Size of Crack #1



180

Poppet #40

LaRC eddy current findings, the colors indicate ???



181

Poppet #41

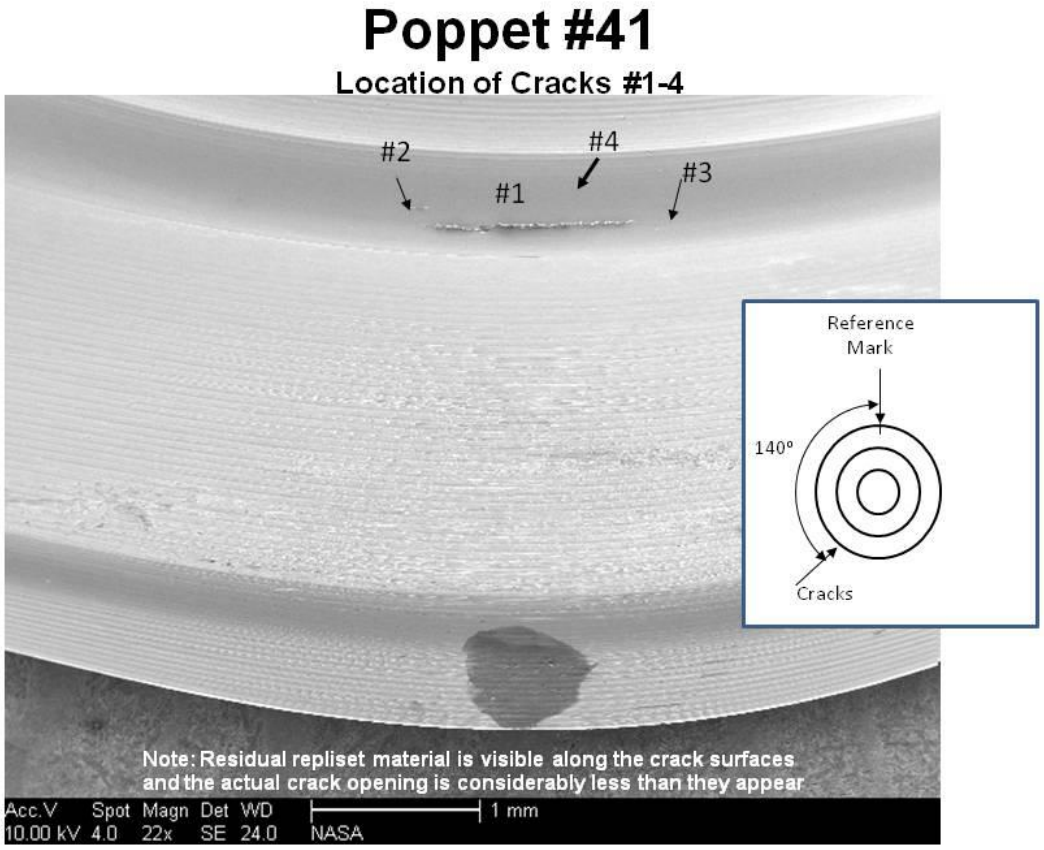
Surface crack sizes and locations

Poppet #41		
Crack Number	Size (inch)	Angle (degrees)
1	0.050	140
2	0.010	140
3	0.001	140
4	0.002	140
5	0.002	320

Boeing Eddy Current Findings

Poppet #41									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.767	0.791	0.808	0.812	0.805	0.828	0.802	Yes	130
J. Engel	-	-	-	-	-	-	-	No	320
B. Devries	-	-	-	-	-	-	-	No	320
B. Devries	0.820	0.824	0.819	0.824	0.819	0.817	0.821	Yes	130

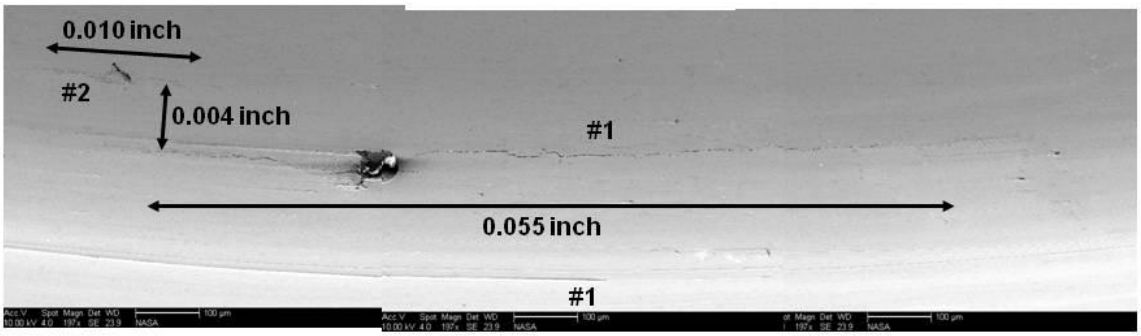
182


Poppet #41
Location of Cracks #1-4
#2
#1
#4
#3
Reference Mark
140°
Cracks
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
Acc.V Spot Magn Det WD
10.00 kV 4.0 22x SE 24.0
1 mm
NASA

183

Poppet #41

Location and size of Cracks #1 and 2

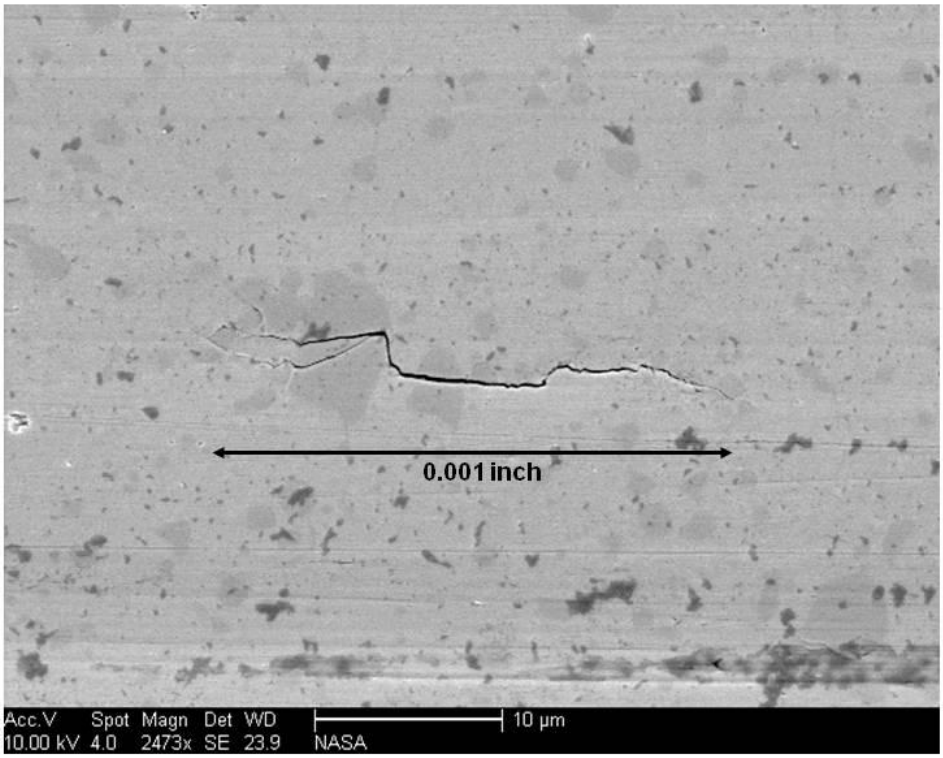


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

184

Poppet #41

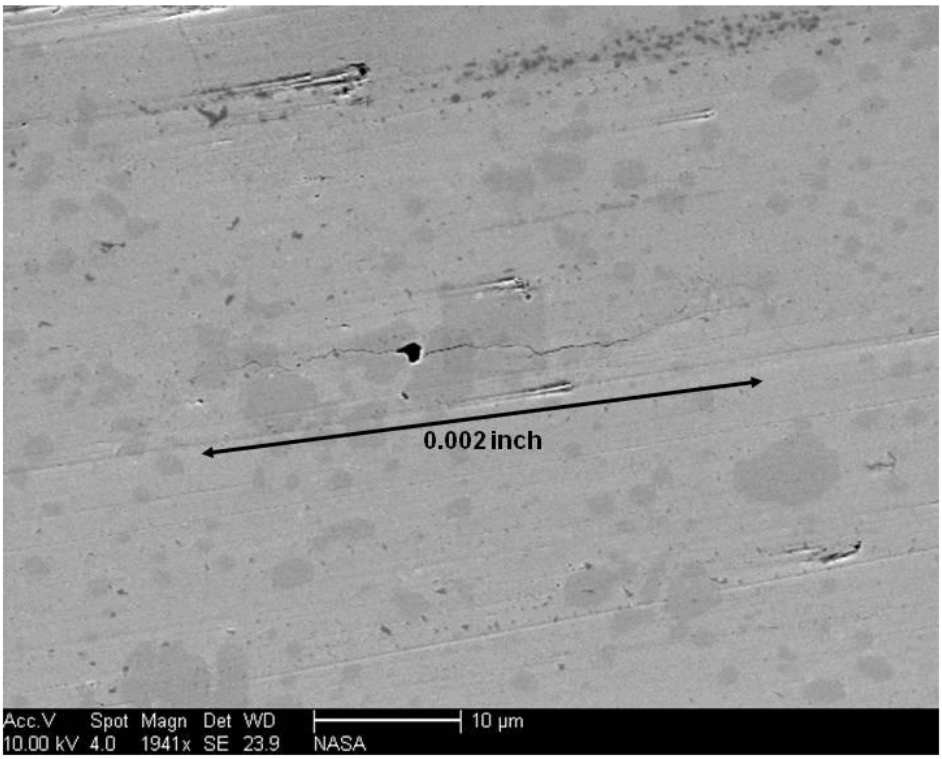
Size of Crack #3



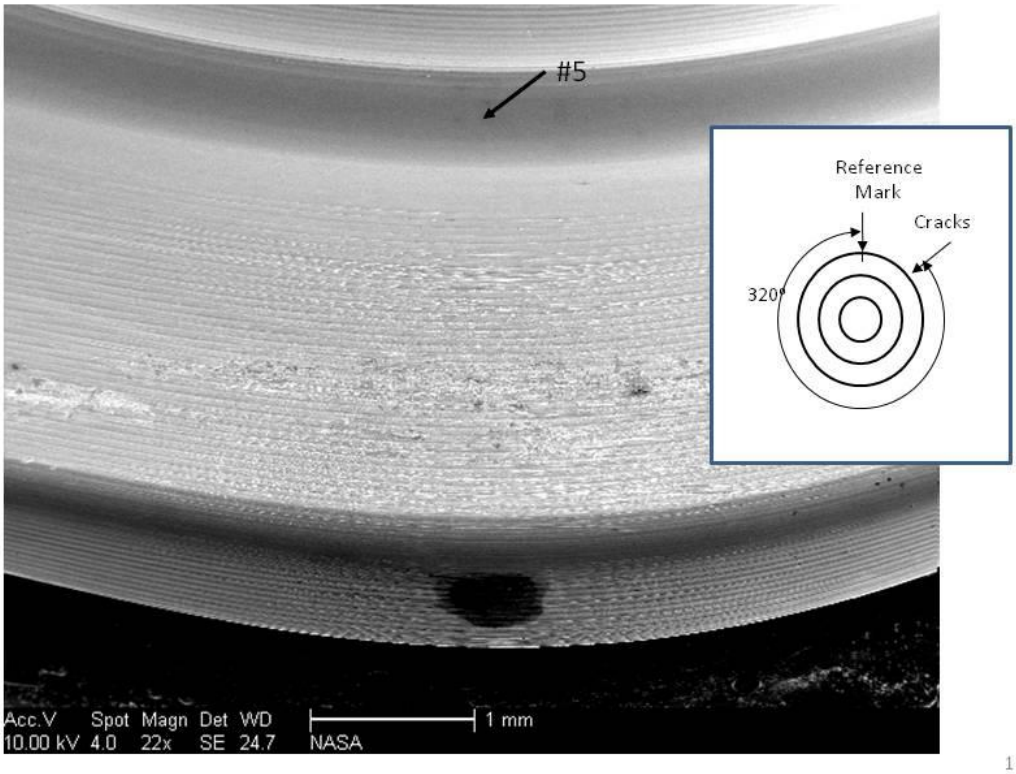
185

Poppet #41

Size of Crack #4

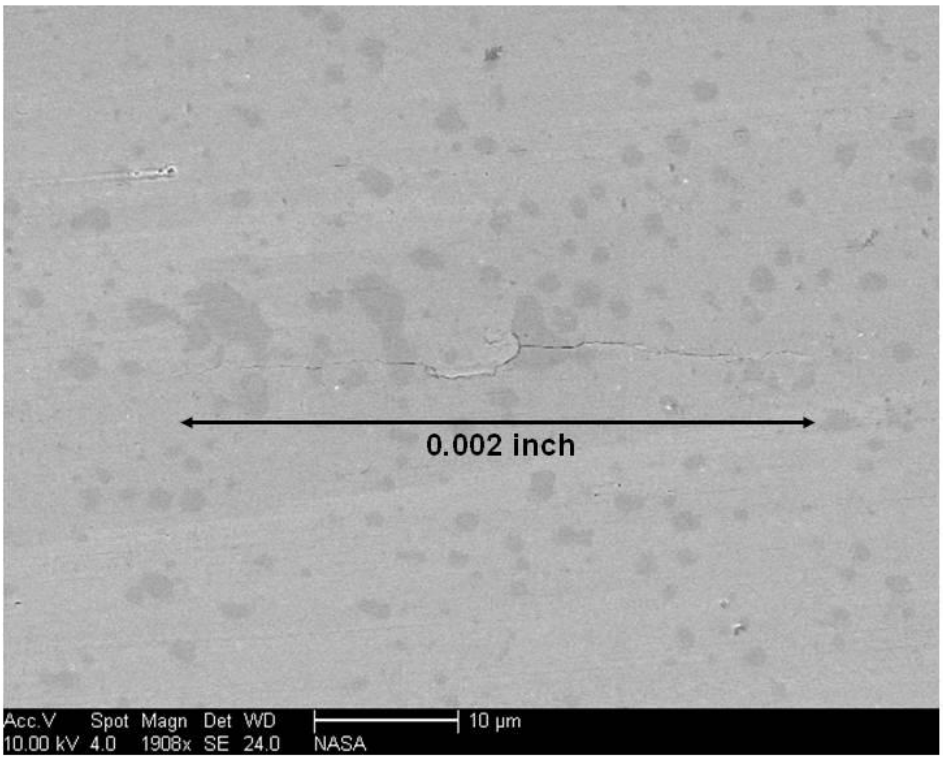


186


Poppet #41
Location of Crack #5
#5
Reference Mark
Cracks
320°
Acc.V Spot Magn Det WD
10.00 kV 4.0 22x SE 24.7
1 mm
NASA
187

Poppet #41

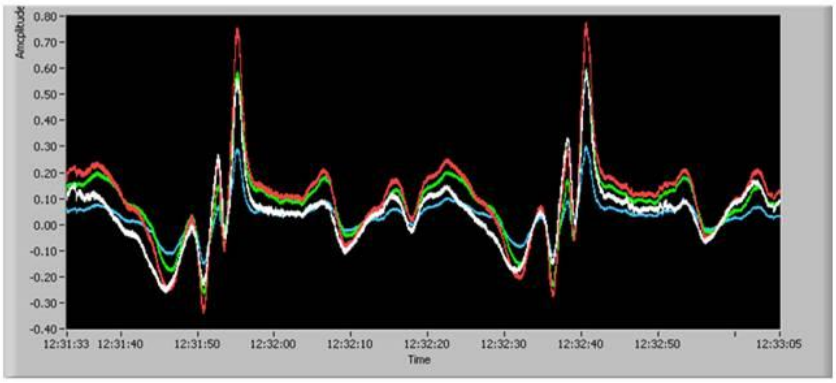
Size of Crack #5



188

Poppet #41

LaRC eddy current findings, the colors indicate ???



189

Poppet #42

Surface crack sizes and locations

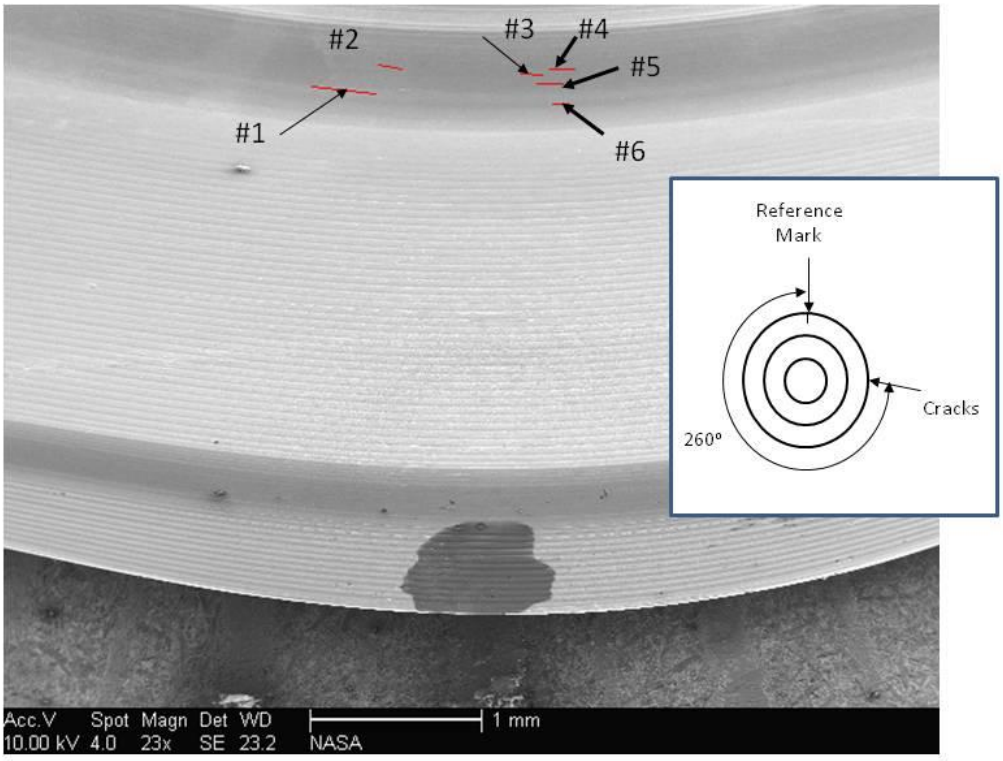
Poppet #42		
Crack Number	Size (inch)	Angle (degrees)
1	0.025	260
2	0.002	260
3	0.004	260
4	0.002	260
5	0.004	260
6	0.004	260

Boeing Eddy Current Findings

Poppet #42									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.242	0.243	0.243	0.240	0.243	0.246	0.243	Crack	60
J. Engel	0.043	0.040	0.042	0.041	0.040	0.040	0.041	False	280 (Not 3:1 S/N ratio)
B. Devries	0.253	0.268	0.263	0.259	0.264	0.281	0.265	Crack	75

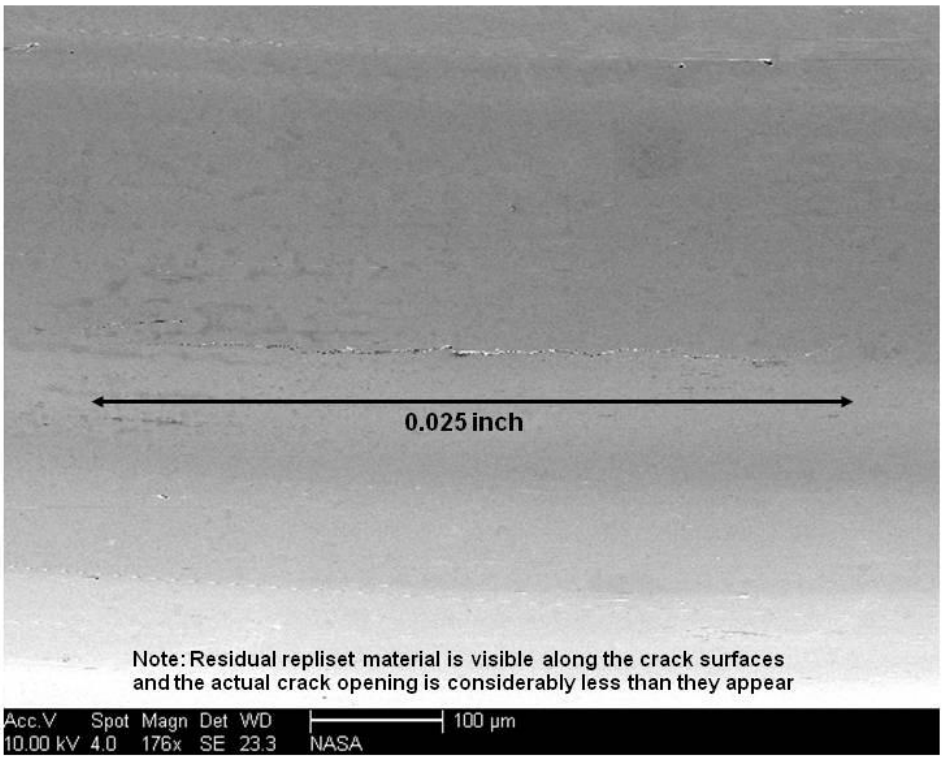
Note: The reference mark was very faint and a machining mark may have been mistaken for the reference mark

190


Poppet #42
Location of Cracks #1-6
#1
#2
#3
#4
#5
#6
Reference Mark
Cracks
260°
Acc.V Spot Magn Det WD
10.00 kV 4.0 23x SE 23.2
1 mm
NASA
191

Poppet #42

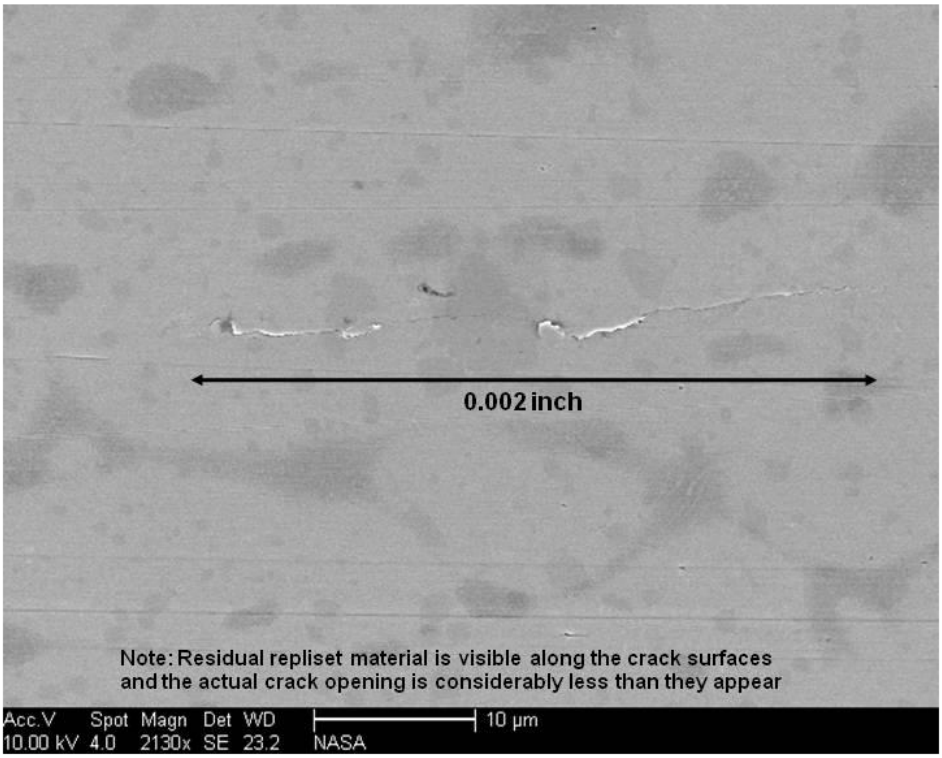
Size of Crack #1



192

Poppet #42

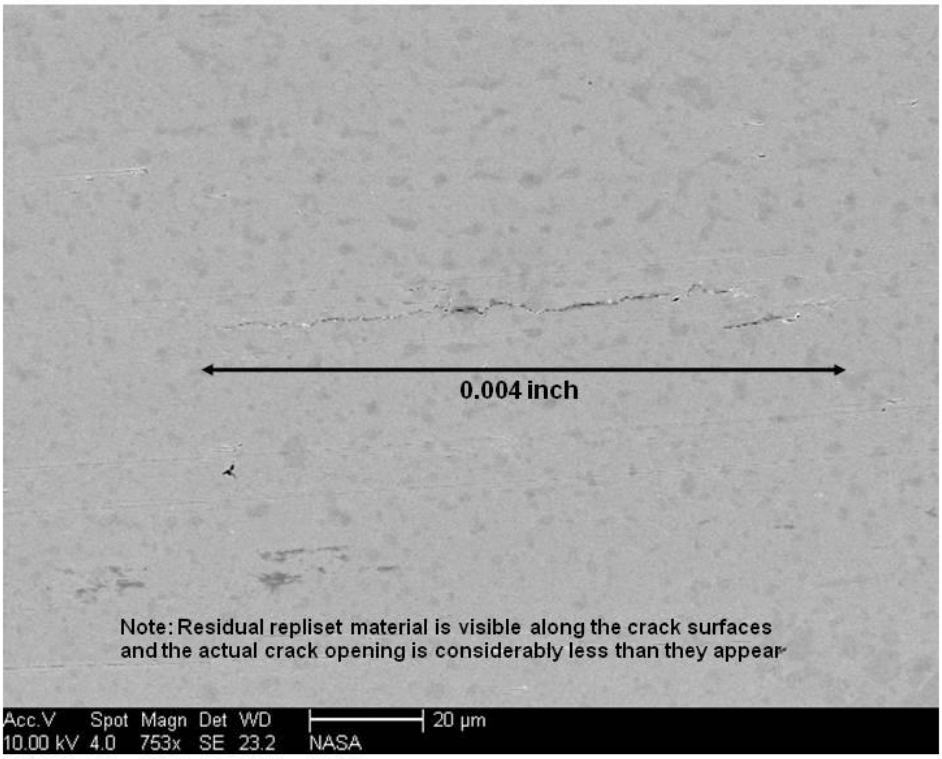
Size of Crack #2



193

Poppet #42

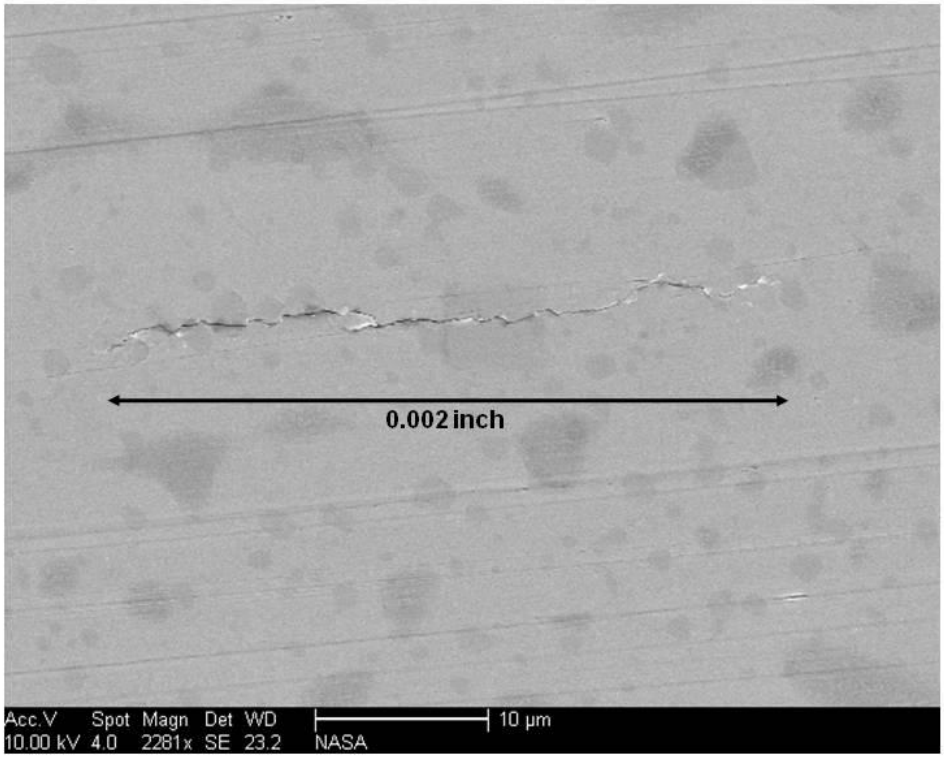
Size of Crack #3



194

Poppet #42

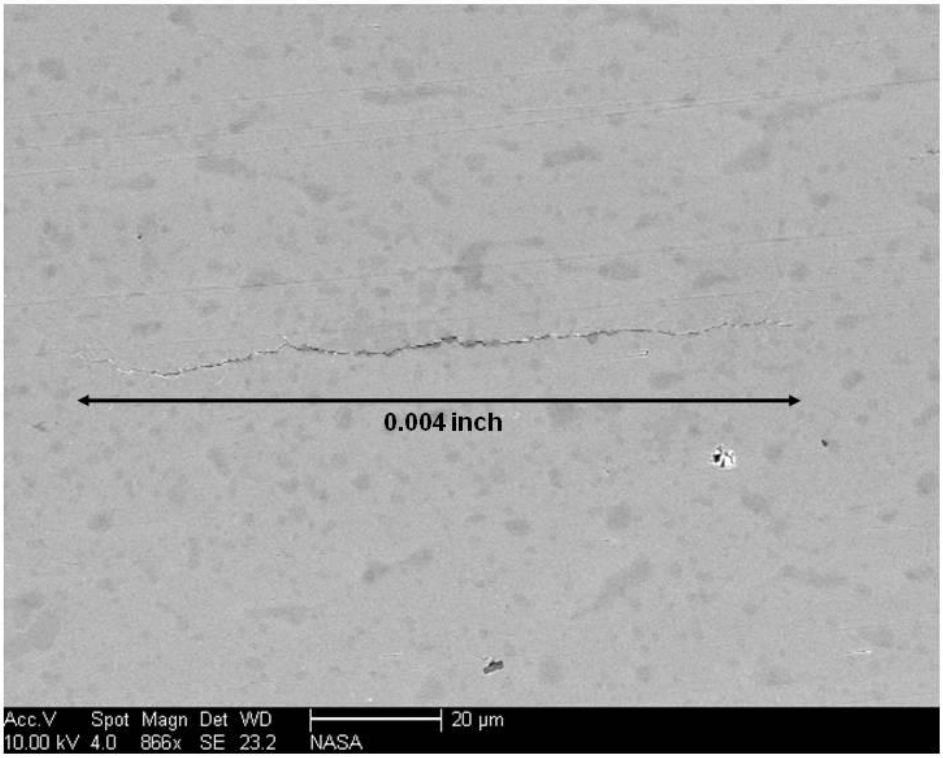
Size of Crack #4



195

Poppet #42

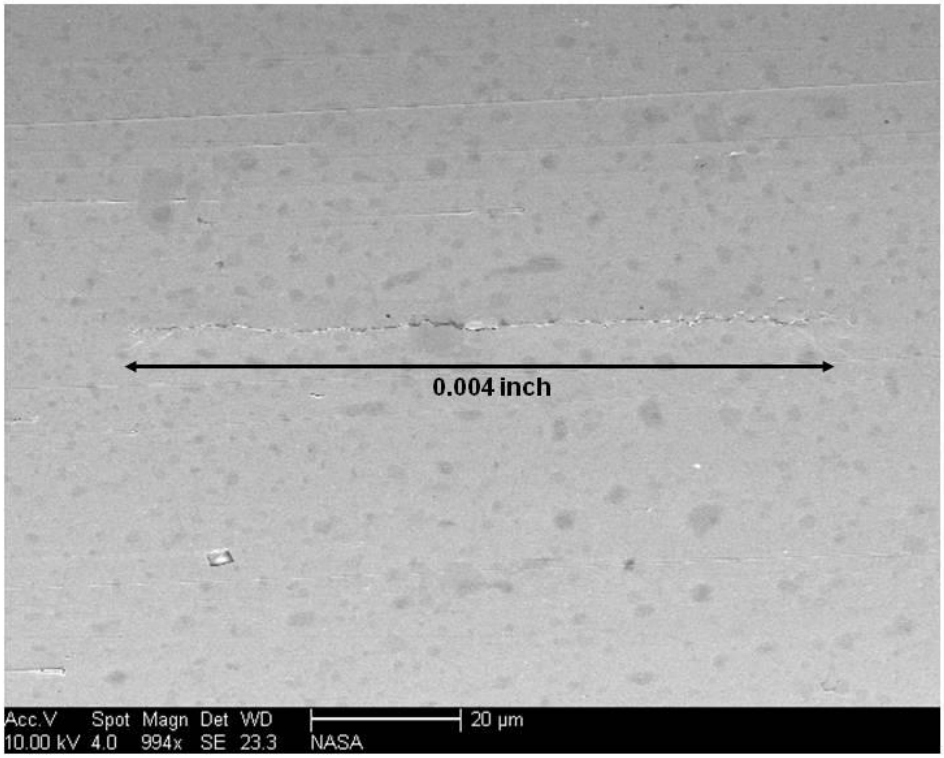
Size of Crack #5



196

Poppet #42

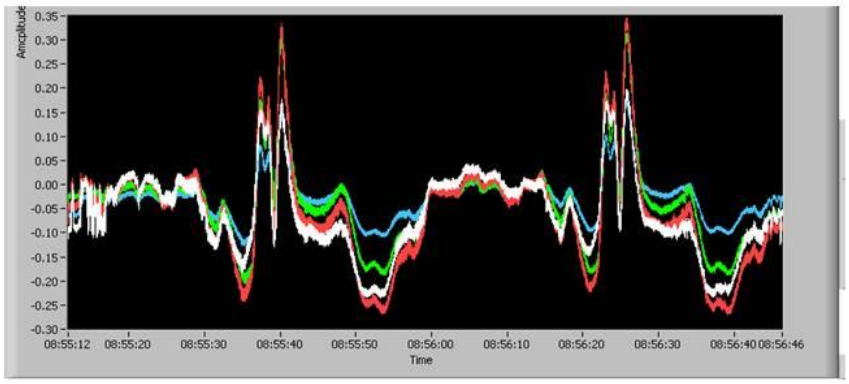
Size of Crack #6



197

Poppet #42

LaRC eddy current findings, the colors indicate ???



198

Poppet #43

Surface crack sizes and locations

Poppet #43						
Crack Number	Size (inch)	Angle (degrees)		Crack Number	Size (inch)	Angle (degrees)
1	0.001	115		16	0.002	115
2	0.005	115		17	0.006	115
3	0.002	115		18	0.005	115
4	0.004	115		19	0.004	115
5	0.003	115		20	0.005	115
6	0.002	115		21	0.002	295
7	0.002	115		22	0.001	295
8	0.002	115		23	0.002	295
9	0.002	115		24	0.001	295
10	0.003	115		25	0.002	295
11	0.001	115		26	0.001	295
12	0.004	115		27	0.002	295
13	0.012	115				
14	0.004	115				
15	0.001	115				

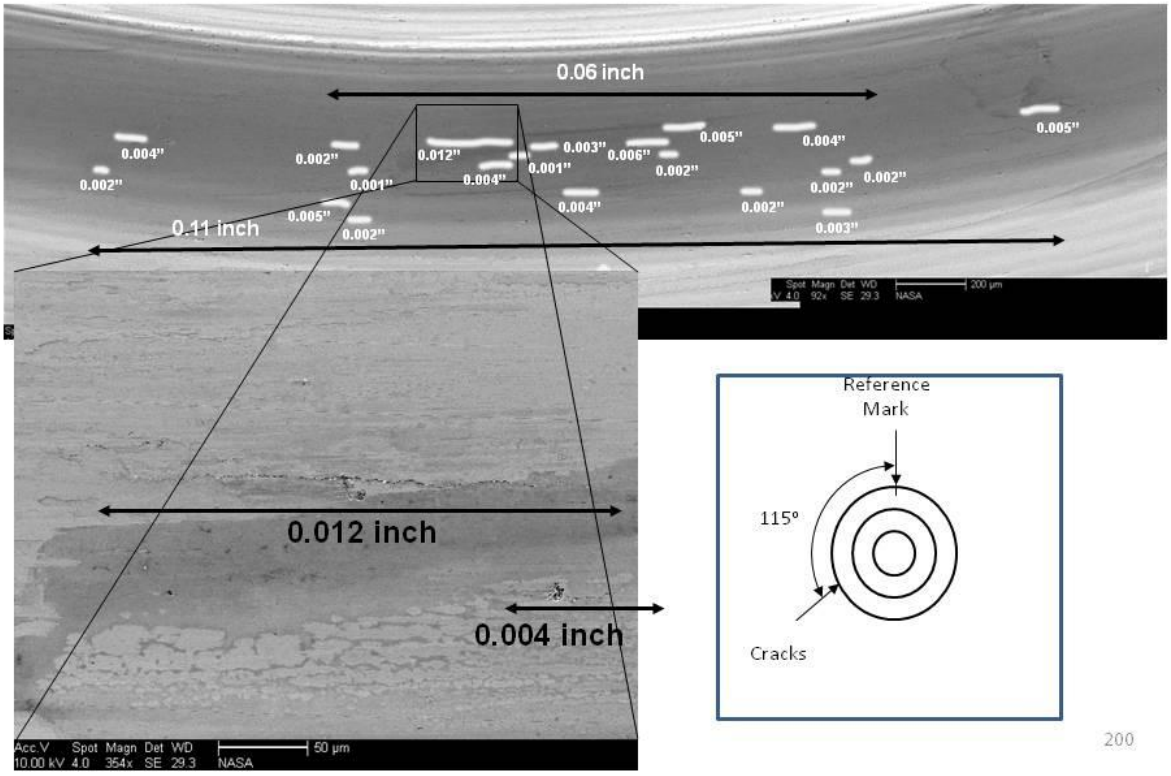
Boeing Eddy Current Findings

Poppet #43									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.152	0.147	0.144	0.143	0.148	0.145	0.147	Yes	355?
J. Engel	-	-	-	-	-	-	-	No	295
J. Engel	0.047	0.045	0.040	0.041	0.045	0.043	0.044	Yes	115
B. Devries	0.146	0.150	0.148	0.144	0.151	0.151	0.148	Yes	115
B. Devries	-	-	-	-	-	-	-	No	295

199

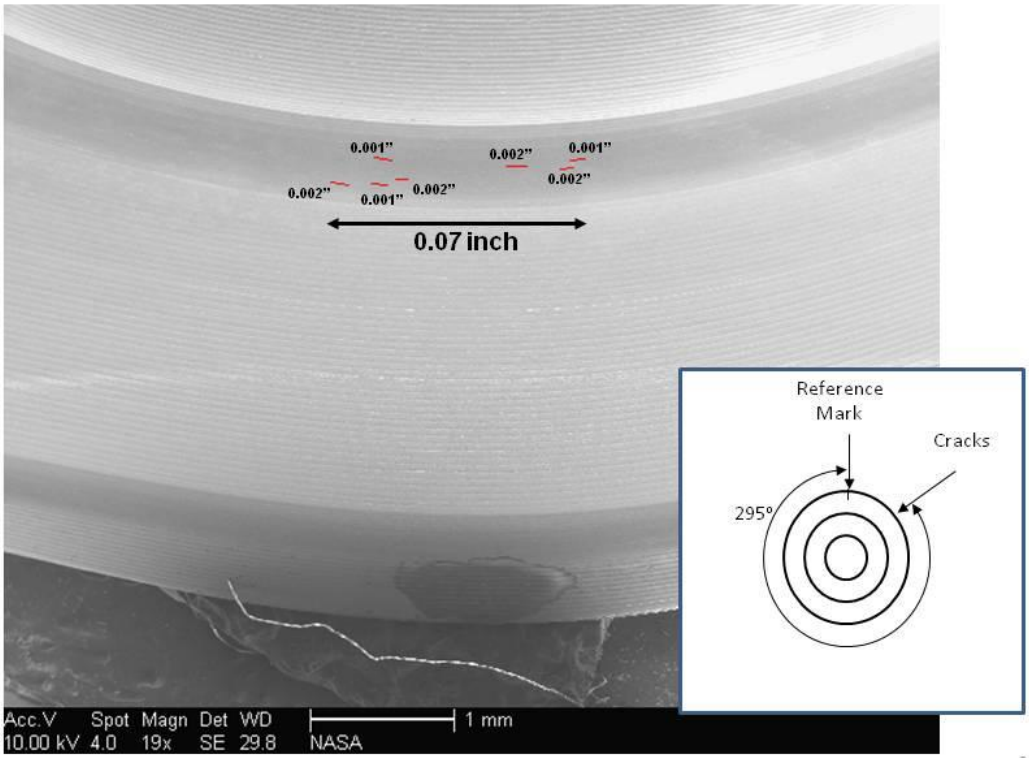
Poppet #43

Location and size of Cracks #1-20



Poppet #43

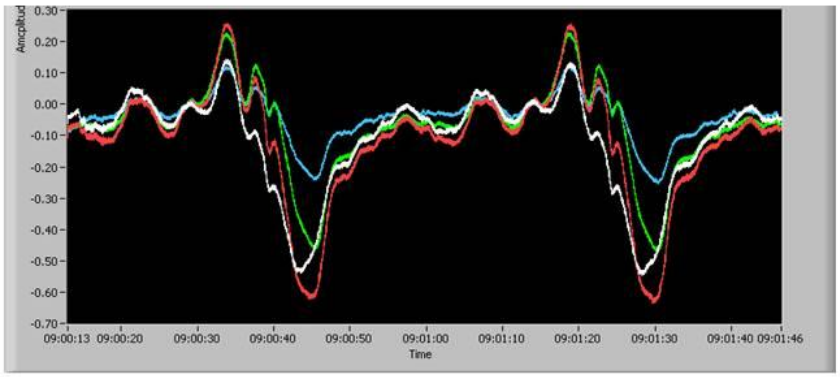
Location of Cracks #22-29



201

Poppet #43

LaRC eddy current findings, the colors indicate ???



202

Poppet #44

Surface crack sizes and locations

Poppet #44		
Crack Number	Size (inch)	Angle (degrees)
1	0.029	80
2	0.008	80
3	0.002	80
4	0.002	80
5	0.009	80
6	0.002	80
7	0.007	80
8	0.004	80
9	0.004	80
10	0.002	80
11	0.008	80
12	0.004	80
13	0.006	260
14	0.004	260
15	0.003	260

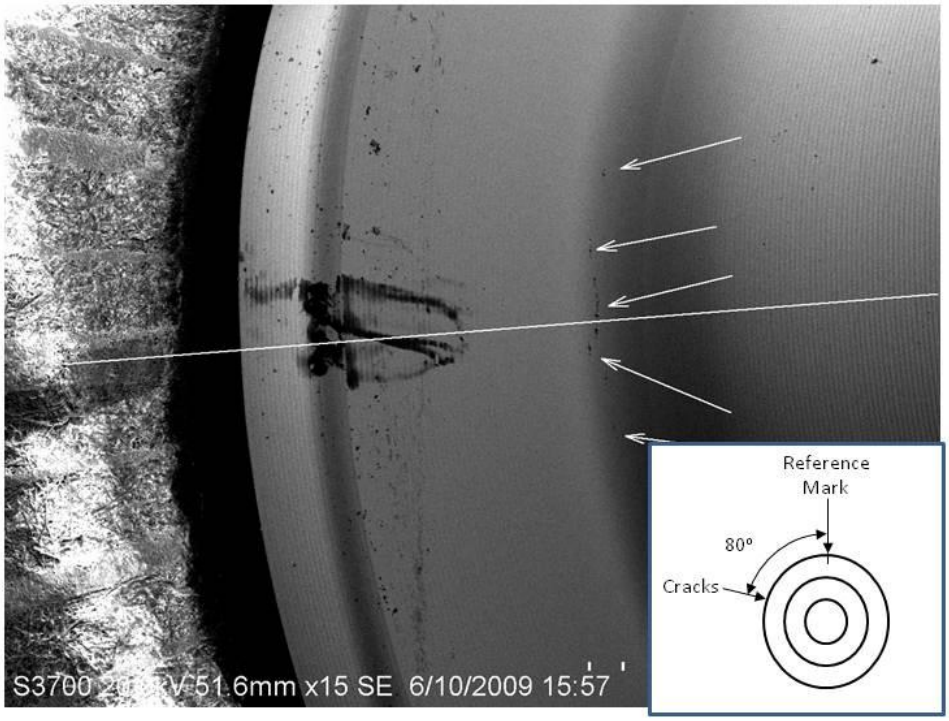
Boeing Eddy Current Findings

Poppet #44									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.246	0.253	0.279	0.279	0.281	0.282	0.270	Yes	80
J. Engel	0.040	0.043	0.041	0.045	0.041	0.045	0.043	Yes	260 (Not 3:1 S/N ratio)
B. Devries	-	-	-	-	-	-	-	No	260
B. Devries	0.284	0.277	0.282	0.284	0.251	0.271	0.275	Yes	75

203

Poppet #44

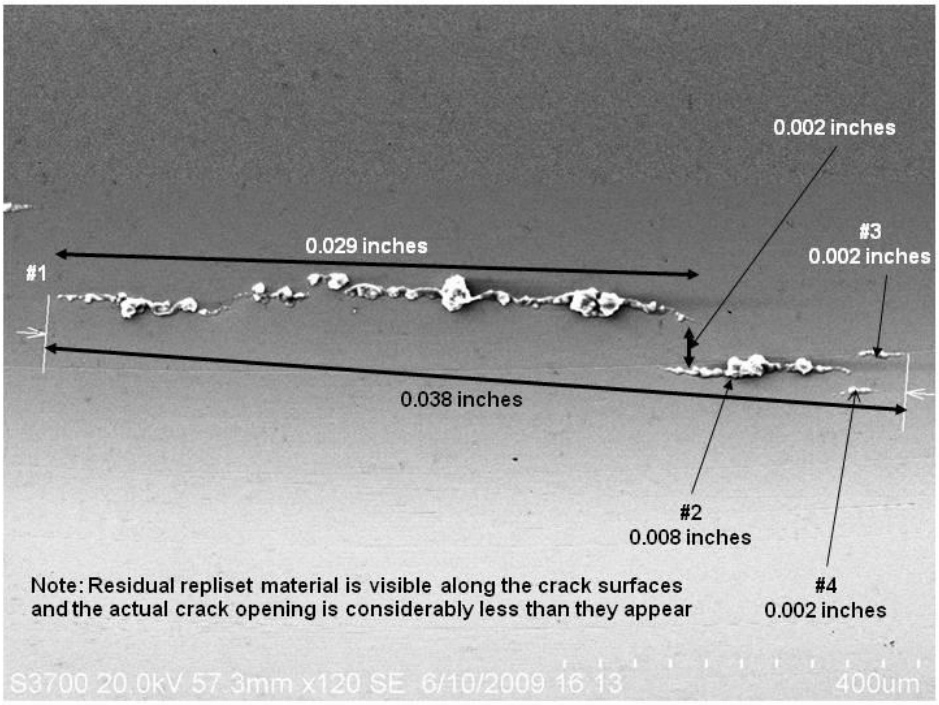
Location of Cracks #1-7



204

Poppet #44

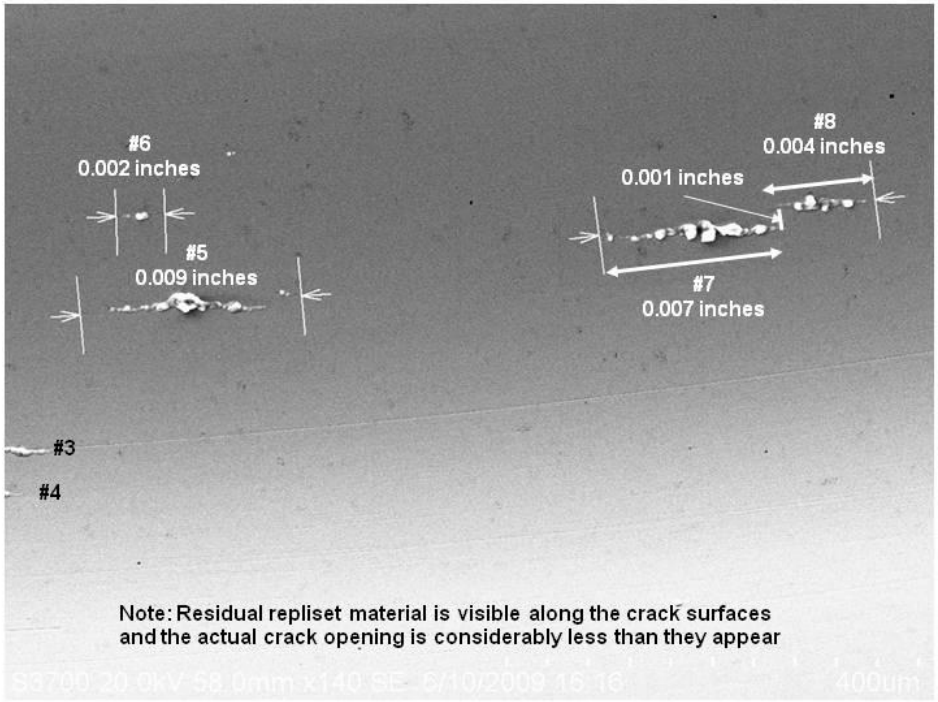
Location and size of Crack #1-4



205

Poppet #44

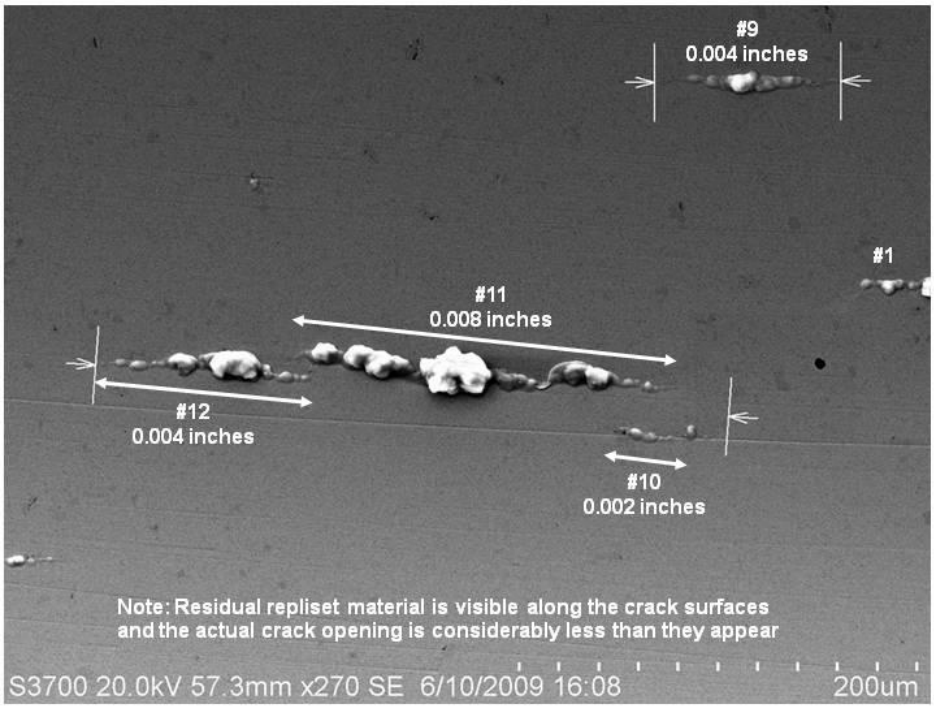
Location and size of Cracks #5-8



206

Poppet #44

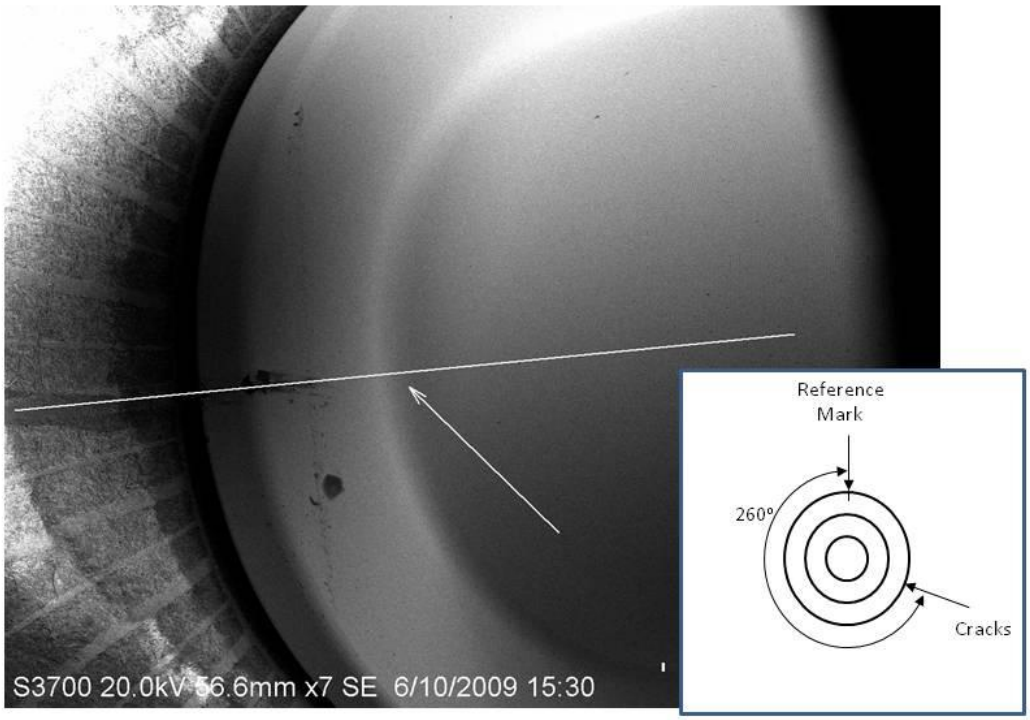
Location and size of Cracks #9-12



207

Poppet #44

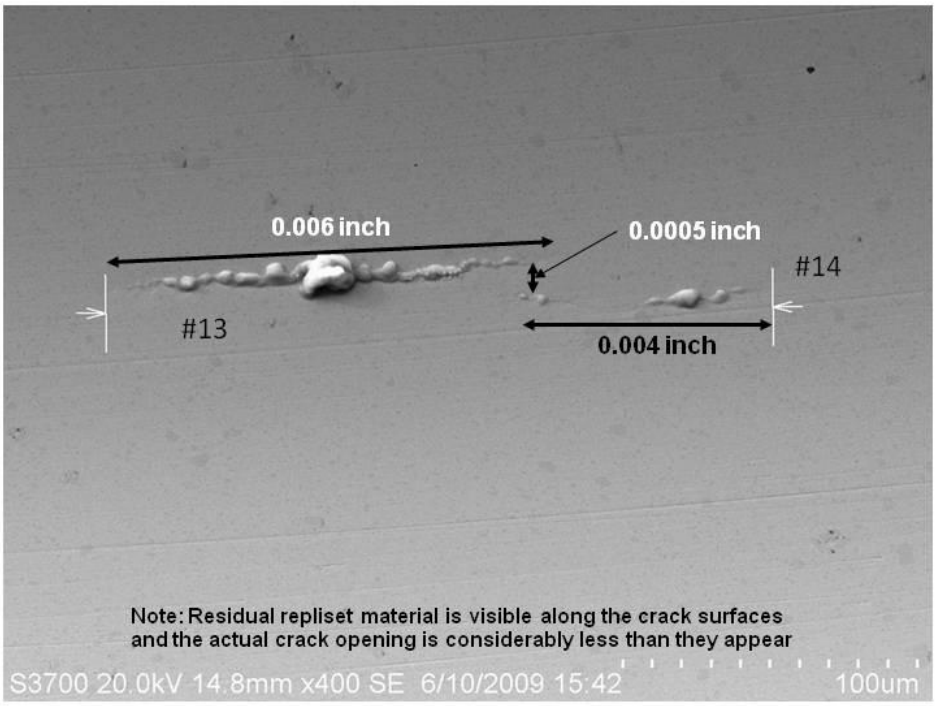
Location of Cracks #13 and 14



208

Poppet #44

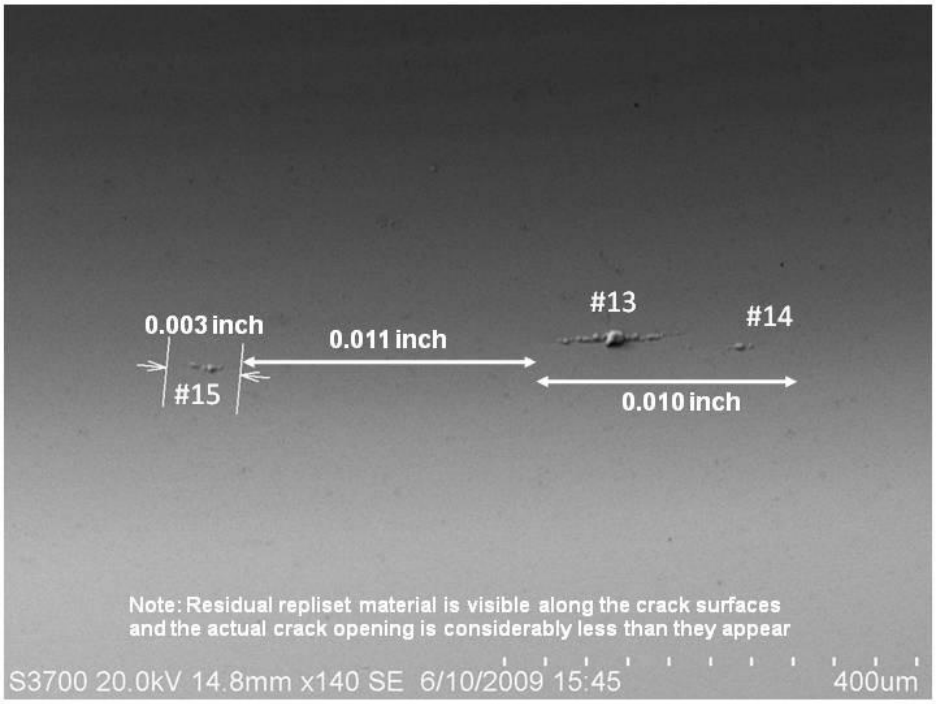
Location and size of Cracks #8 & 9



209

Poppet #44

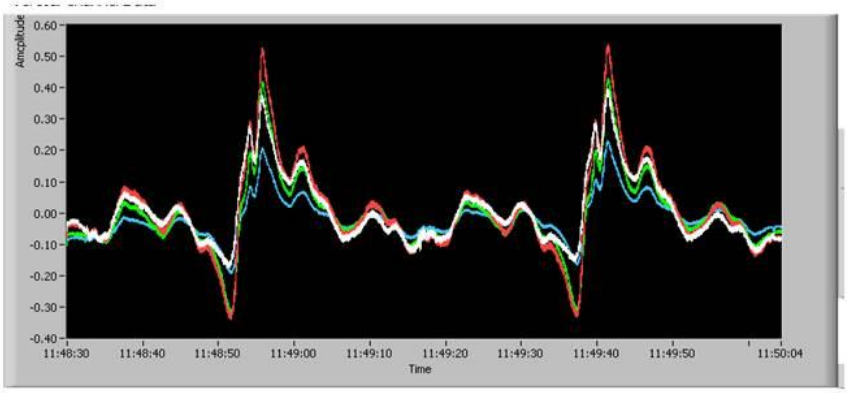
Location and size of Cracks #13-14



210

Poppet #44

LaRC eddy current findings, the colors indicate ???



211

Poppet #45

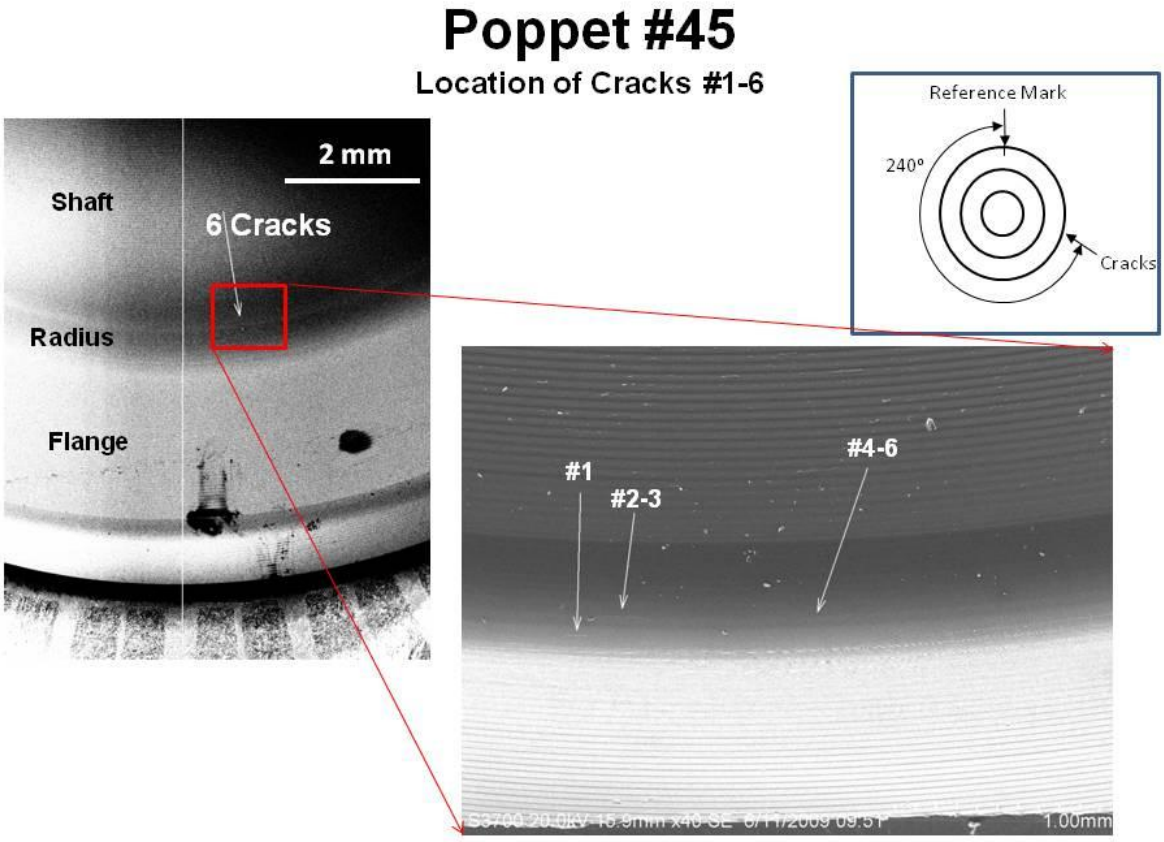
Surface crack sizes and locations

Poppet #45		
Crack Number	Size (inch)	Angle (degrees)
1	0.014	240
2	0.009	240
3	0.006	240
4	0.005	240
5	0.004	240
6	0.002	240
7	0.005	55
8	0.004	55
9	0.009	55
10	0.006	55

Boeing Eddy Current Findings

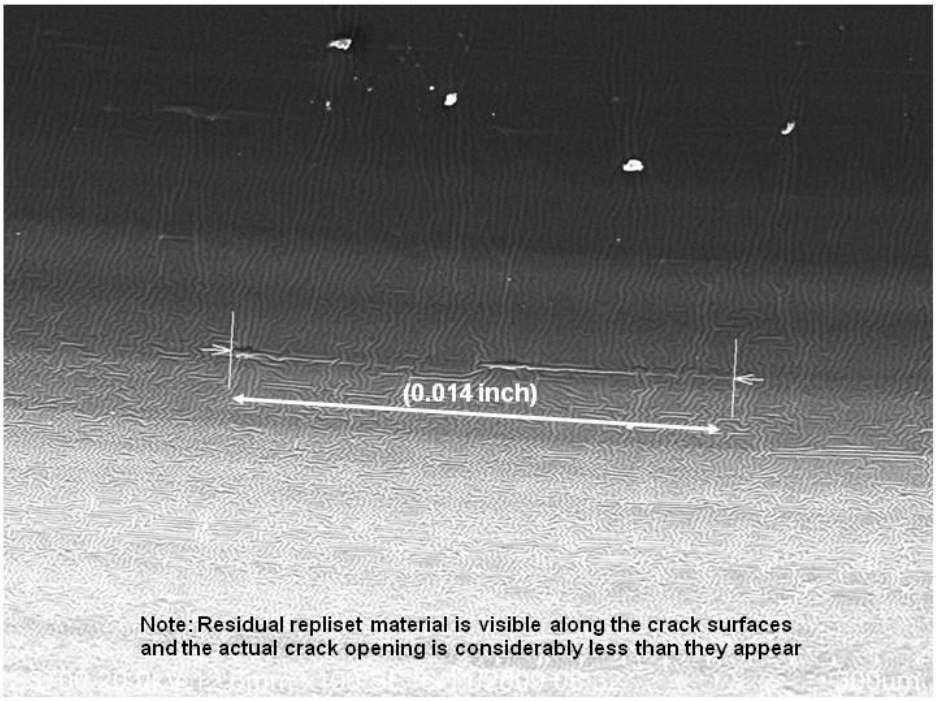
Poppet #45									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.091	0.075	0.075	0.082	0.078	0.078	0.080	Yes	225 (Short indication)
J. Engel	0.078	0.072	0.079	0.078	0.081	0.088	0.079	Yes	60 (Longer indication)
B. Devries	0.068	0.060	0.065	0.069	0.063	0.066	0.065	Yes	240
B. Devries	0.084	0.079	0.086	0.091	0.090	0.095	0.088	Yes	60

212


Poppet #45
Location of Cracks #1-6
Reference Mark
240°
Cracks
2 mm
Shaft
6 Cracks
Radius
Flange
#1
#2-3
#4-6
1.00mm
213

Poppet #45

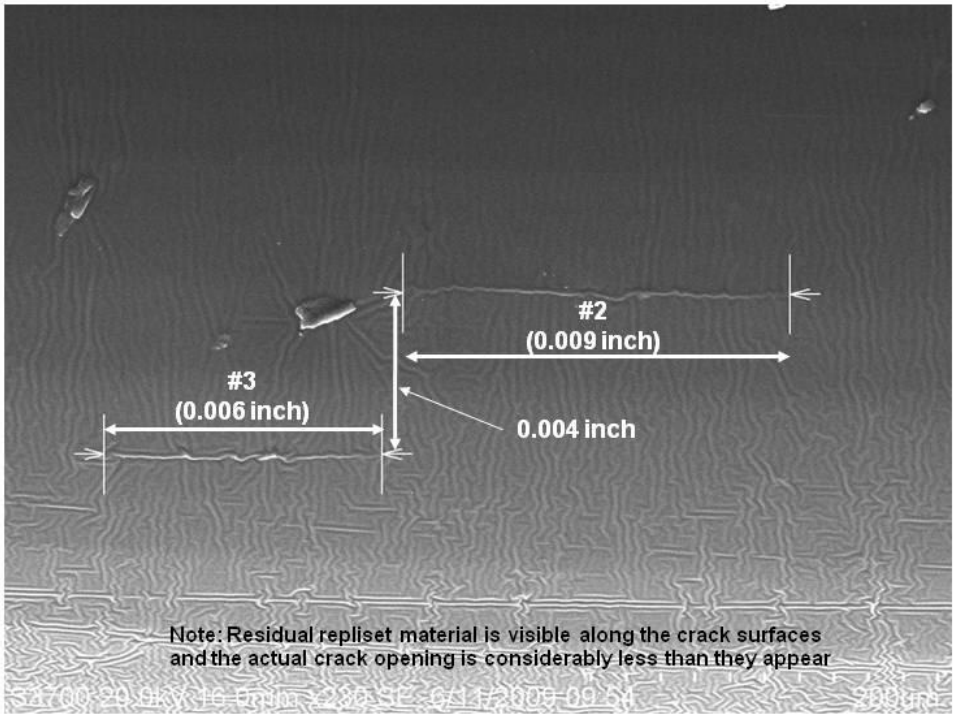
Size of Crack #1



214

Poppet #45

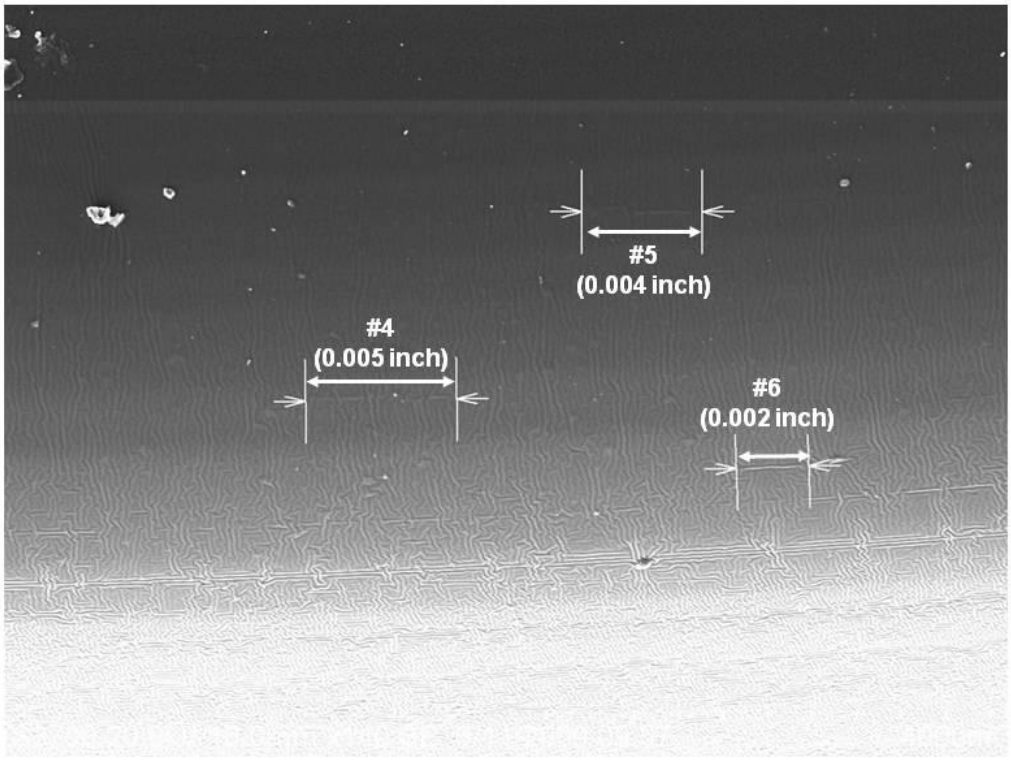
Location and size of Cracks #2-3



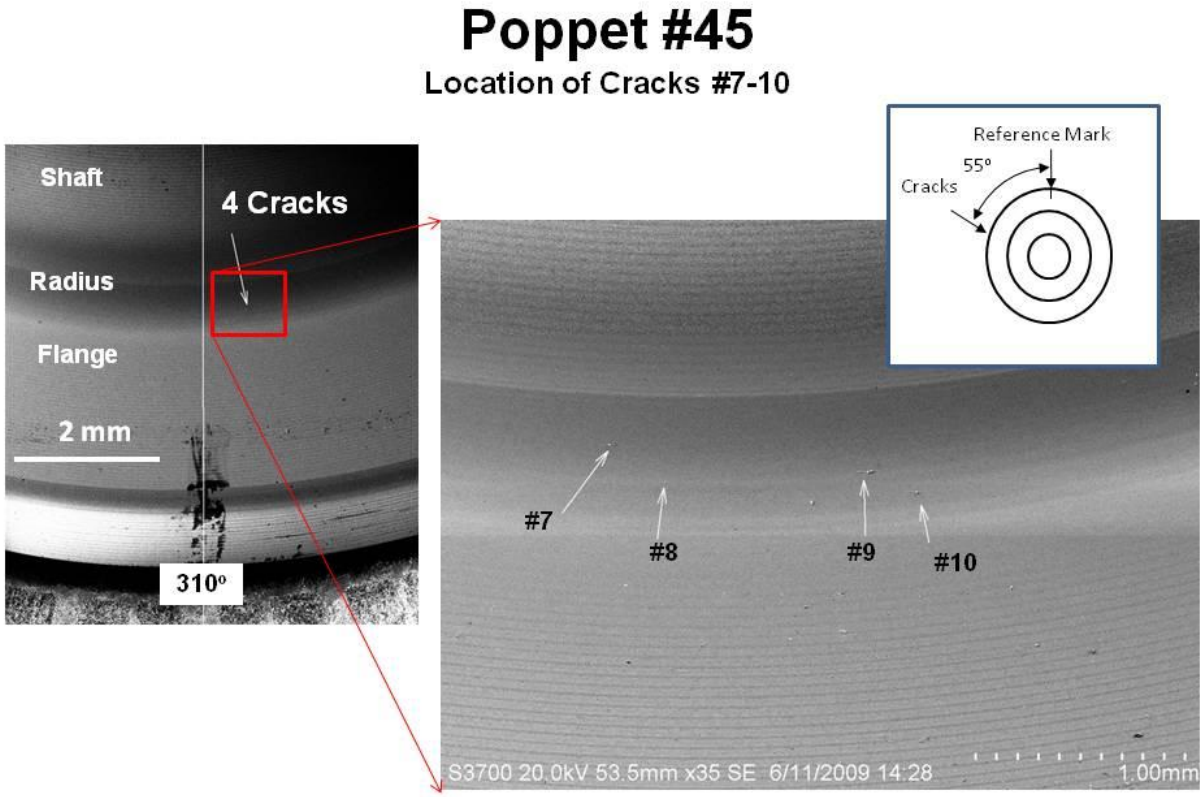
215

Poppet #45

Location and size of Cracks #4-6



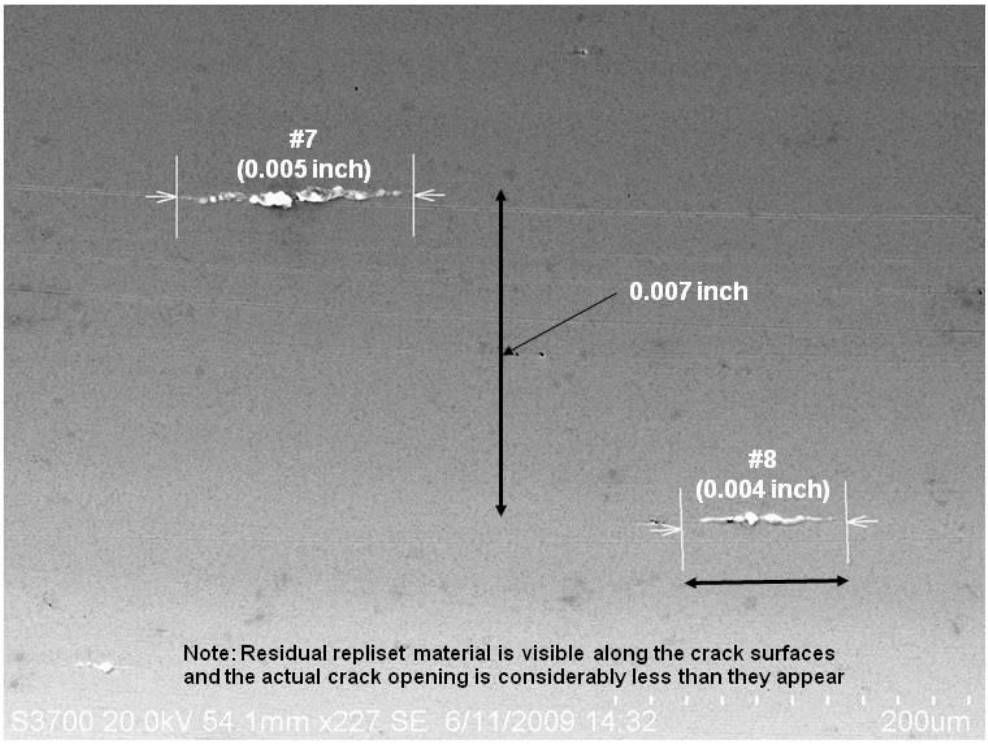
216


Poppet #45
Location of Cracks #7-10
Shaft
4 Cracks
Radius
Flange
2 mm
310°
Reference Mark
55°
Cracks
#7
#8
#9
#10
S3700 20.0kV 53.5mm x35 SE 6/11/2009 14:28
1.00mm

217

Poppet #45

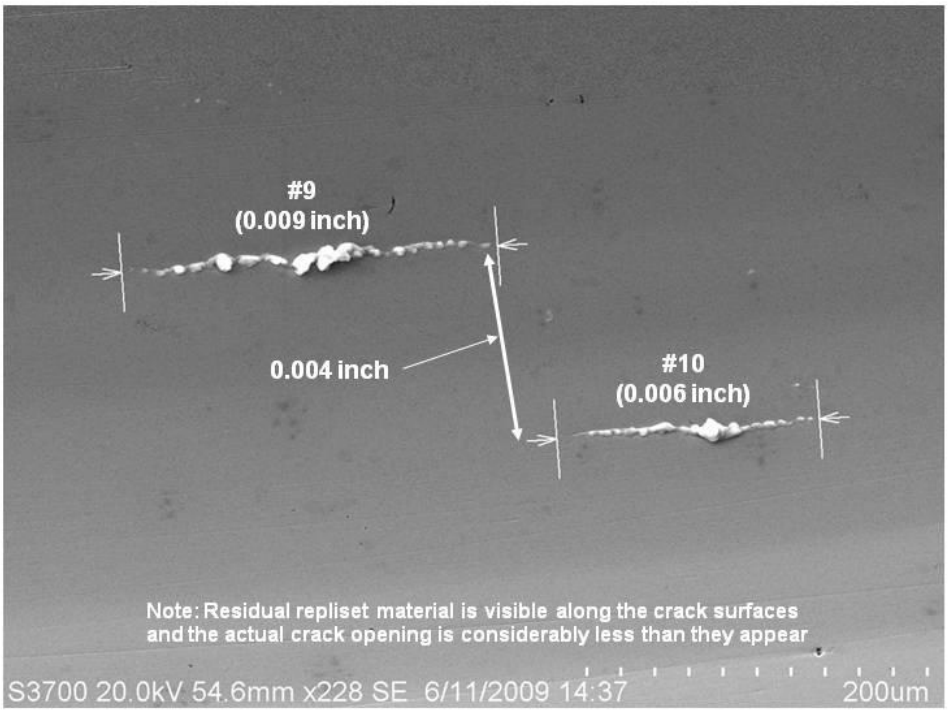
Location and size of Cracks #7 and 8



218

Poppet #45

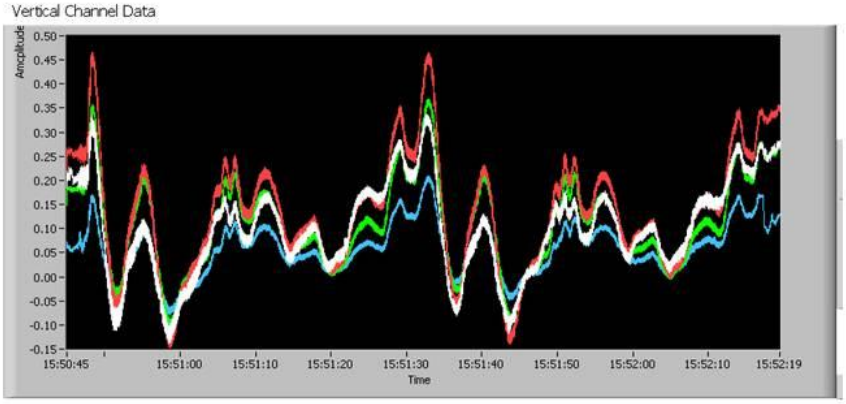
Location and size of Cracks #9 and 10



219

Poppet #45

LaRC eddy current findings, the colors indicate ???



220

Poppet #46

Surface crack sizes and locations

Poppet #46		
Crack Number	Size (inch)	Angle (degrees)
1	0.004	25
2	0.005	25
3	0.003	25
4	0.004	25
5	0.006	25
6	0.005	25
7	0.003	25
8	0.003	25
9	0.004	25
10	0.004	25
11	0.012	230
12	0.007	230
13	0.003	230
14	0.005	230
15	0.004	230
16	0.003	230
17	0.002	220
18	0.002	220

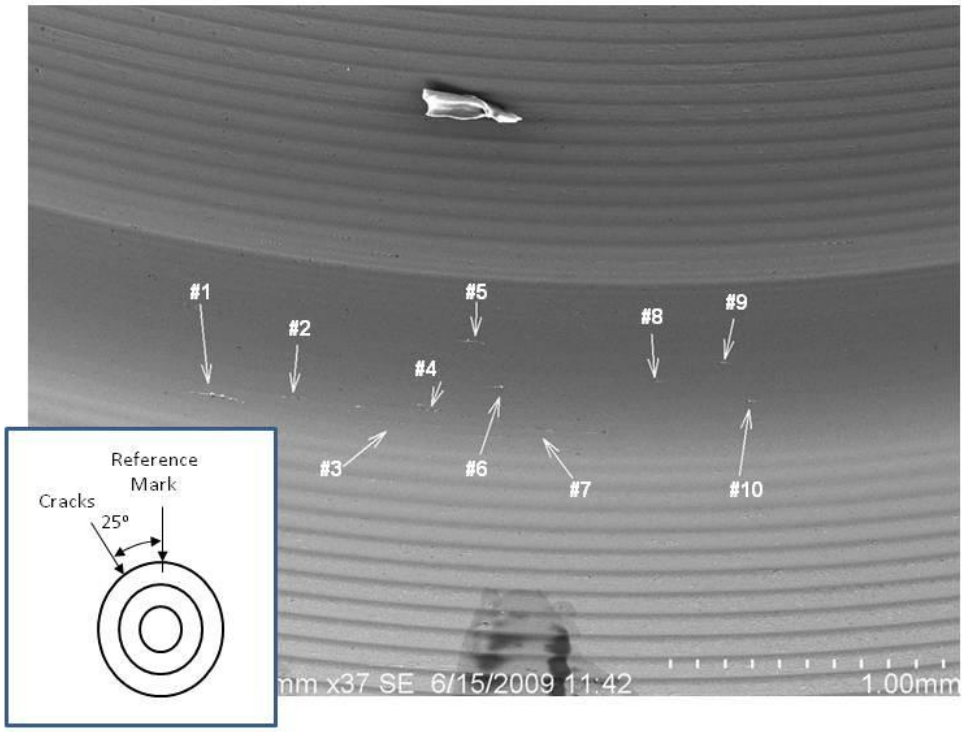
Boeing Eddy Current Findings

Poppet #46									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.098	0.099	0.100	0.093	0.092	0.103	0.098	Yes	195
J. Engel	0.067	0.066	0.073	0.066	0.068	0.073	0.069	Yes	10 (Not 3:1 S/N ratio)
B. Devries	-	-	-	-	-	-	-	No	25
B. Devries	0.103	0.104	0.106	0.102	0.095	0.098	0.101	Yes	200

221

Poppet #46

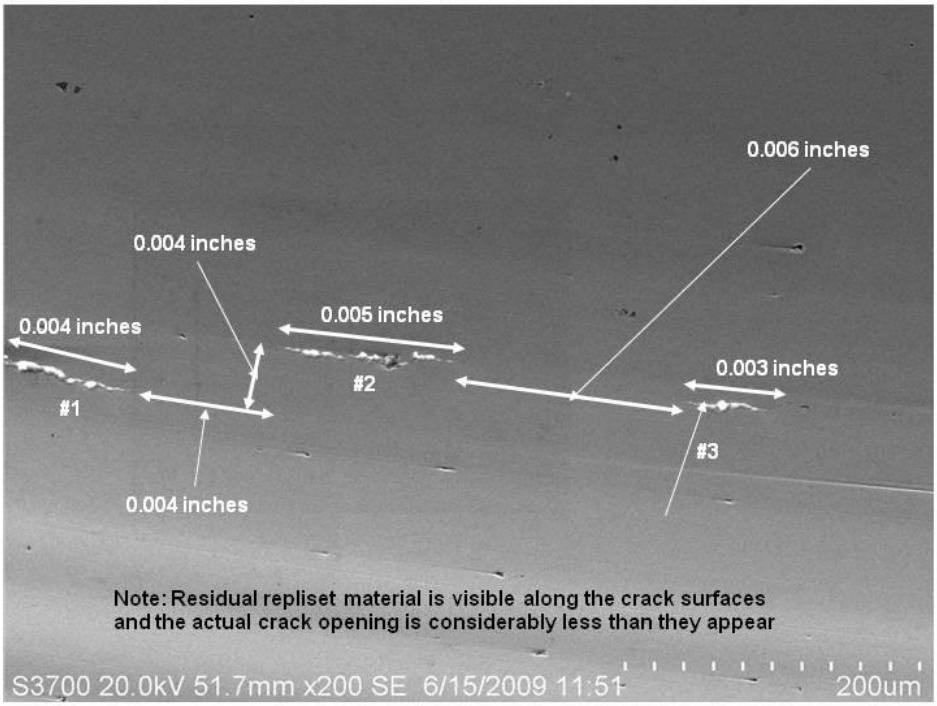
Location of Cracks #1-10



222

Poppet #46

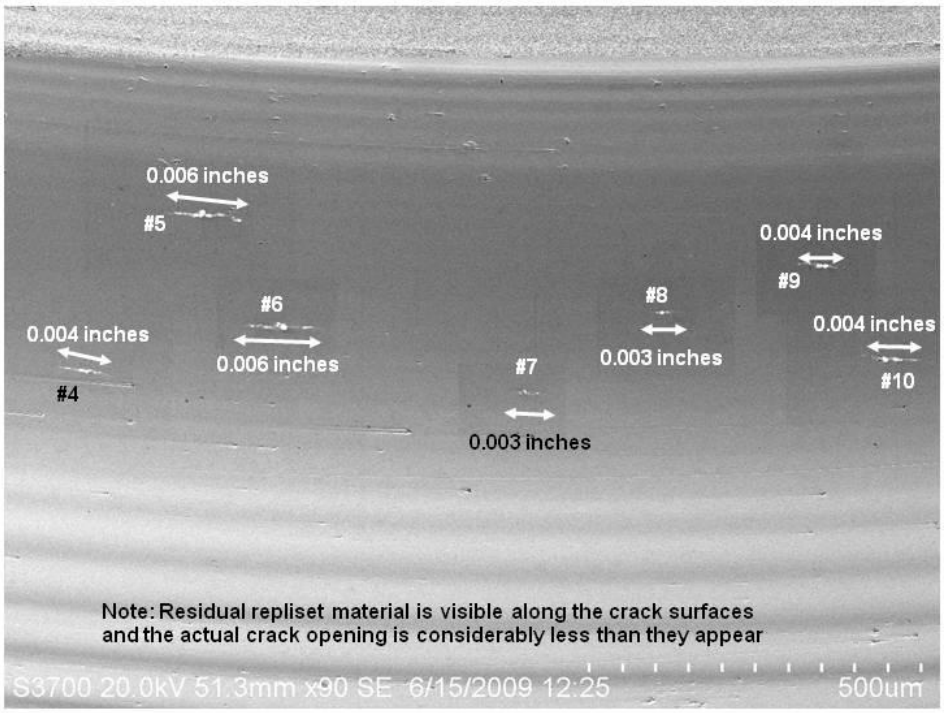
Location and size of Cracks #1-3



223

Poppet #46

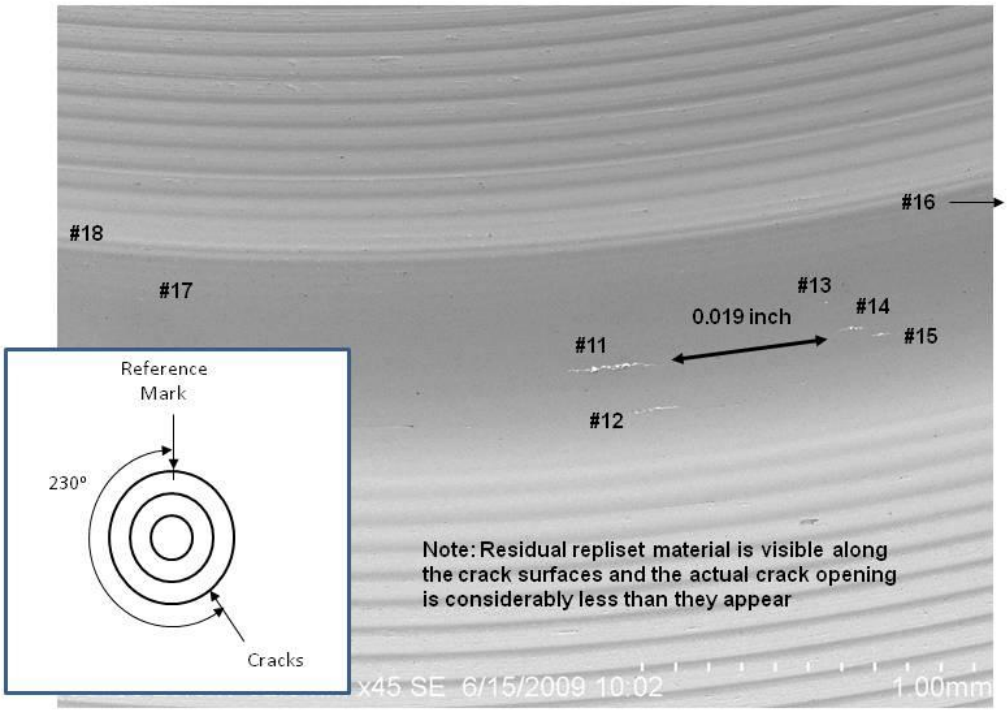
Location and size of Cracks #4-10



224

Poppet #46

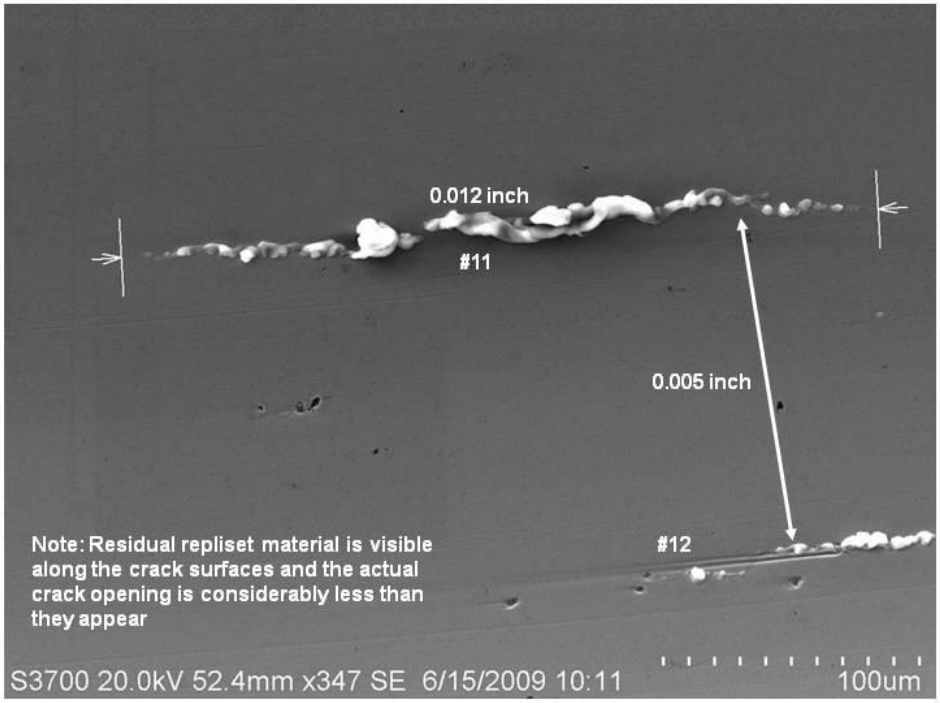
Location of Cracks #11-18



225

Poppet #46

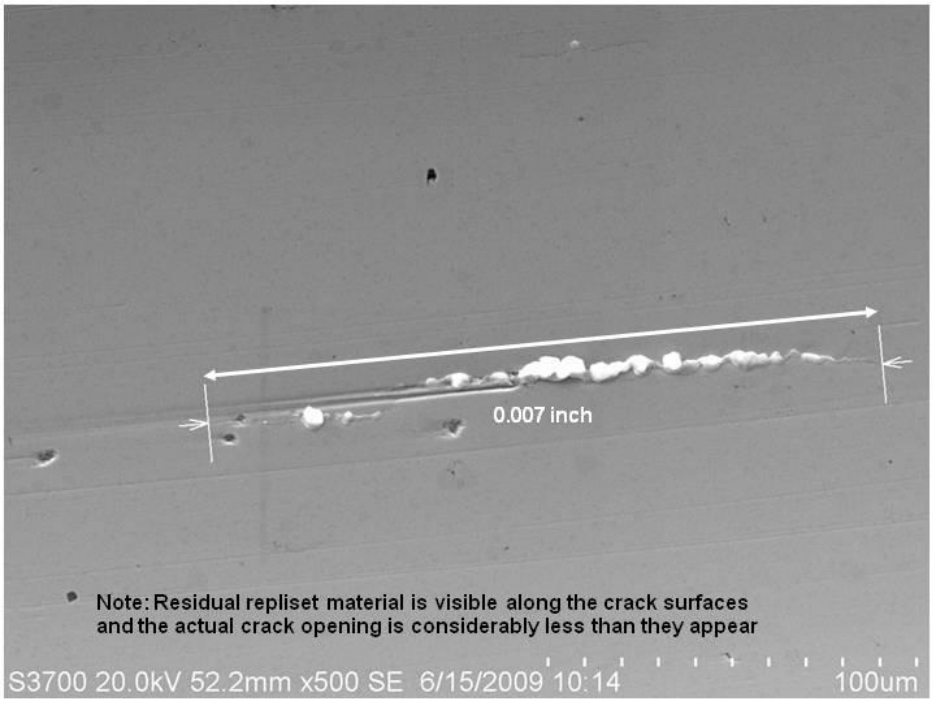
Location and size of Cracks #11 and 12



226

Poppet #46

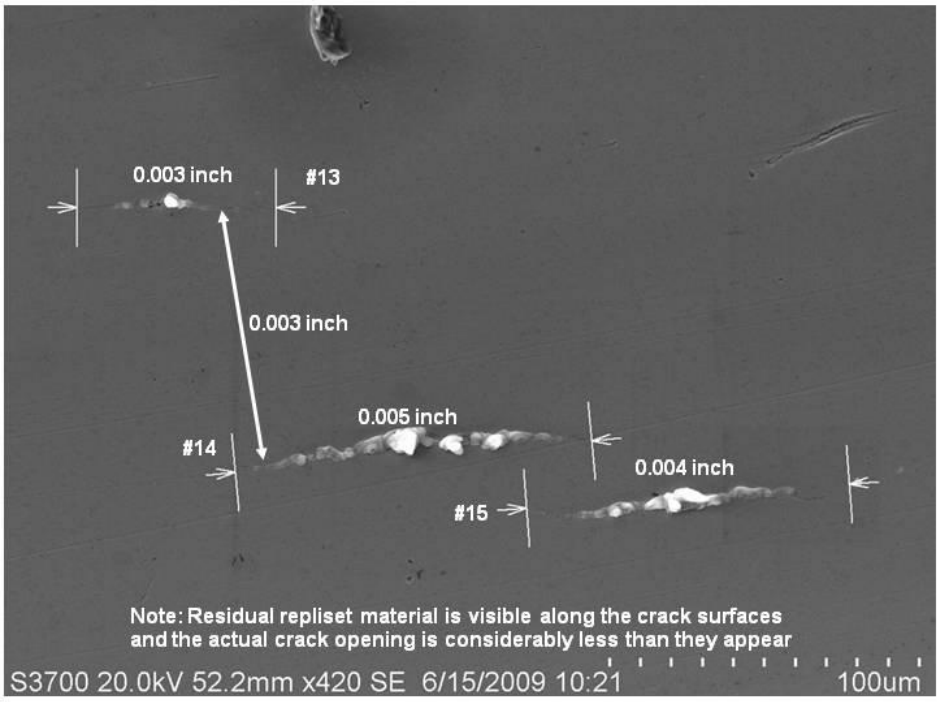
Size of Crack #12



227

Poppet #46

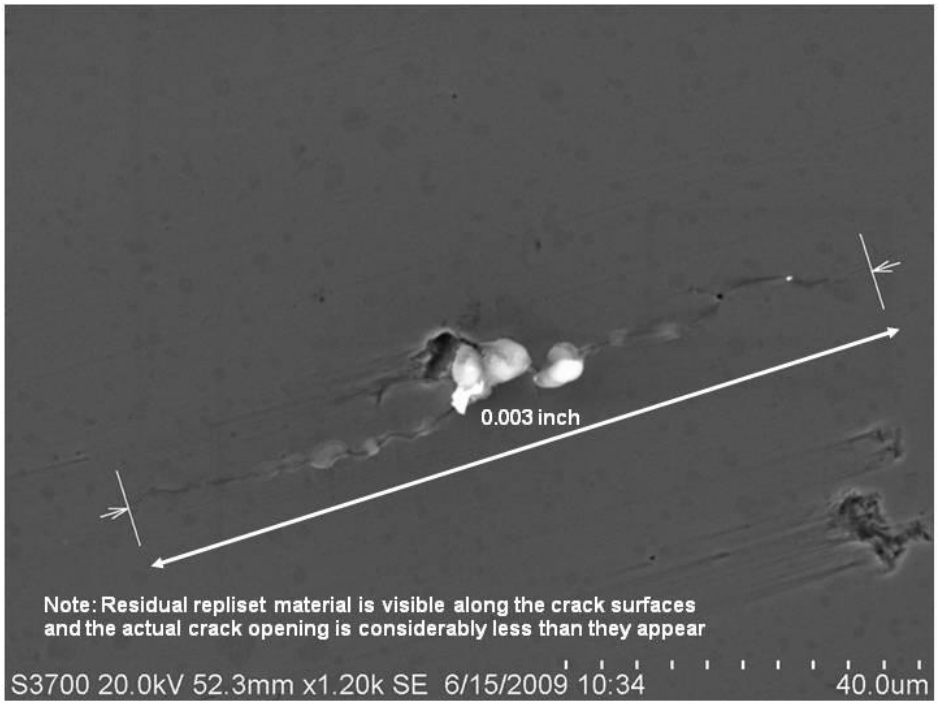
Location and size of Cracks #13-15



228

Poppet #46

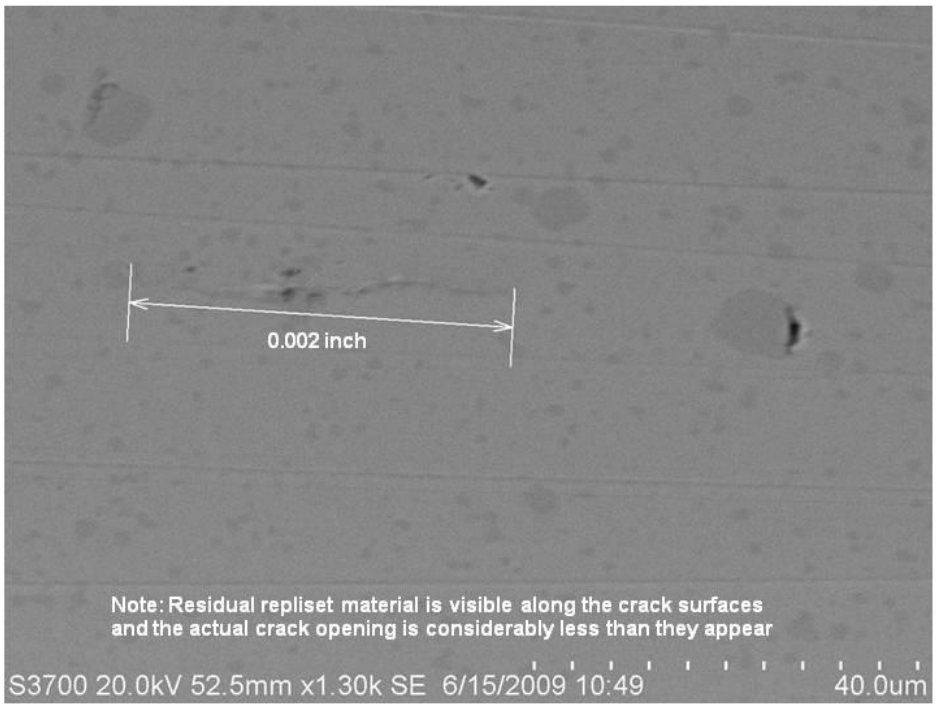
Size of Crack #16



229

Poppet #46

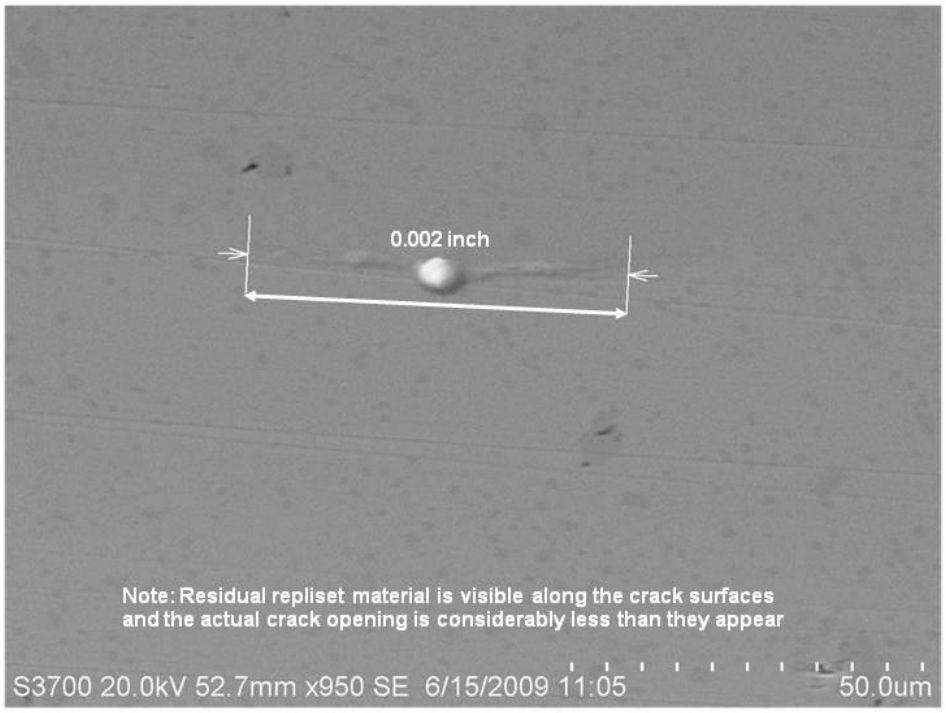
Size of Crack #17



230

Poppet #46

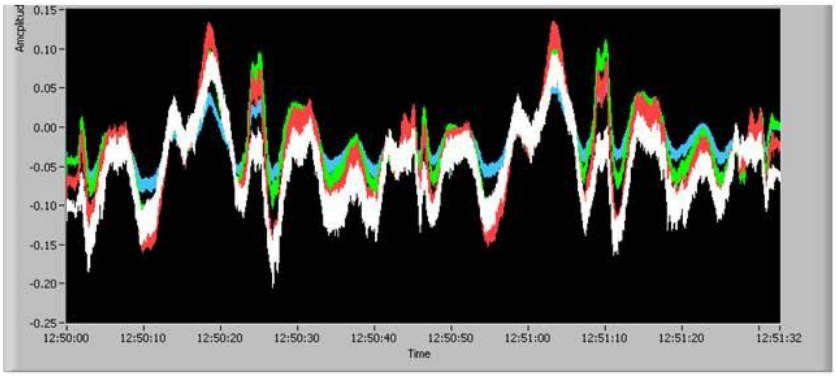
Size of Crack #18



231

Poppet #46

LaRC eddy current findings, the colors indicate ???



232

Poppet #47

Surface crack sizes and locations

Poppet #47		
Crack Number	Size (inch)	Angle (degrees)
1	0.014	245
2	0.011	245
3	0.005	245
4	0.005	245
5	0.004	245
6	0.004	245
7	0.004	65

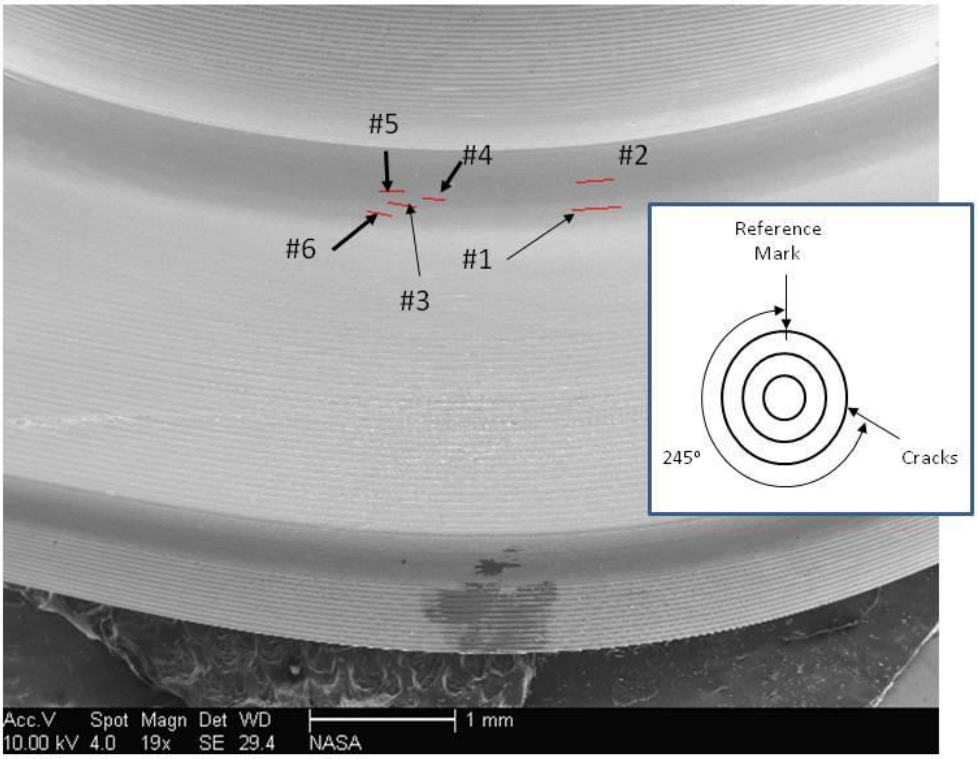
Boeing Eddy Current Findings

Poppet #47									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.139	0.140	0.140	0.141	0.142	0.142	0.141	Yes	245
J. Engel	0.056	0.059	0.062	0.060	0.058	0.059	0.059	Yes	65 (Not 3:1 S/N ratio)
B. Devries	0.144	0.141	0.146	0.150	0.144	0.141	0.144	Yes	255
B. Devries	-	-	-	-	-	-	-	No	65

233

Poppet #47

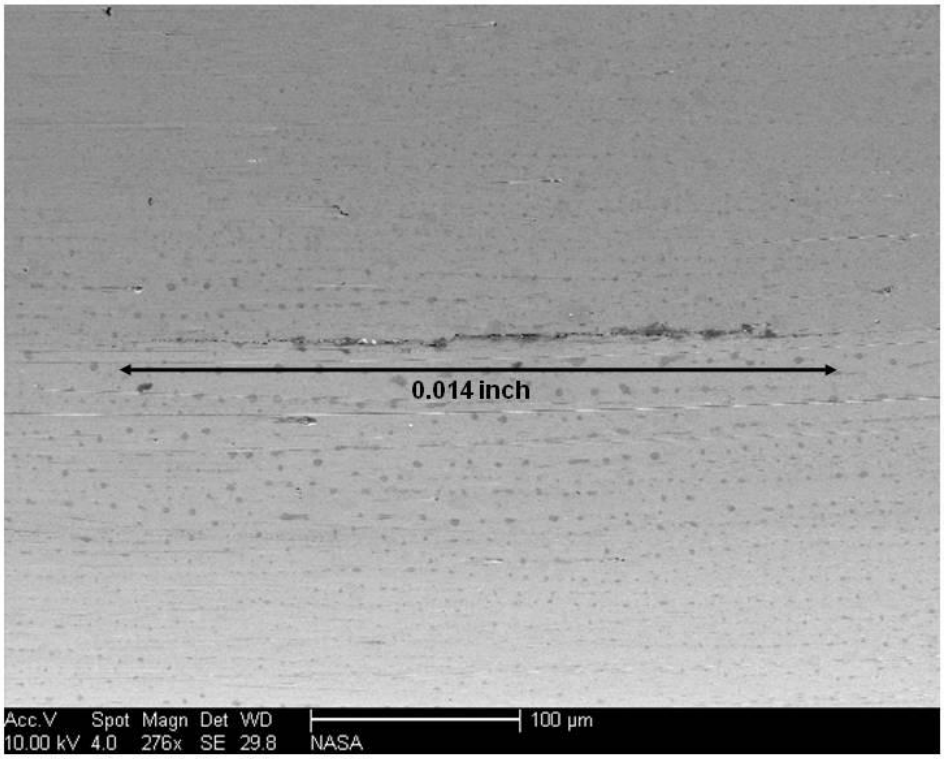
Location of Cracks #1-6



234

Poppet #47

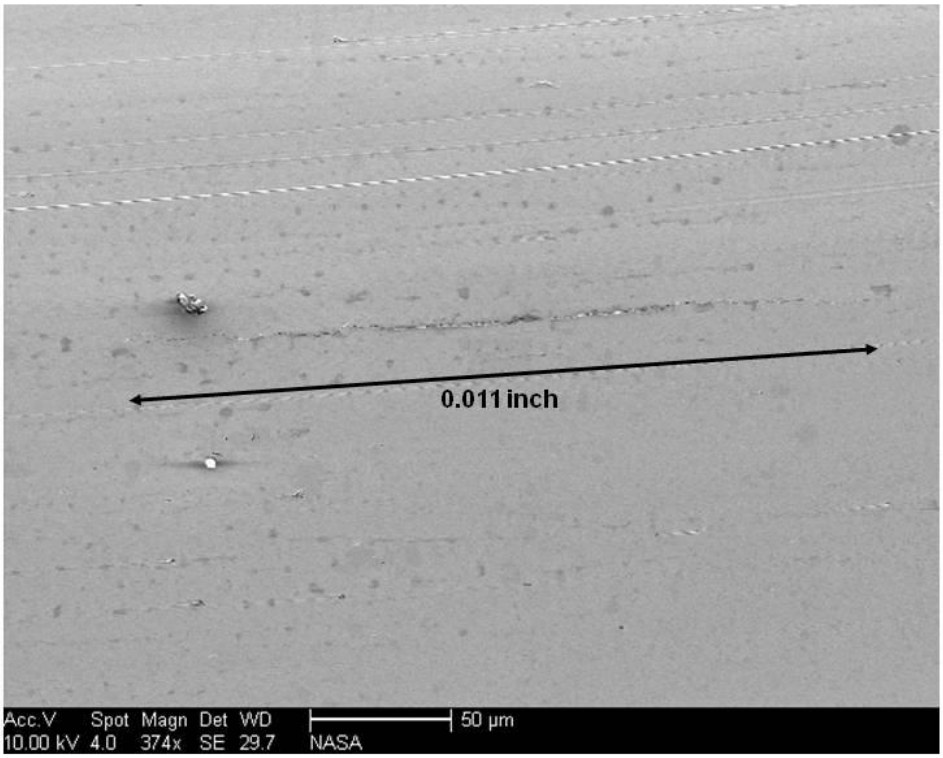
Size of Crack #1



235

Poppet #47

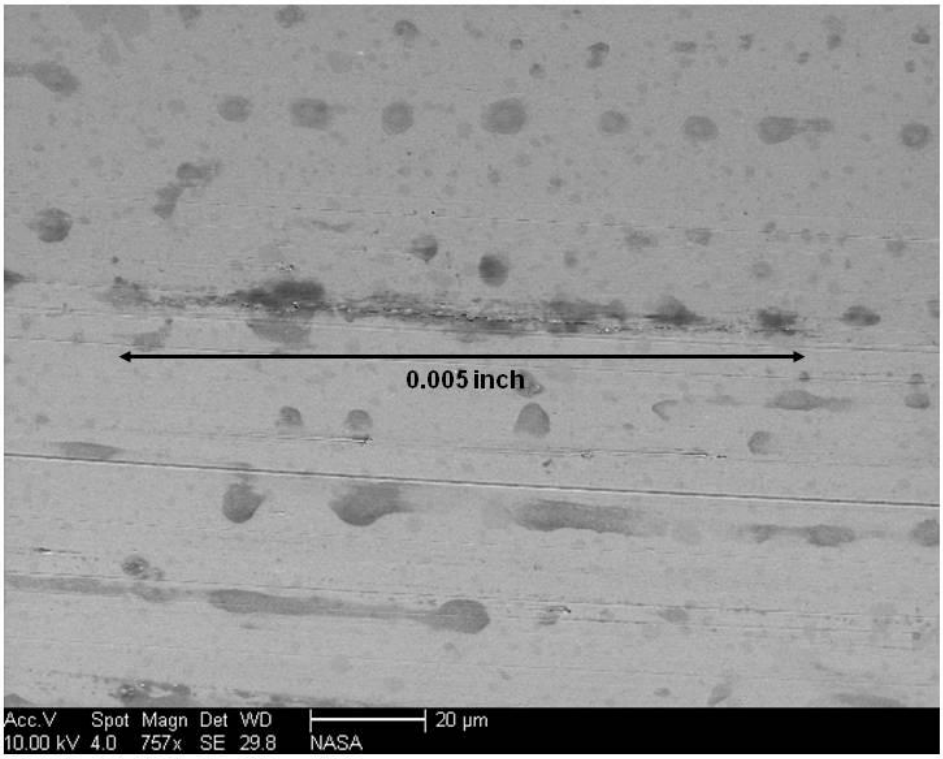
Size of Crack #2



236

Poppet #47

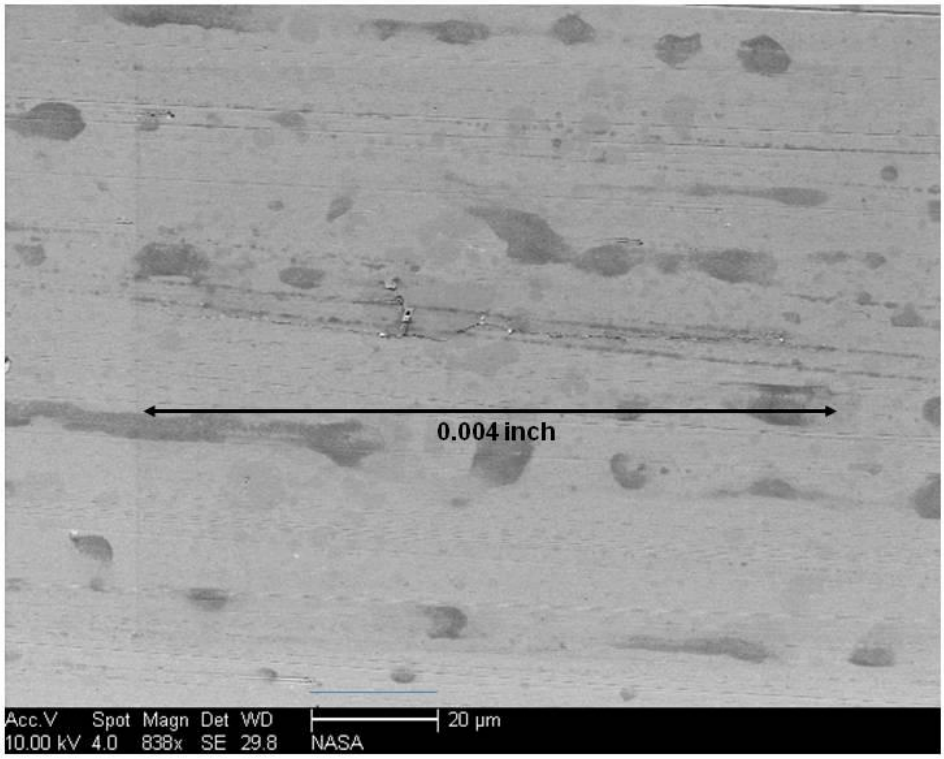
Size of Crack #3



237

Poppet #47

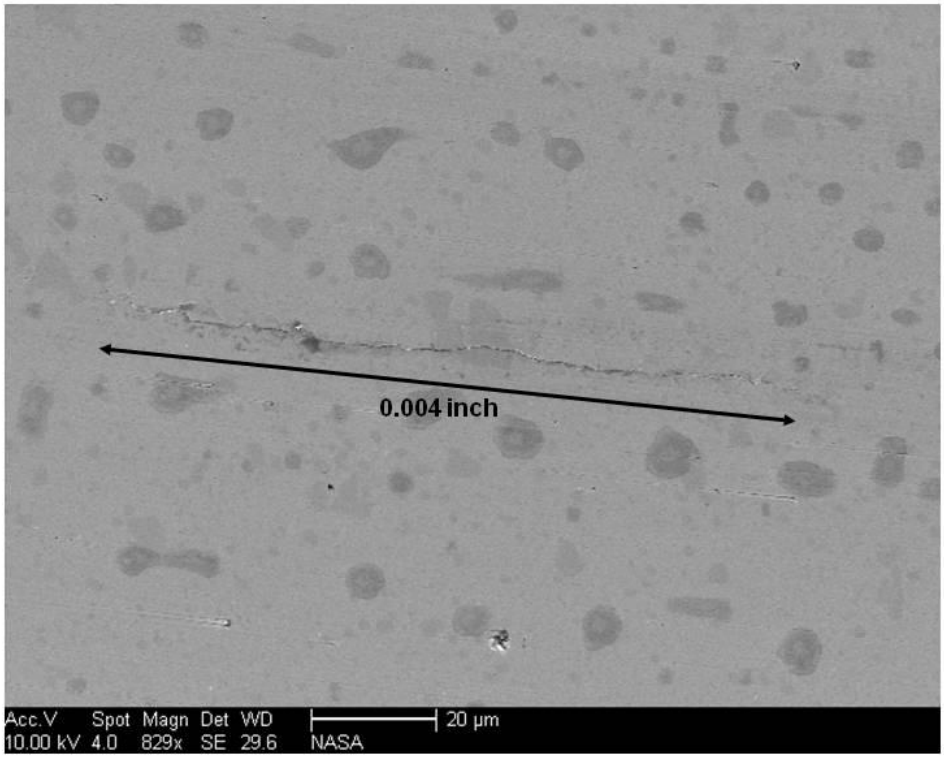
Size of Crack #4



238

Poppet #47

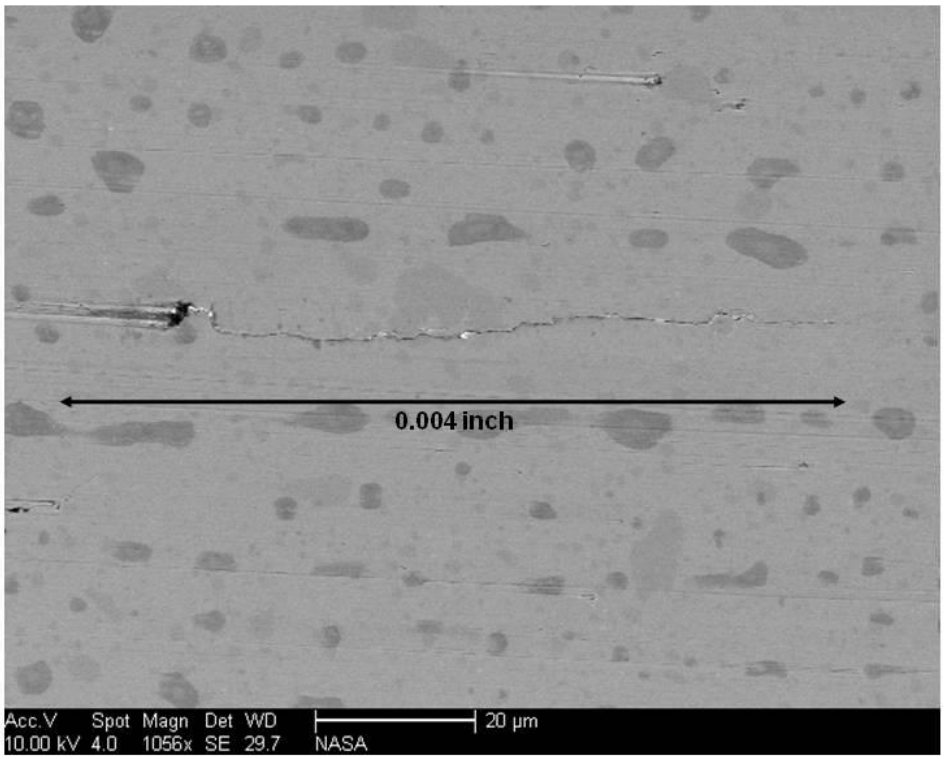
Size of Crack #5



239

Poppet #47

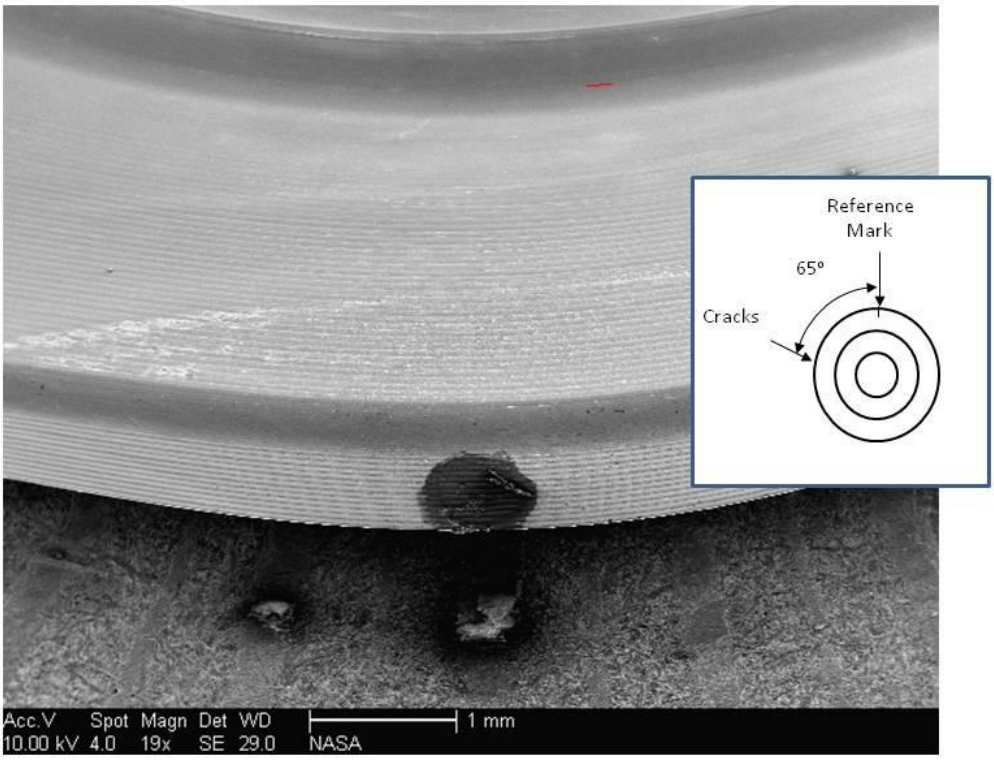
Size of Crack #6



240

Poppet #47

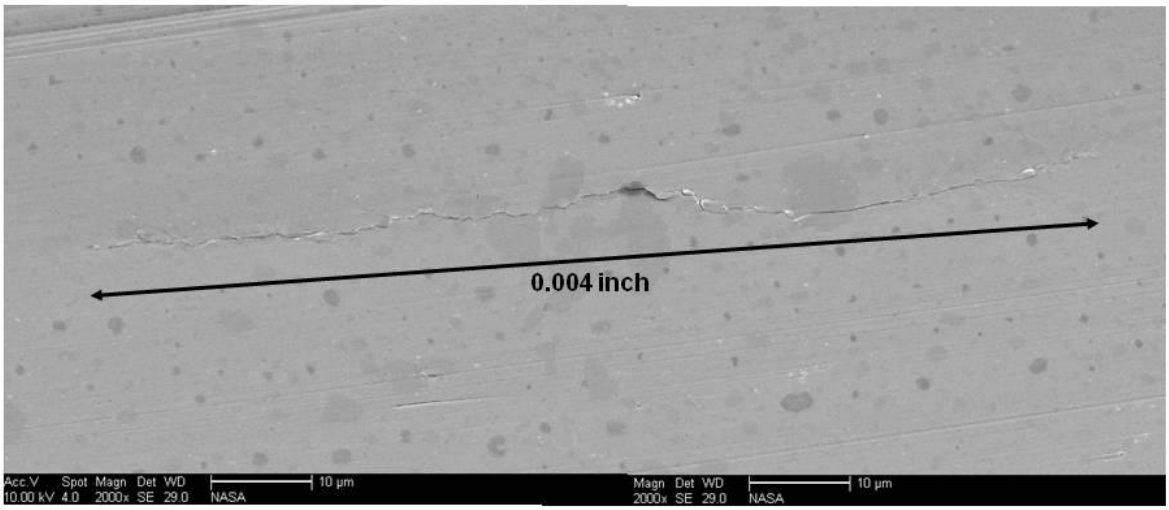
Location of Crack #7



241

Poppet #47

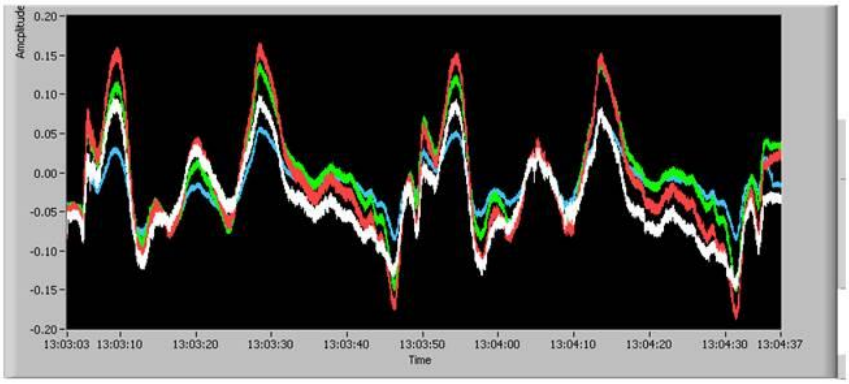
Size of Crack #7



242

Poppet #47

LaRC eddy current findings, the colors indicate ???



243

Poppet #48

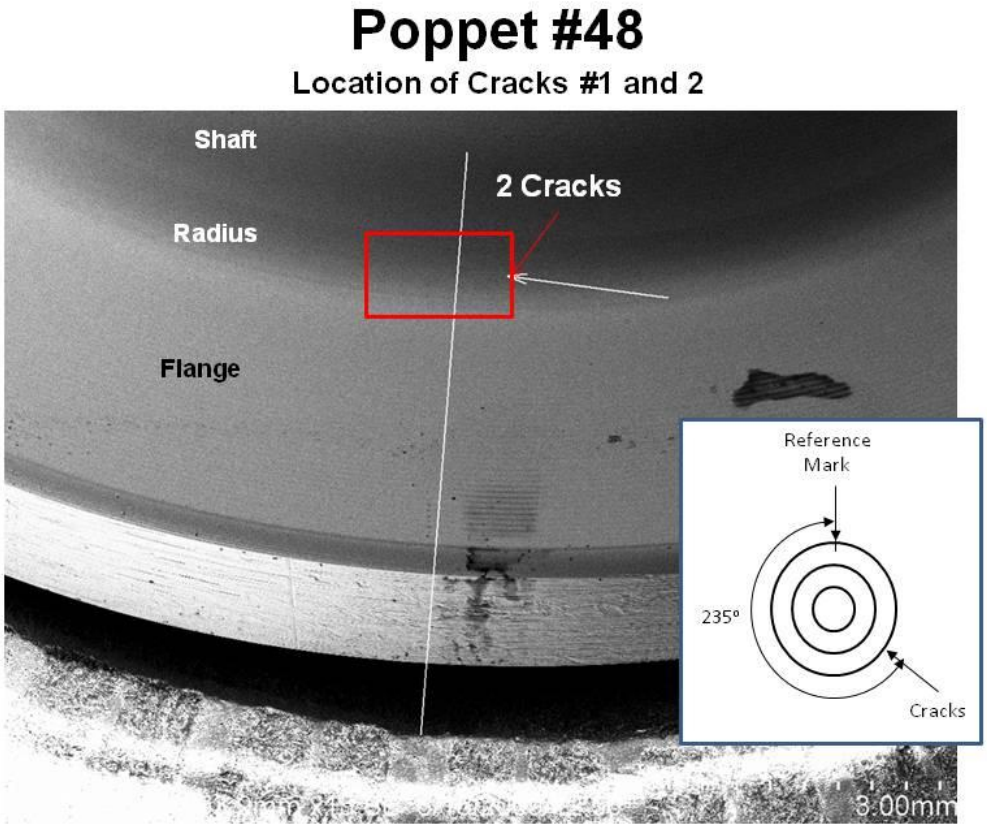
Surface crack sizes and locations

Poppet #48		
Crack Number	Size (inch)	Angle (degrees)
1	0.005	235
2	0.004	235
3	0.002	55
4	0.034	55
5	0.007	55
6	0.012	55
7	0.006	55
8	0.002	55
9	0.001	55
10	0.003	55
11	0.002	55
12	0.002	55
13	0.004	55
14	0.002	55

Boeing Eddy Current Findings

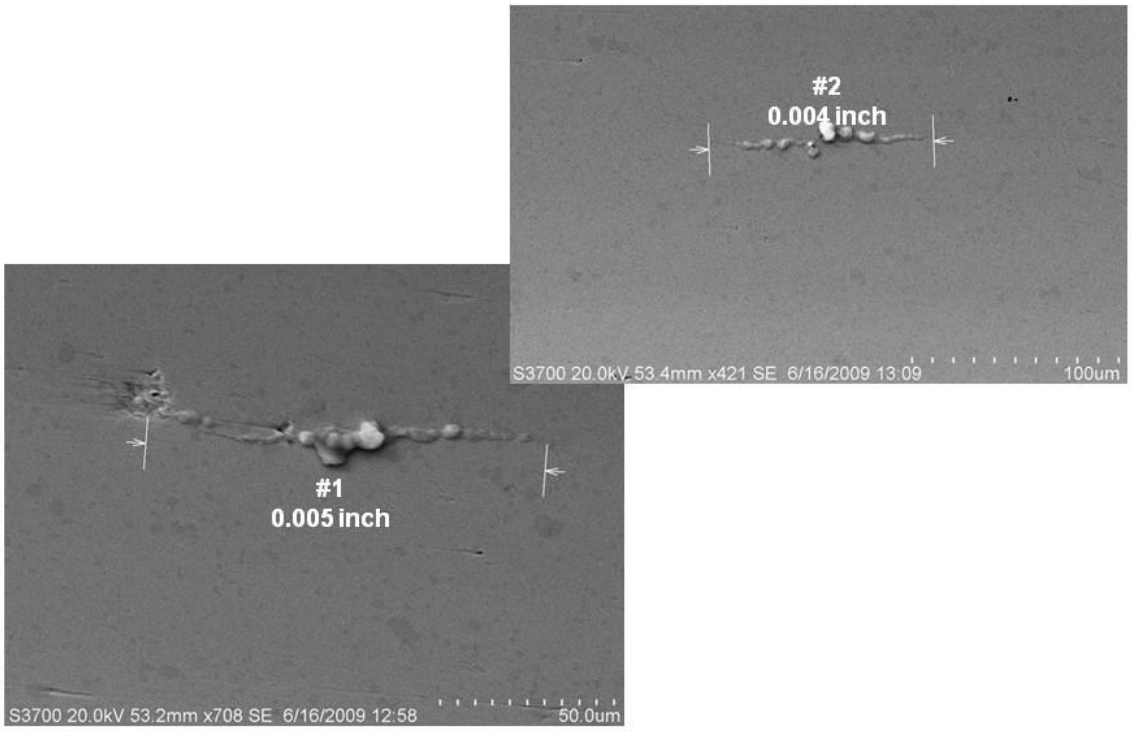
Poppet #48									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.344	0.350	0.351	0.358	0.361	0.355	0.353	Yes	45
J. Engel	-	-	-	-	-	-	-	Yes	235 (Samll indication slightly above noise)
B. Devries	-	-	-	-	-	-	-	No	235
B. Devries	0.342	0.340	0.342	0.342	0.341	0.344	0.342	Yes	45

244

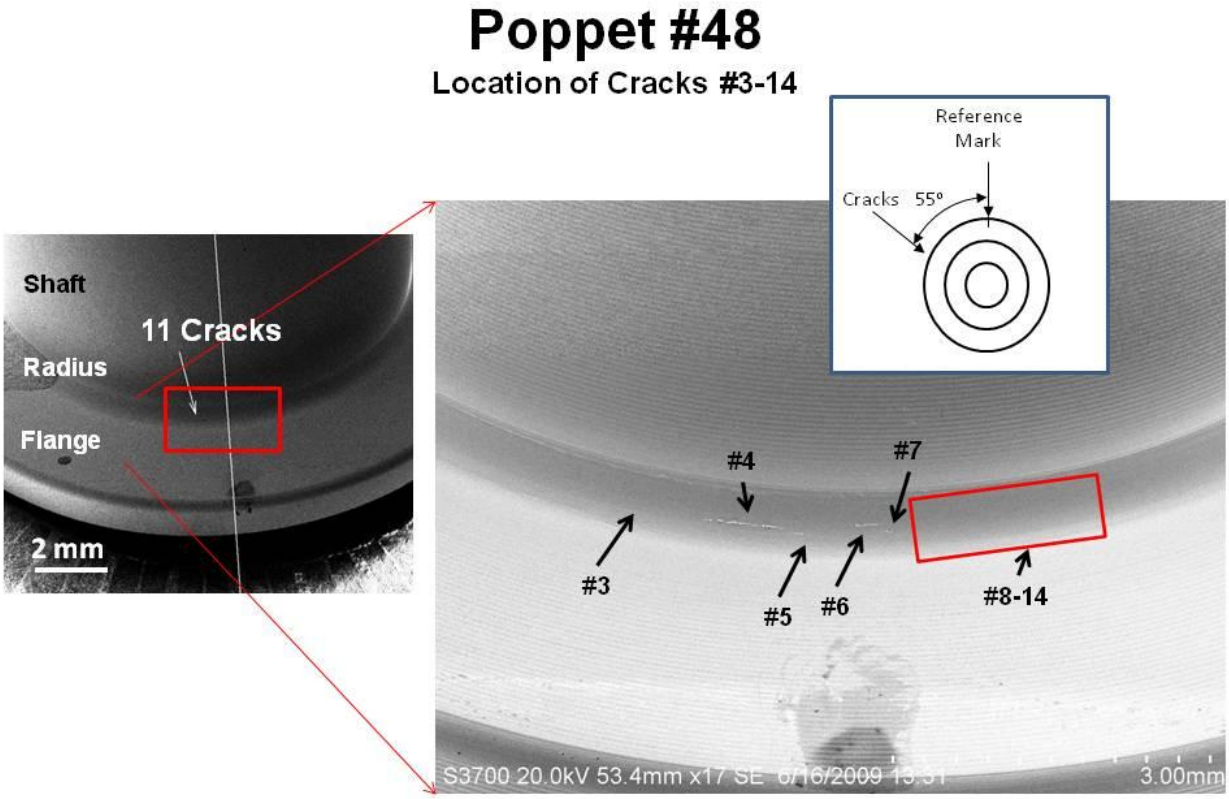

Poppet #48
Location of Cracks #1 and 2
Shaft
2 Cracks
Radius
Flange
Reference Mark
235°
Cracks
3.00mm
245

Poppet #48

Location and size of Cracks #1 and 2



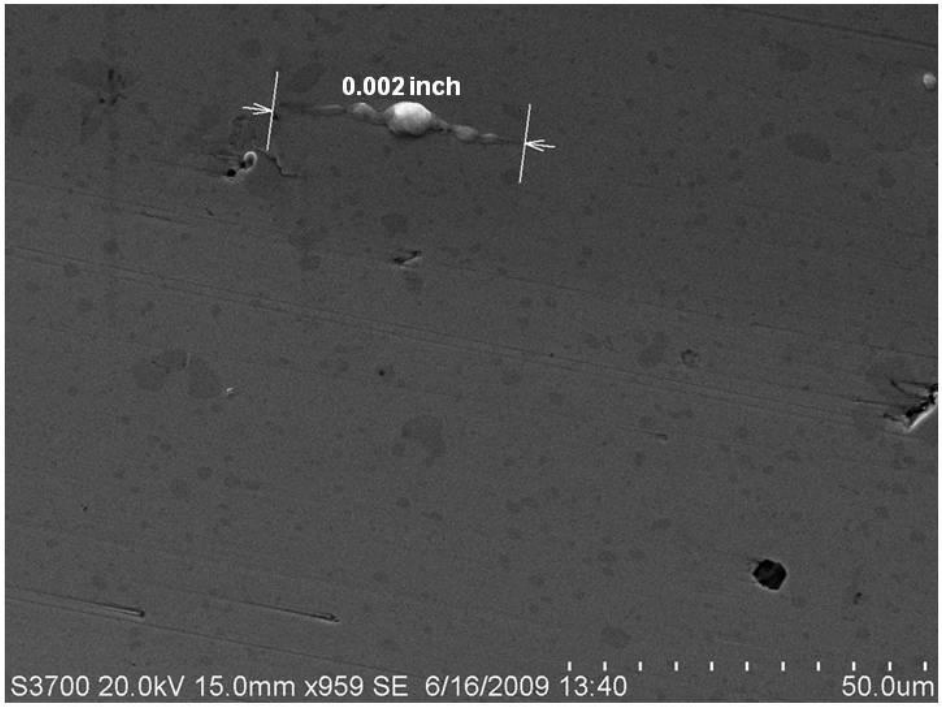
246


Poppet #48
Location of Cracks #3-14
Reference Mark
Cracks 55°
Shaft
11 Cracks
Radius
Flange
2 mm
#3
#4
#5
#6
#7
#8-14
S3700 20.0kV 53.4mm x17 SE 6/16/2009
3.00mm

247

Poppet #48

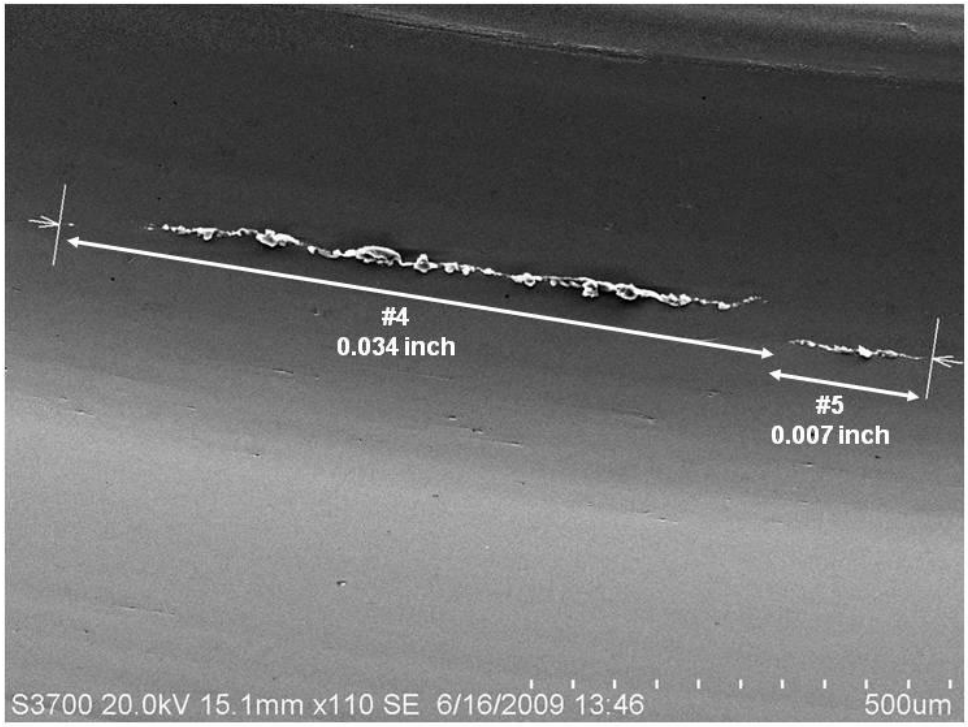
Size of Crack #3



248

Poppet #48

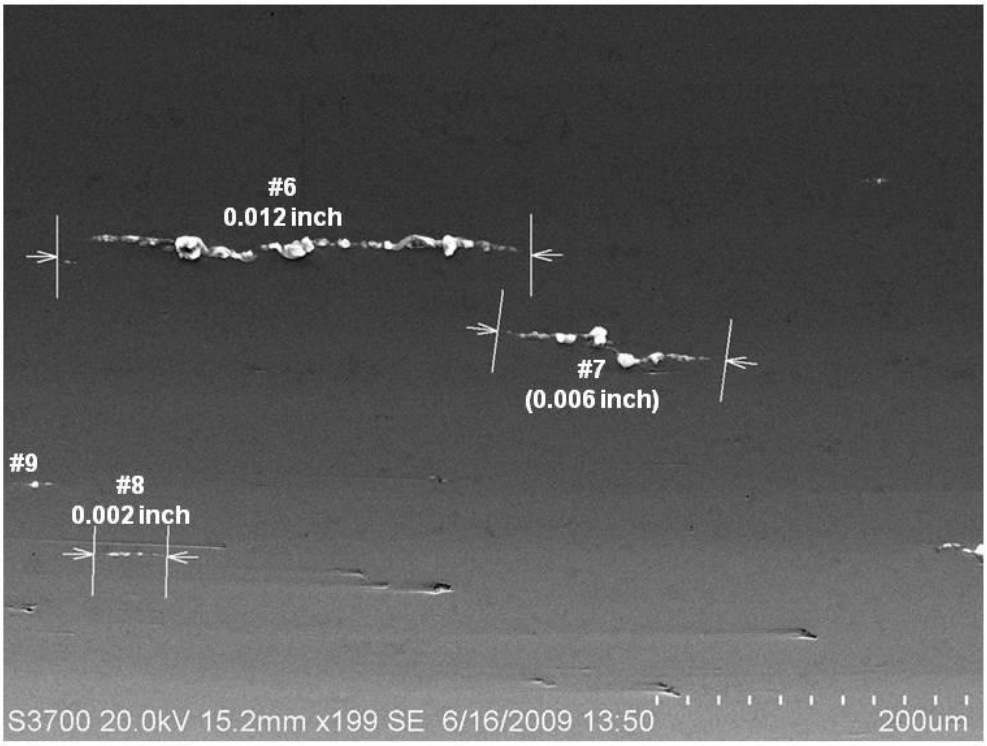
Size of Cracks #4 and 5



249

Poppet #48

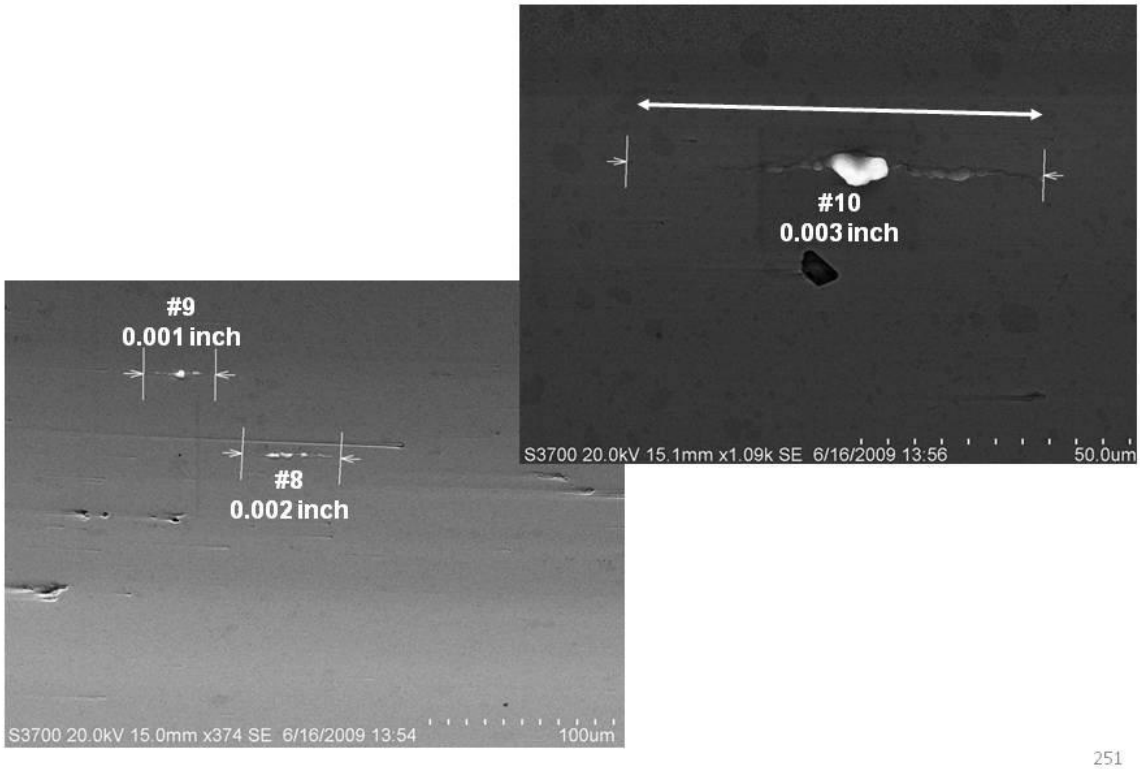
Location and size of Cracks #6-9



250

Poppet #48

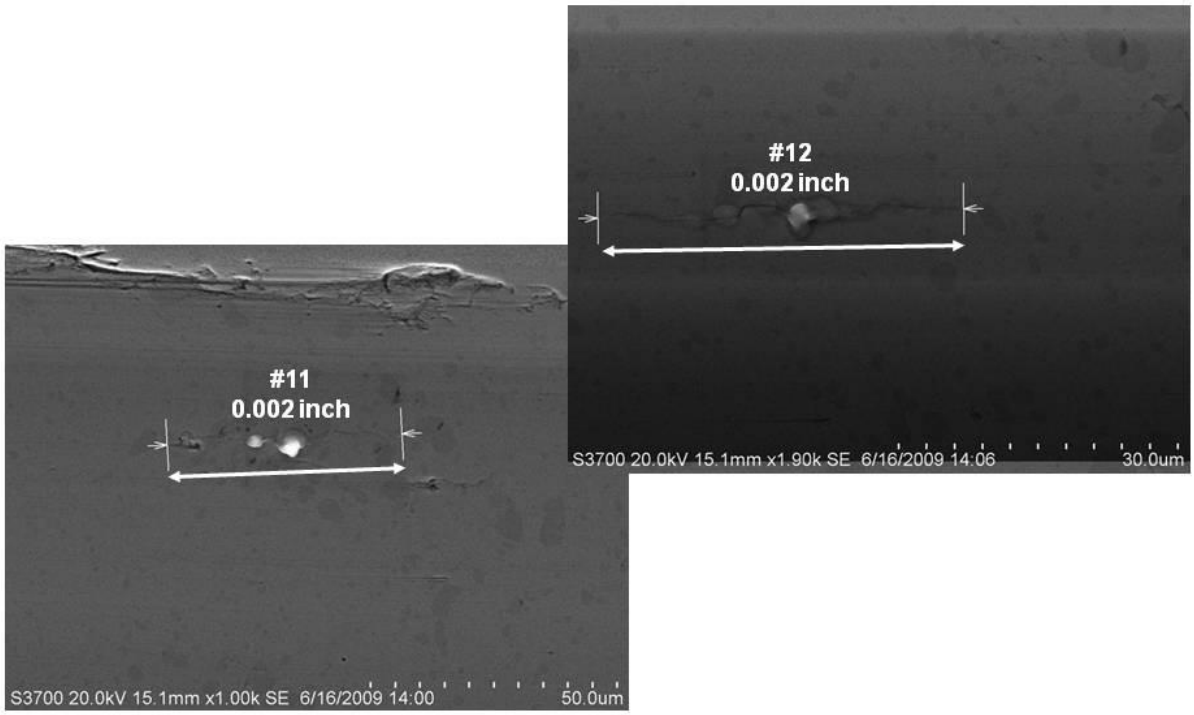
Location and size of Cracks #8-10



251

Poppet #48

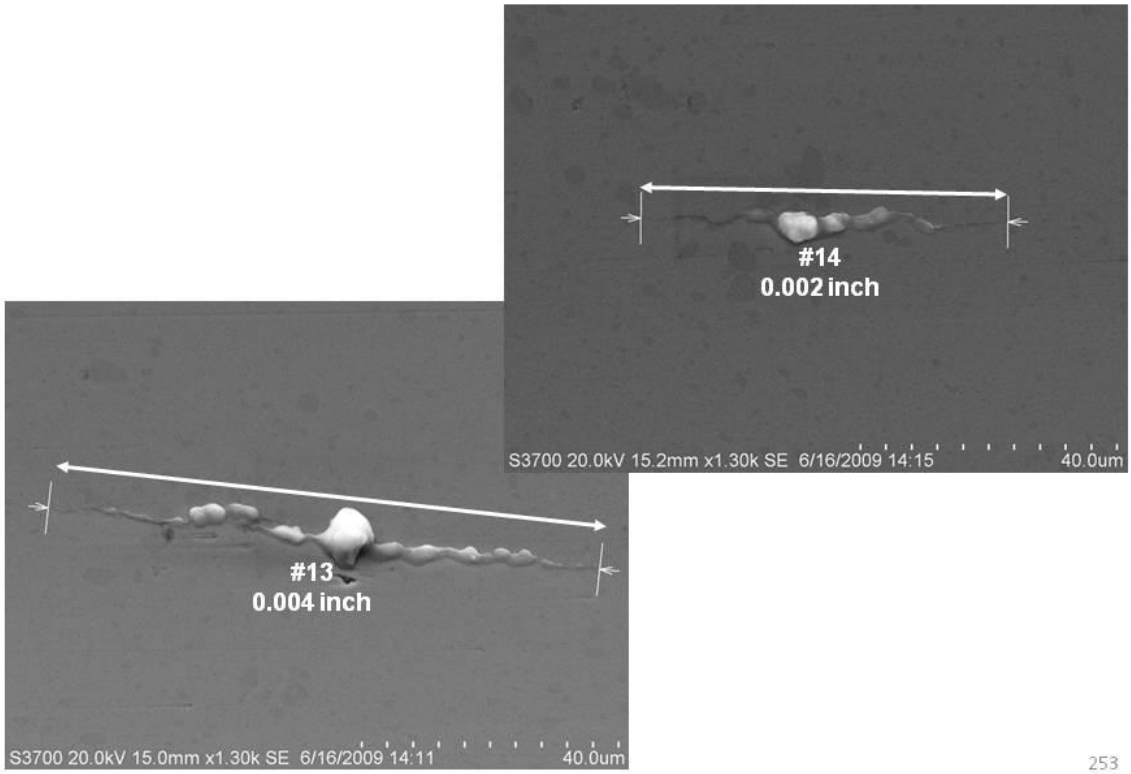
Location and size of Cracks #11-12



252

Poppet #48

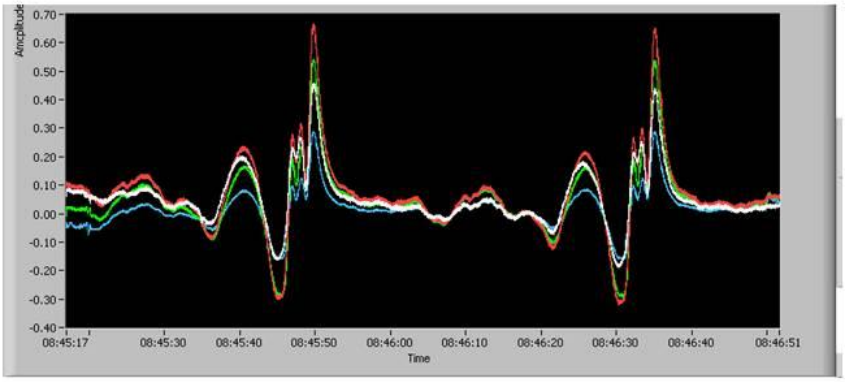
Location and size of Cracks #13-14



253

Poppet #48

LaRC eddy current findings, the colors indicate ???



254

Poppet #49

Surface crack sizes and locations

Poppet #49		
Crack Number	Size (inch)	Angle (degrees)
1	0.045	345
2	0.003	345
3	0.003	345
4	0.007	345
5	0.004	345
6	0.002	165

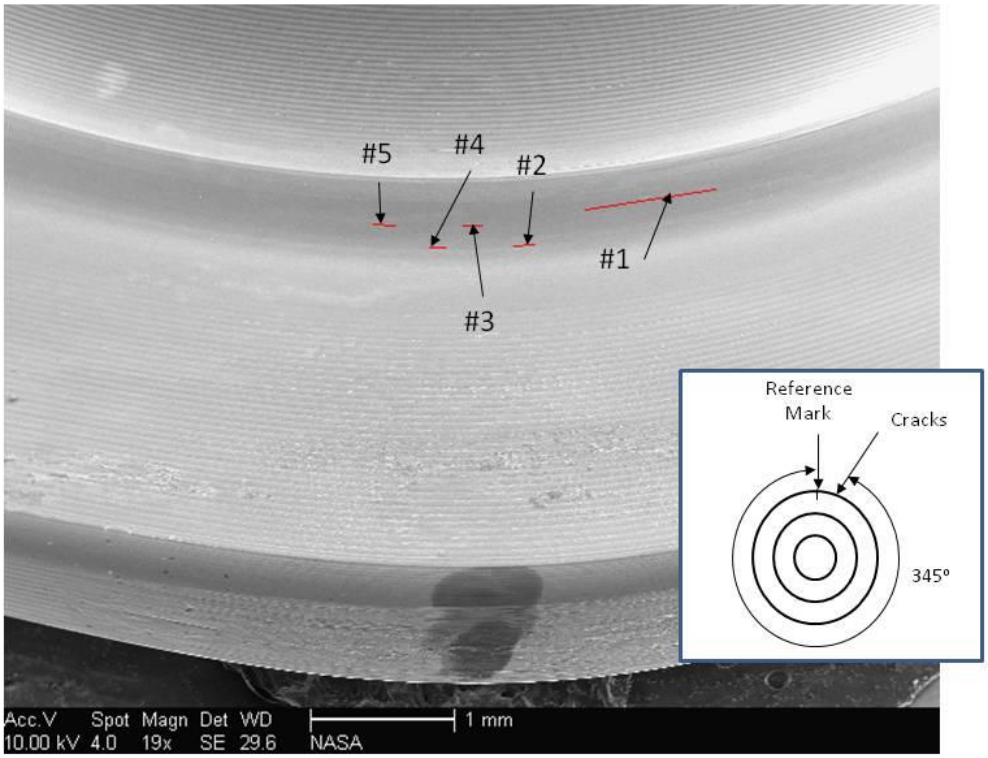
Boeing Eddy Current Findings

Poppet #49									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	-	-	-	-	-	-	-	No	165
J. Engel	0.827	0.795	0.801	0.805	0.810	0.802	0.807	Yes	350
B. Devries	-	-	-	-	-	-	-	No	165
B. Devries	0.777	0.789	0.789	0.818	0.814	0.822	0.802	Yes	350

255

Poppet #49

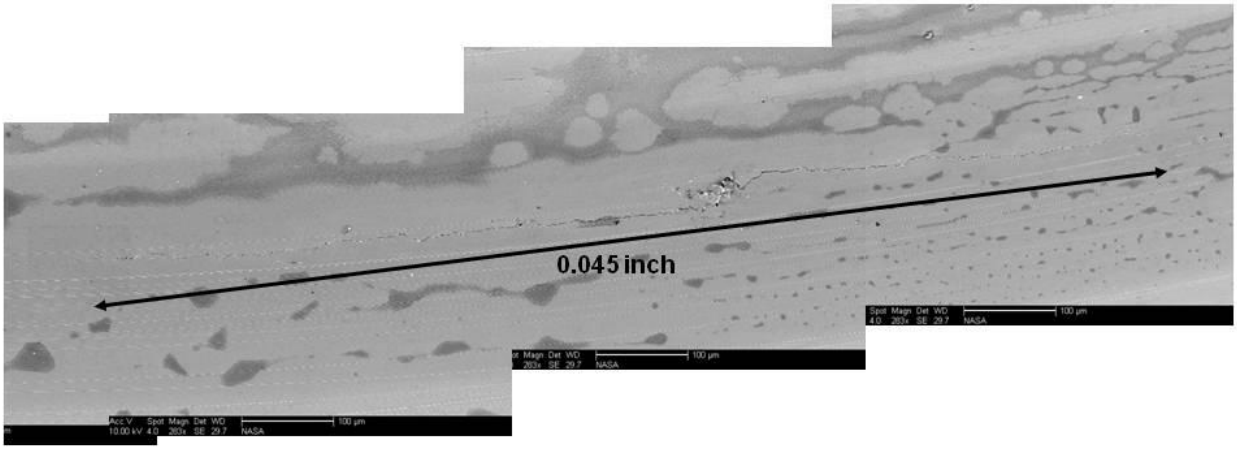
Location of Cracks #1-6



256

Poppet #49

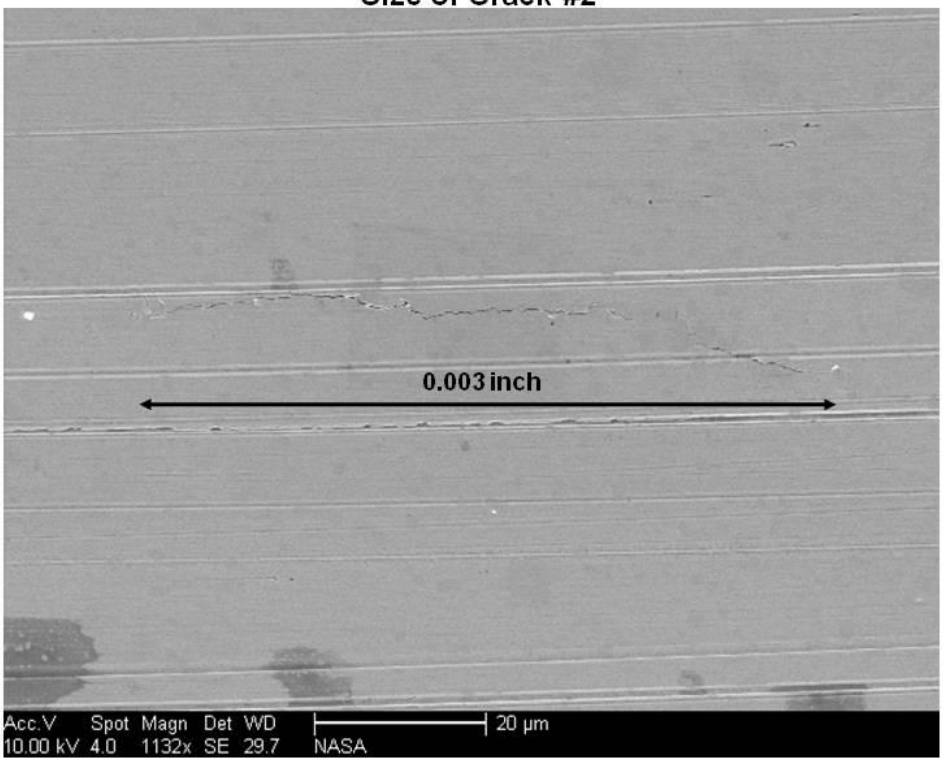
Size of Crack #1



257

Poppet #49

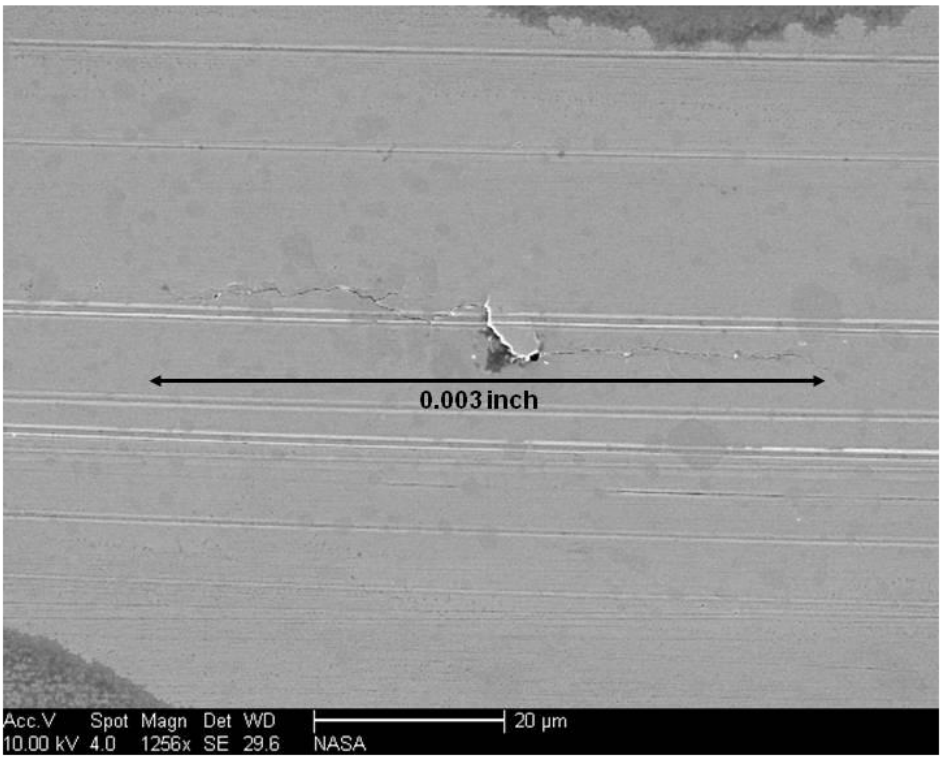
Size of Crack #2



258

Poppet #49

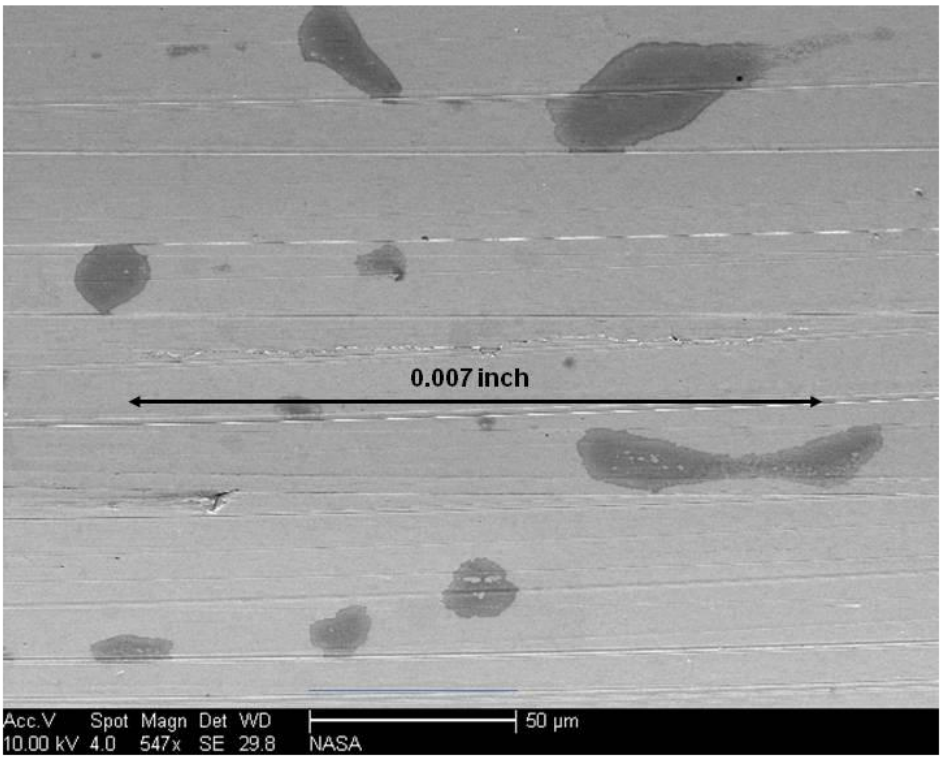
Size of Crack #3



259

Poppet #49

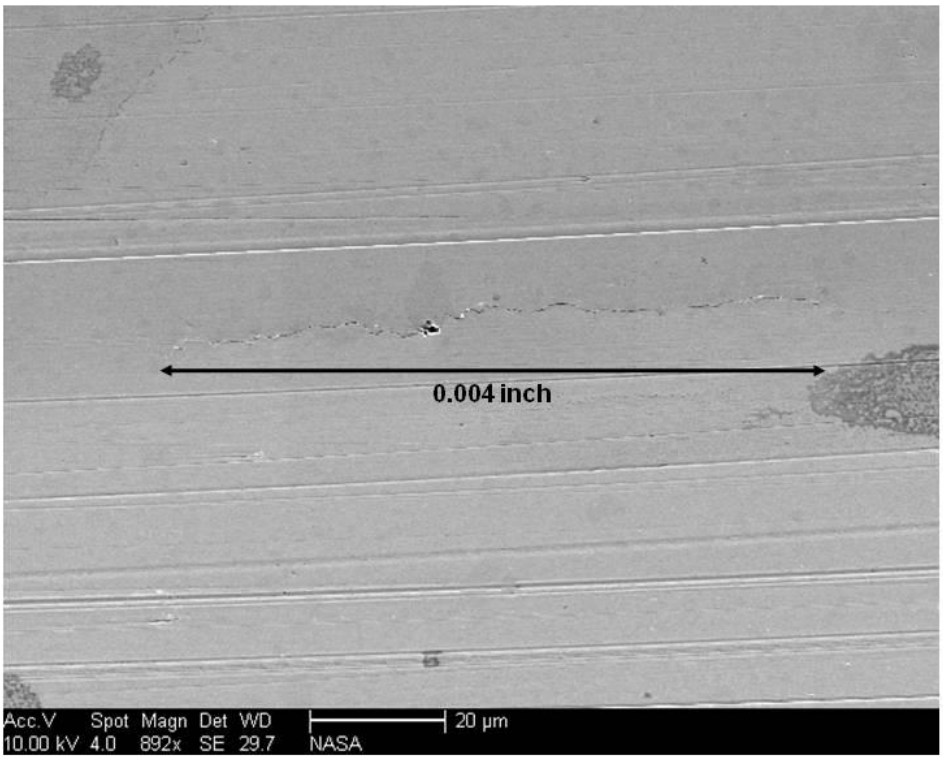
Size of Crack #4



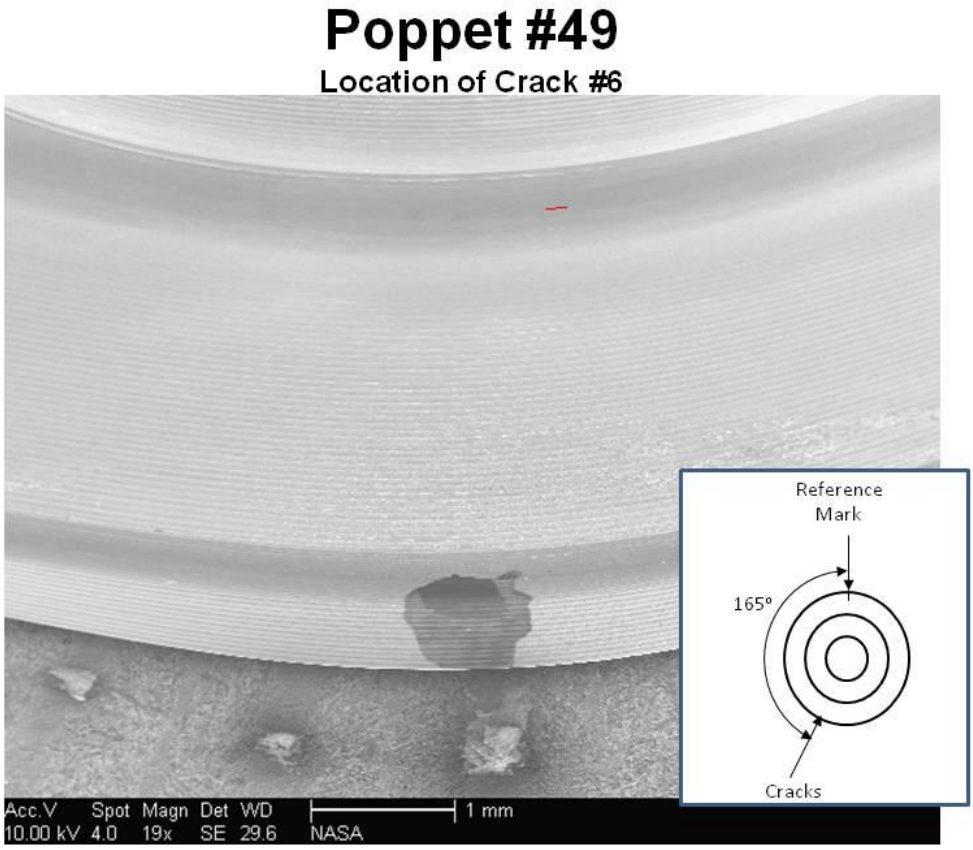
260

Poppet #49

Size of Crack #5



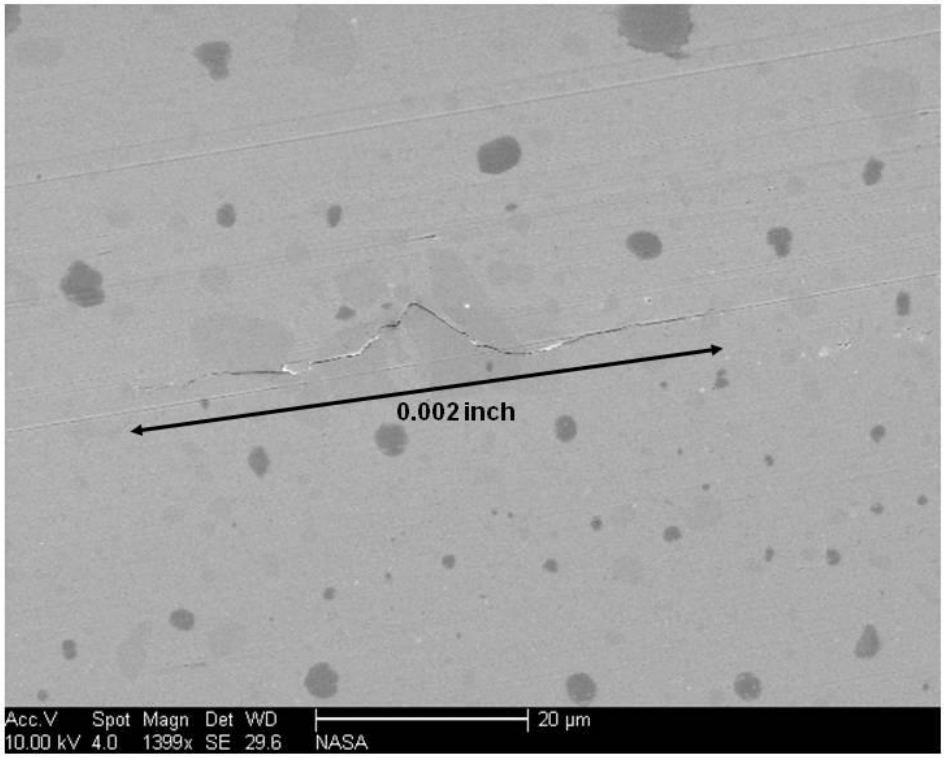
261


Poppet #49
Location of Crack #6
Reference Mark
165°
Cracks
Acc.V Spot Magn Det WD
10.00 kV 4.0 19x SE 29.6
1 mm
NASA

262

Poppet #49

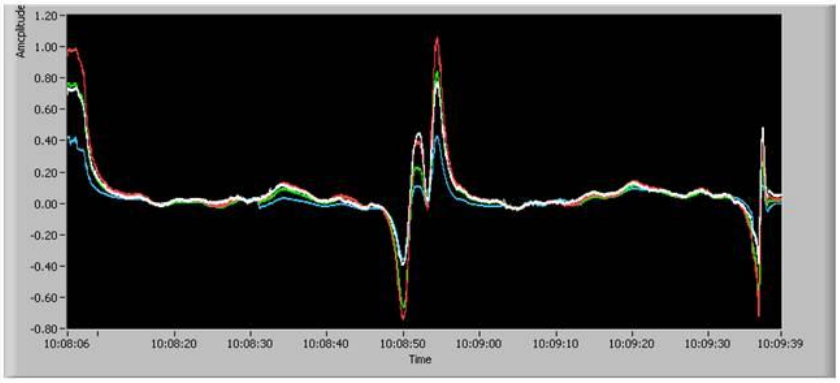
Size of Crack #6



263

Poppet #49

LaRC eddy current findings, the colors indicate ???



264

Poppet #50

Surface crack sizes and locations

Poppet #50		
Crack Number	Size (inch)	Angle (degrees)
1	0.004	155
2	0.003	155
3	0.005	155
4	0.003	155
5	0.006	335
6	0.009	335
7	0.010	335
8	0.005	335
9	0.010	335
10	0.003	335
11	0.002	335

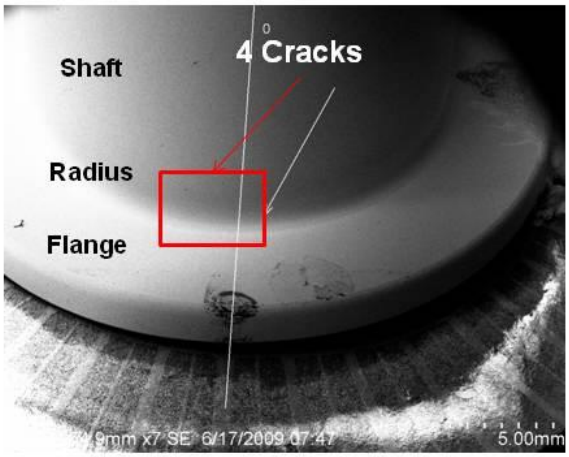
Boeing Eddy Current Findings

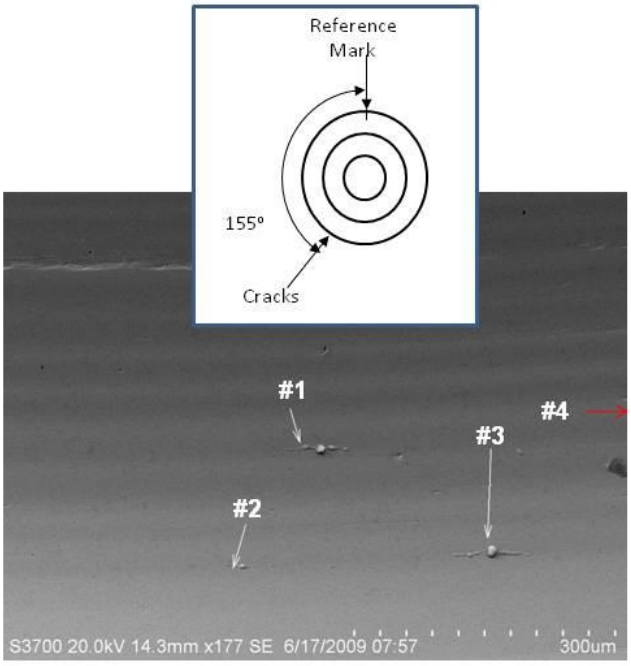
Poppet #50									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.213	0.204	0.211	0.216	0.215	0.212	0.212	Yes	340
J. Engel	0.055	0.052	0.059	0.061	0.062	0.053	0.057	Yes	170 (Not 3:1 S/N ratio)
B. Devries	-	-	-	-	-	-	-	No	155
B. Devries	0.205	0.210	0.210	0.211	0.208	0.207	0.209	Yes	330

265

Poppet #50

Location of Cracks #1-4

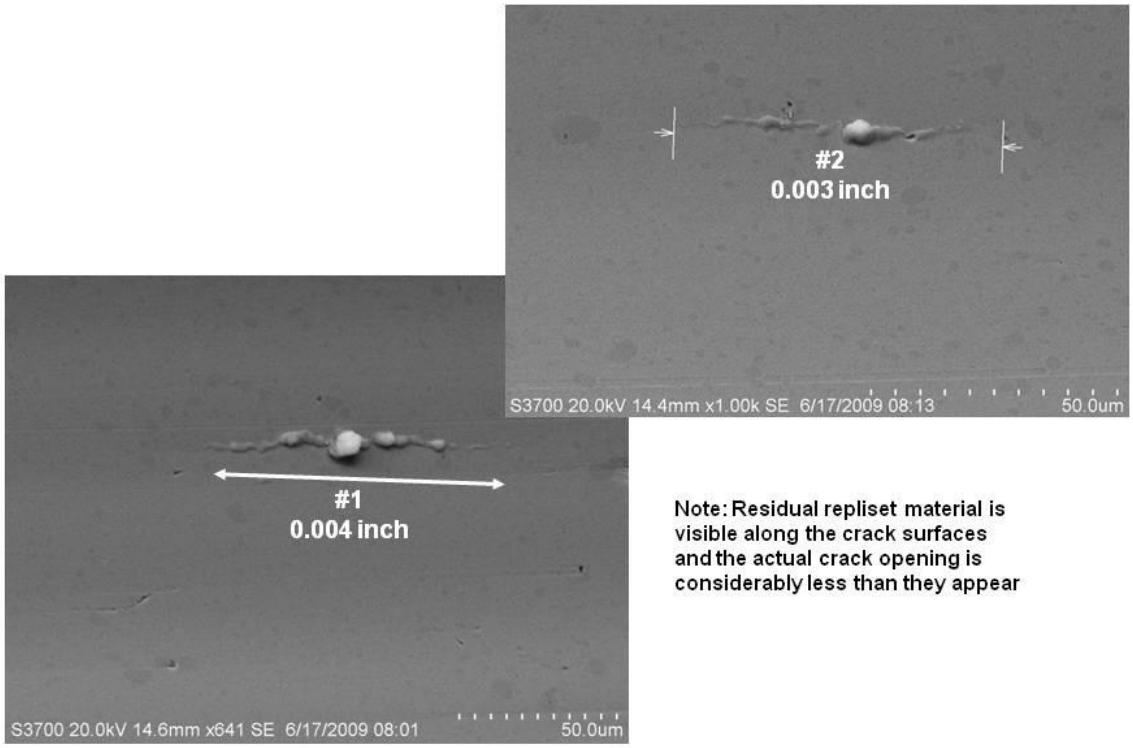




266

Poppet #50

Size of Cracks #1 and 2

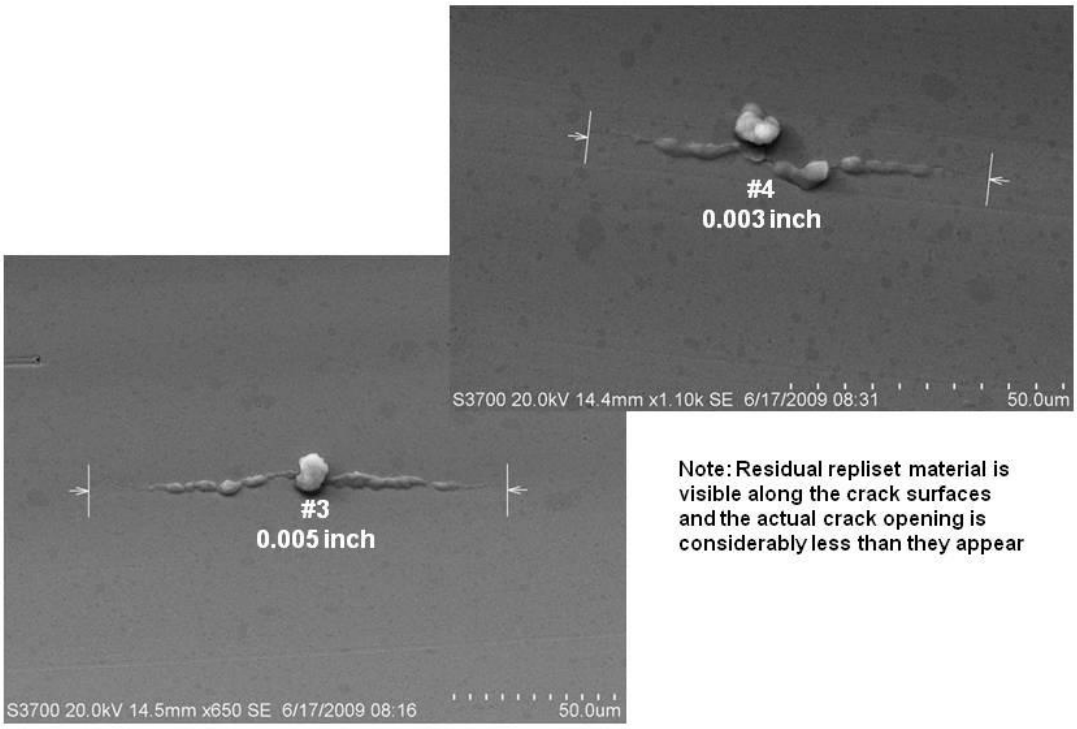


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

267

Poppet #50

Location and size of Cracks #3 and 4

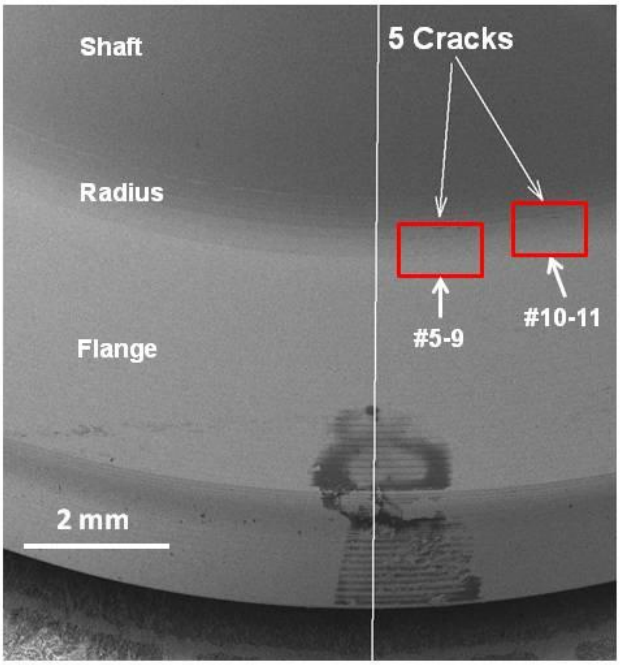


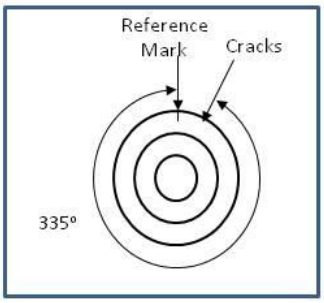
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

268

Poppet #50

Location of Cracks #5-9

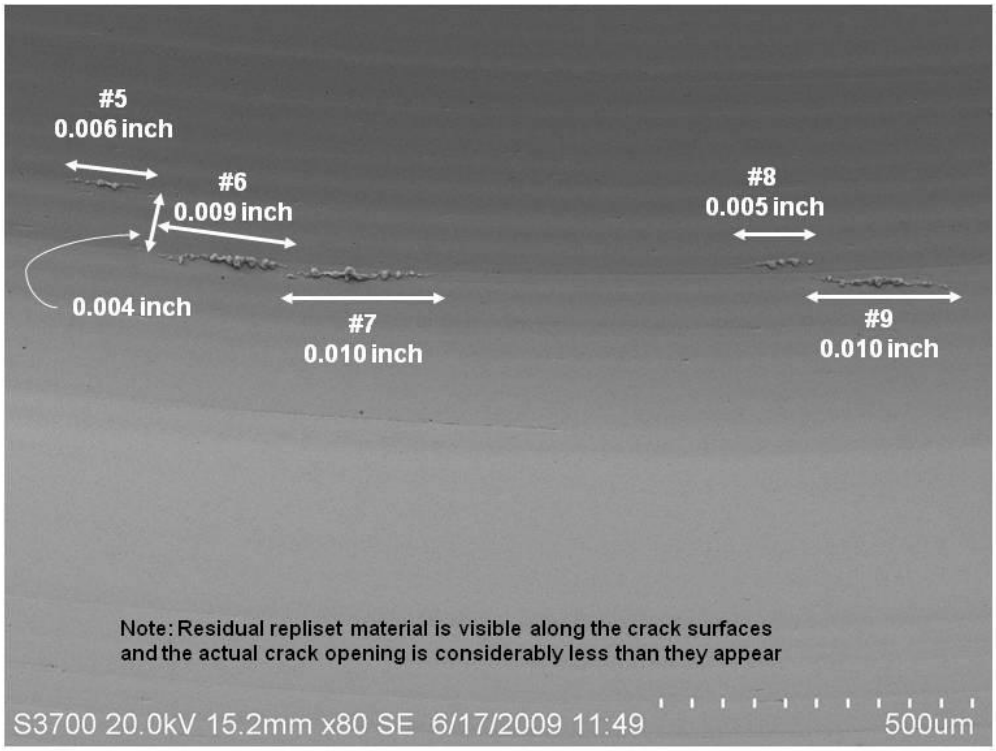




269

Poppet #50

Location and size of Cracks #5-9

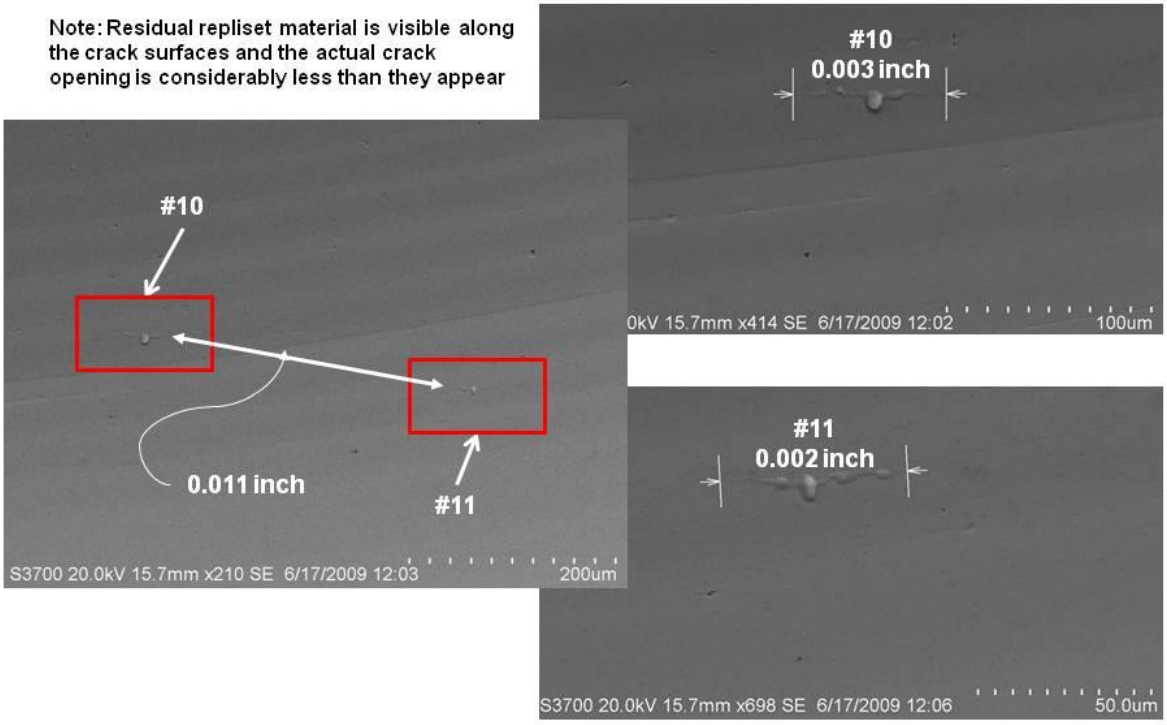


270

Poppet #50

Size of Cracks #10-11

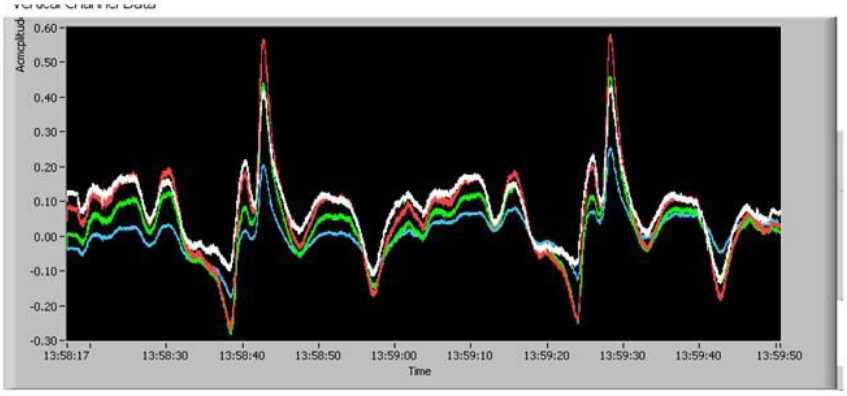
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear



271

Poppet #50

LaRC eddy current findings, the colors indicate ???



272

Poppet #51

Surface crack sizes and locations

Poppet #51		
Crack Number	Size (inch)	Angle (degrees)
1	0.032	195
2	0.108	15

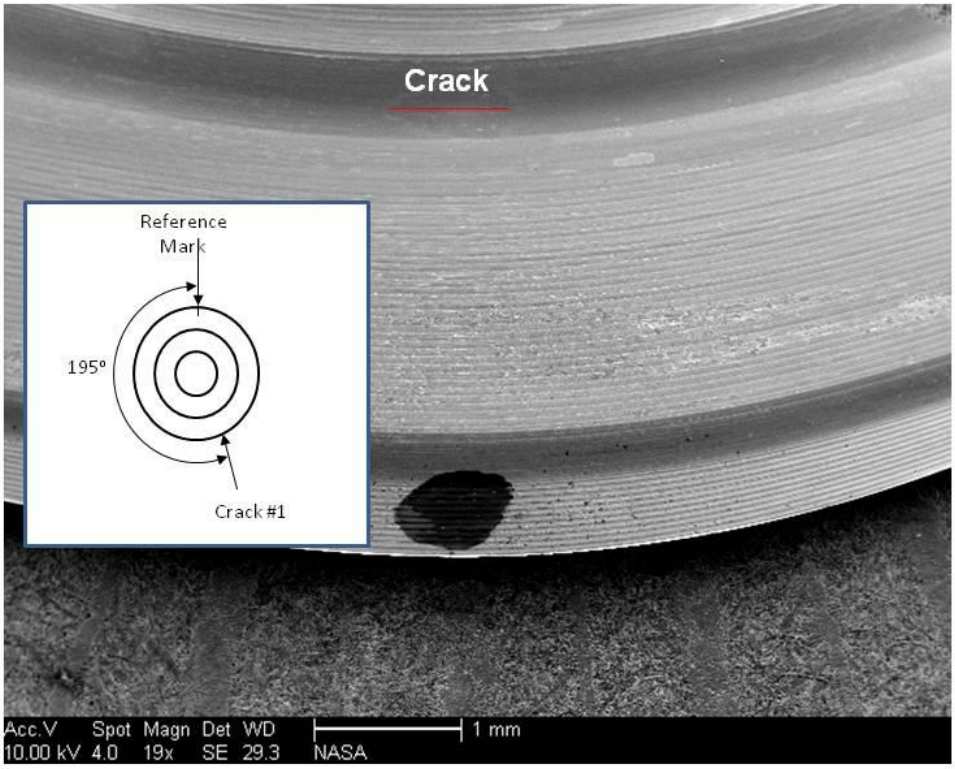
Boeing Eddy Current Findings

Poppet #51									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	1.006	1.022	1.048	1.054	1.071	1.068	1.045	Yes	35
J. Engel	0.410	0.415	0.412	0.422	0.422	0.430	0.419	Yes	210
B. Devries	1.047	1.059	1.067	1.063	1.082	1.064	1.064	Yes	20
B. Devries	0.420	0.420	0.420	0.416	0.420	0.420	0.419	Yes	200

273

Poppet #51

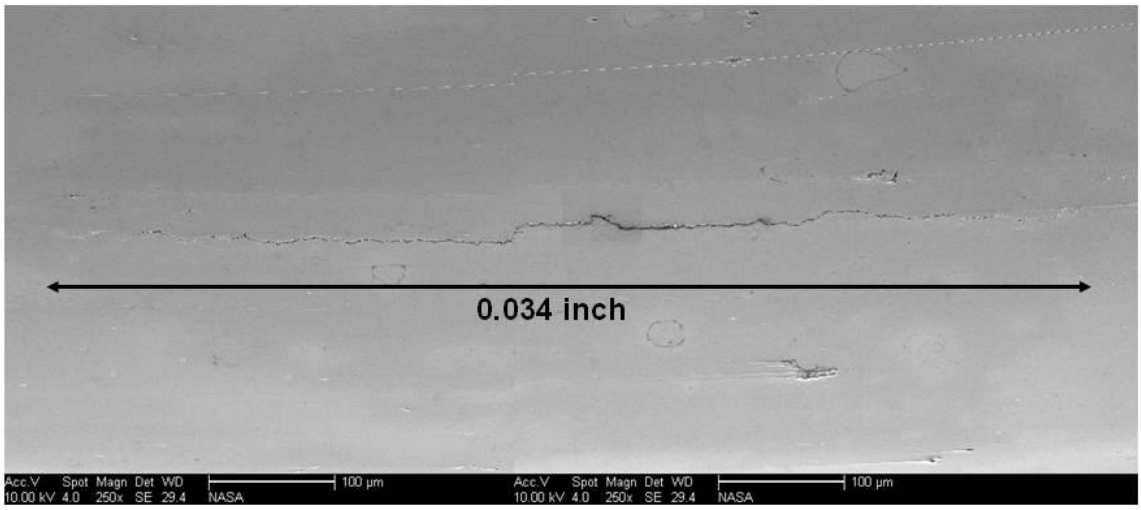
Location of Crack #1



274

Poppet #51

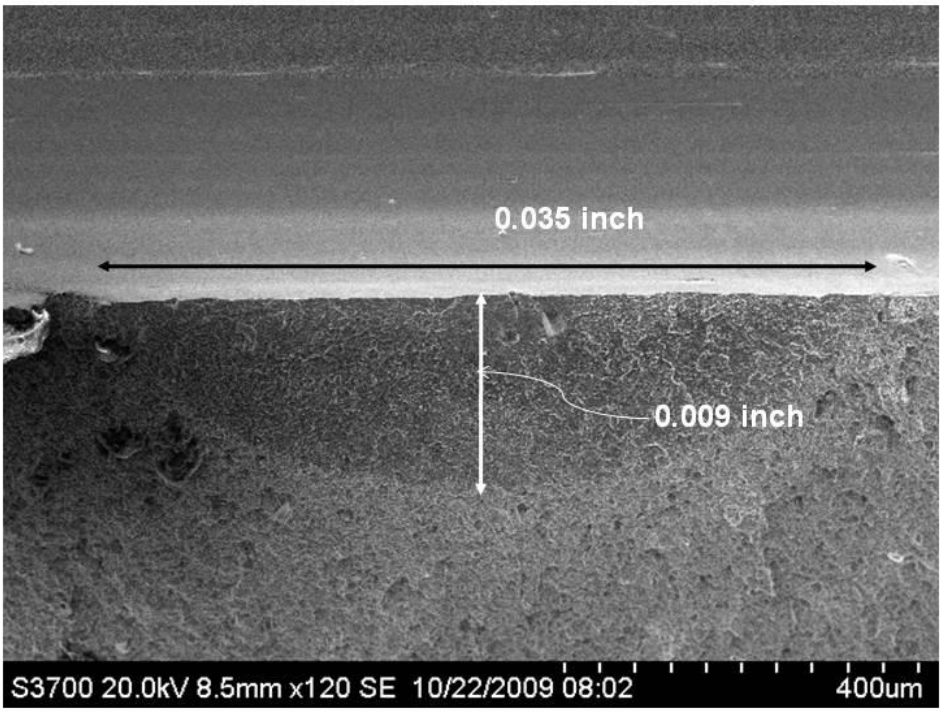
Size of Crack #1



275

Poppet #51

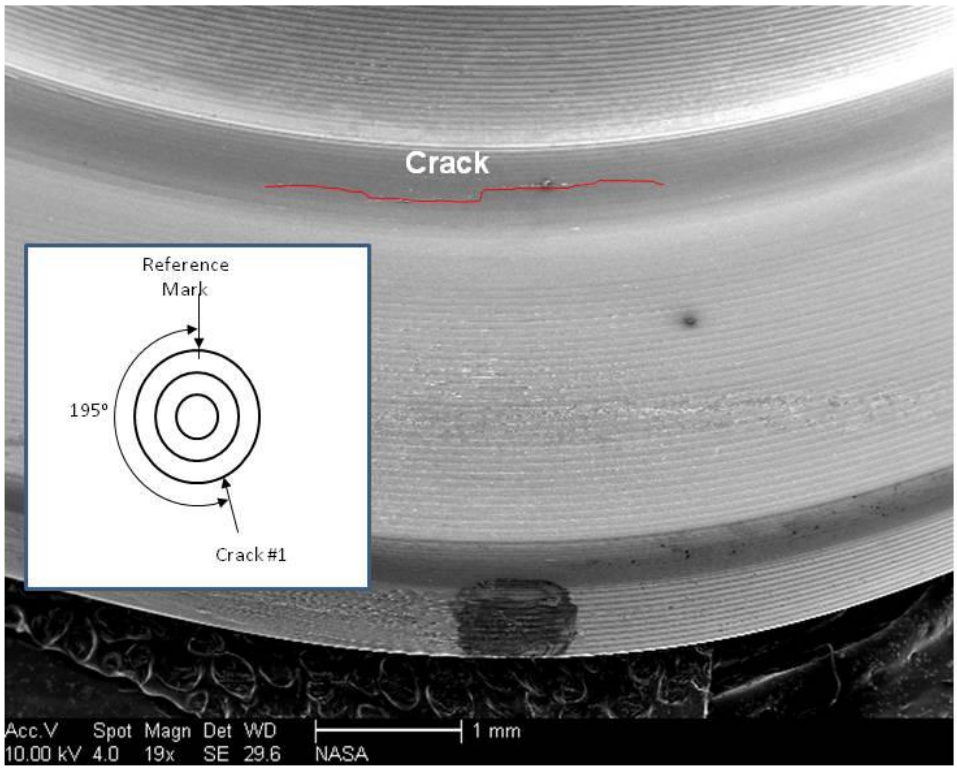
Crack depth and correlation with surface measurements for Crack #1



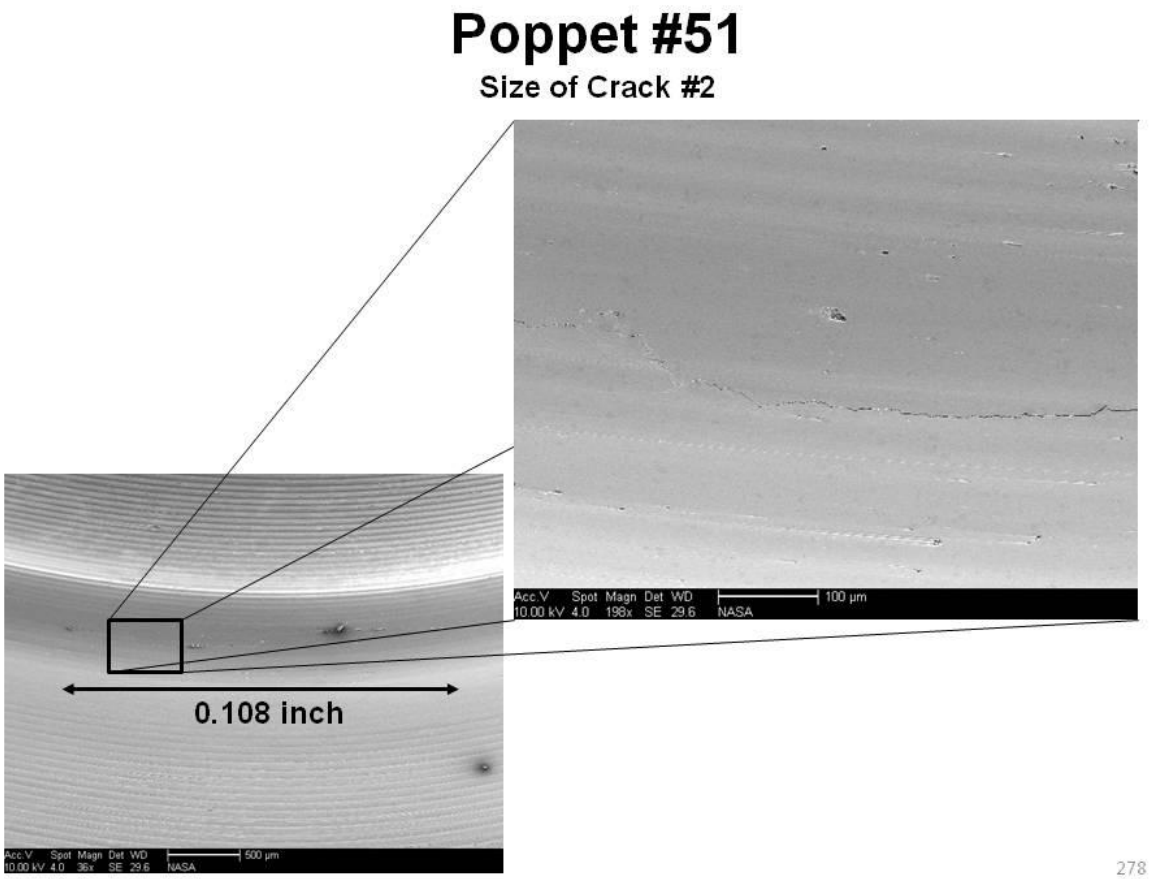
276

Poppet #51

Location of Crack #2

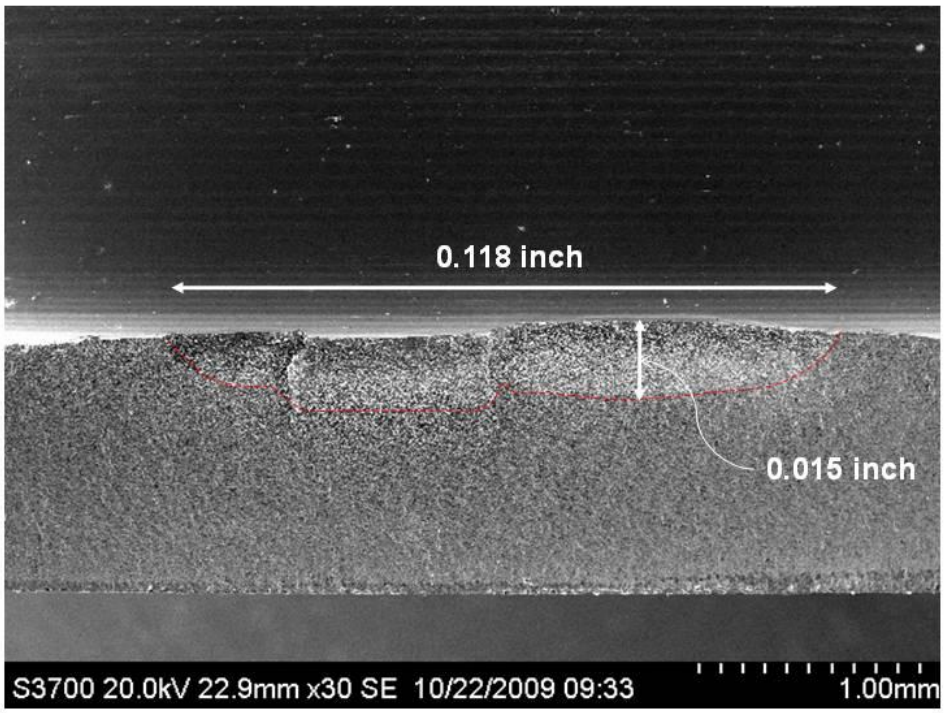


277


Poppet #51
Size of Crack #2
0.108 inch
278

Poppet #51

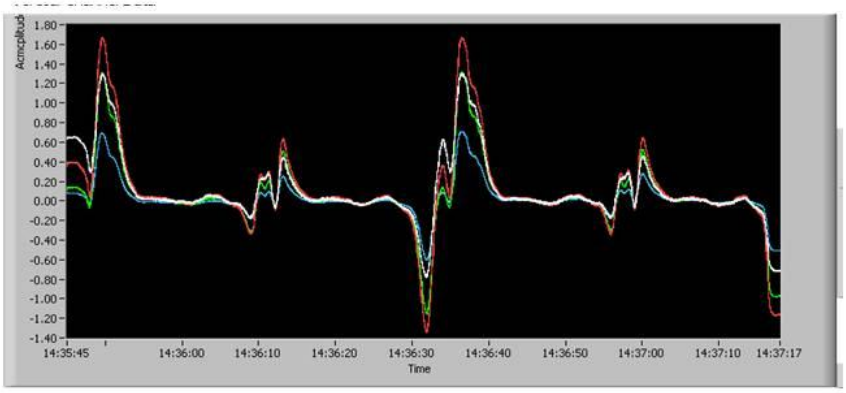
Crack depth and correlation with surface measurements for Crack #2



279

Poppet #51

LaRC eddy current findings, the colors indicate ???



280

Poppet #52

Surface crack sizes and locations

Poppet #52					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.003	115	11	0.014	295
2	0.004	115	12	0.006	295
3	0.004	115	13	0.014	295
4	0.004	115	14	0.008	295
5	0.006	115	15	0.006	295
6	0.005	115	16	0.014	295
7	0.010	115	17	0.008	295
8	0.005	115	18	0.004	295
9	0.012	295	19	0.005	295
10	0.013	295	20	0.003	295

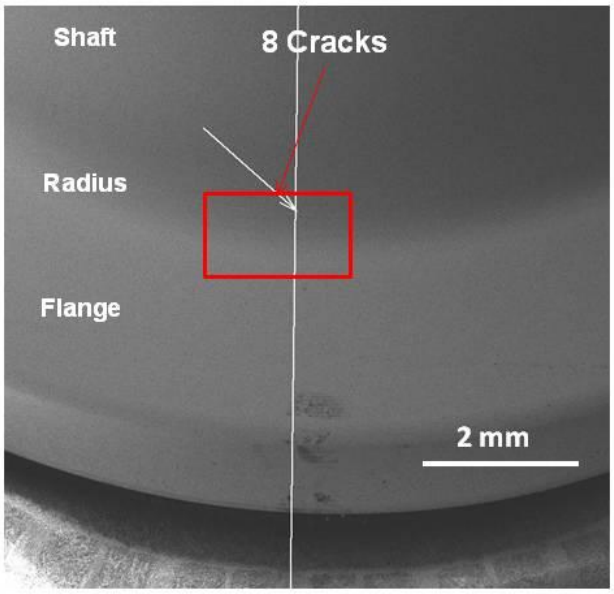
Boeing Eddy Current Findings

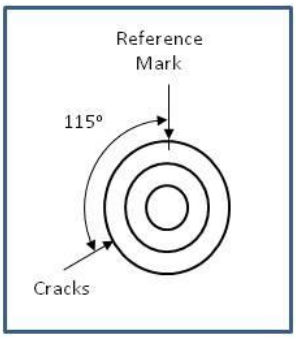
Poppet #52									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.214	0.219	0.223	0.220	0.227	0.222	0.221	Yes	290
J. Engel	0.096	0.096	0.096	0.101	0.099	0.106	0.099	Yes	115
B. Devries	0.093	0.098	0.092	0.099	0.092	0.097	0.095	Yes	110
B. Devries	0.218	0.217	0.215	0.218	0.219	0.218	0.218	Yes	290

281

Poppet #52

Location of Cracks #1-8

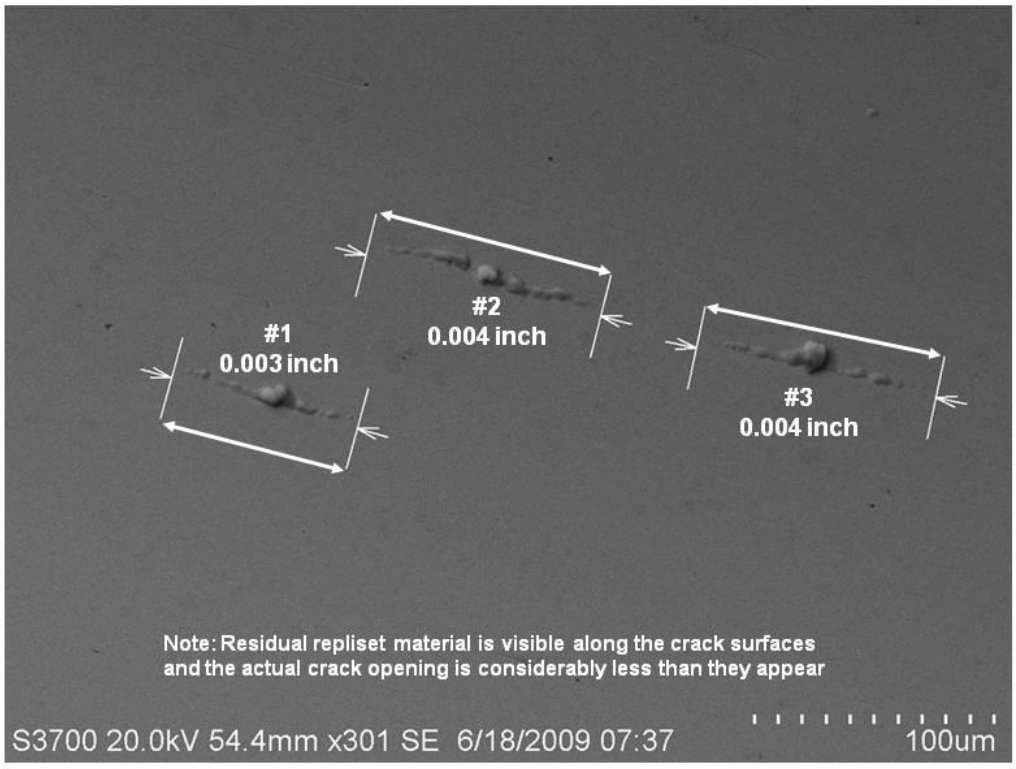




282

Poppet #52

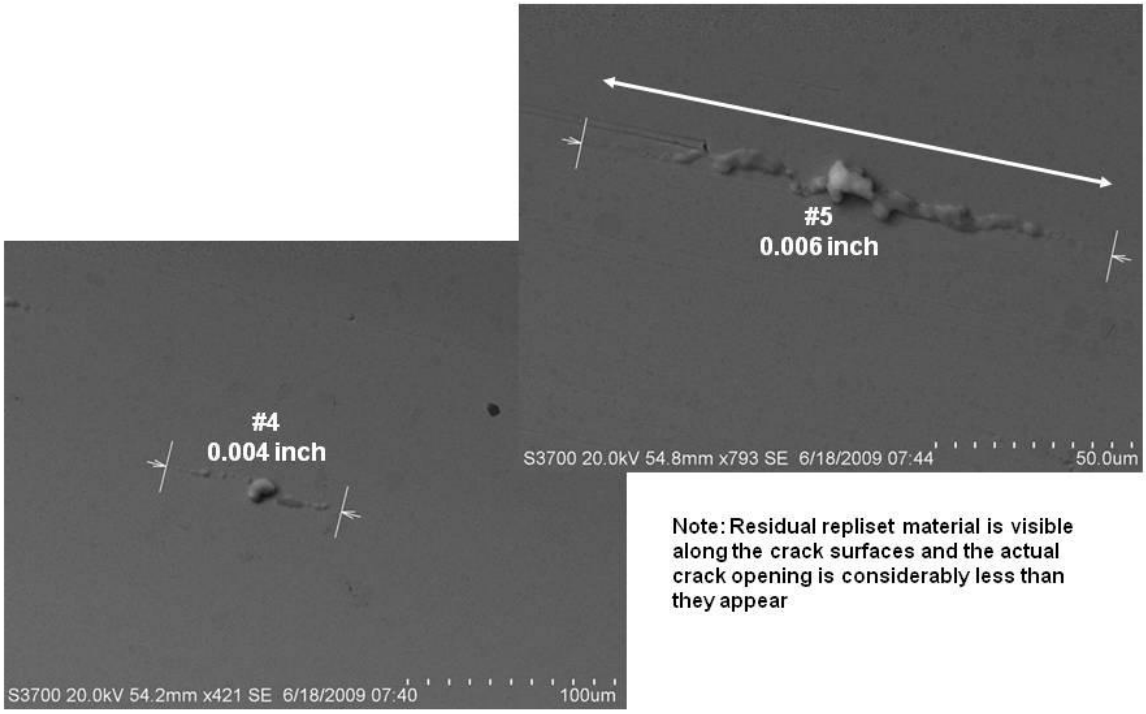
Location and size of Cracks #1-3



283

Poppet #52

Size of Cracks #4-5

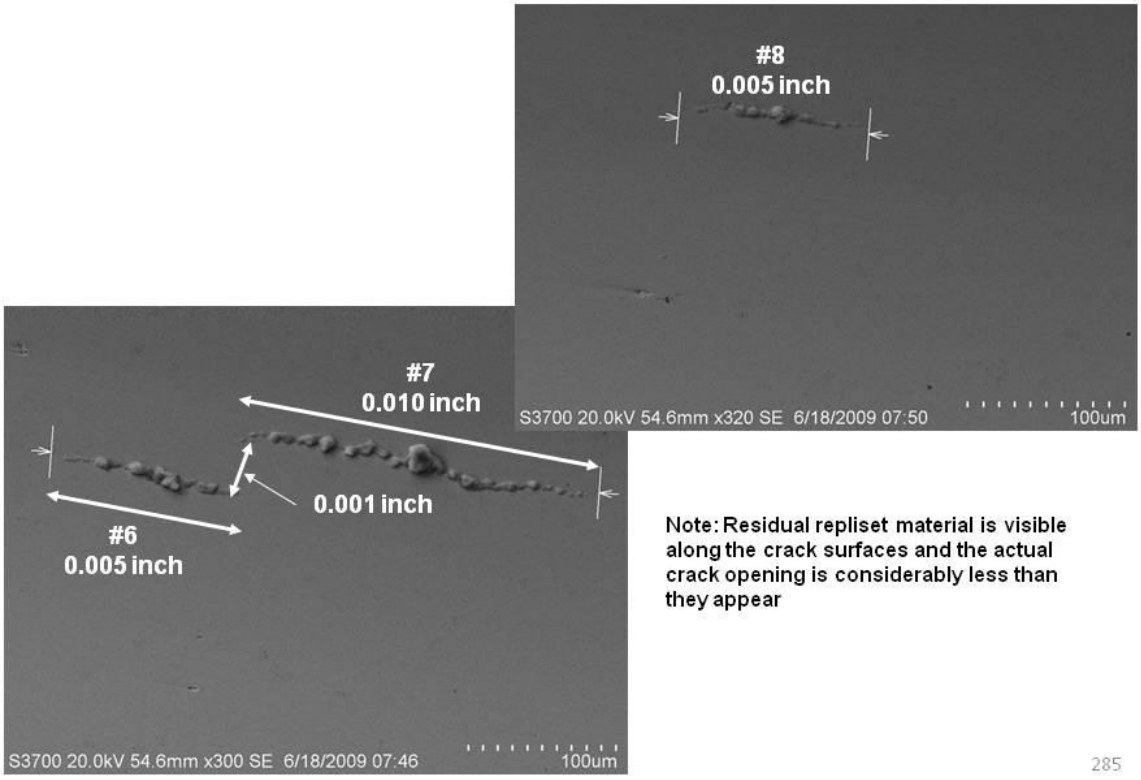


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

284

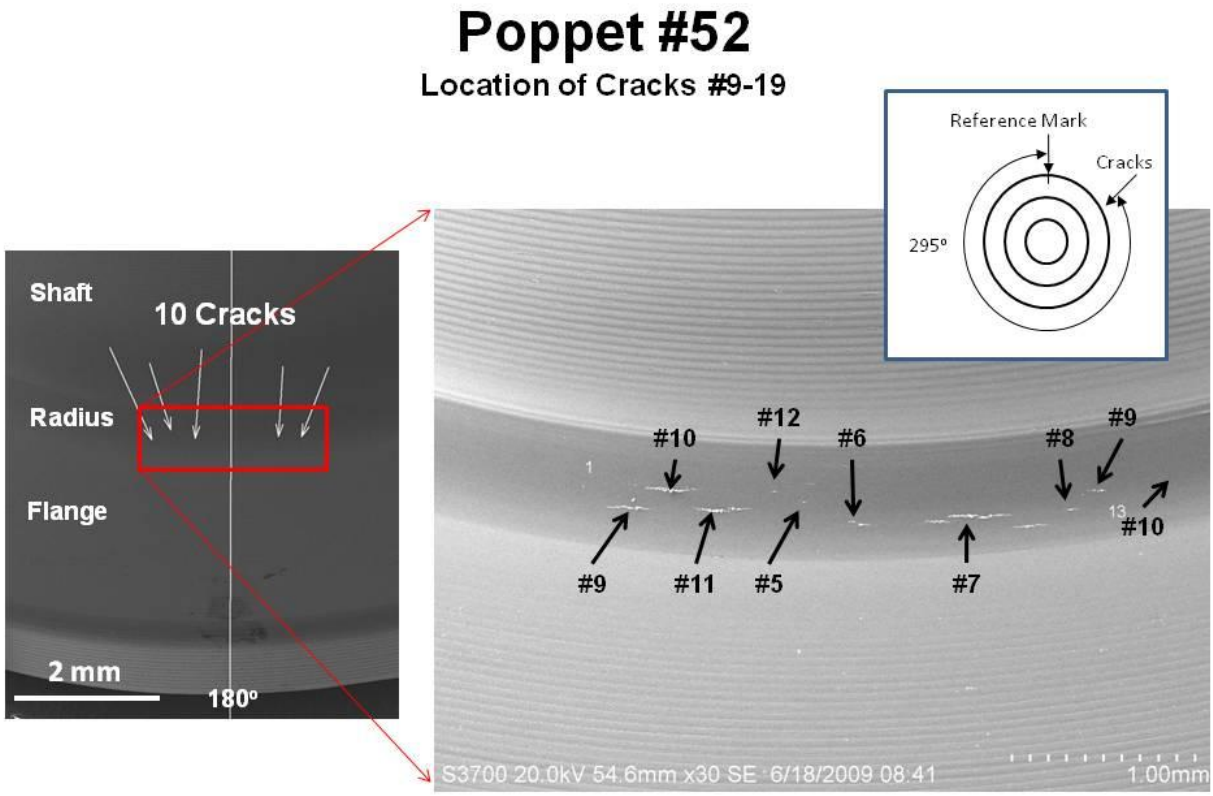
Poppet #52

Location and size of Cracks #6-8



Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

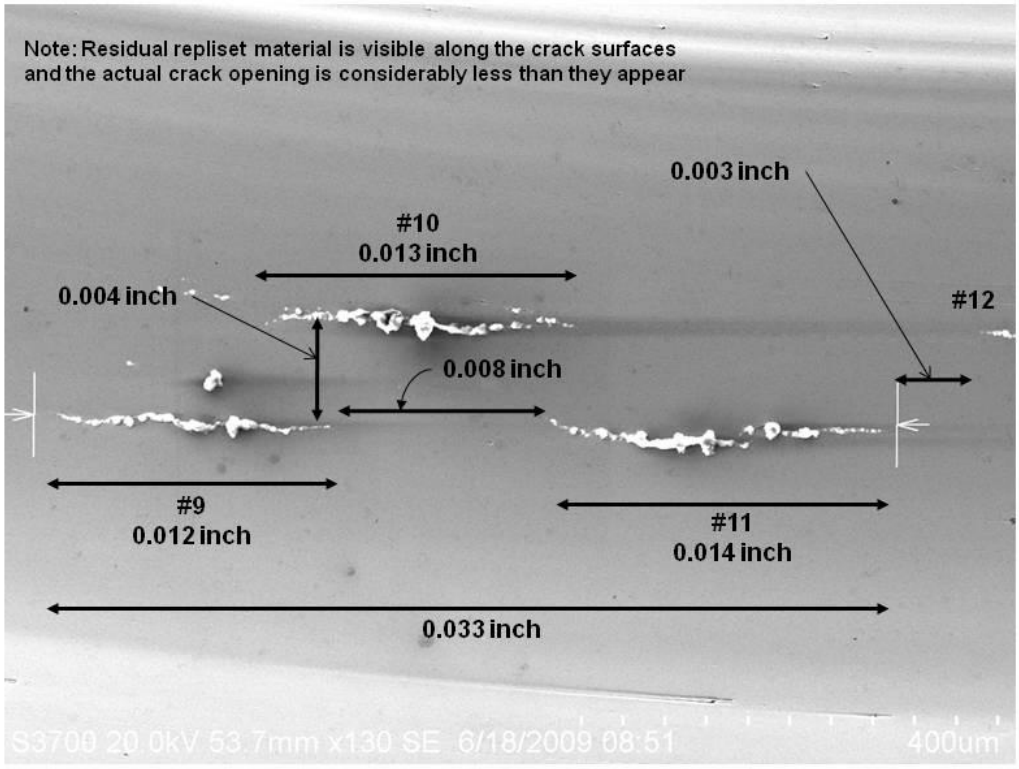
285


Poppet #52
Location of Cracks #9-19
Reference Mark
Cracks
295°
Shaft
10 Cracks
Radius
Flange
2 mm
180°
#10
#12
#6
#8
#9
#9
#11
#5
#7
#10
S3700 20.0kV 54.6mm x30 SE 6/18/2009 08:41
1.00mm

286

Poppet #52

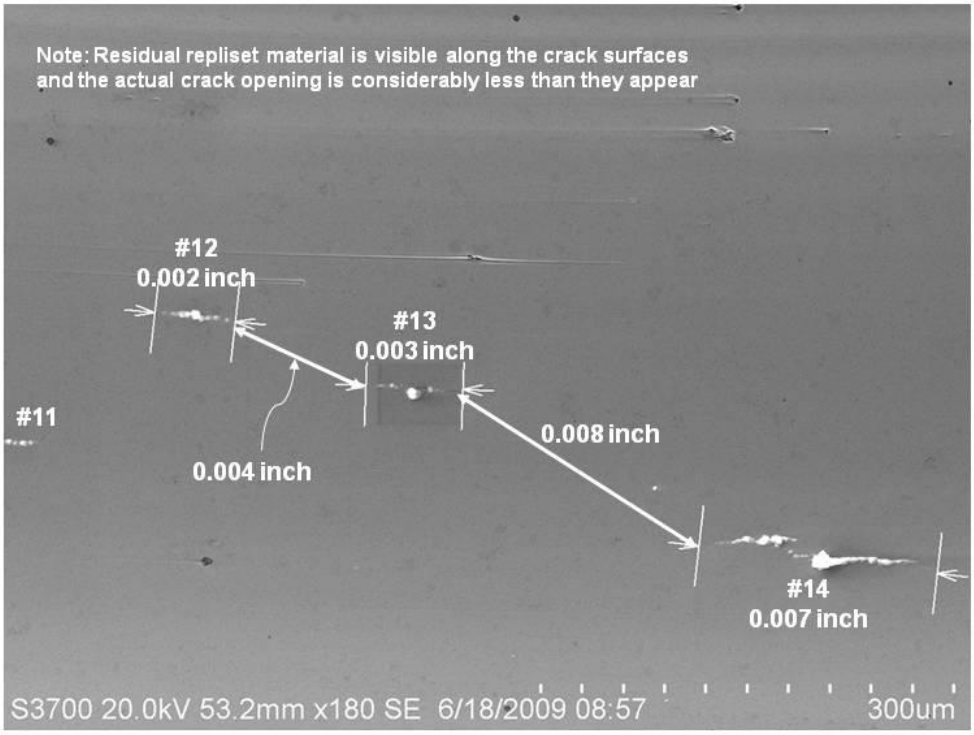
Location and size of Cracks #9-11



287

Poppet #52

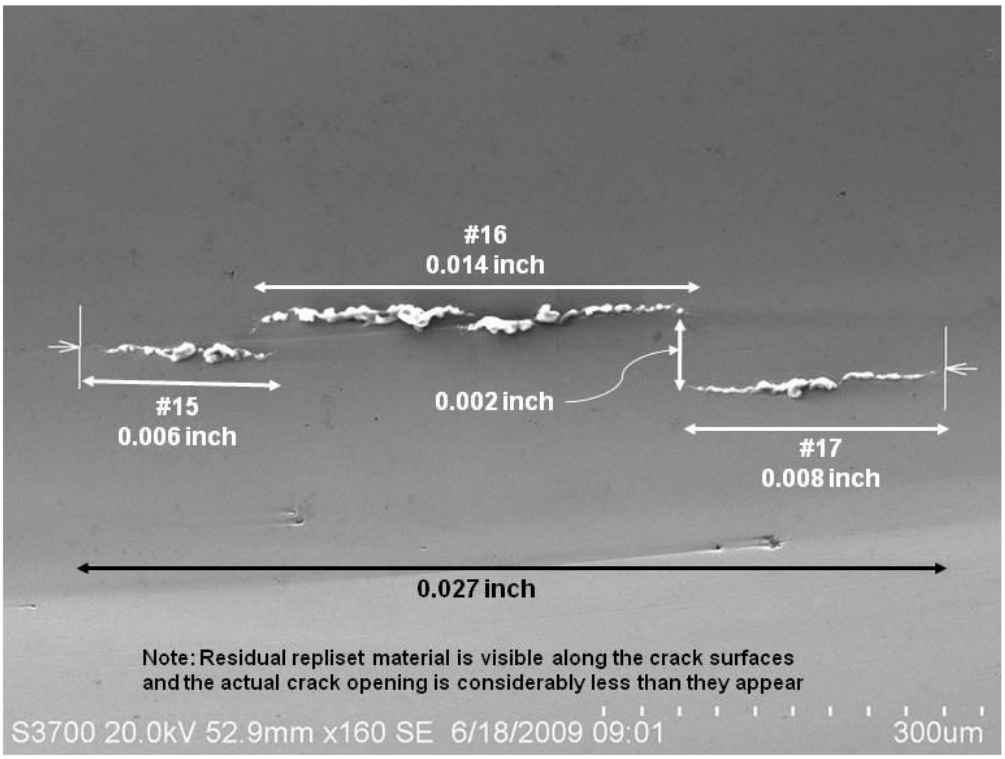
Location and size of Cracks #12-14



288

Poppet #52

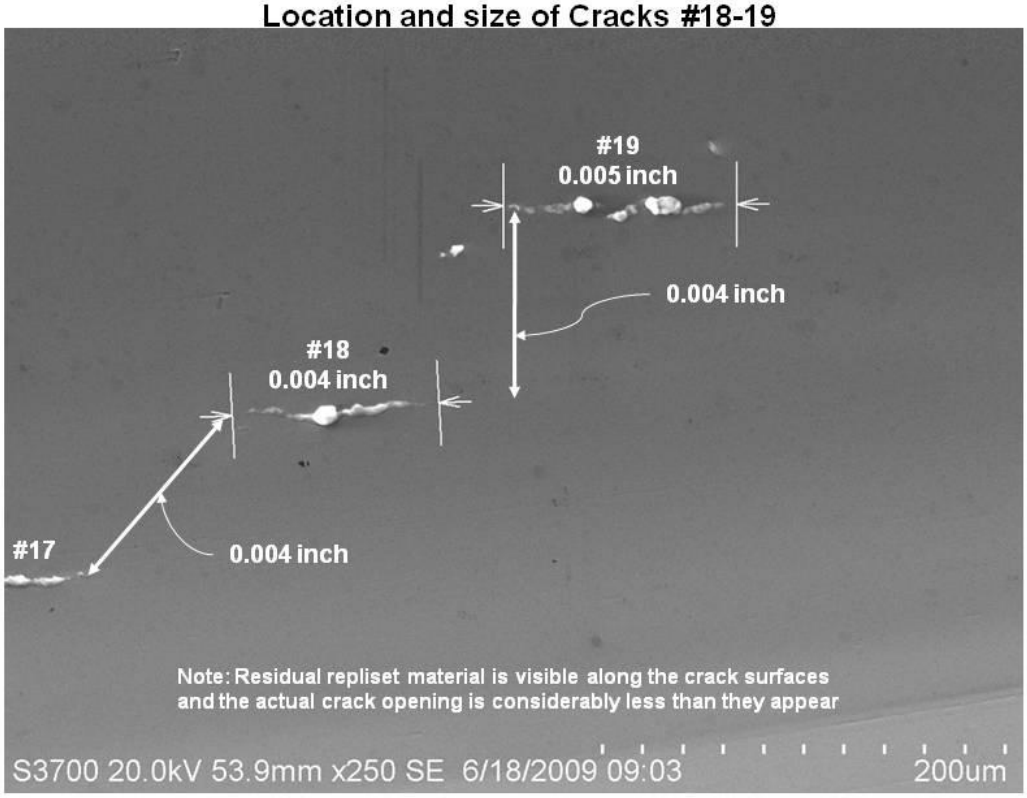
Location and size of Crack #15-17



289

Poppet #52

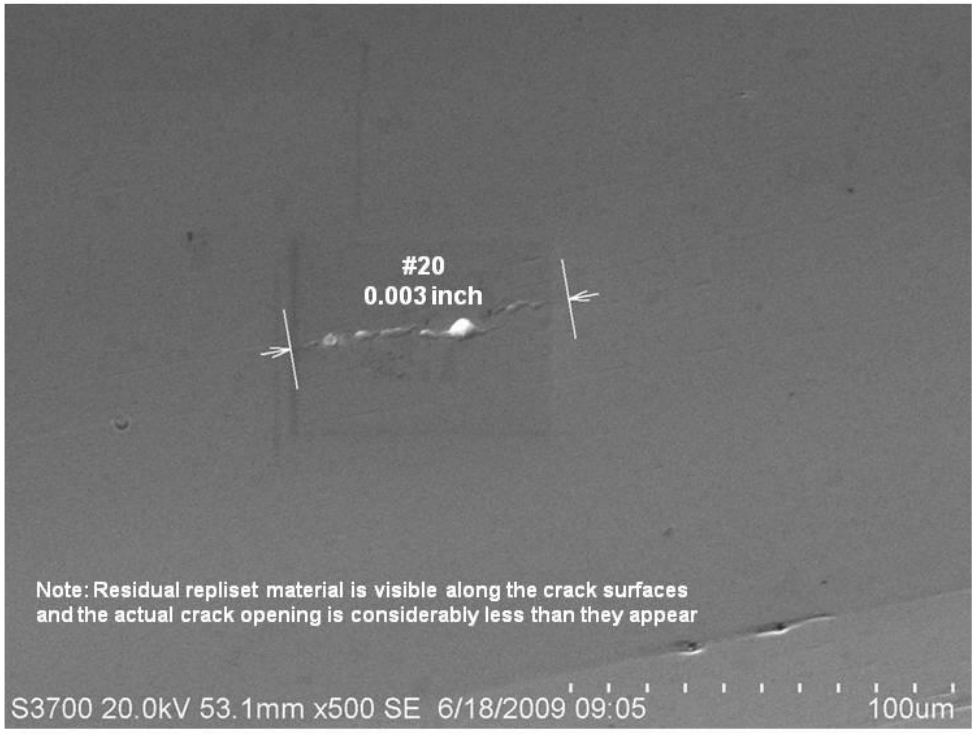
Location and size of Cracks #18-19



290

Poppet #52

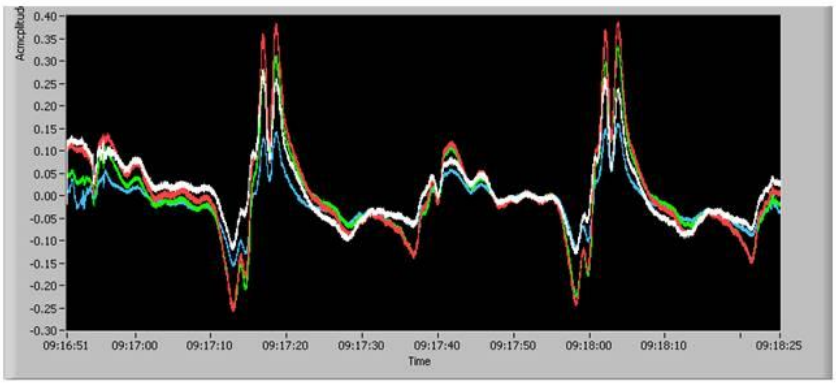
Size of Crack #20



291

Poppet #52

LaRC eddy current findings, the colors indicate ???



292

Poppet #53

Surface crack sizes and locations

Poppet #53		
Crack Number	Size (inch)	Angle (degrees)
1	0.136	35

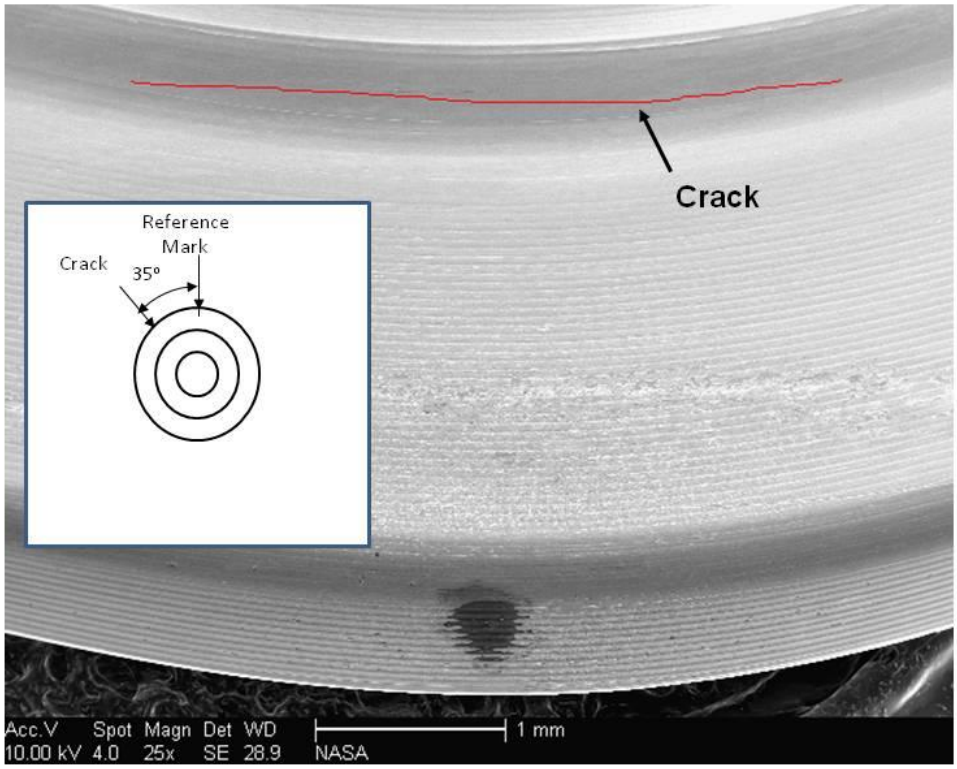
Boeing Eddy Current Findings

Poppet #53									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	1.080	1.093	1.115	1.135	1.139	1.129	1.115	Yes	20
B. Devries	1.080	1.103	1.114	1.113	1.099	1.129	1.106	Yes	25

293

Poppet #53

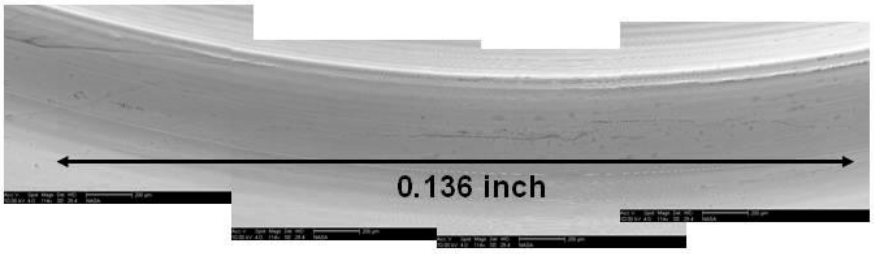
Location of Crack #1



294

Poppet #53

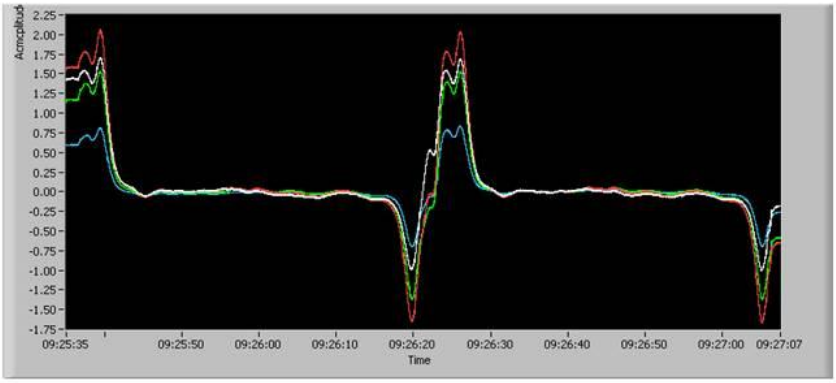
Size of Crack #1



295

Poppet #53

LaRC eddy current findings, the colors indicate ???



296

Poppet #54

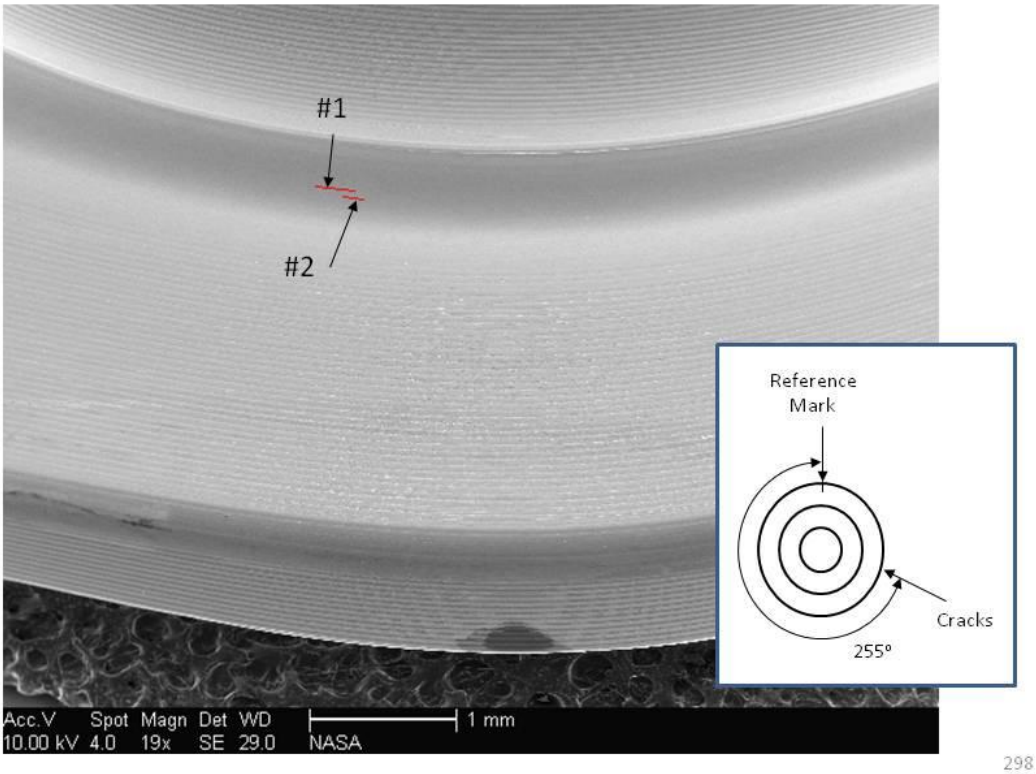
Surface crack sizes and locations

Poppet #54		
Crack Number	Size (inch)	Angle (degrees)
1	0.017	255
2	0.007	255

Boeing Eddy Current Findings

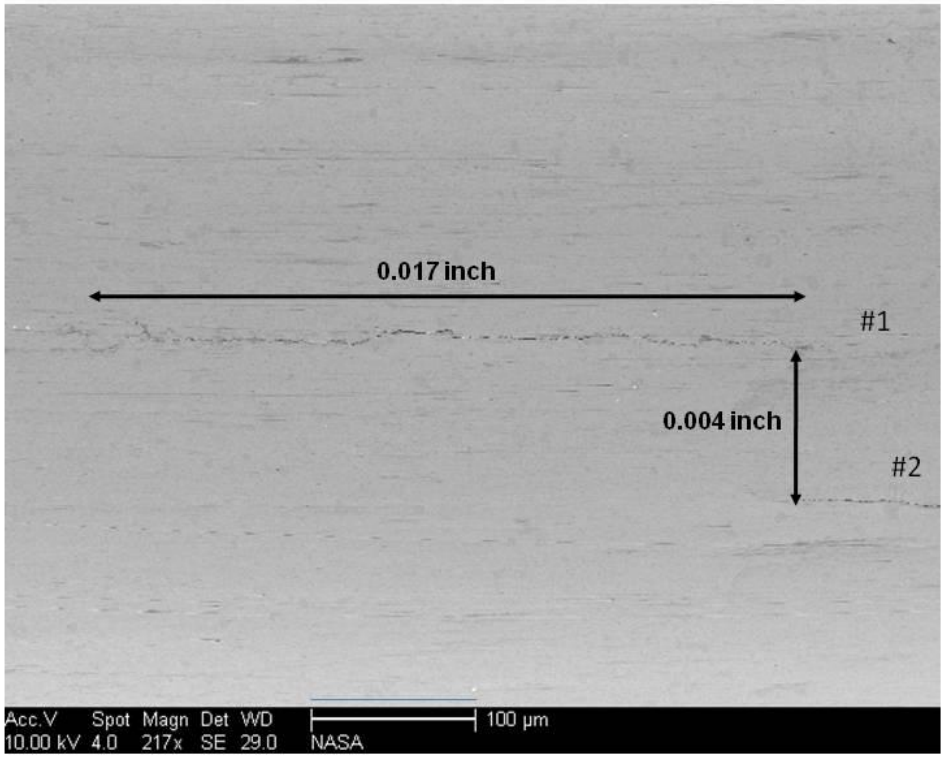
Poppet #54									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.212	0.211	0.209	0.212	0.212	0.216	0.212	Yes	250
B. Devries	0.217	0.216	0.226	0.216	0.221	0.219	0.219	Yes	255

297


Poppet #54
Location of Cracks #1-6
#1
#2
Reference Mark
Cracks
255°
Acc.V Spot Magn Det WD
10.00 kV 4.0 19x SE 29.0
1 mm
NASA
298

Poppet #54

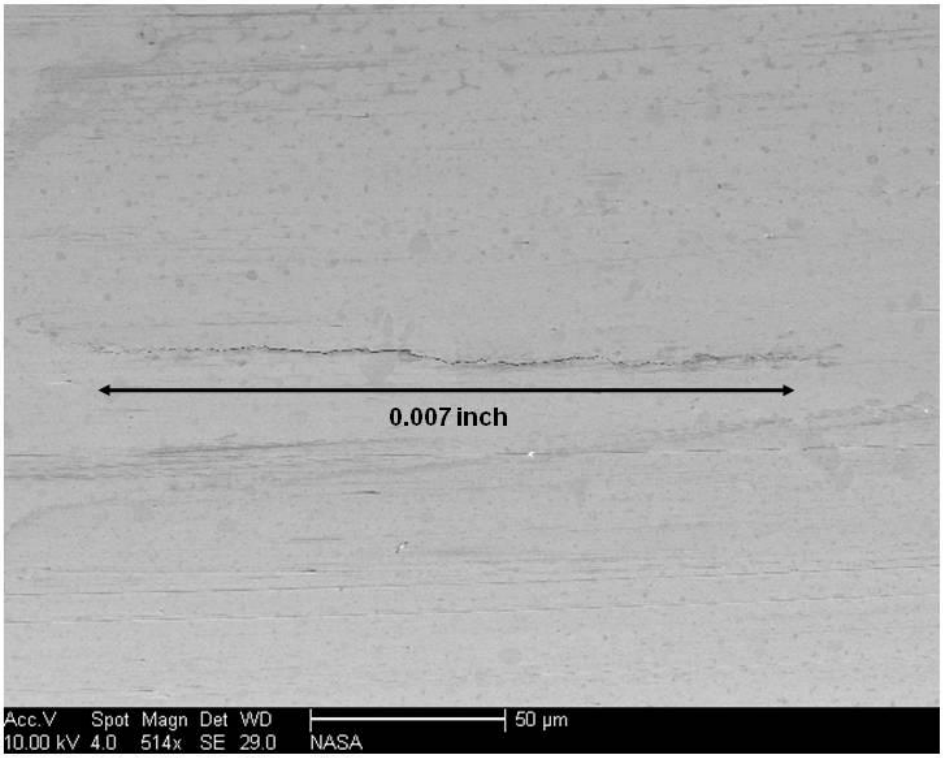
Size of Crack #1



299

Poppet #54

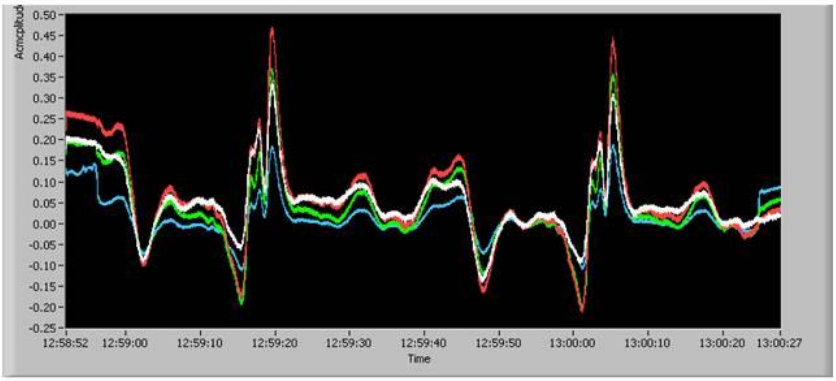
Size of Crack #2



300

Poppet #54

LaRC eddy current findings, the colors indicate ???



301

Poppet #55

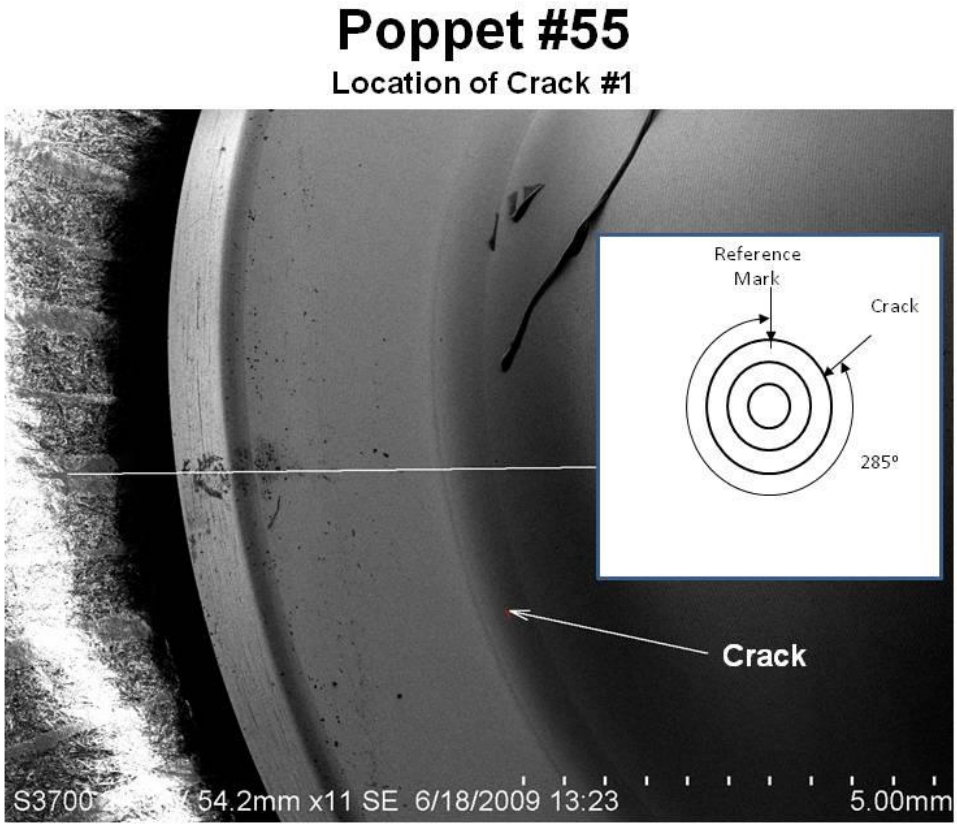
Surface crack sizes and locations

Poppet #55		
Crack Number	Size (inch)	Angle (degrees)
1	0.004	285

Boeing Eddy Current Findings

Poppet #55									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.044	0.039	0.035	0.041	0.040	0.044	0.041	No	285
B. Devries	0.036	0.035	0.033	0.038	0.035	0.031	0.035	No	285

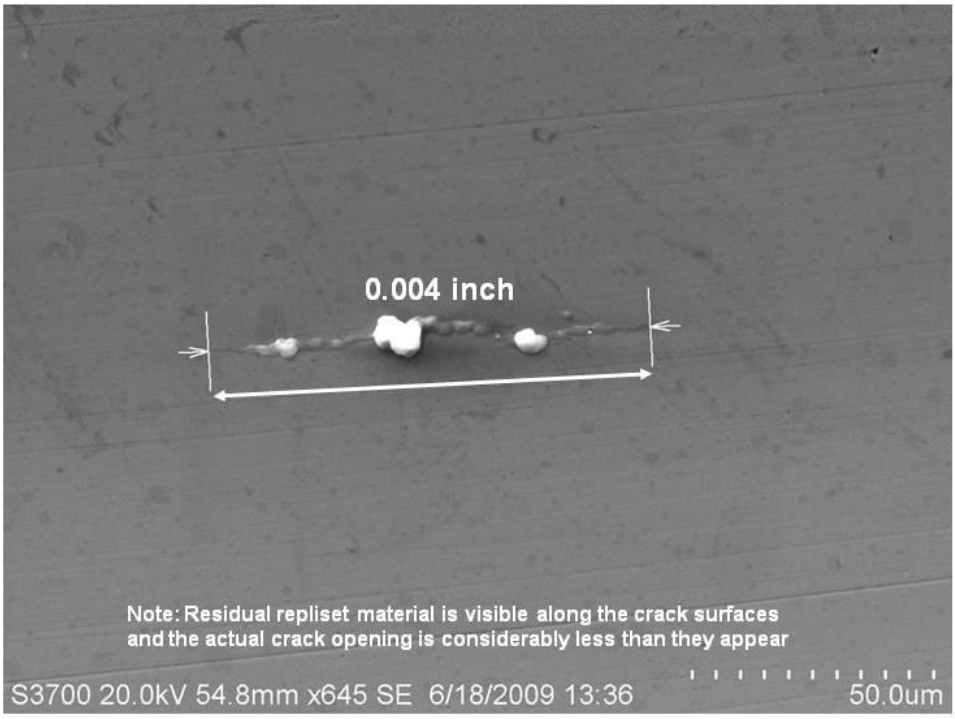
302


Poppet #55
Location of Crack #1
Reference Mark
Crack
285°
Crack
S3700
54.2mm x11 SE 6/18/2009 13:23
5.00mm

303

Poppet #55

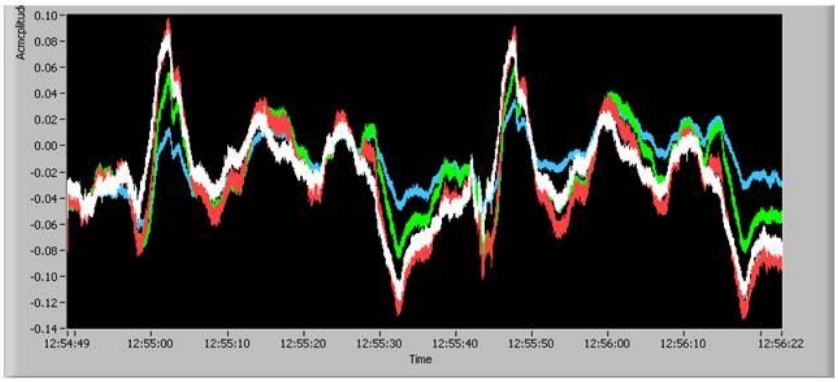
Size of Crack #1



304

Poppet #55

LaRC eddy current findings, the colors indicate ???



305

Poppet #56

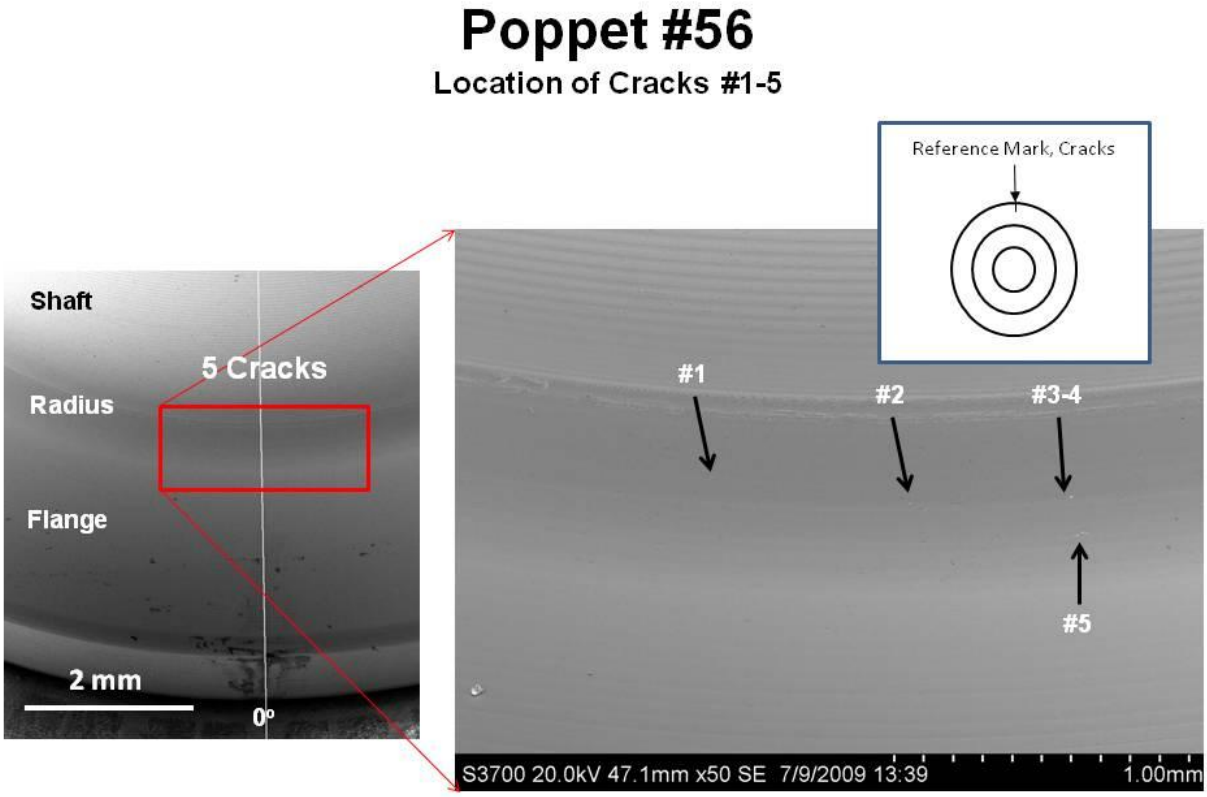
Surface crack sizes and locations

Poppet #56					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.002	0	11	0.003	180
2	0.003	0	12	0.002	180
3	0.004	0	13	0.002	180
4	0.005	0	14	0.002	180
5	0.006	0	15	0.002	180
6	0.003	180	16	0.004	180
7	0.002	180	17	0.004	180
8	0.002	180	18	0.002	180
9	0.004	180	19	0.003	180
10	0.045	180			

Boeing Eddy Current Findings

None Provided

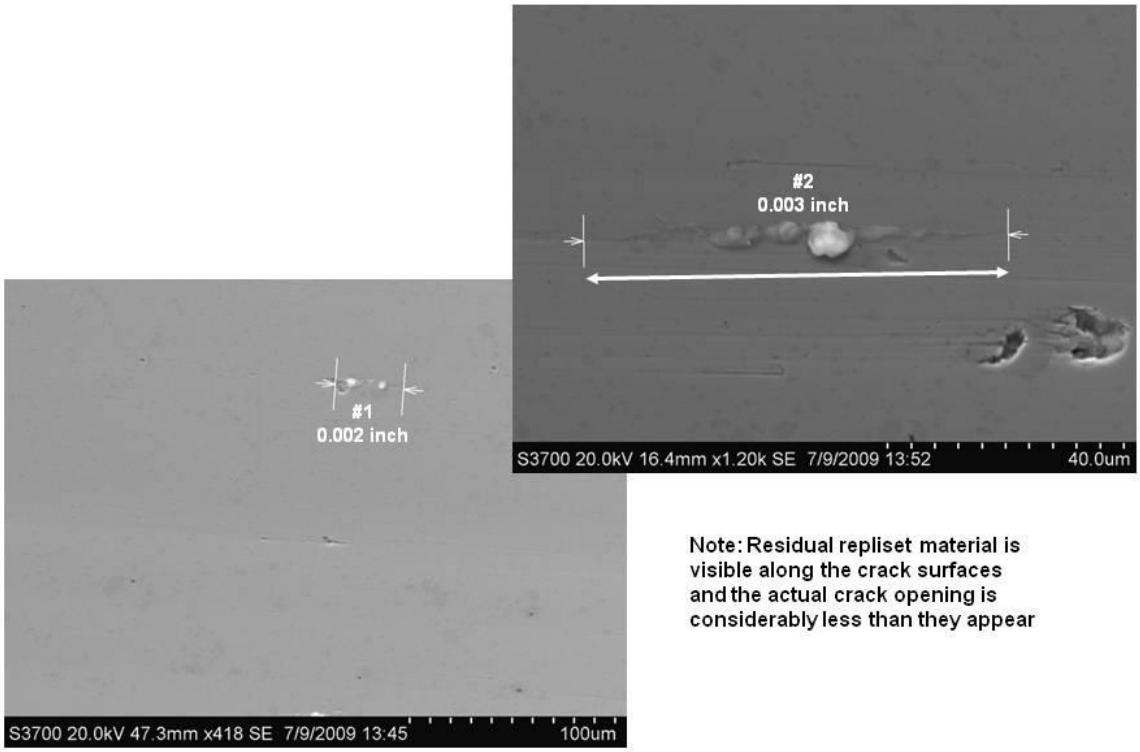
306


Poppet #56
Location of Cracks #1-5
Reference Mark, Cracks
Shaft
5 Cracks
Radius
Flange
2 mm
0°
#1
#2
#3-4
#5
S3700 20.0kV 47.1mm x50 SE 7/9/2009 13:39
1.00mm

307

Poppet #56

Size of Cracks #1 and 2

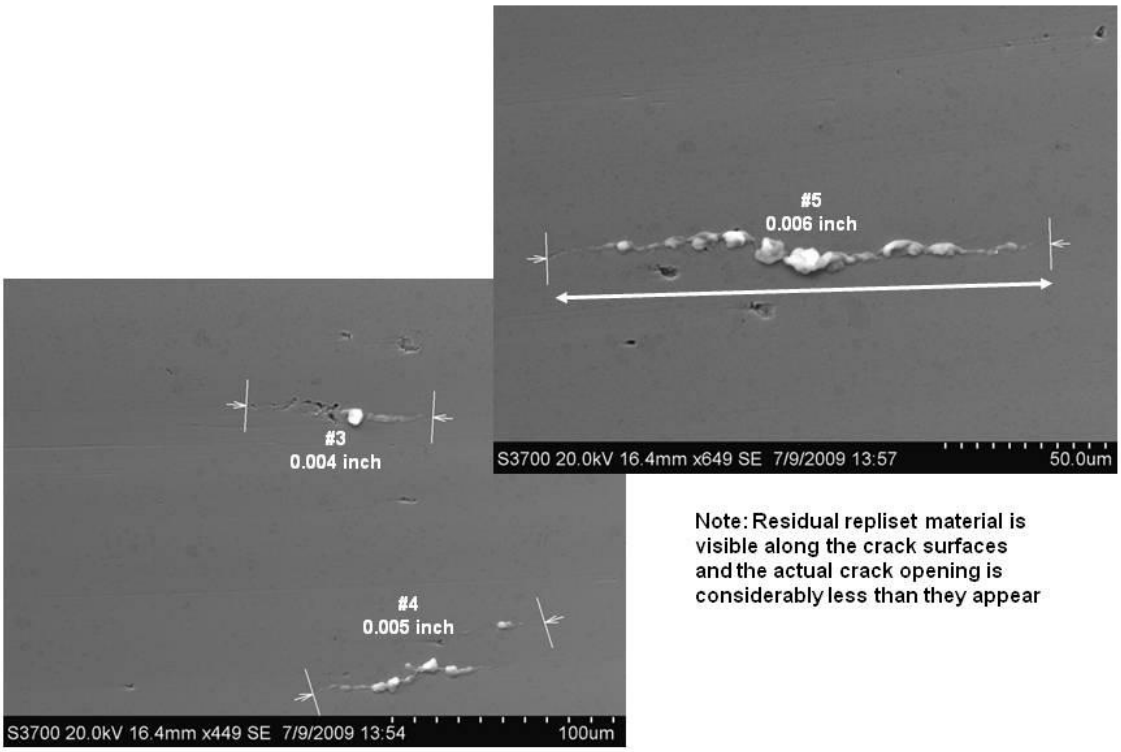


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

308

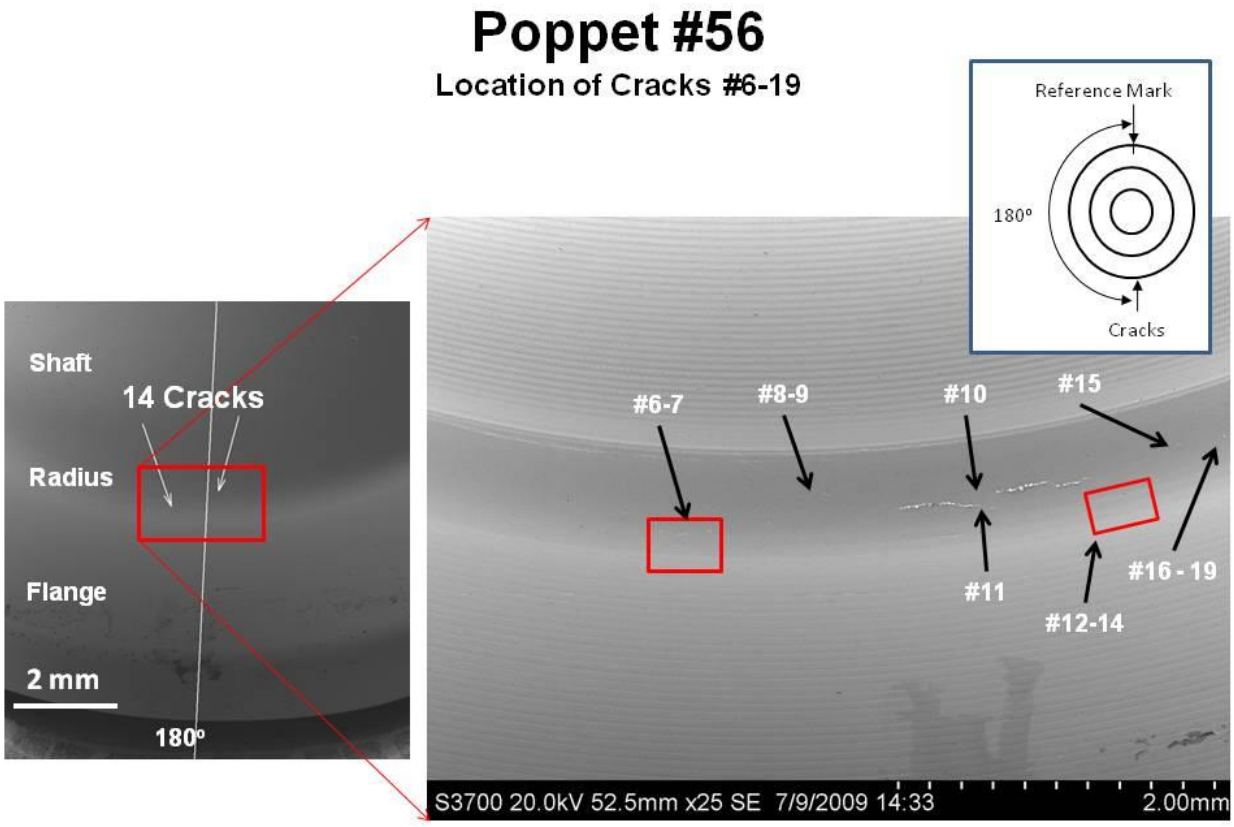
Poppet #56

Size of Cracks #3-5



Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

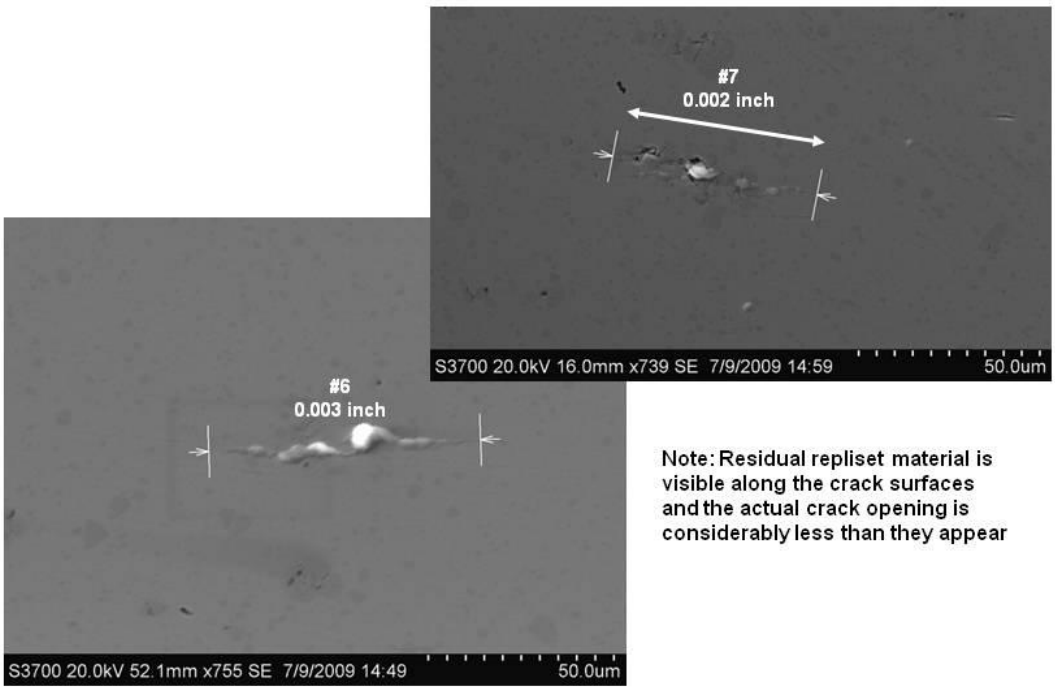
309


Poppet #56
Location of Cracks #6-19
Reference Mark
180°
Cracks
Shaft
14 Cracks
Radius
Flange
2 mm
180°
#6-7
#8-9
#10
#15
#11
#12-14
#16 - 19
S3700 20.0kV 52.5mm x25 SE 7/9/2009 14:33
2.00mm

310

Poppet #56

Size of Cracks #6 and 7

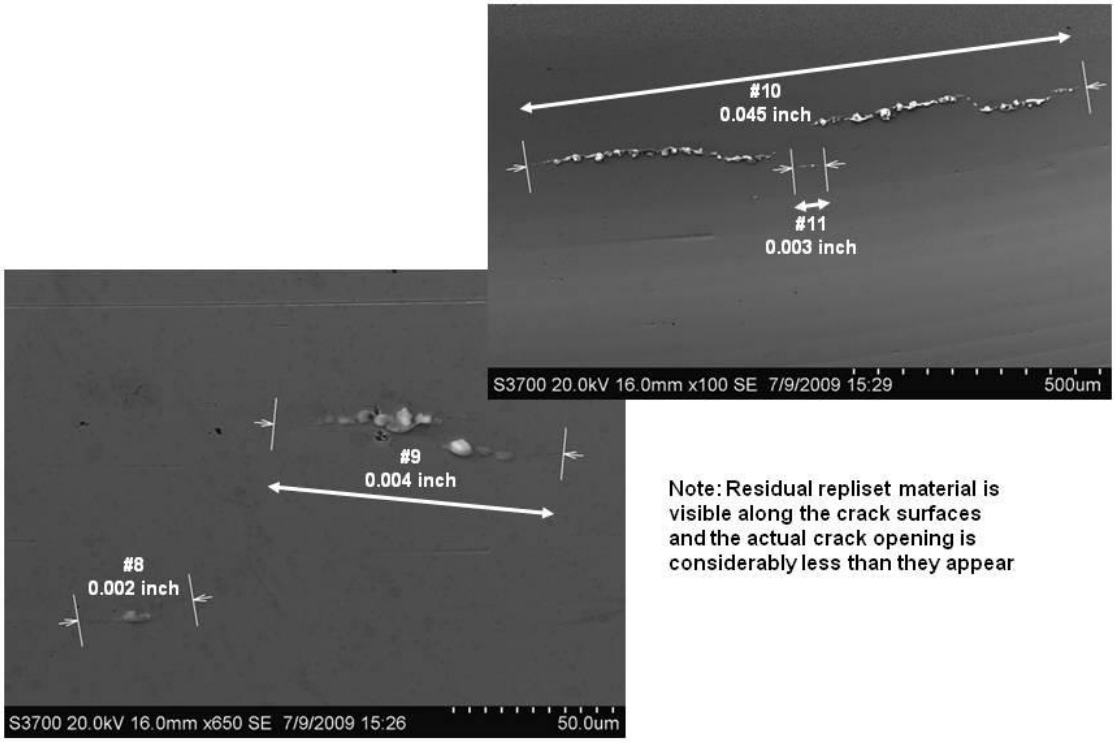


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

311

Poppet #56

Size of Cracks #8-11

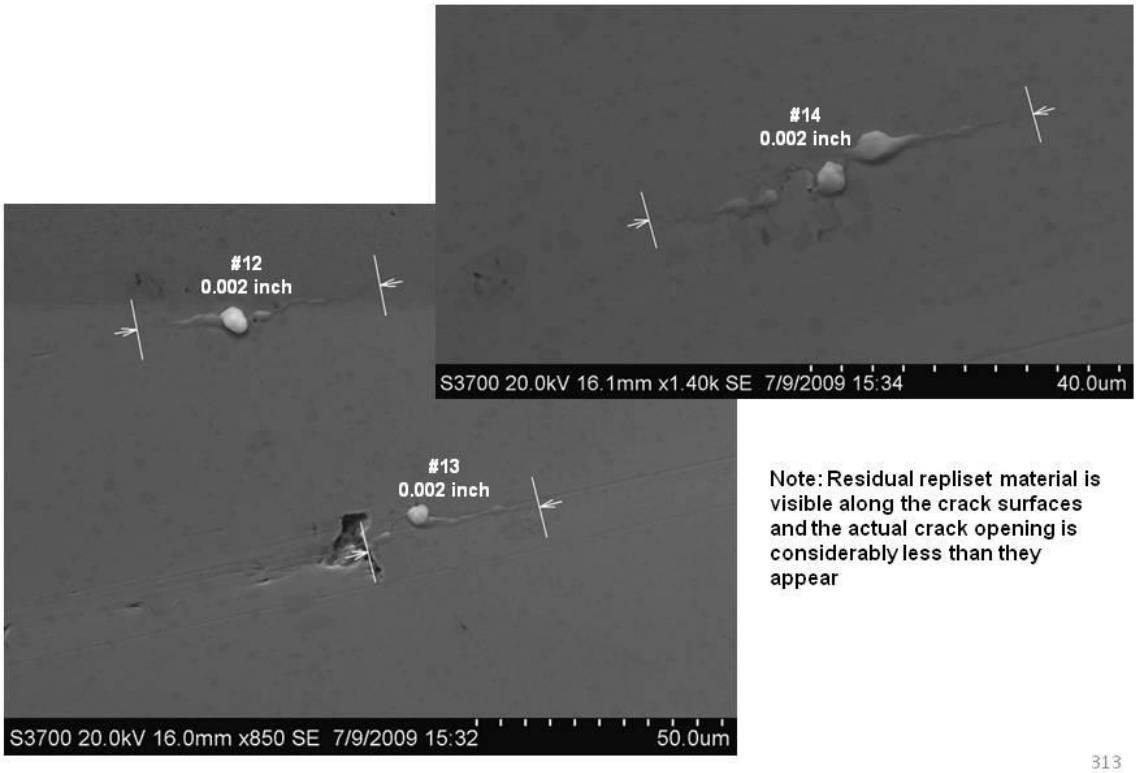


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

312

Poppet #56

Size of Cracks #12-14

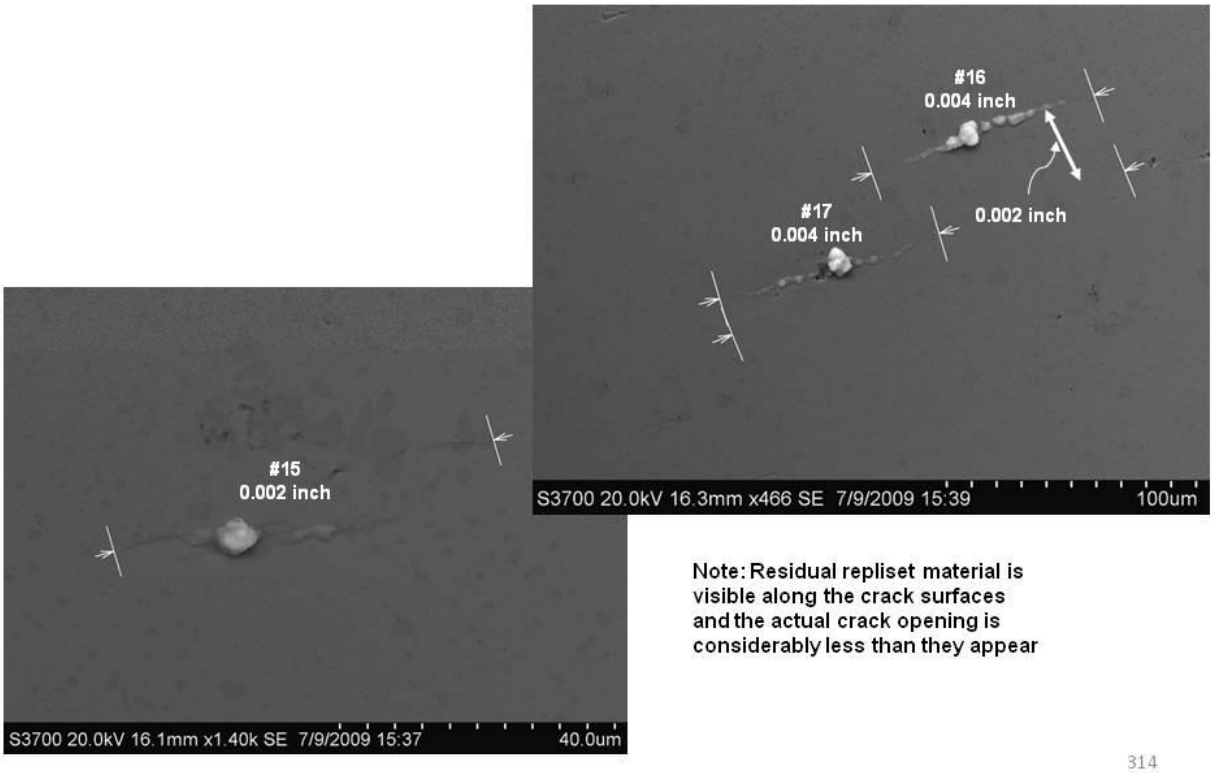


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

313

Poppet #56

Size of Cracks #15-17

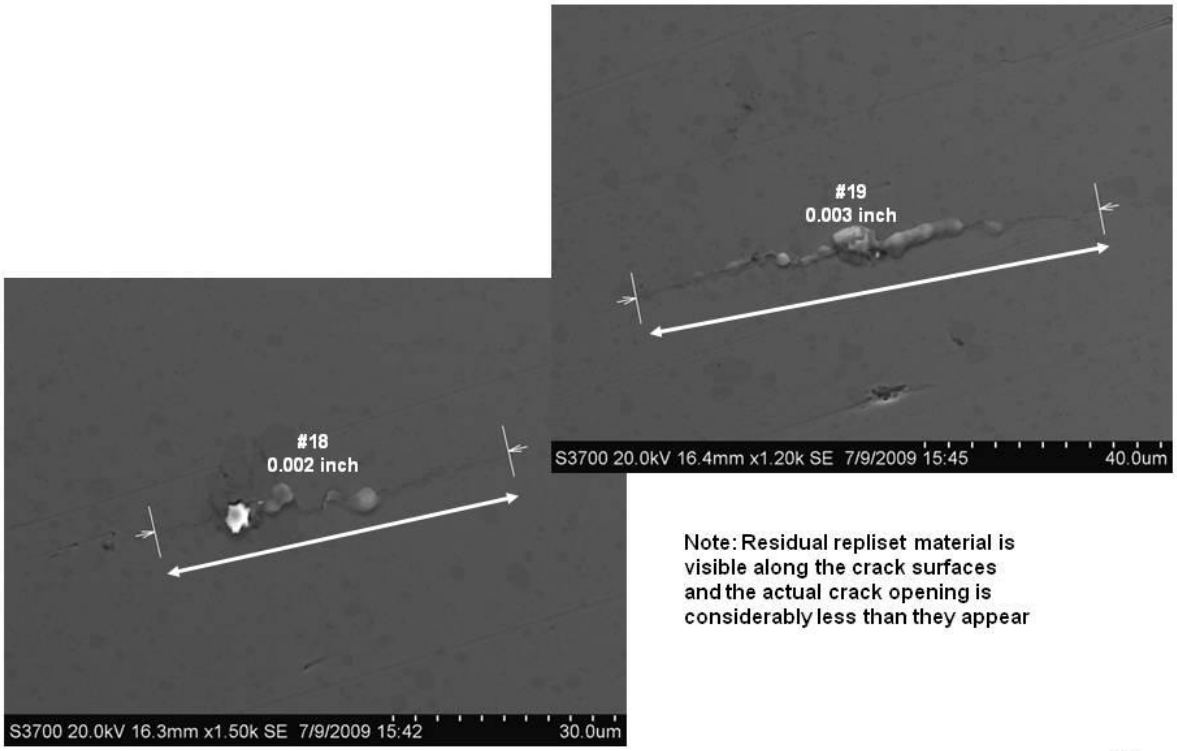


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

314

Poppet #56

Size of Cracks #18 and 19

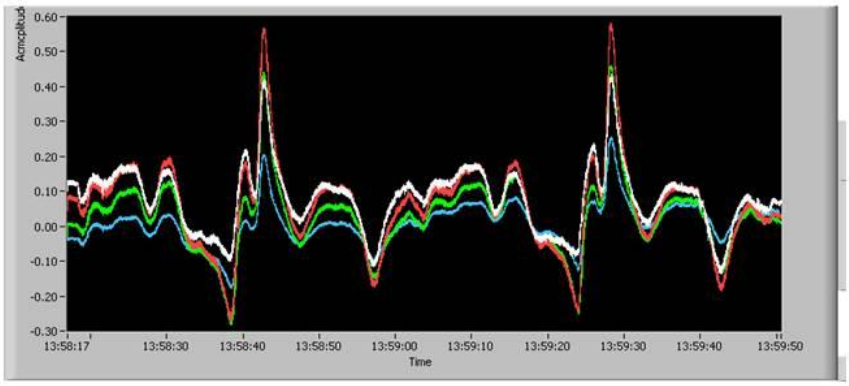


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

315

Poppet #56

LaRC eddy current findings, the colors indicate ???



316

Poppet #57

Surface crack sizes and locations

Poppet #57		
Crack Number	Size (inch)	Angle (degrees)
1	0.079	335
2	0.005	335
3	0.014	335
4	0.005	335
5	0.007	155
6	0.002	155
7	0.005	155

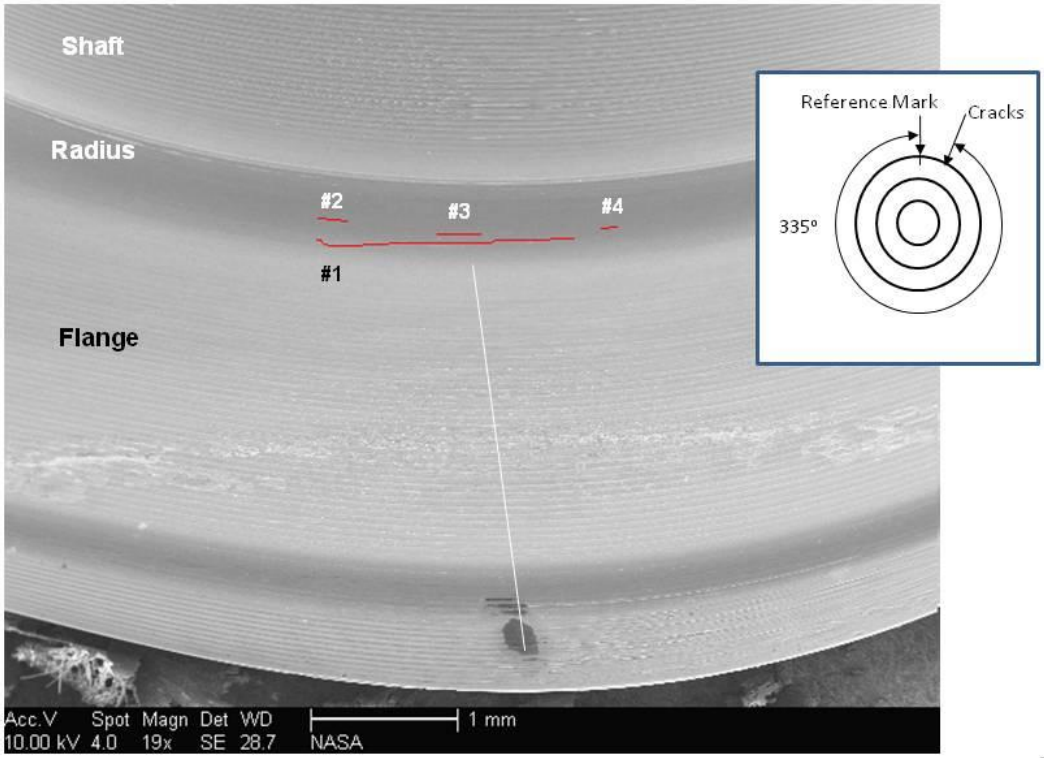
Boeing Eddy Current Findings

Poppet #57									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.498	0.488	0.480	0.478	0.486	0.480	0.485	Yes	335
J. Engel	0.170	0.160	0.169	0.165	0.174	0.171	0.168	Yes	160
B. Devries	0.487	0.491	0.488	0.494	0.447	0.494	0.484	Yes	330
B. Devries	0.170	0.167	0.168	0.165	0.149	0.157	0.163	No	160

317

Poppet #57

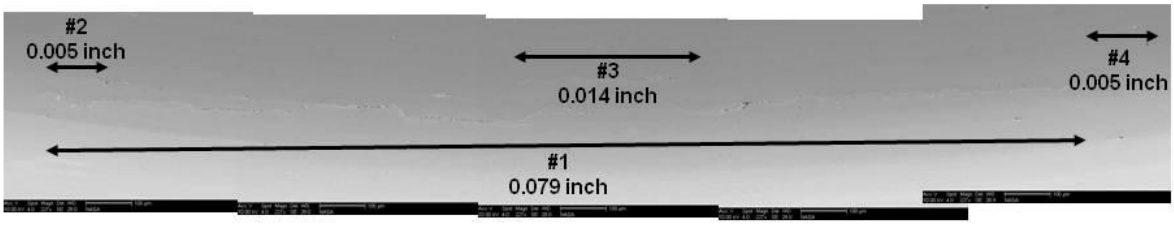
Location of Cracks #1-4



318

Poppet #57

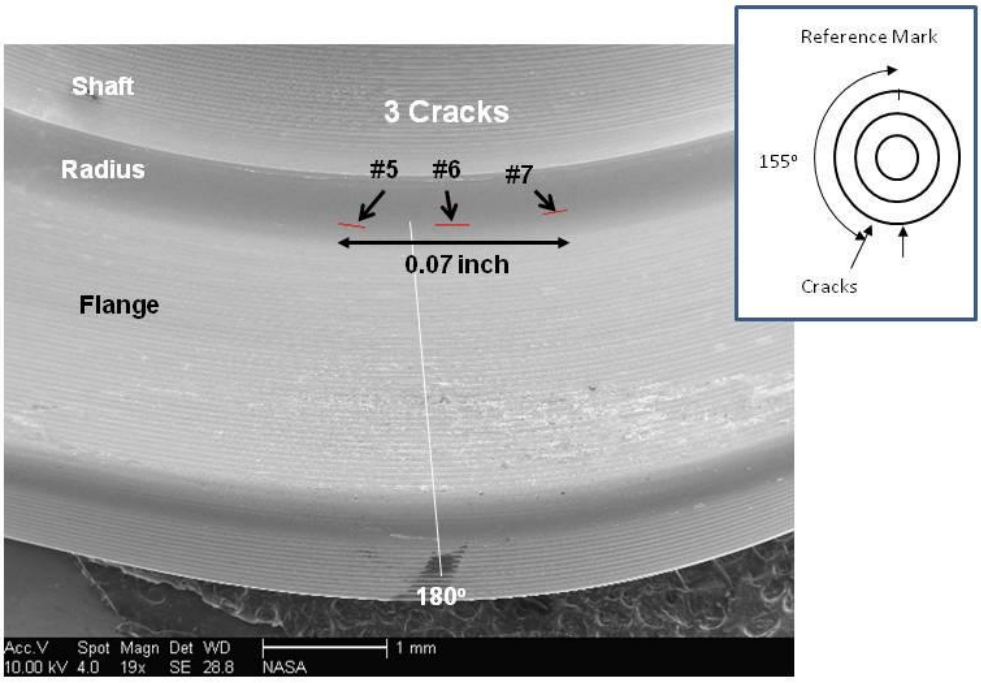
Size of Cracks #1-4



319

Poppet #57

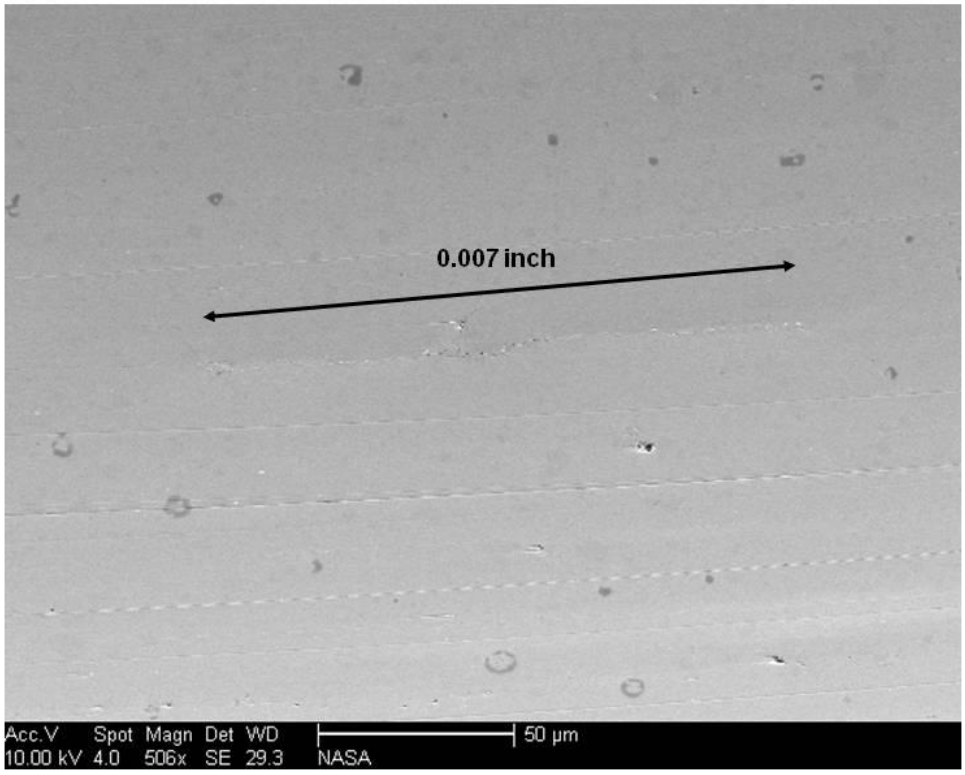
Location of Cracks #5-7



320

Poppet #57

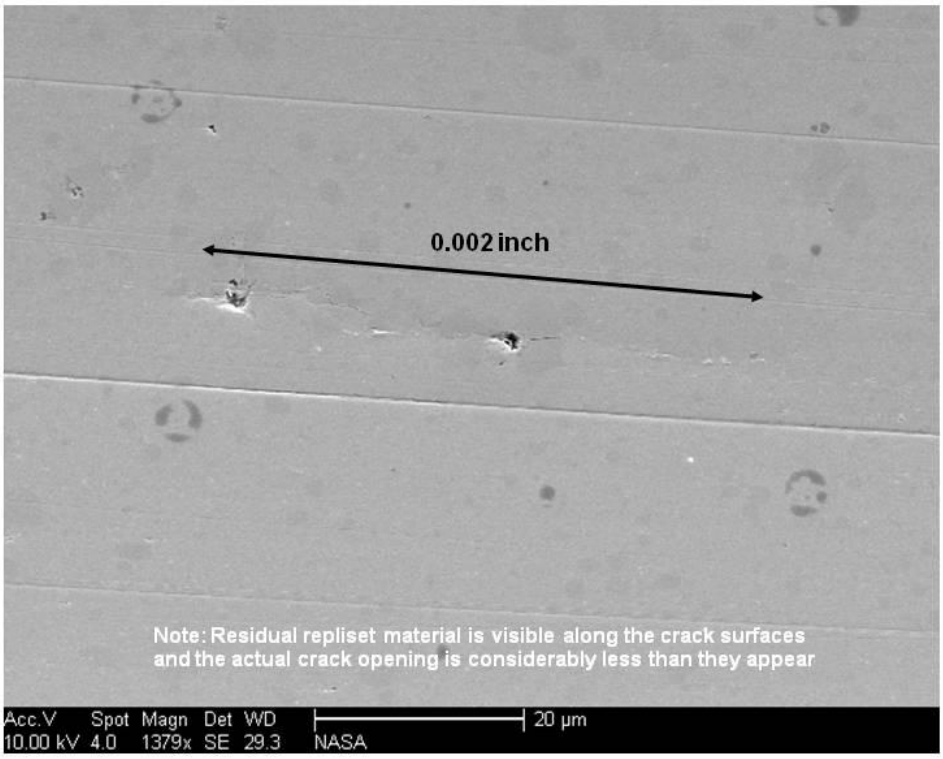
Size of Crack #5



321

Poppet #57

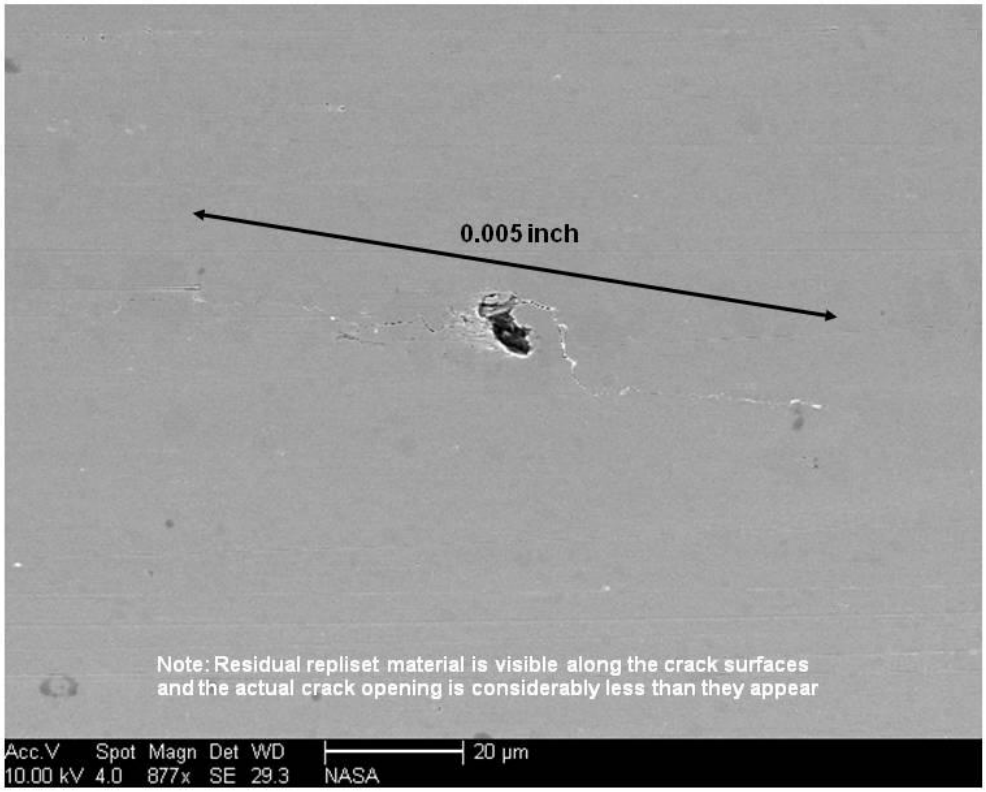
Size of Crack #6



322

Poppet #57

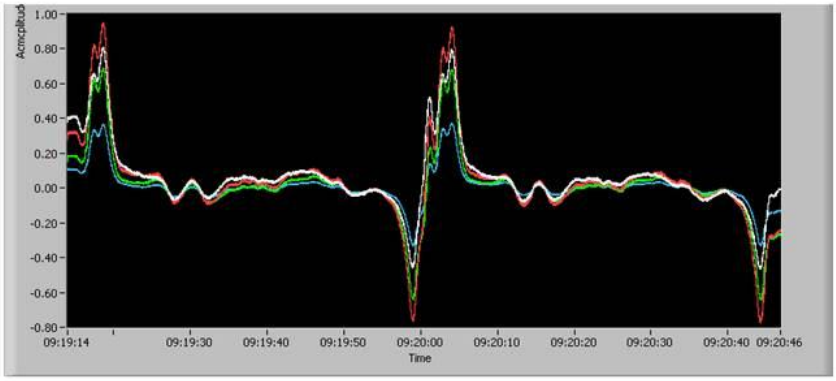
Size of Crack #7



323

Poppet #57

LaRC eddy current findings, the colors indicate ???



324

Poppet #58

Surface crack sizes and locations

Poppet #58					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.005	0	12	0.002	180
2	0.003	0	13	0.003	180
3	0.004	0	14	0.002	180
4	0.005	0	15	0.009	180
5	0.008	0	16	0.015	180
6	0.002	0	17	0.003	180
7	0.002	0	18	0.014	180
8	0.005	180	19	0.003	180
9	0.005	180	20	0.002	180
10	0.004	180	21	0.002	180
11	0.002	180			

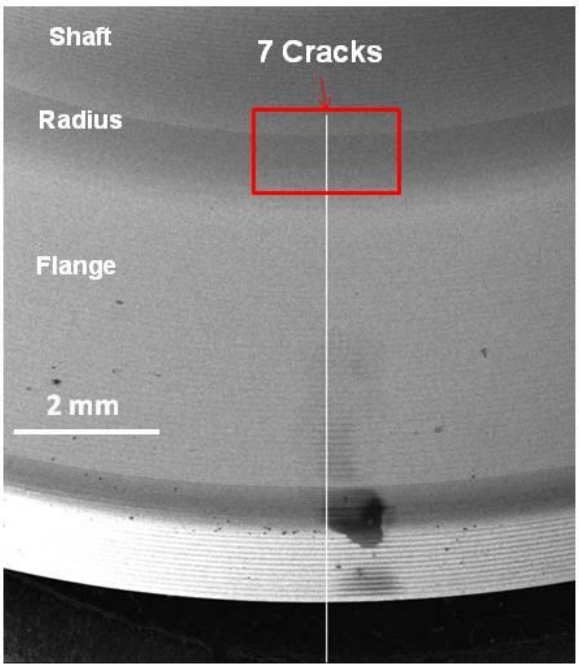
Boeing Eddy Current Findings

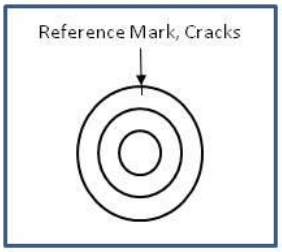
None Provided

325

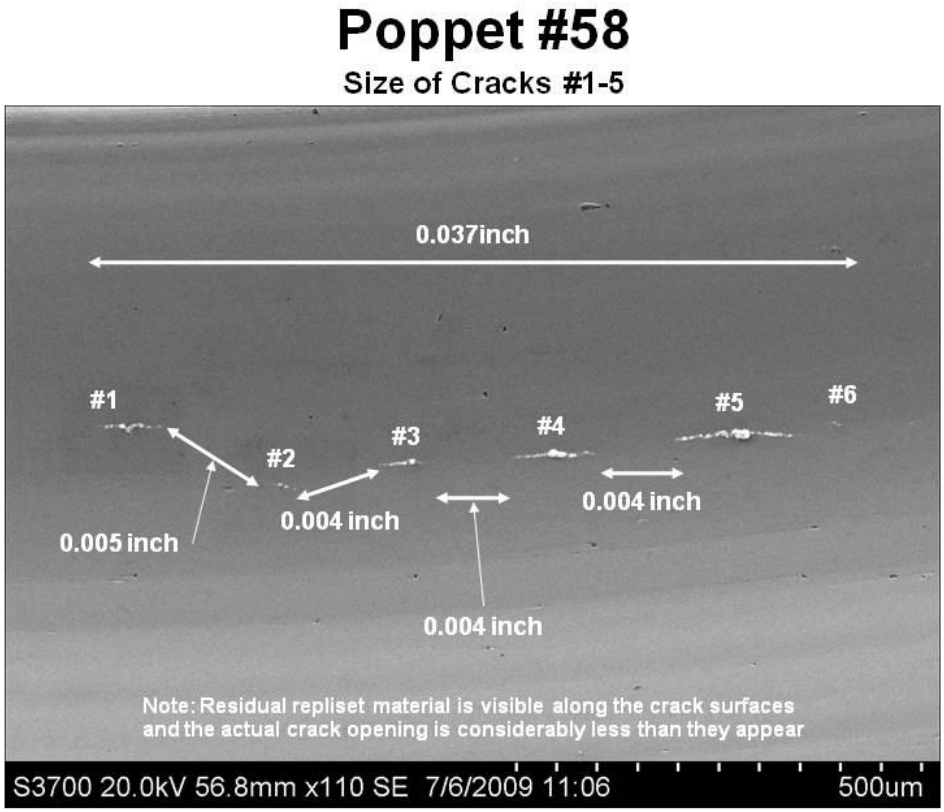
Poppet #58

Location of Cracks #1-7





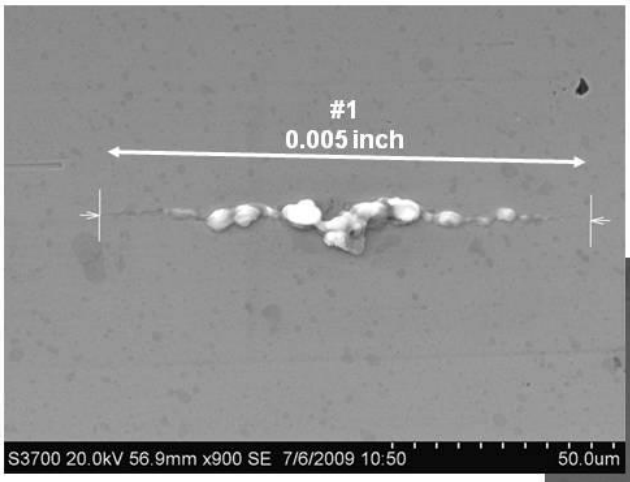
326

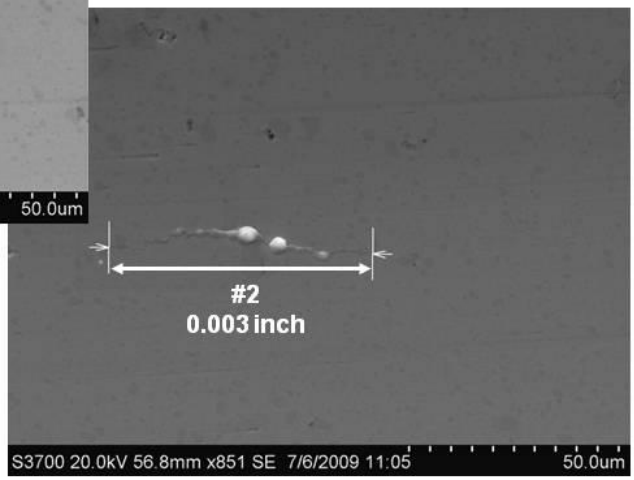

Poppet #58
Size of Cracks #1-5
0.037inch
#1
#2
#3
#4
#5
#6
0.005 inch
0.004 inch
0.004 inch
0.004 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 56.8mm x110 SE 7/6/2009 11:06
500um

327

Poppet #58

Size of Cracks #1 and 2



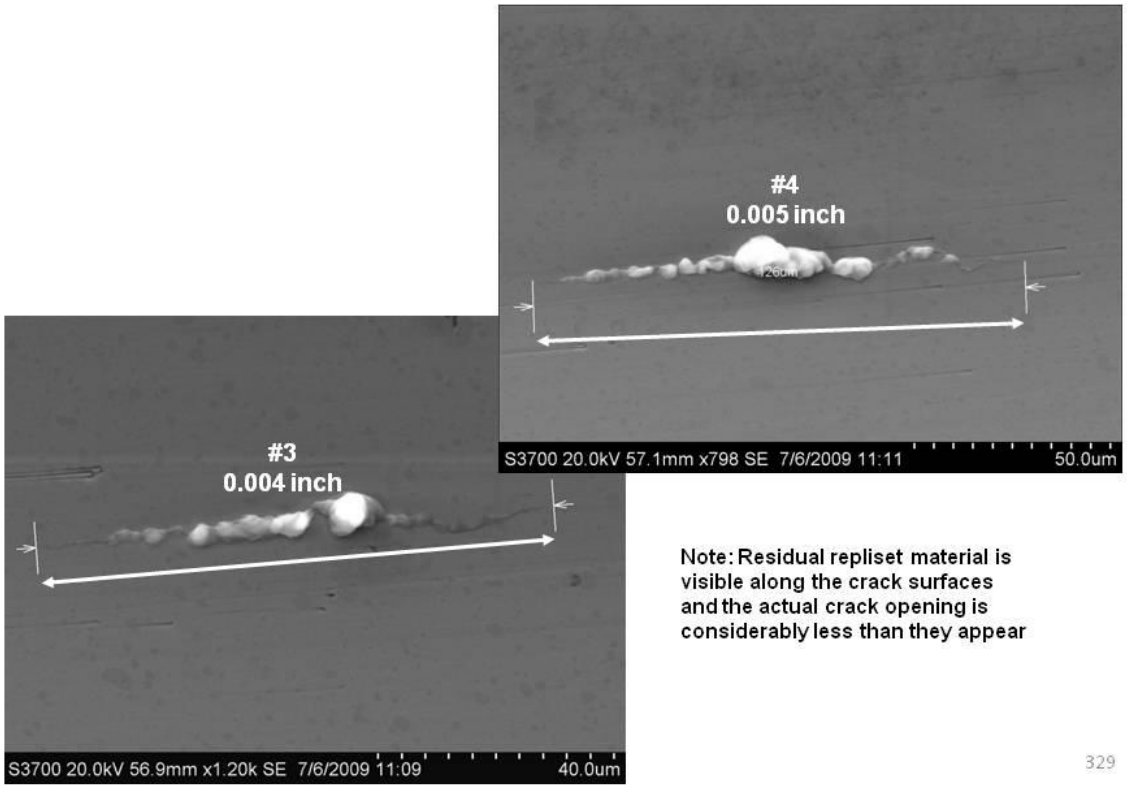


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

328

Poppet #58

Size of Cracks #3 and 4

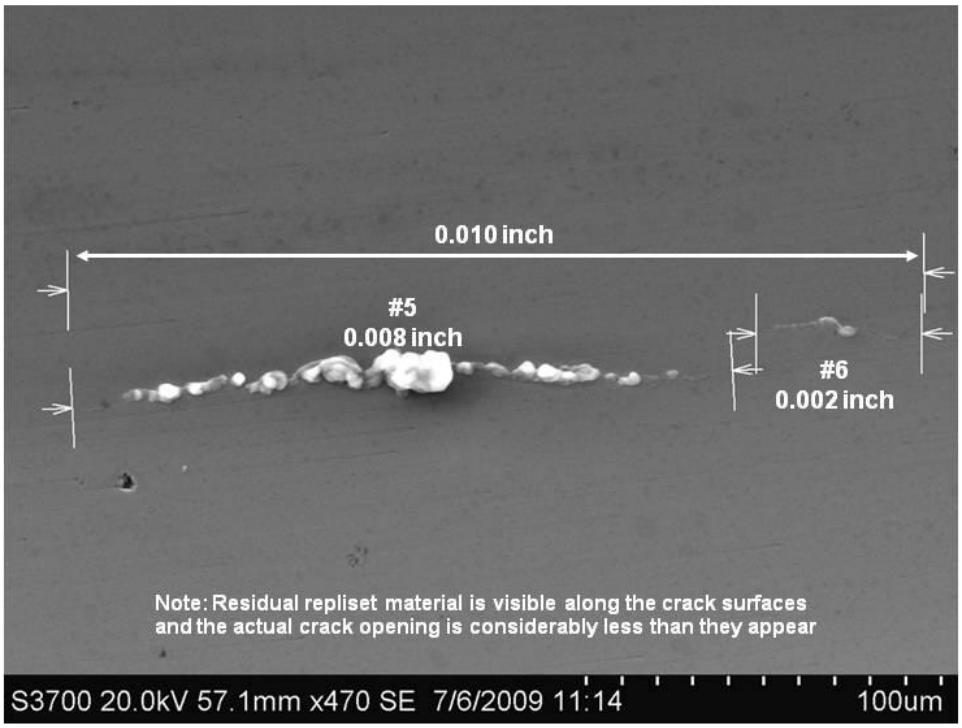


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

329

Poppet #58

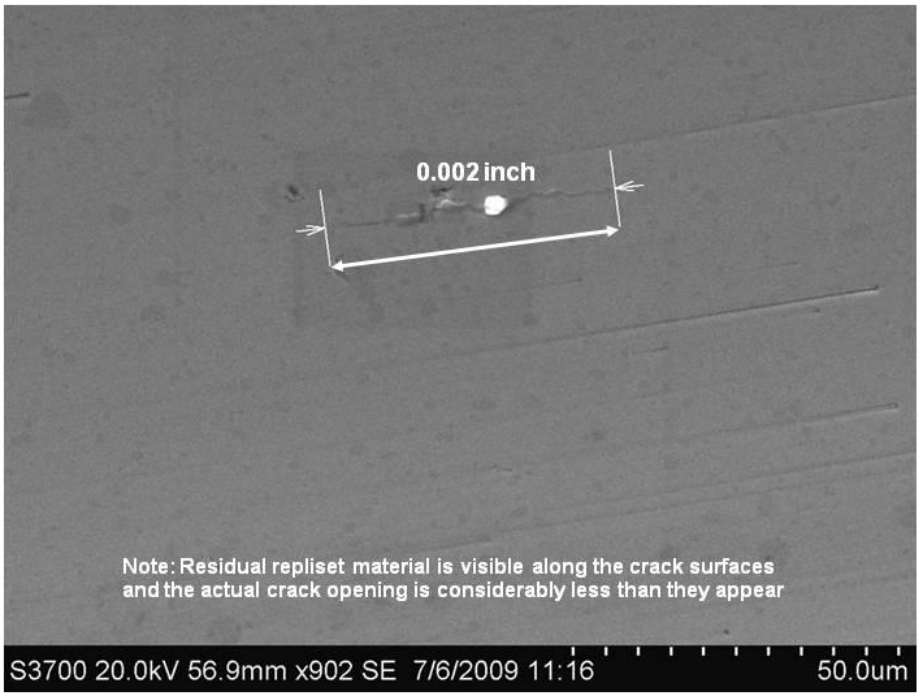
Size of Cracks #5 and 6



330

Poppet #58

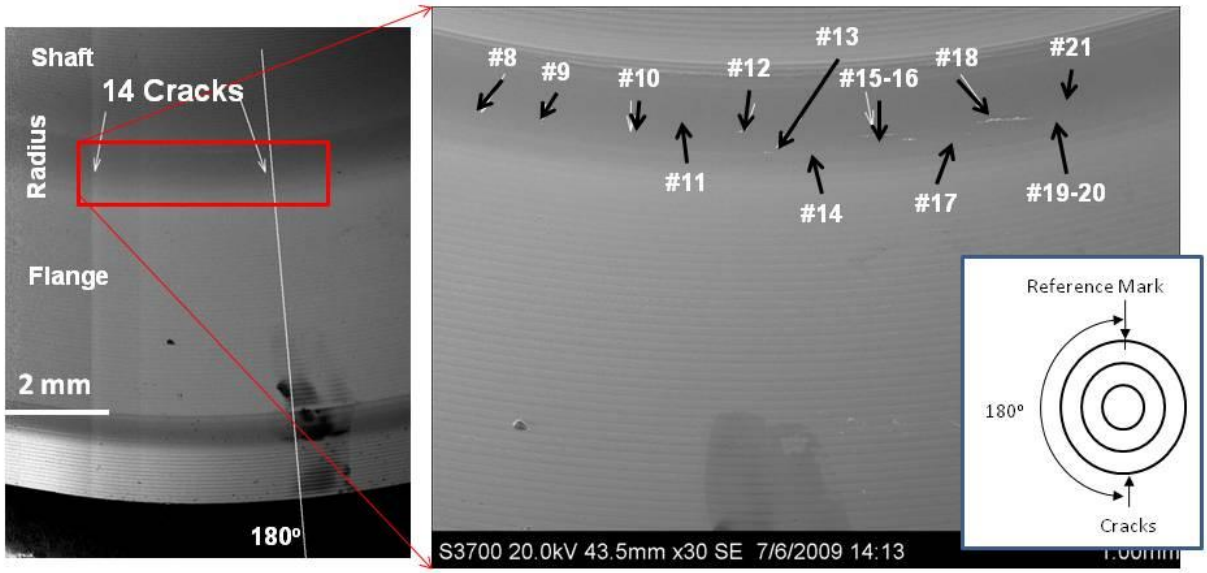
Size of Crack #7



331

Poppet #58

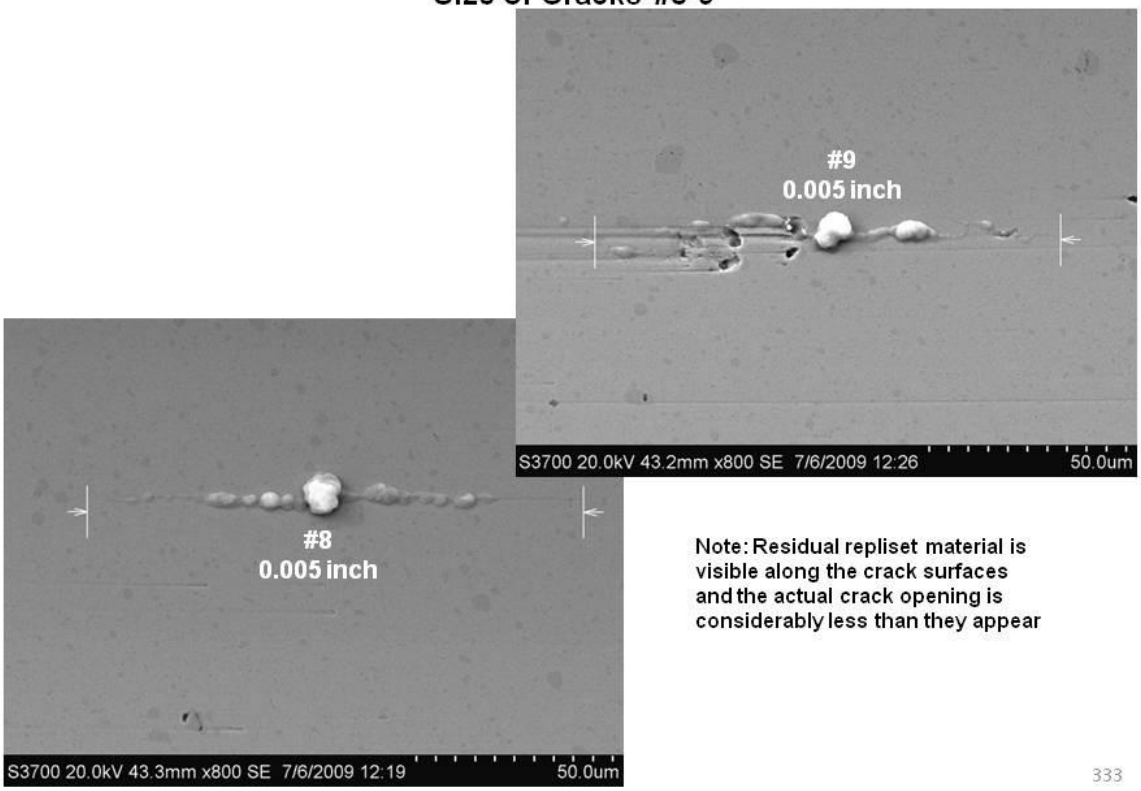
Location of Cracks #8-21



332

Poppet #58

Size of Cracks #8-9

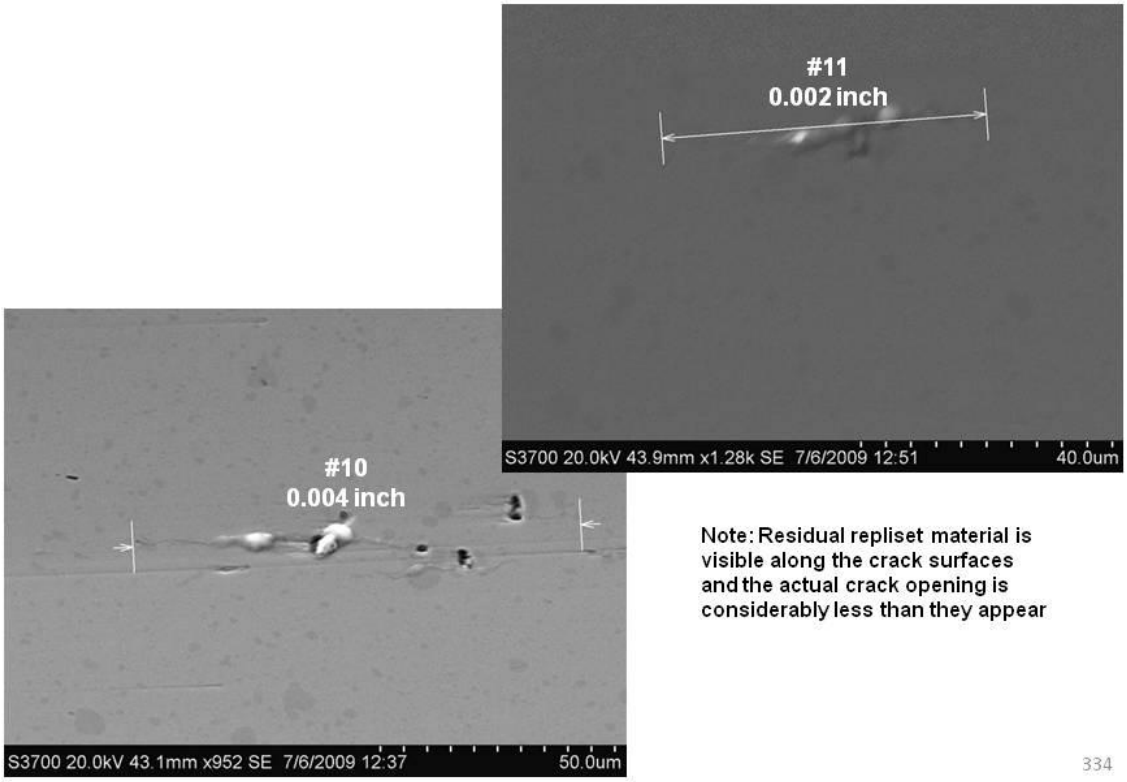


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

333

Poppet #58

Size of Cracks #10-11

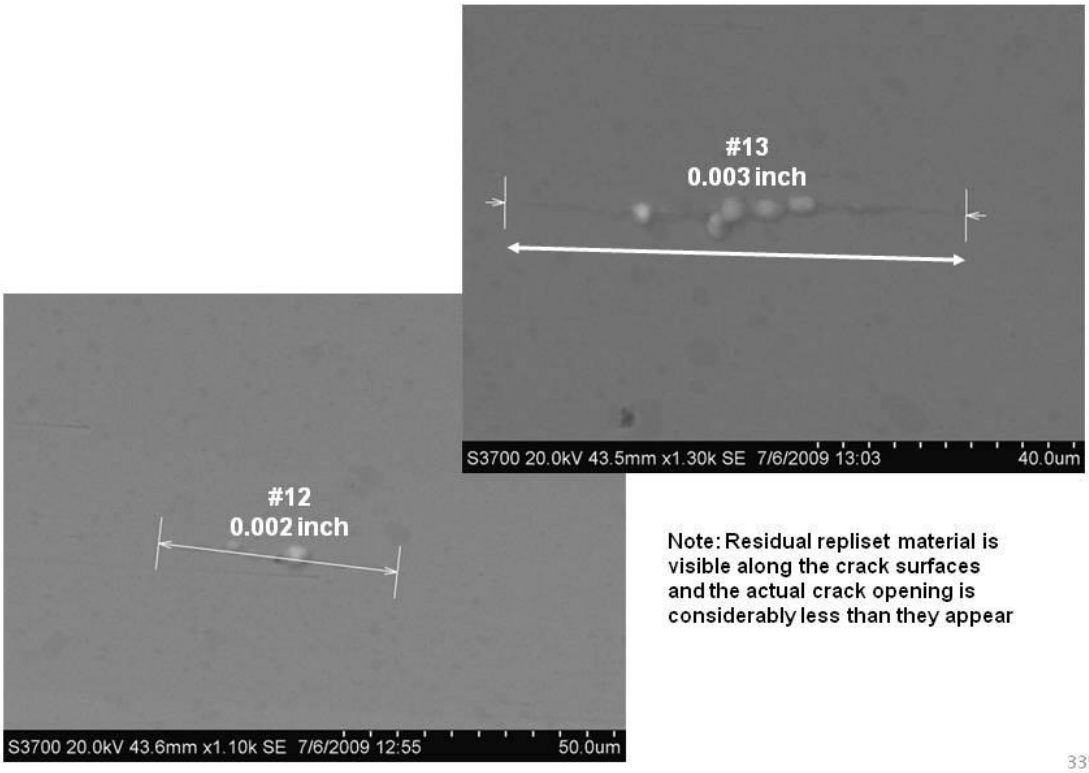


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

334

Poppet #58

Size of Cracks #12 and 13

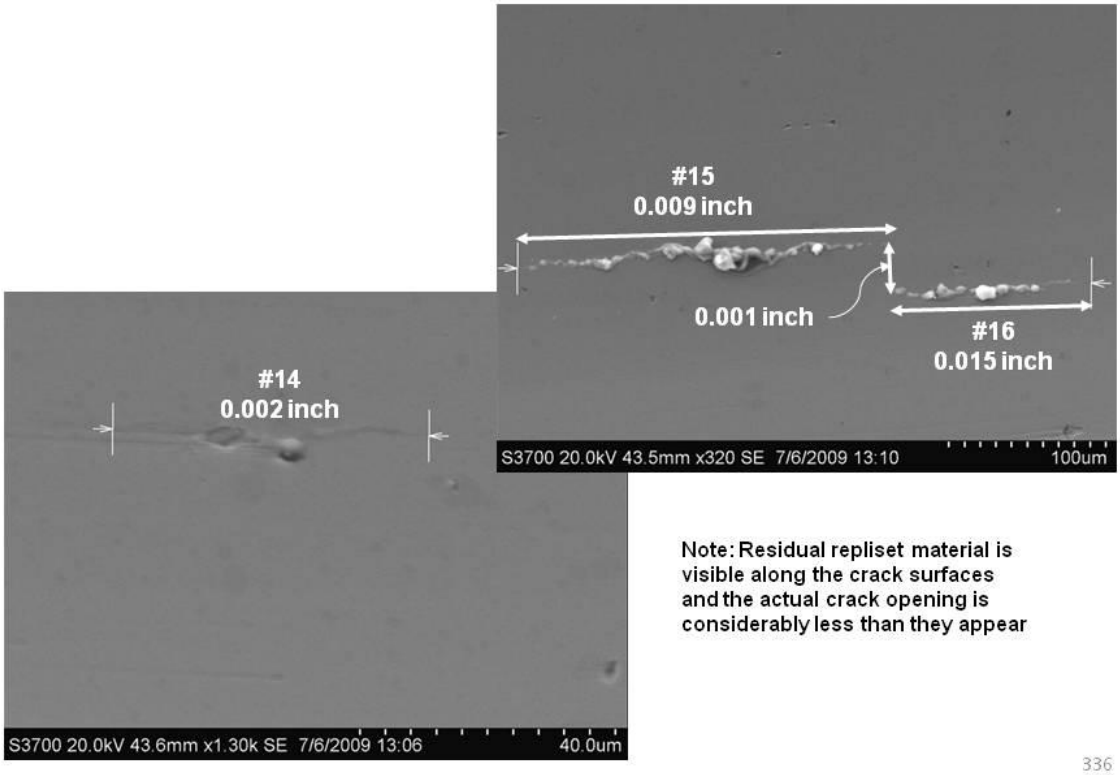


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

335

Poppet #58

Size of Cracks #14-16

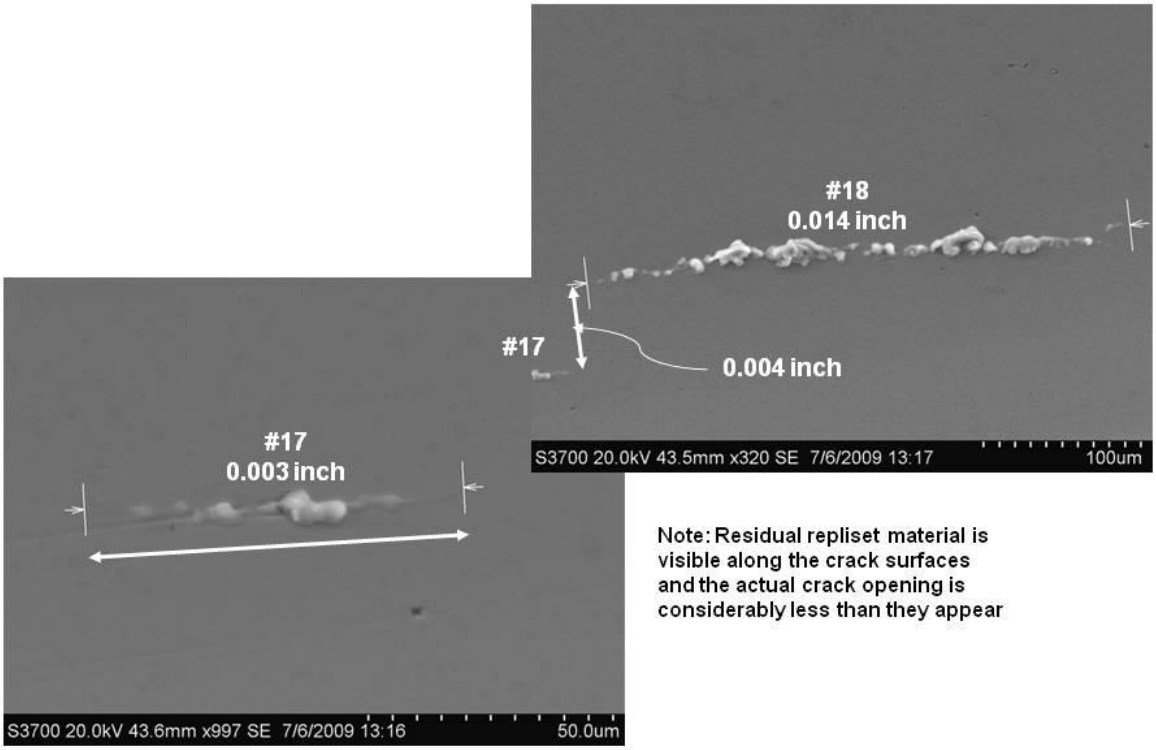


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

336

Poppet #58

Size of Cracks #17-18

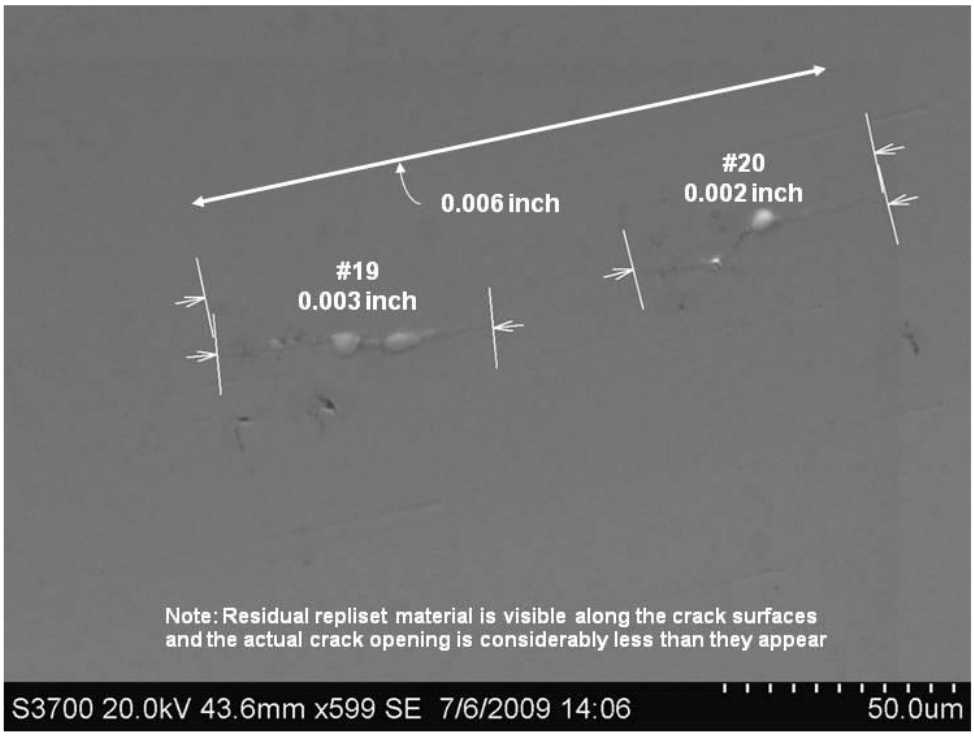


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

337

Poppet #58

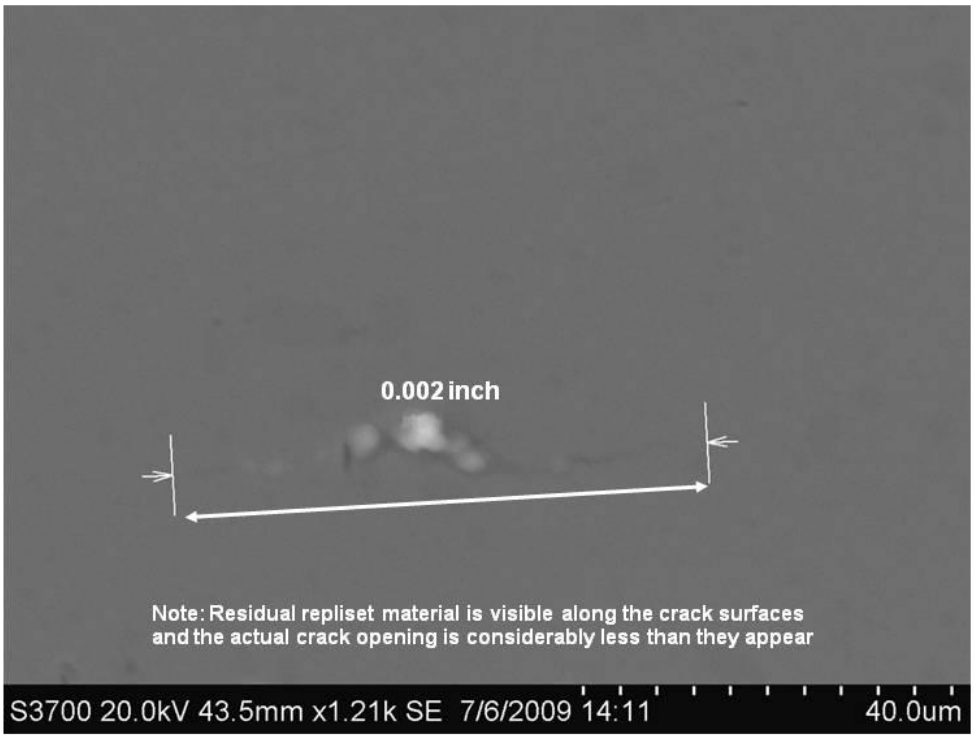
Size of Cracks #19-20



338

Poppet #58

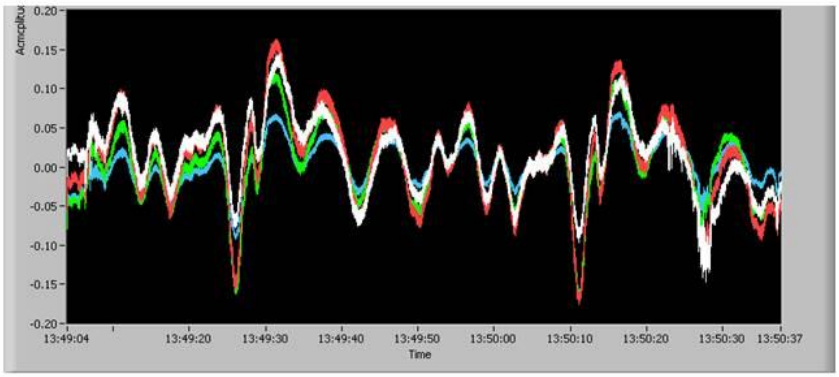
Size of Crack #21



339

Poppet #58

LaRC eddy current findings, the colors indicate ???



340

Poppet #59

Surface crack sizes and locations

Poppet #59		
Crack Number	Size (inch)	Angle (degrees)
1	0.008	0
2	0.002	0
3	0.002	0
4	0.010	0
5	0.002	180
6	0.002	180
7	0.003	180
8	0.004	180
9	0.001	180

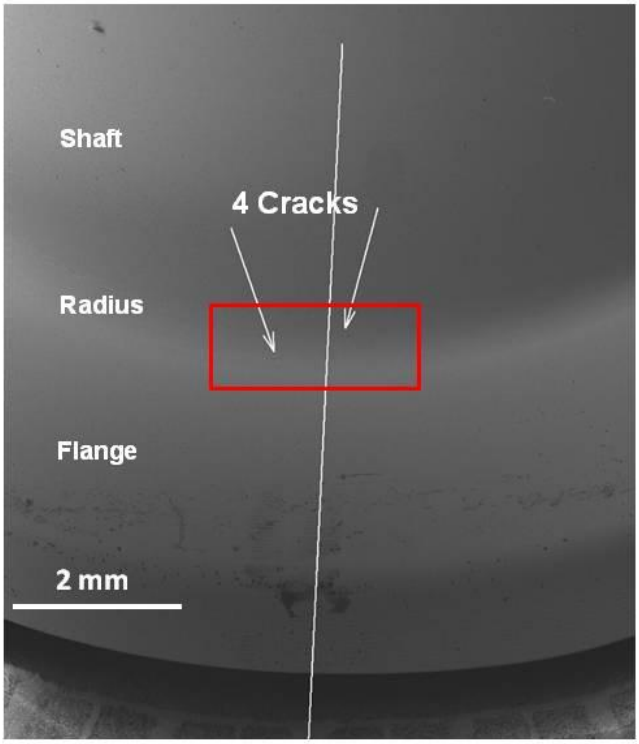
Boeing Eddy Current Findings

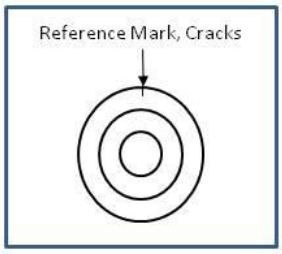
None Provided

341

Poppet #59

Location of Cracks #1-4

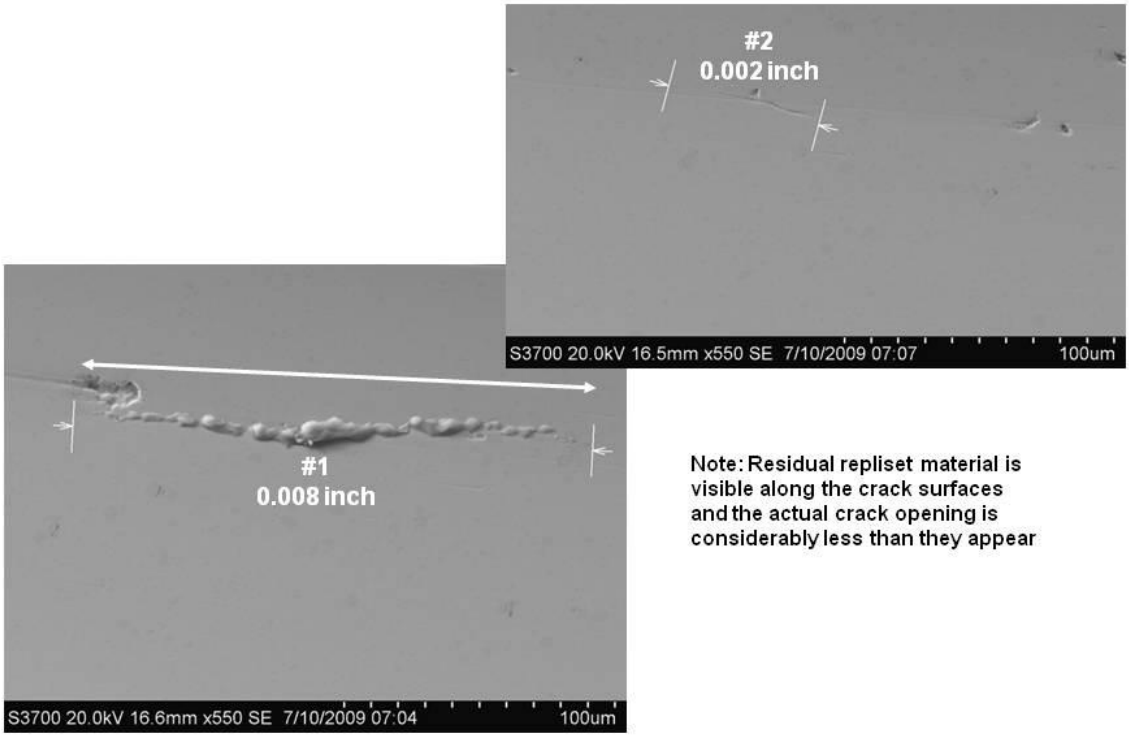




342

Poppet #59

Size of Cracks #1 and 2

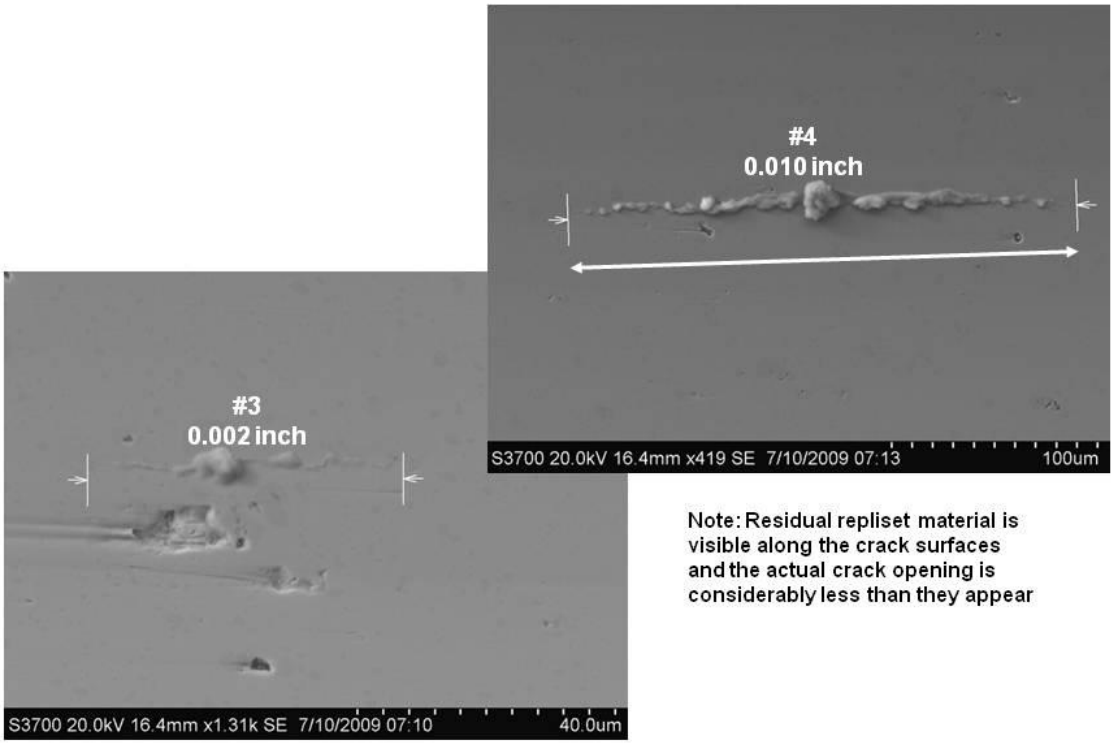


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

343

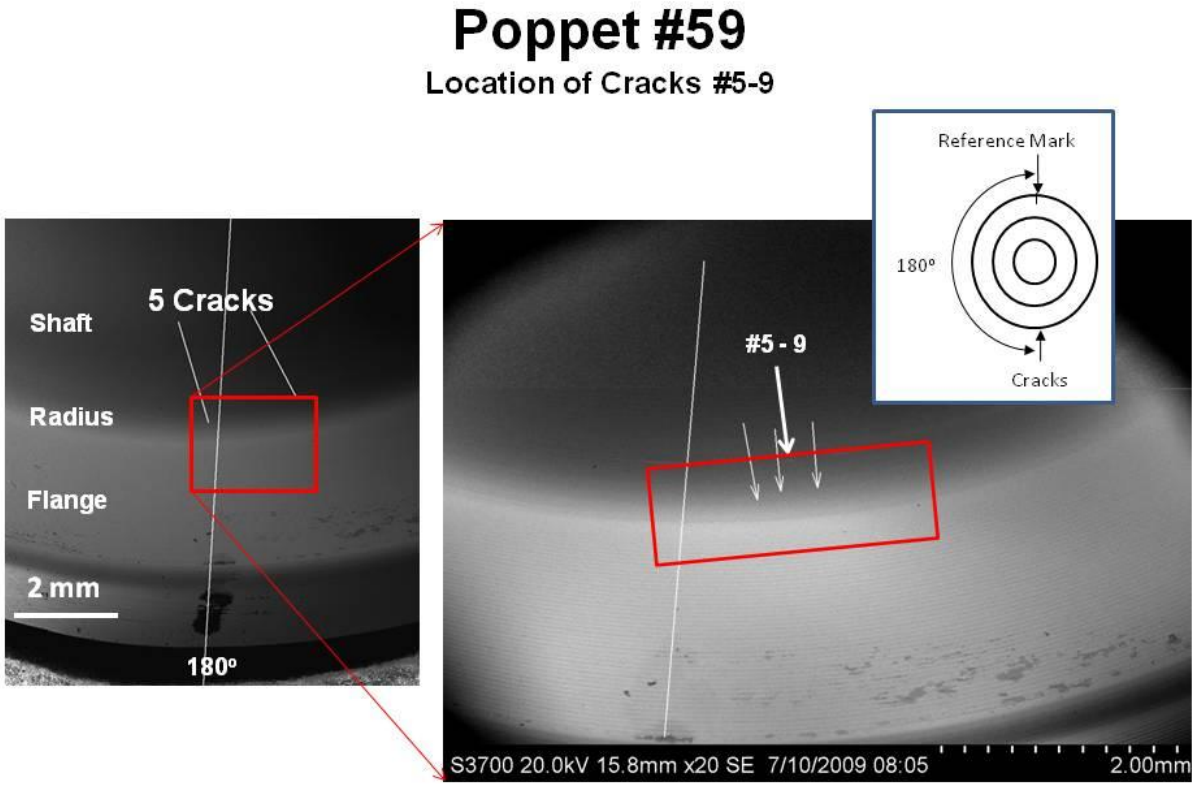
Poppet #59

Size of Cracks #3 and 4



Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

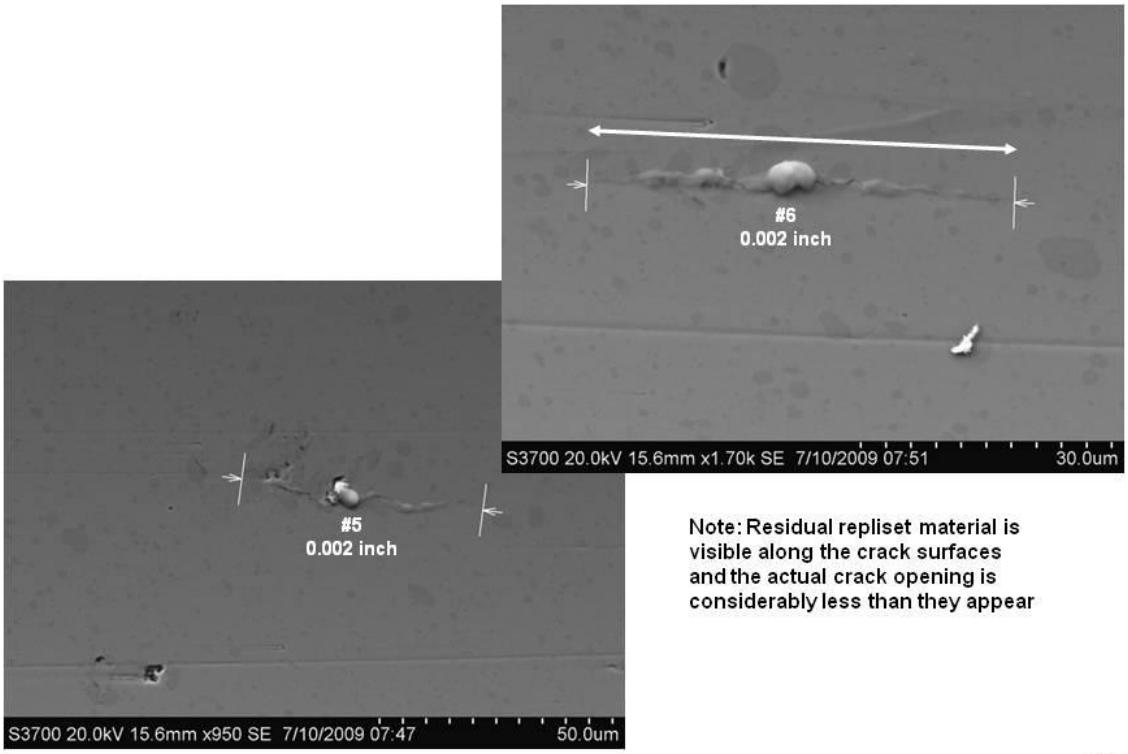
344


Poppet #59
Location of Cracks #5-9
Reference Mark
180°
Cracks
Shaft
5 Cracks
Radius
Flange
2 mm
180°
#5 - 9
S3700 20.0kV 15.8mm x20 SE 7/10/2009 08:05
2.00mm

345

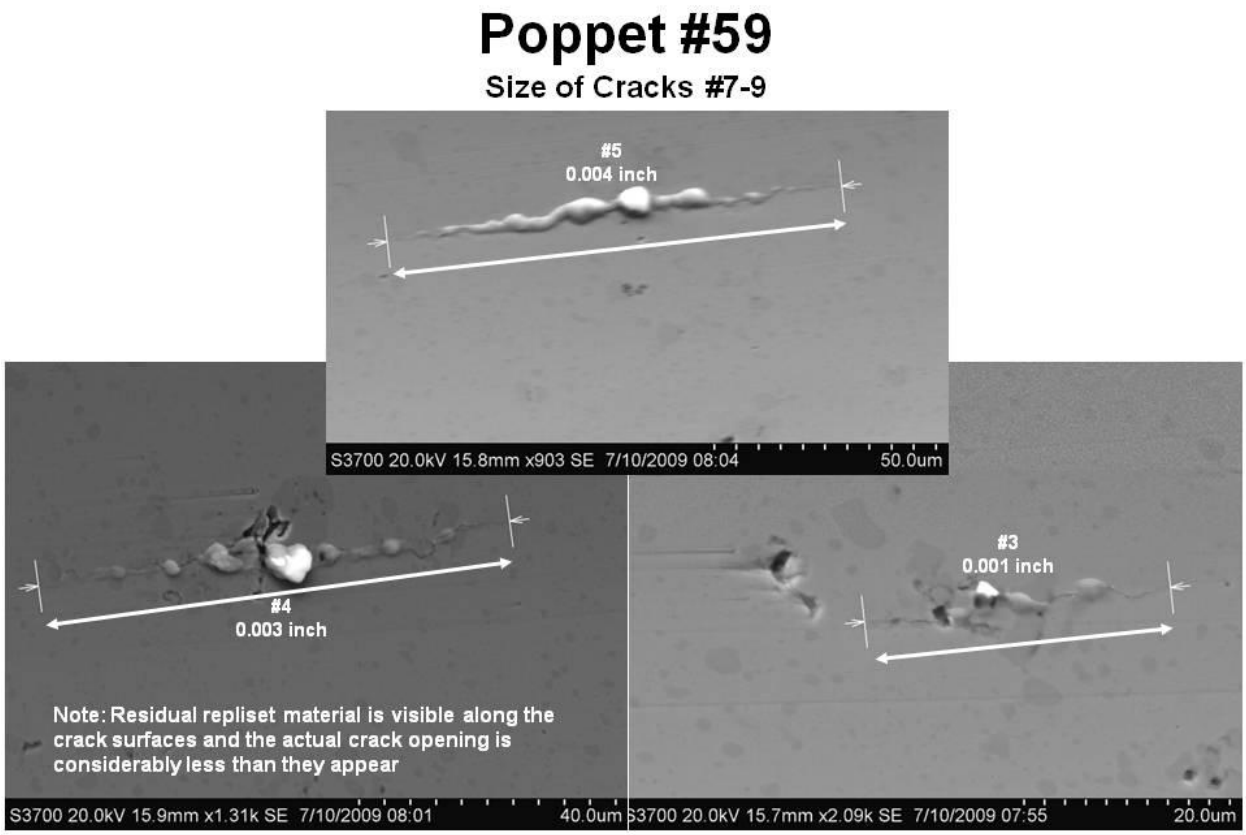
Poppet #59

Size of Cracks #5-6



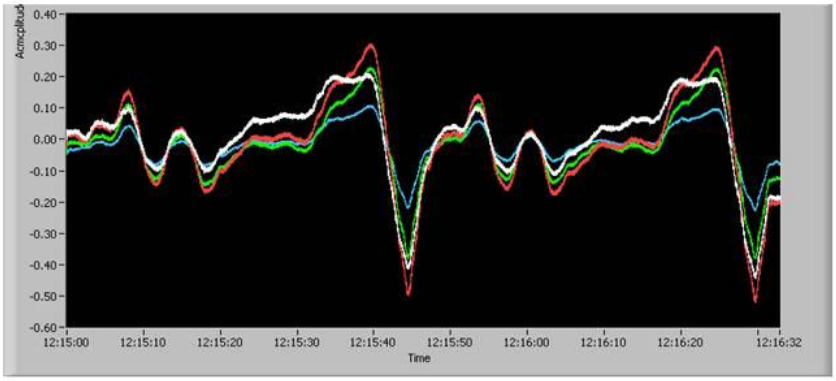
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

346


Poppet #59
Size of Cracks #7-9
#5
0.004 inch
S3700 20.0kV 15.8mm x903 SE 7/10/2009 08:04 50.0um
#4
0.003 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 15.9mm x1.31k SE 7/10/2009 08:01 40.0um
#3
0.001 inch
S3700 20.0kV 15.7mm x2.09k SE 7/10/2009 07:55 20.0um
347

Poppet #59

LaRC eddy current findings, the colors indicate ???



348

Poppet #60

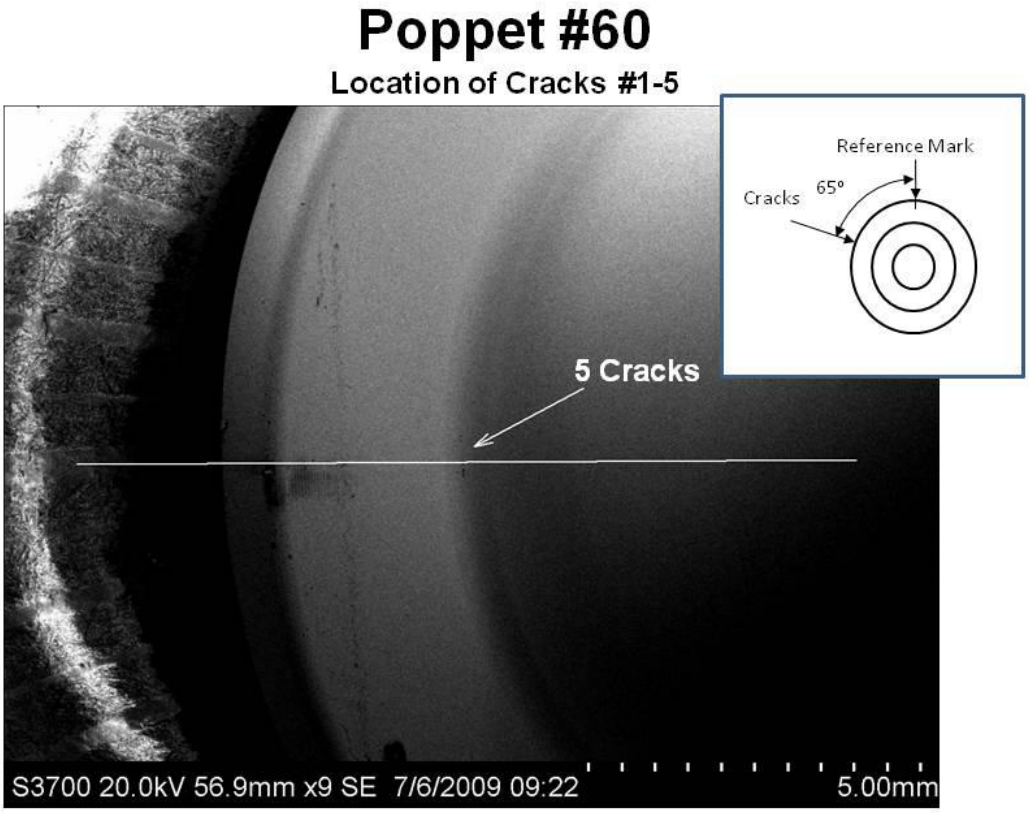
Surface crack sizes and locations

Poppet #60		
Crack Number	Size (inch)	Angle (degrees)
1	0.038	65
2	0.003	65
3	0.005	65
4	0.003	65
5	0.004	65

Boeing Eddy Current Findings

Poppet #60									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.589	0.591	0.613	0.620	0.622	0.622	0.610	Yes	80
B. Devries	0.614	0.611	0.609	0.607	0.607	0.615	0.611	Yes	75

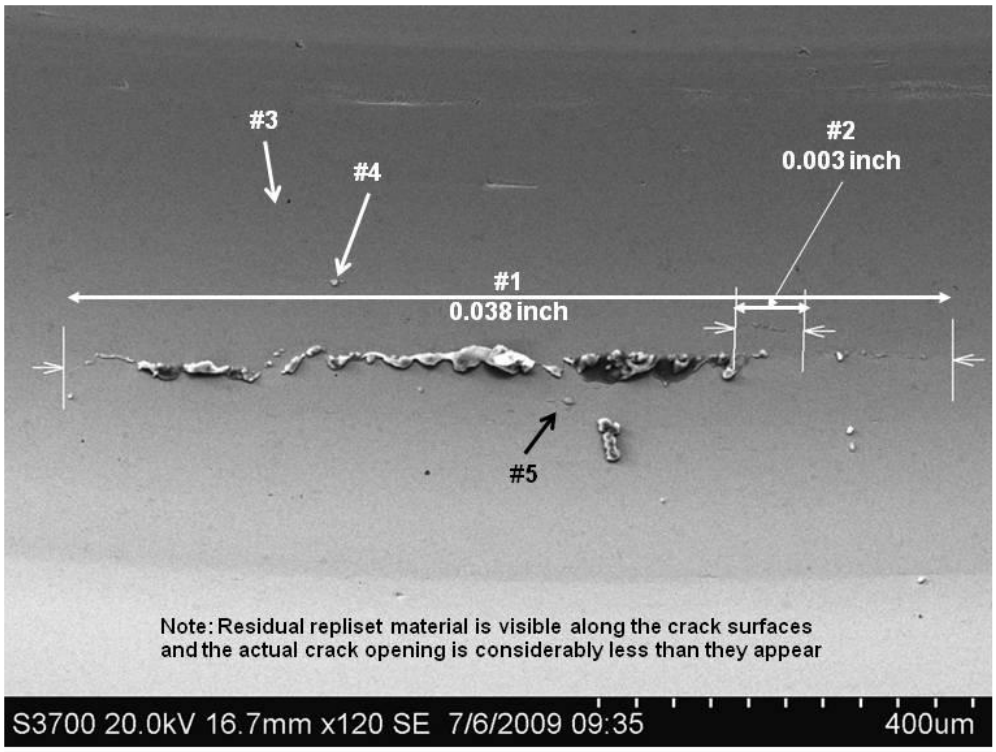
349


Poppet #60
Location of Cracks #1-5
Reference Mark
Cracks
65°
5 Cracks
S3700 20.0kV 56.9mm x9 SE 7/6/2009 09:22
5.00mm

350

Poppet #60

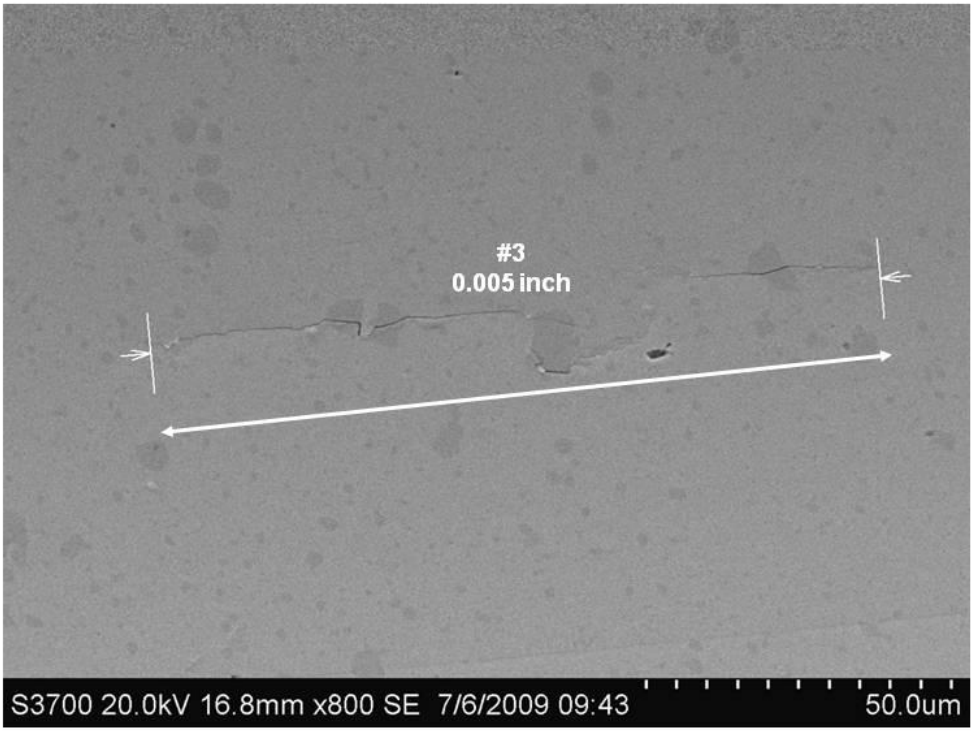
Size of Cracks #1-5



351

Poppet #60

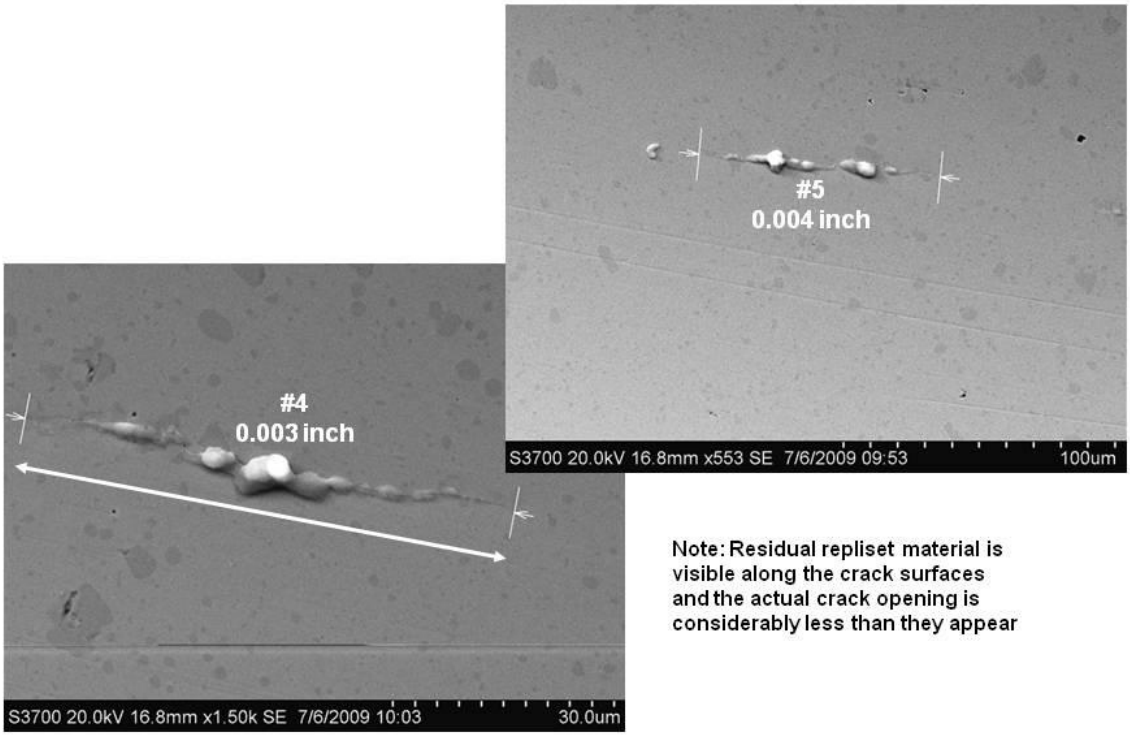
Size of Crack #3



352

Poppet #60

Size of Cracks #4 and 5

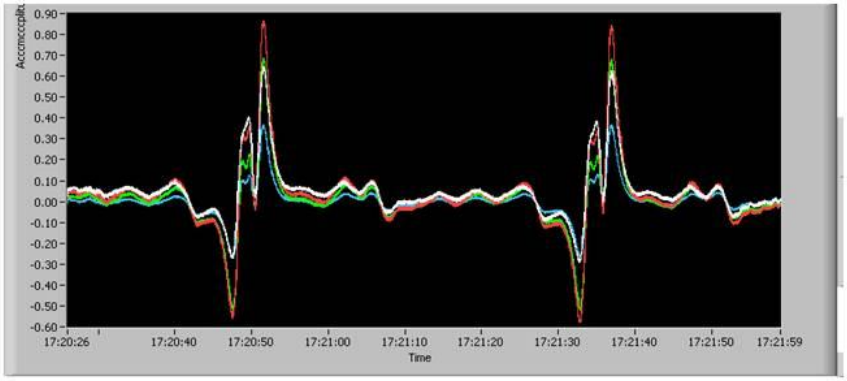


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

353

Poppet #60

LaRC eddy current findings, the colors indicate ???



354

Poppet #61

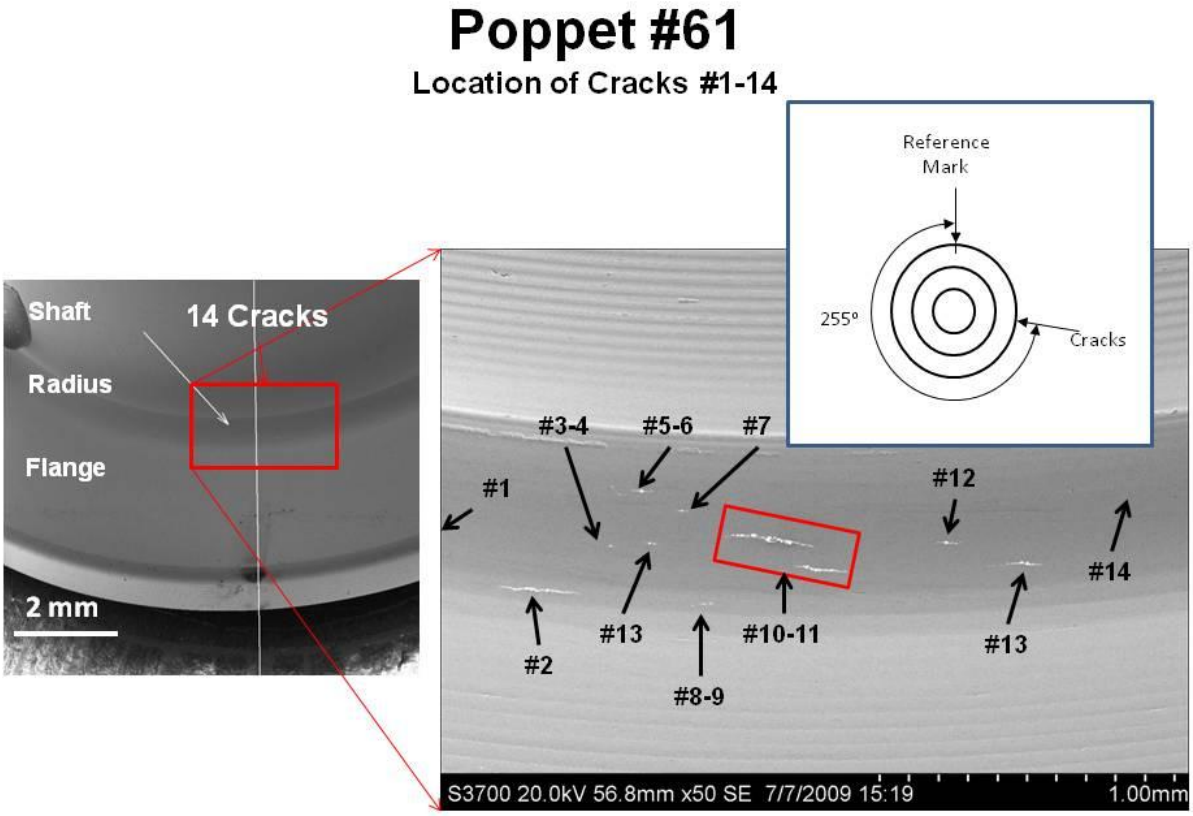
Surface crack sizes and locations

Poppet #61					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.003	255	15	0.003	75
2	0.011	255	16	0.006	75
3	0.002	255	17	0.002	75
4	0.003	255	18	0.003	75
5	0.002	255	19	0.003	75
6	0.004	255	20	0.006	75
7	0.002	255	21	0.003	75
8	0.001	255	22	0.006	75
9	0.003	255	23	0.004	75
10	0.012	255	24	0.004	75
11	0.007	255	25	0.013	75
12	0.004	255	26	0.005	75
13	0.005	255	27	0.006	75
14	0.002	255	28	0.004	75

Boeing Eddy Current Findings

Poppet #61									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.188	0.198	0.190	0.188	0.194	0.200	0.193	Yes	75
J. Engel	0.168	0.176	0.176	0.170	0.185	0.183	0.176	Yes	255
B. Devries	0.196	0.199	0.203	0.207	0.204	0.206	0.203	Yes	80
B. Devries	0.174	0.175	0.177	0.175	0.181	0.178	0.177	Yes	260

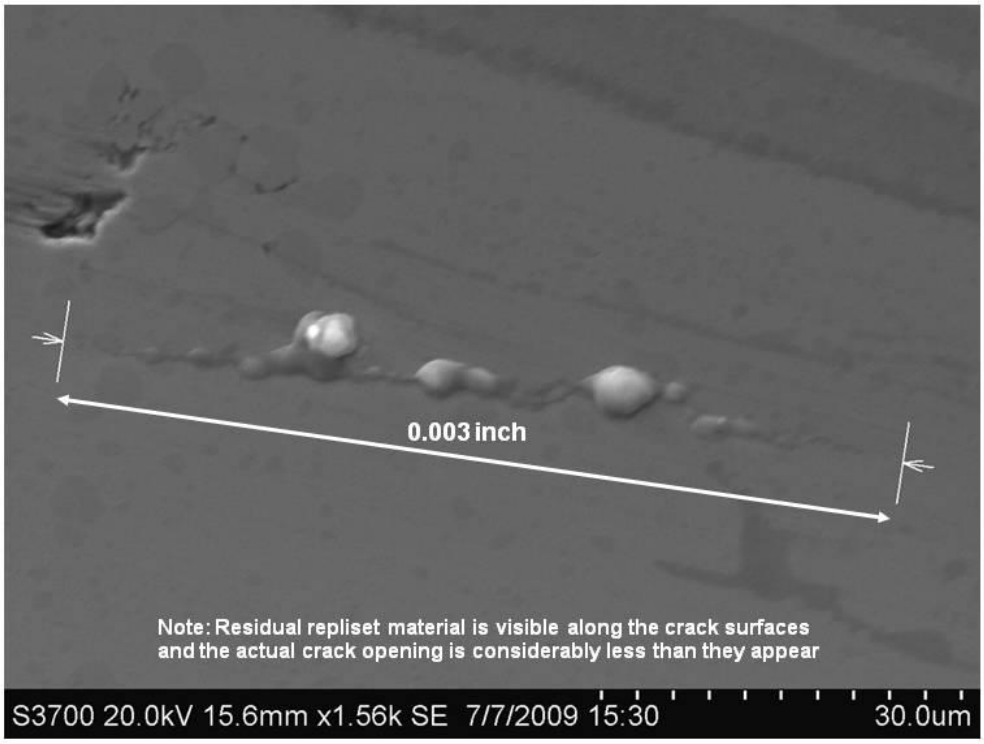
355


Poppet #61
Location of Cracks #1-14
Reference Mark
255°
Cracks
Shaft
14 Cracks
Radius
Flange
2 mm
#1
#2
#3-4
#5-6
#7
#8-9
#10-11
#12
#13
#13
#14
S3700 20.0kV 56.8mm x50 SE 7/7/2009 15:19
1.00mm

356

Poppet #61

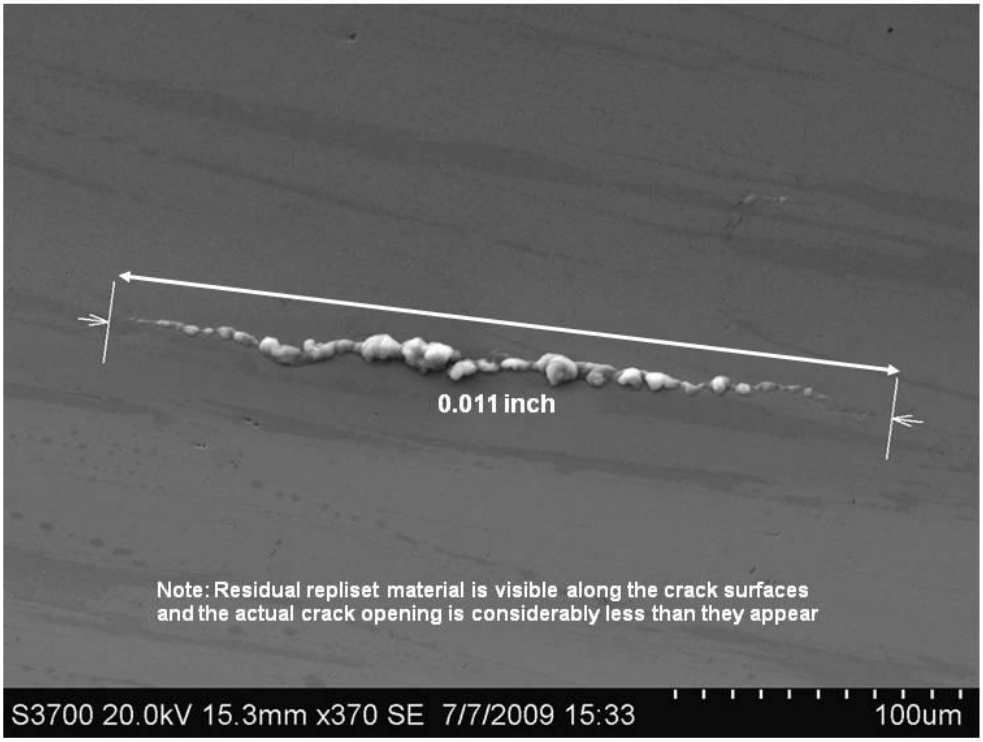
Size of Crack #1



357

Poppet #61

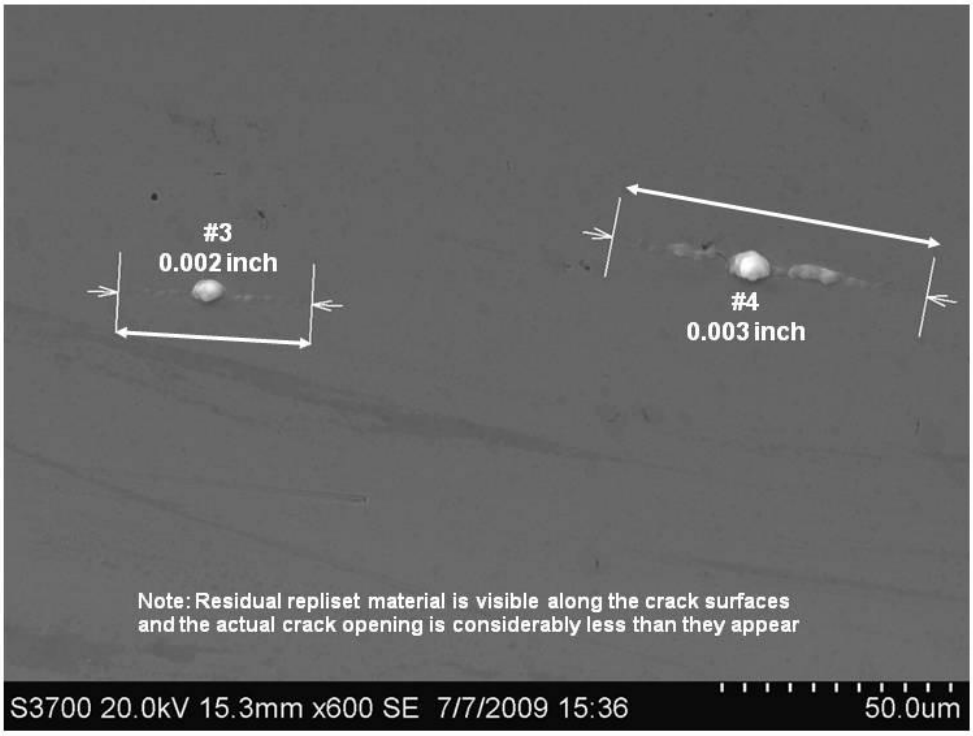
Size of Crack #2



358

Poppet #61

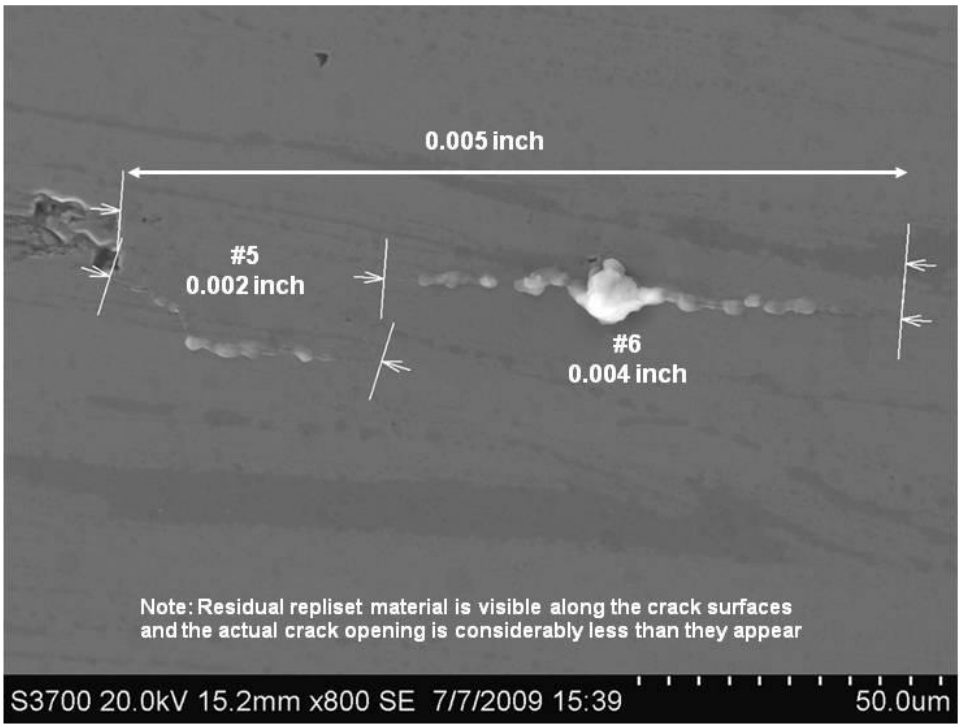
Size of Cracks #3 and 4



359

Poppet #61

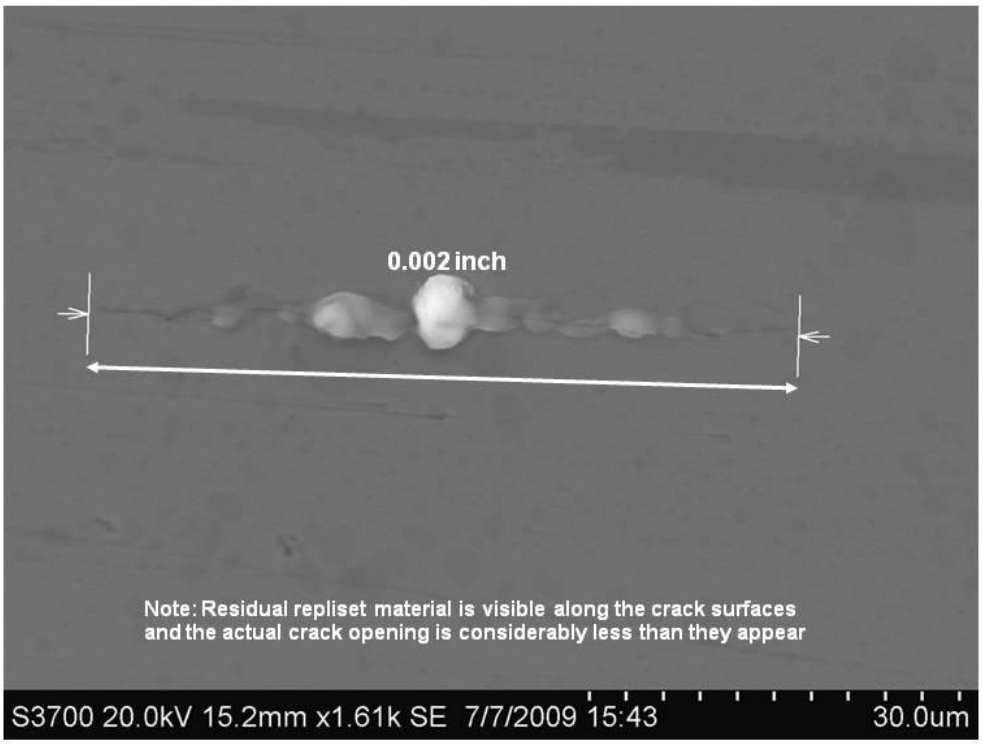
Size of Cracks #5 and 6



360

Poppet #61

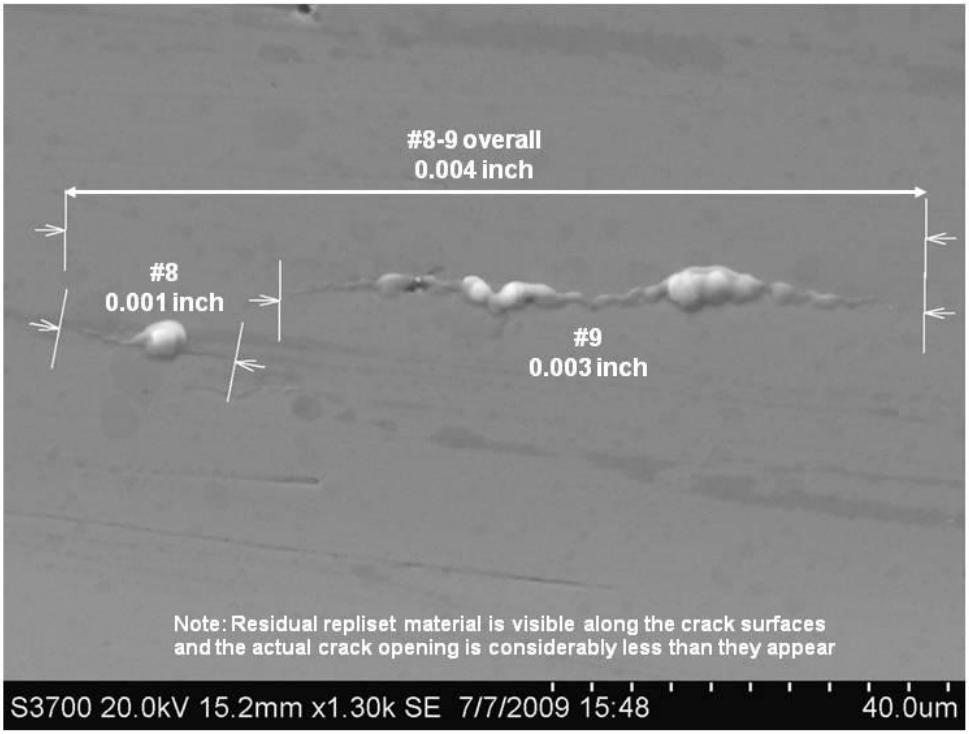
Size of Crack #7



361

Poppet #61

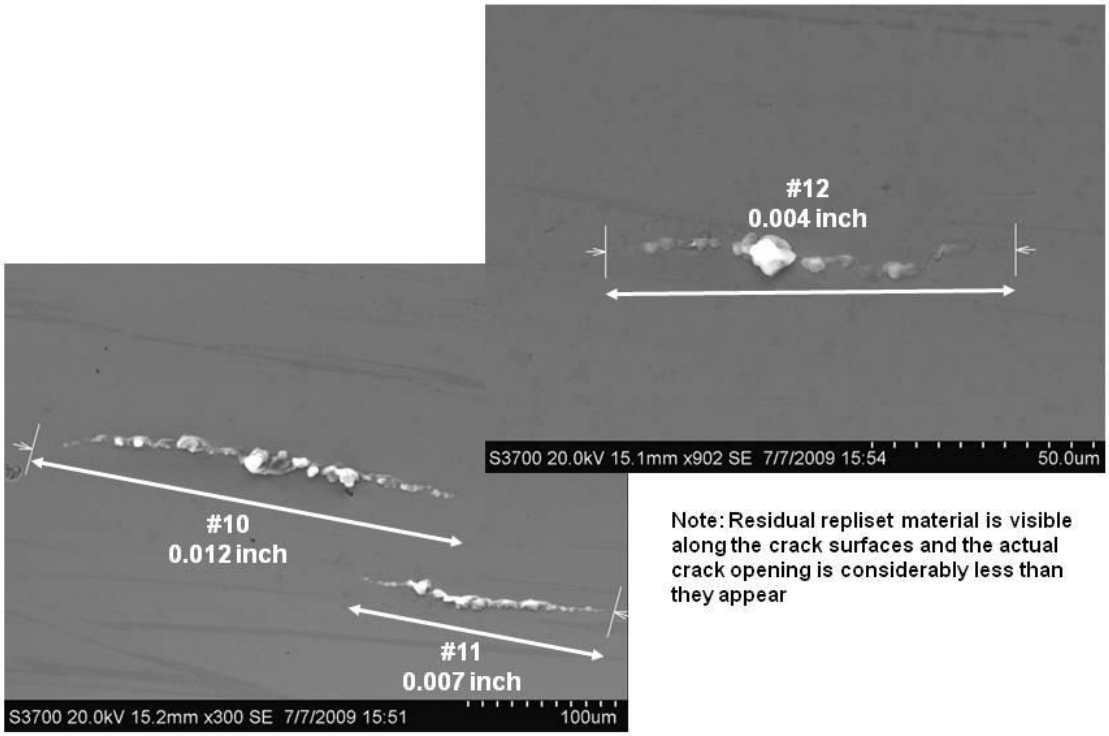
Location and size of Cracks #8 and 9



362

Poppet #61

Location and size of Cracks #10-12

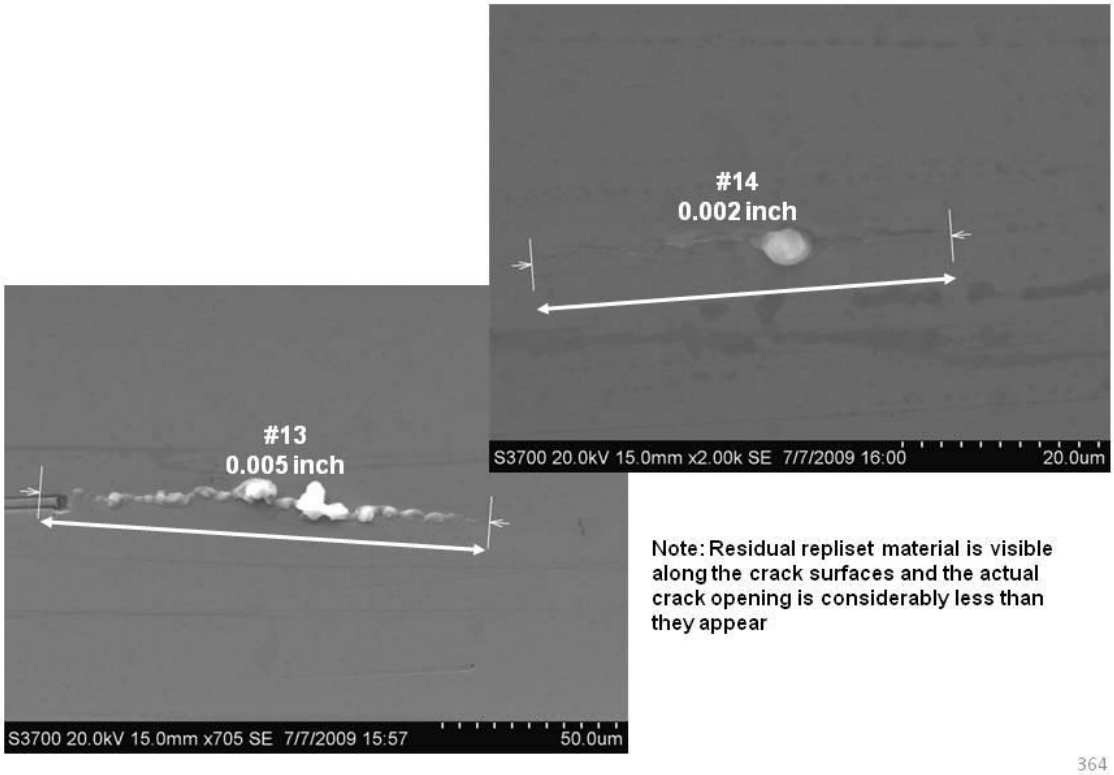


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

363

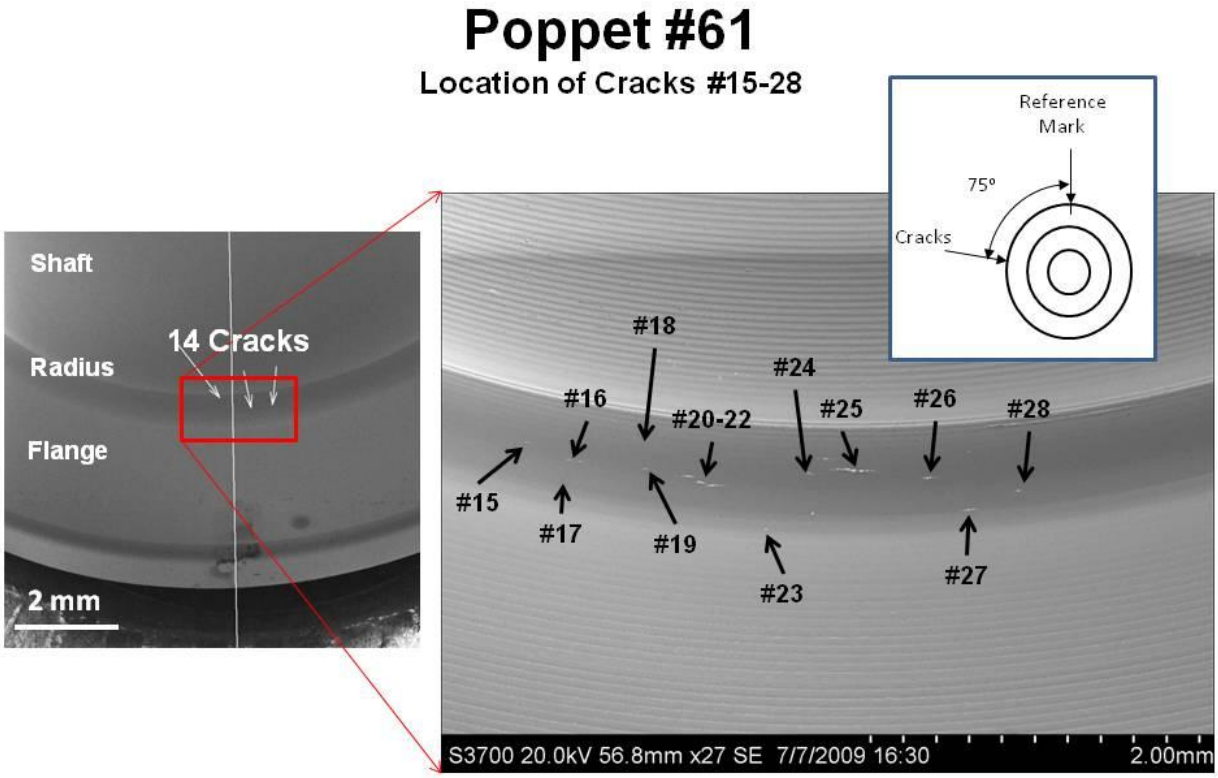
Poppet #61

Location and size of Cracks #13 and 14



Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

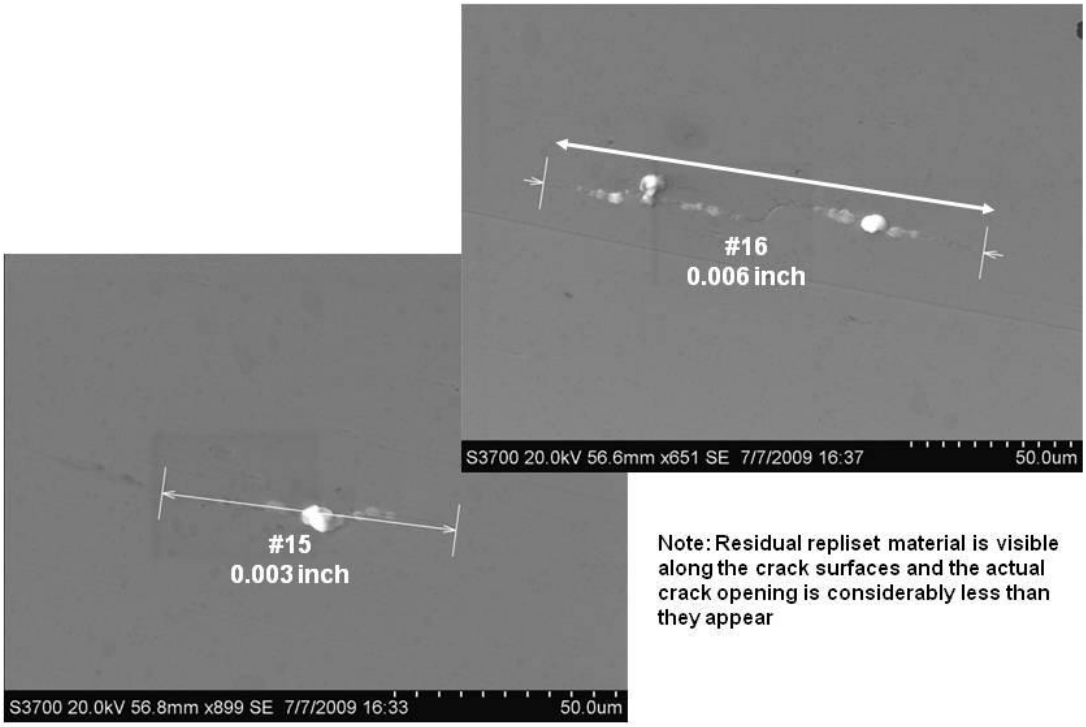
364


Poppet #61
Location of Cracks #15-28
Reference Mark
75°
Cracks
Shaft
Radius
Flange
14 Cracks
2 mm
#15
#16
#17
#18
#19
#20-22
#23
#24
#25
#26
#27
#28
S3700 20.0kV 56.8mm x27 SE 7/7/2009 16:30
2.00mm

365

Poppet #61

Location and size of Cracks #15-16

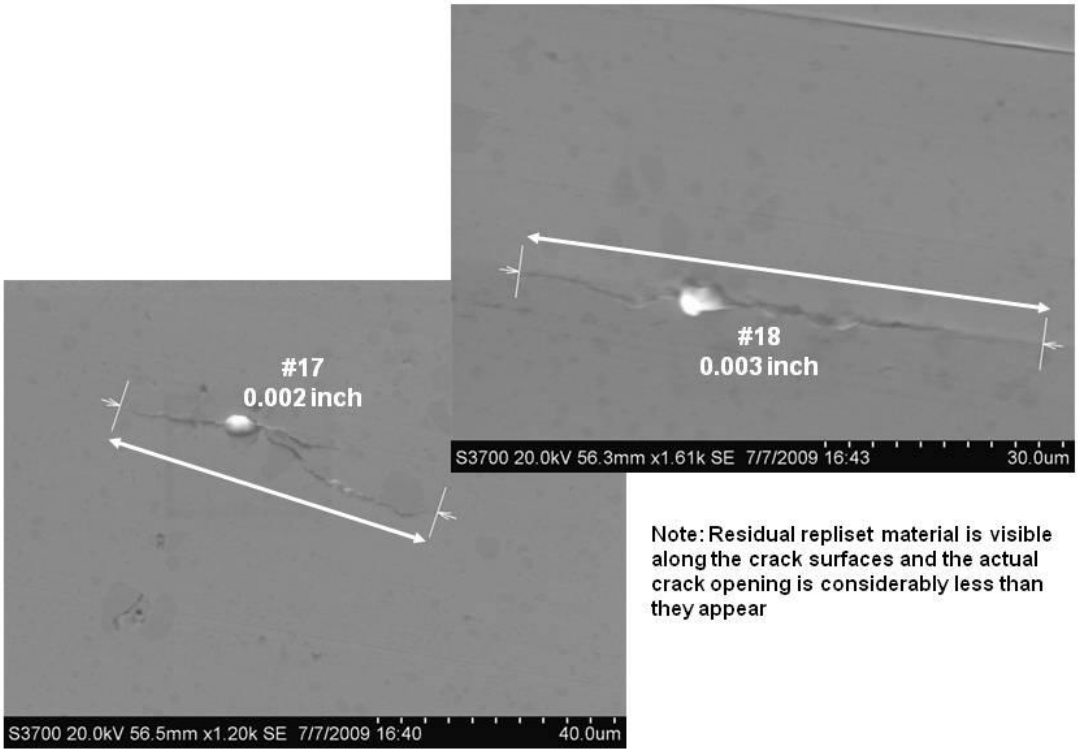


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

366

Poppet #61

Location and size of Cracks #17-18

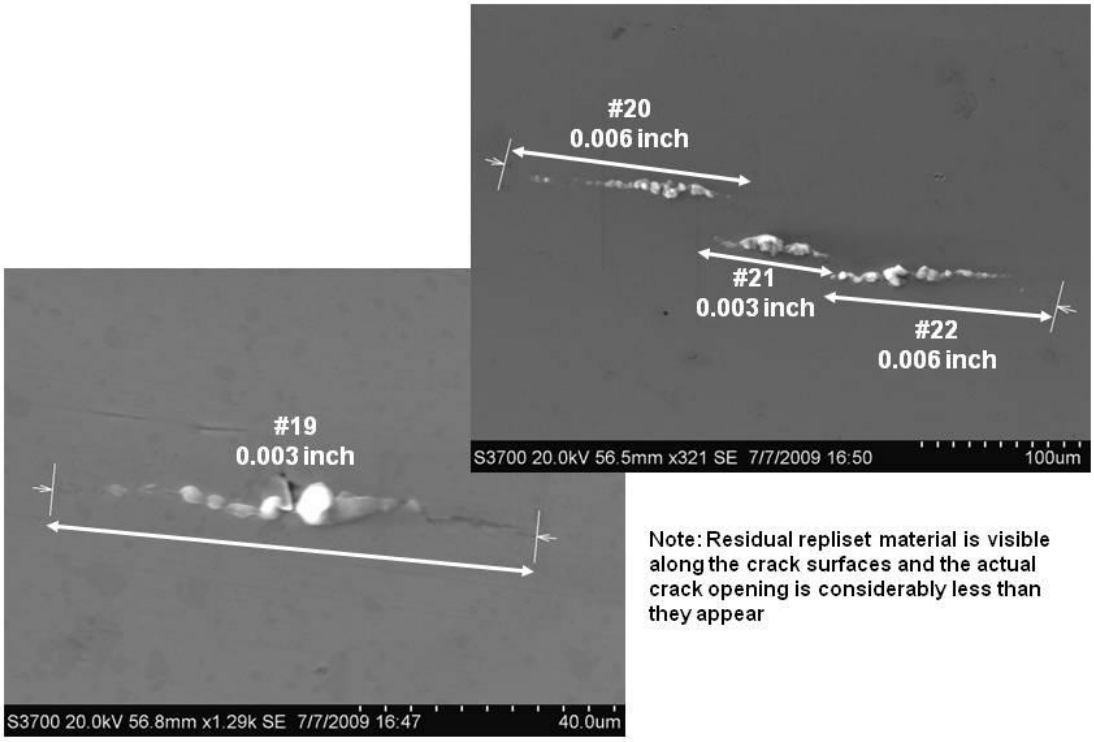


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

367

Poppet #61

Location and size of Cracks #19-22

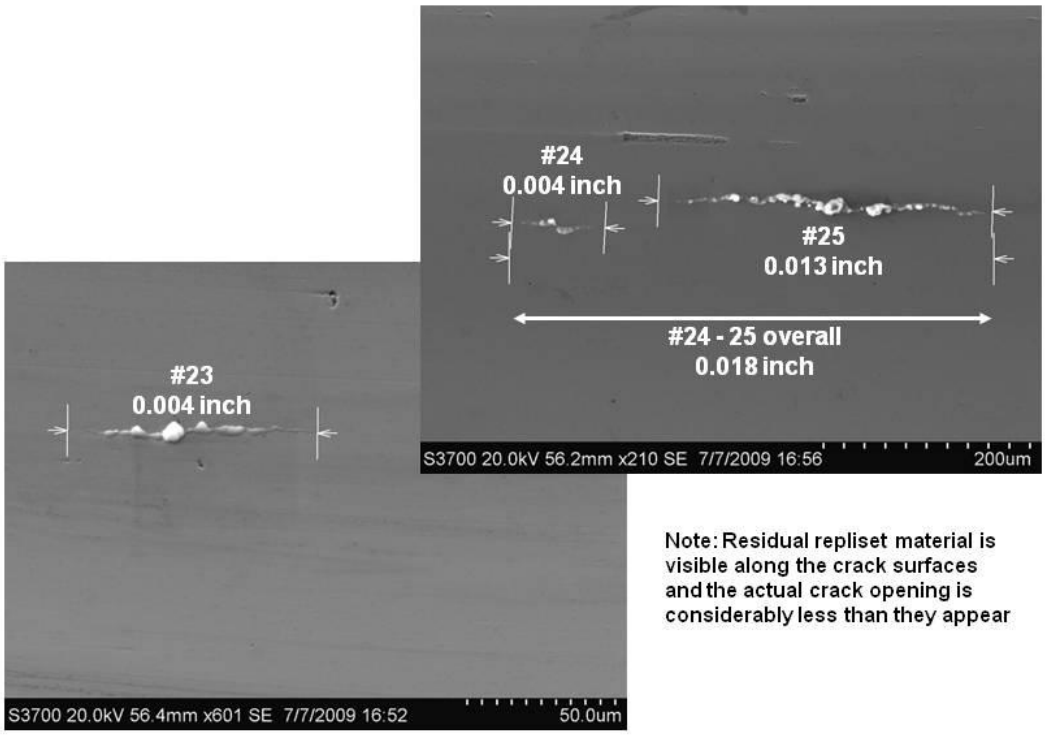


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

368

Poppet #61

Location and size of Cracks #23-25

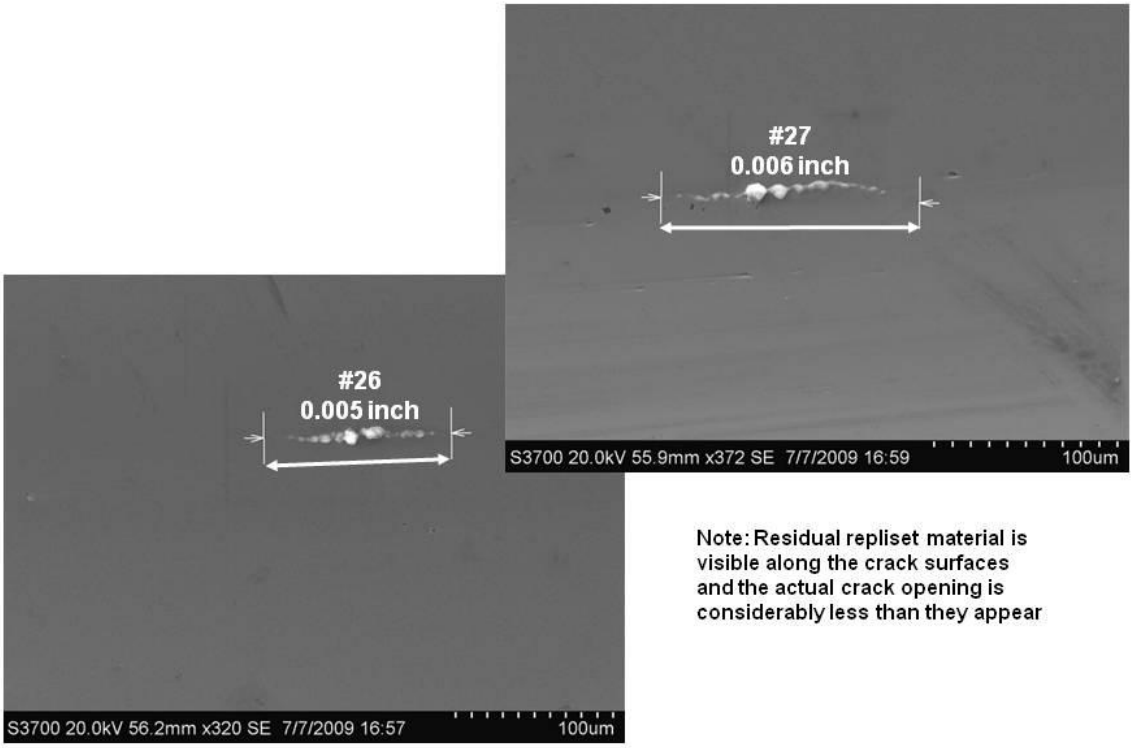


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

369

Poppet #61

Location and size of Cracks #26-27

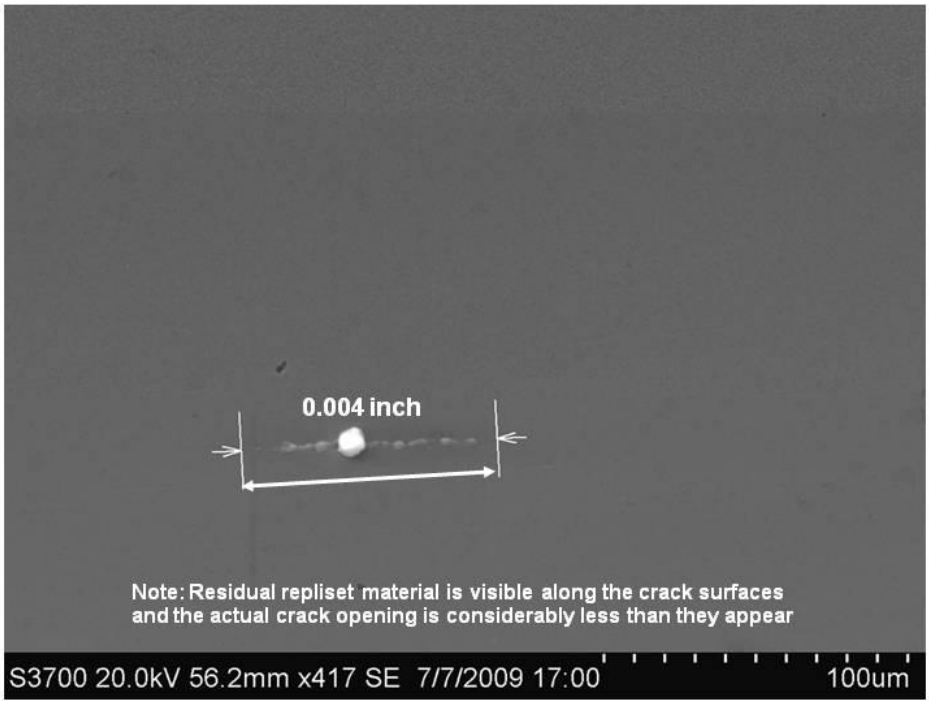


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

370

Poppet #61

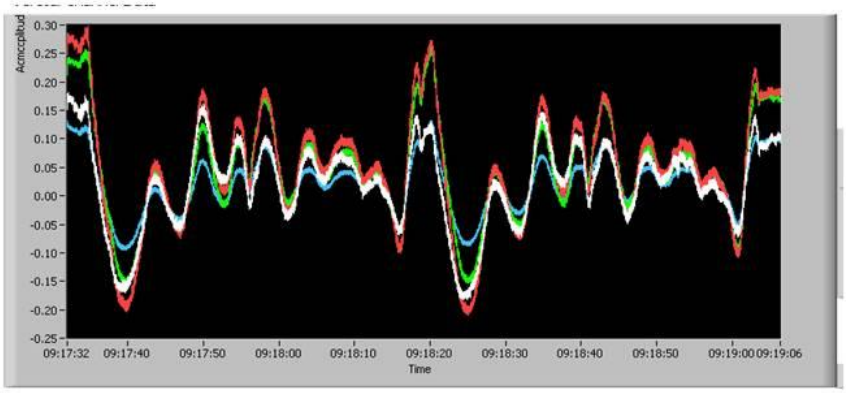
Size of Crack #28



371

Poppet #61

LaRC eddy current findings, the colors indicate ???



372

Poppet #62

Surface crack sizes and locations

Poppet #62					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.009	0	11	0.008	180
2	0.006	0	12	0.002	180
3	0.008	0	13	0.003	180
4	0.006	0	14	0.005	180
5	0.004	180	15	0.004	180
6	0.004	180	16	0.002	180
7	0.002	180	17	0.002	180
8	0.003	180	18	0.004	180
9	0.008	180	19	0.002	180
10	0.004	180	20	0.004	180

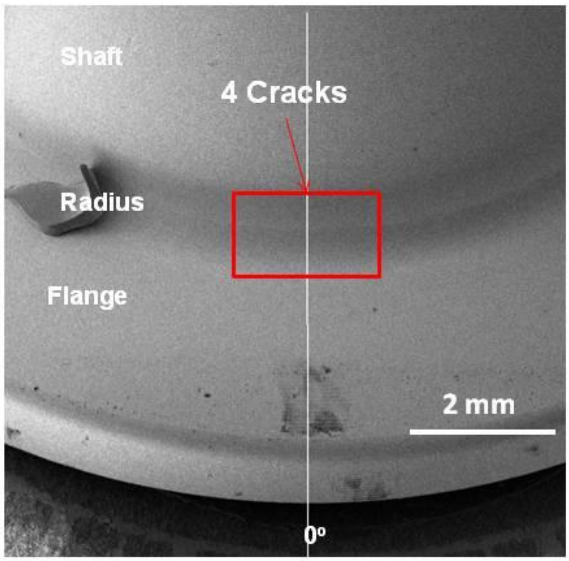
Boeing Eddy Current Findings

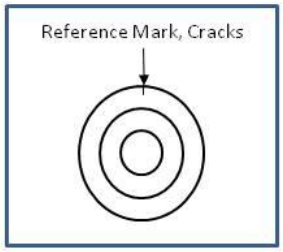
None Provided

373

Poppet #62

Location of Cracks #1-4

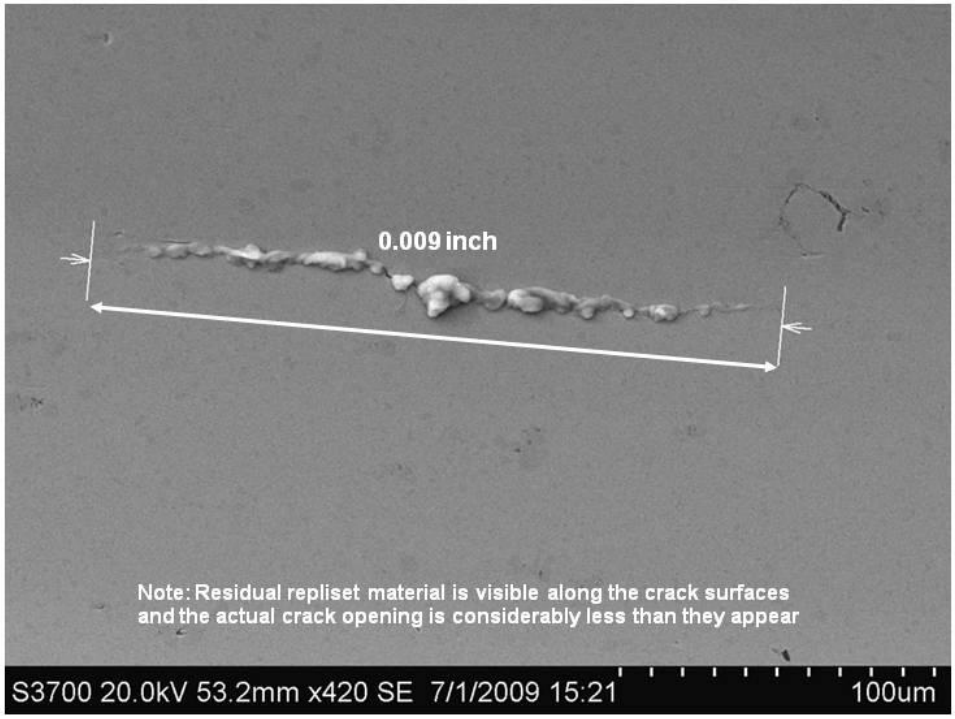




374

Poppet #62

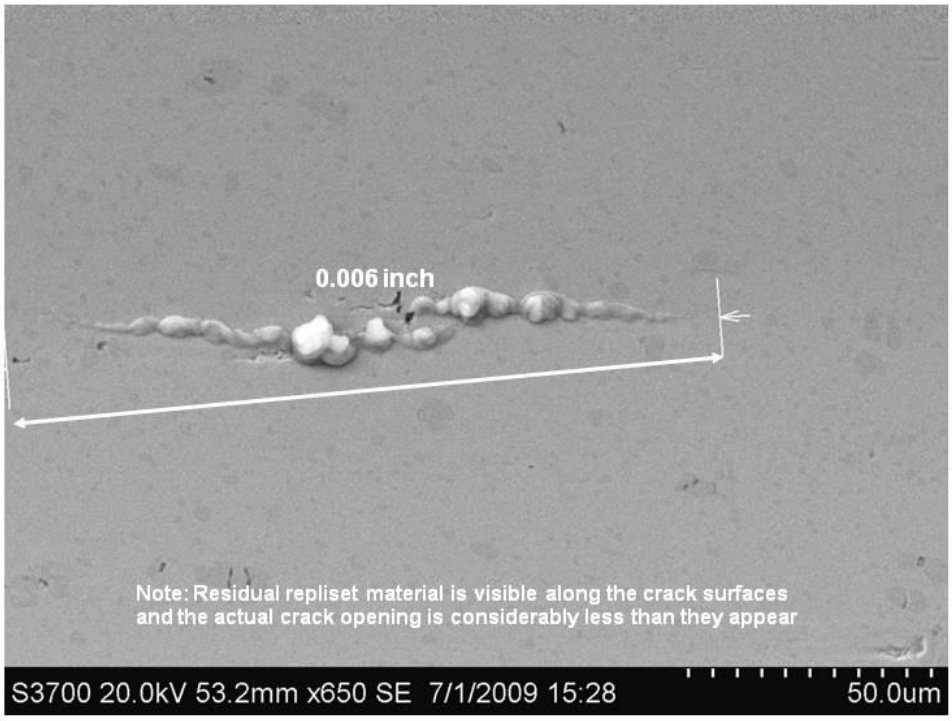
Size of Crack #1



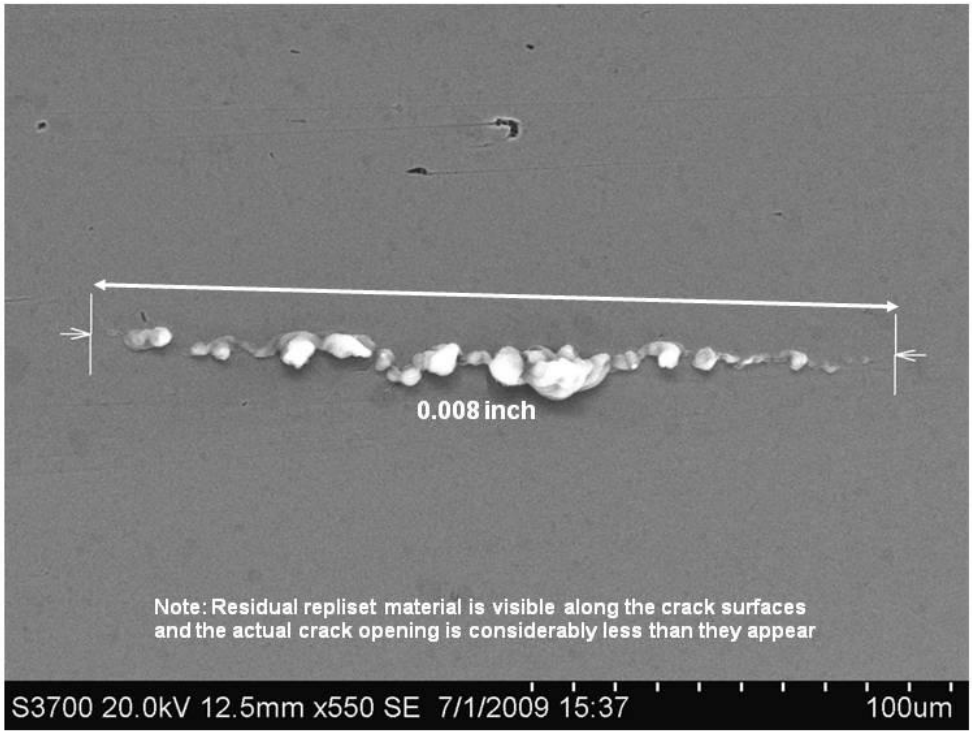
375

Poppet #62

Size of Crack #2



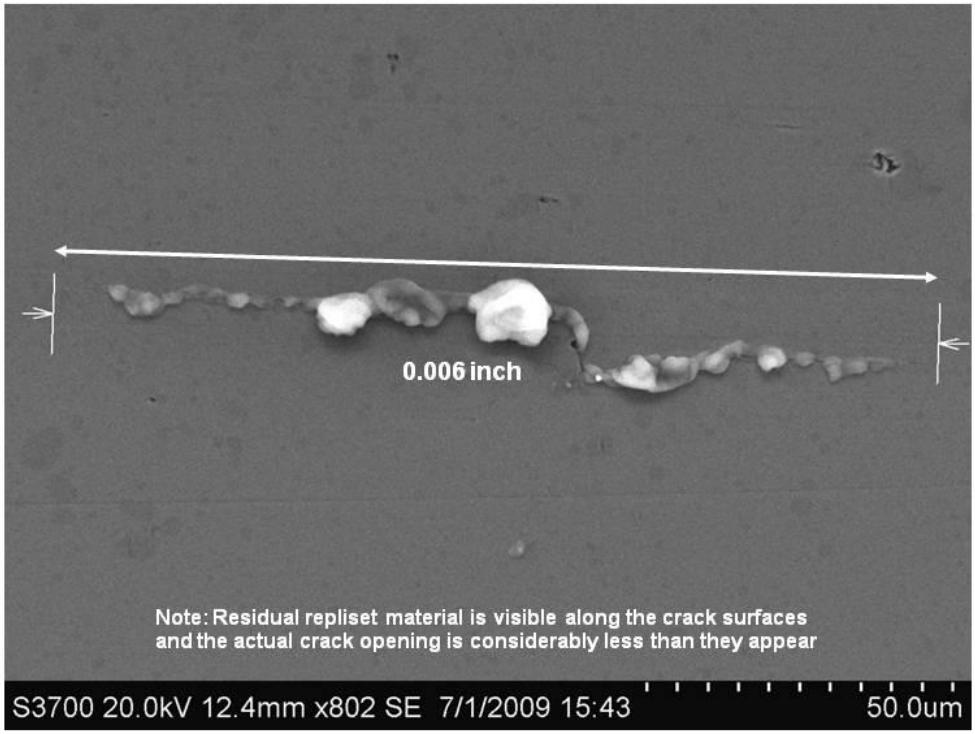
376


Poppet #62
Size of Crack #3
0.008 inch
Note: Residual repliset material is visible along the crack surfaces
and the actual crack opening is considerably less than they appear
S3700 20.0kV 12.5mm x550 SE 7/1/2009 15:37
100um

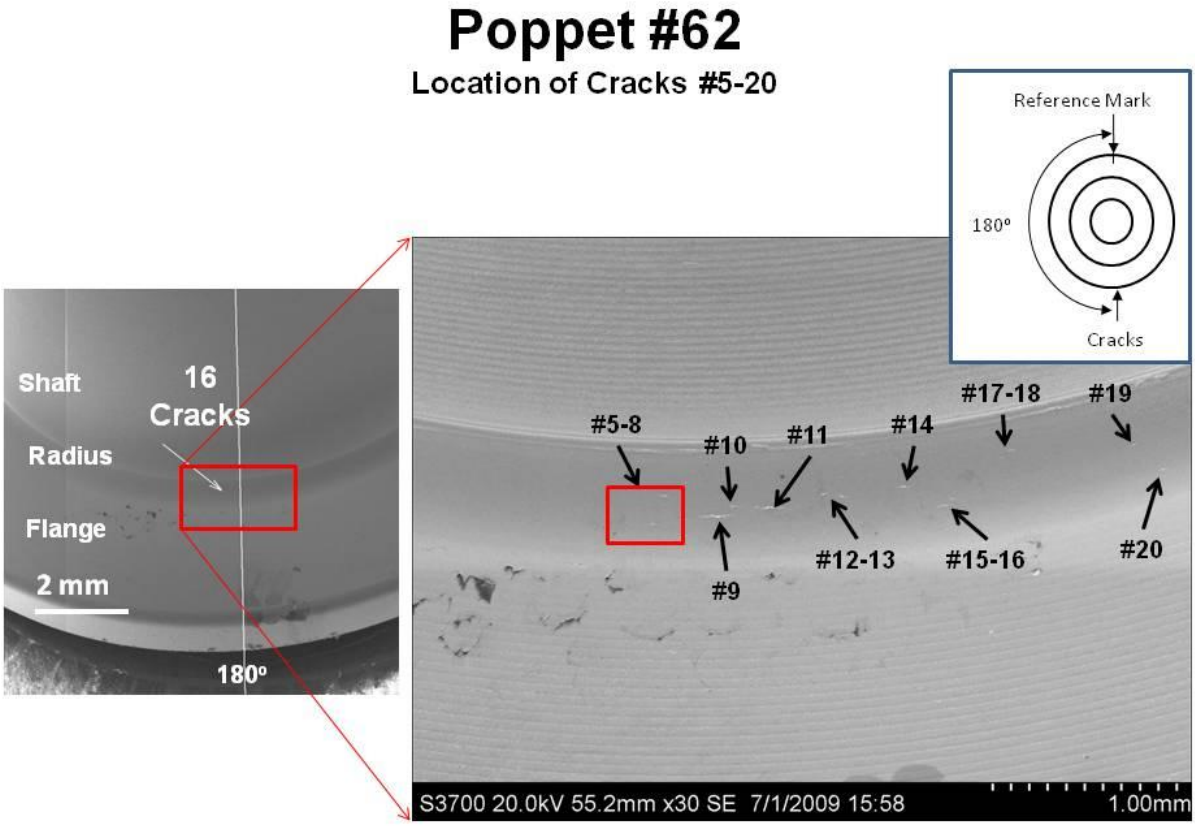
377

Poppet #62

Size of Crack #4



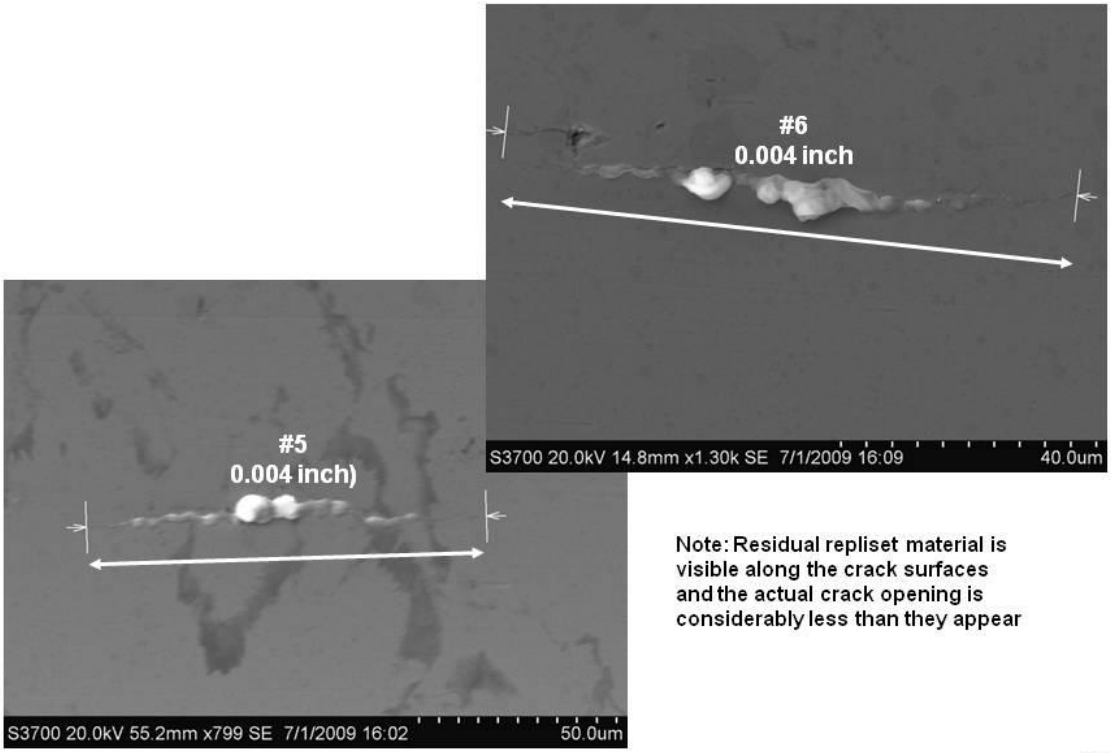
378


Poppet #62
Location of Cracks #5-20
Reference Mark
180°
Cracks
Shaft
16 Cracks
Radius
Flange
2 mm
180°
#5-8
#10
#11
#14
#17-18
#19
#9
#12-13
#15-16
#20
S3700 20.0kV 55.2mm x30 SE 7/1/2009 15:58
1.00mm

379

Poppet #62

Location and size of Cracks #5 and 6

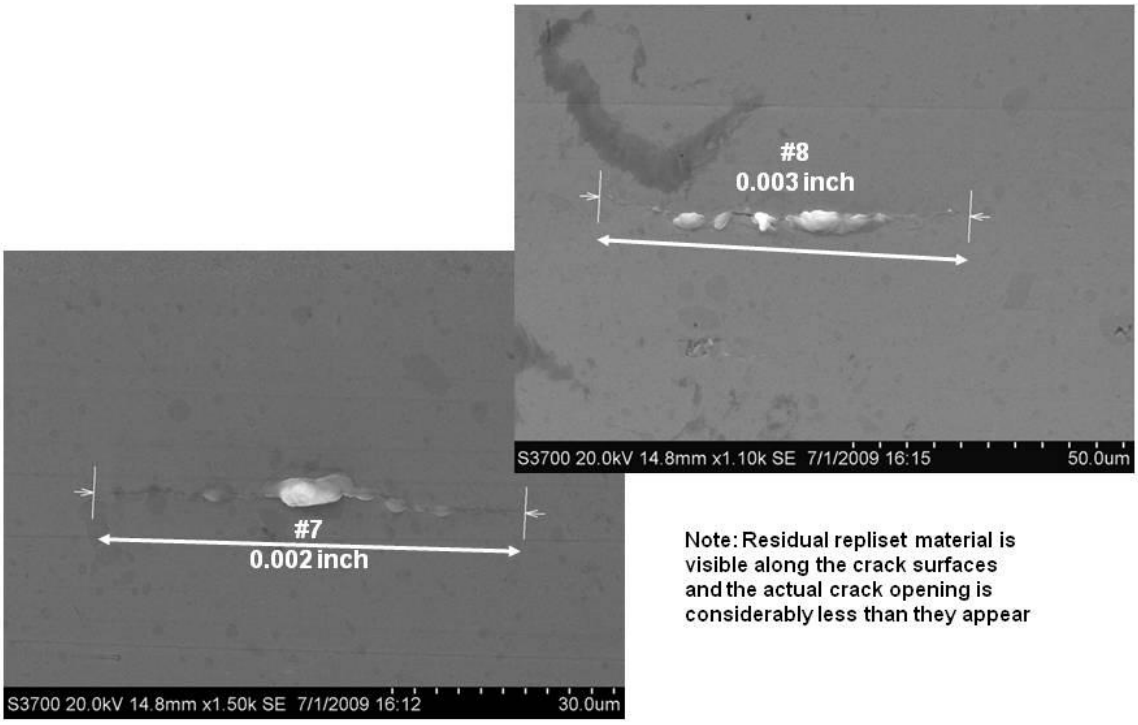


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

380

Poppet #62

Location and size of Cracks #7 and 8

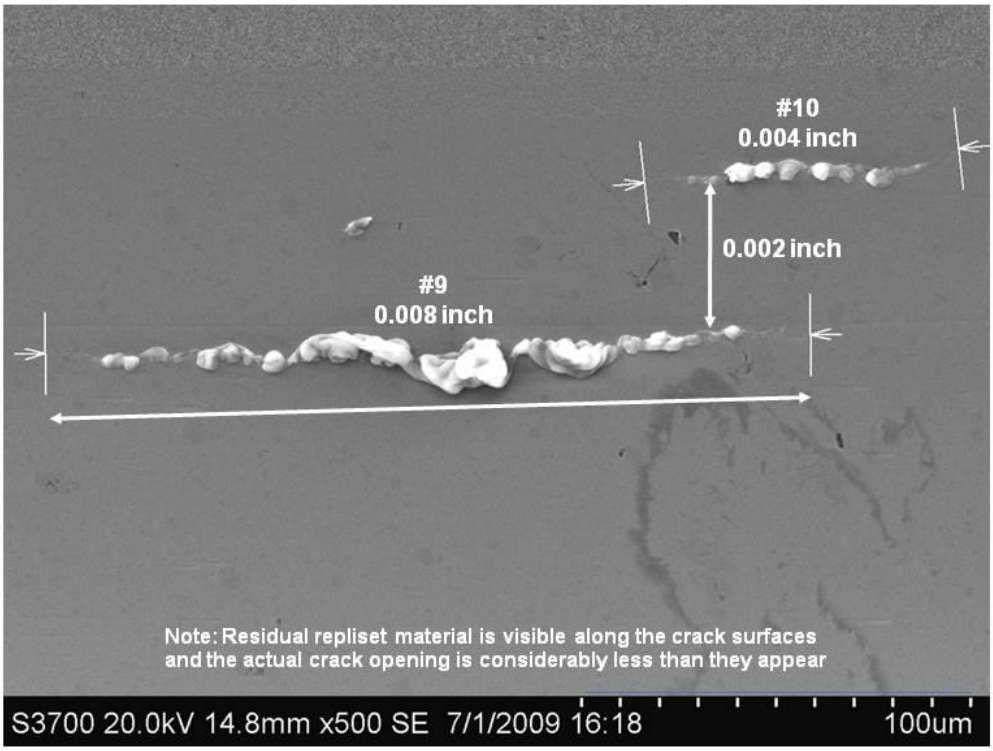


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

381

Poppet #62

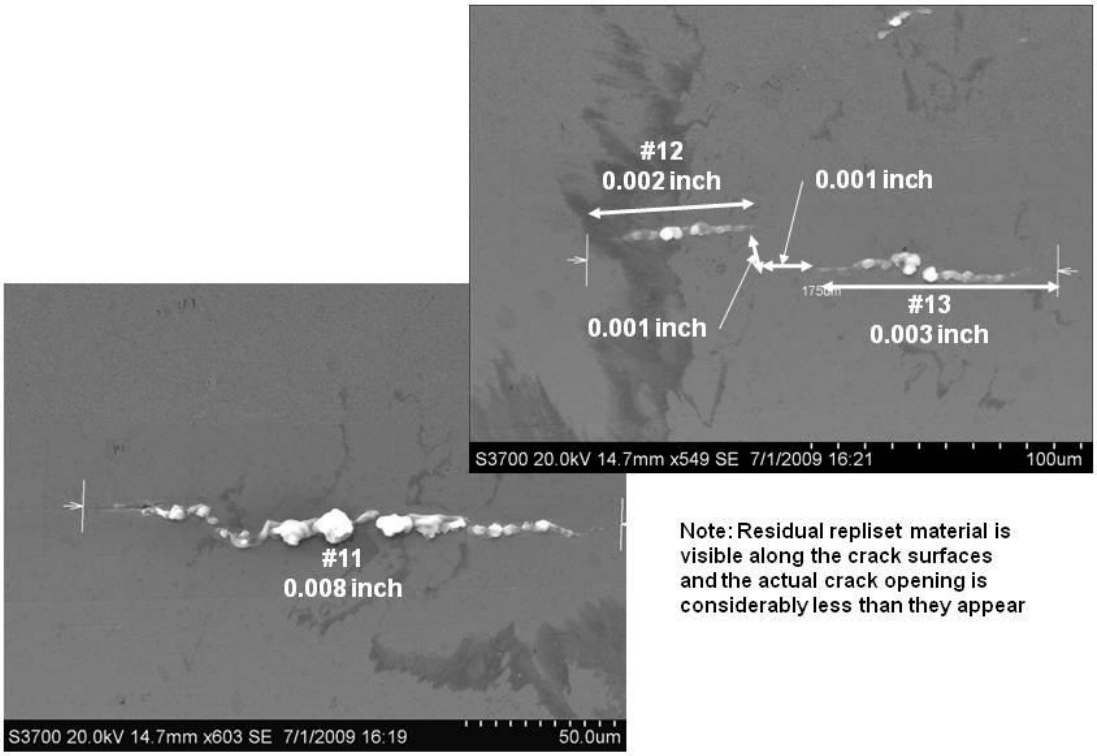
Location and size of Cracks #9 and 10



382

Poppet #62

Location and size of Cracks #11-13

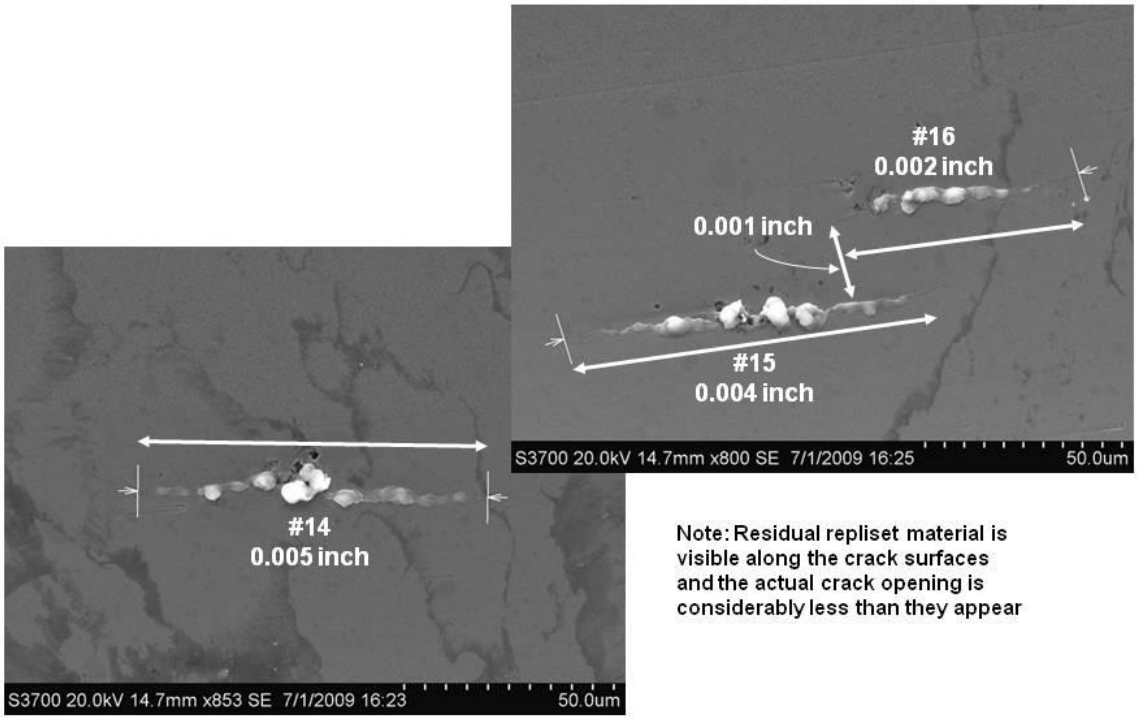


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

383

Poppet #62

Location and size of Cracks #14-16

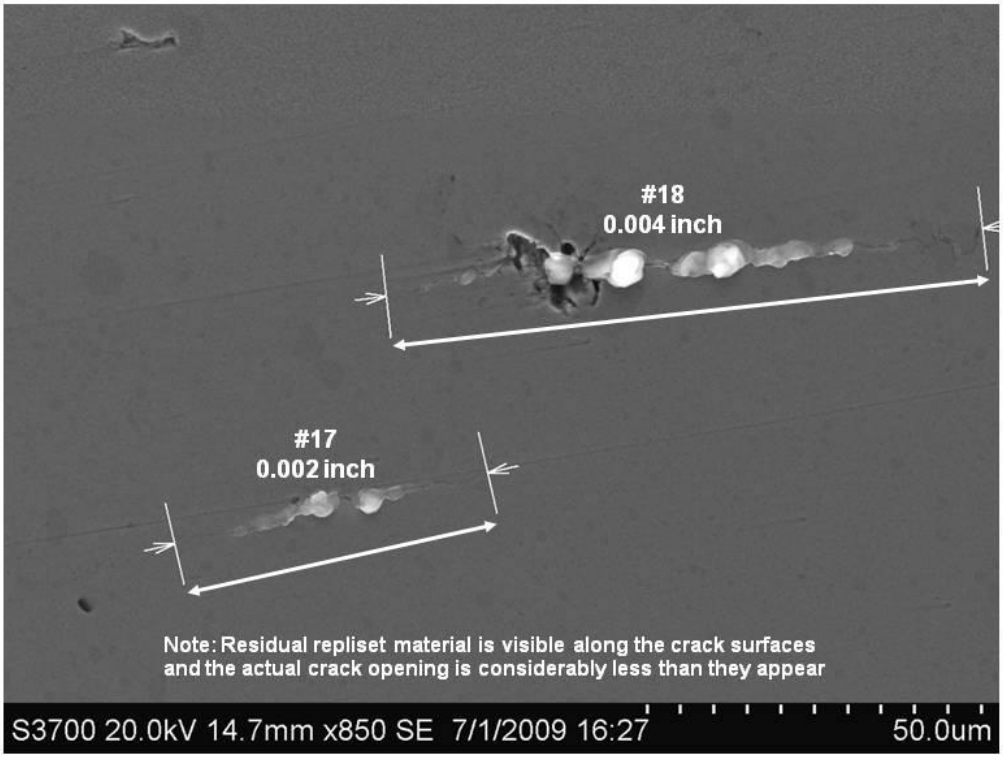


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

384

Poppet #62

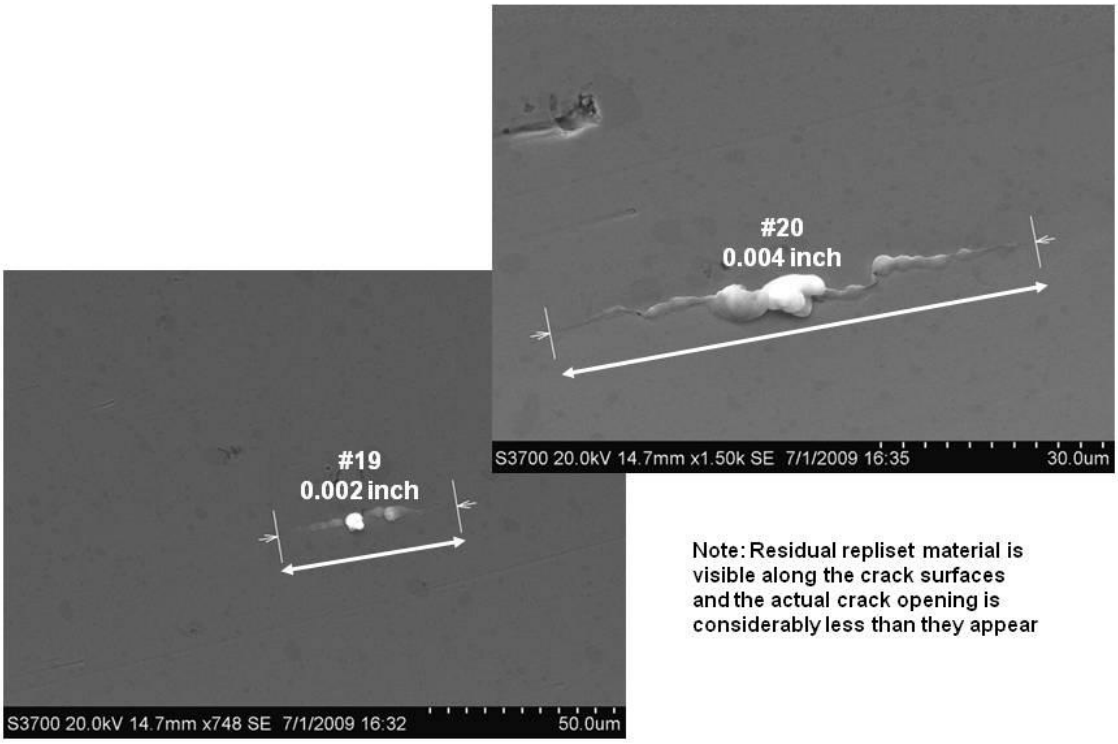
Location and size of Cracks #17 and 18



385

Poppet #62

Size of Cracks #19 and 20

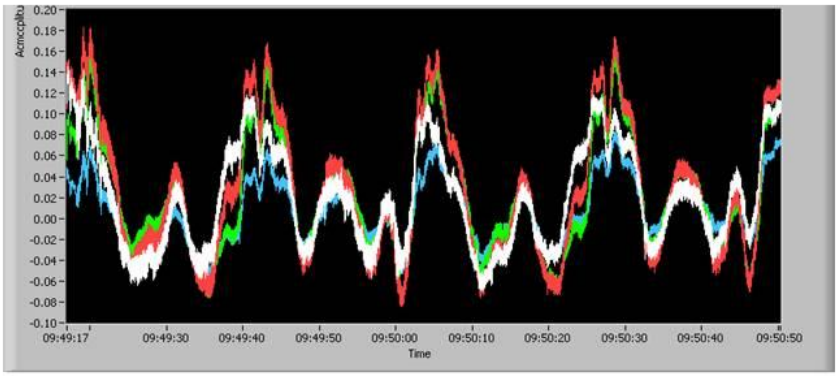


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

386

Poppet #62

LaRC eddy current findings, the colors indicate ???



387

Poppet #63

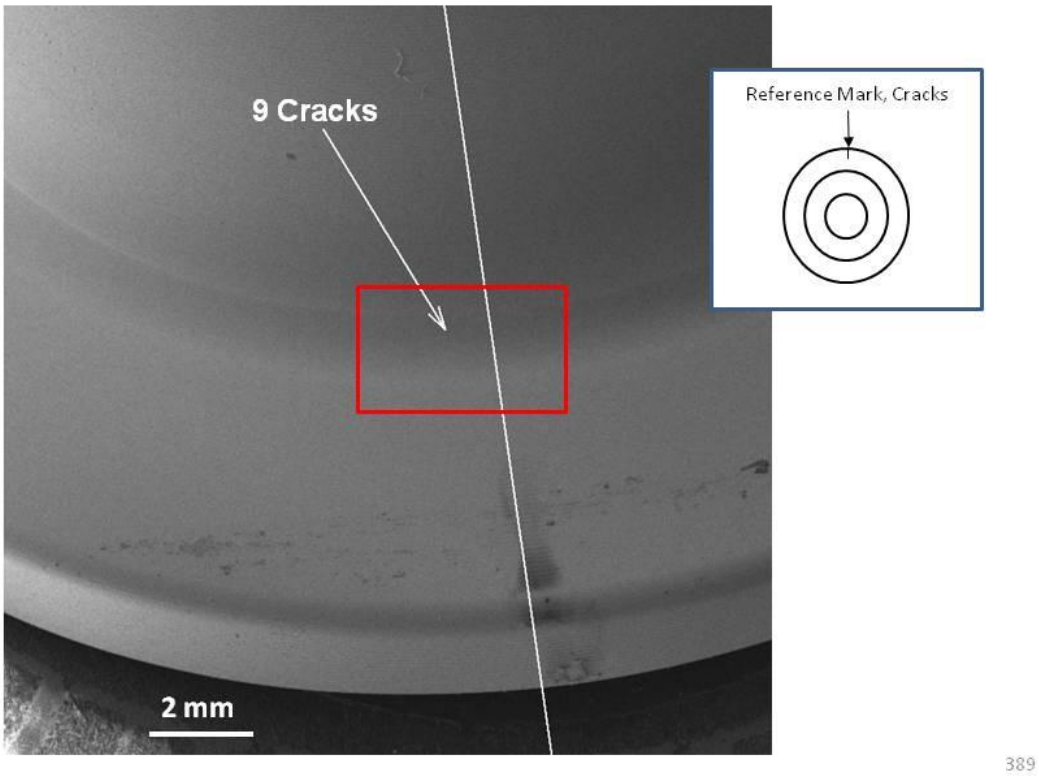
Surface crack sizes and locations

Poppet #63					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.005	0	11	0.006	180
2	0.002	0	12	0.012	180
3	0.015	0	13	0.002	180
4	0.002	0	14	0.002	180
5	0.004	0	15	0.007	180
6	0.004	0	16	0.010	180
7	0.006	0	17	0.006	180
8	0.004	0	18	0.015	180
9	0.002	0	19	0.002	180
10	0.002	180	20	0.002	180

Boeing Eddy Current Findings

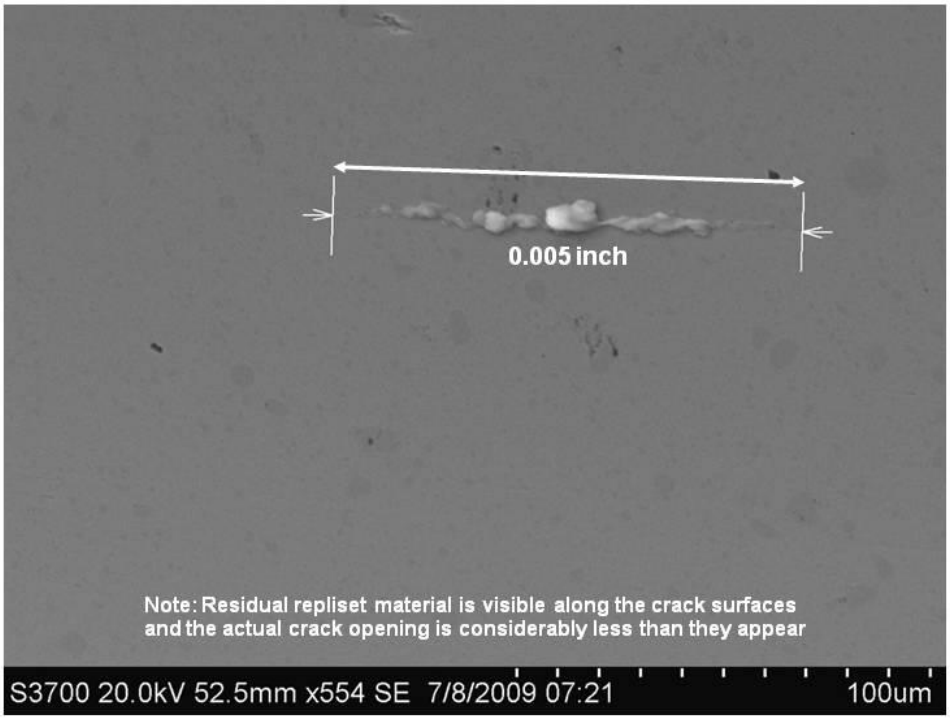
None Provided

388

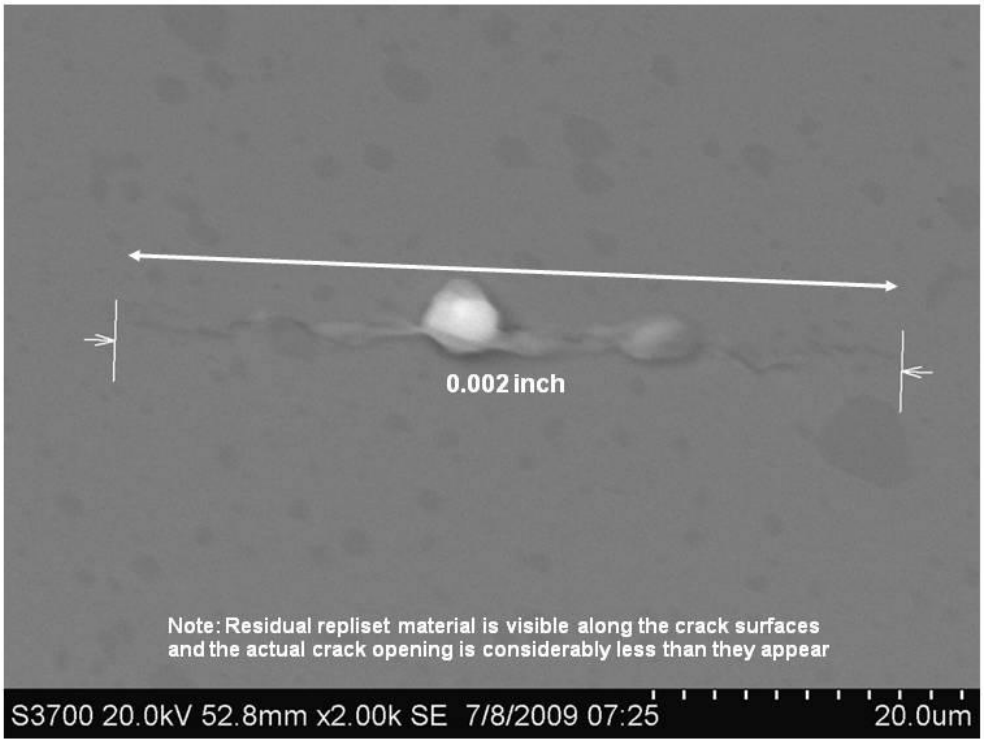

Poppet #63
Location of Cracks #1-9
9 Cracks
Reference Mark, Cracks
2 mm
389

Poppet #63

Size of Crack #1



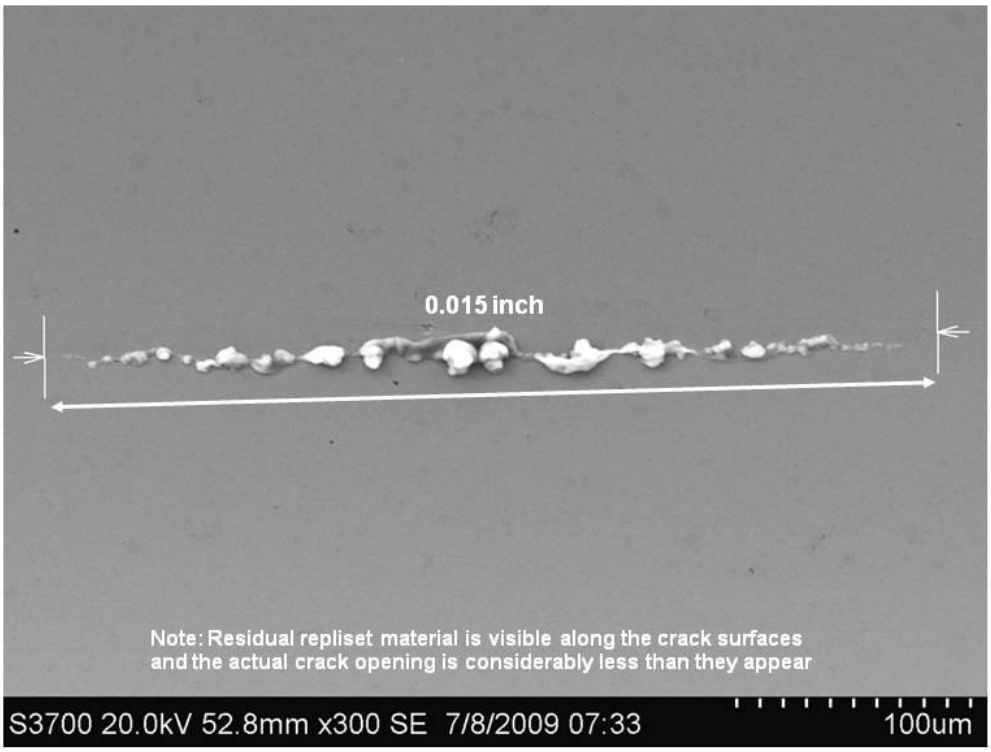
390


Poppet #63
Size of Crack #2
0.002 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 52.8mm x2.00k SE 7/8/2009 07:25
20.0um

391

Poppet #63

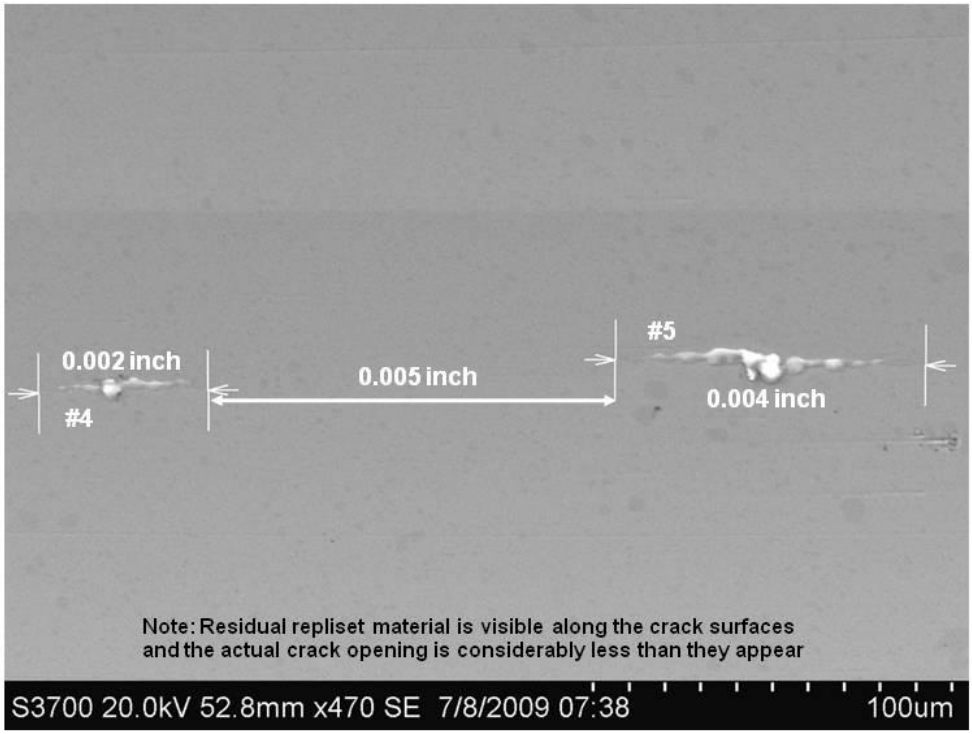
Size of Crack #3



392

Poppet #63

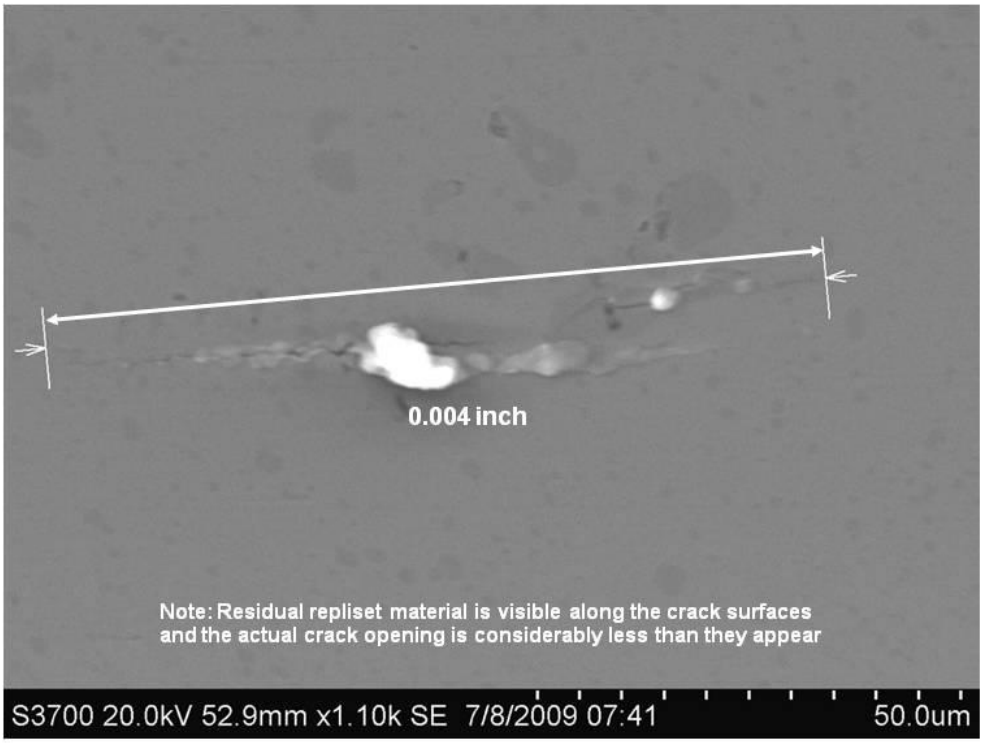
Location and size of Cracks #4 and 5



393

Poppet #63

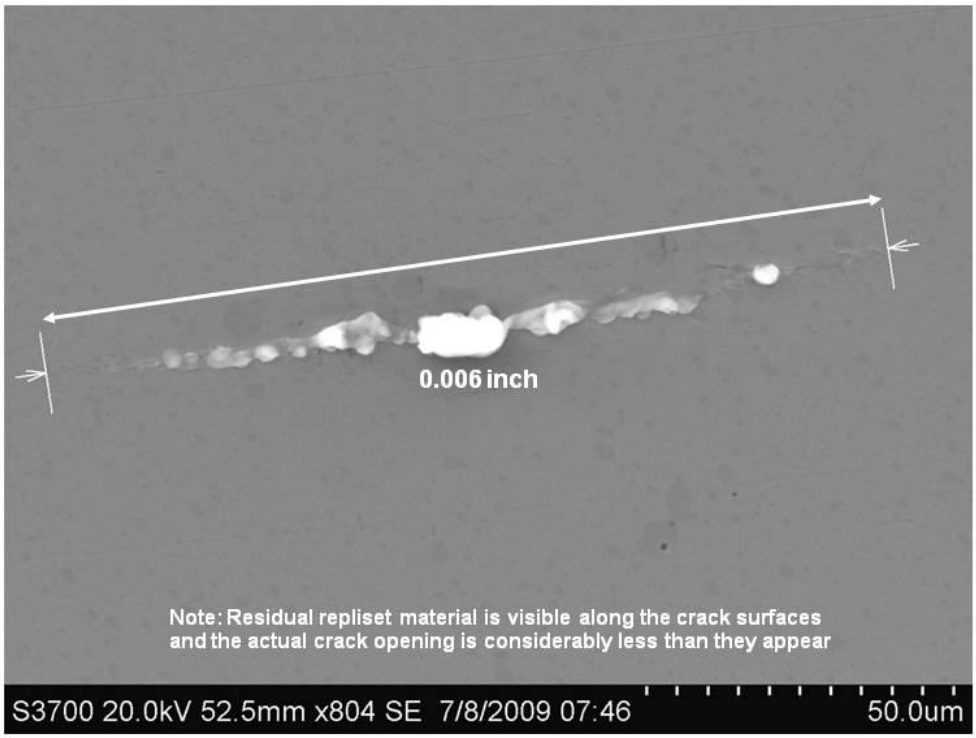
Size of Crack #6



394

Poppet #63

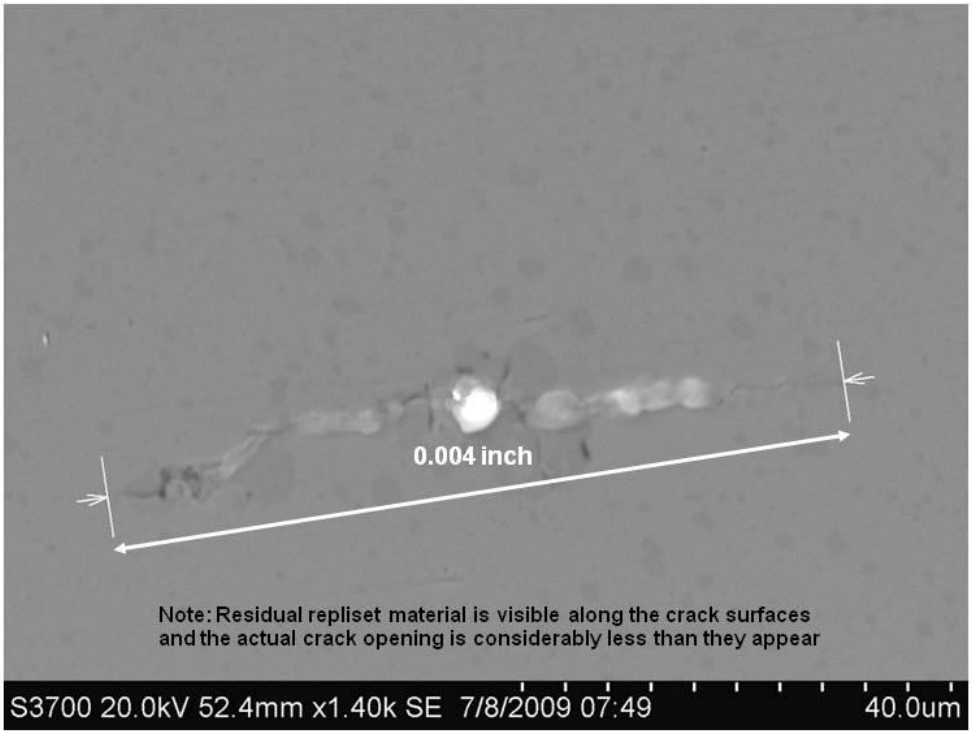
Size of Crack #7



395

Poppet #63

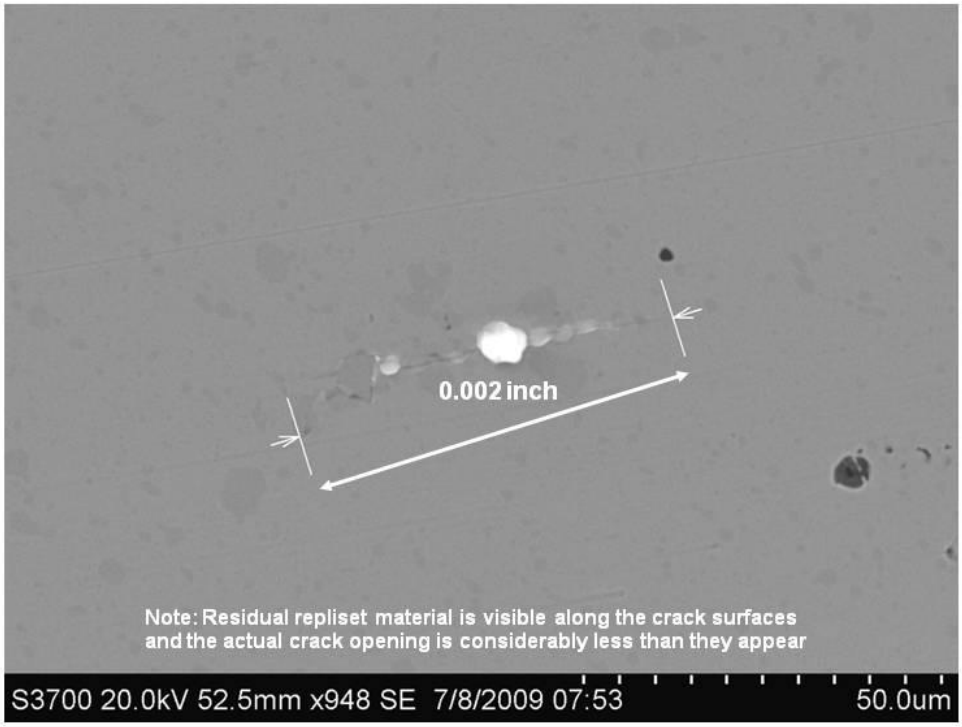
Size of Crack #8



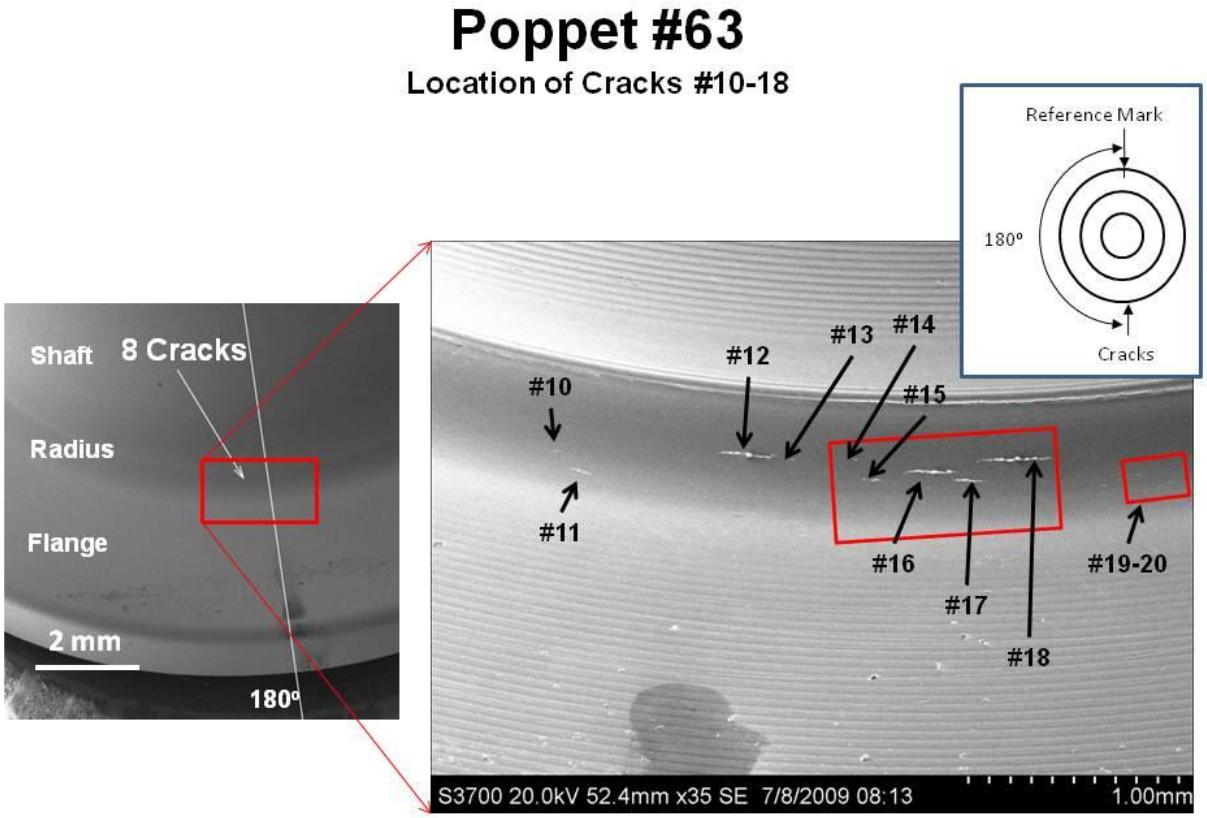
396

Poppet #63

Size of Crack #9



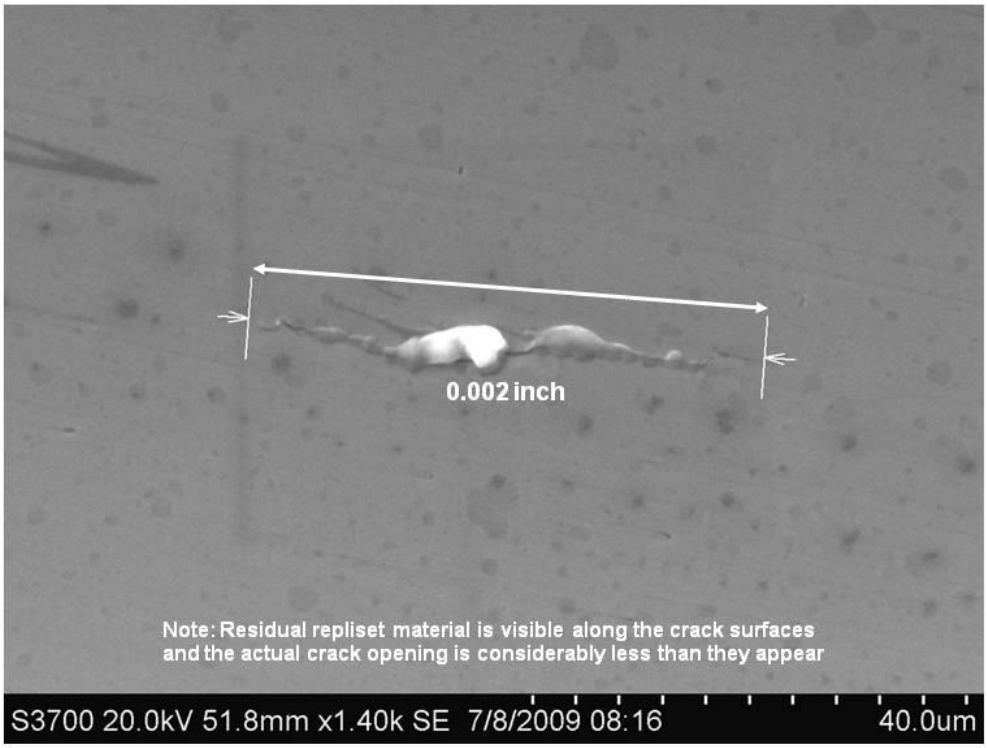
397


Poppet #63
Location of Cracks #10-18
Reference Mark
180°
Cracks
Shaft
8 Cracks
Radius
Flange
2 mm
180°
#10
#11
#12
#13
#14
#15
#16
#17
#18
#19-20
S3700 20.0kV 52.4mm x35 SE 7/8/2009 08:13
1.00mm

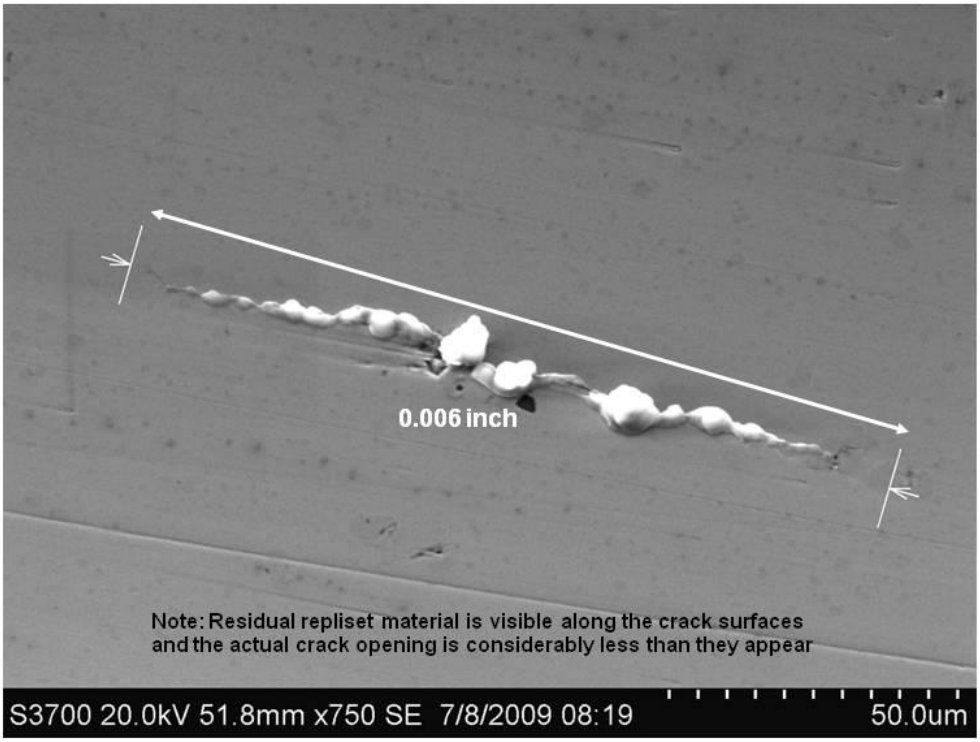
398

Poppet #63

Size of Crack #10



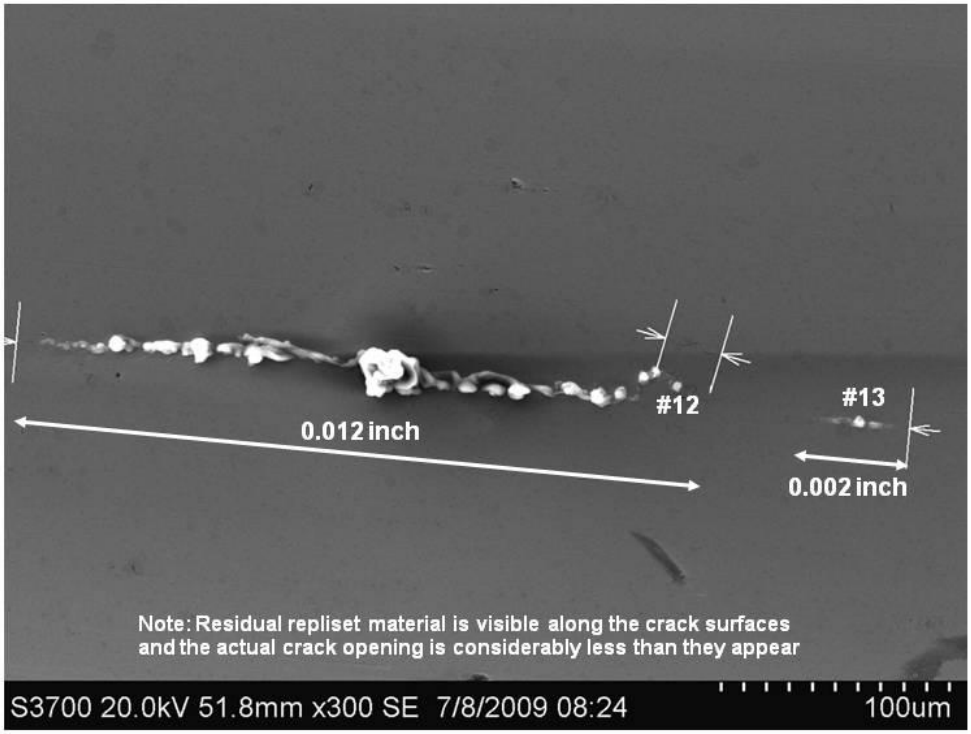
399


Poppet #63
Size of Crack #11
0.006 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 51.8mm x750 SE 7/8/2009 08:19
50.0um

400

Poppet #63

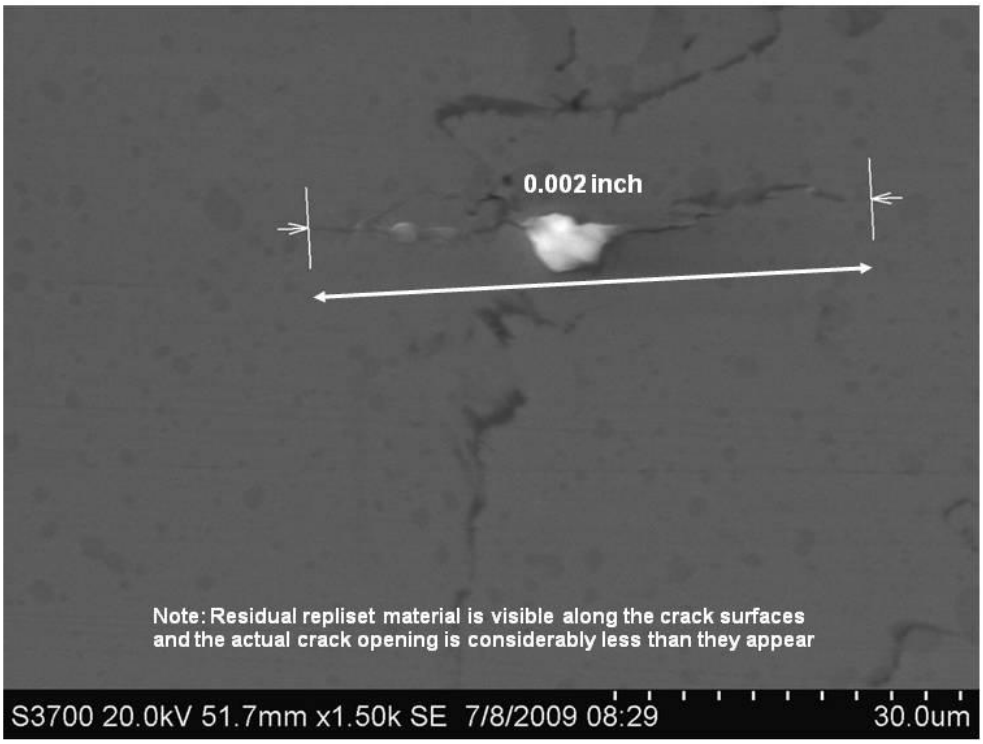
Location and size of Cracks #12 and 13



401

Poppet #63

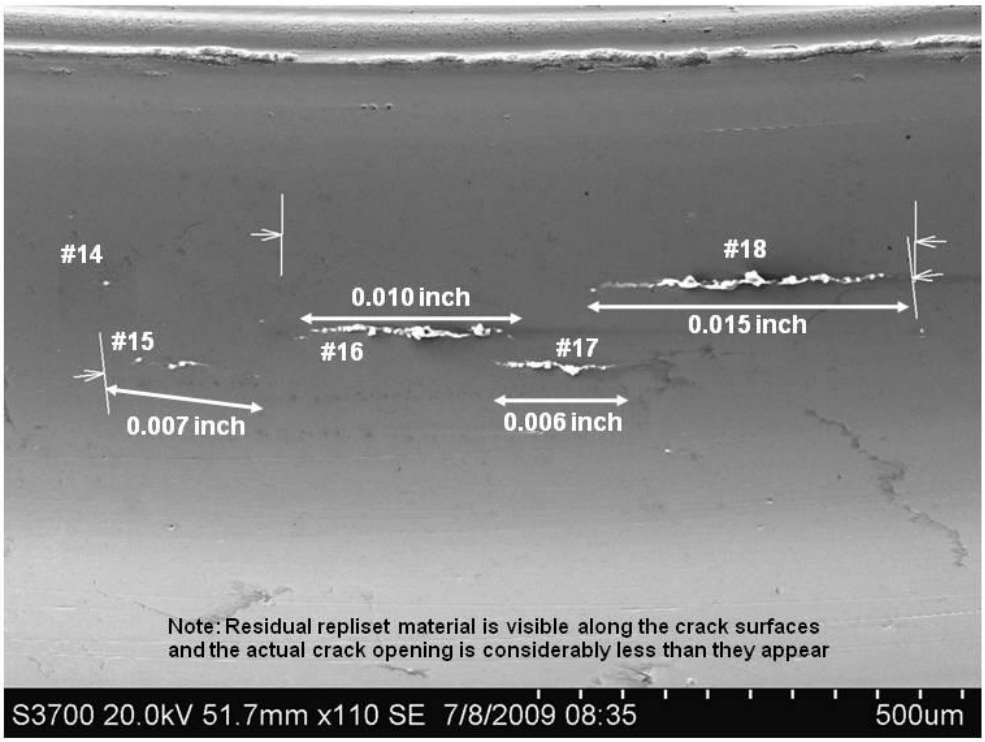
Size of Crack #14



402

Poppet #63

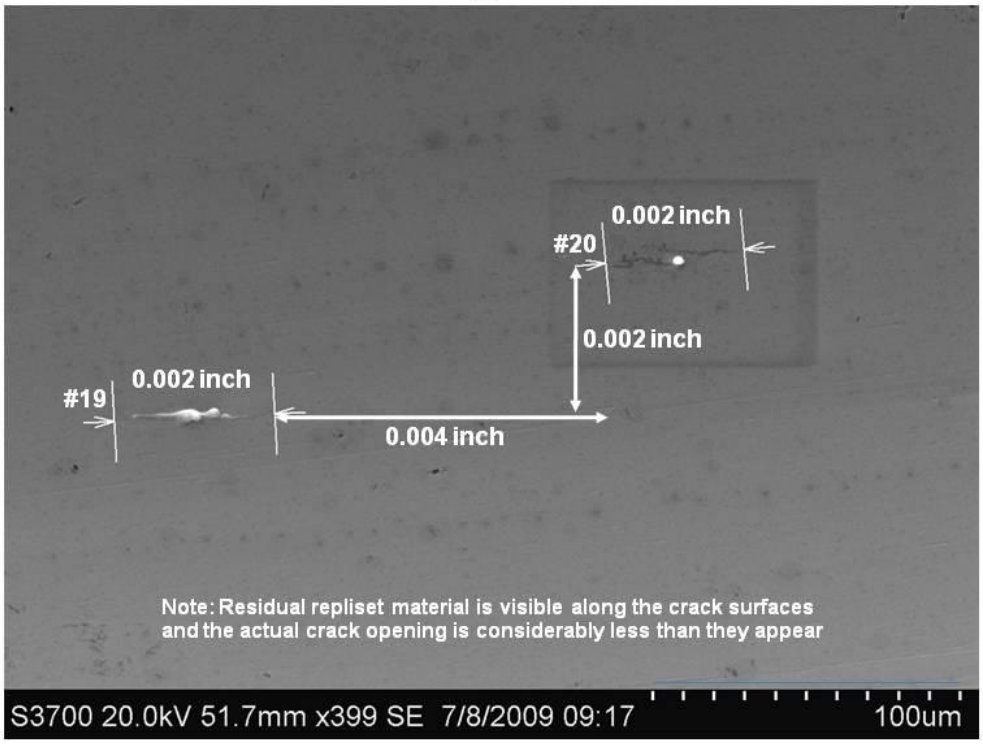
Location and size of Cracks #14-18



403

Poppet #63

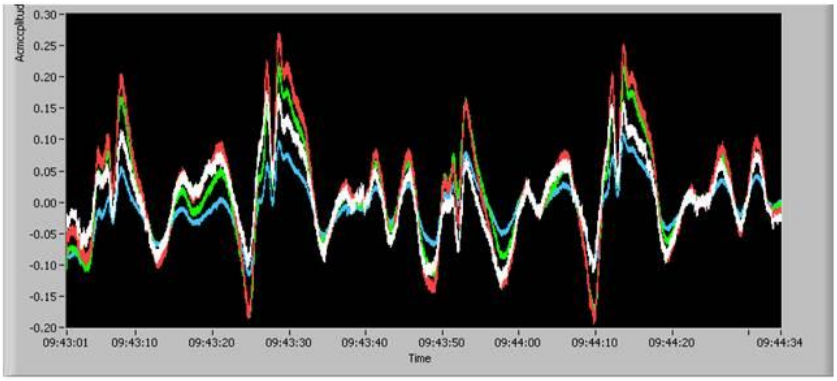
Location and size of Region B Cracks #19 and 20



404

Poppet #63

LaRC eddy current findings, the colors indicate ???



405

Poppet #64

Surface crack sizes and locations

Poppet #64					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.002	225	11	0.009	45
2	0.002	225	12	0.009	45
3	0.004	225	13	0.007	45
4	0.002	225	14	0.006	45
5	0.001	225	15	0.009	45
6	0.002	225	16	0.002	45
7	0.004	45	17	0.003	45
8	0.004	45	18	0.003	45
9	0.002	45	19	0.004	45
10	0.004	45	20	0.025	45

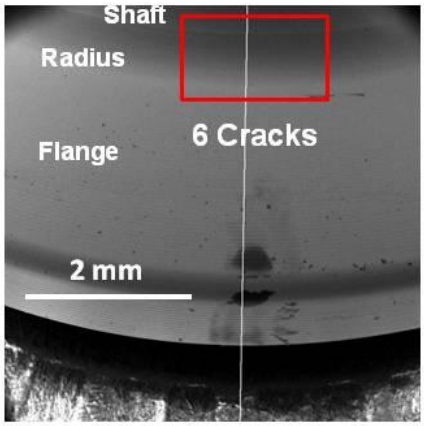
Boeing Eddy Current Findings

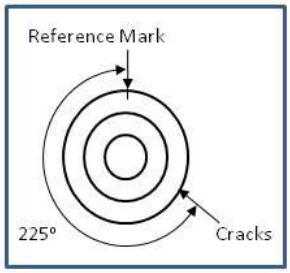
Poppet #64									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.233	0.237	0.239	0.244	0.240	0.244	0.240	Yes	195
J. Engel	0.066	0.068	na	0.070	0.071	0.072	0.069	Yes	5 (Not 3:1 S/N ratio)
B. Devries	-	-	-	-	-	-	-	No	45
B. Devries	0.242	0.241	0.247	0.246	0.240	0.235	0.242	Yes	210

406

Poppet #64

Location of Cracks #1-6

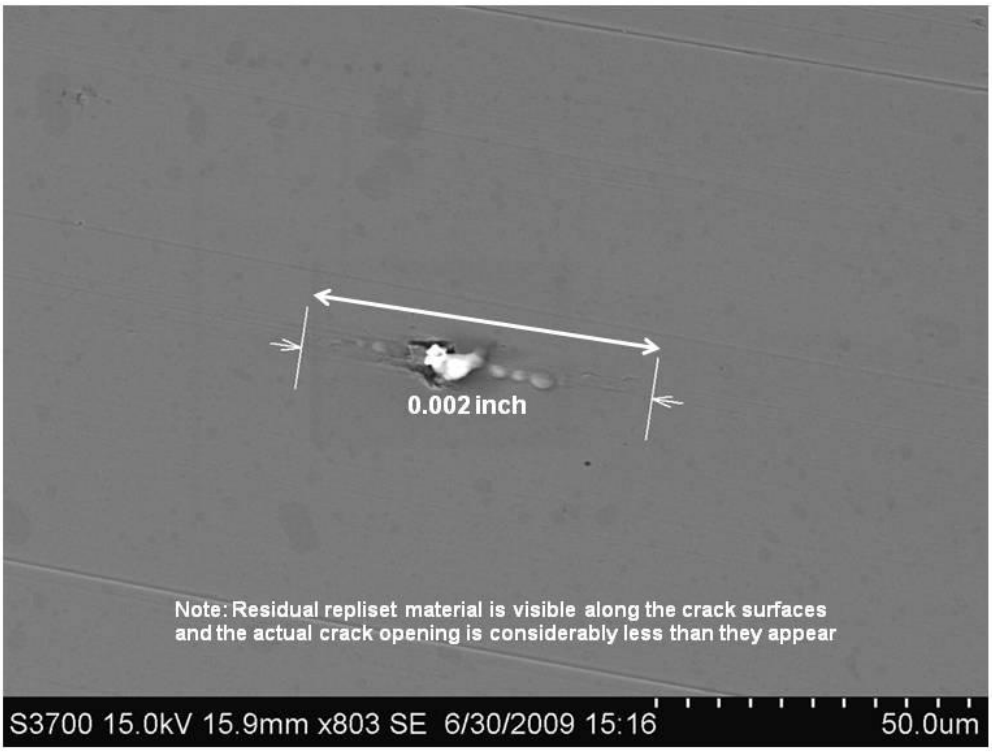




407

Poppet #64

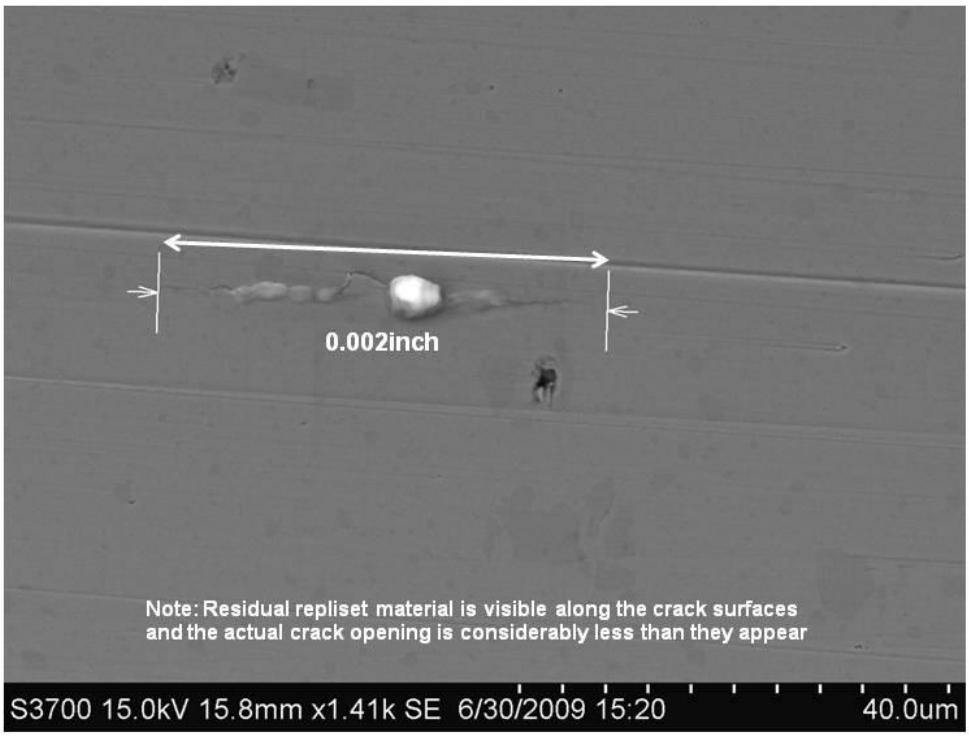
Size of Crack #1



408

Poppet #64

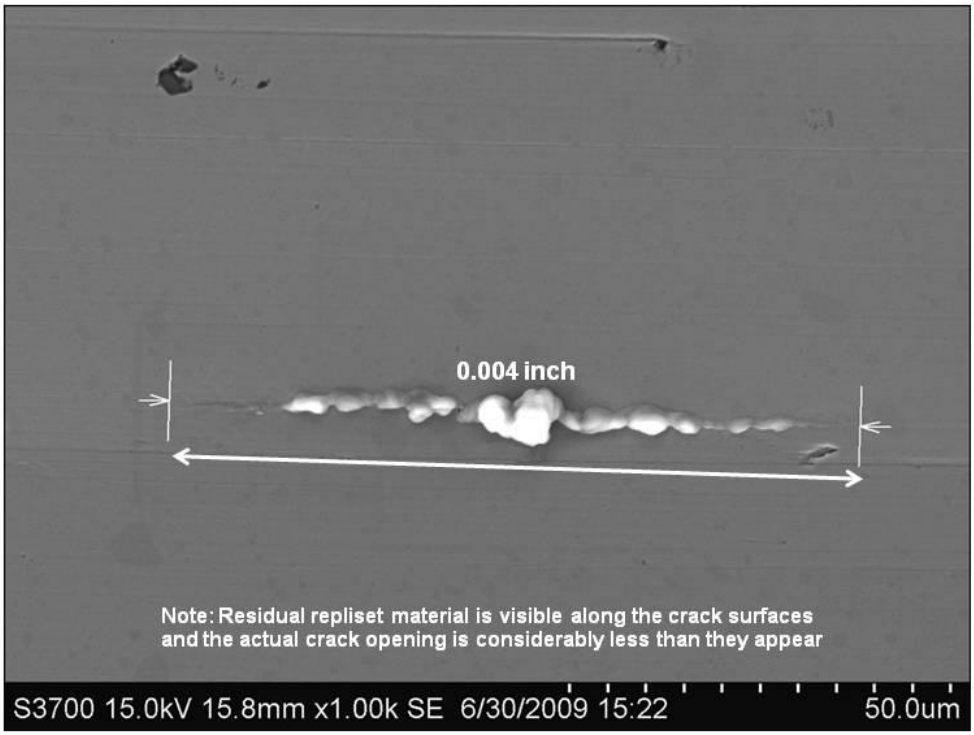
Size of Crack #2



409

Poppet #64

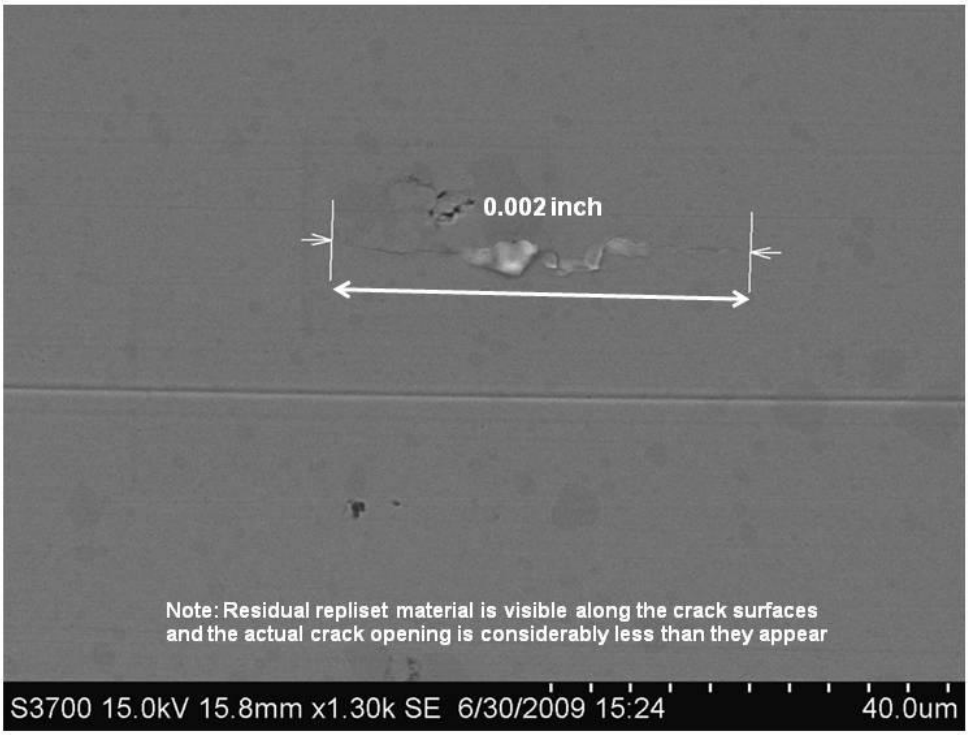
Size of Crack #3



410

Poppet #64

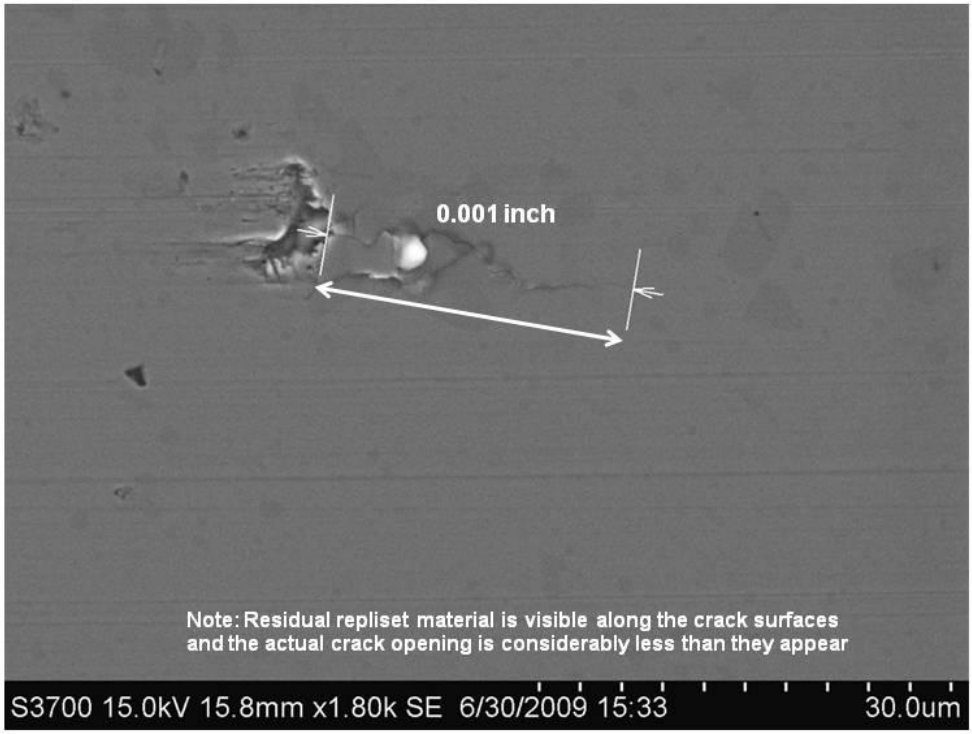
Size of Crack #4



411

Poppet #64

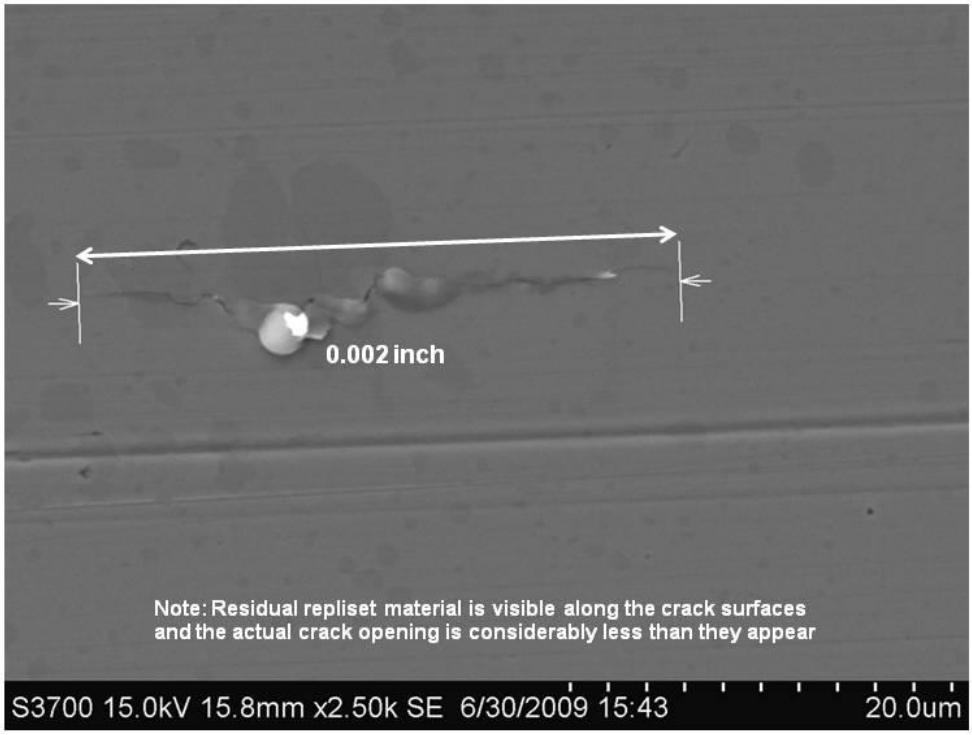
Size of Crack #5



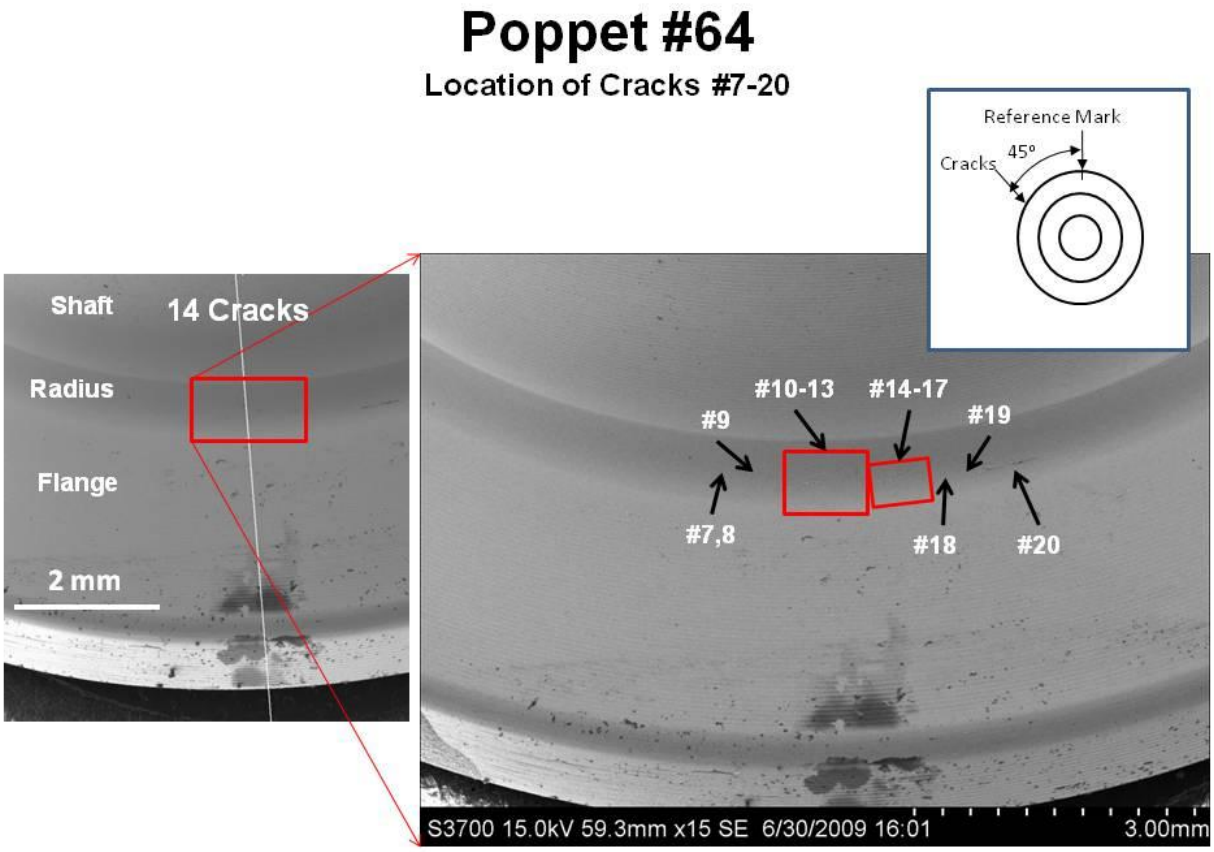
412

Poppet #64

Size of Crack #6

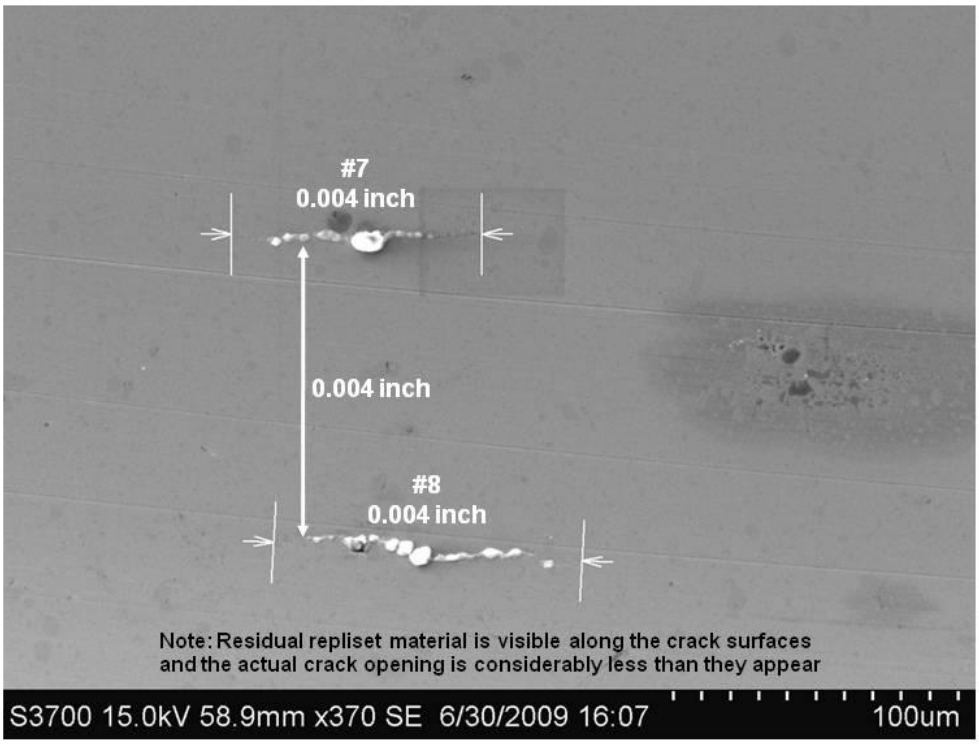


413


Poppet #64
Location of Cracks #7-20
Reference Mark
45°
Cracks
Shaft
14 Cracks
Radius
Flange
2 mm
#9
#10-13
#14-17
#19
#7,8
#18
#20
S3700 15.0kV 59.3mm x15 SE 6/30/2009 16:01
3.00mm
414

Poppet #64

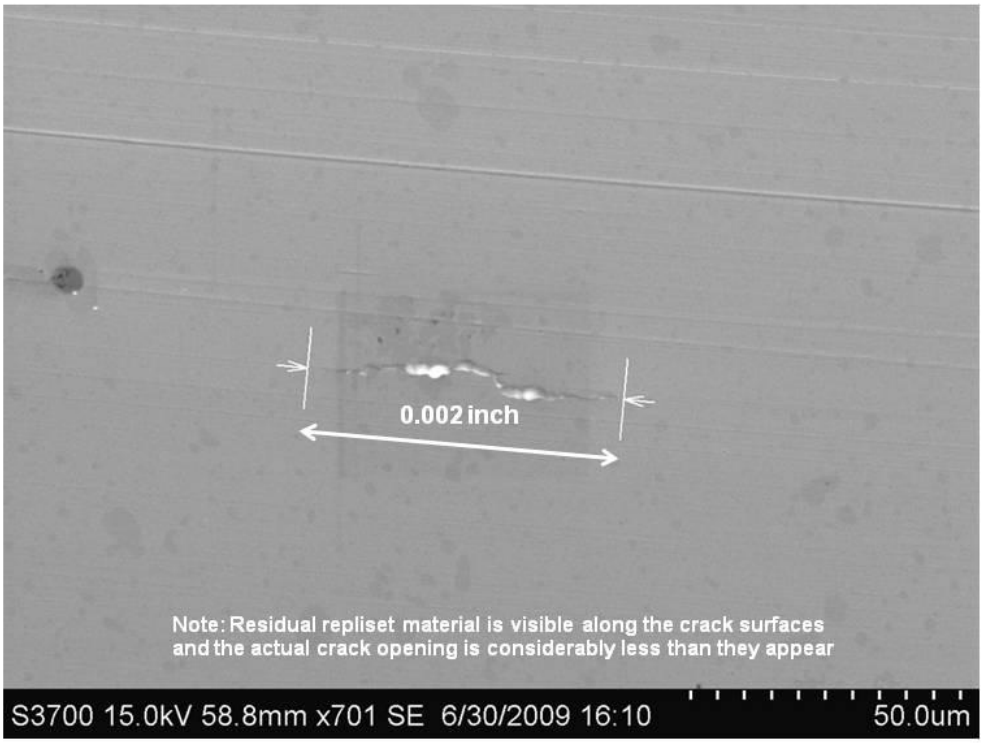
Location and size of Cracks #7 and 8



415

Poppet #64

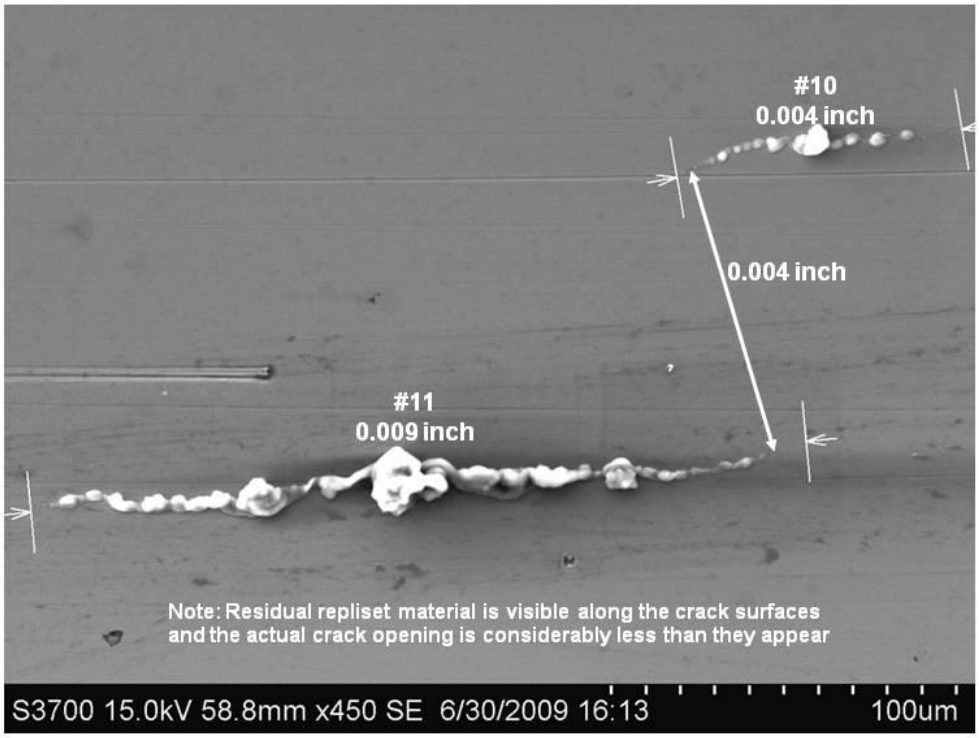
Size of Crack #9



416

Poppet #64

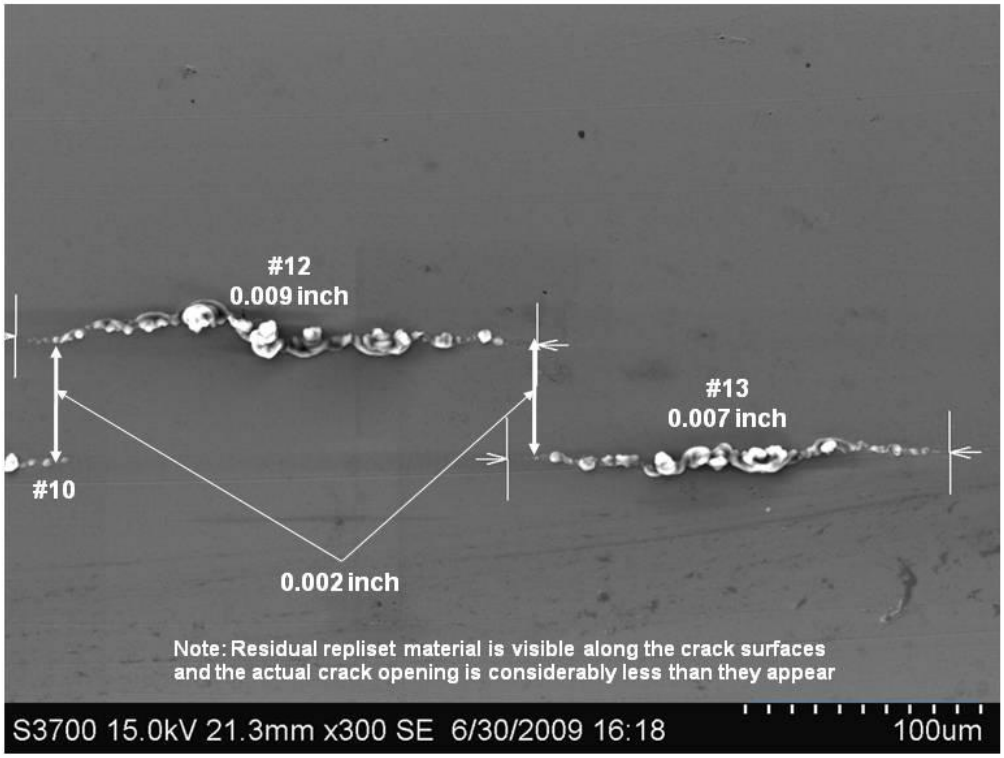
Location and size of Cracks #10-11



417

Poppet #64

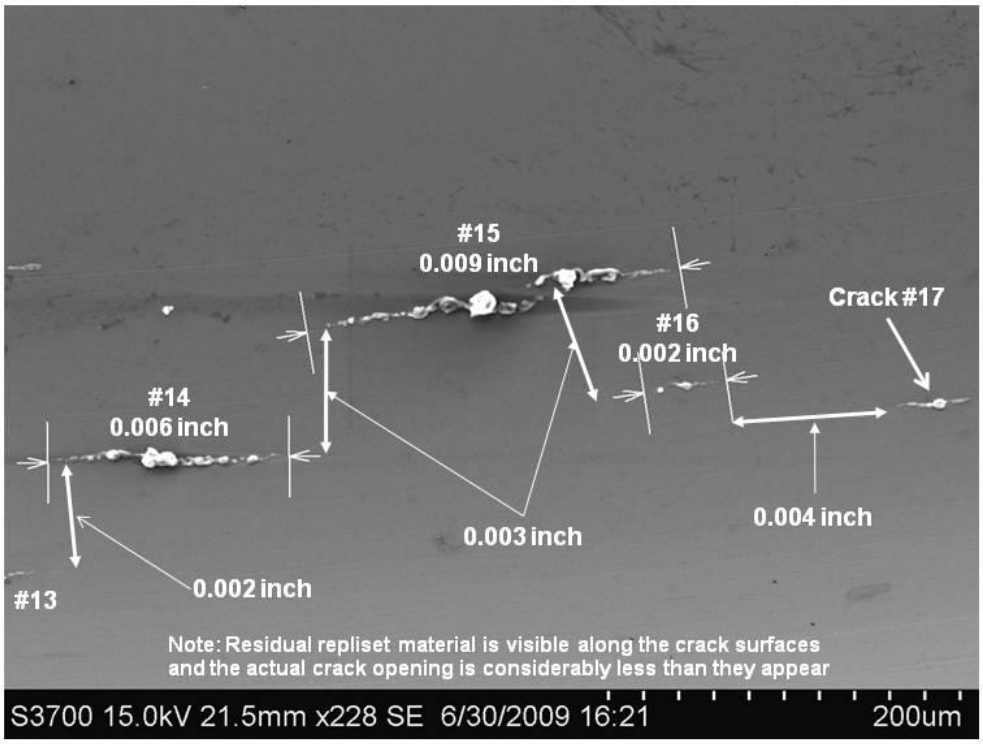
Location and size of Cracks #12-13



418

Poppet #64

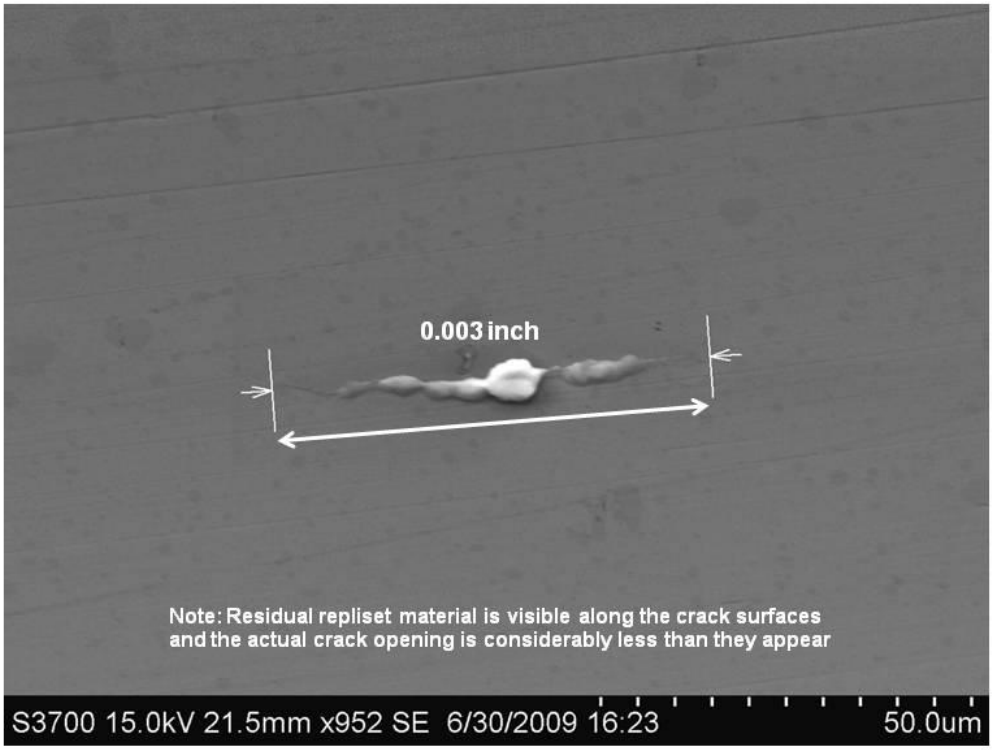
Location and size of Region B Cracks #14-16



419

Poppet #64

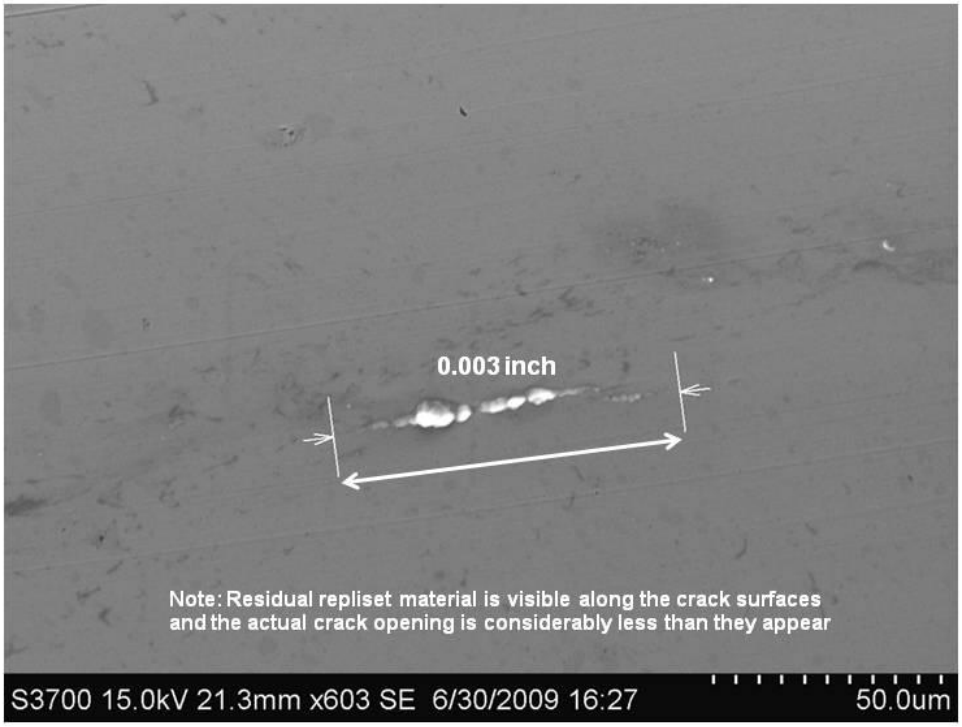
Size of Crack #17



420

Poppet #64

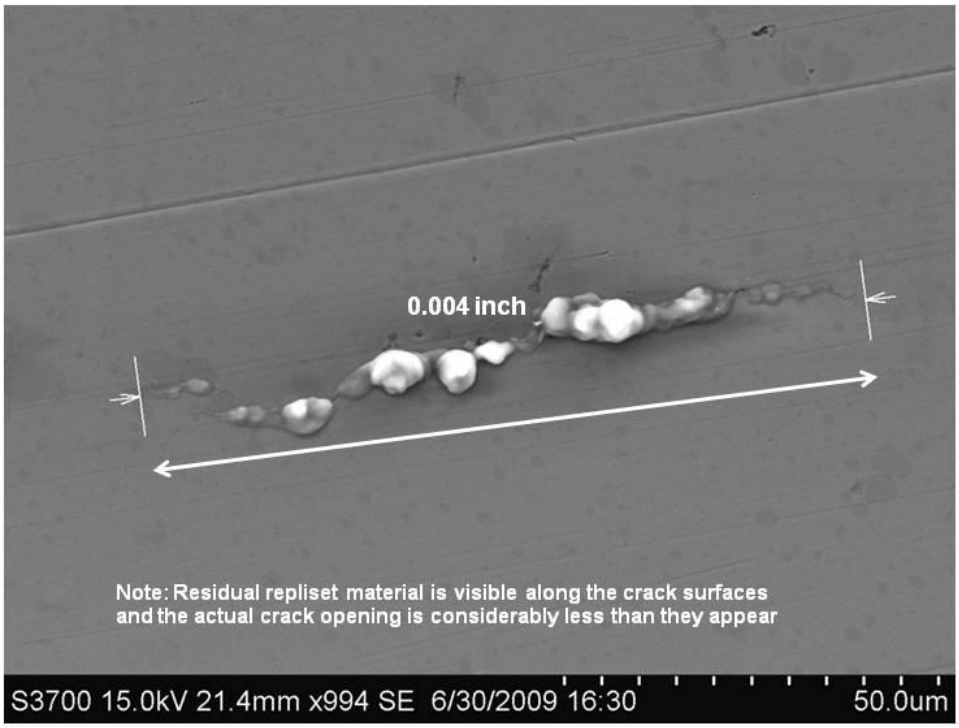
Size of Crack #18



421

Poppet #64

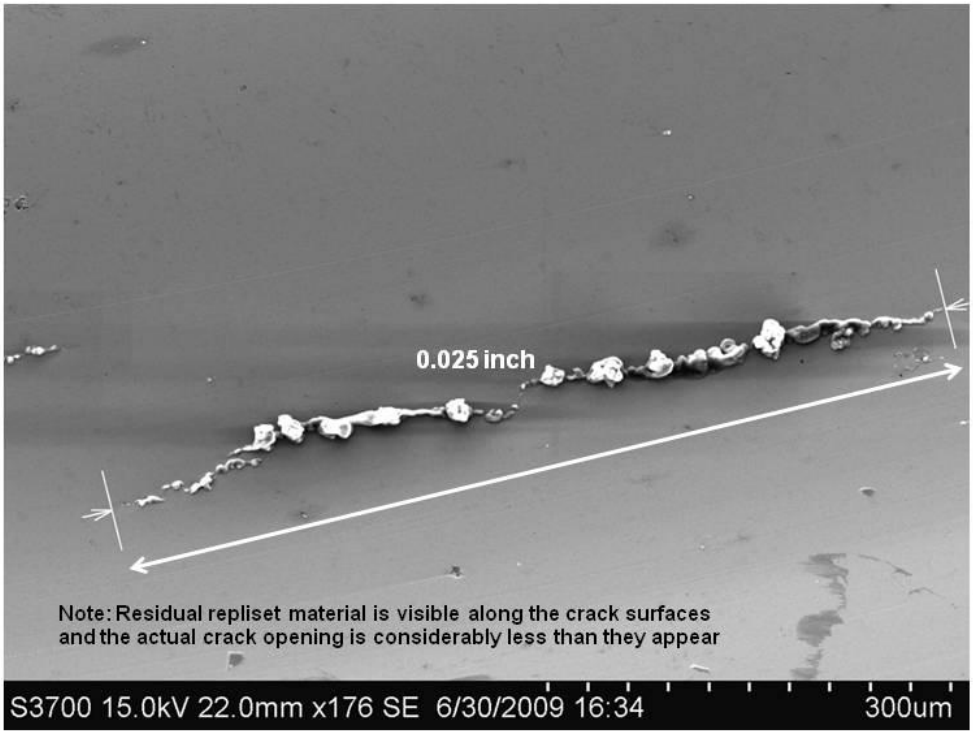
Size of Crack #19



422

Poppet #64

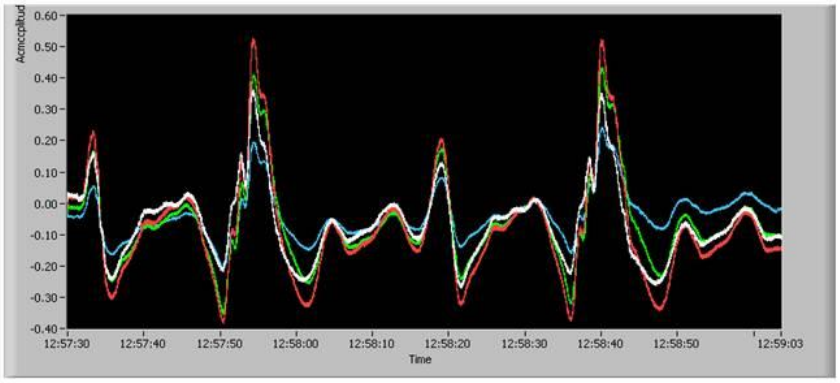
Size of Crack #20



423

Poppet #64

LaRC eddy current findings, the colors indicate ???



424

Poppet #65

Surface crack sizes and locations

Poppet #65		
Crack Number	Size (inch)	Angle (degrees)
1	0.002	115
2	0.002	115
3	0.001	115
4	0.003	295
5	0.004	295

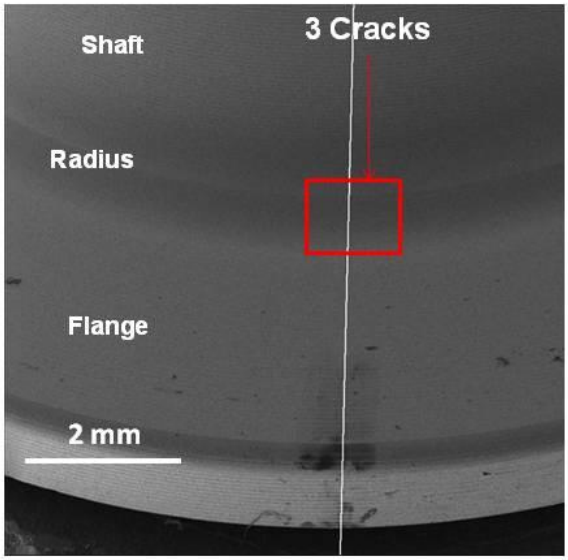
Boeing Eddy Current Findings

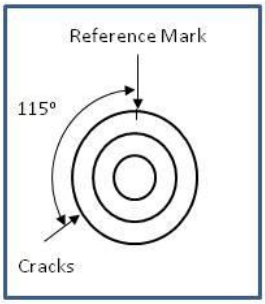
Poppet #65									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.074	0.075	0.078	0.078	0.080	0.079	0.077	No	0 ?
J. Engel	-	-	-	-	-	-	-	No	295
B. Devries	-	-	-	-	-	-	-	No	295
B. Devries	0.085	0.078	0.077	0.078	0.081	0.088	0.081	No	15 ?

425

Poppet #65

Location of Cracks #1-3

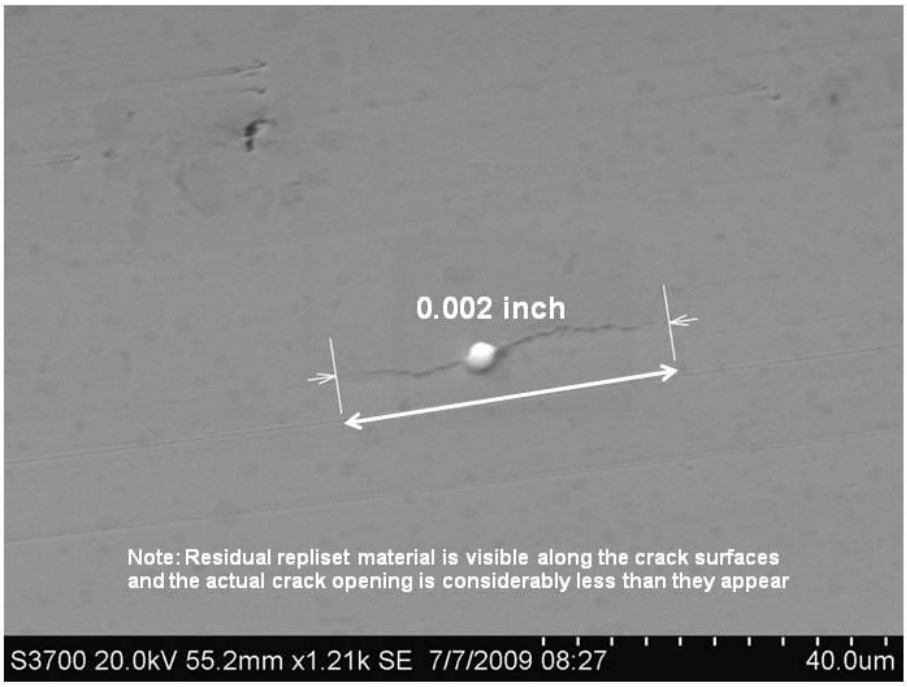




426

Poppet #65

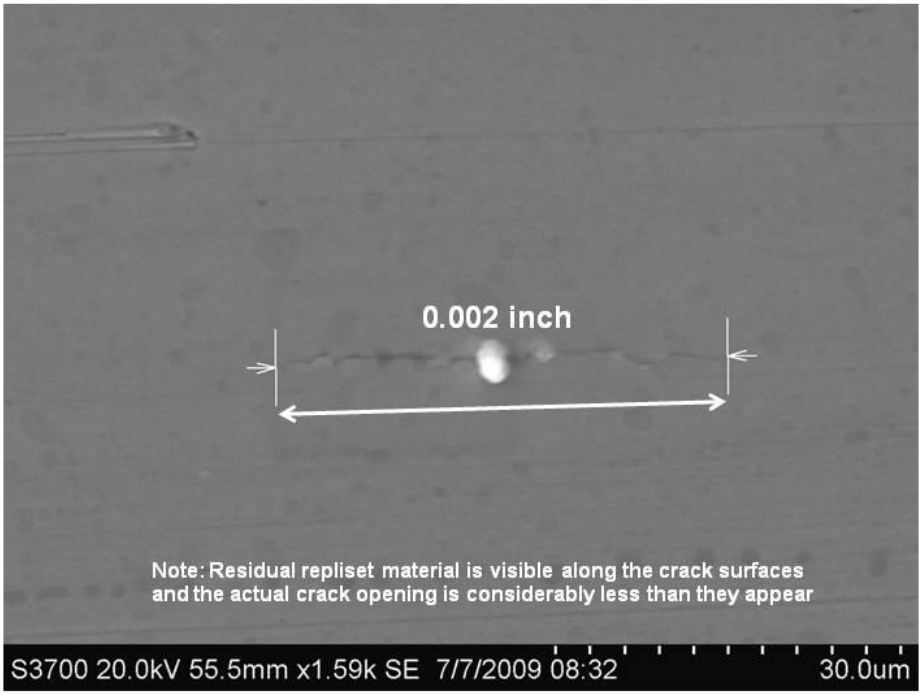
Size of Crack #1



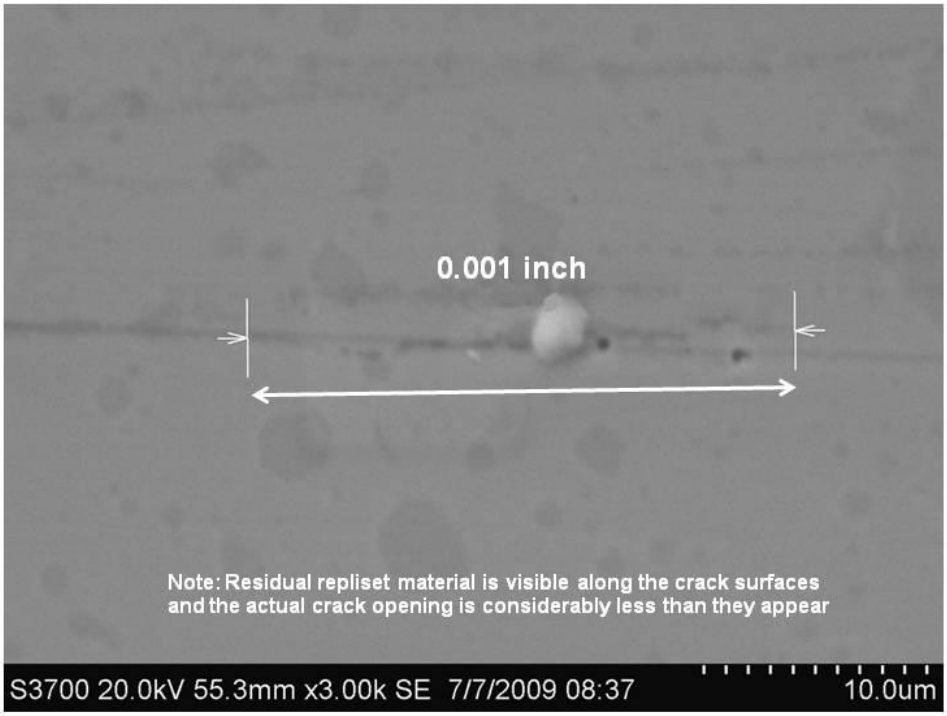
427

Poppet #65

Size of Crack #2



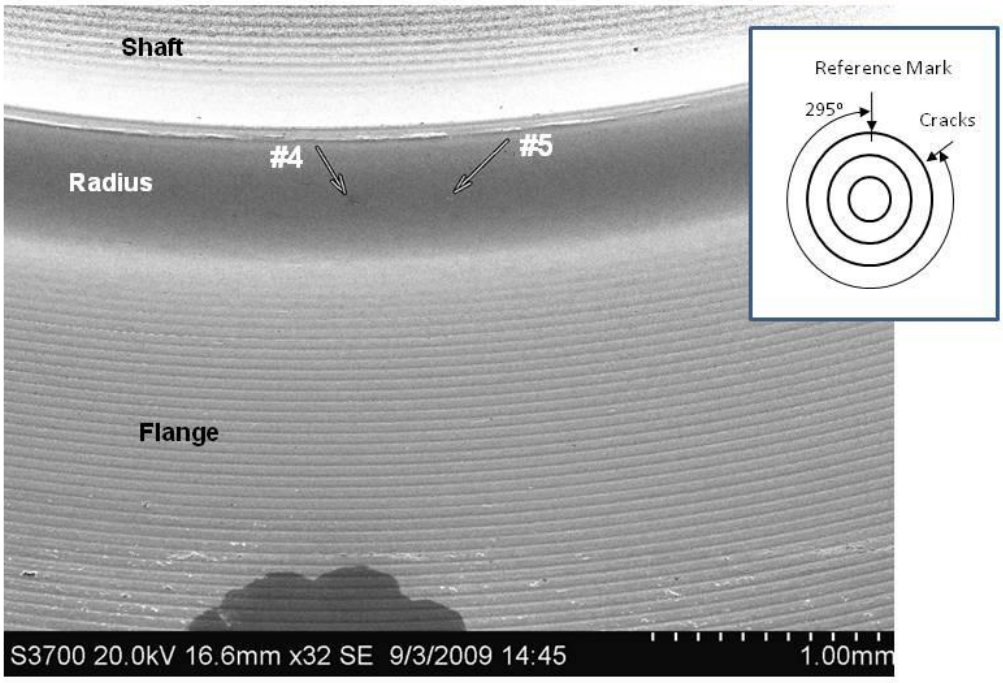
428


Poppet #65
Size of Crack #3
0.001 inch
Note: Residual repliset material is visible along the crack surfaces
and the actual crack opening is considerably less than they appear
S3700 20.0kV 55.3mm x3.00k SE 7/7/2009 08:37
10.0um

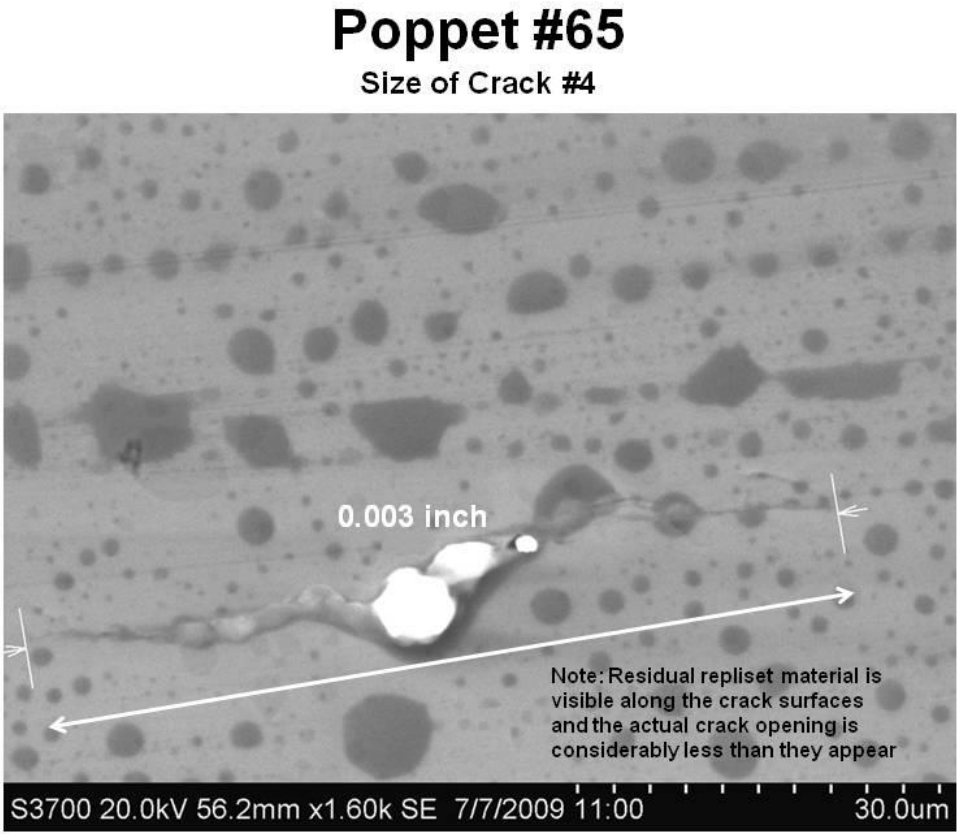
429

Poppet #65

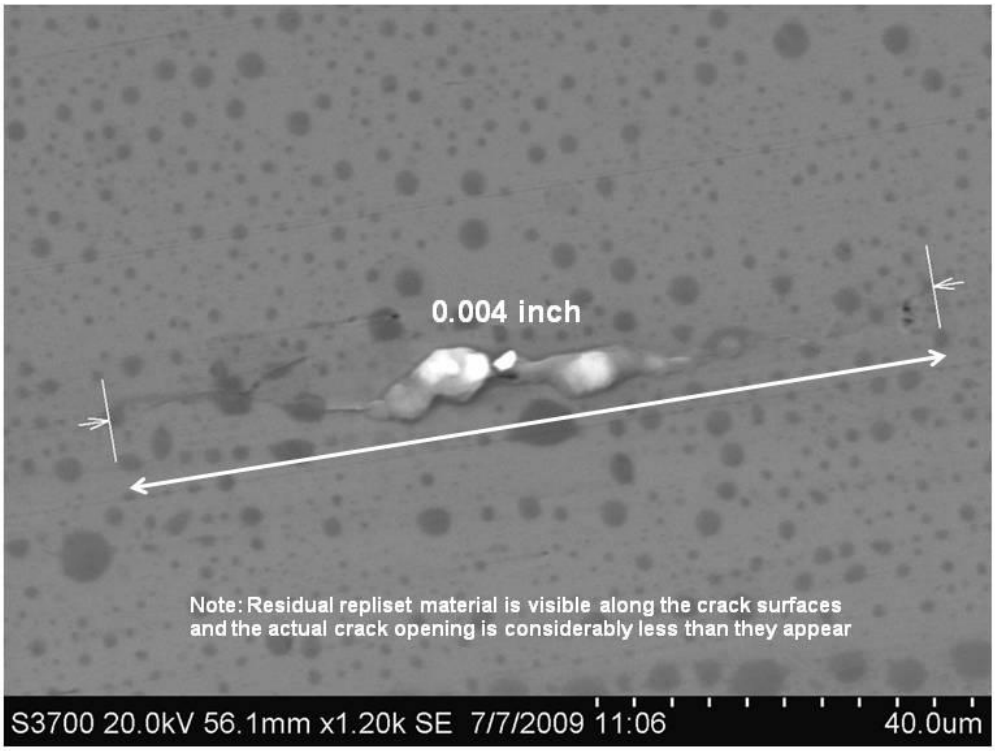
Location of Cracks #4 and 5



430


Poppet #65
Size of Crack #4
0.003 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 56.2mm x1.60k SE 7/7/2009 11:00
30.0um

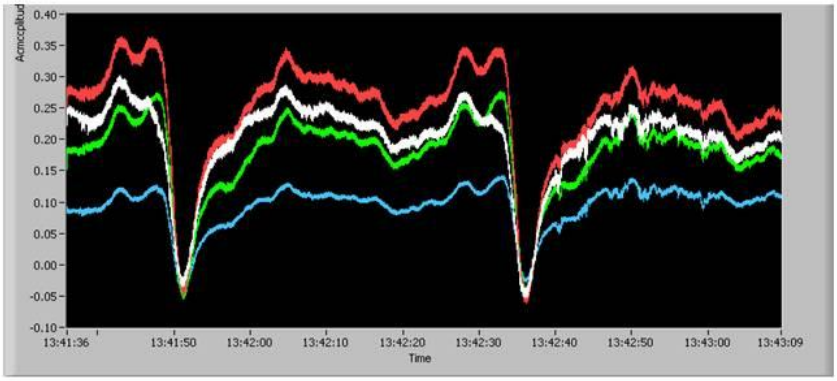
431


Poppet #65
Size of Crack #5
0.004 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 56.1mm x1.20k SE 7/7/2009 11:06
40.0um

432

Poppet #65

LaRC eddy current findings, the colors indicate ???



433

Poppet #66

Surface crack sizes and locations

Poppet #66		
Crack Number	Size (inch)	Angle (degrees)
1	0.006	70
2	0.004	70
3	0.025	250
4	0.018	250
5	0.024	250
6	0.006	250
7	0.005	250

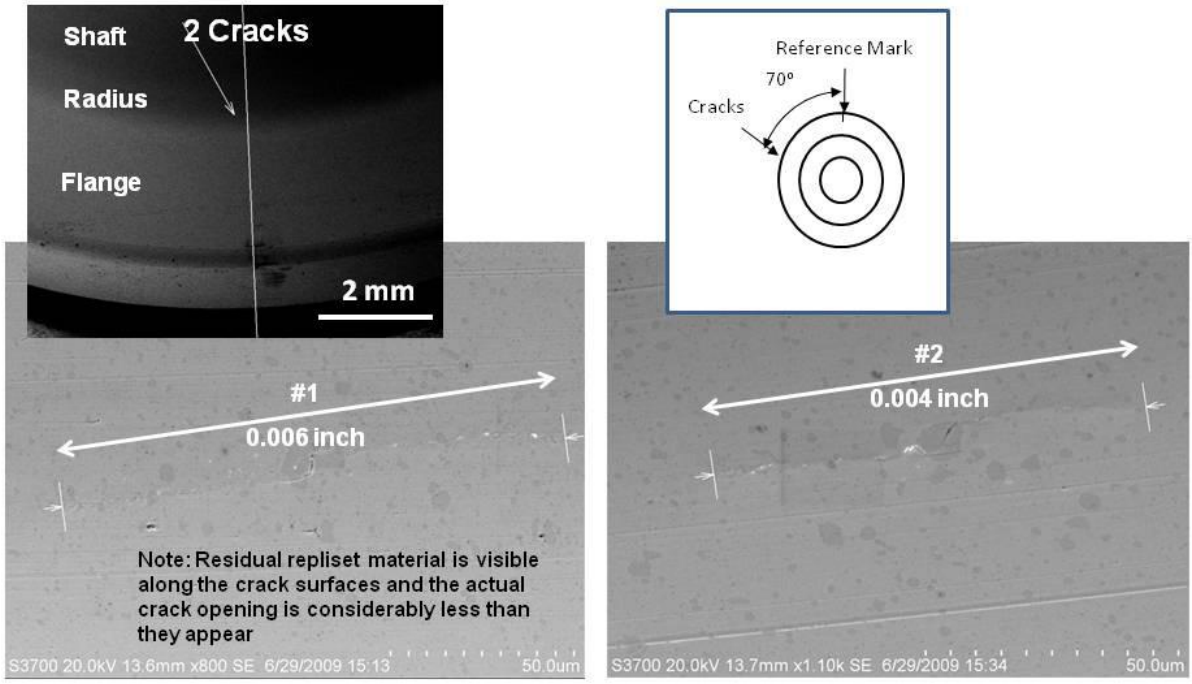
Boeing Eddy Current Findings

Poppet #66									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.190	0.194	0.183	0.189	0.186	0.192	0.189	Yes	235
J. Engel	-	-	-	-	-	-	-	No	70
B. Devries	-	-	-	-	-	-	-	No	70
B. Devries	0.186	0.185	0.188	0.201	0.193	0.190	0.191	Yes	240

434

Poppet #66

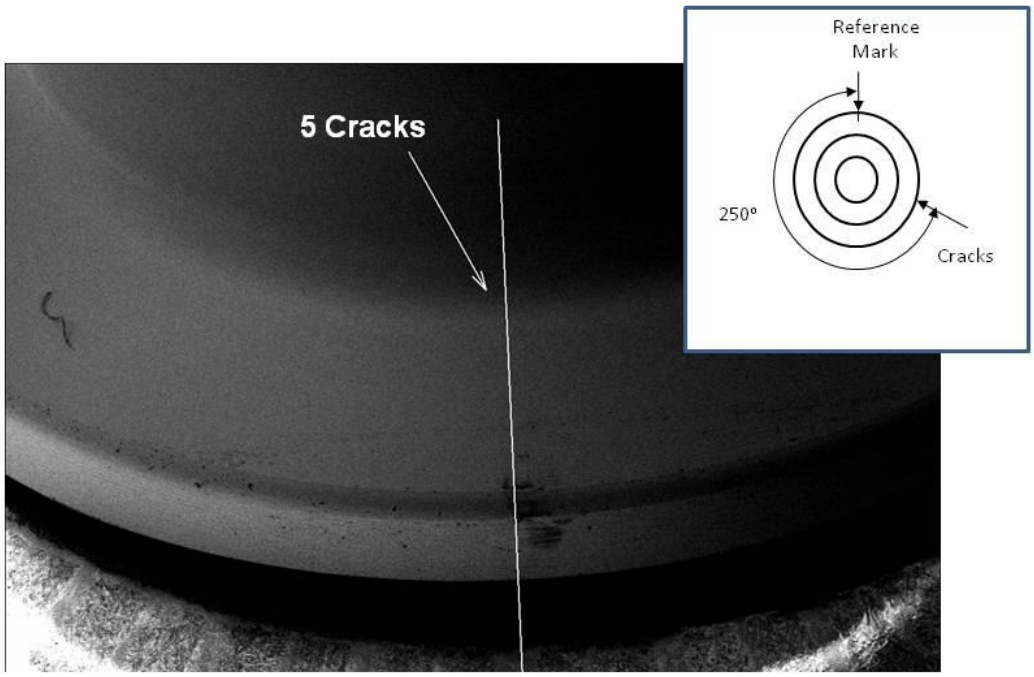
Location and size of Cracks #1 and 2



435

Poppet #66

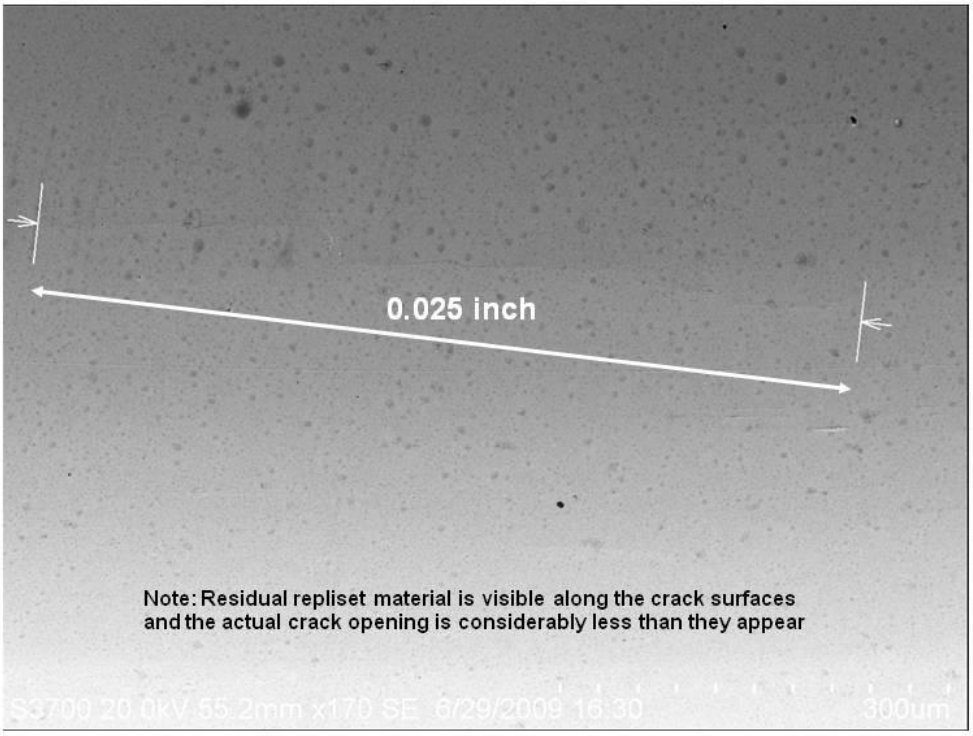
Location of Cracks #3-7



436

Poppet #66

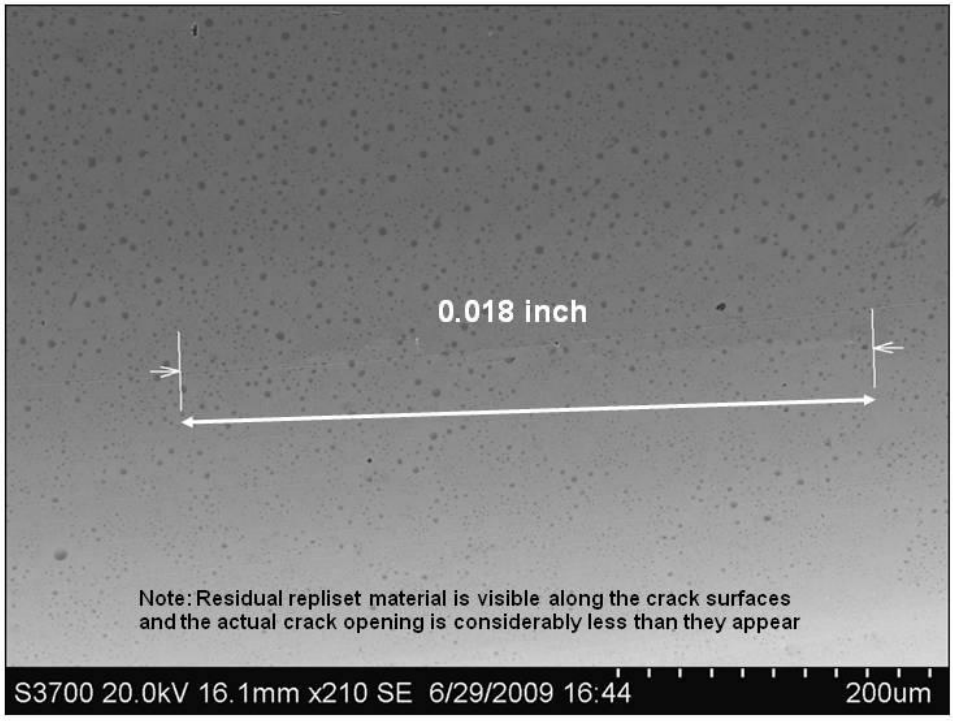
Size of Crack #3



437

Poppet #66

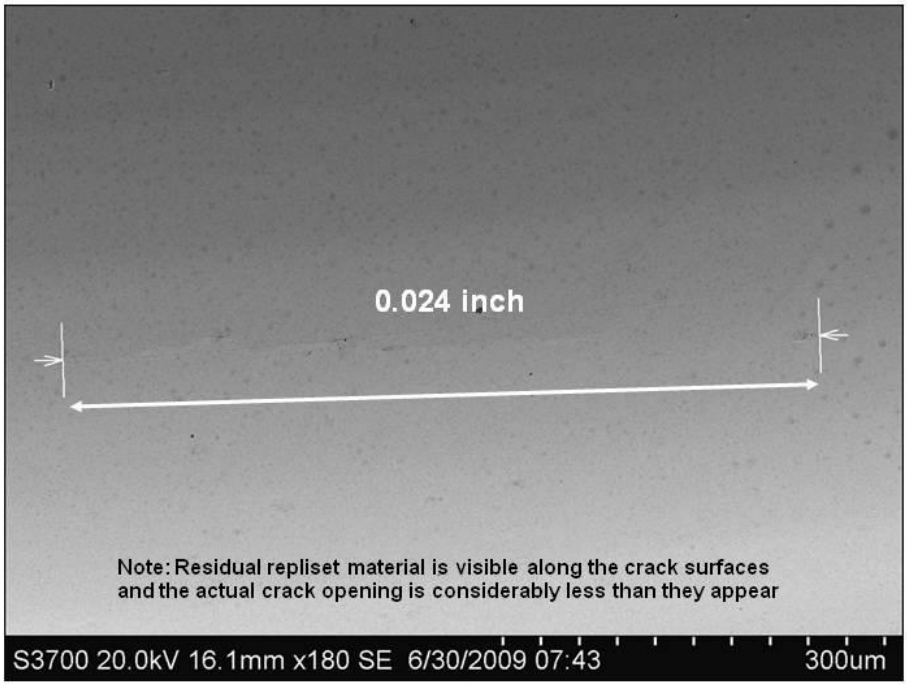
Size of Crack #4



438

Poppet #66

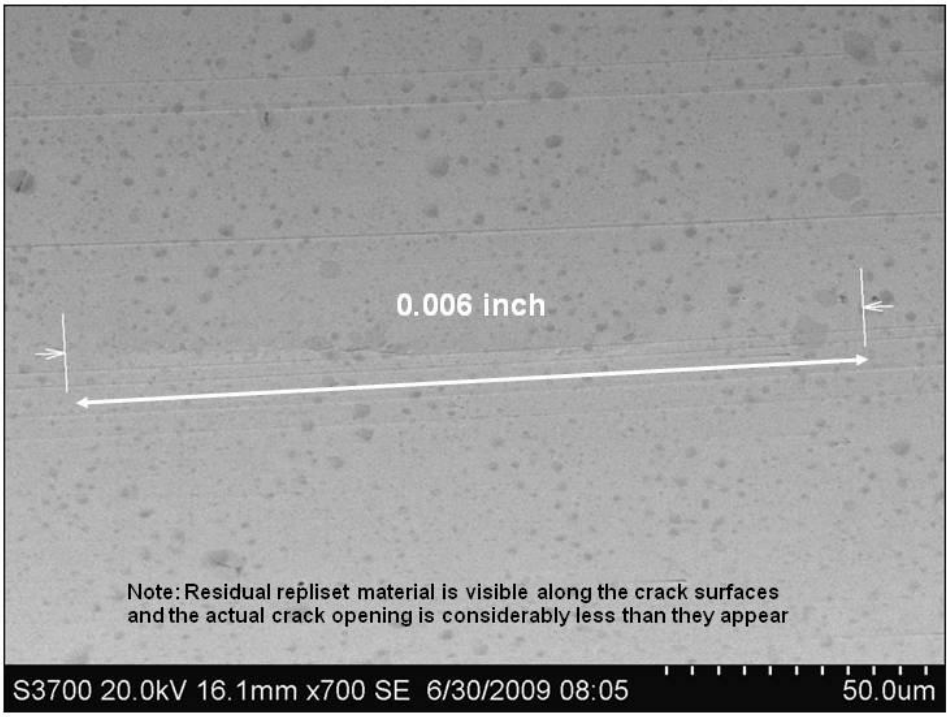
Size of Crack #5



439

Poppet #66

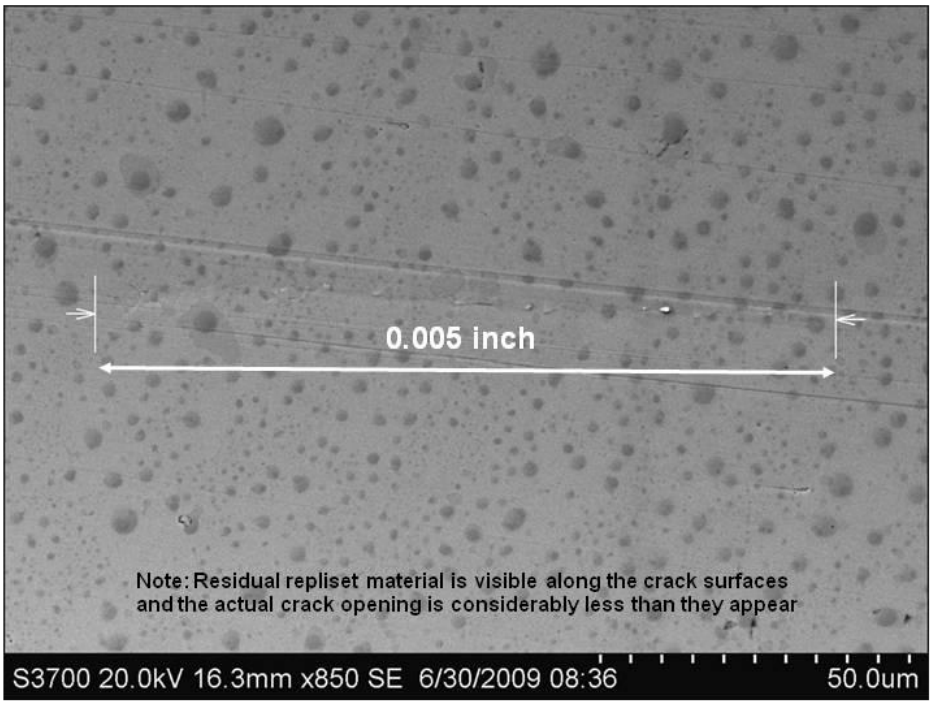
Size of Crack #6



440

Poppet #66

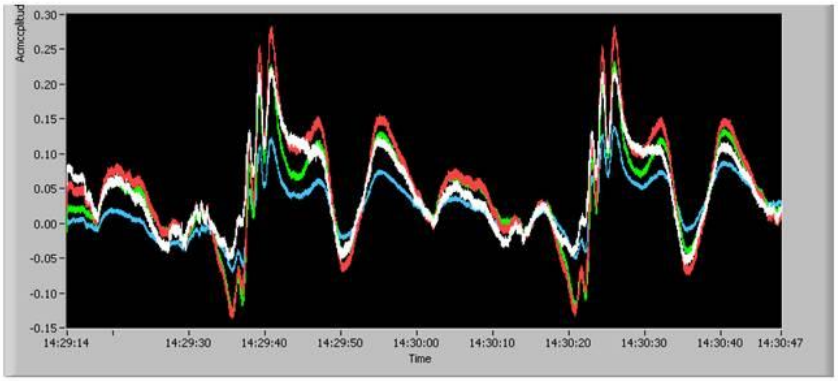
Size of Crack #7



441

Poppet #66

LaRC eddy current findings, the colors indicate ???



442

Poppet #67

Surface crack sizes and locations

Poppet #67		
Crack Number	Size (inch)	Angle (degrees)
1	0.002	285
2	0.006	285
3	0.003	285
4	0.004	285
5	0.002	285
6	0.008	285
7	0.002	285
8	0.009	105
9	0.006	105
10	0.002	105
11	0.003	105
12	0.003	105
13	0.003	105

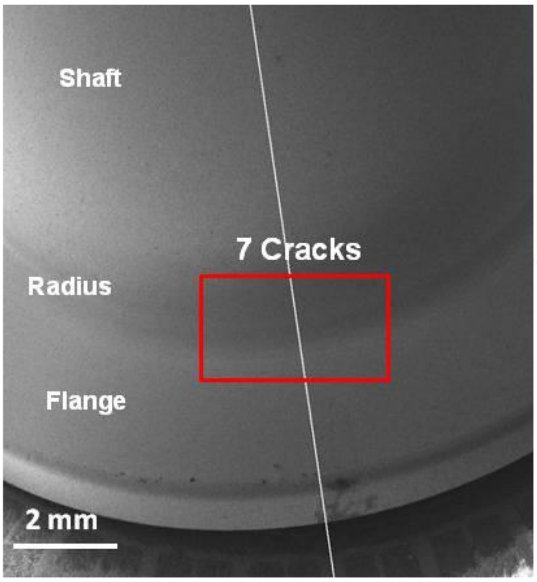
Boeing Eddy Current Findings

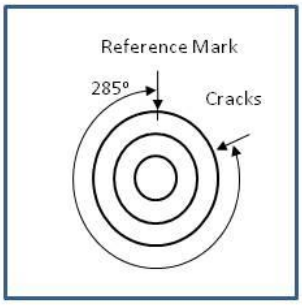
Poppet #67									
Inspector	Run Data (Vpp)							Crack Detected	Location (degrees)
	1	2	3	4	5	6	Average		
J. Engel	0.089	0.086	0.089	0.092	0.095	0.095	0.091	Yes	275 (Not 3:1 S/N ratio)
J. Engel	-	-	-	-	-	-	-	No	105
B. Devries	-	-	-	-	-	-	-	No	105
B. Devries	0.091	0.089	0.091	0.095	0.117	0.100	0.097	No	285

443

Poppet #67

Location of Cracks #1-7

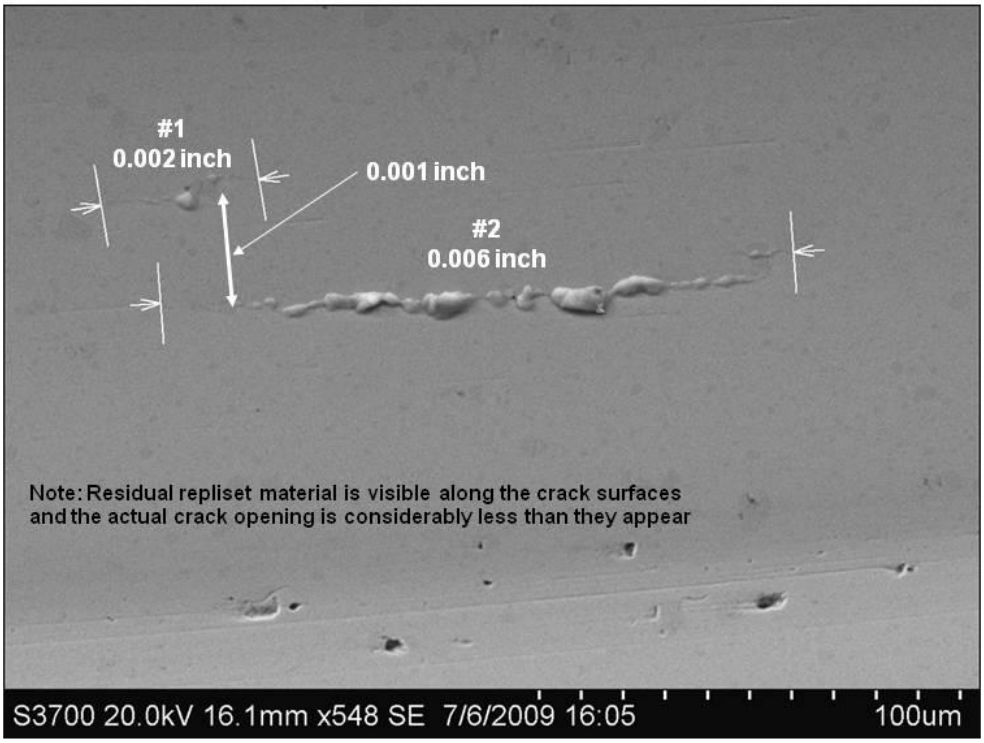




444

Poppet #67

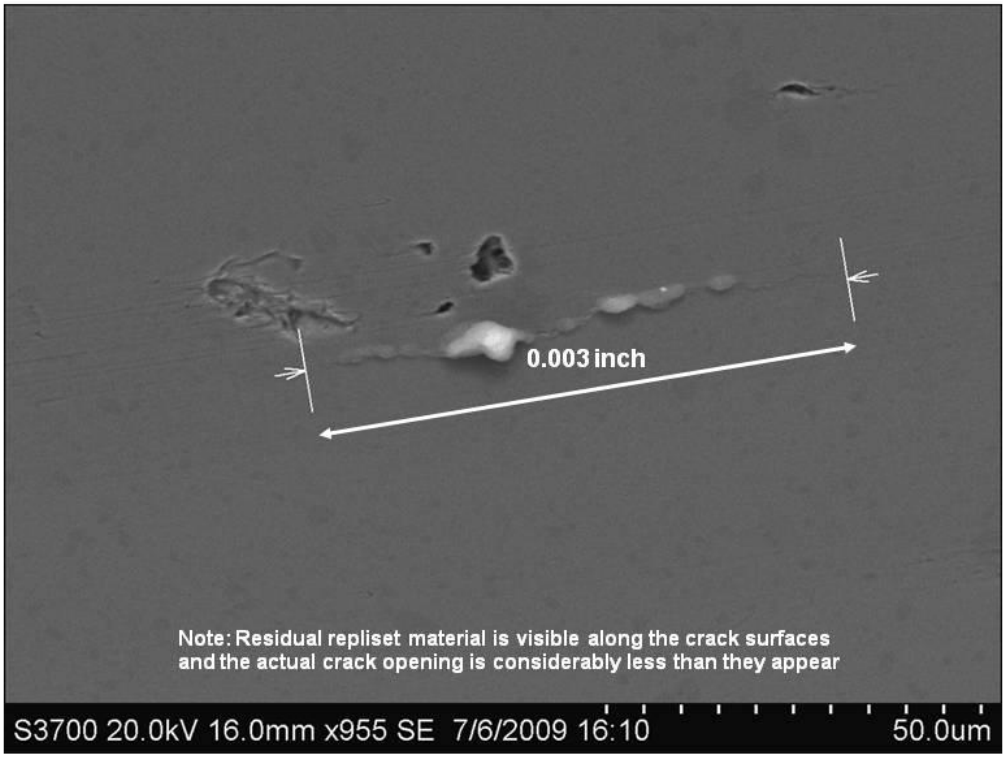
Location and size of Cracks #1 and 2



445

Poppet #67

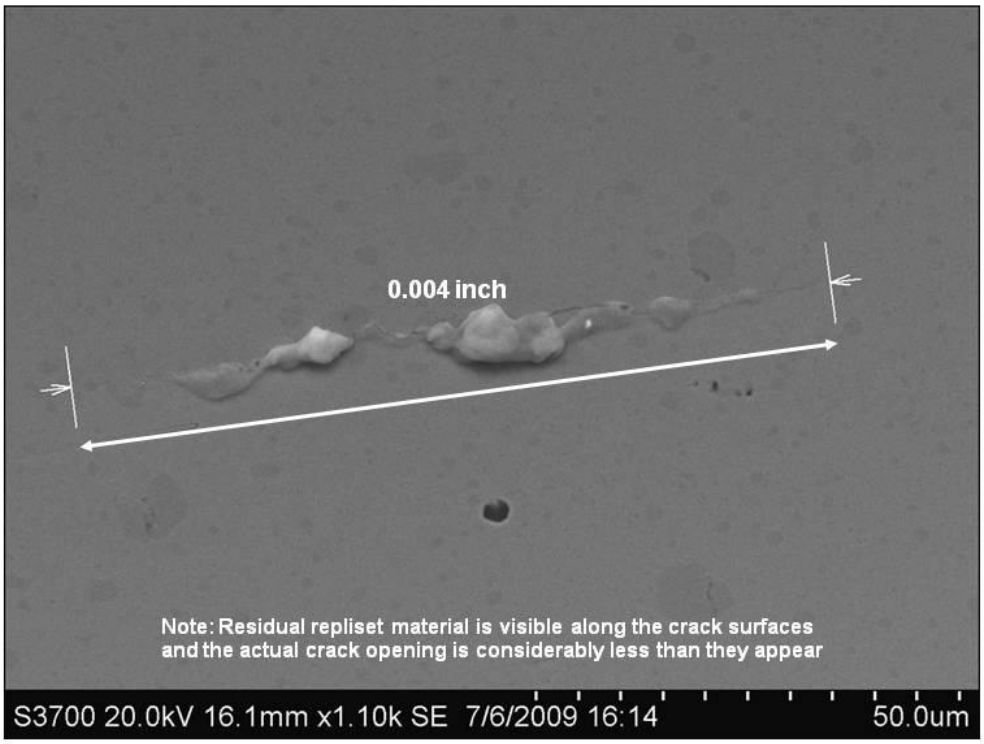
Size of Crack #3



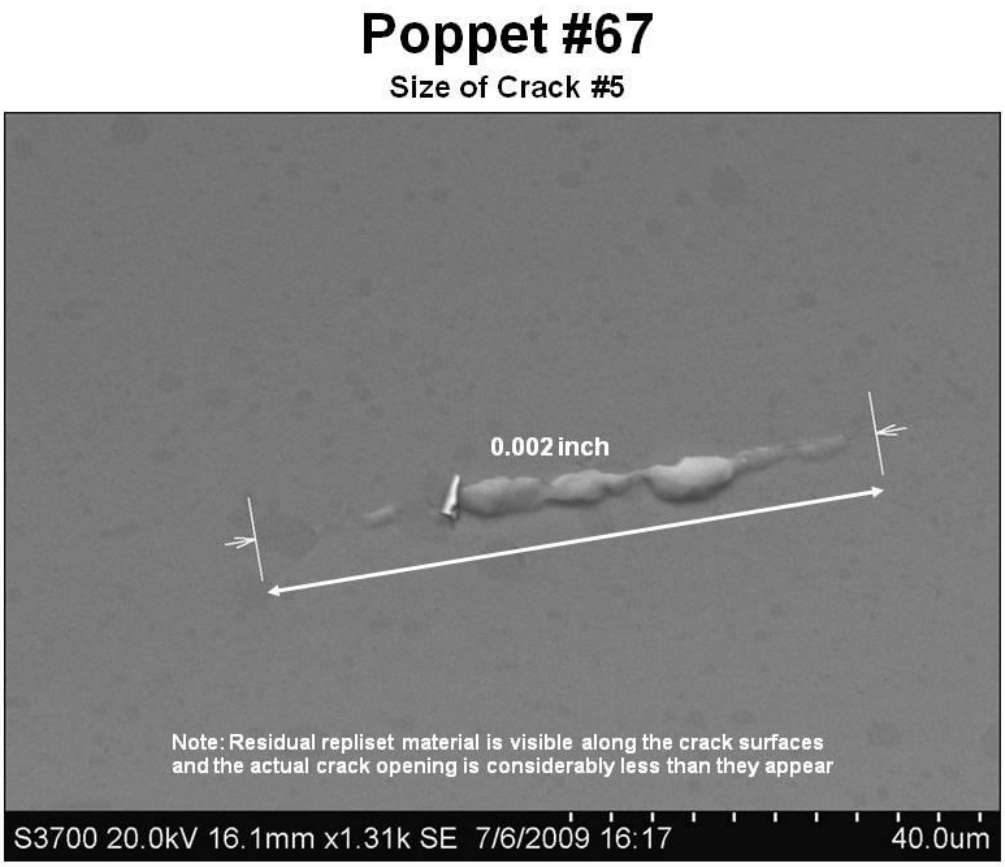
446

Poppet #67

Size of Crack #4

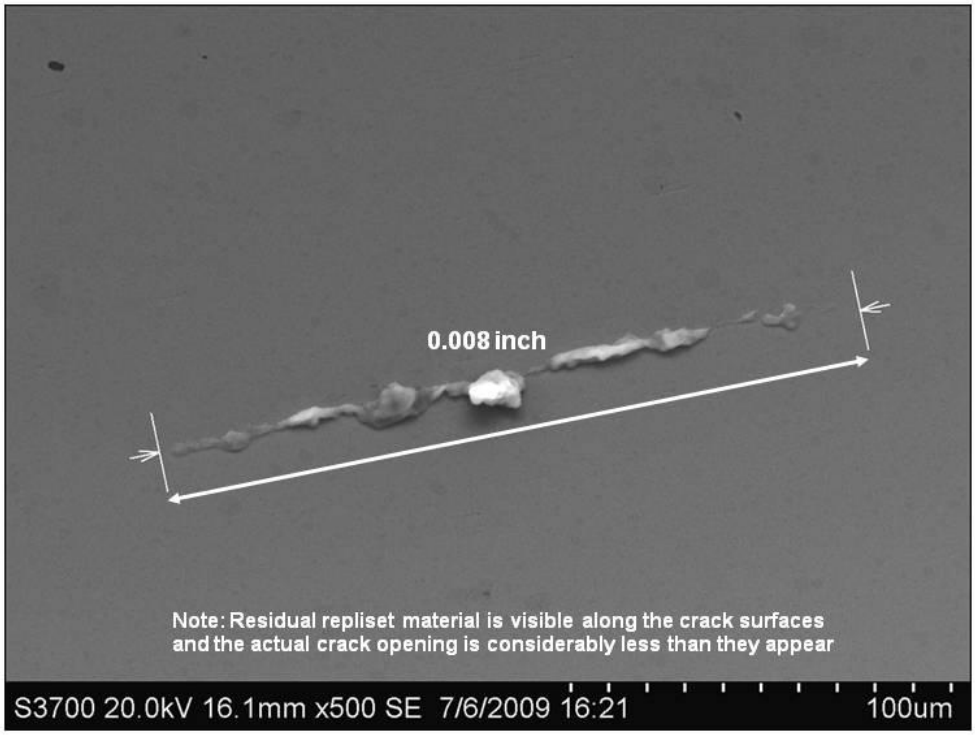


447


Poppet #67
Size of Crack #5
0.002 inch
Note: Residual repliset material is visible along the crack surfaces
and the actual crack opening is considerably less than they appear
S3700 20.0kV 16.1mm x1.31k SE 7/6/2009 16:17
40.0um
448

Poppet #67

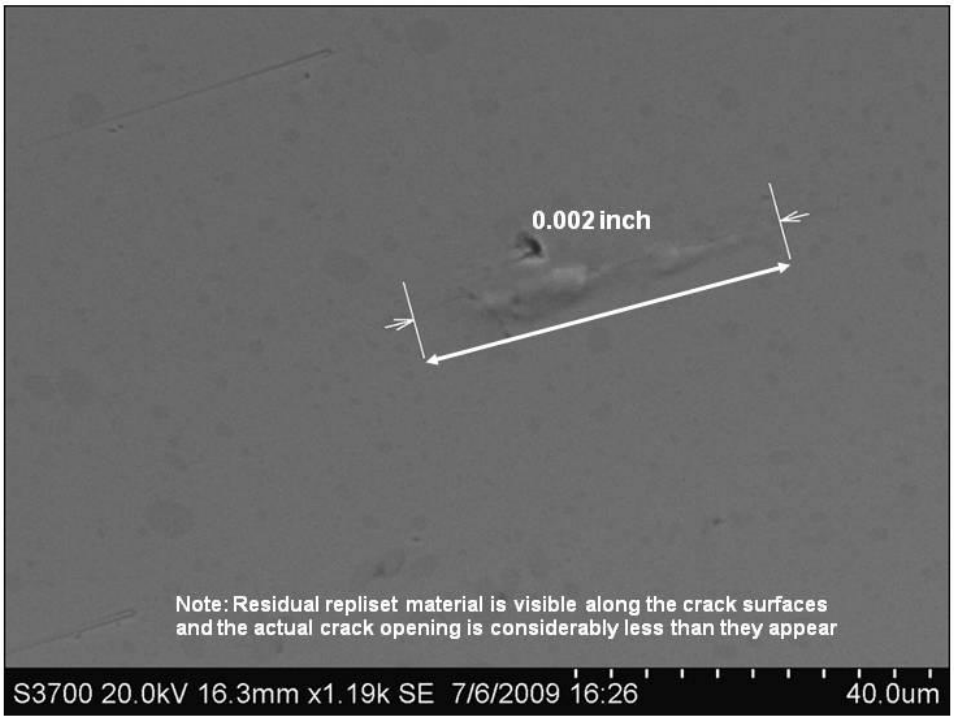
Size of Crack #6



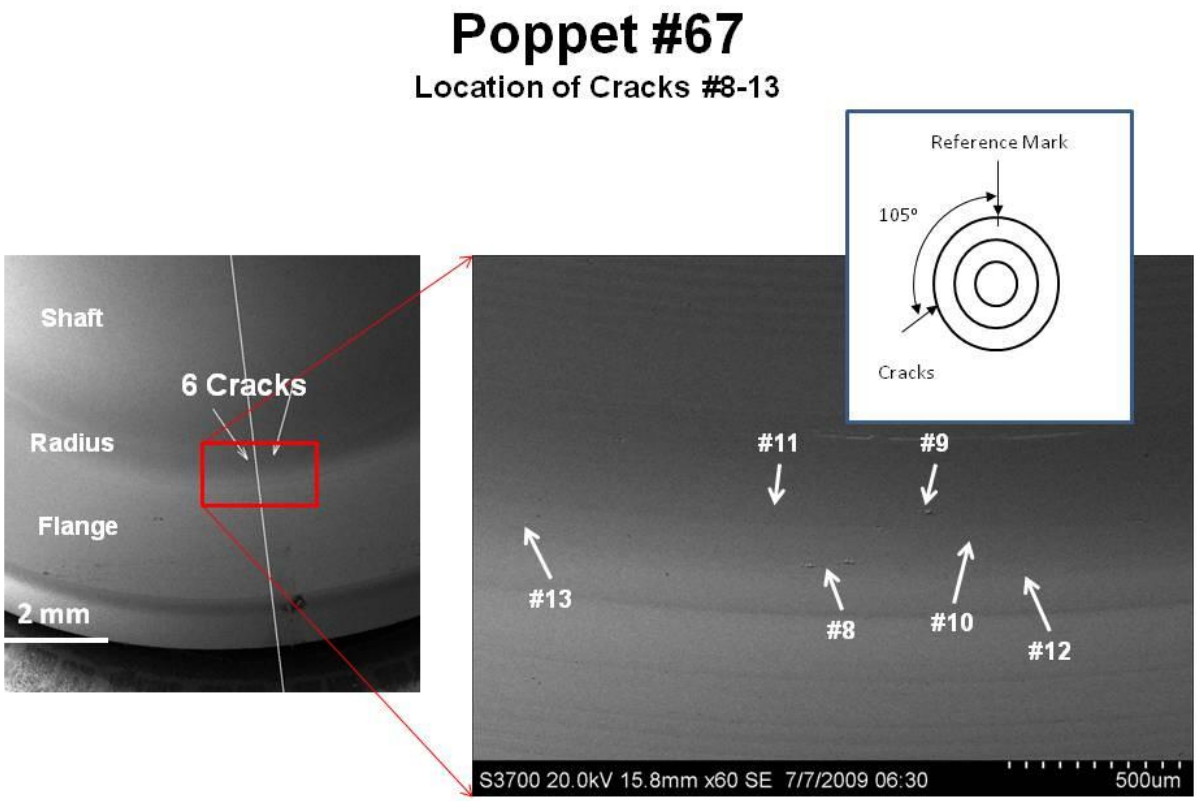
449

Poppet #67

Size of Crack #7



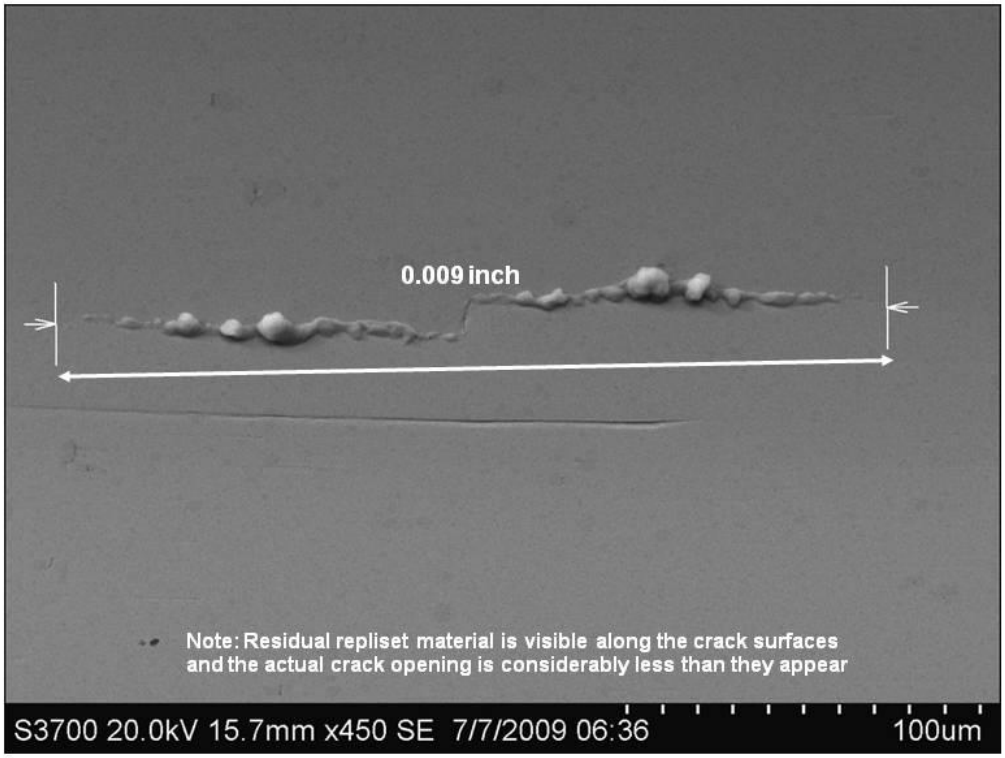
450


Poppet #67
Location of Cracks #8-13
Reference Mark
105°
Cracks
Shaft
6 Cracks
Radius
Flange
2 mm
#11
#9
#13
#8
#10
#12
S3700 20.0kV 15.8mm x60 SE 7/7/2009 06:30
500um

451

Poppet #67

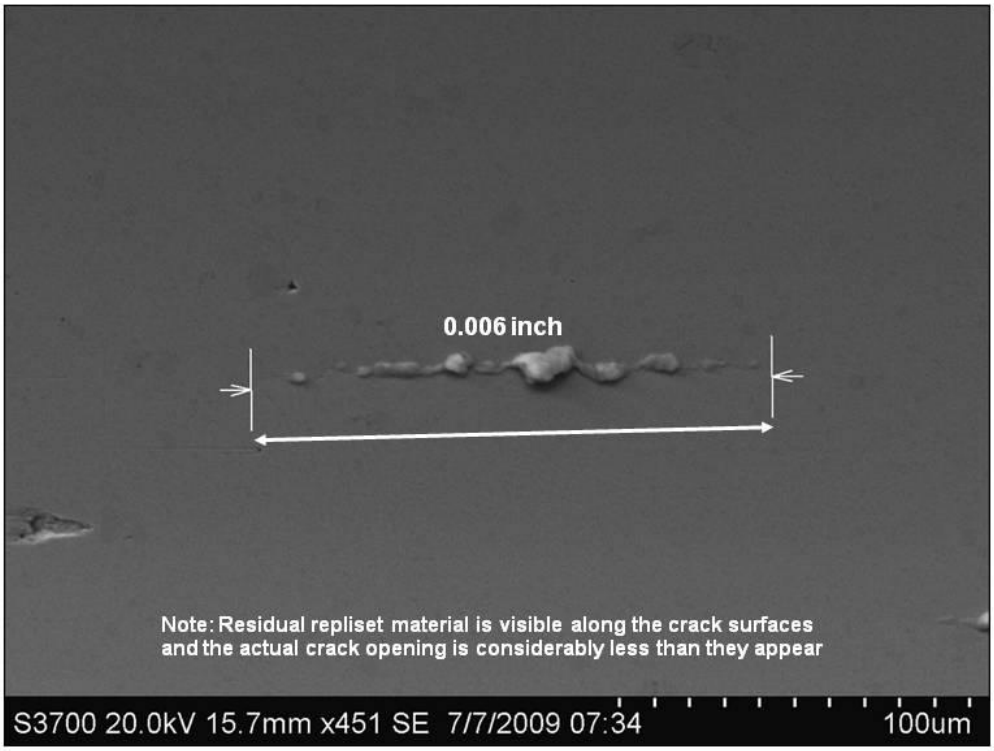
Size of Crack #8



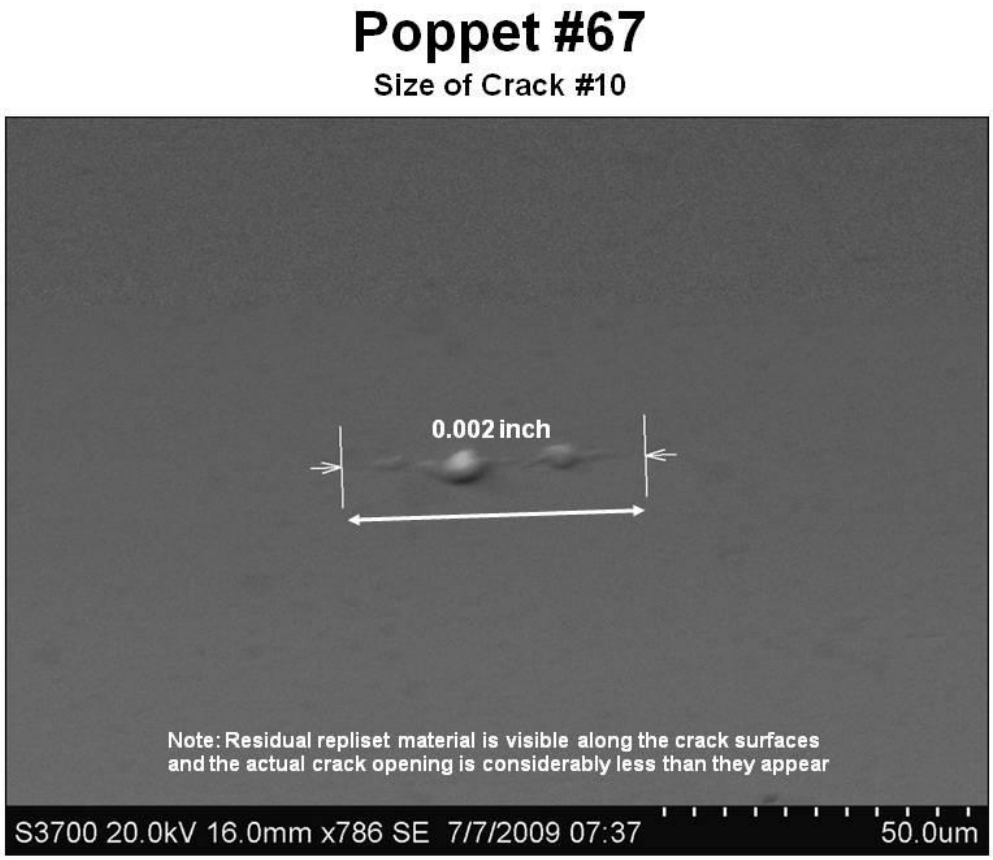
452

Poppet #67

Size of Crack #9



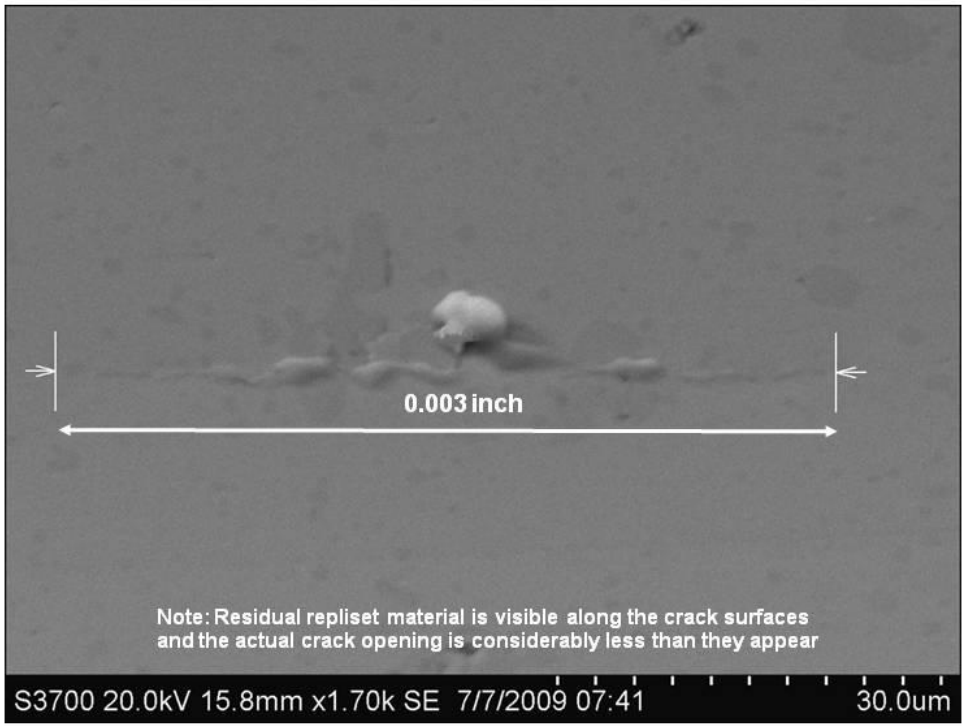
453


Poppet #67
Size of Crack #10
0.002 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 16.0mm x786 SE 7/7/2009 07:37
50.0um

454

Poppet #67

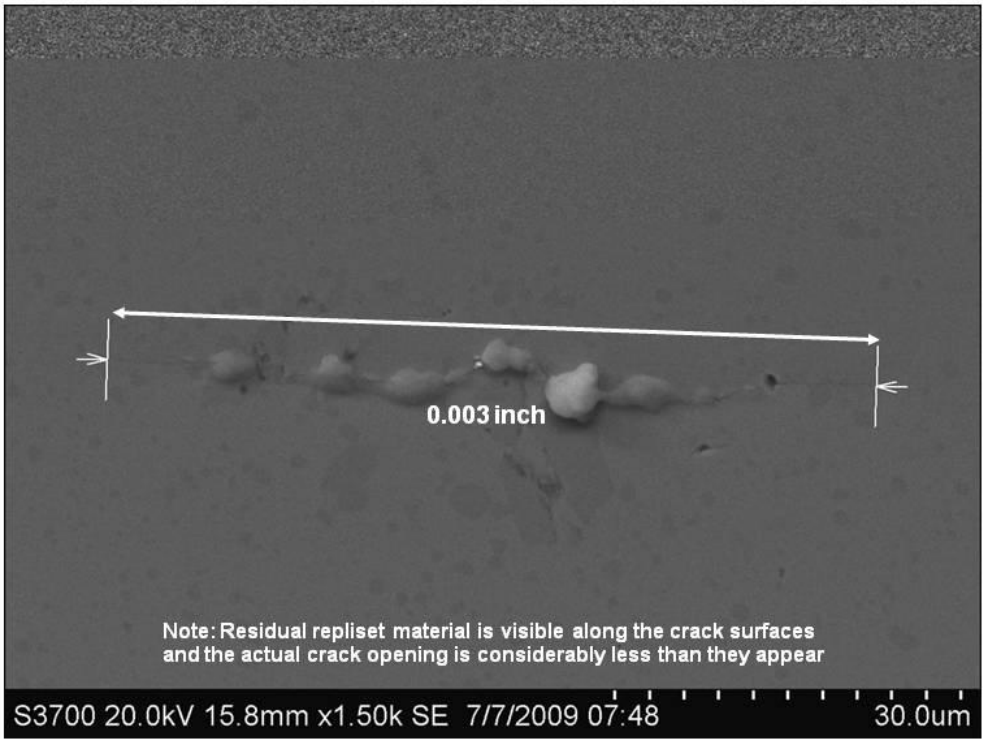
Size of Crack #11



455

Poppet #67

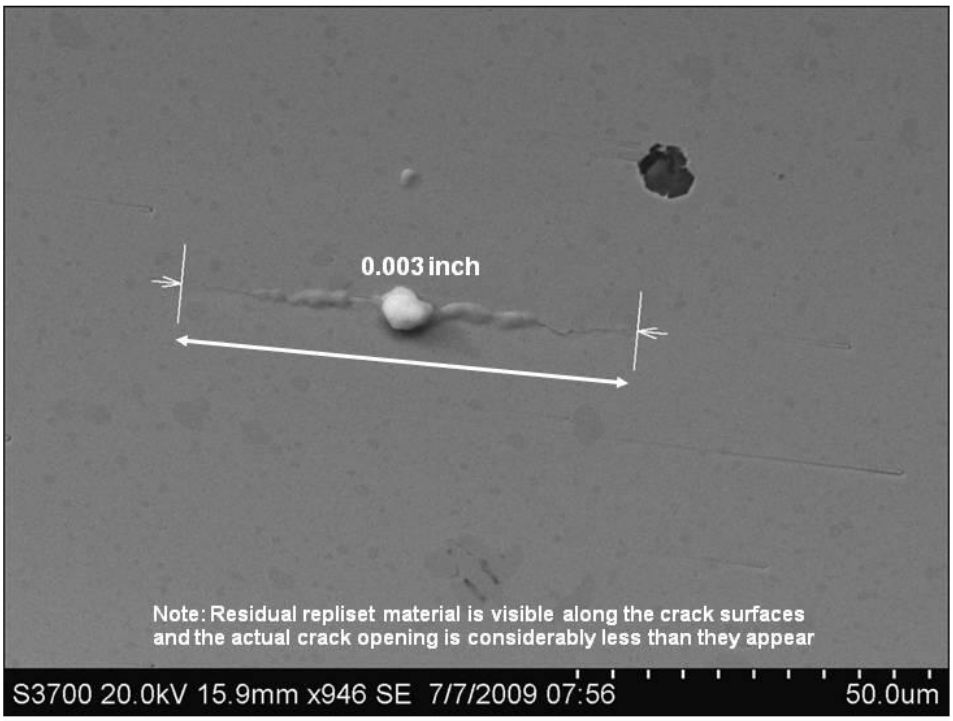
Size of Crack #12



456

Poppet #67

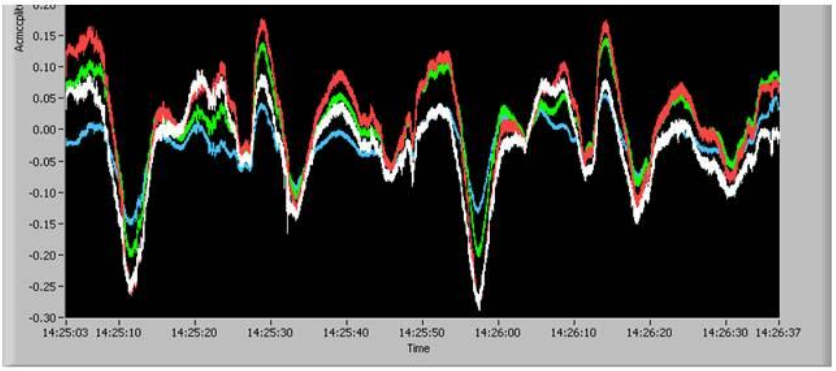
Size of Crack #13



457

Poppet #67

LaRC eddy current findings, the colors indicate ???



458

Poppet #68

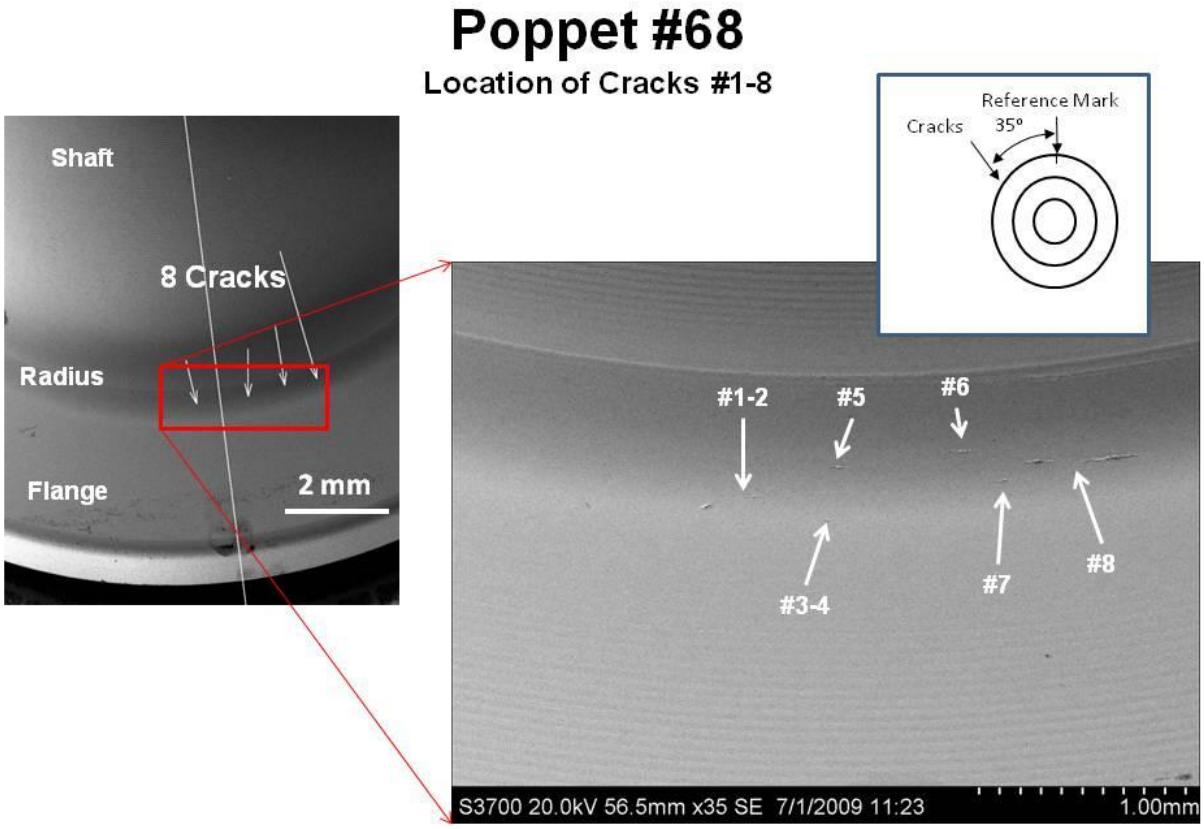
Surface crack sizes and locations

Poppet #68		
Crack Number	Size (inch)	Angle (degrees)
1	0.003	35
2	0.005	35
3	0.003	35
4	0.002	35
5	0.008	35
6	0.009	35
7	0.006	35
8	0.026	35
9	0.010	215
10	0.003	215
11	0.003	215
12	0.005	215
13	0.012	215
14	0.006	215
15	0.004	215

Boeing Eddy Current Findings

Poppet #68									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.197	0.202	0.216	0.220	0.218	0.208	0.210	Yes	40
J. Engel	0.117	0.120	0.124	0.130	0.125	0.127	0.124	Yes	215
B. Devries	0.213	0.219	0.222	0.220	0.224	0.220	0.220	Yes	45
B. Devries	0.118	0.120	0.119	0.121	0.122	0.123	0.121	Yes	225

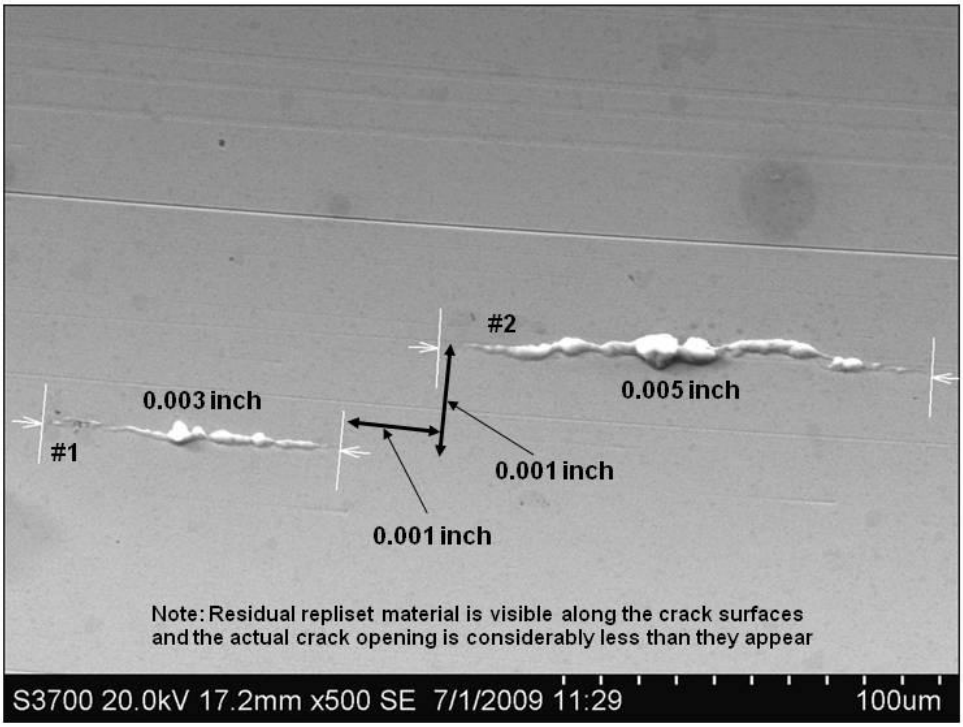
459


Poppet #68
Location of Cracks #1-8
Shaft
8 Cracks
Radius
Flange
2 mm
Reference Mark
Cracks
35°
#1-2
#5
#6
#3-4
#7
#8
S3700 20.0kV 56.5mm x35 SE 7/1/2009 11:23
1.00mm

460

Poppet #68

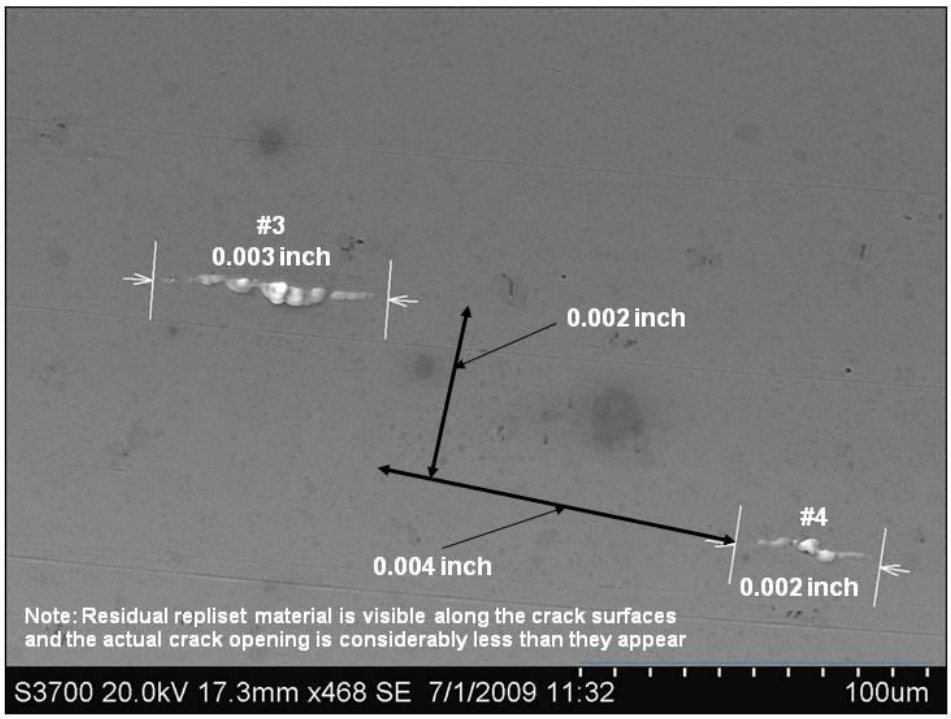
Location and size of Cracks #1 and 2



461

Poppet #68

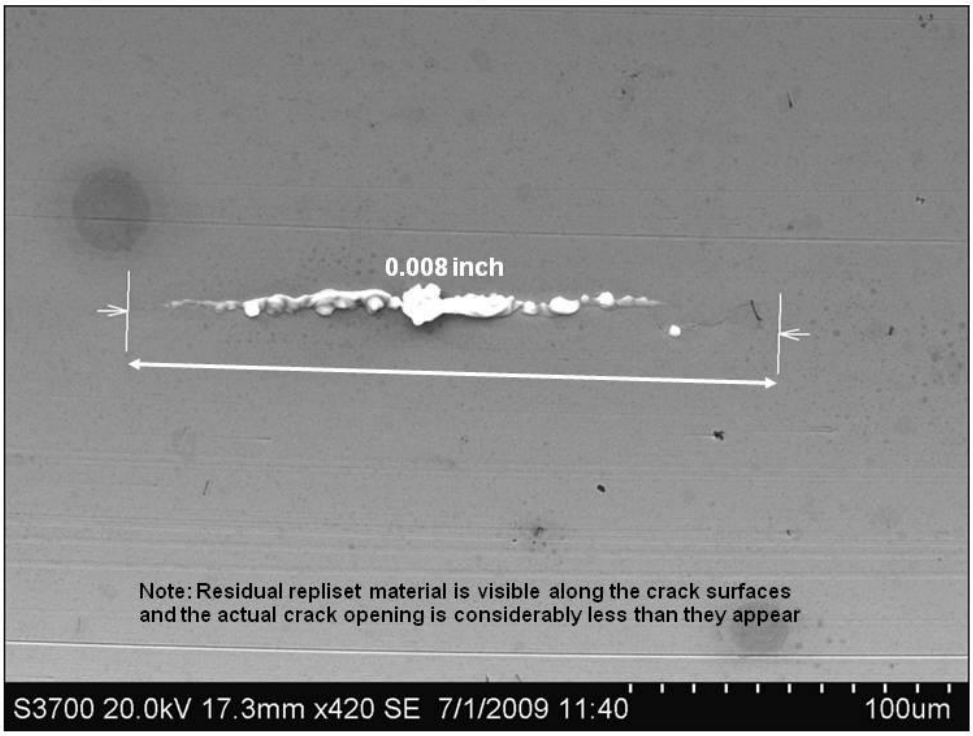
Location and size of Cracks #3-4



462

Poppet #68

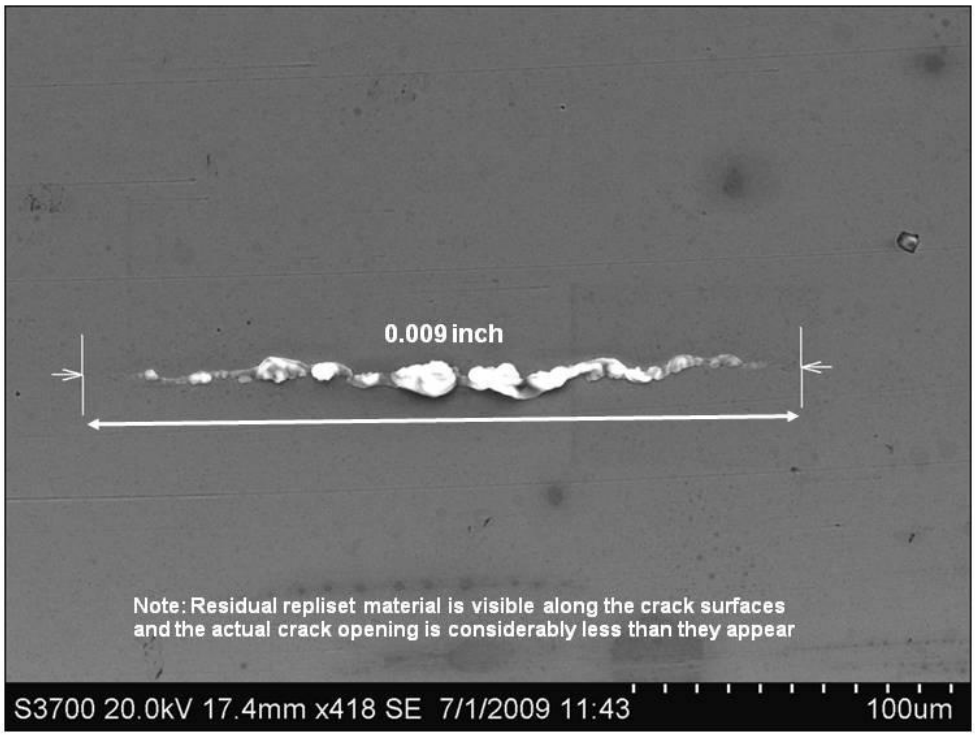
Size of Crack #5



463

Poppet #68

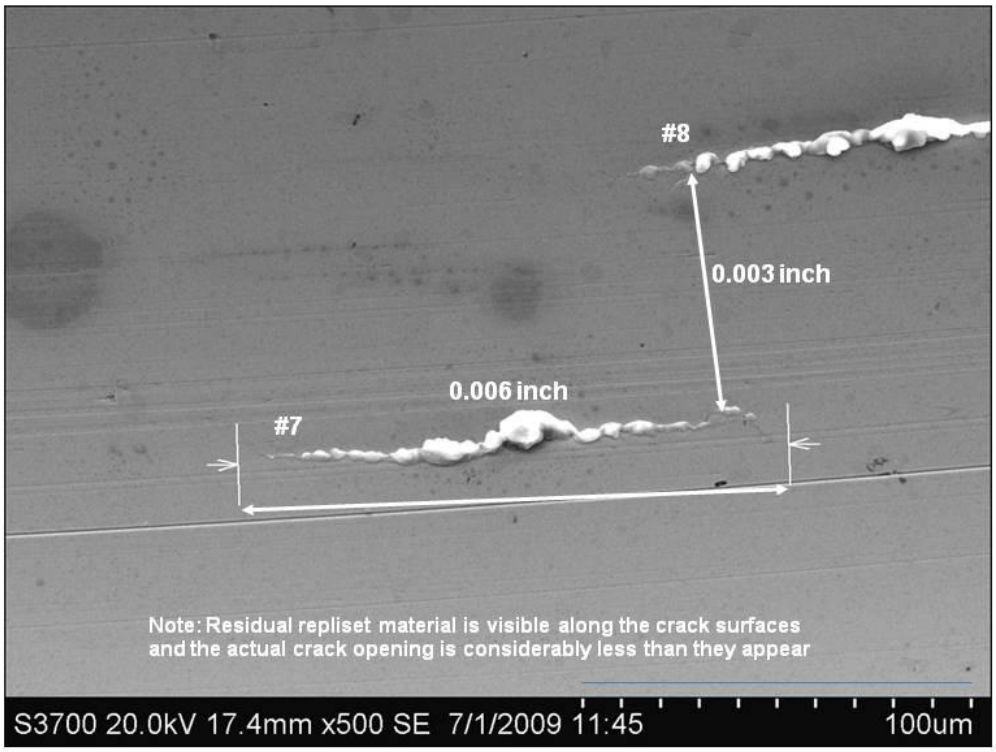
Size of Crack #6



464

Poppet #68

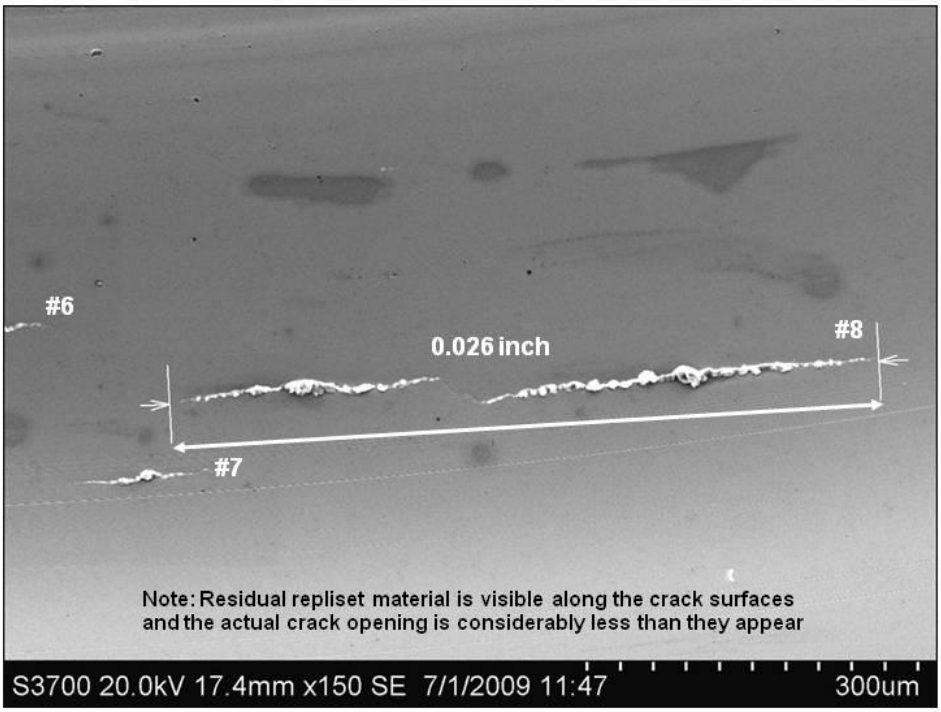
Size of Crack #7



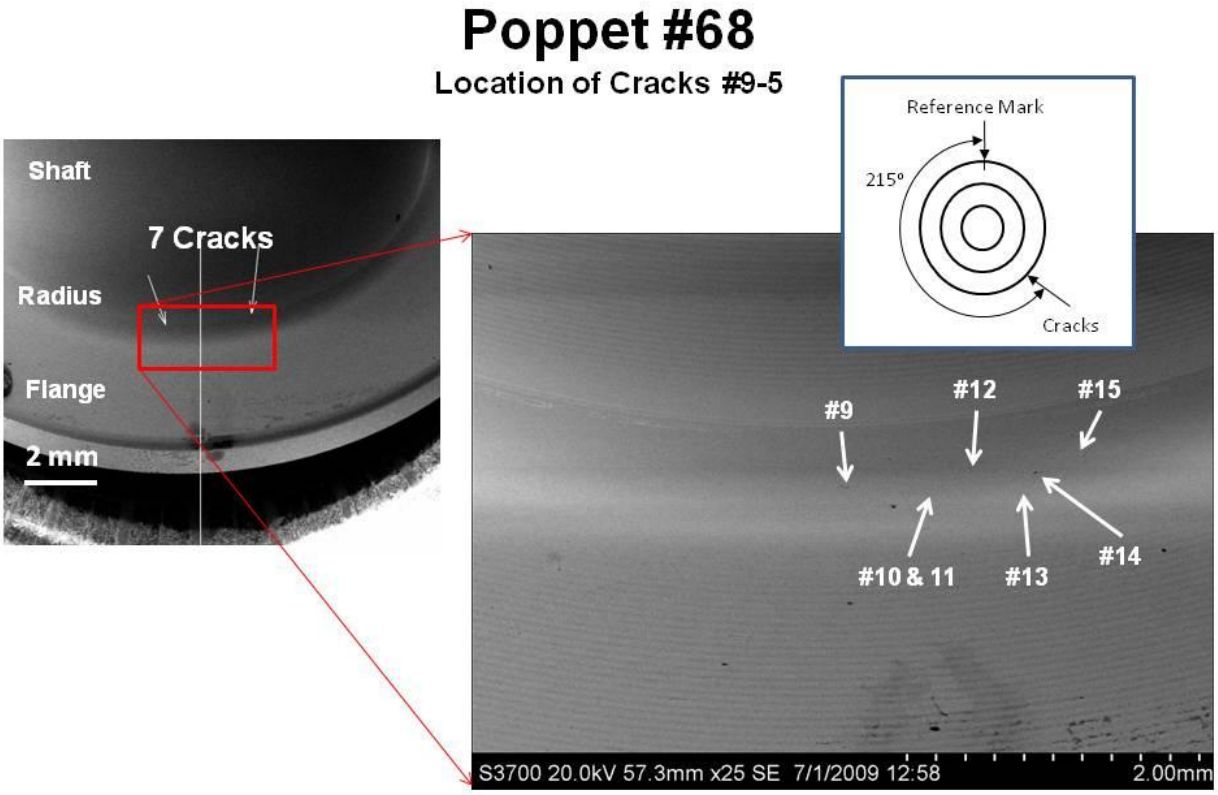
465

Poppet #68

Size of Crack #8



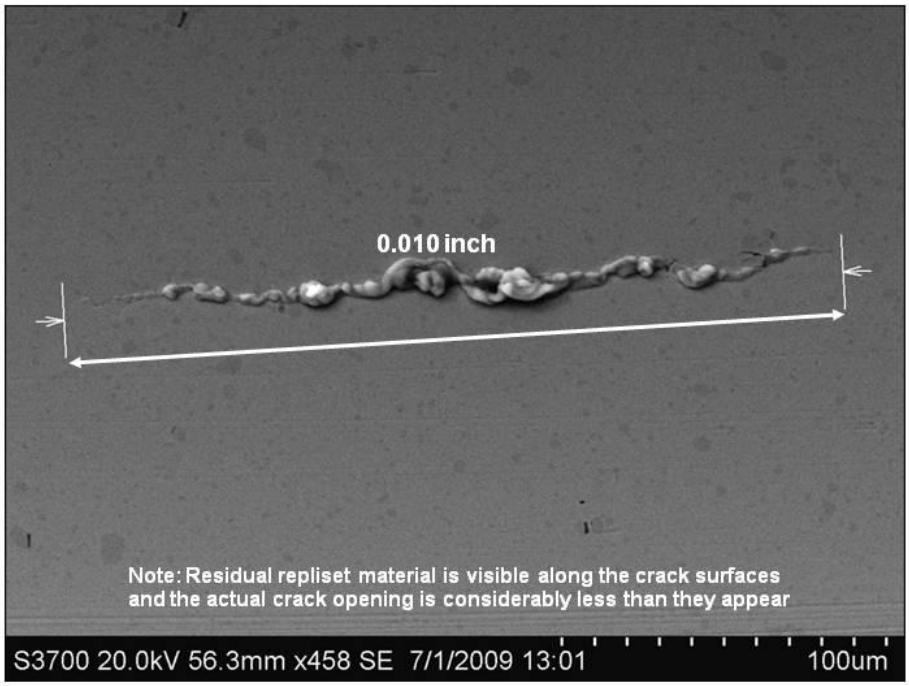
466


Poppet #68
Location of Cracks #9-5
Shaft
7 Cracks
Radius
Flange
2 mm
Reference Mark
215°
Cracks
#9
#12
#15
#10 & 11
#13
#14
S3700 20.0kV 57.3mm x25 SE 7/1/2009 12:58
2.00mm

467

Poppet #68

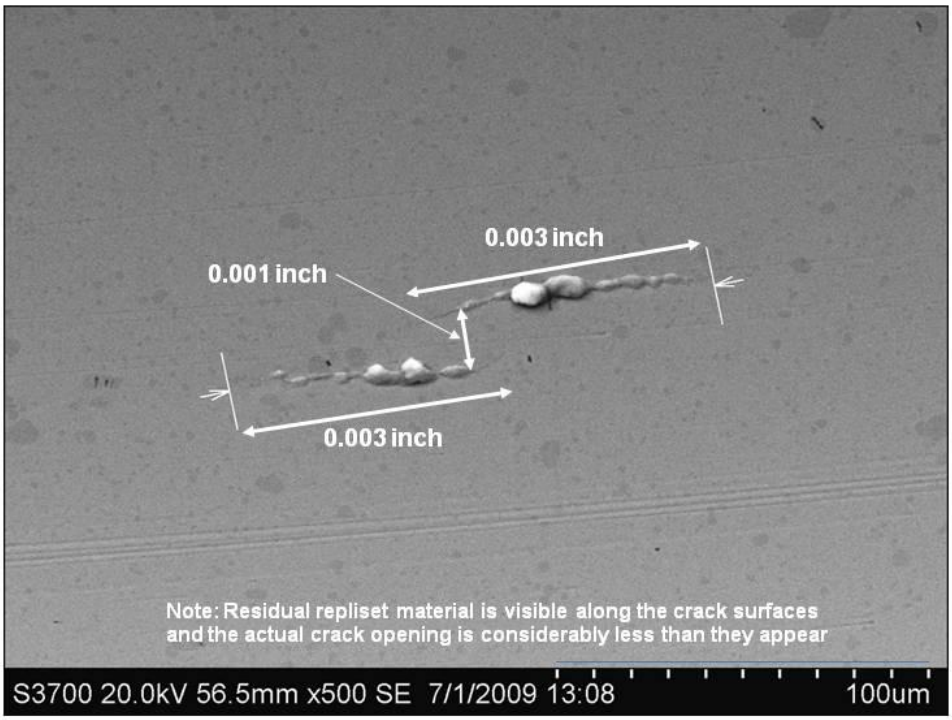
Size of Crack #9



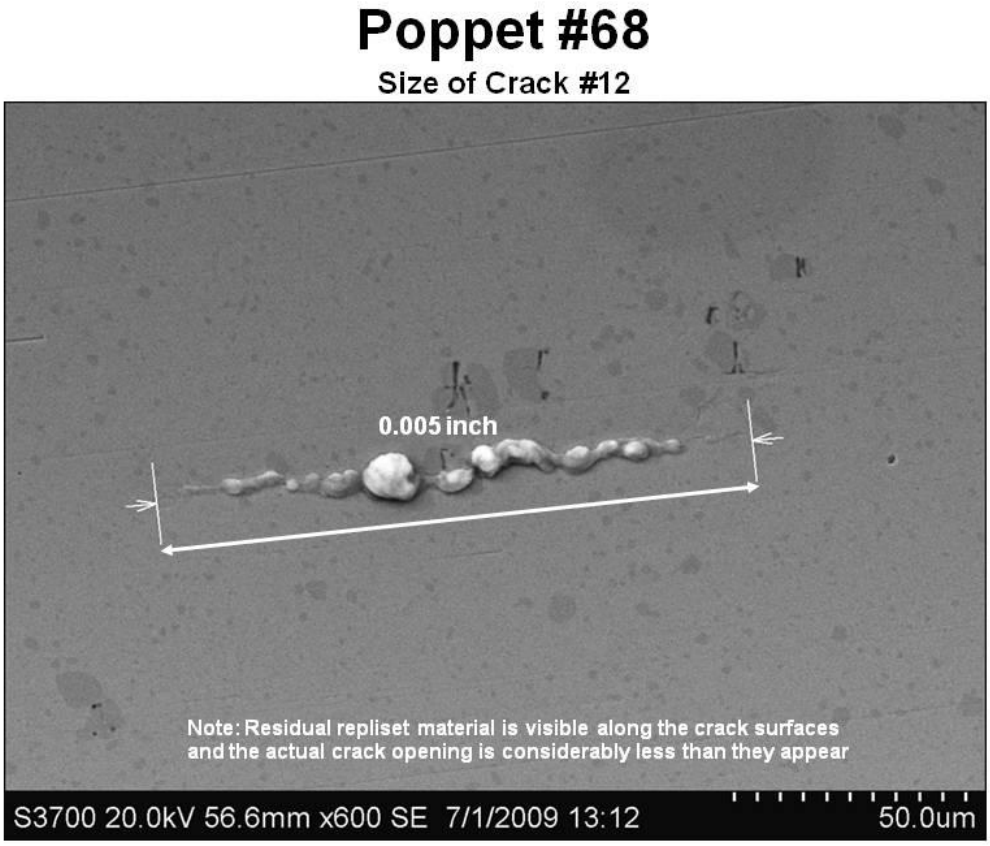
468

Poppet #68

Size of Cracks #10 and 11



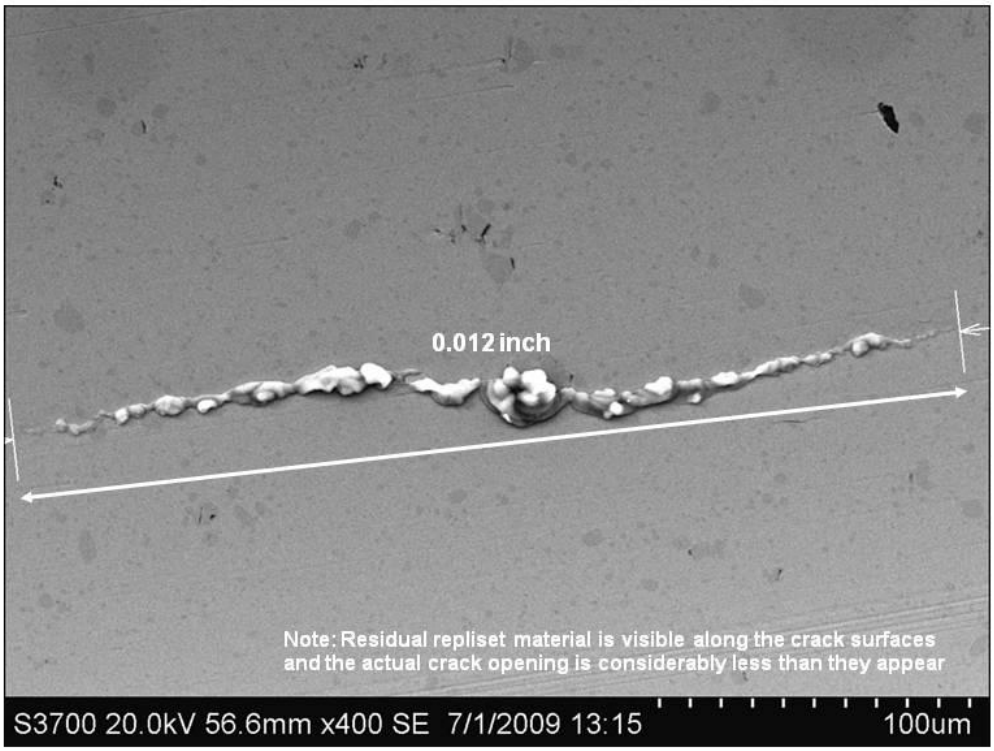
469


Poppet #68
Size of Crack #12
0.005 inch
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 56.6mm x600 SE 7/1/2009 13:12
50.0um

470

Poppet #68

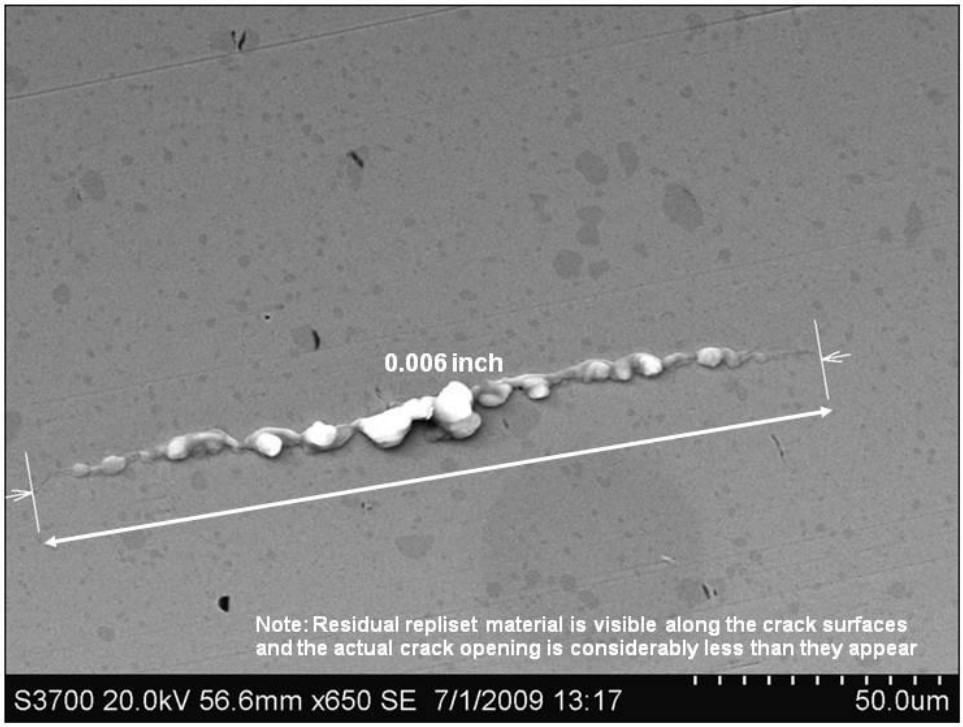
Size of Crack #13



471

Poppet #68

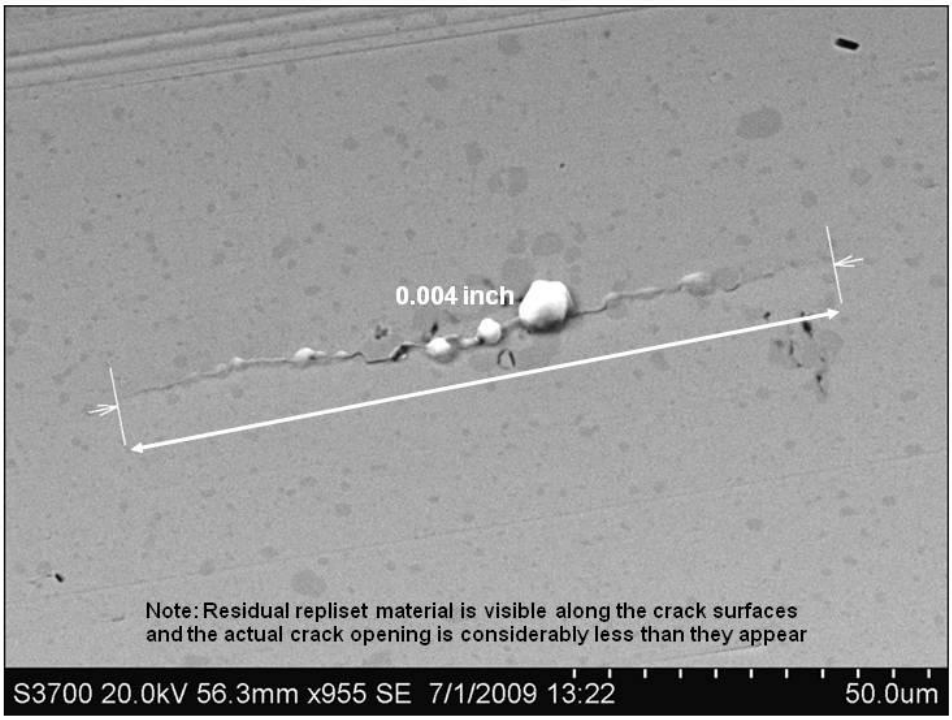
Size of Crack #14



472

Poppet #68

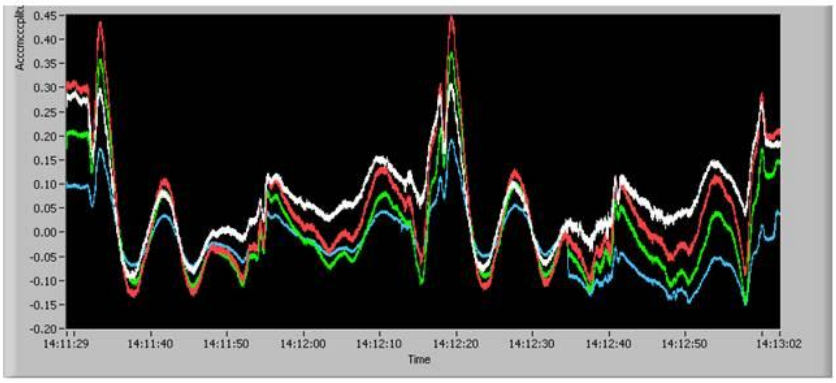
Size of Crack #15



473

Poppet #68

LaRC eddy current findings, the colors indicate ???



474

Poppet #69

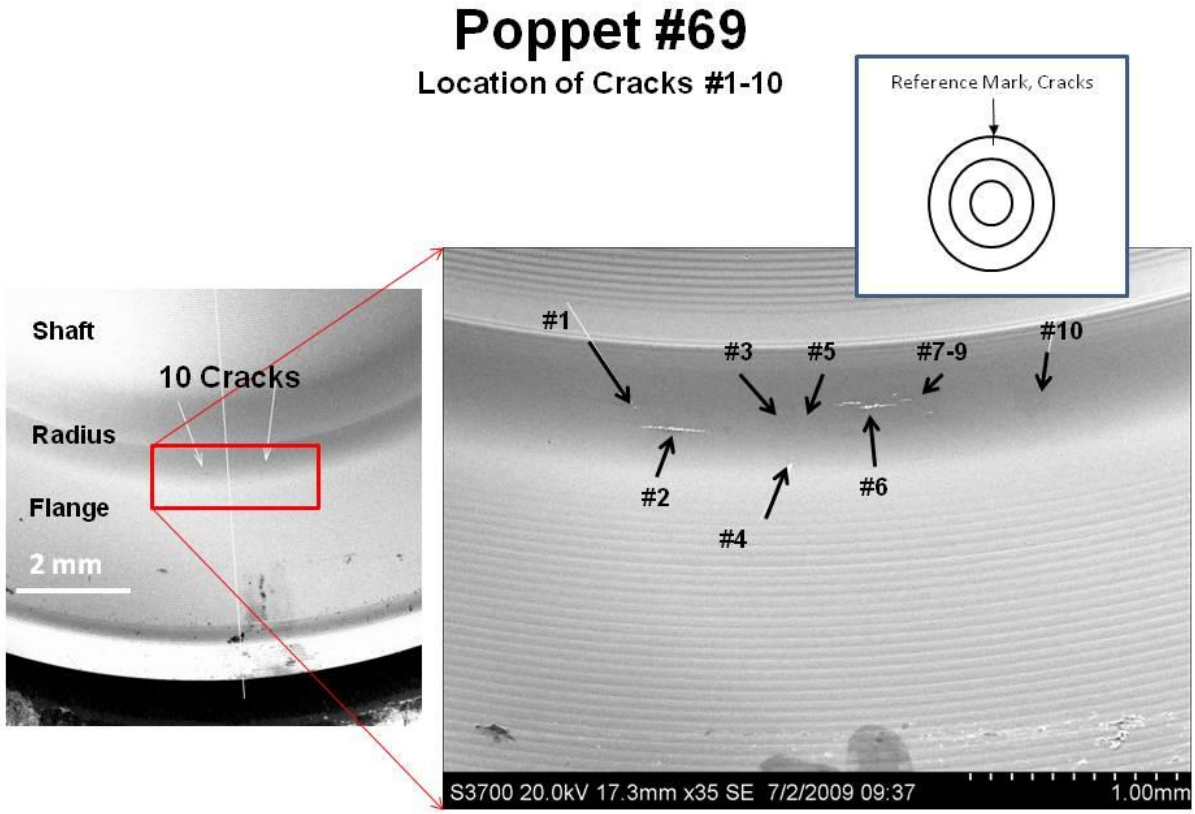
Surface crack sizes and locations

Poppet #69					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.003	0	11	0.004	180
2	0.015	0	12	0.004	180
3	0.002	0	13	0.011	180
4	0.002	0	14	0.007	180
5	0.001	0	15	0.006	180
6	0.014	0	16	0.006	180
7	0.003	0	17	0.008	180
8	0.003	0	18	0.003	180
9	0.003	0	19	0.008	180
10	0.002	0	20	0.003	180
			21	0.005	180

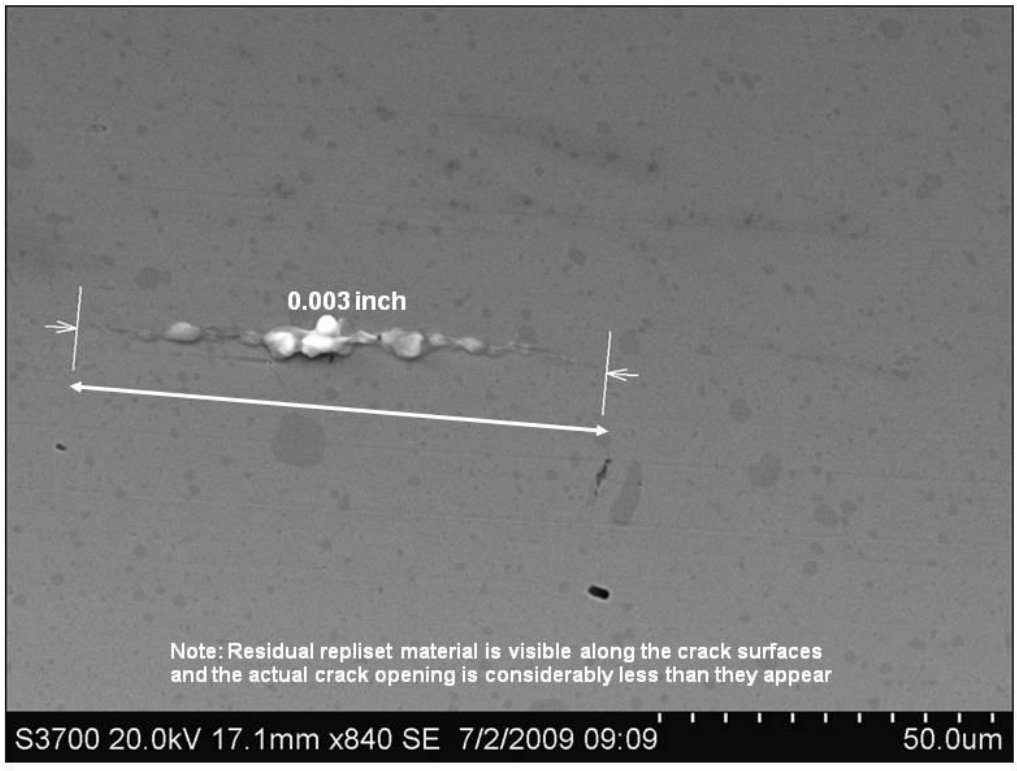
Boeing Eddy Current Findings

None Provided

475

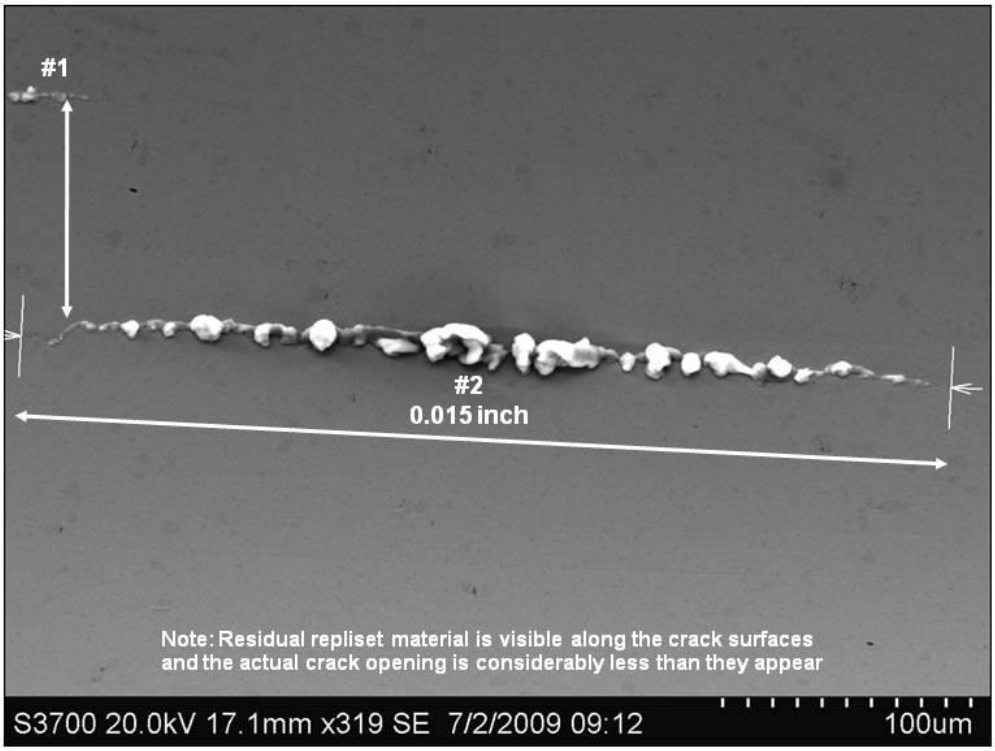

Poppet #69
Location of Cracks #1-10
Reference Mark, Cracks
Shaft
10 Cracks
Radius
Flange
2 mm
#1
#2
#3
#4
#5
#6
#7-9
#10
S3700 20.0kV 17.3mm x35 SE 7/2/2009 09:37
1.00mm

476


Poppet #69
Size of Crack #1
0.003 inch
Note: Residual repliset material is visible along the crack surfaces
and the actual crack opening is considerably less than they appear
S3700 20.0kV 17.1mm x840 SE 7/2/2009 09:09
50.0um
477

Poppet #69

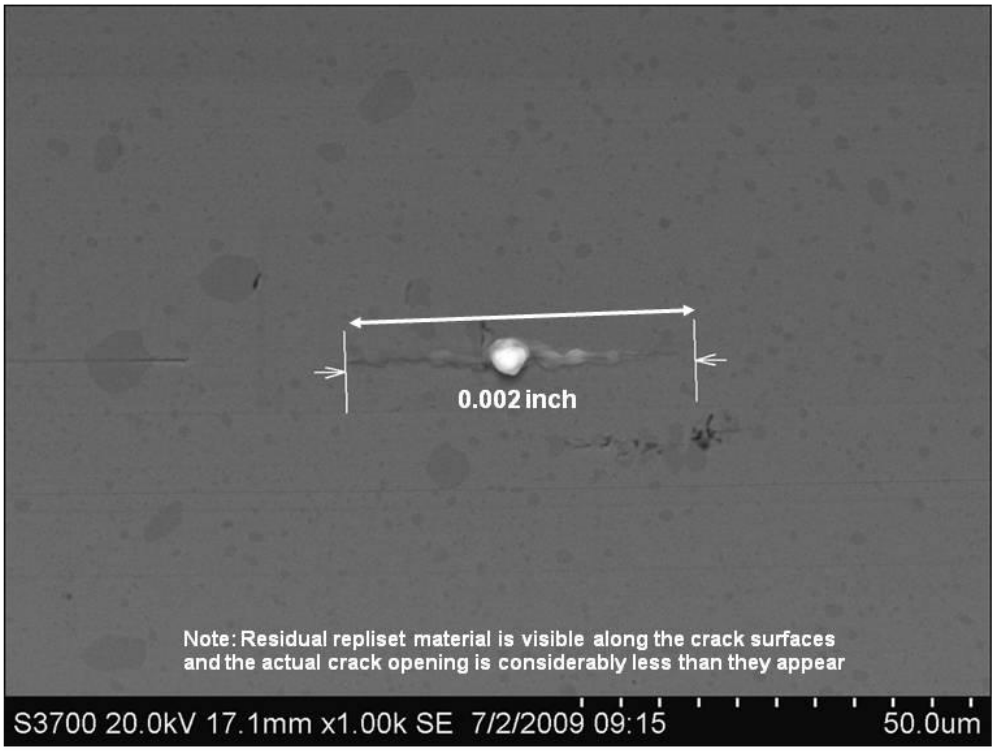
Location and size of Crack #2



478

Poppet #69

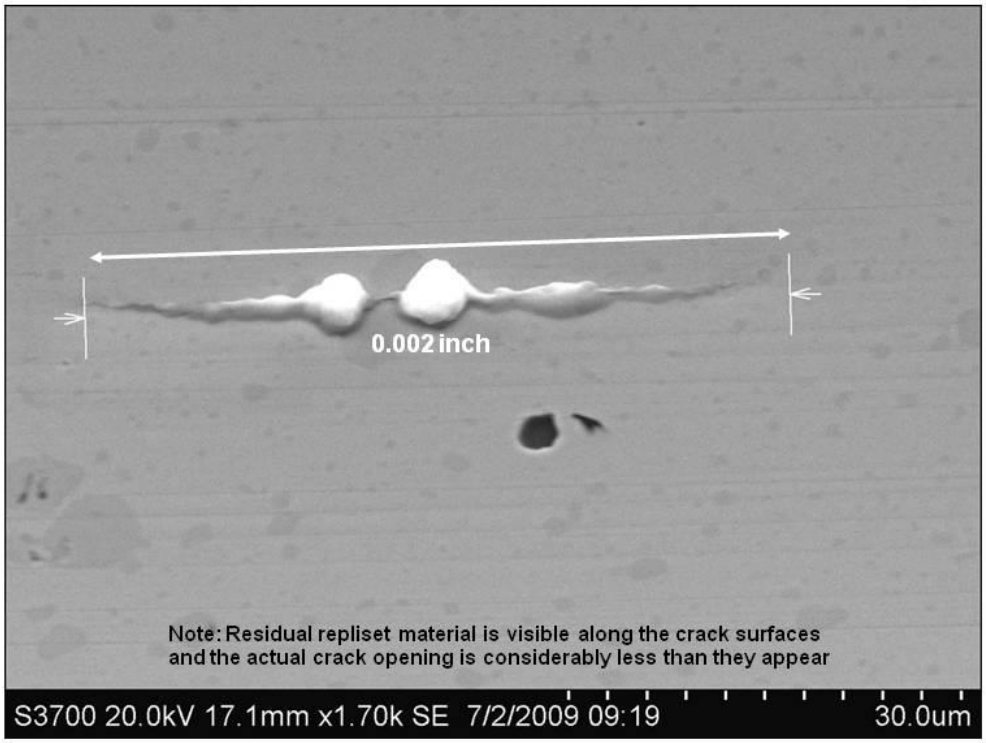
Size of Crack #3



479

Poppet #69

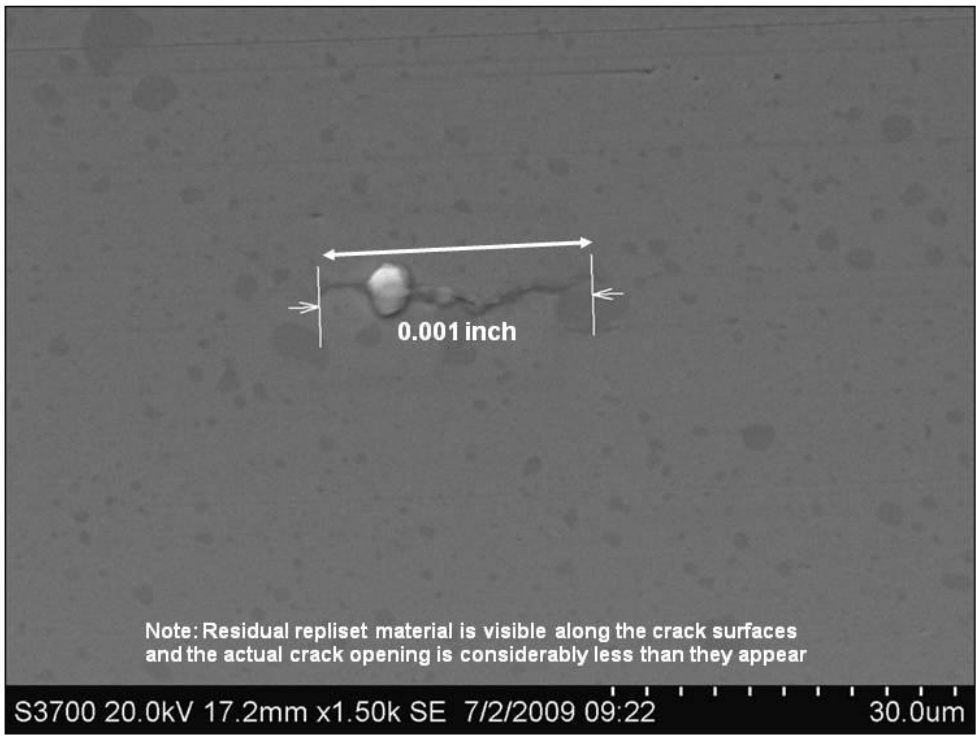
Size of Crack #4



480

Poppet #69

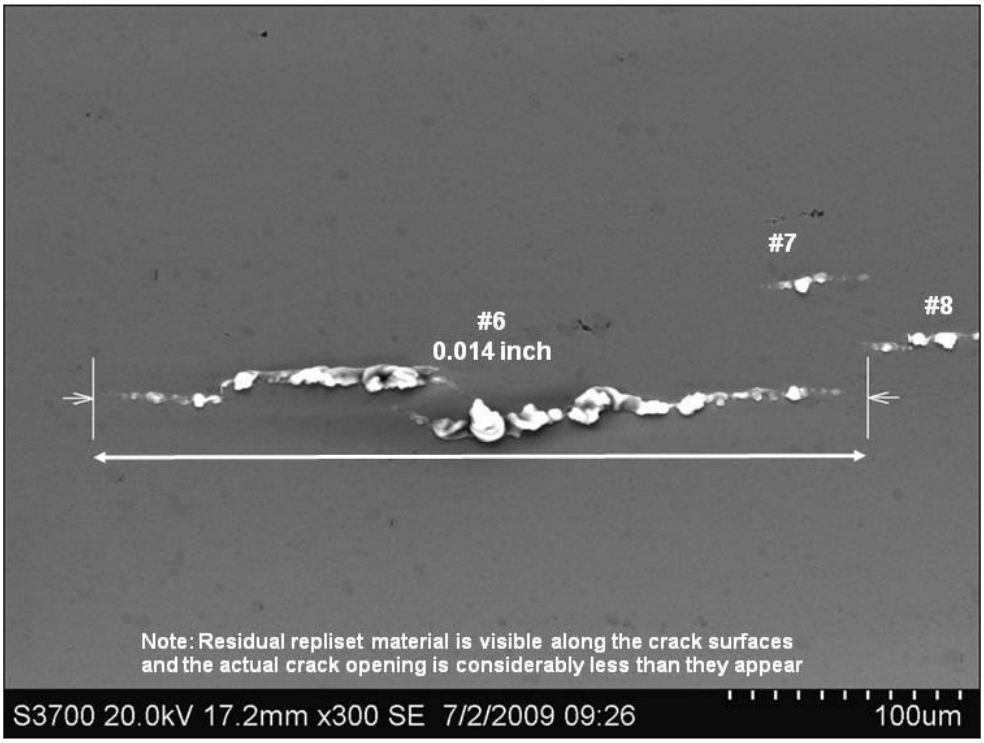
Size of Crack #5



481

Poppet #69

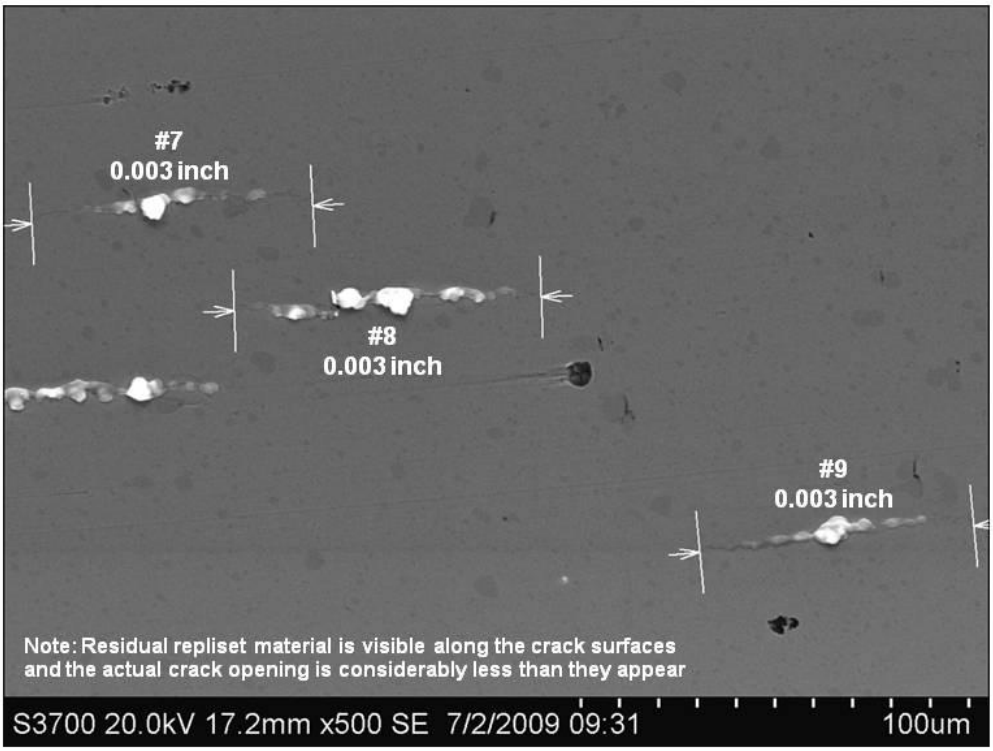
Location of Cracks #6-8



482

Poppet #69

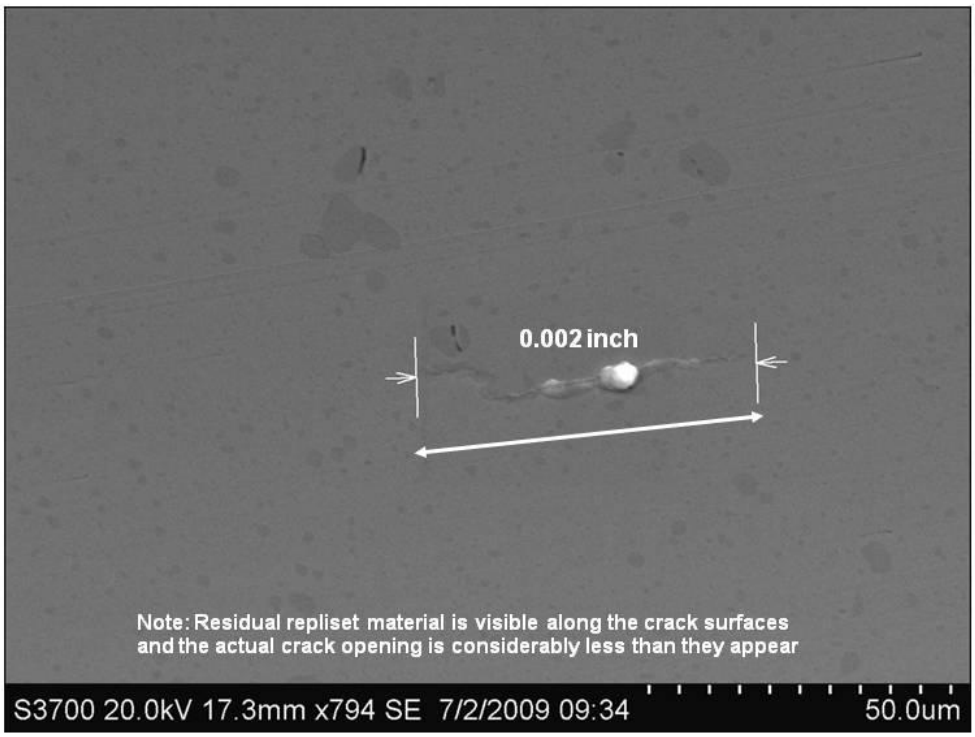
Location and size of Cracks #7-9



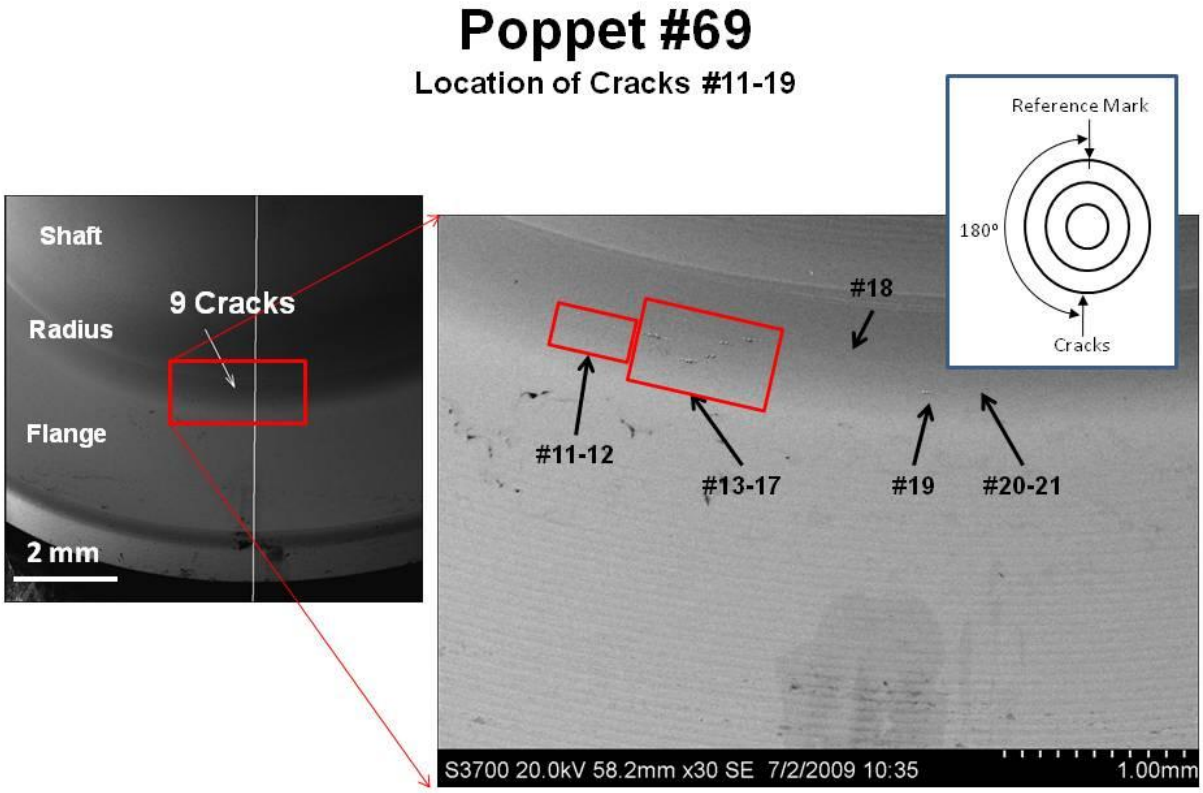
483

Poppet #69

Size of Crack #10



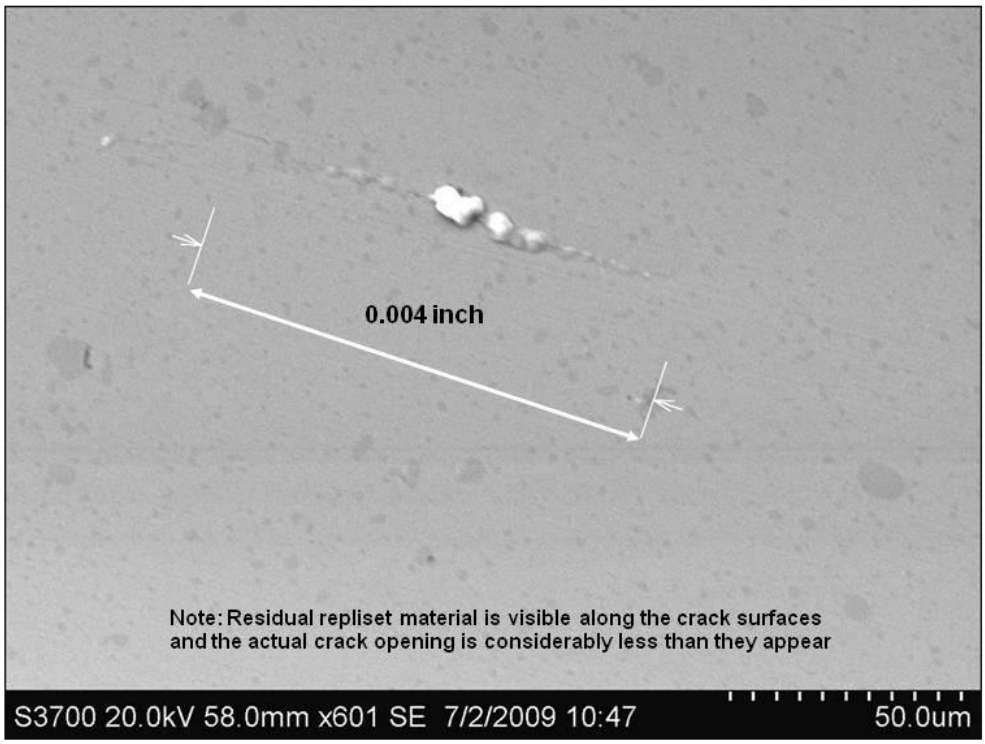
484


Poppet #69
Location of Cracks #11-19
Shaft
Radius
Flange
9 Cracks
2 mm
Reference Mark
180°
Cracks
#18
#11-12
#13-17
#19
#20-21
S3700 20.0kV 58.2mm x30 SE 7/2/2009 10:35
1.00mm

485

Poppet #69

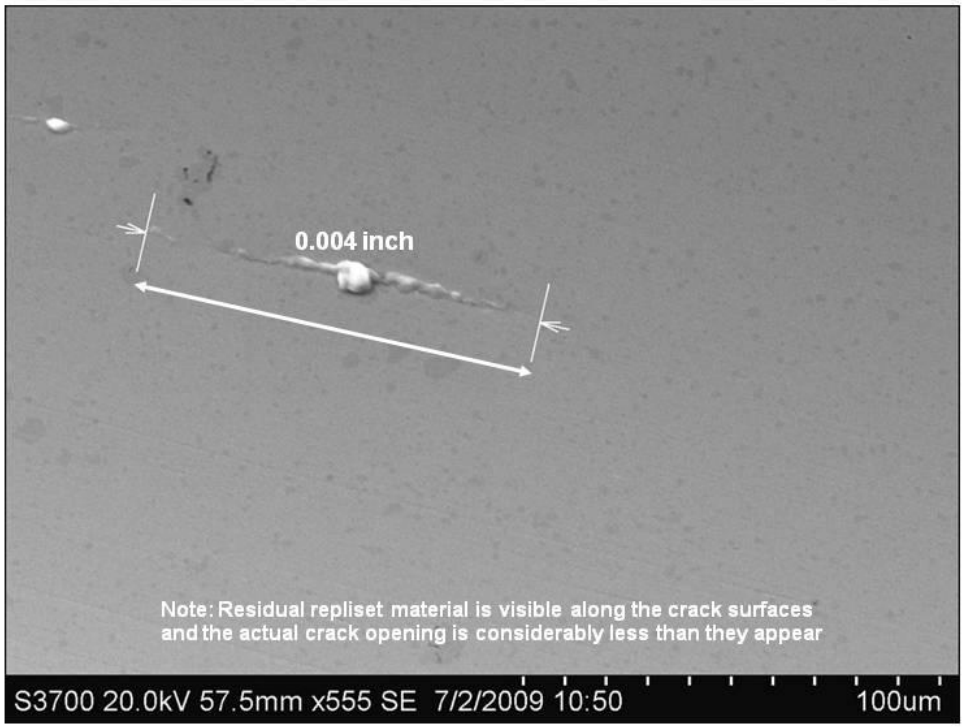
Size of Crack #11



486

Poppet #69

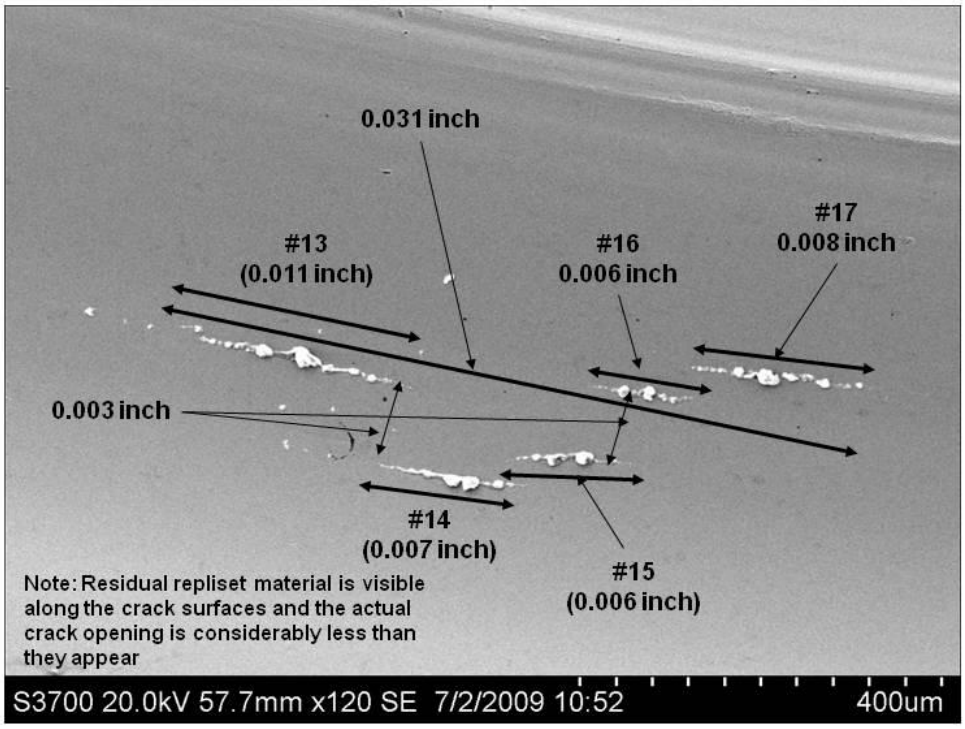
Size of Crack #12



487

Poppet #69

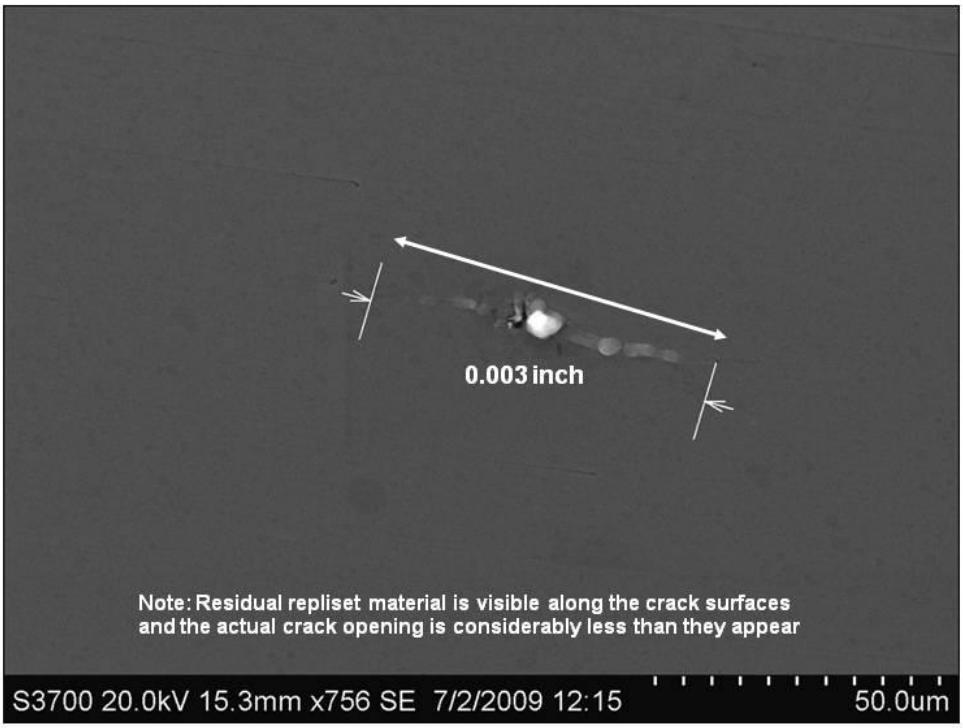
Location and size of Cracks #13-17



488

Poppet #69

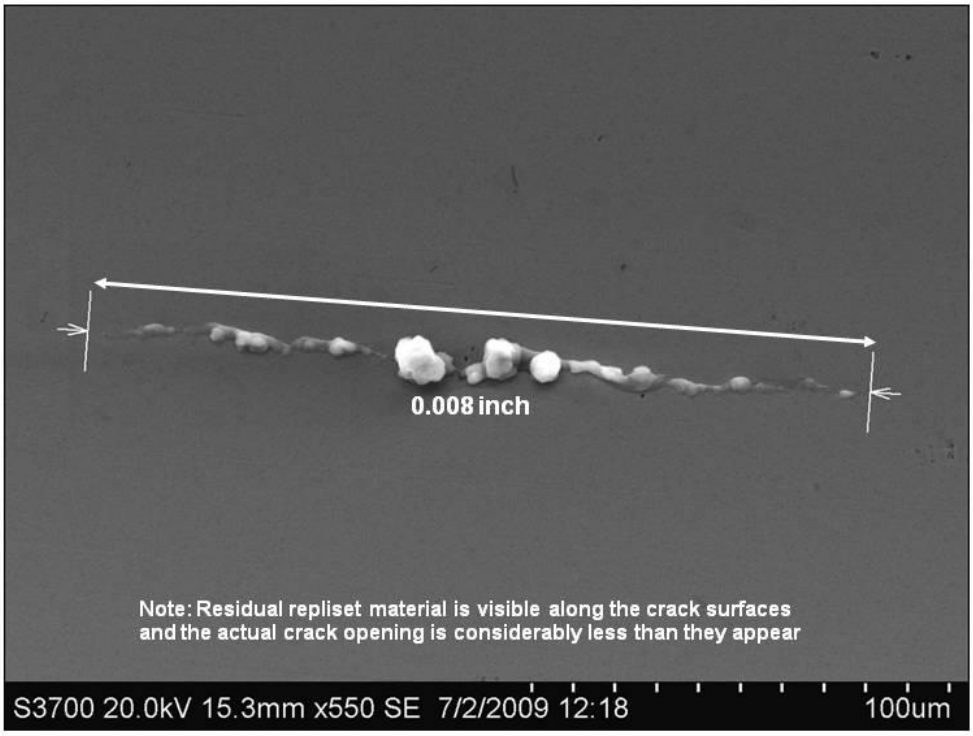
Size of Crack #18



489

Poppet #69

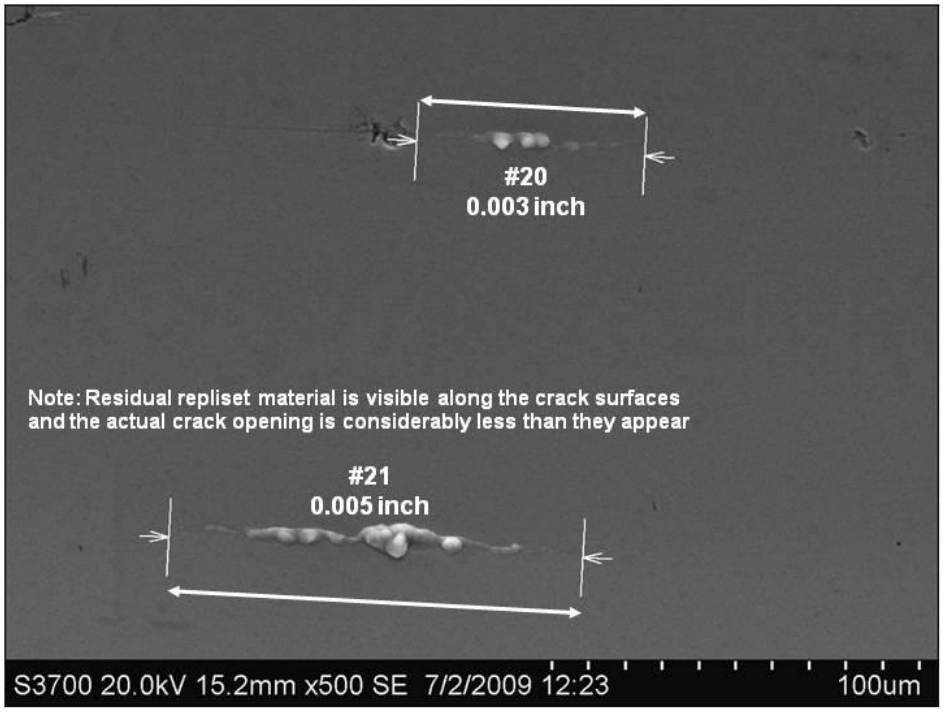
Size of Crack #19



490

Poppet #69

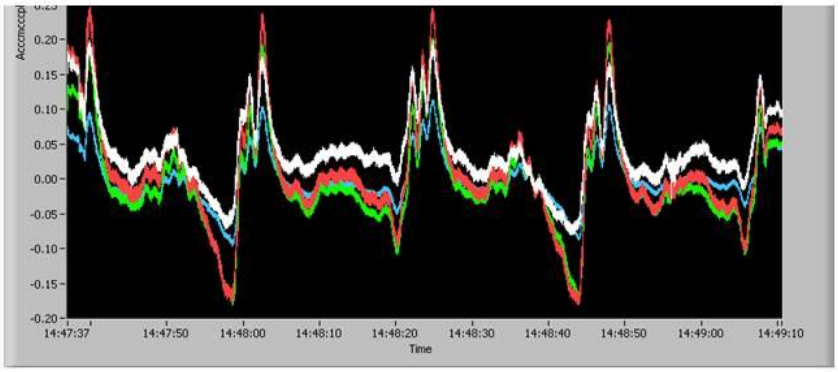
Location and size of Region B Cracks #20-21



491

Poppet #69

LaRC eddy current findings, the colors indicate ???



492

Poppet #70

Surface crack sizes and locations

Poppet #70		
Crack Number	Size (inch)	Angle (degrees)
1	0.005	145
2	0.016	145
3	0.003	145
4	0.008	325
5	0.004	325

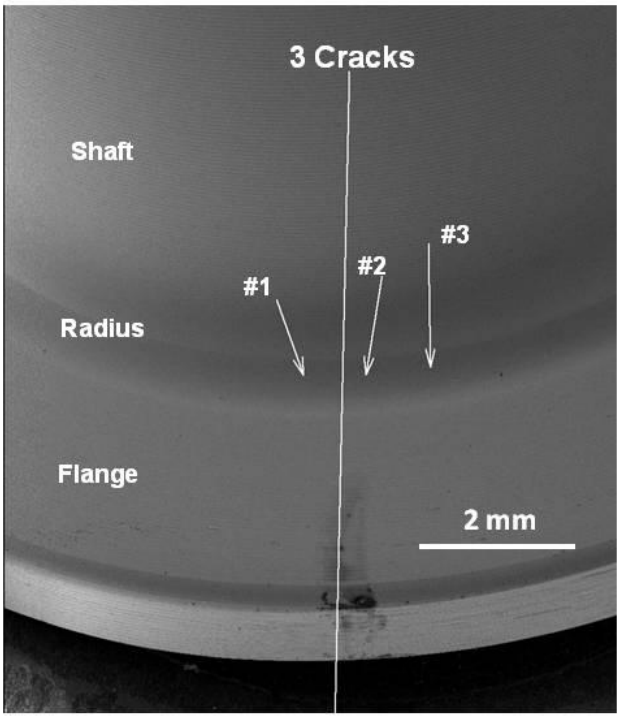
Boeing Eddy Current Findings

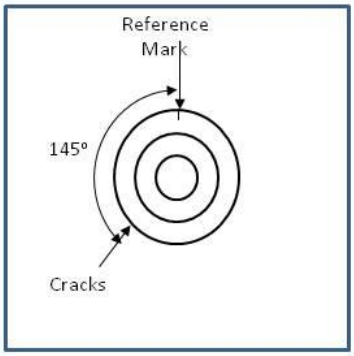
Poppet #70									
Inspector	Run Data (Vpp)								
	1	2	3	4	5	6	Average	Crack Detected	Location (degrees)
J. Engel	0.184	0.187	0.174	0.172	0.176	0.178	0.179	Yes	145
J. Engel	0.093	0.097	0.100	0.100	0.102	0.100	0.099	Yes	345 (Not 3:1 S/N ratio)
B. Devries	0.171	0.181	0.177	0.190	0.189	0.201	0.185	Yes	150
B. Devries	0.095	0.089	0.096	0.108	0.101	0.102	0.099	No	355

493

Poppet #70

Location of Cracks #1-3

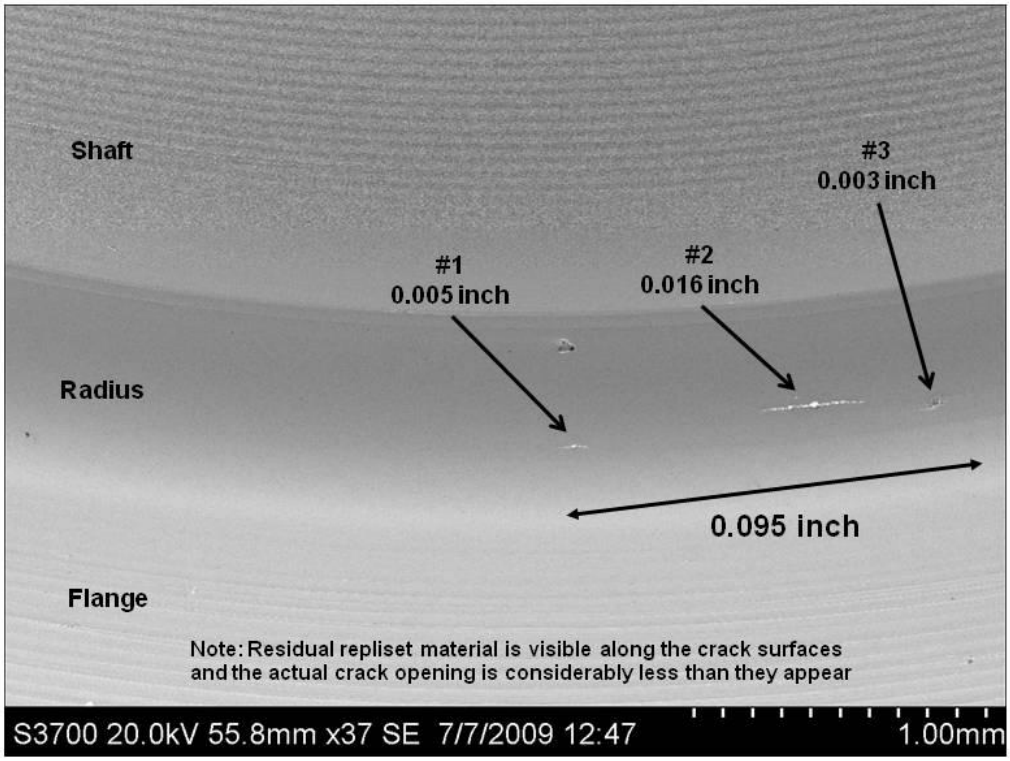




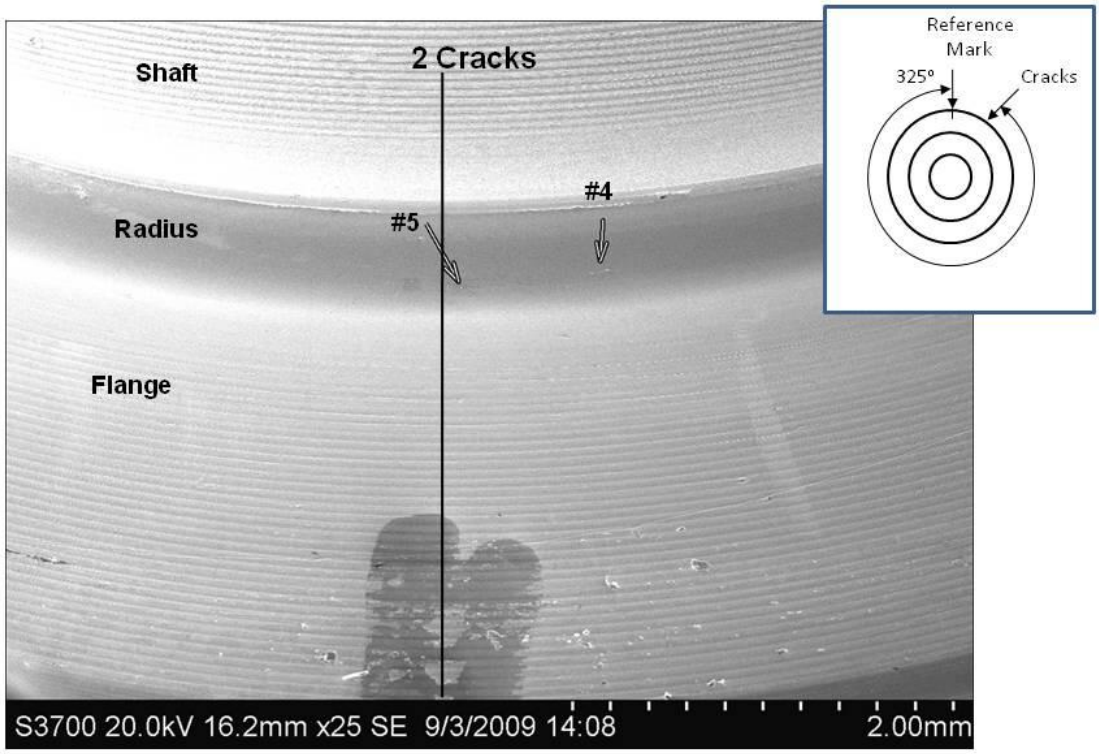
494

Poppet #70

Location and size of Cracks #1-3



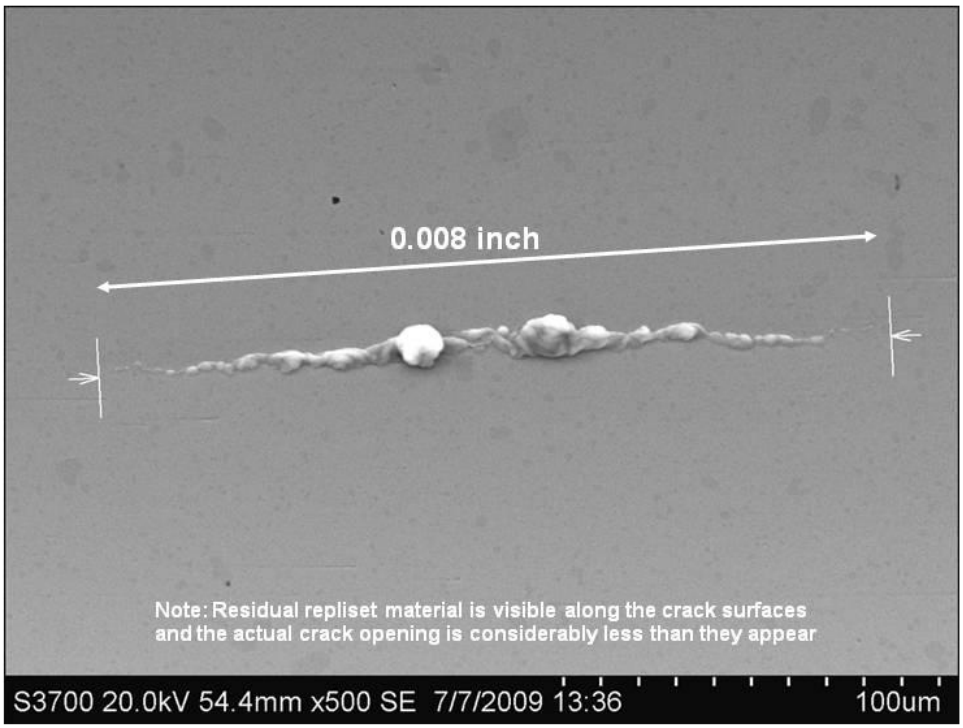
495


Poppet #70
Location of Cracks #4 and 5
Shaft
2 Cracks
Radius
#5
#4
Flange
Reference Mark
325°
Cracks
S3700 20.0kV 16.2mm x25 SE 9/3/2009 14:08
2.00mm

496

Poppet #70

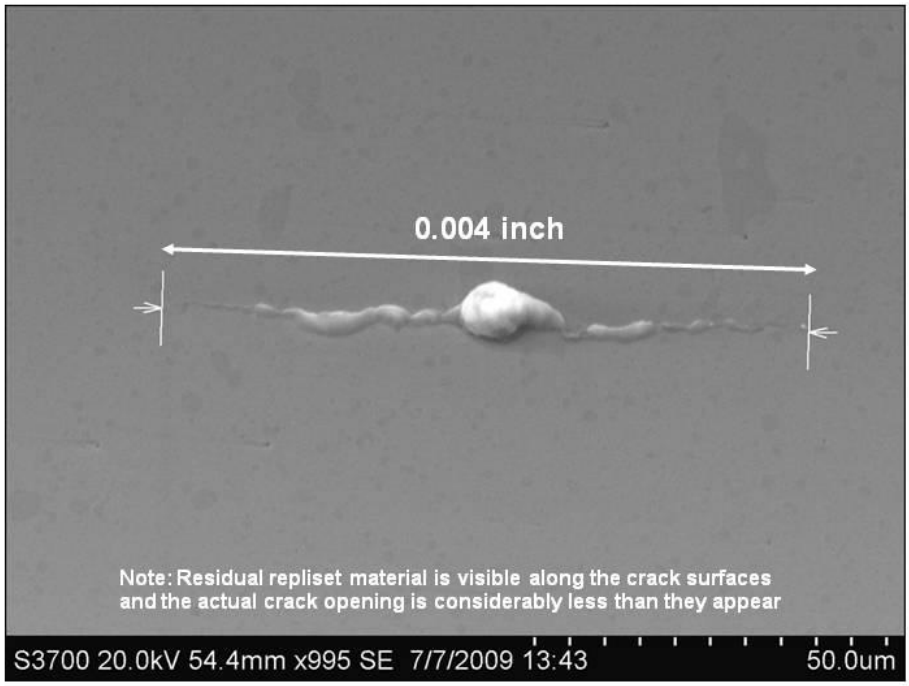
Size of Crack #4



497

Poppet #70

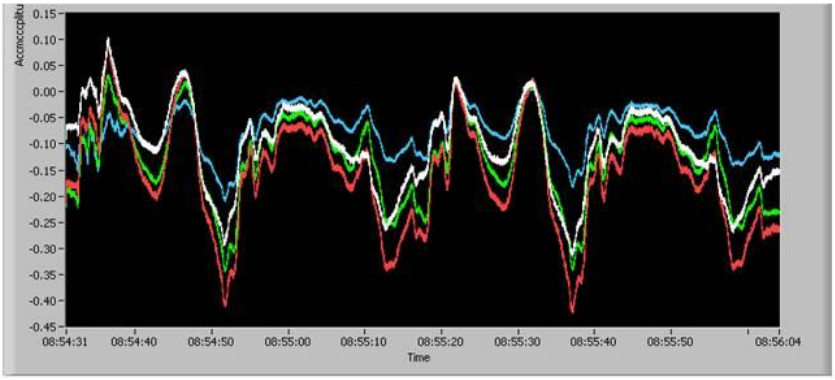
Size of Crack #5



498

Poppet #70

LaRC eddy current findings, the colors indicate ???



499

Poppet #71

Surface crack sizes and locations

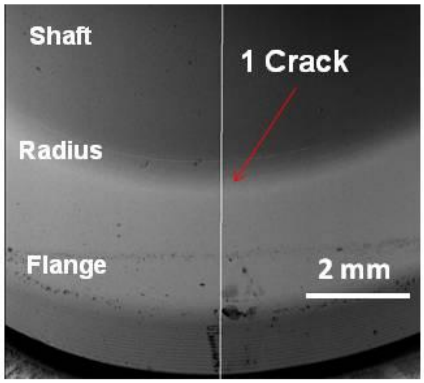
Boeing Eddy Current Findings

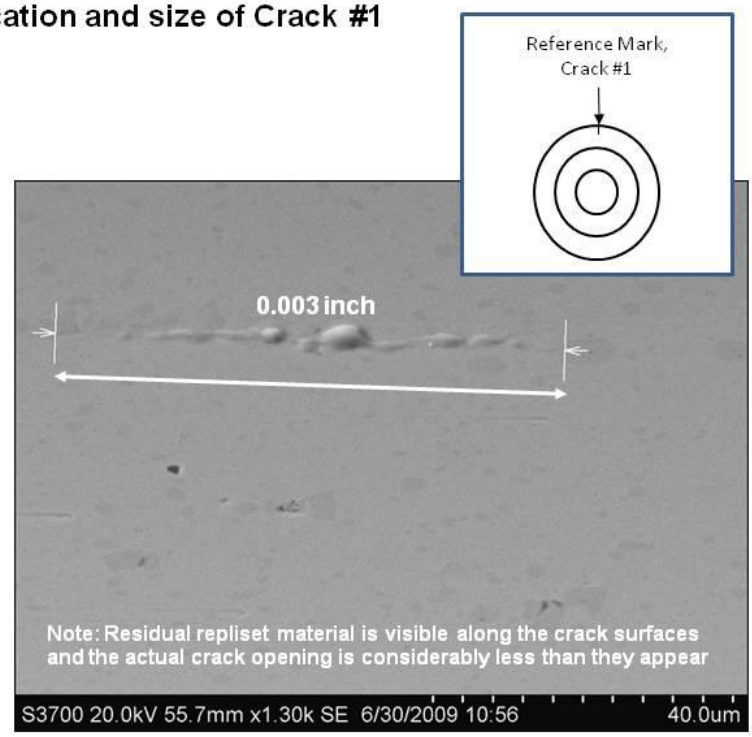
None Provided

500

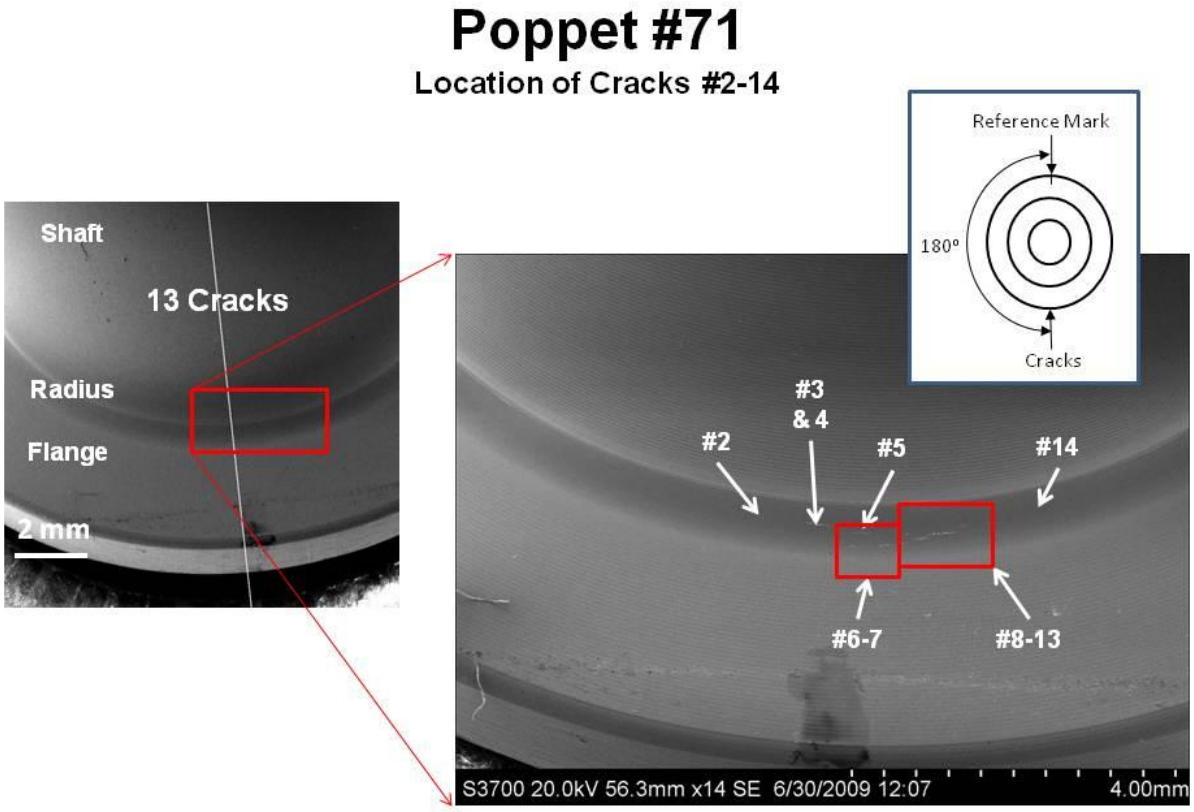
Poppet #71

Location and size of Crack #1





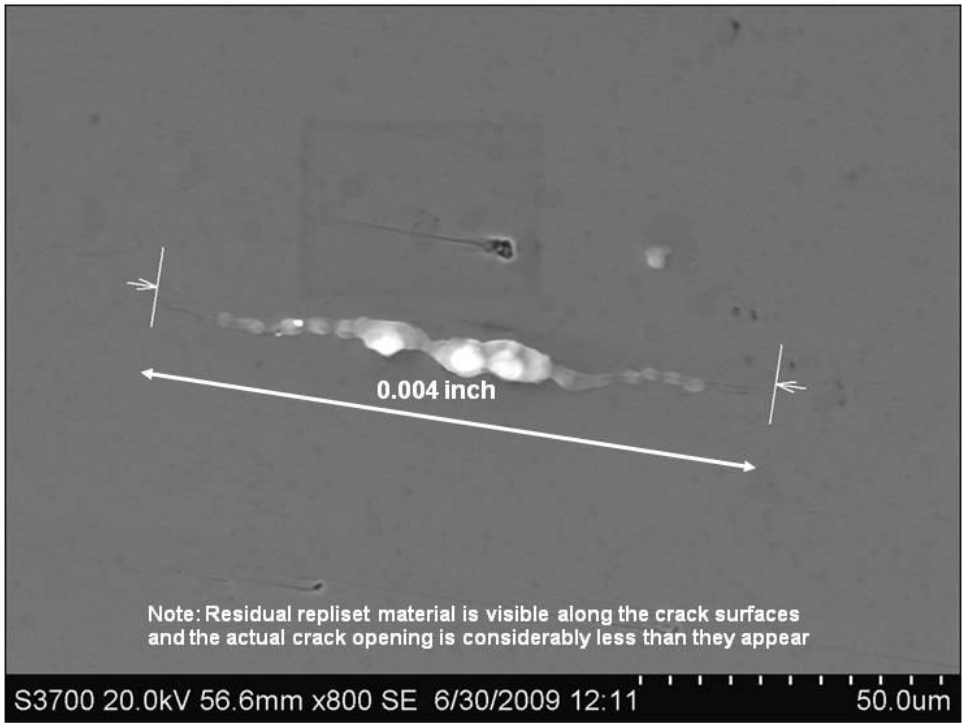
501


Poppet #71
Location of Cracks #2-14
Shaft
13 Cracks
Radius
Flange
2 mm
Reference Mark
180°
Cracks
#2
#3
& 4
#5
#14
#6-7
#8-13
S3700 20.0kV 56.3mm x14 SE 6/30/2009 12:07
4.00mm

502

Poppet #71

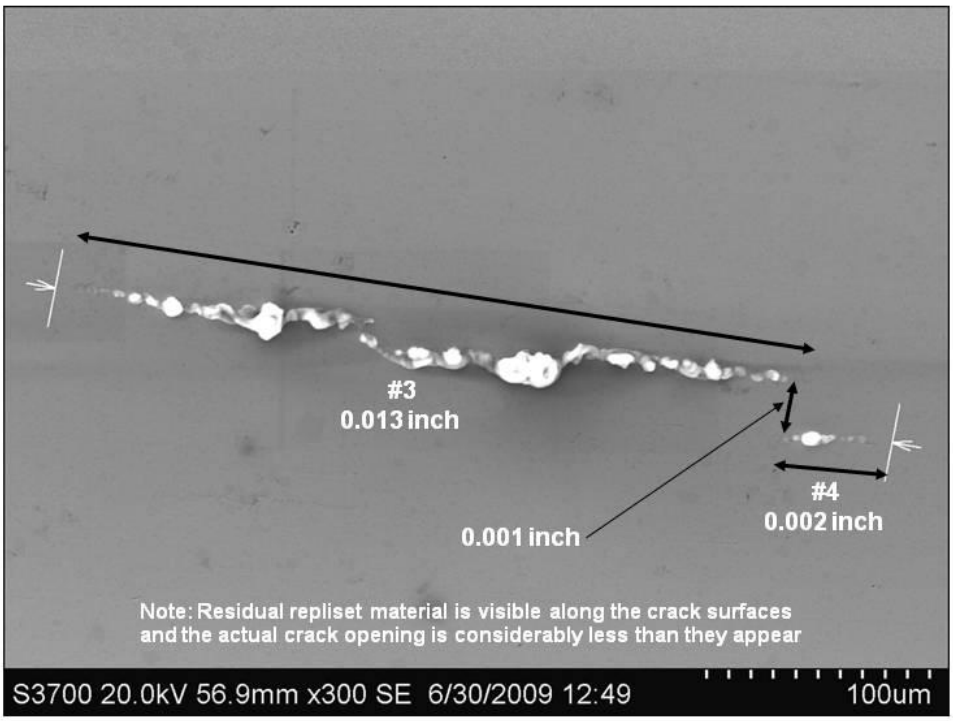
Size of Crack #2



503

Poppet #71

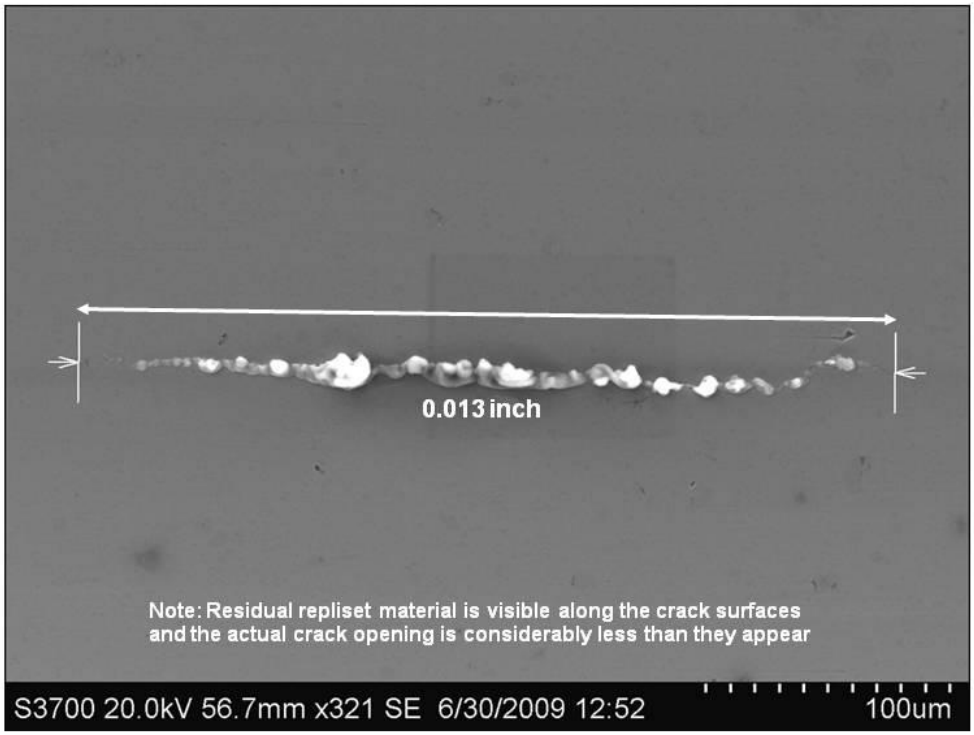
Location and size of Cracks #3 and 4



504

Poppet #71

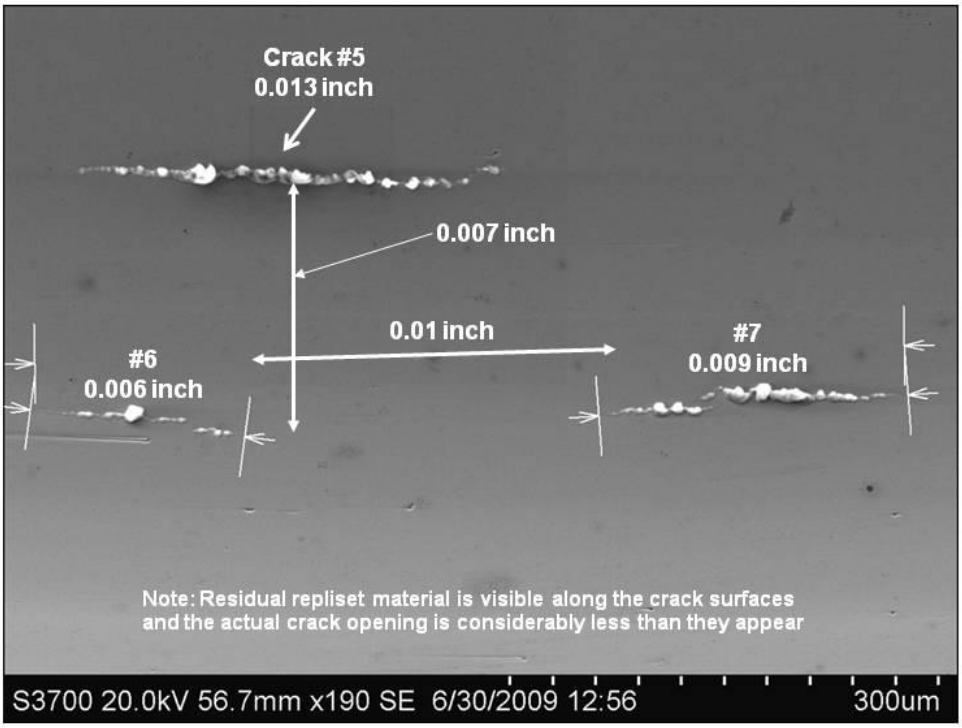
Size of Crack #5



505

Poppet #71

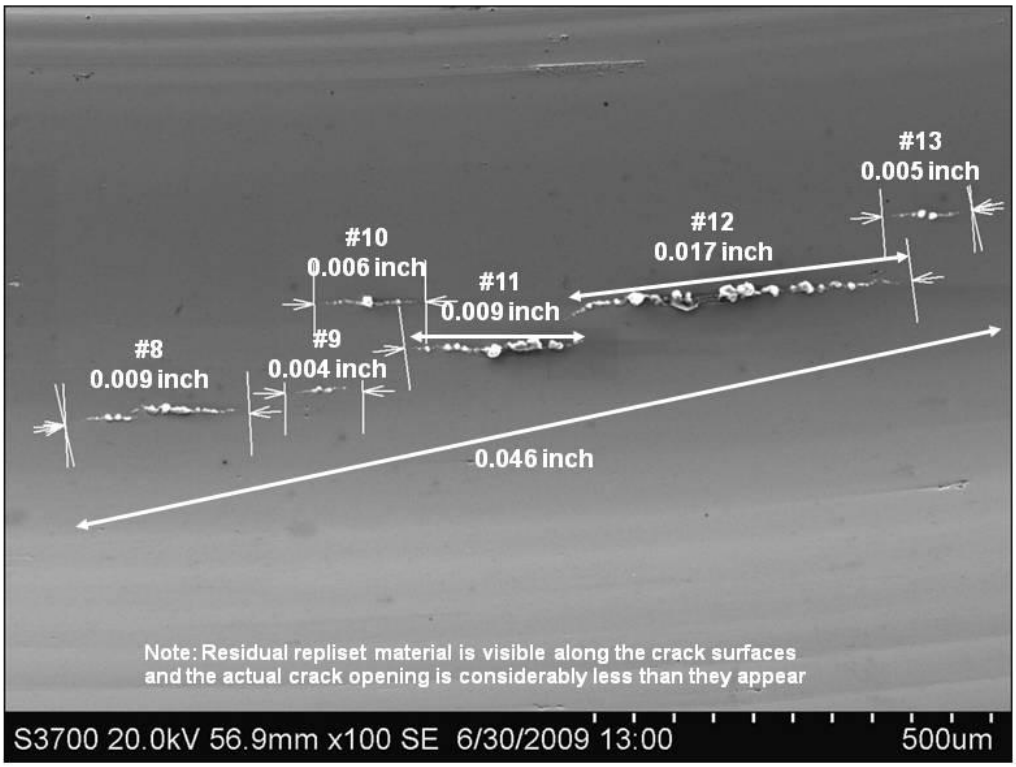
Location and size of Cracks #5-7



506

Poppet #71

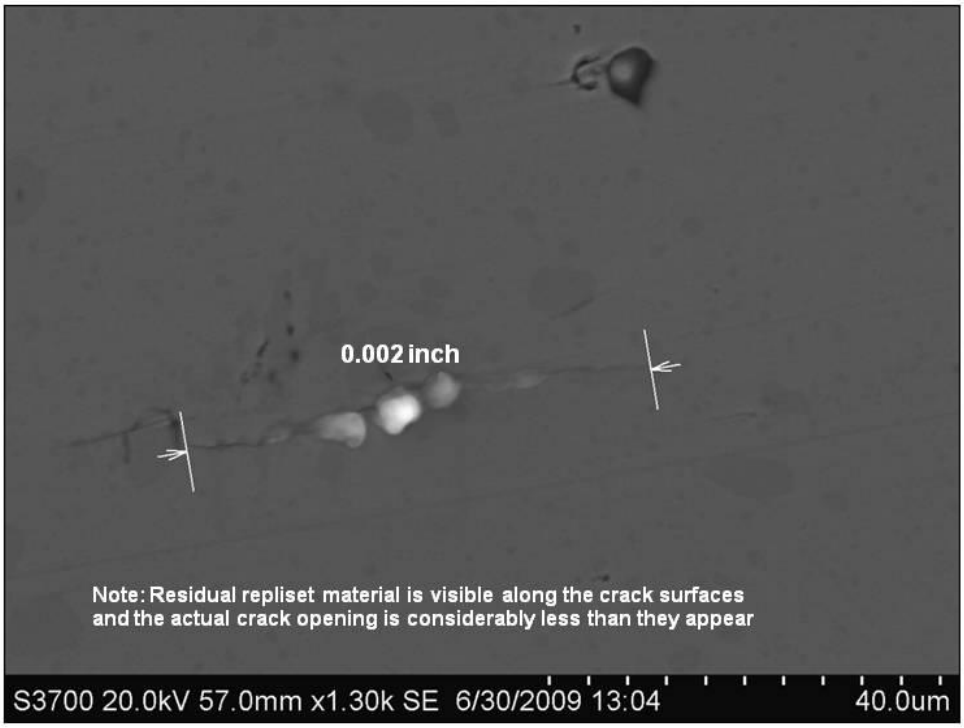
Location and size of Crack #8-13



507

Poppet #71

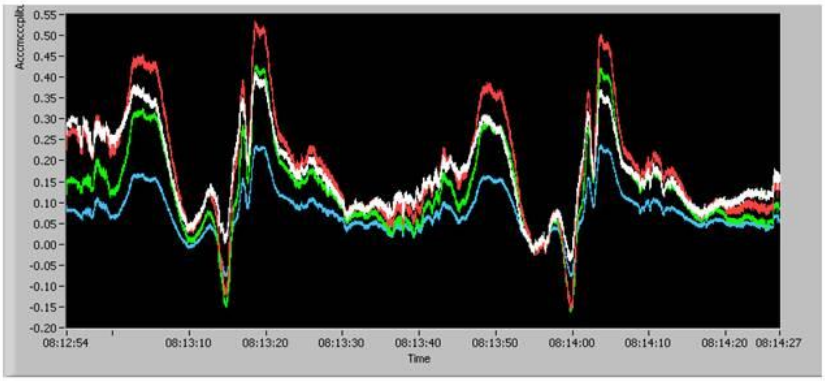
Size of Crack #14



508

Poppet #71

LaRC eddy current findings, the colors indicate ???



509

Poppet #72

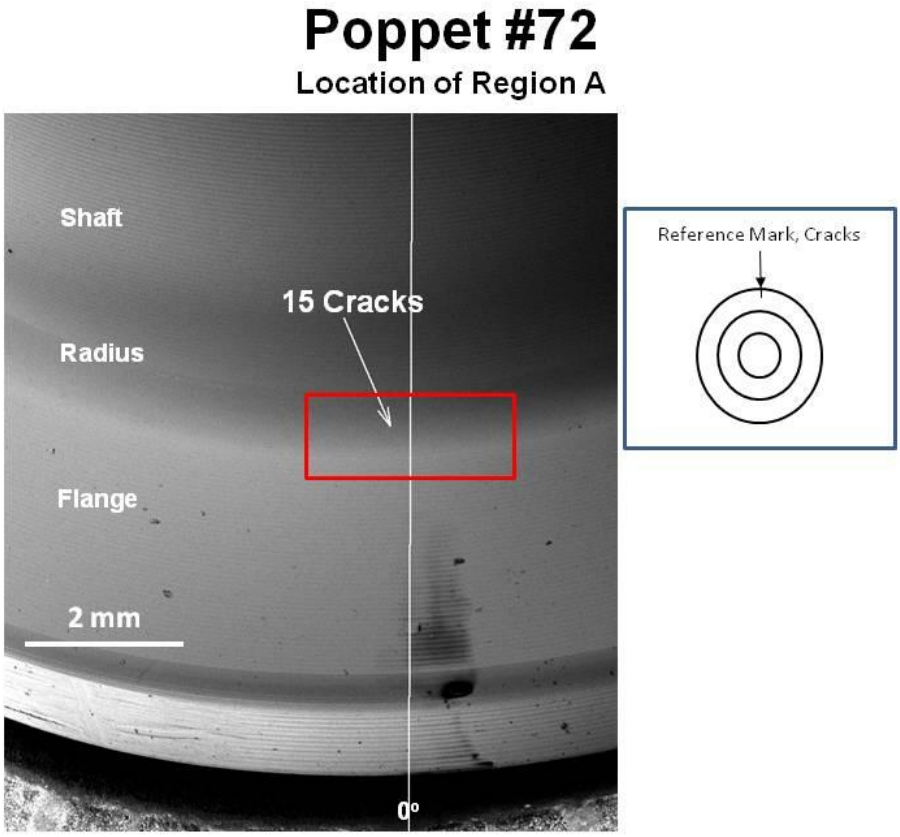
Surface crack sizes and locations

Poppet #72					
Crack Number	Size (inch)	Angle (degrees)	Crack Number	Size (inch)	Angle (degrees)
1	0.006	0	15	0.003	0
2	0.002	0	16	0.003	180
3	0.004	0	17	0.005	180
4	0.002	0	18	0.010	180
5	0.004	0	19	0.006	180
6	0.006	0	20	0.002	180
7	0.002	0	21	0.027	180
8	0.001	0	22	0.006	180
9	0.001	0	23	0.007	180
10	0.002	0	24	0.009	180
11	0.003	0	25	0.004	180
12	0.002	0	26	0.004	180
13	0.002	0	27	0.005	180
14	0.002	0	28	0.004	180

Boeing Eddy Current Findings

None Provided

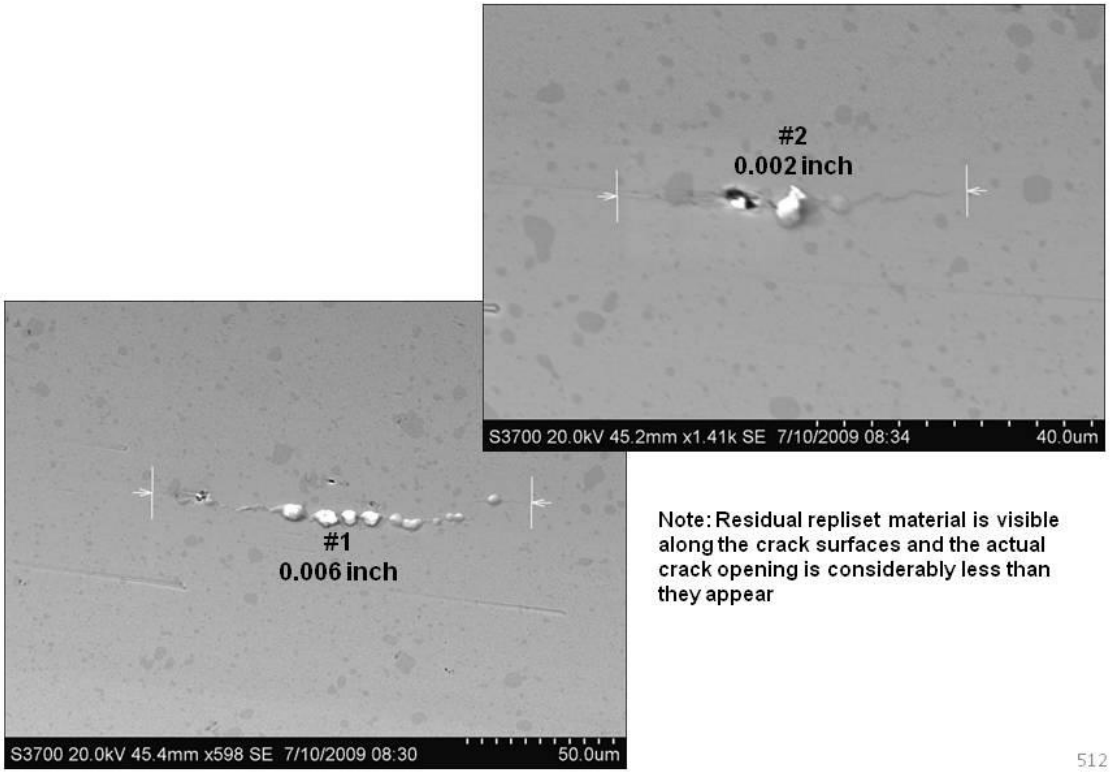
510


Poppet #72
Location of Region A
Shaft
15 Cracks
Radius
Flange
2 mm
0°
Reference Mark, Cracks

511

Poppet #72

Location and size of Cracks #1 and 2

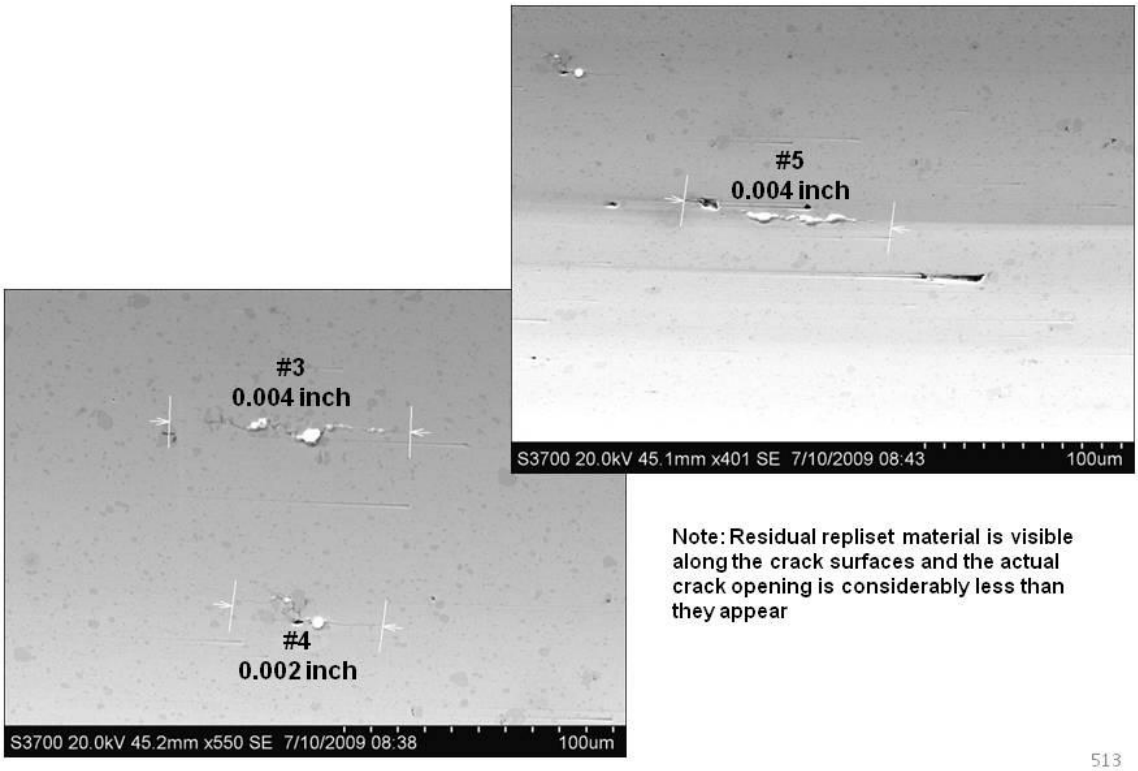


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

512

Poppet #72

Location and size of Cracks #3-5

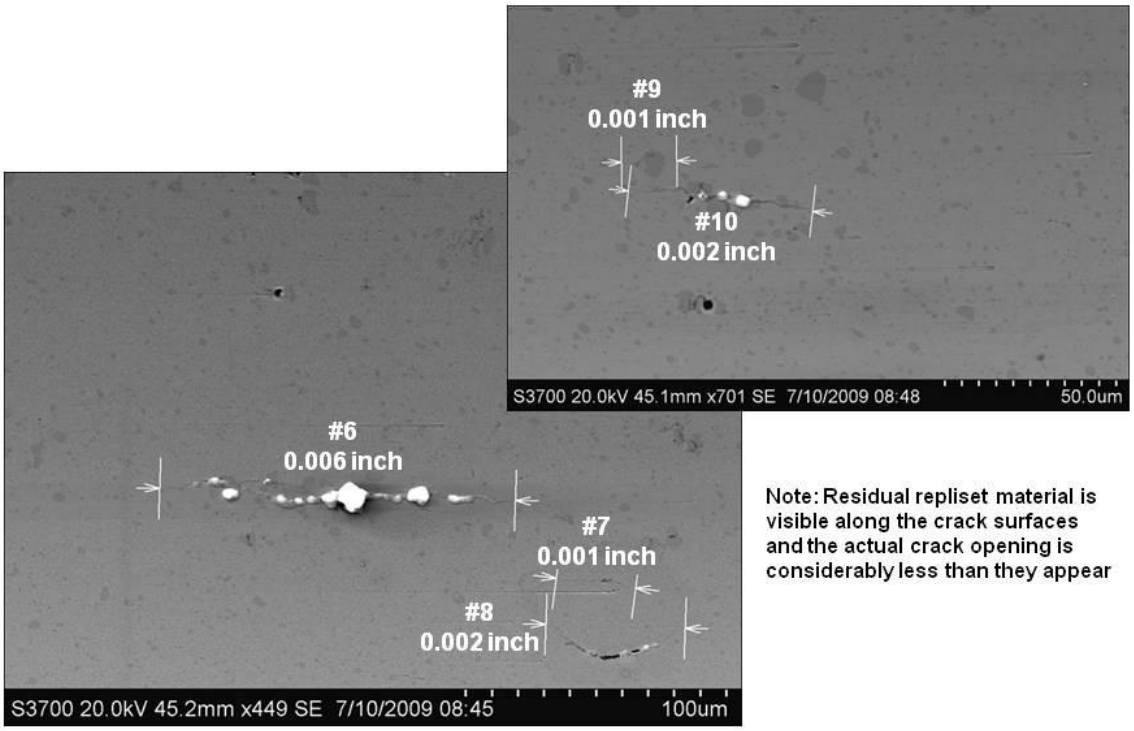


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

513

Poppet #72

Location and size of Cracks #6-10

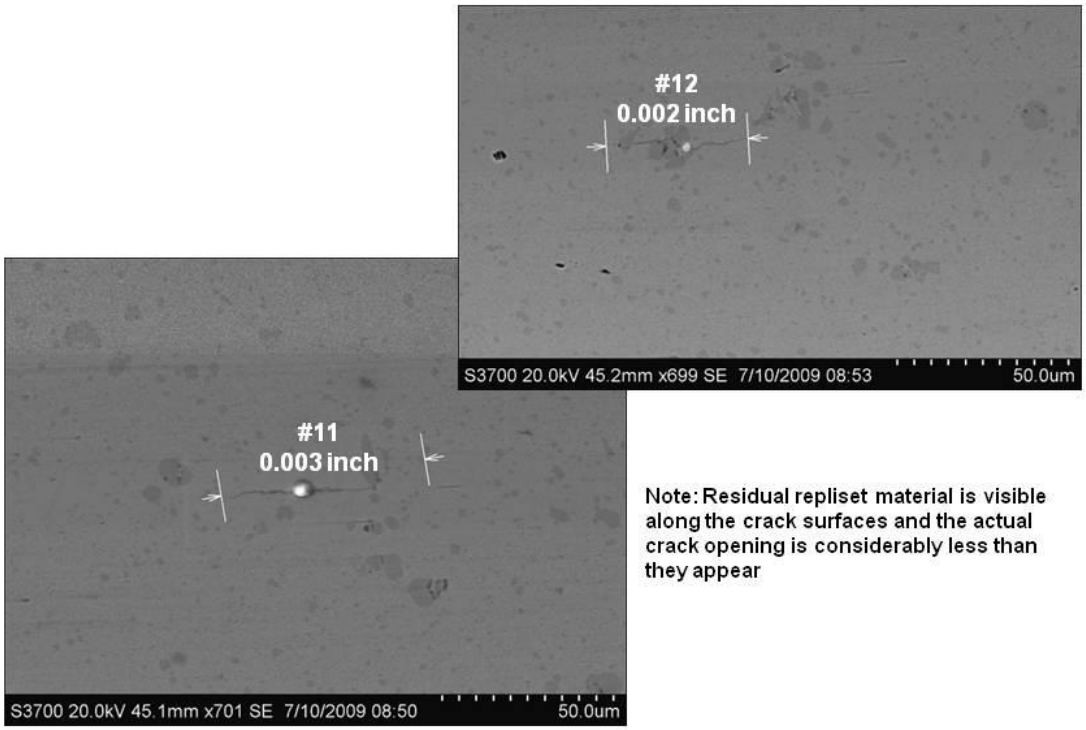


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

514

Poppet #72

Location and size of Cracks #11-12

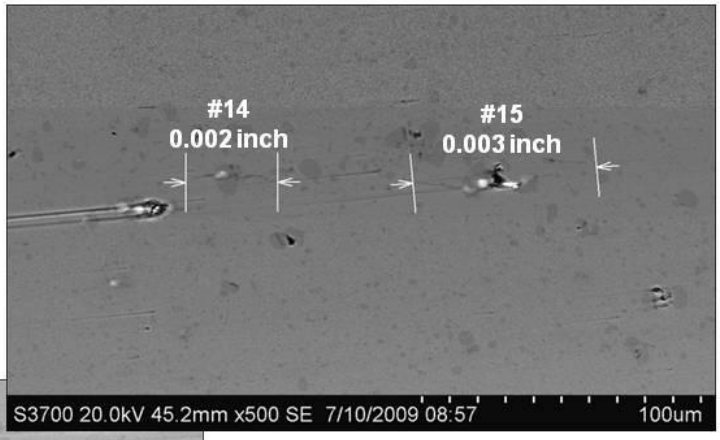


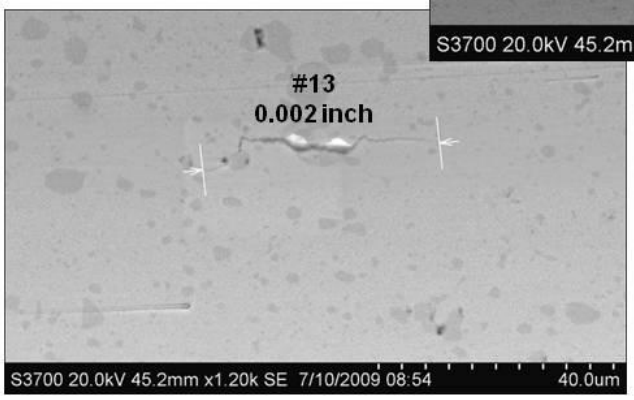
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

515

Poppet #72

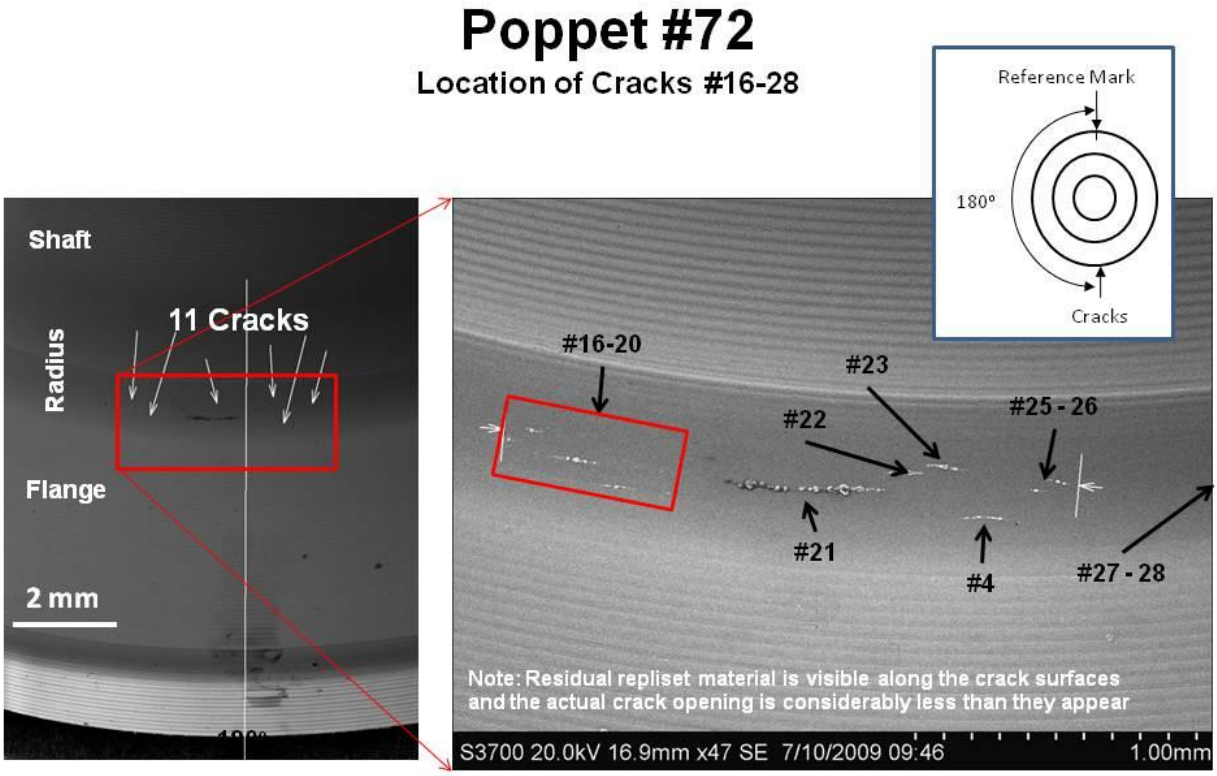
Location and size of Cracks #13-15





Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

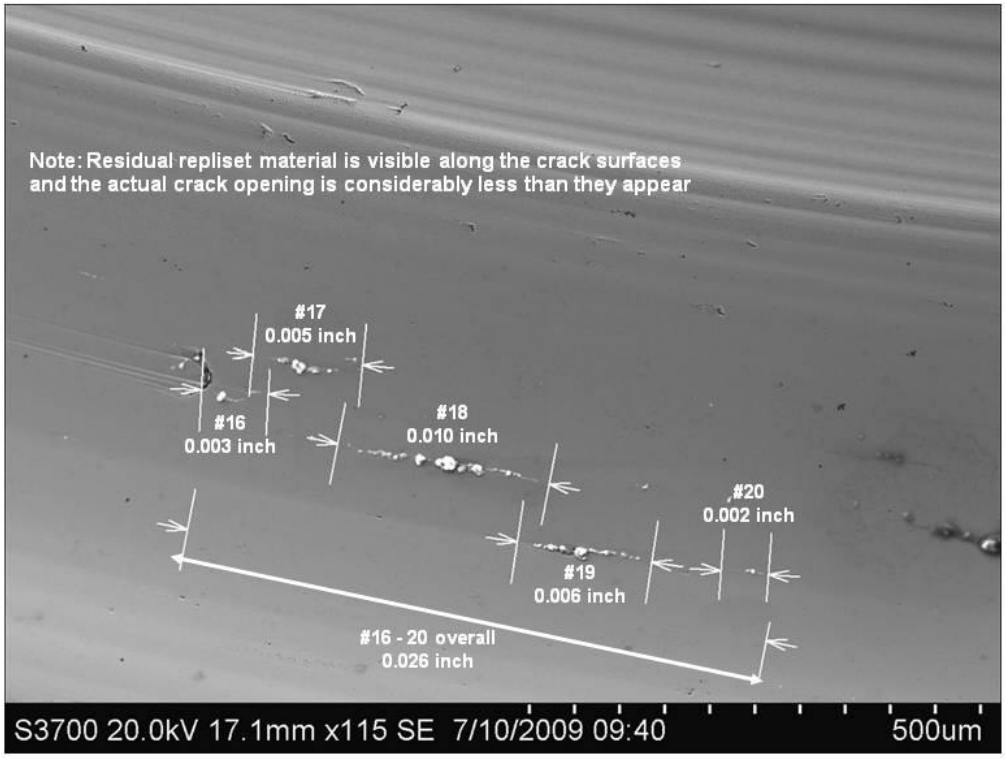
516


Poppet #72
Location of Cracks #16-28
Reference Mark
180°
Cracks
Shaft
Radius
Flange
11 Cracks
2 mm
#16-20
#23
#22
#25 - 26
#21
#4
#27 - 28
Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear
S3700 20.0kV 16.9mm x47 SE 7/10/2009 09:46
1.00mm

517

Poppet #72

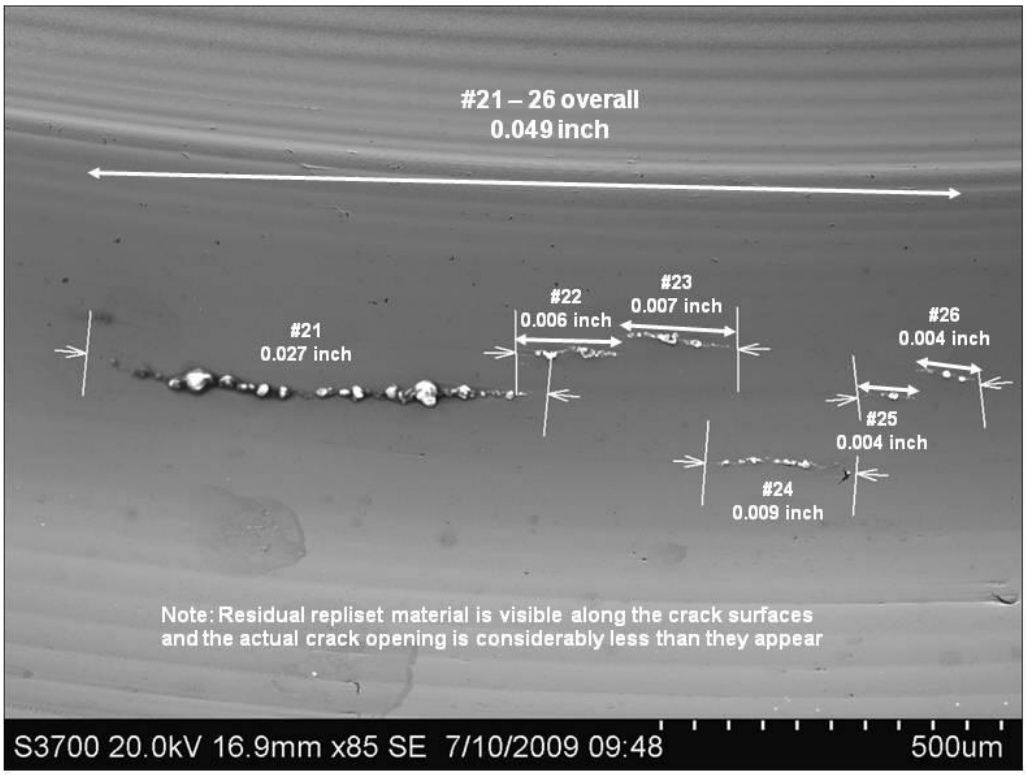
Location and size of Cracks #16-20



518

Poppet #72

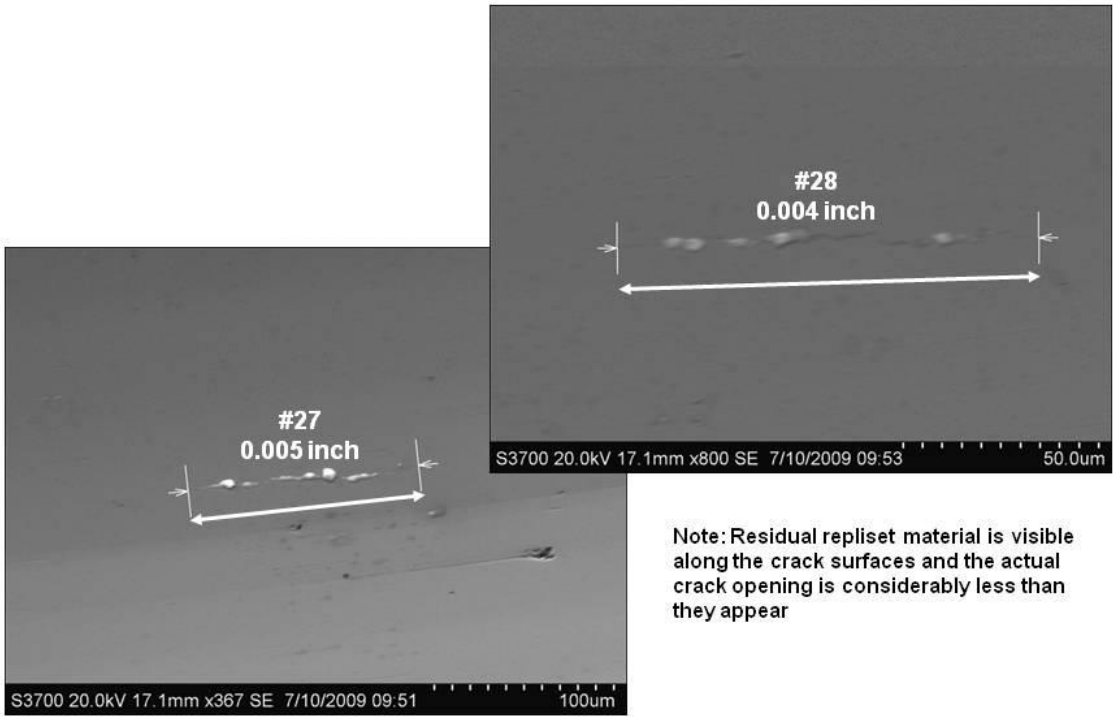
Location and size of Cracks #21-26



519

Poppet #72

Location and size of Cracks #27-28

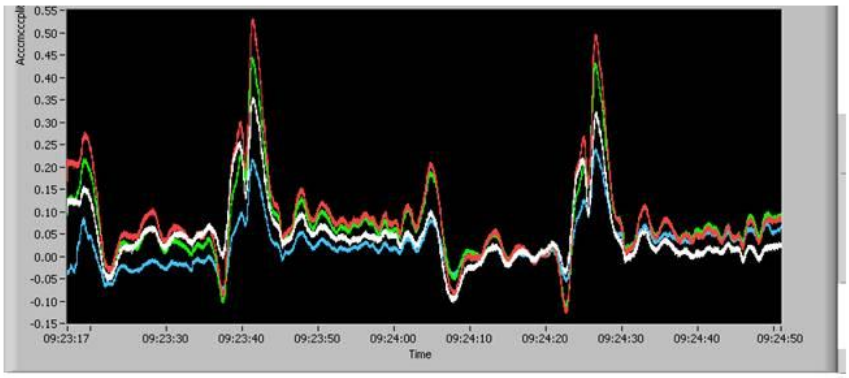


Note: Residual repliset material is visible along the crack surfaces and the actual crack opening is considerably less than they appear

520

Poppet #72

LaRC eddy current findings, the colors indicate ???



521

Appendix B. Boeing Eddy Current Procedure/Technique Sheet Flow Control Valve Poppet - #SSO-01, Revision C

Authors of the contents of this appendix were Team members for the NESC and were under NASA funding at the time the work was conducted.

Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

Title: Flow Control Valve Poppet

Program: Space Shuttle Orbiter

Part Name and Number: Flow Control Valve Poppet, 80913 (Figure 1)

Applicable Documents: MT0501-513, "Inspection, Eddy Current, Requirements for"

Material & Condition: Cres 440A or 440C
Material Thickness: Approximately 0.100" in shank and 0.045" at flange

Instrumentation: UniWest US-454 Eddy Current Flaw Detector (Figure 2), or equivalent.
Recording Devices: US-454 electronic strip chart
Alarm: Not required

Probes: US-1839 differential coil, 0.0312" radius, S/N 37072 (Figure 3), 37073 or equivalent.

Fixtures and Scanning Aids: US-1779 Bolt Inspection Scanner (Figure 4). The scanner includes a probe fixture to hold probe at a 45-degree angle into the flange radius. In addition to the scanner, a threaded bolt with handle and a rubber band allows a slow and steady index.

Reference Standard: NASA supplied Titanium fastener with EDM notches (Figure 5-7) "VM Ti/TB-STD-JSC, VM PRODUCTS, INC., JS-061208-01"

Standardization Checks: Before inspecting the first part and after inspecting all poppet hardware, or at 4-hour intervals if less time, check the system sensitivity by scanning the reference standard EDM notch A in the shank and notch B in the radius.

Scan Rate and Index: Scan speed shall be the same for both reference standard and hardware. Index turn speed used to inspect the part shall not exceed that used to scan the reference standard.

Acceptance Criteria: Reject all relevant indications that exceed 0.2 Vpp.

Test Facility: Boeing, 5301 Bolsa Ave., Huntington Beach, California. 92647

Prepared By: Bob DeVries **Validated By:** Jim Engel

BOEING	Eddy Current Procedure/Technique Sheet Flow Control Valve Poppet - #SSO-01 Revision: C

Level III Approval: _____ Date: 11/6/09

Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

A. Setup/Preparation

1. Verify that the serial number on the part is identical to the serial number on the Fabrication Order (FO) or Work Order (WO). Notify inspection supervisor if the above criterion fail.
2. Verify calibration of the eddy current instrument prior to inspecting hardware.
3. Prior to performing eddy current inspection, remove dust, machining chips, oil, or other foreign matter that could interfere with the inspection from the inspection surface.
4. Prior to performing eddy current inspection, test each poppet for a residual magnetic field using a field indicator. If the field is greater than 0.5 Gauss, demagnetize the poppet using a Parker Probe on the AC setting.
5. Prior to performing eddy current inspection, replace the Kapton tape on the probe tip. After inspecting six poppets, replace Kapton tape. Install probe in probe holder at bottom of slot in probe with probe S/N annotation located on the right side.
6. Connect probe, power and printer cables.

B. Standardization

1. Turn on the eddy current test instrument.
2. Choose large strip chart display on the left side and small impedance plane display on the right side by pressing DISPLAY ON/OFF.
3. Establish the following parameters on the eddy current instrument. Recall file # "poppet", by pressing the ENTER button, turning the scroll wheel until RECALL SET is highlighted, press ENTER, scroll to the file "poppet" and press ENTER. Verify the following inspection parameters by comparing them to the displayed values on screen (press ENTER and scroll the wheel to see these parameters).
   - Frequency (FREQ1) = 2 MHz
   - Channel Gain = 20.0 dB
   - Phase Angle (ROT) = 294 Deg.
   - Probe Drive = HI
   - Low Pass Filter = 100 Hz
   - High Pass Filter = OFF
   - X sensitivity = 0.5 V/div
   - Y sensitivity = X
4. Place the reference standard on the rollers of the scanner (Figure 8). Adjust the head side thrust bearing so that it lightly contacts the standard head at centerline of head. Spin test by turning the roller RPM control to lowest RPM (first setting). Confirm that the standard spins freely but does not rock or climb onto rollers and stop the scanner.

5. Lower the probe, rotate to a vertical position, make an adjustment to probe height in probe holder, if necessary, and contact the spinning standard such that the probe coil area contacts the bolt shank. Locate probe on the shaft near the threads, turn index screw to meet probe holder and apply rubber bands as shown in Figure 8.
6. **Shank Standardization.** Scroll to SAVE DATA, leaving the cursor in that position. Start scanner and press NULL and ERASE. Scan the reference standard shank by turning the index handle and slowly index probe across shank to image the small notch with the probe held at zero degrees (normal). Press ENTER. Stop scanner. Remove probe from shank.
7. Continue to save data by scrolling to the file name "tishank1" and press ENTER four times. Scroll to RECALL DATA, press ENTER and scroll to saved file name "tishank1" and press ENTER. Press F1 (FRAME AT) and scroll to view the largest signal on the strip chart and press F2 (FRAME LENGTH), ENTER and scroll to enlarge the chart, keeping the largest signal in the right side chart (showing twice). Press CANCEL twice.
8. Evaluate the signal from Notch A, 0.030-inch deep notch (Figure 6) and verify that the signal height from this notch is at least 0.2 Vpp or re-scan shank.
9. **Radius Standardization.** Press ENTER and scroll to SAVE DATA. Move the probe onto the standard shank; translate the probe to contact the 0.030" radius with the rubber band removed. Move probe in probe holder to contact part radius, if needed. Angle the probe 45-degrees and turn on bolt scanner. Press NULL and erase. Maximize signal from 0.050" long EDM notch by angulating probe. Press ENTER.
10. Re-save scan data under the file name "tirad1" and move probe from reference standard. Save, recall file and press CANCEL, as in step 7.
11. Evaluate the signal from Notch B in the radius (only one in radius), and verify that the signal height from this notch is at least 0.7 Vpp or re-scan radius.
12. The eddy current signal from the reference notch in the radius shall be greater than 0.7 Vpp or re-run the standardization. Retract probe and remove reference standard from bolt scanner.

C. Inspection

1. Personnel performing this inspection require a minimum Level II certification in eddy current per BSS 7698. The inspector must wear clean gloves while handling flight poppets. Perform a magnified visual inspection of the 0.045" flange and radius at 25 to 30X magnification and report all nicks, burrs, dents, pitting, or scratches on the appropriate documentation.
2. Inspection area is limited to the 0.480" diameter shank (as much as possible with the probe normal to the shank) and the 0.030" radius located between the 0.480" shank, and 0.045" flange of the part unless otherwise specified.

3. Assure that the scanner is not moving. Install probe in probe holder at top of slot in probe with probe S/N annotation located on the right side. Verify that there is Teflon tape attached to the entire end of the head side thrust bearing or apply new tape.

CAUTION: Use extreme care to prevent damage to the end flange of the poppet as this is a critical dimension for the functionality of the poppet.

4. Wearing clean gloves place the poppet on the rollers of the scanner and attach a tie-strap to secure poppet during flange scanning (Figure 9). Move probe in probe holder to top of slot in probe. Lower the probe to verify that the probe coil is in contact with the shank. If needed, adjust the probe in the probe holder to assure intimate contact with the radius. Retract the probe. Rotate the indexing screw clockwise to allow full range of probe.
5. **Shank Inspection.** Spin the poppet by turning the scanner using the first speed setting and assure that the poppet spins in a stable manner. Lower the probe onto the poppet shank normal to the shank so that the coil area contacts the shank between the flanges of the poppet and away from either flange. Attach the rubber band and press NULL. Turn the index screw clockwise until reaching the mid-flange and press ERASE. Scan the shank by turning the indexing handle counterclockwise and slowly indexing probe across shank to cover entire length between the end flange and the mid-flange. Press ENTER and retract the probe and stop the scanner. Save file with the part S/N appended with an "s" for shank scan as follows. Press ENTER, scroll to locate each alphanumeric character, press F2 after displaying each character and press ENTER (e.g. 00023s1 for first inspection, 00023s2 for second, etc.). Recall file and print data to maintain hard copy records (described in step 7).
6. **Radius Inspection.** Place the poppet on the rollers of the scanner and attach a tie-strap to secure poppet during flange scanning (Figure 10). Adjust the head thrust bearing to contact the poppet flange. Move probe in probe holder to contact part radius. Turn on scanner, move the probe tip into the flange radius, and turn the probe to 45-degrees. Ensure a light but steady contact and press NULL and ERASE. After scanning the radius area for a few seconds, slowly lift the probe vertically by up to 1/16" to scan the radius flange area. Slowly lower the probe; continue scanning across the radius into the shank while gradually changing the probe angle lower than 45 degrees until the probe reaches between 0 and 30 degrees to the shank. Stop scanning after approximately 1/8 inch of shank has been scanned. Relocate the probe in the radius at 45-degrees. Move probe slightly by angling while maintaining contact with the radius to maximize any signals shown on the strip chart. Press ENTER on SAVE DATA. Retract the probe and stop the scanner.
7. **Save and Print Data.** Save file with the part S/N appended with an "r" for radius scan. Press ENTER, scroll to PRINT SCREEN and press ENTER. The screen will freeze as the printing process takes about one minute. Press CANCEL twice after printing to return to the scrolling strip chart screen.

8. Perform standardization after inspecting the last poppet in the lot, if four hours have passed or before turning off the instrument. Scan and save files with names of "tishank2" and "tirad2" as detailed in step B for this post-inspection reference standard scan. If standardization results do not repeat per step B-8 and B-11, re-inspect all hardware up to the point of the last successful standardization.

D. Evaluation:

1. Analyze the data by observing phase angle and vertical amplitude of the indication (Figure 11). Interpret signals by comparison of strip chart signature from poppets with strip chart signatures of reference standard EDM notches.
2. Eddy current signal amplitude in volts, peak-to-peak (Vpp) displays a relative severity of cracks. Crack length, depth and separation will increase the amplitude. Length effect may saturate the signal on longer cracks. Depth effect saturates the signal on cracks deeper than four mils.
3. Crack signals have a phase angle of 100 to 130 degrees and typically have higher amplitudes than machine grove signals. Small, tight fatigue cracks produce a signal with a single hump similar to the calibration notch. Longer cracks (>.2") show two humps due to the differential coil design. Machine grove (tool mark) signals are less than 0.15 - 0.2 Vpp and may have a flatter shape.
4. A small circumferential crack signature appears as a single hump. A small surface anomaly (missing carbide particle, pore) would also appear as small hump. Use high magnification visual inspection to rule out these non-relevant indications (if applicable). A long circumferential crack (>.15") may appear as a double-humped signal.
5. Ensure that minimal lift-off signal is included in the Vpp calculation (signal that projects to the left of the baseline or negative reading). Also, ensure that the etched in serial number on the shank does not create non-relevant signals with a flat top shape that may exceed 0.2 Vpp.
6. Reject all relevant indications that exceed 0.2 Vpp. Relevant indications are suspect if they increase by ≥0.020 Vpp from a previous scan of ≥0.050 Vpp (send reports to engineering for further evaluation).
7. Report all rejections on nonconformance paperwork, noting the Vpp level and circumferential location of indications.

BOEING Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

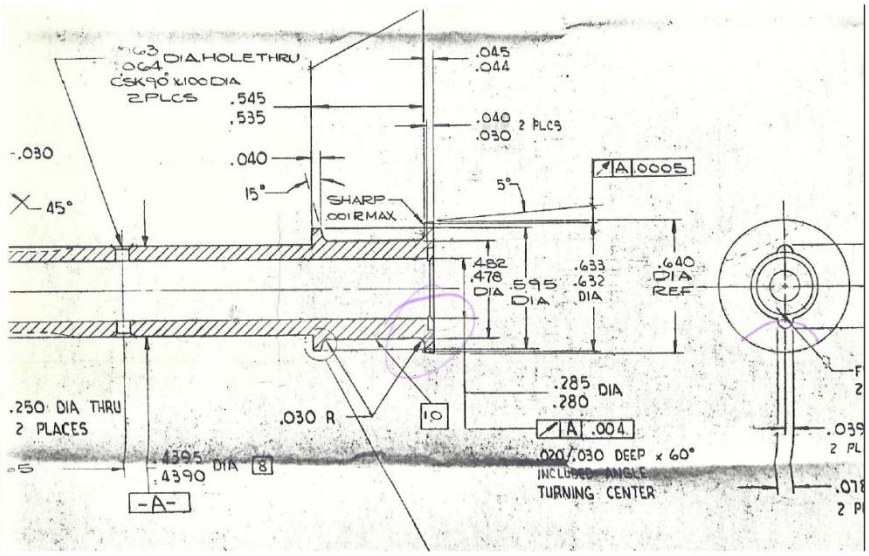


Figure 1: Poppet Drawing

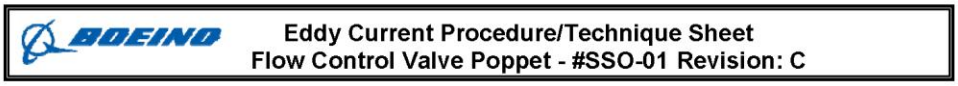


Figure 2: UniWest US-454 Eddy Current Flaw Detector

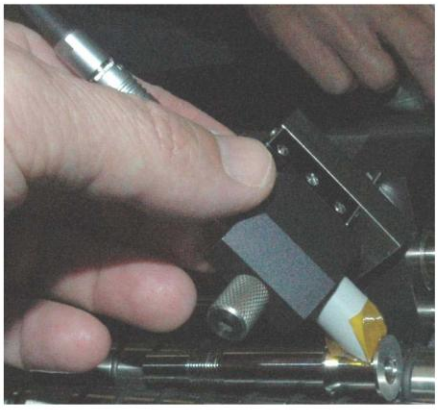


Figure 3: US-1839 Probe with "V" Shape 0.0312" Radius

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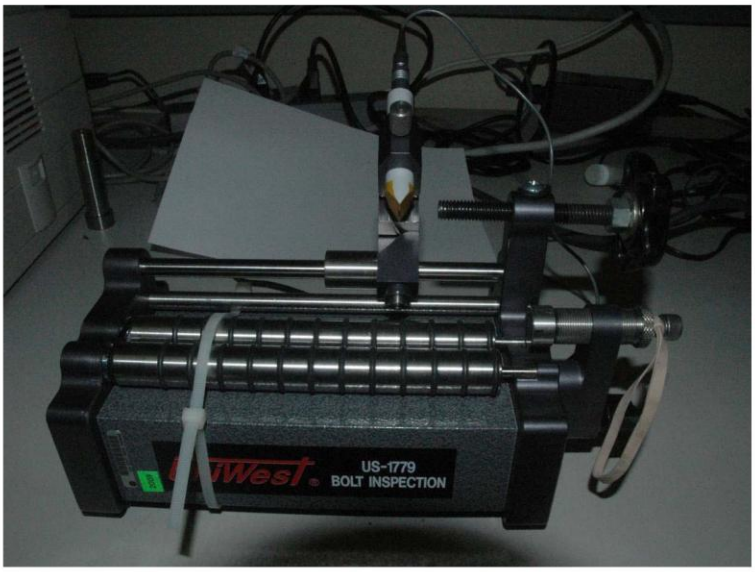
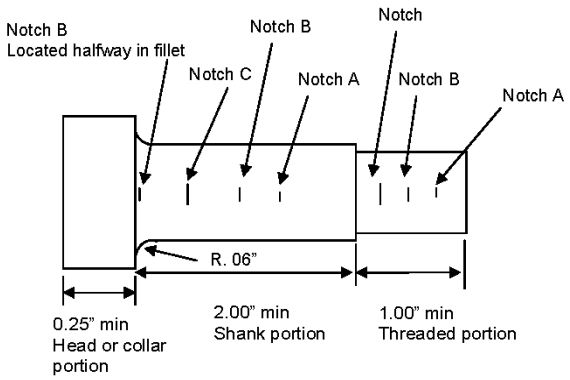


Figure 4: US-1779 Bolt Inspection Scanner

Figure 5: Reference Standard

Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

Eddy Current Standard



Notes:
0.750-16 UNJF-3A threads
Shank diameter: 0.795" +/- .050"
Finish 32 RHR, Break/deburr sharp corners
Tolerance where not provided explicitly: .0" => +/- .1", .00" =>+/-.02"
Spacing between the notches = 0.25" min.
Notches in the threads at the bottom of the root. All notches along one axial line.
Notch geometry semicircular, width not to exceed 0.005"
Three notch sizes (Size A: 0.030" long x 0.015" deep, Size B: 0,050" long x 0.025" deep, Size C: 0.070" long by 0.035" deep)
Tolerance on the measured values of depth and length +/- 0.002"
The material (Titanium) electrical conductivity about 1.0% to 3% IACS.
Standard Identification number: JS-061208-01

Figure 6: Reference Standard Design Drawing

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Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

VM PRODUCTS, INC.

Certificate of Compliance

Customer: Jacobs Sverdrup **Date:** December 8, 2006

Certificate number: JS-N6DB-061208-01 **Part number:** VMTi/TB-STD-JSC

Purchase order no.: N622507FDB **Serial no.:** JS-061208-01

Memo: Eddy current bolt reference standard: 6AL-4V Titanium, 3/4-16 UNJF-3A Thread

ACTUAL MEASUREMENTS

Notch number/Description	Length	Width	Depth
Thread Root Notch: .030" L x .015" DP	0.0303	0.0045	0.0151
Thread Root Notch: .050" L x .025" DP	0.0499	0.0042	0.0251
Thread Root Notch: .070" L x .035" DP	0.0703	0.0046	0.0350
Shank Surface Notch: .030" L x .015" DP	0.0303	0.0038	0.0152
Shank Surface Notch: .050" L x .025" DP	0.0500	0.0039	0.0250
Shank Surface Notch: .070" L x .035" DP	0.0703	0.0040	0.0350
Fillet Surface Notch: .050" L x .025" DP	0.0506	0.0045	0.0250

The above measurements were taken with the use of: optical Comparator ID No. 146011789, and/or micrometer SN 2236-4211, traceable to NIST.

By Mike Porter Signed: _____

Figure 7: Reference Standard Certification

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BOEING Eddy Current Procedure/Technique Sheet
Flow Control Valve Poppet - #SSO-01 Revision: C

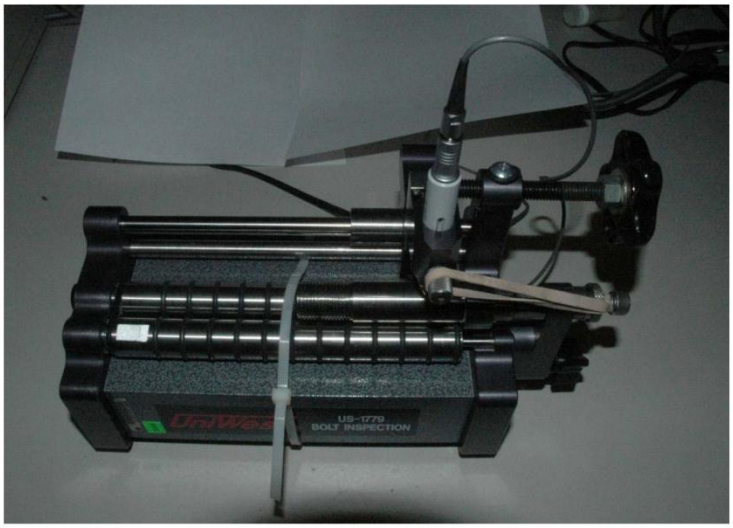

Figure 8: Reference Standard Positioned on Scanner

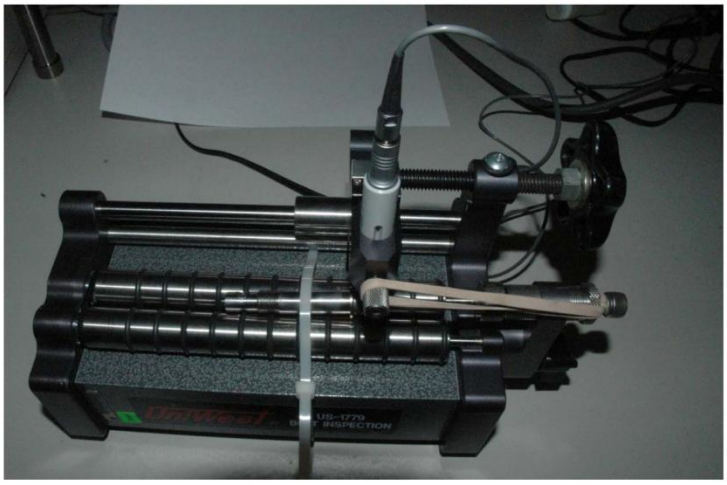

Figure 9: Poppet Positioned for Shank Scanning

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Flow Control Valve Poppet - #SSO-01 Revision: C

Figure 10: Poppet Positioned for Radius Scanning

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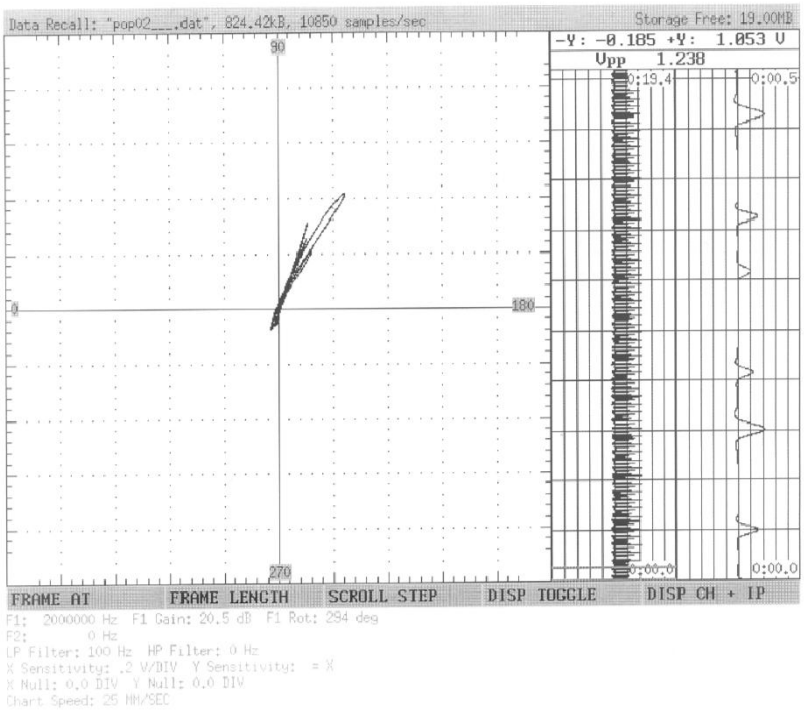

Figure 11: Eddy Current Crack Signal on Poppet

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

The Director of the NASA Engineering and Safety Center (NESC), requested an independent assessment of the anomalous gaseous hydrogen (GH2) flow incident on the Space Shuttle Program (SSP) Orbiter Vehicle (OV)-105 during the Space Transportation System (STS)-126 mission. The main propulsion system (MPS) engine #2 GH2 flow control valve (FCV) LV-57 transition from low towards high flow position without being commanded. Post-flight examination revealed that the FCV LV-57 poppet had experienced a fatigue failure that liberated a section of the poppet flange. The NESC assessment provided a peer review of the computational fluid dynamics (CFD), stress analysis, and impact testing. A probability of detection (POD) study was requested by the SSP Orbiter Project for the eddy current (EC) nondestructive evaluation (NDE) techniques that were developed to inspect the flight FCV poppets. This report contains the Appendices to the main report.

15. SUBJECT TERMS

Computational fluid dynamics; Nondestructive evaluation; NASA Engineering and Safety Center; Flow control valve; Anomalous gaseous hydrogen flow; Poppet

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