

ANEXOS

ANEXO A

Bloques de material usados para la fabricación de probetas

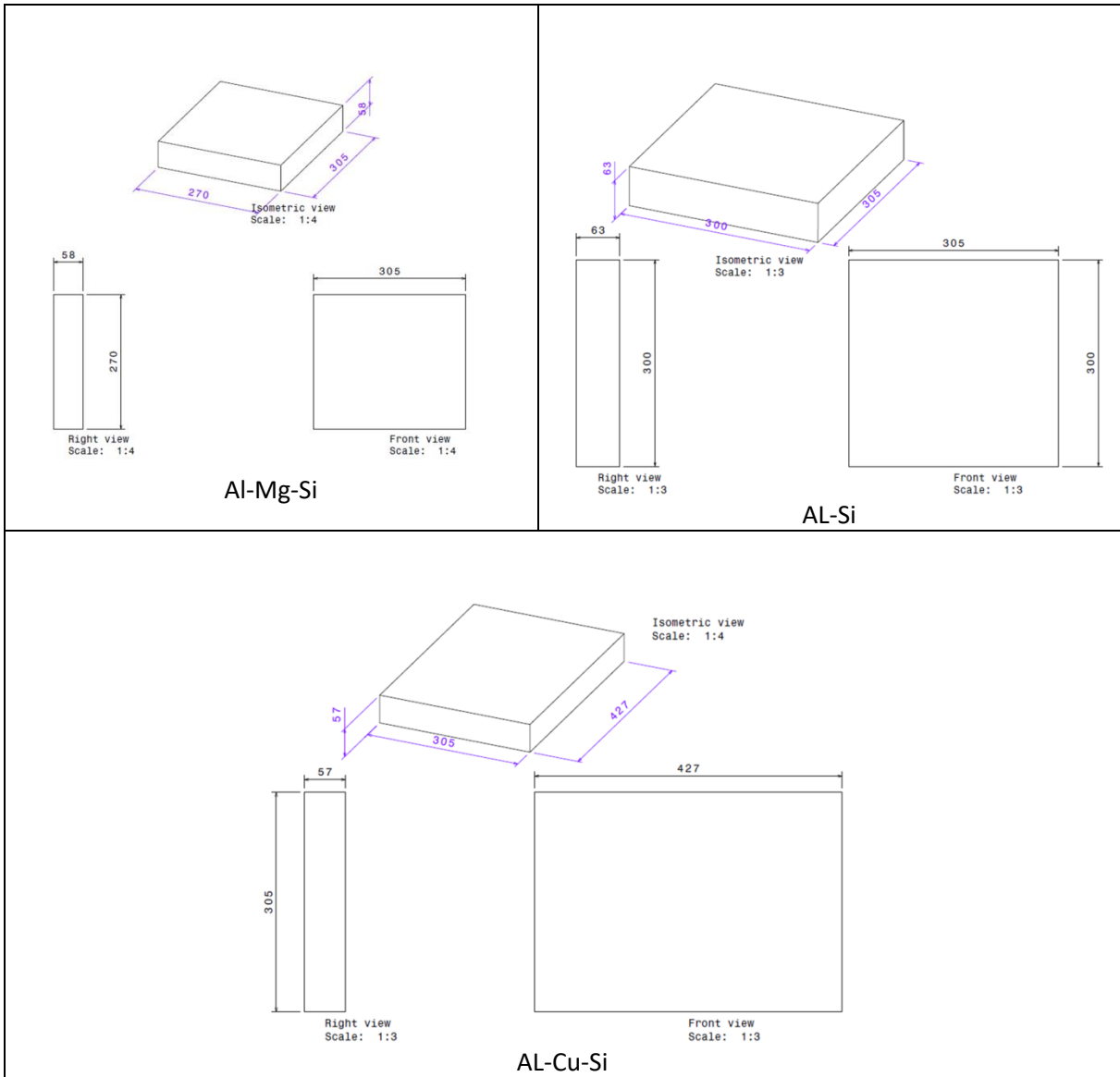


Tabla A1. Bloques de material para obtener probetas para pre-agrietamiento

ANEXO B

DATOS PREAGRIETAMIENTO DE PROBETAS, DESIGNACIÓN, CARGAS, CRECIMIENTO DE GRIETA Y TAMAÑO FINAL.

Probetas Al- Mg – Si (D1)

Probetas Al-Mg-Si (D1 paralelo a la dirección del lingote)							
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)
52	133,22	60	8000	35000		9,58	167
53	133,22	60	6000	36000		9,4	
54	133,22	60	5000	31000		9,4	
55	133,22	55	10000	46000		9,6	
61	133,22	55	11000	59000		9,85	177
62	133,22	60	7000	31000		9,4	
63	133,22	60	7000	45000		9,46	
64	133,22	55	12000	57000		9,76	
68	133,22	55	12000	58000		9,16	187
69	133,22	55	15000	127000		9,2	
70	133,22	55	12000	63000		9,1	
71	133,22	55	15000		51000		

Tabla B 1. Dirección del lingote D1

Probetas Al- Mg – Si (D2)

Probetas Al-Mg-Si (D2 perpendicular a la dirección del lingote)							
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)
77	204,96	60	8000	17000		9,47	167
78	204,96	60	9000	20000		9,46	
79	204,96	60	9000	24000		9,29	
80	204,96	60	7000	22000		9,91	
81	204,96	60	8000	21000		9,8	
82	204,96	60	10000	20000		9,61	
83	204,96	60	8000	21000		9,94	
84	204,96	60	10000	20000		9,42	
85	204,96	60	8000	22000		9,34	177
86	204,96	60	10000	22000		9,7	
87	204,96	60	8000	20000		9,47	
88	204,96	60	9000	21000		9,36	
89	204,96	60	10000	26000		9,6	
90	204,96	60	8000	20000		9,62	
91	204,96	60	9000	21000		9,51	
92	204,96	60	9000	21000		9,25	
93	204,96	60	8000	22000		9,54	187
94	204,96	60	9000	22000		9,74	
95	204,96	60	9000	16000		9,28	
96	204,96	60	8000	23000		9,37	
97	204,96	60	8000	20000		9,6	
98	204,96	60	9000	25000		9,31	
99	204,96	60	10000	26000		9,56	
100	204,96	60	9000	25000		9,71	
101	204,96	60	9000	21000		9,92	

Tabla B 2. Dirección del lingote D2

Probetas Al- Si (D3)

Probetas Al-Si (D3 paralelo a la dirección del lingote)											
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclaje adicional	Ciclaje adicional carga estática	Ciclaje adicional carga dinámica	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)	
24	204,96	60	10000	23000	5000	163,98	60		9,6	150	
25	204,96	60	9000	21000	6000	163,98	60		9,45		
26	204,96	60	8000	17000					9,49		
27	153,72	60	8000	31000					9,95		
28	204,96	64	8000					17000			
29	204,96	60	8000	19000	5000	163,98	60		9,96		
30	204,96	60	9000	20000	6000	163,98	55		9,62		
31	204,96	60	9000	25000	7000	163,98	60		9,36		
32	204,96	60	11000	24000	12000	163,98	60		9,8		
33	204,96	60	9000	18000	2000	163,98	55		9,6		
					2000	163,98	50				
34	153,72	60	9000	32000					10,2	160	
35	163,98	60	8000	42000					9,5		
36	204,96	60	7000	16000	2000	163,98	50		9,74		
					4000	163,98	45				
37	204,96	60	10000	22000	4000	163,98	60		9,59		
38	204,96	60	9000	16000	7000	163,98	45		9,46		
39	204,96	60	10000	20000					9,18		
40	153,72	60	6000	20000					9,56		
41	204,96	60	9000	21000					9,35		
42	153,72	60	4000					18000			
43	204,96	60	6000	15000	2000	163,98	60	17000			
44	204,96	60	10000	17000	3000	163,98	60		9,52		
45	204,96	60	9000	21000	4000	163,98	50		9,1		
46	204,96	60	10000	25000	7000	163,98	60		9,51		
47	204,96	60	9000	20000	4000	163,98	50		9,3		
48	153,72	60	8000	34000					10,04		
49	153,72	60	8000	34000					10,15		
50	204,96	60	9000	21000					9,38		
51	163,98	60	9000	33000					9,43		

Tabla B 3. Dirección del lingote D3

Probetas Al- Si (D4)

Probetas Al-Si (D4 perpendicular a la dirección del lingote)										
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclaje adicional	Ciclaje adicional carga estática	Ciclaje adicional carga dinámica	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)
1	204,96	64	6000	14000					9,85	150
2	204,96	64	12000	33000					10,9	
3	204,96	60	10000	20000	4000	163,98	45		9,51	
4	204,96	64	12000	36000					10,62	
5	204,96	64	17000	40000					10,89	
6	204,96	64	10000					12000		
7	204,96	64	10000	24000				24000		
8	204,96	64	7000	26000					10,08	160
9	153,72	60	8000	23000					9,94	
10	204,96	64	11000	27000					10,56	
11	163,98	60	7000	15000					10,11	
12	204,96	60	10000	19000					9,6	
13	204,96	60	11000	21000					9,47	
14	204,96	64	12000	23000					10,43	
15	204,96	64	7000	18000					9,99	170
16	204,96	64	11	26					10,45	
17	204,96	64	9000	28000					10,74	
18	204,96	60	10000	20000	10000	163,98	45		9,6	
19	204,96	64	13000	32000					10,59	
20	204,96	64	18000	45000					10,79	
21	204,96	60	7000	21000					9,22	
22	204,96	64	15000	28000					10,57	
23	153,72	60	8000	28000					10,24	

Tabla B 4. Dirección del lingote D4

Probetas Al- Cu- Si (D5)

Probetas Al-Cu-Si (D5 perpendicular a la dirección del lingote)							
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)
102	112,728	55	19000	35000		9,28	181
103	112,728	60	9000	23000		9,1	
104	102,48	60	12000	45000		9,76	
105	204,96	60			1000		
106	112,728	60	21000	34000		9,75	
107	112,728	60	13000	34000		9,61	
108	112,728	50	22000			9,3	
	112,728	60	28000	55000			
109	102,48	60	11000	55000		9,78	
110	102,48	60	11000	21000		9,68	
111	112,728	50	14000	30000		9,7	
112	112,728	50	5000	20000		10	
113	112,728	50	11000		19000		191
114	112,728	50	9000	22000		10,17	
115	112,728	50	9000	23000		10,2	
116	112,728	50	9000	24000		9,27	
117	112,728	50	21000	100000		9,97	
118	112,728	50	9000	23000		10,2	
119	112,728	50	10000	19000		9,43	
120	102,48	50	58000	92000		9,87	
121	112,728	55	13000	24000		9,5	
122						Fractura	201
123	112,728	50	10000	37000		9,81	
124	112,728	55	7000	13000		9,43	
125	112,728	55	12000	22000		9,15	
126	112,728	55	11000	26000		9,48	
127	112,728	50	8000	37000		9,88	
128	204,96	50			4000		
129	112,728	50	12000	45000		9,7	

Tabla B 5. Dirección del lingote D5

Probetas Al- Cu- Si (D6)

Probetas Al-Cu-Si (D6 paralelo a la dirección del lingote)										
Designación probeta de acuerdo a la dirección del lingote	Carga estática (Kg-f)	Carga Dinámica (Kg-f)	Nucleación de grieta (número de ciclos)	Parada de preagrietamiento (número de ciclos)	Ciclaje adicional	Ciclaje adicional carga estática	Ciclaje adicional carga dinámica	Ciclo de ruptura (número de ciclos)	Tamaño final de la grieta (mm)	Temperatura de envejecimiento (°C)
130	112,728	50	19000	60000					9,6	181
131	112,728	50	13000	80000					9,67	
132	112,728	50	13000	65000					9,41	
133	112,728	50	21000	88000					9,6	
134	112,728	50	11000	30000	13000	112,728	45		9	
135	112,728	50	21000	97000	5000	112,728	45		9,01	
136	112,728	50	11000	50000					9,1	
137	112,728	50	14000	55000					9,15	
138	112,728	50	11000	47000	4000	112,728	45		9,14	
139	112,728	50	14000	28000	13000	112,728	45		9,17	
140	112,728	50	7000	50000					9,25	
141	112,728	50	12000	28000					9,33	
142	112,728	50	13000	55000					9,41	
143	112,728	50	23000	100000						
144	112,728	50	12000	67000					9,71	
145	112,728	50	20000	80000					9,64	
146	112,728	50	14000	57000					9,6	
147	112,728	50	11000	45000					9,4	
148	112,728	50	11000	24000					9,44	
149	112,728	50	6000	17000					9,42	
150	112,728	50	12000	25000	2000	112,728	45		9,48	
151	112,728	50	10000	49000					9,76	
152	112,728	50	12000	33000					9,68	
153	112,728	50	13000	41000					9,72	
154	112,728	50	12000	60000					9,81	
155	112,728	50	10000					20000		
156	112,728	50	10000	22000					10	
157	112,728	50	13000	33000					9,49	
158	112,728	50	15000	40000					9,74	

Tabla B 6. Dirección del lingote D6

ANEXO C

Trayectoria de pre-crecimiento de grieta a partir de entalla

En el presente anexo C se muestran las trayectorias de grieta a partir de la entalla, se utilizan para verificar el tamaño correcto de la grieta.

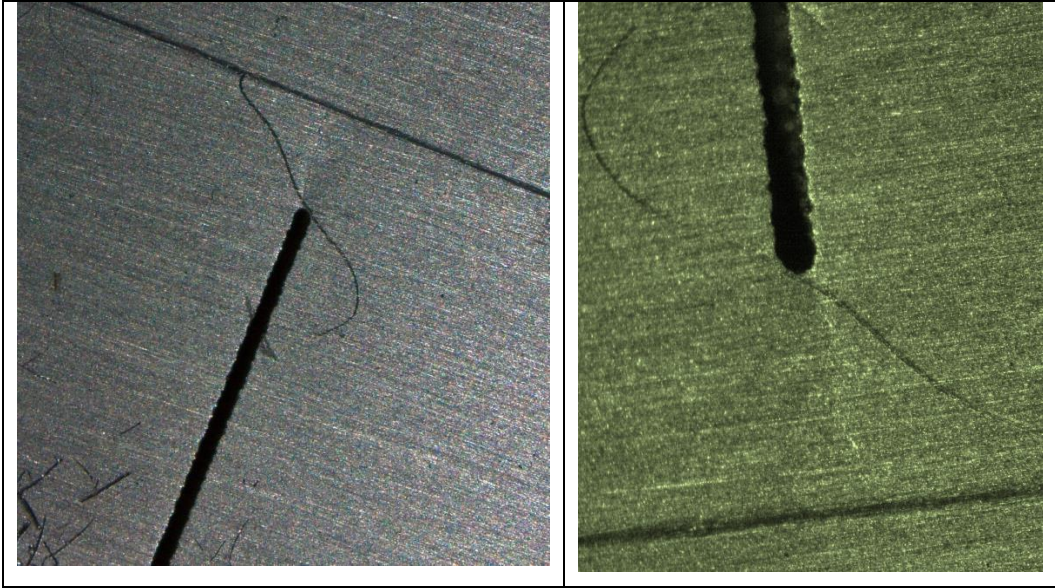


Figura C 1. Probeta D1 52

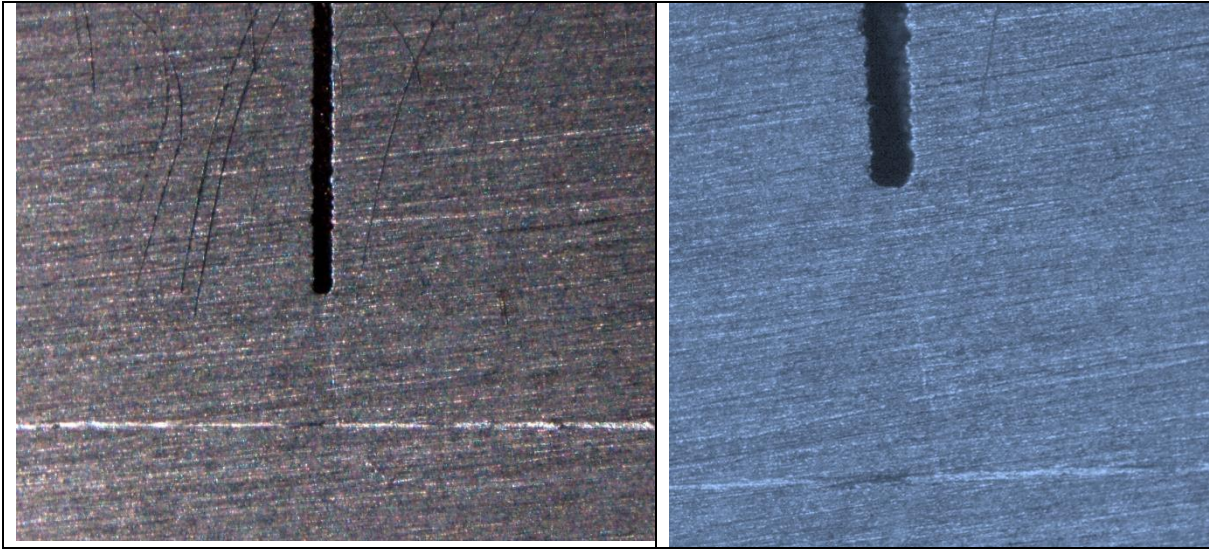


Figura C 2. Probeta D1 53

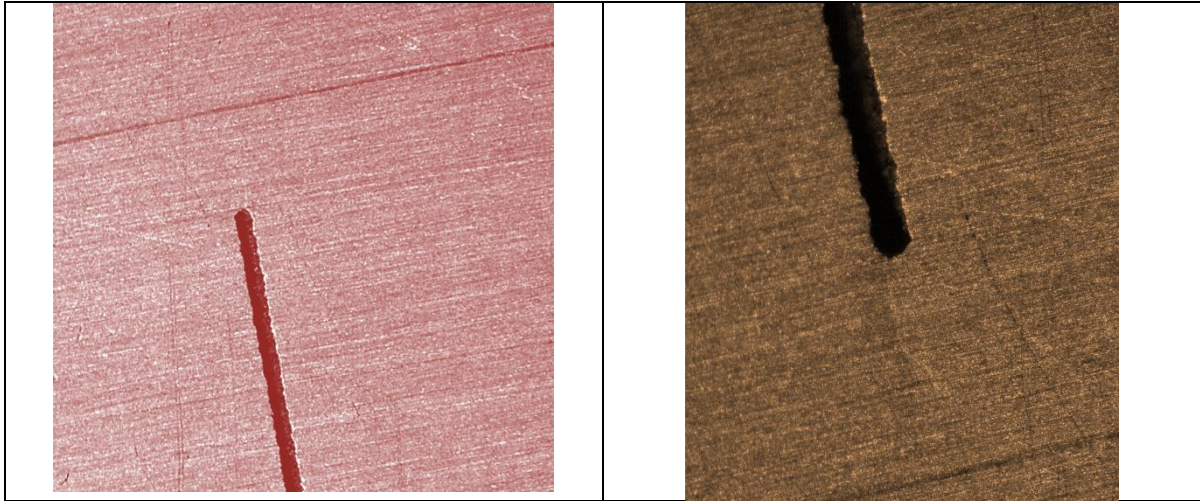


Figura C 3. Probeta D1 54

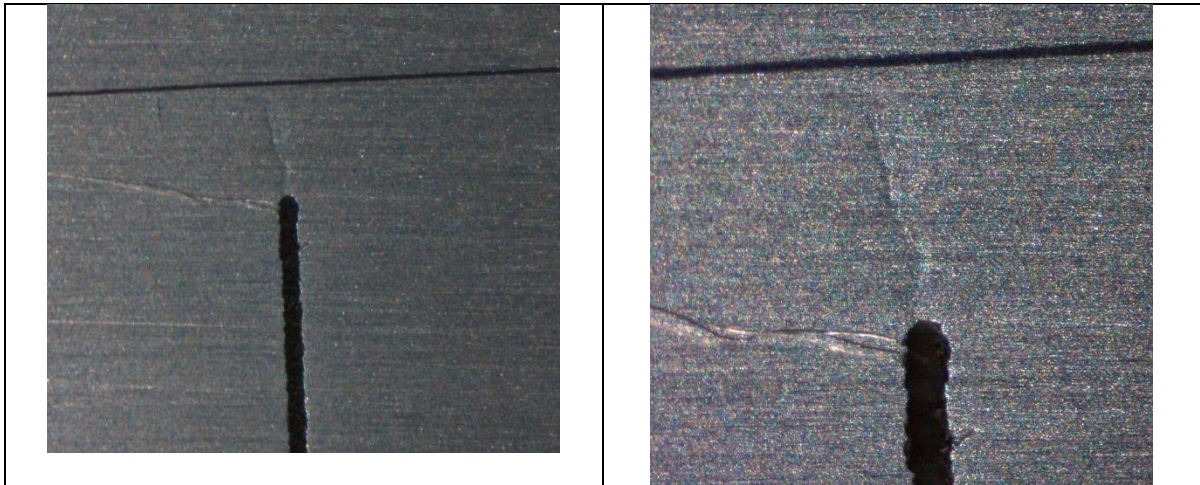


Figura C 4. Probeta D1 55



Figura C 5. Probeta D1 61

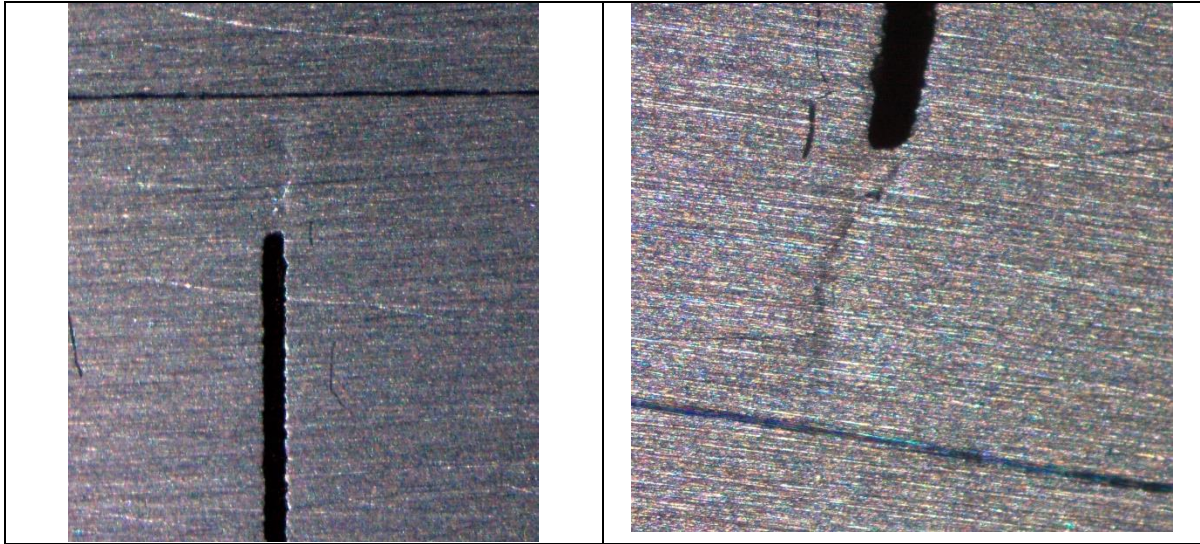


Figura C 6. Probeta D1 62

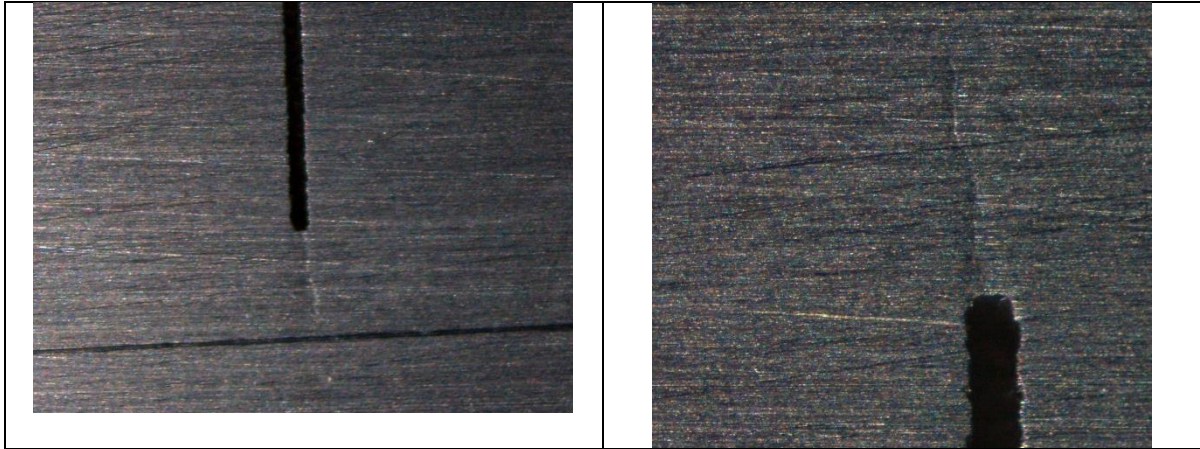


Figura C 7. Probeta D1 63

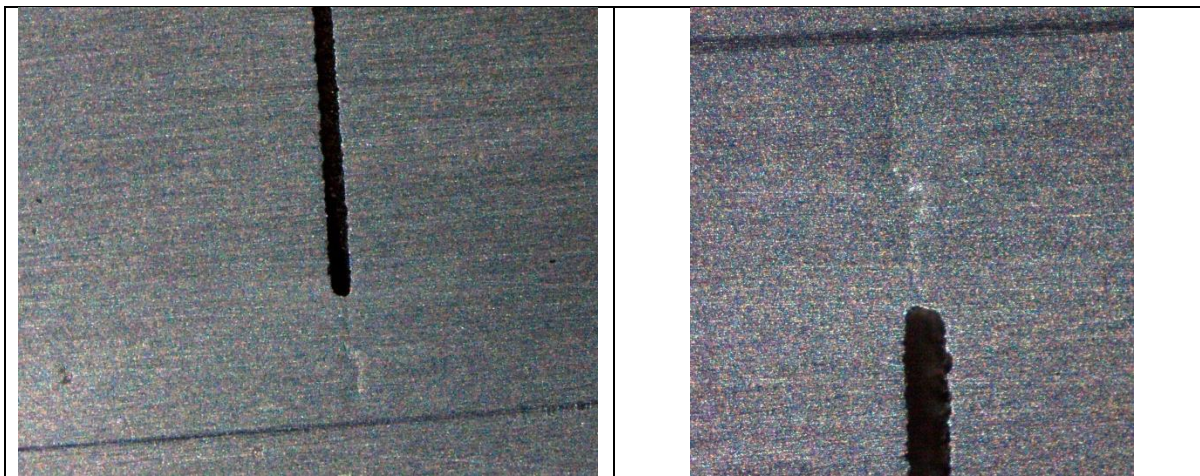


Figura C 8. Probeta D1 64

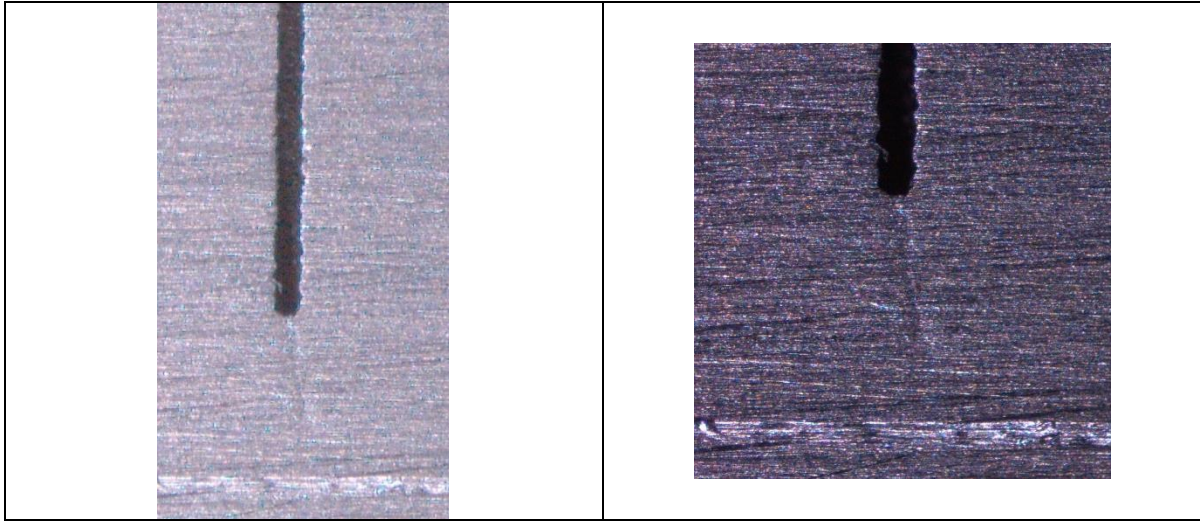


Figura C 9. Probeta D1 68

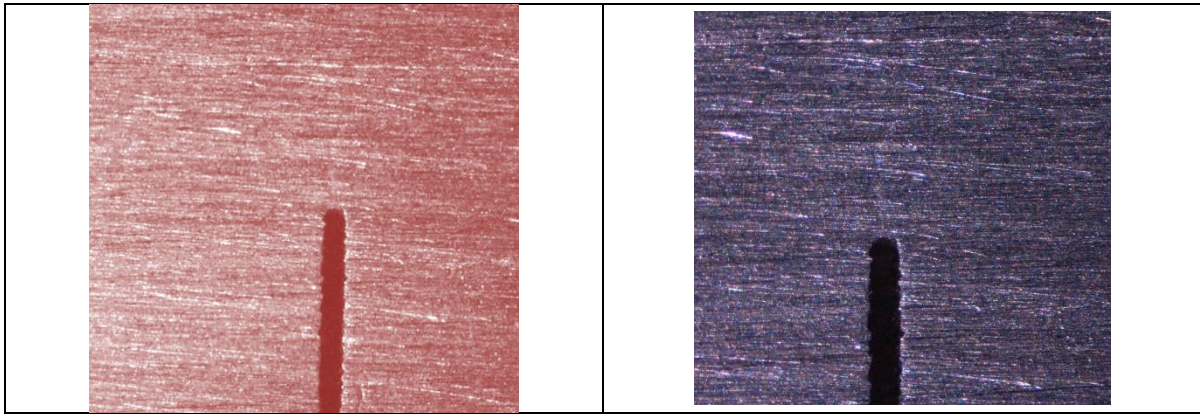


Figura C 10. Probeta D1 69



Figura C 11. Probeta D1 70

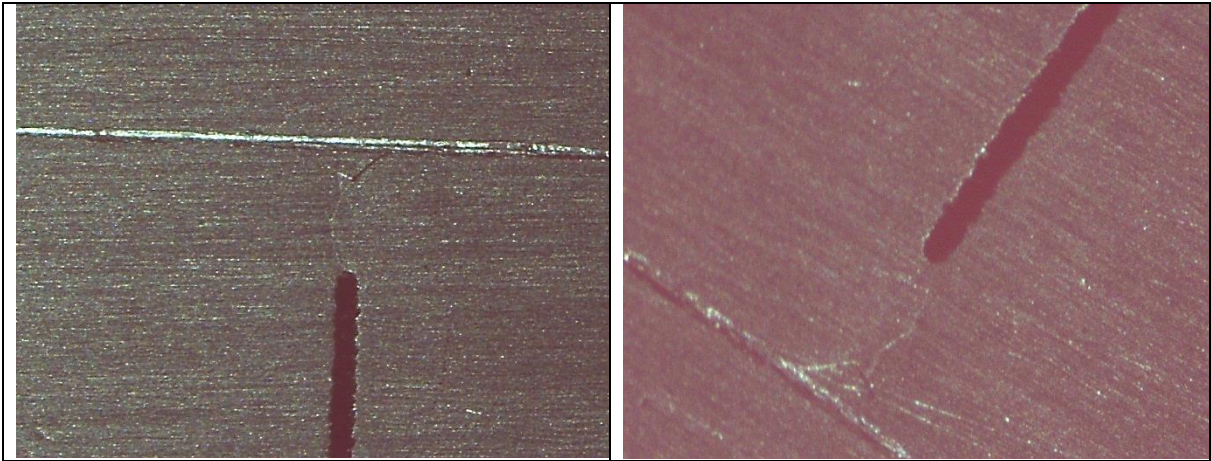


Figura C 12. Probeta D2 95

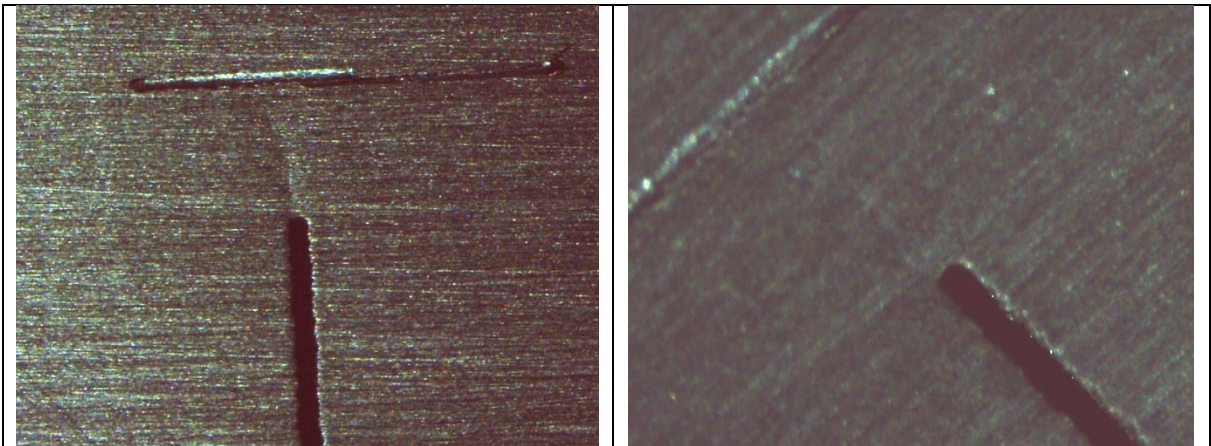


Figura C 13. Probeta D2 91

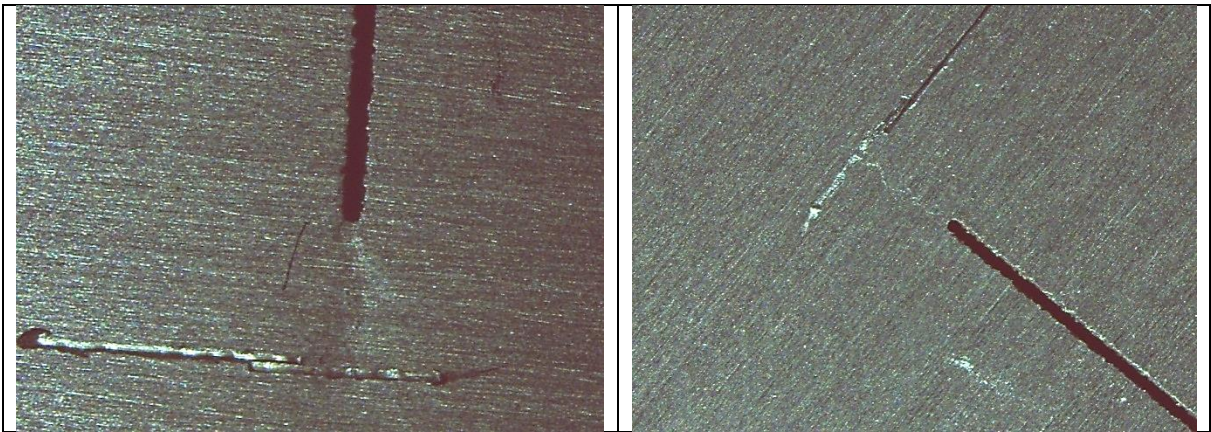


Figura C 14. Probeta D2 83

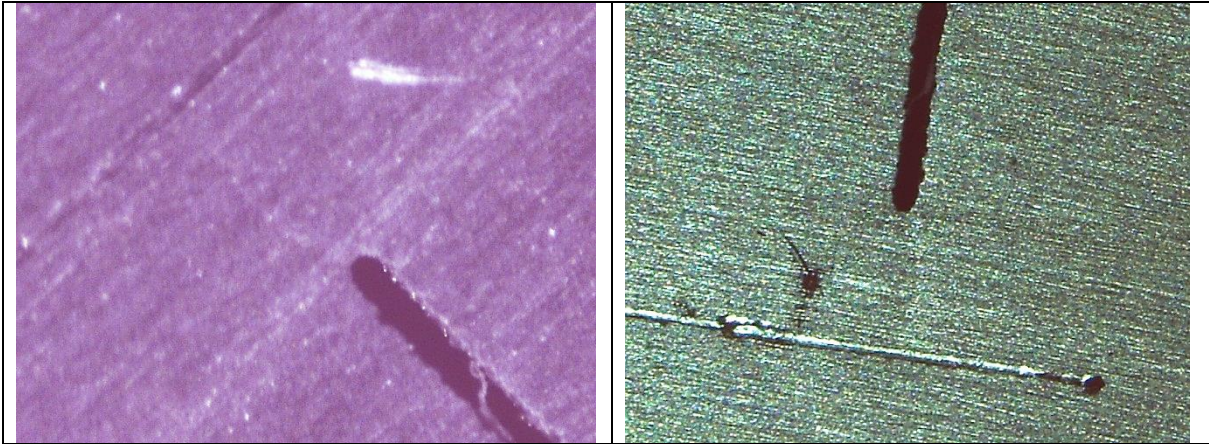


Figura C 15. Probeta D2 98

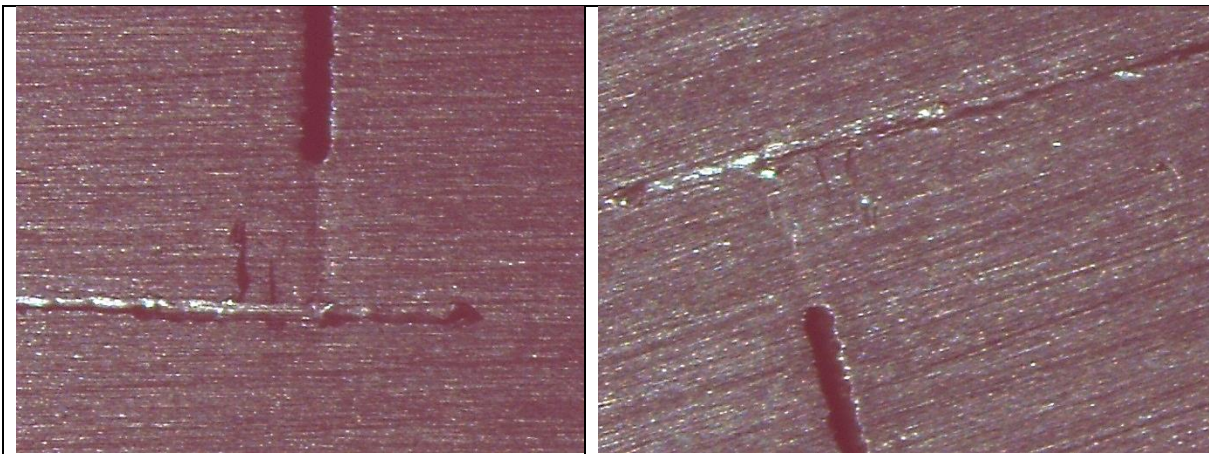


Figura C 16. Probeta D2 85

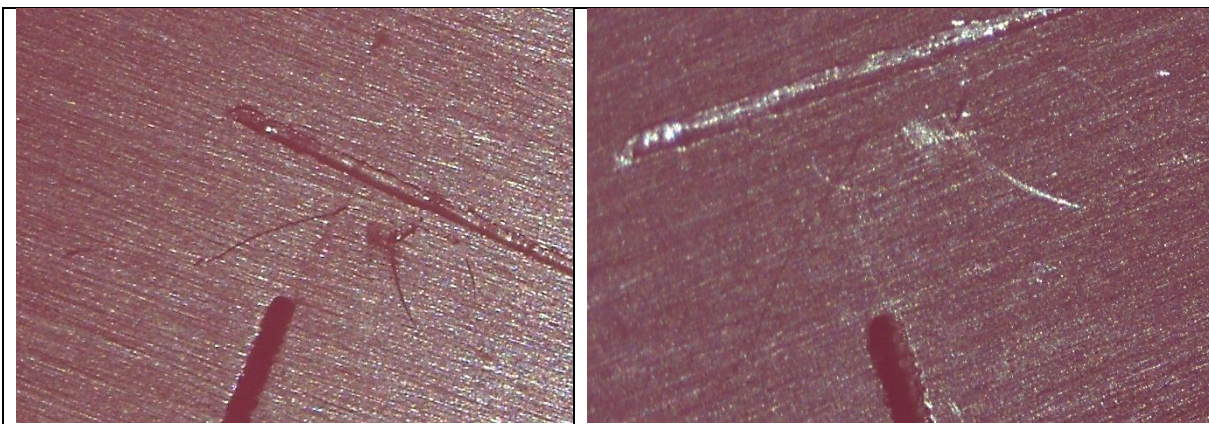


Figura C 17. Probeta D2 79

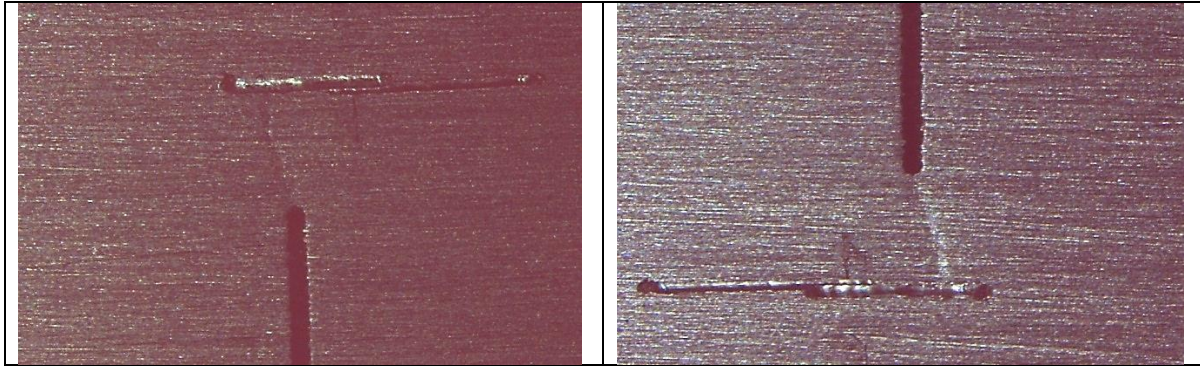


Figura C 18. Probeta D2 81

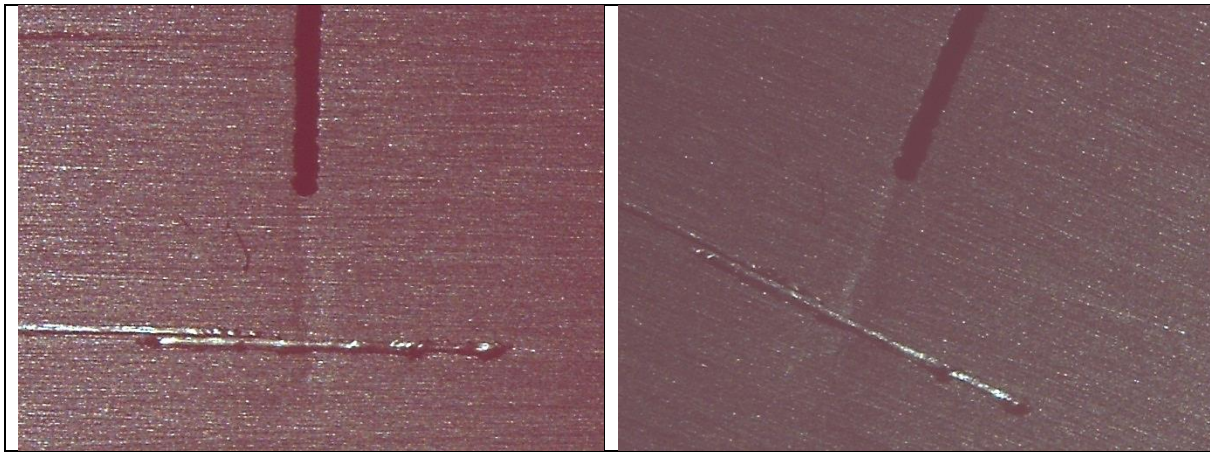


Figura C 19. Probeta D2 101

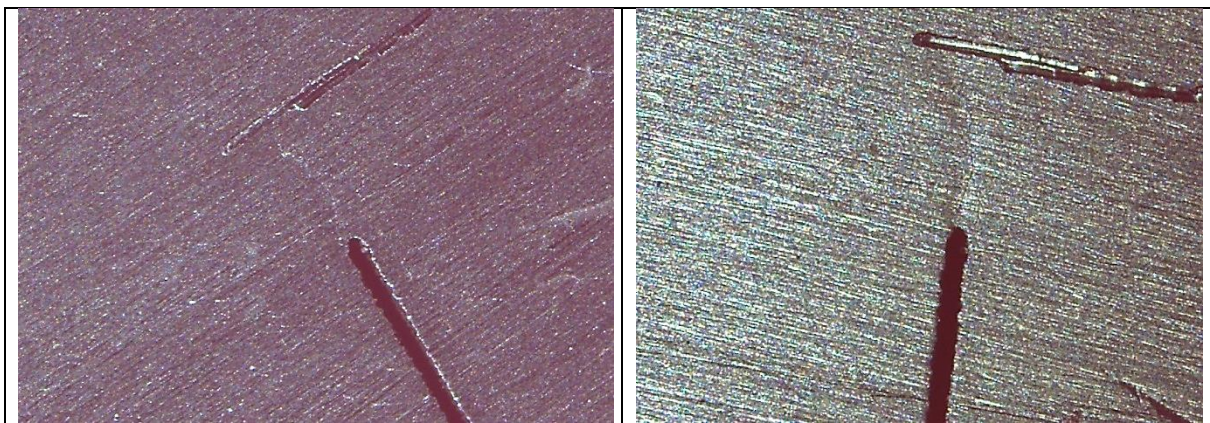


Figura C 20. Probeta D2 100

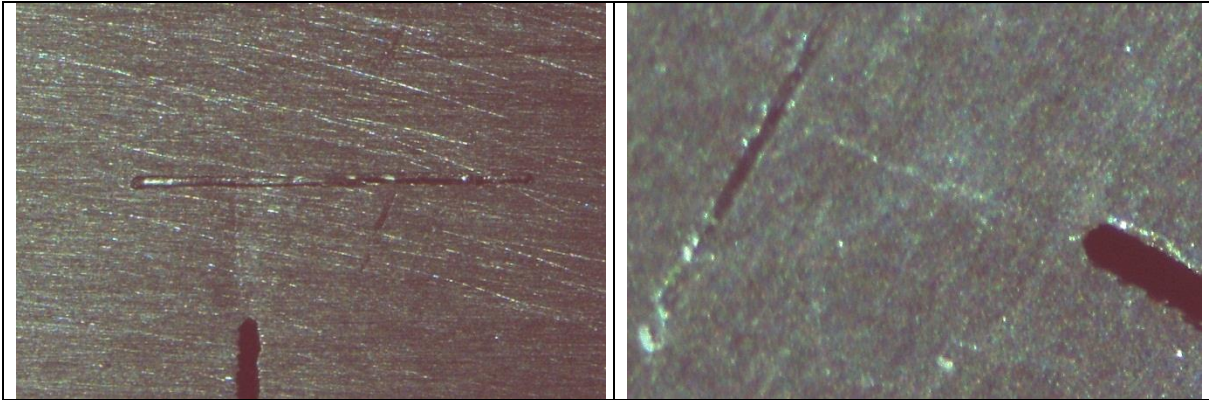


Figura C 21. Probeta D2 82

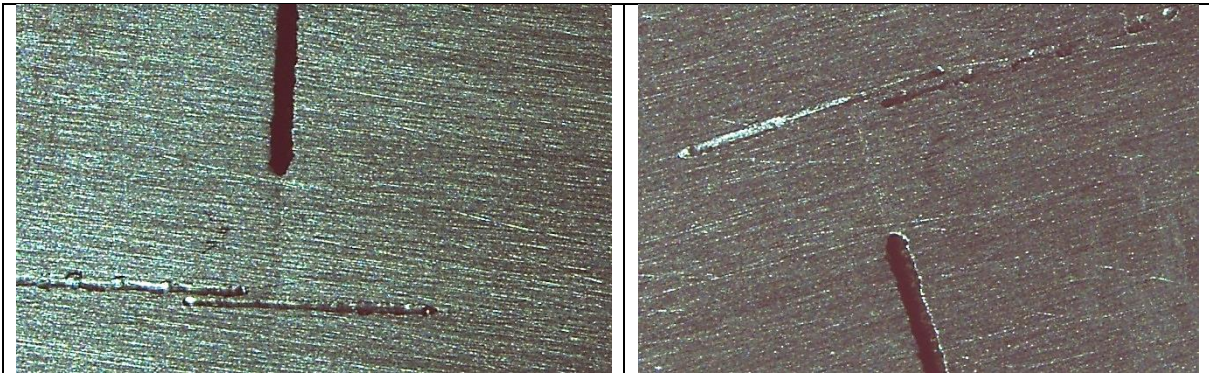


Figura C 22. Probeta D2 99

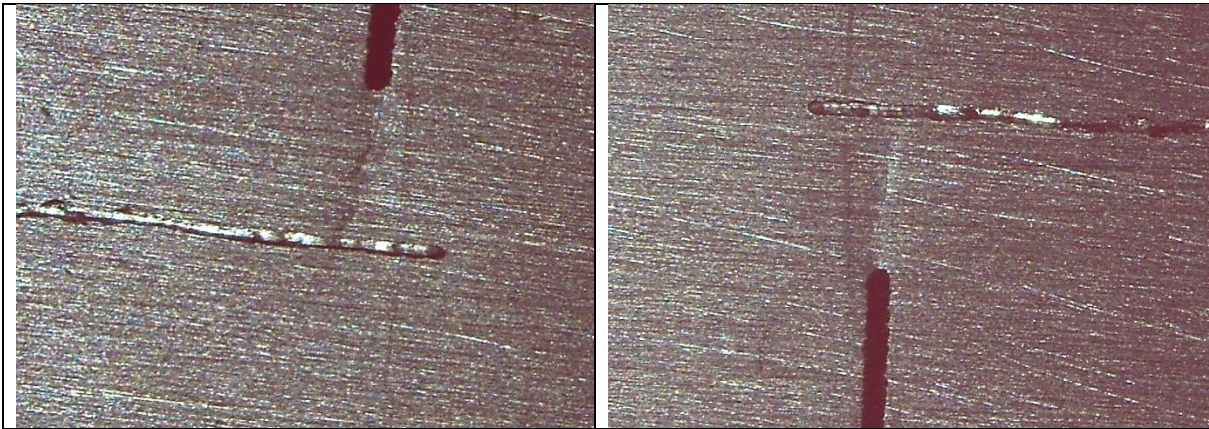


Figura C 23. Probeta D2 94

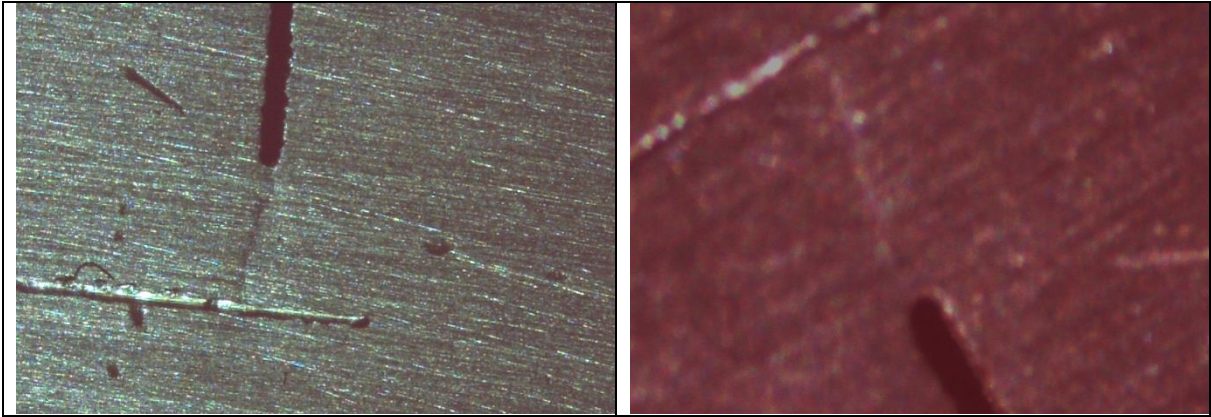


Figura C 24. Probeta D2 97

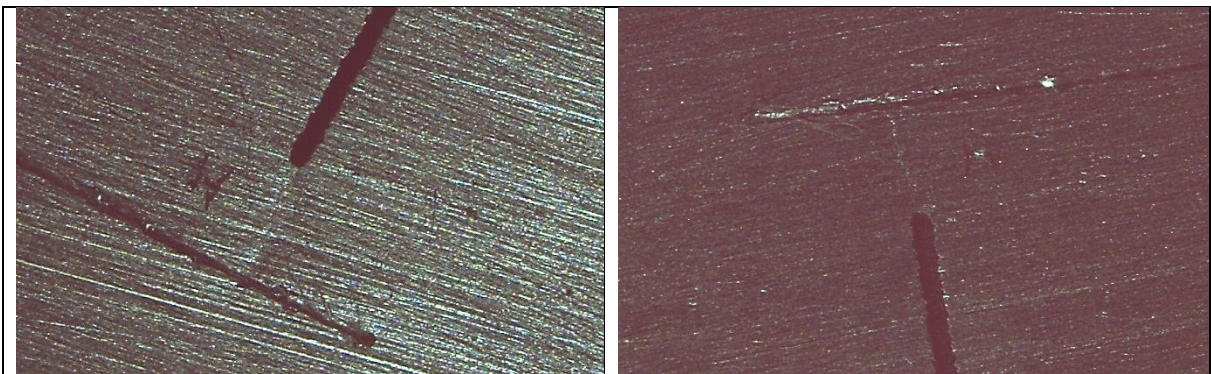


Figura C 25. Probeta D2 77

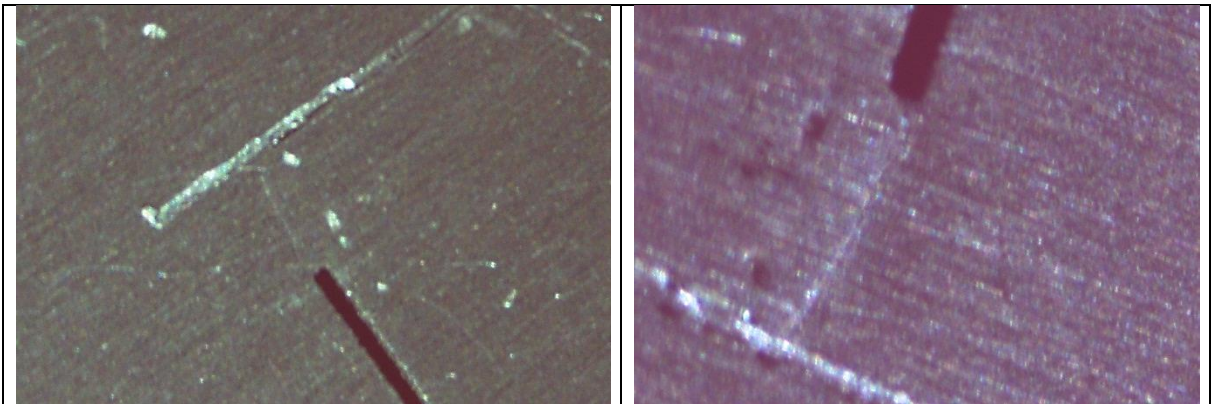


Figura C 26. Probeta D2 84

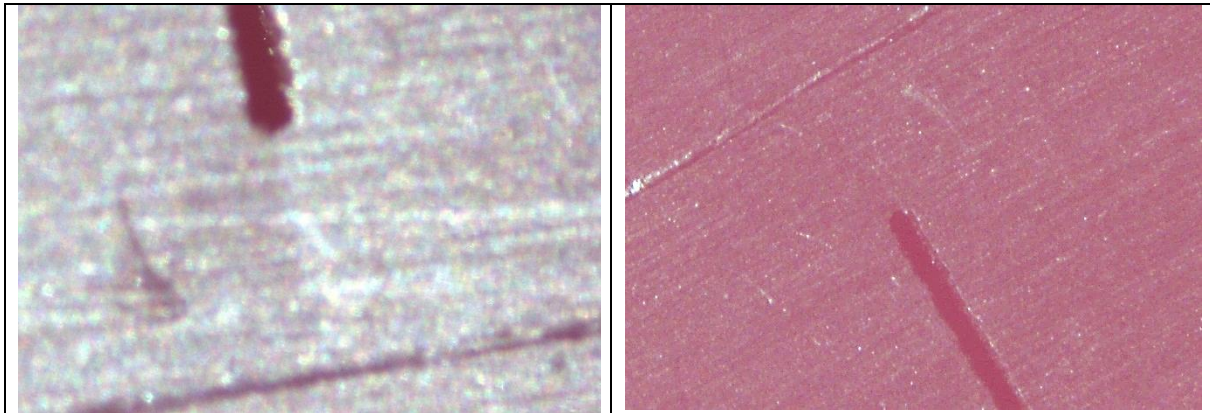


Figura C 27. Probeta D2 96

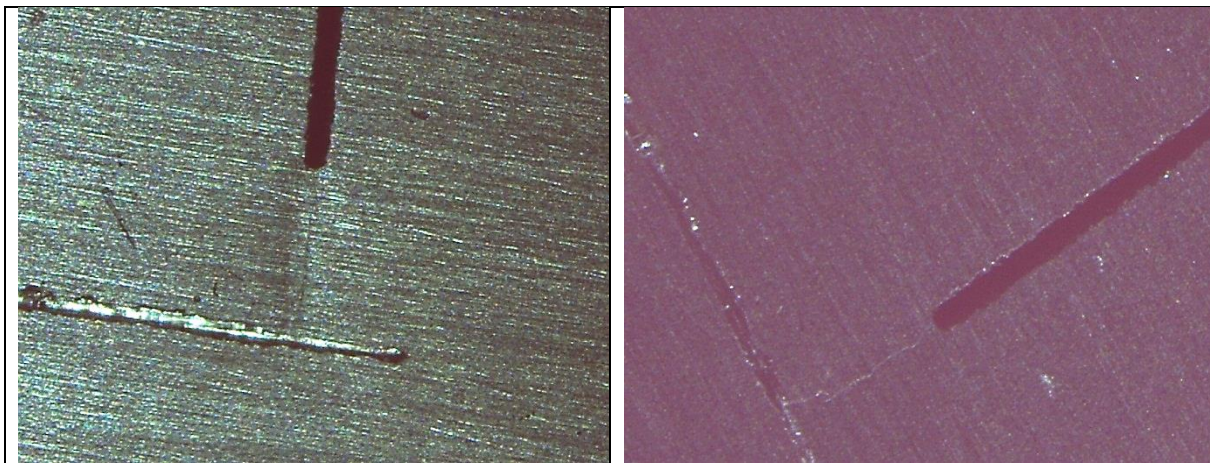


Figura C 28. Probeta D2 80

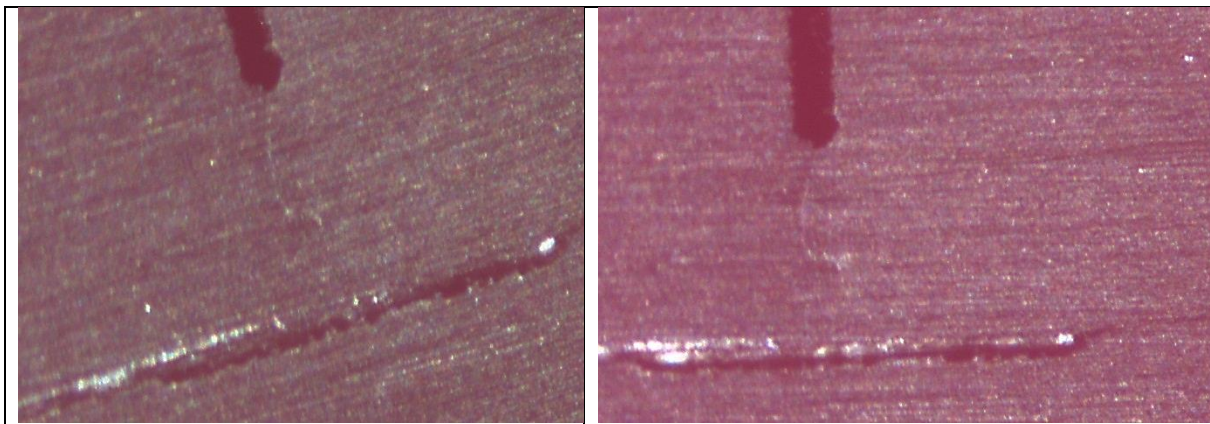


Figura C 29. Probeta D2 92

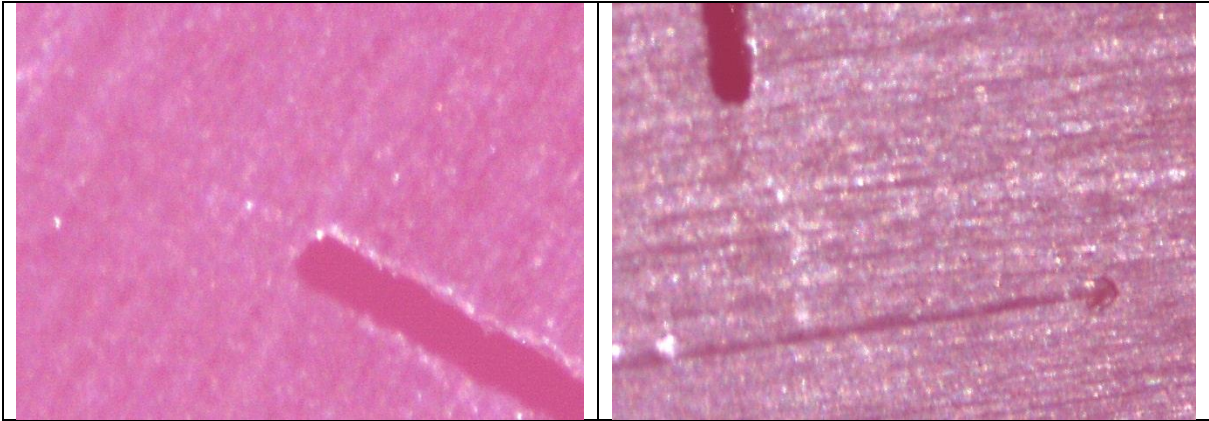


Figura C 30. Probeta D278

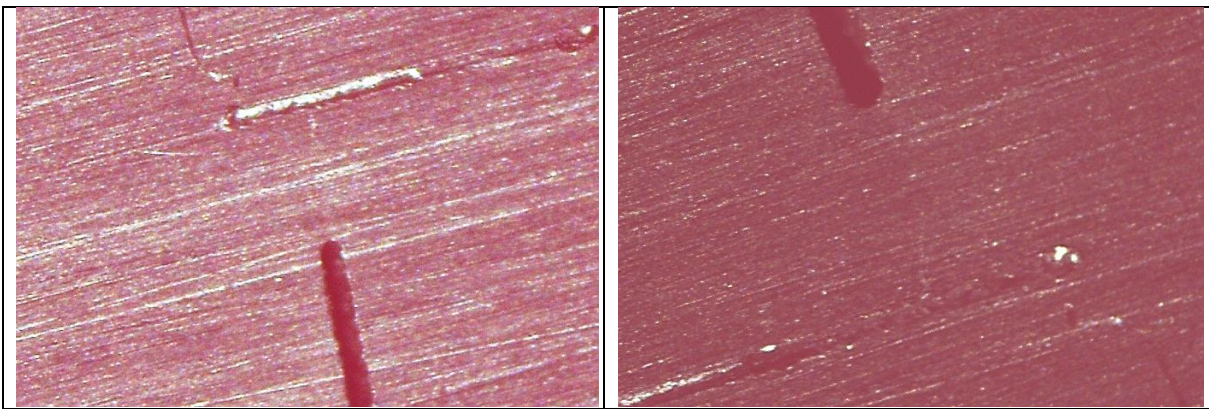


Figura C 31. Probeta D2 87

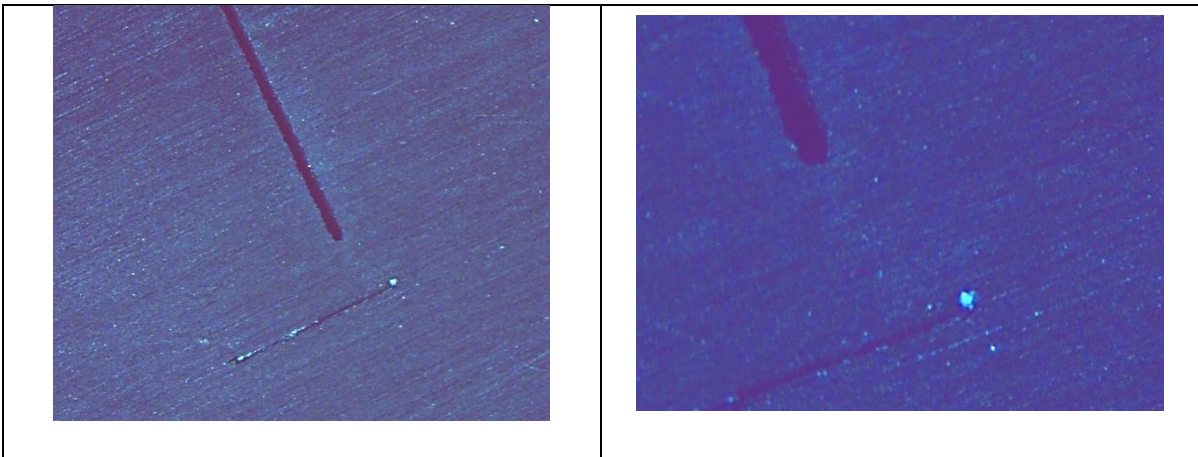


Figura C 32. Probeta D2 88

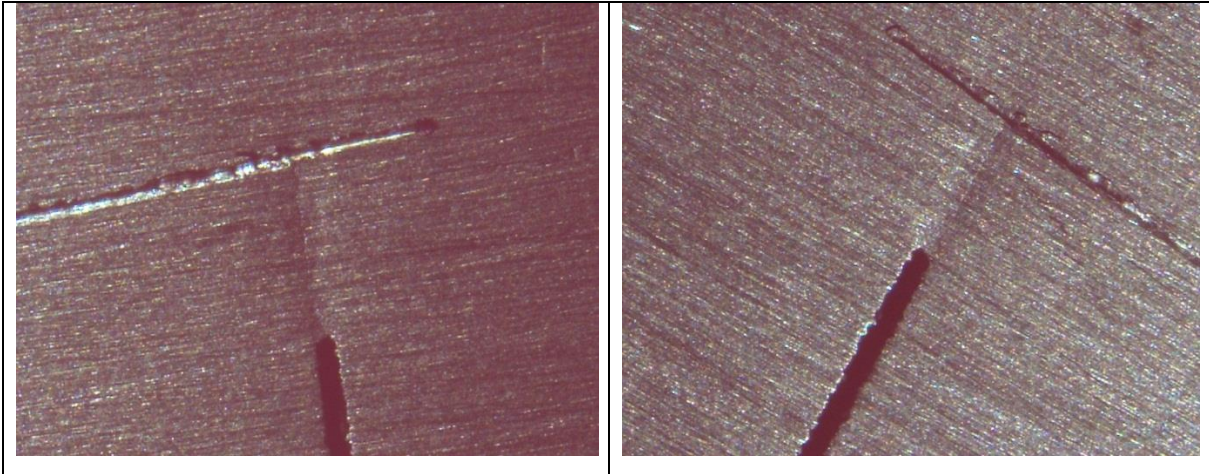


Figura C 33. Probeta D2 90

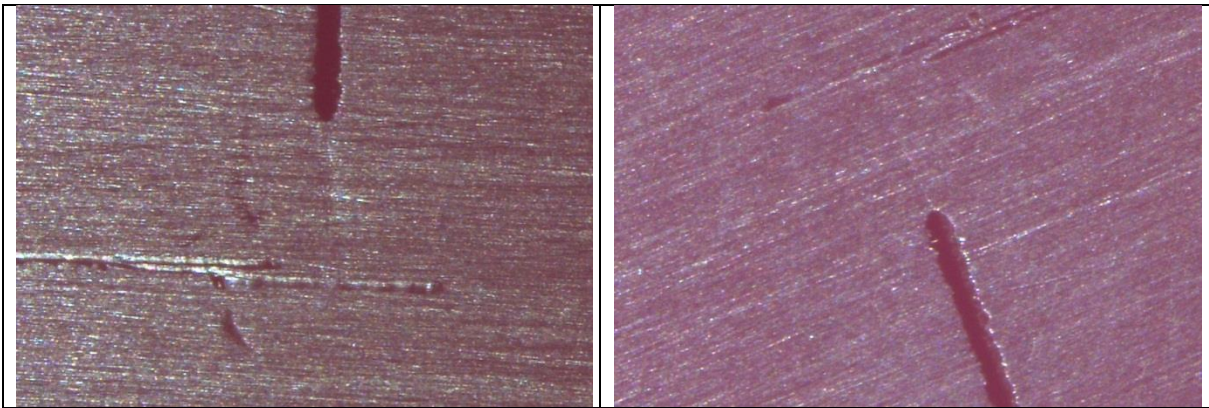


Figura C 34. Probeta D2 89

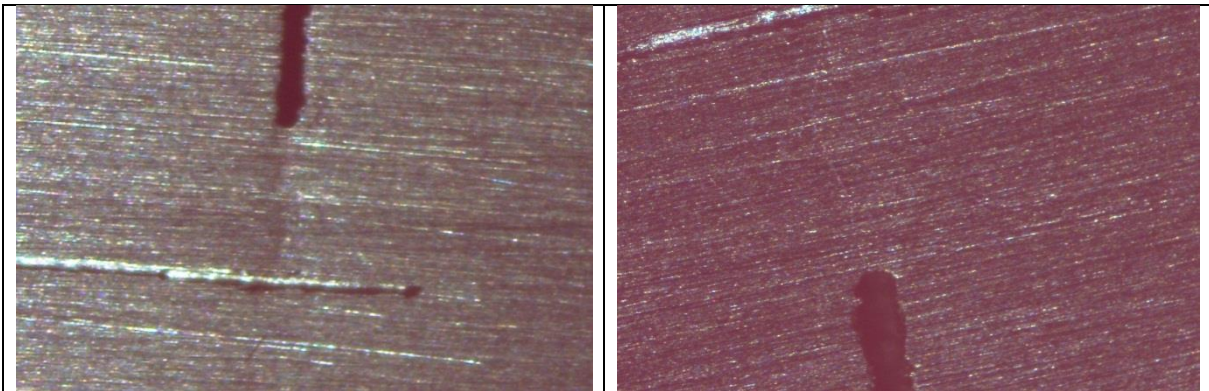


Figura C 35. Probeta D2 93

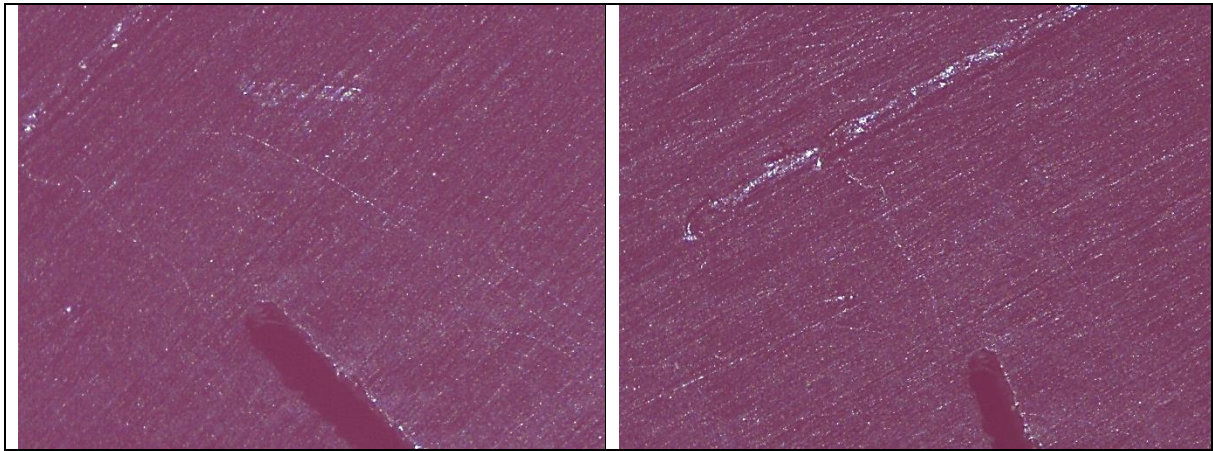


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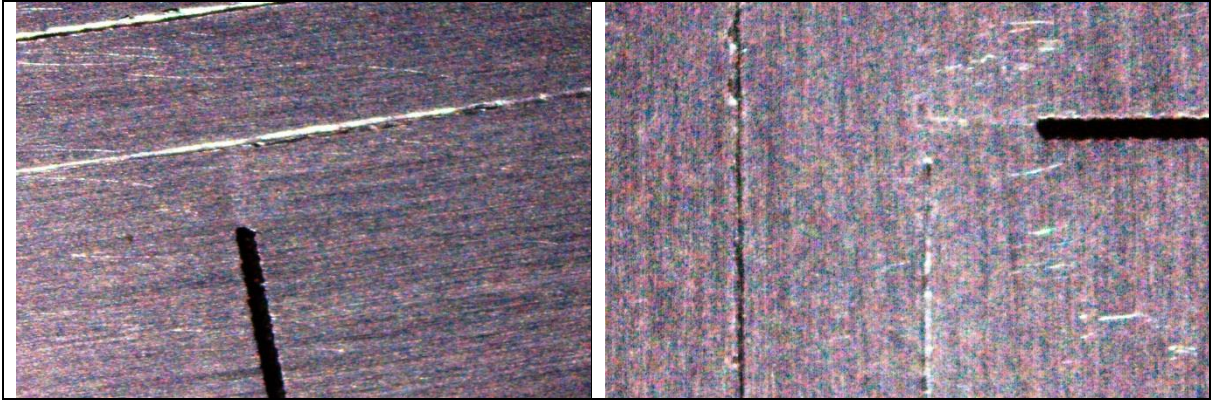


Figura C 37. Probeta D3 41

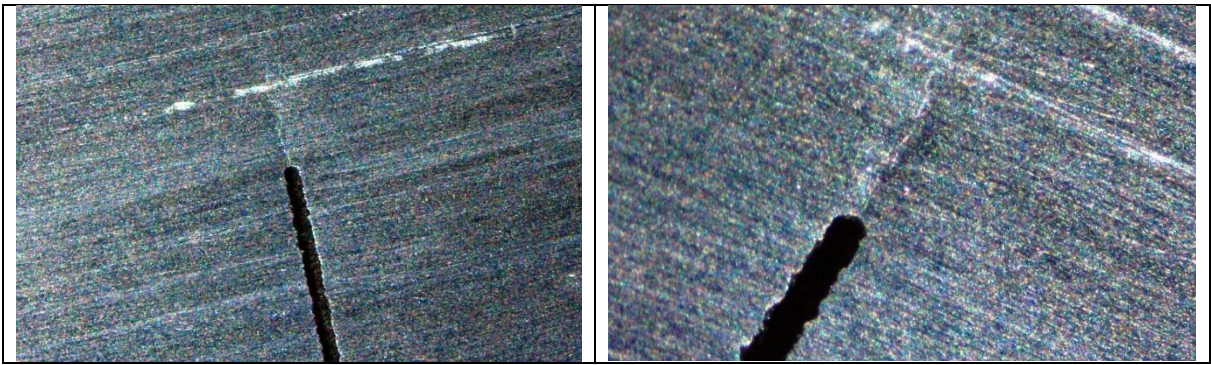


Figura C 38. Probeta D3 40

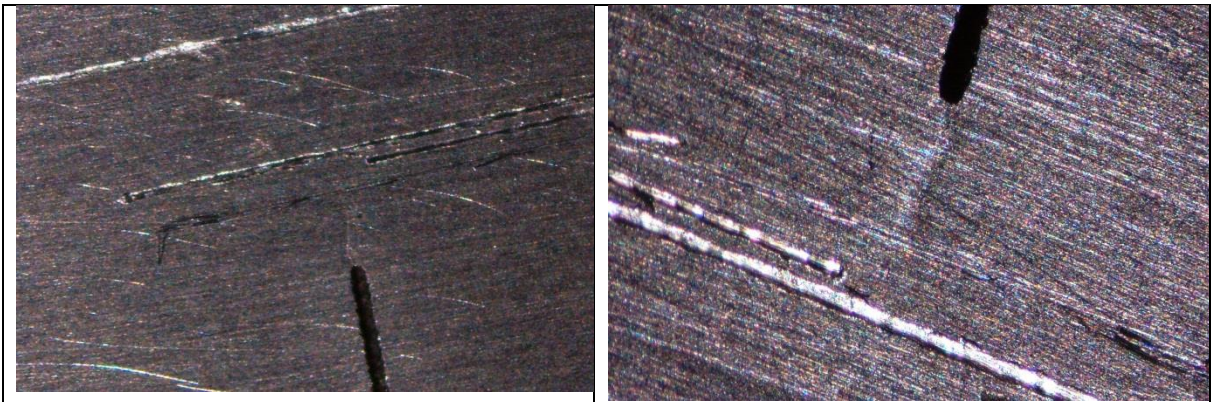


Figura C 39. Probeta D3 39

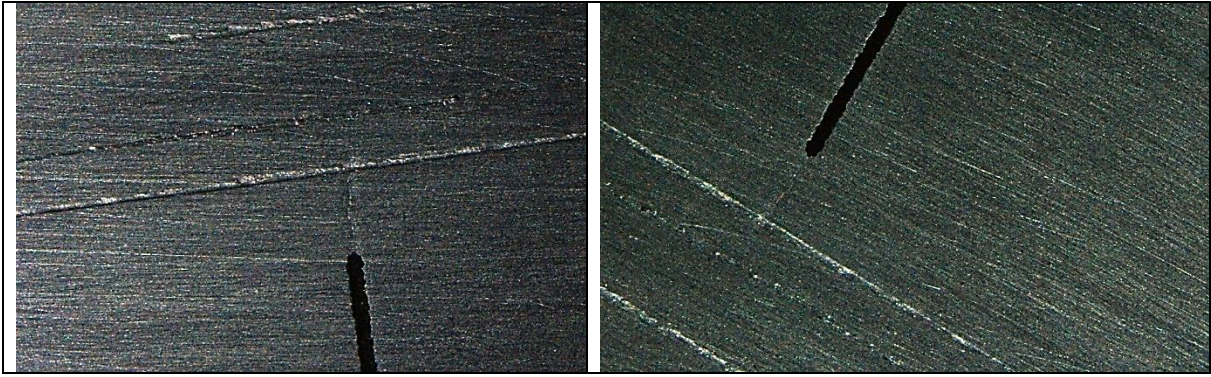


Figura C 40. Probeta D3 35

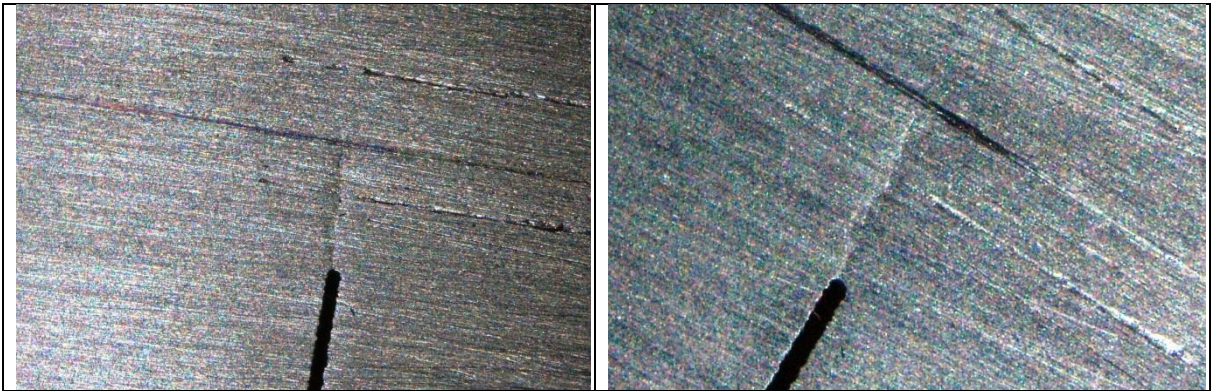


Figura C 41. Probeta D3 34

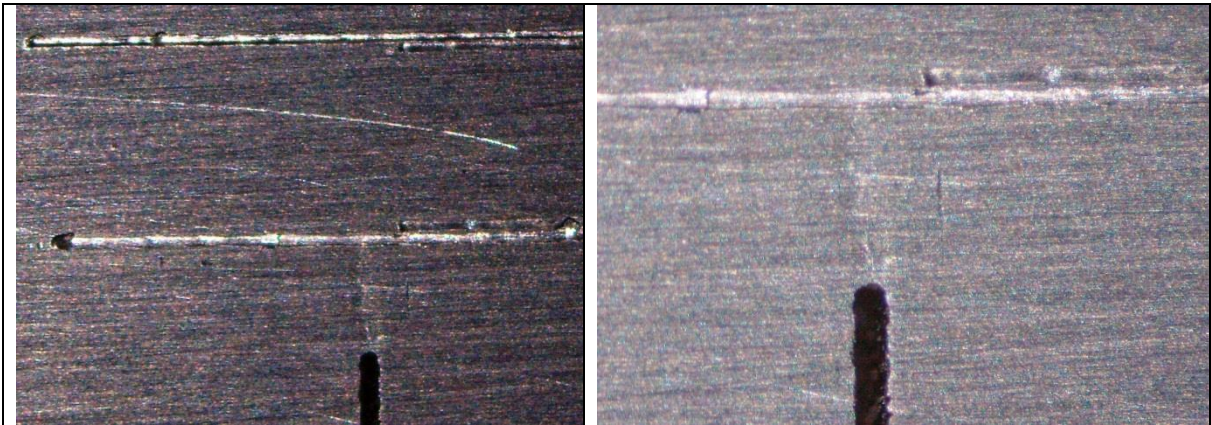


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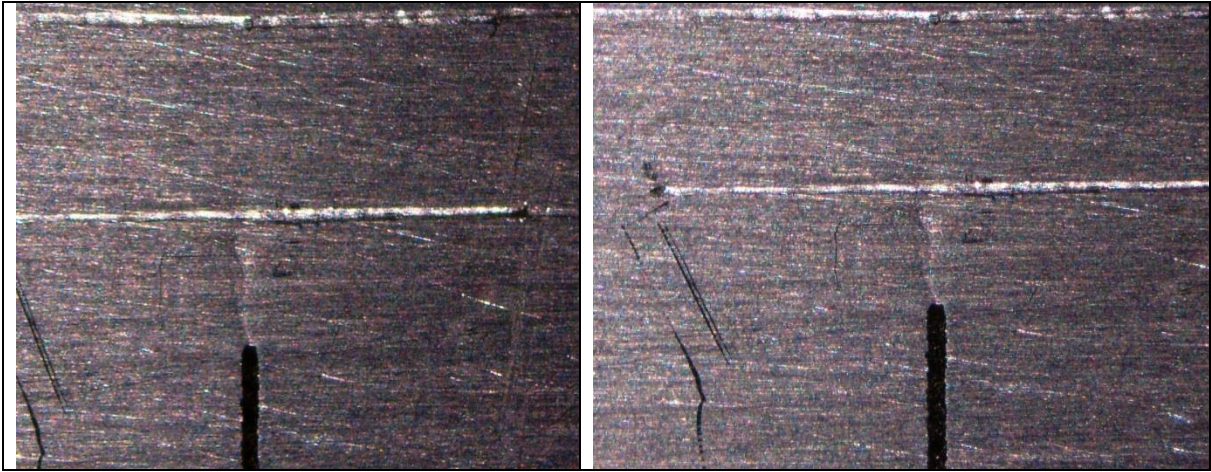


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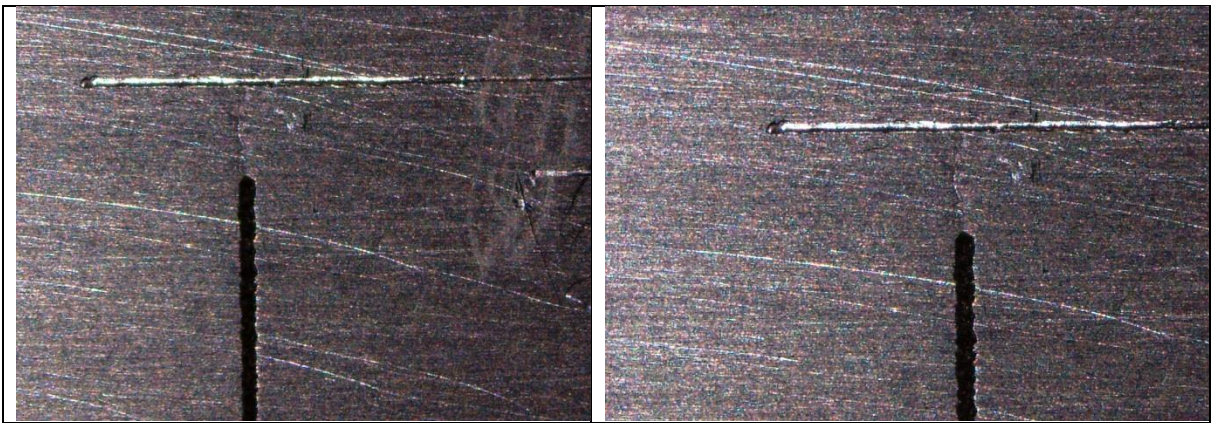


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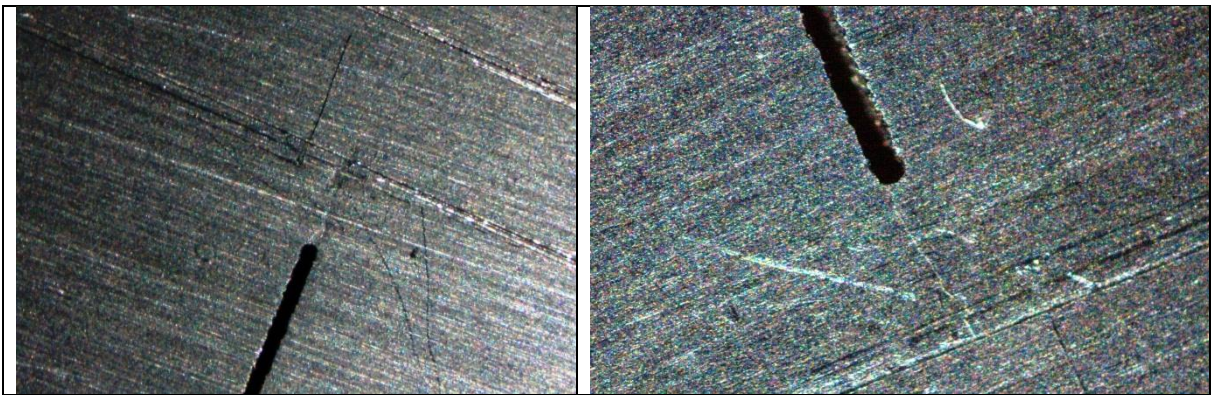


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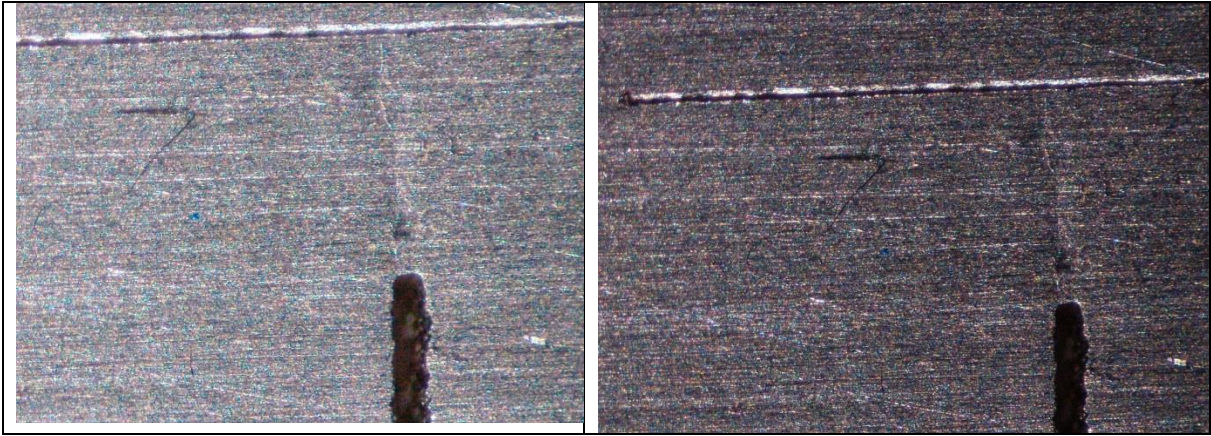


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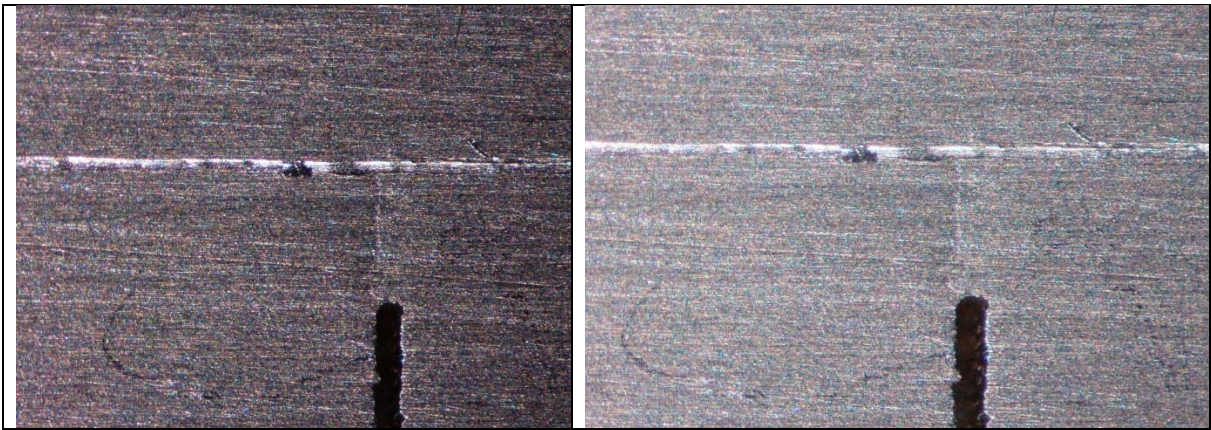


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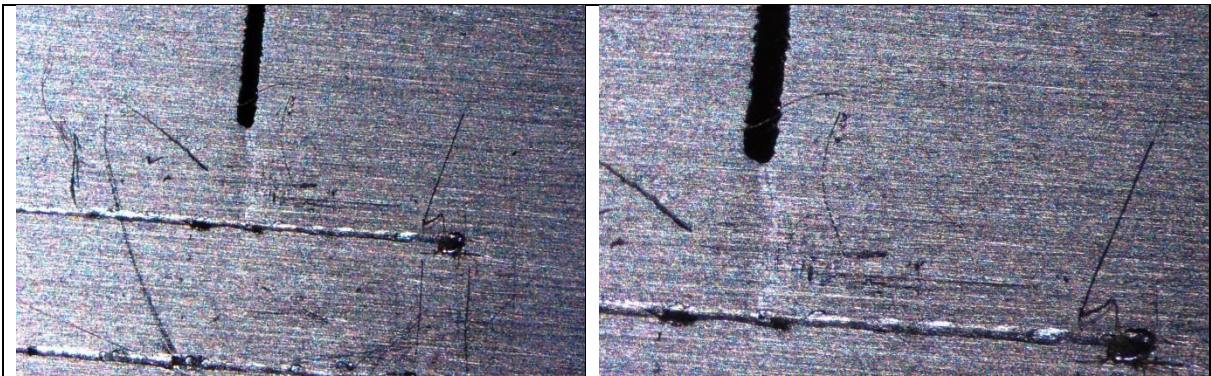


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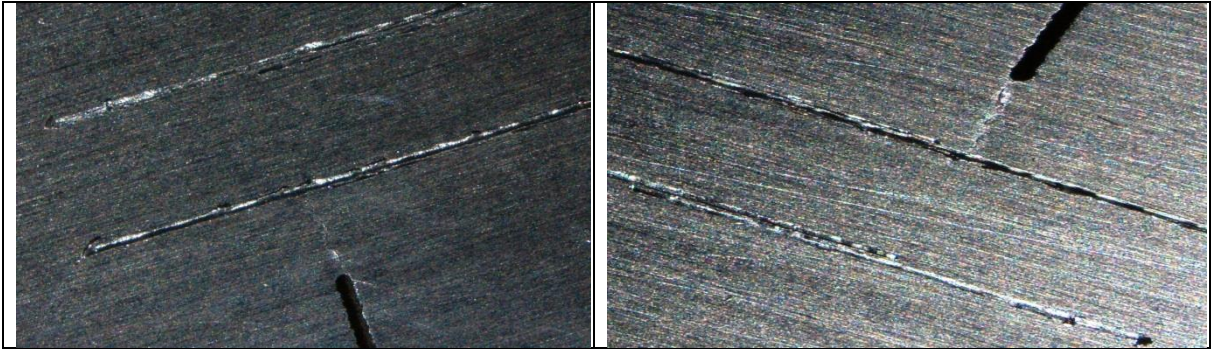


Figura C 49. Probeta D3 24

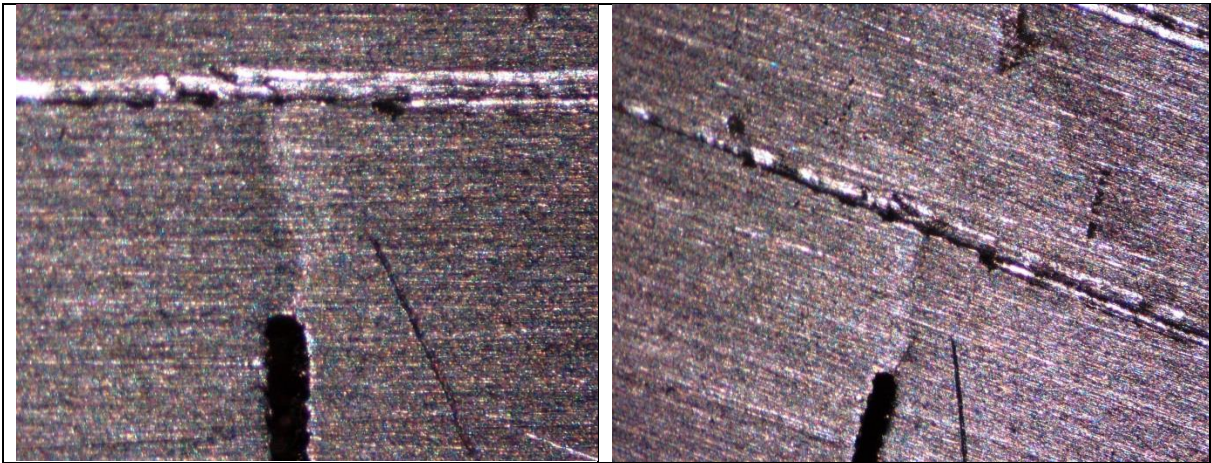


Figura C 50. Probeta D3 44

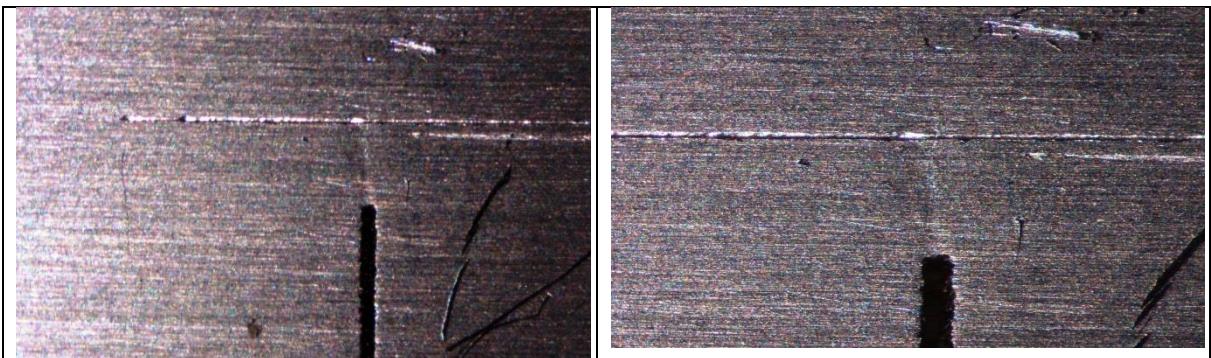


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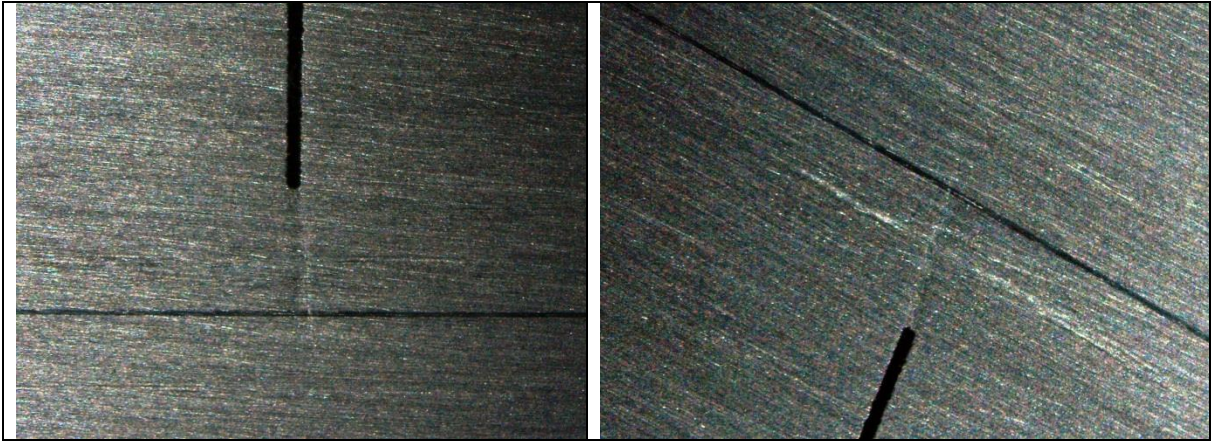


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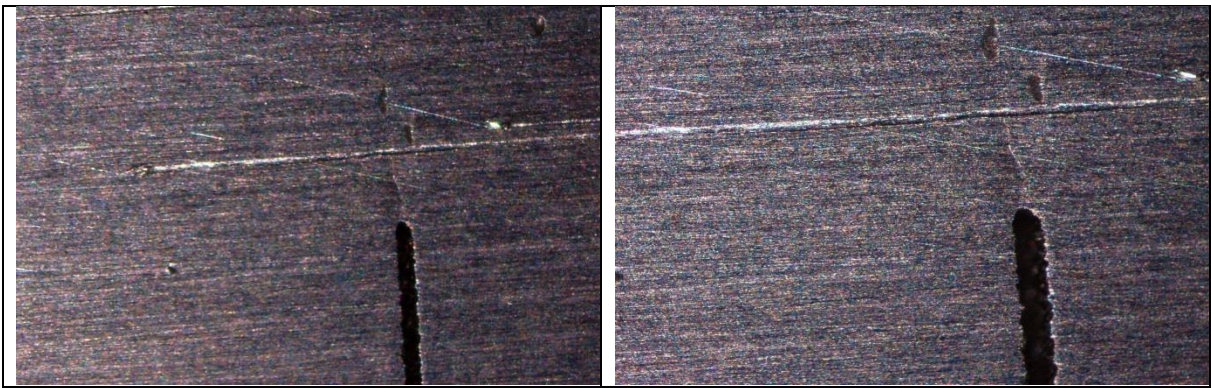


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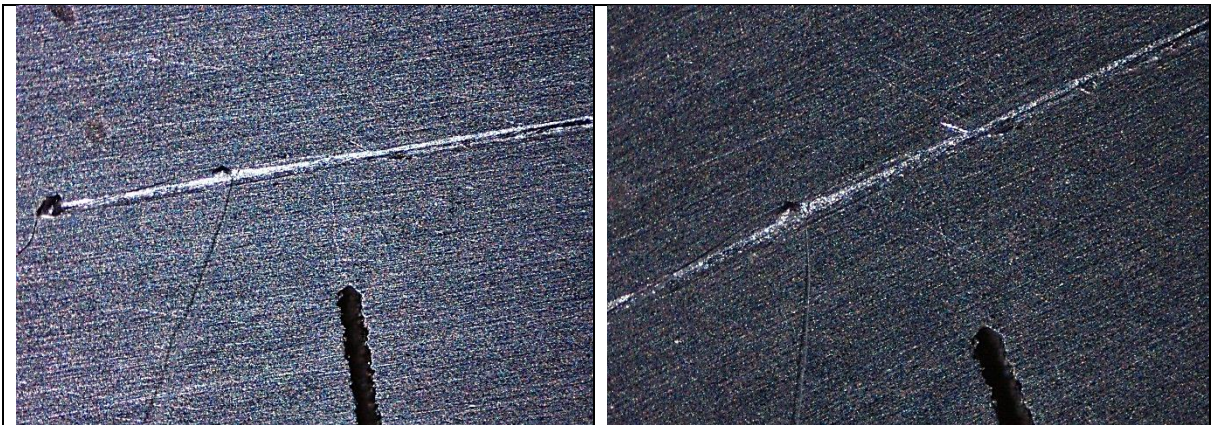


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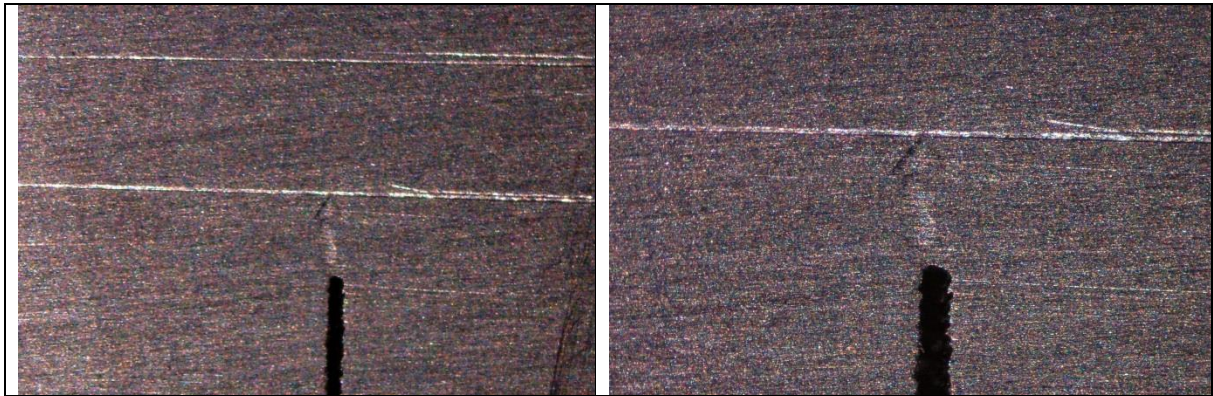


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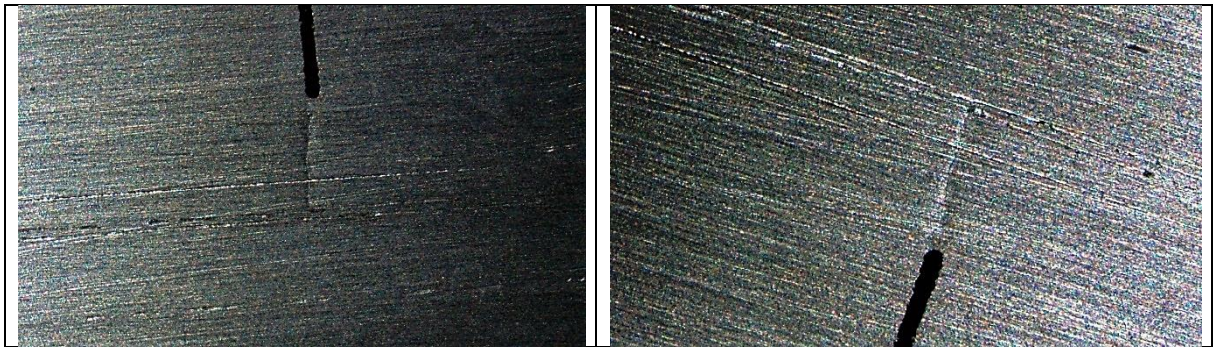


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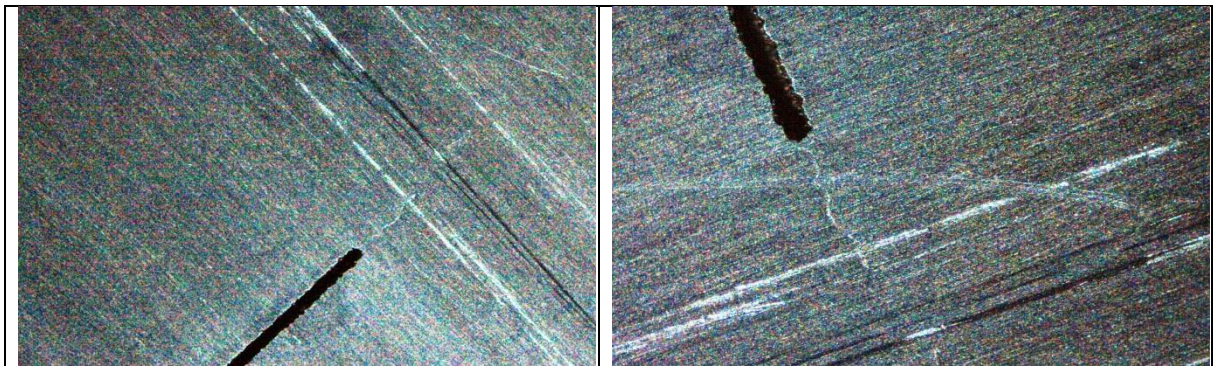


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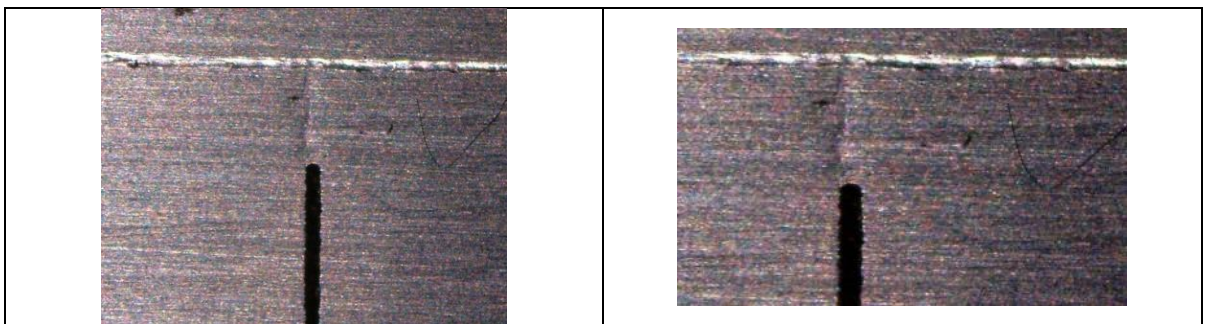


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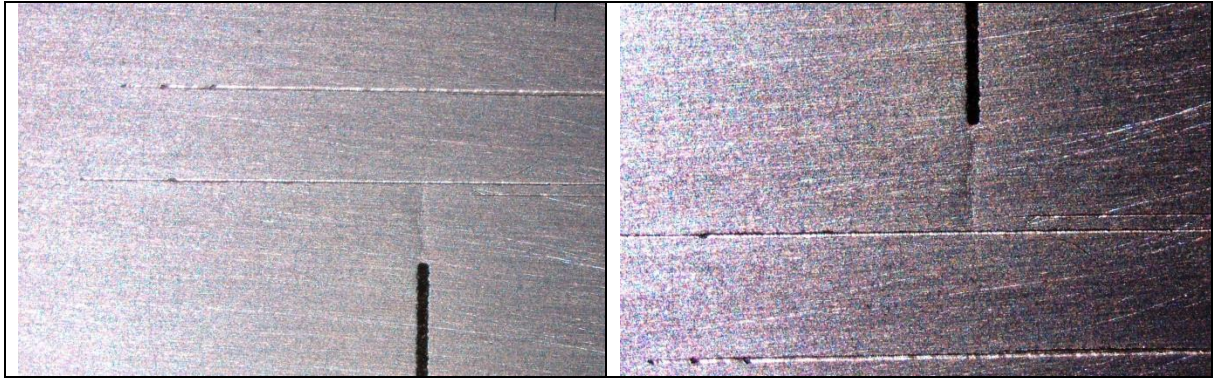


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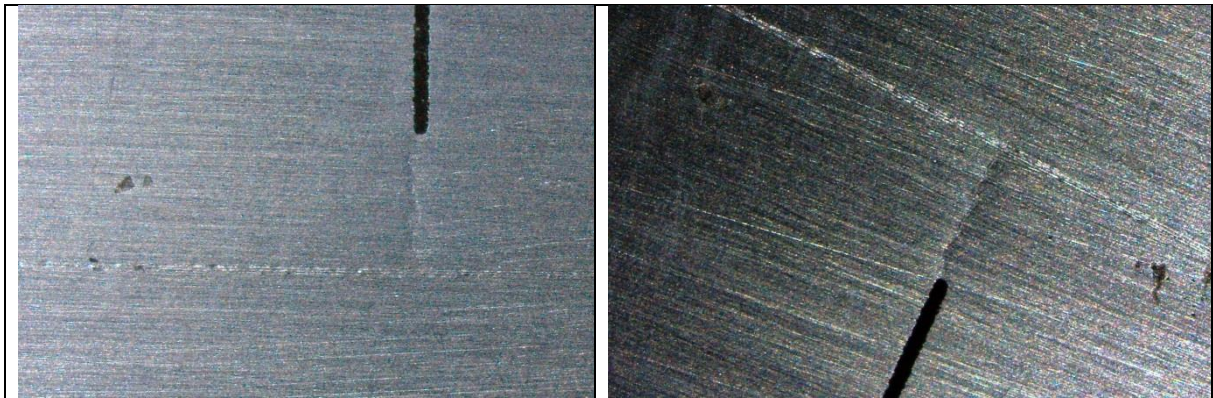


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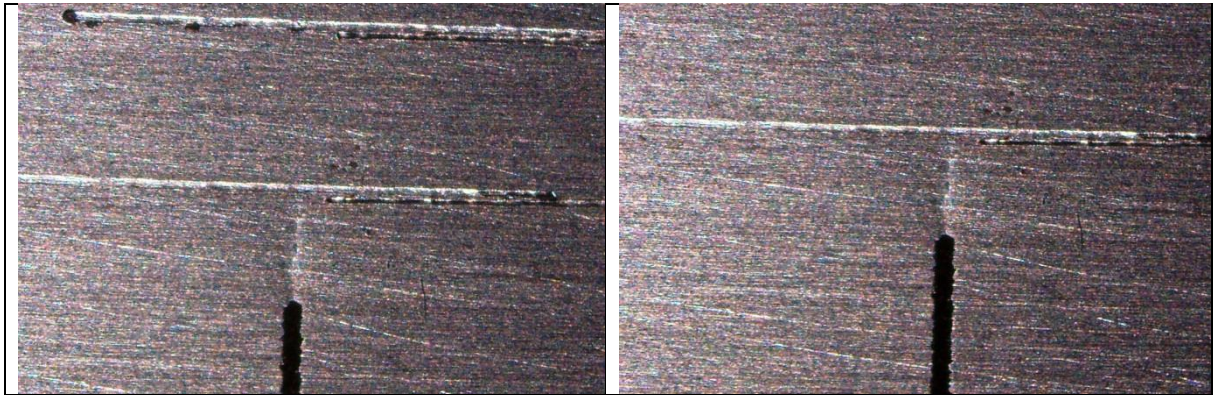


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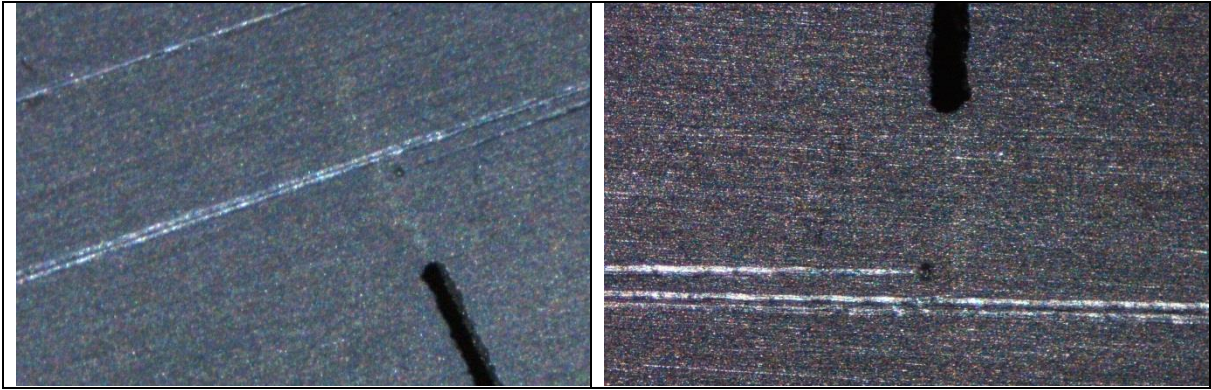


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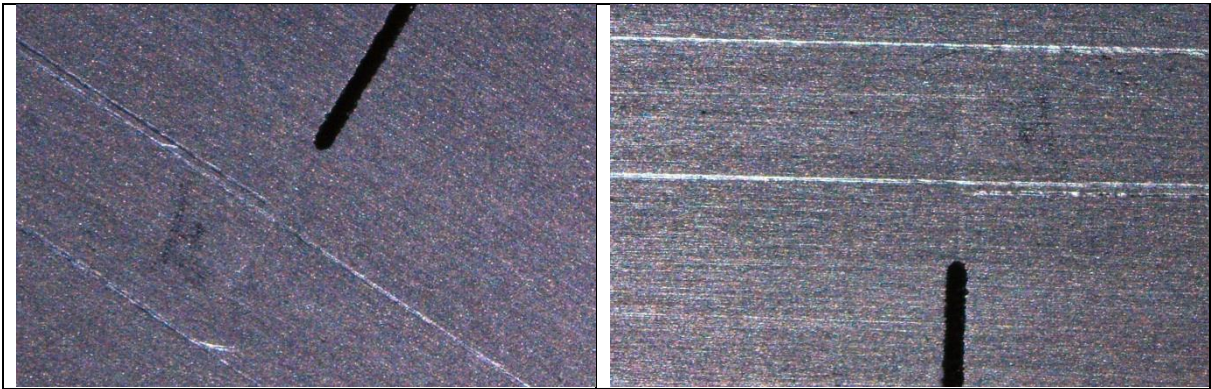


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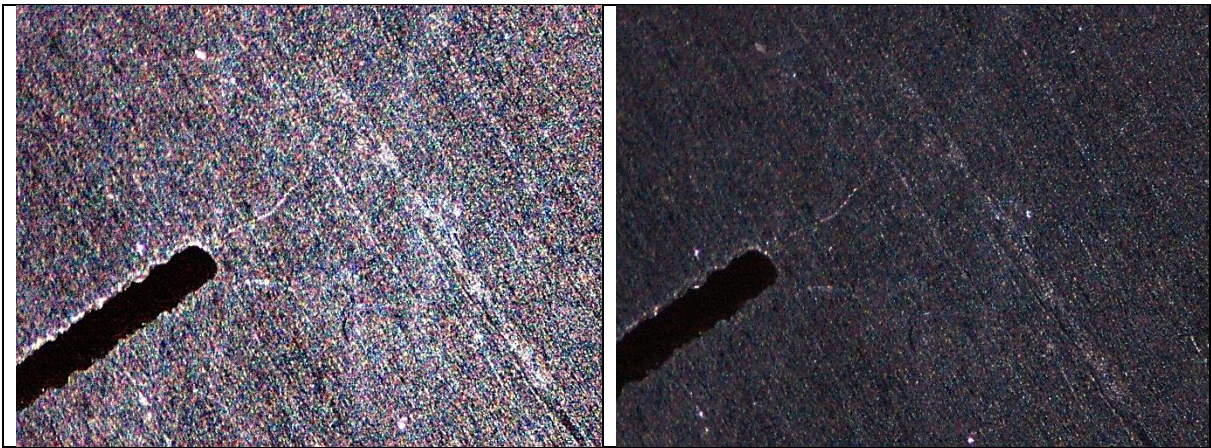


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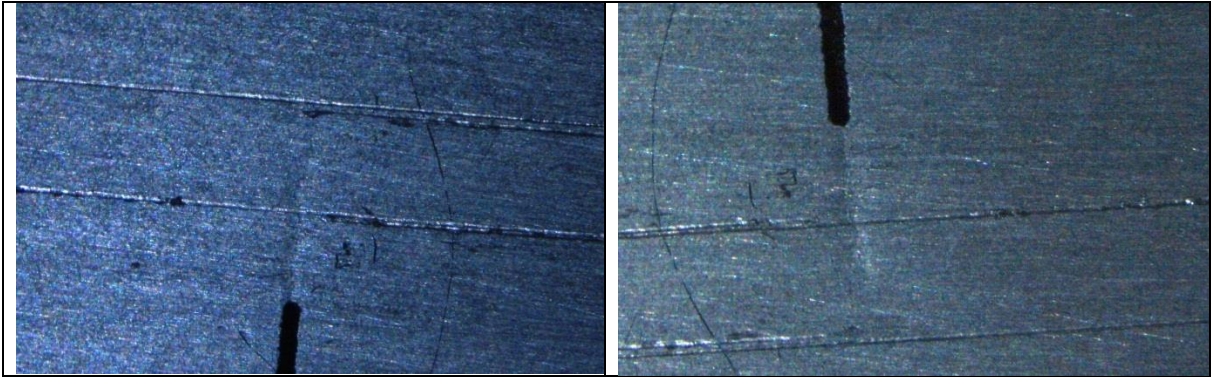


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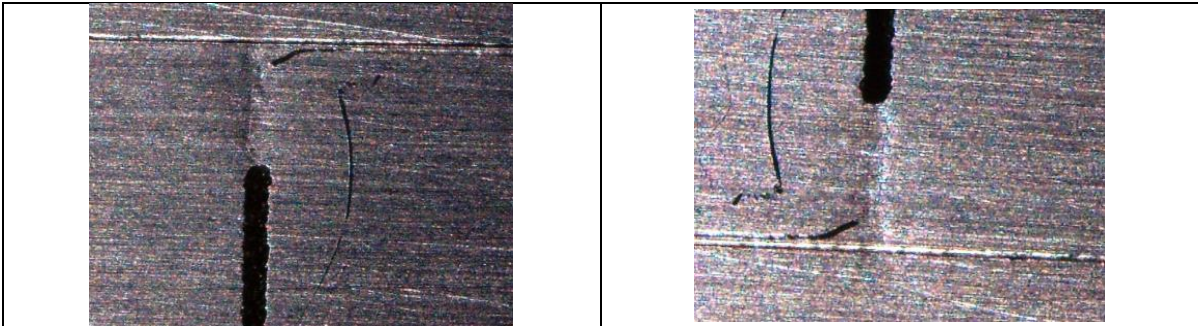


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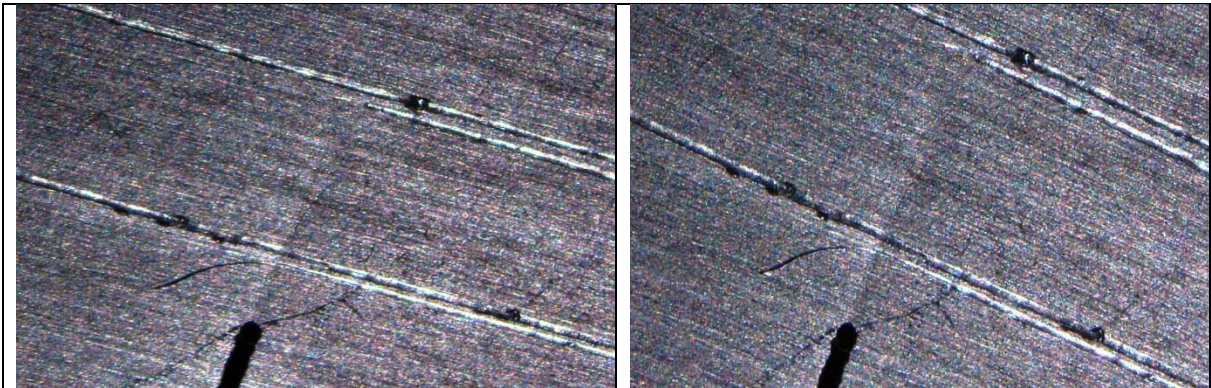


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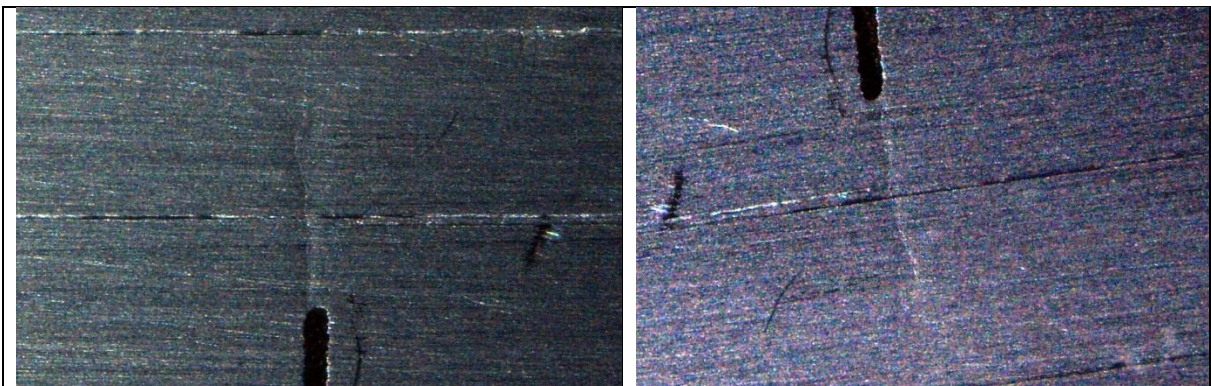


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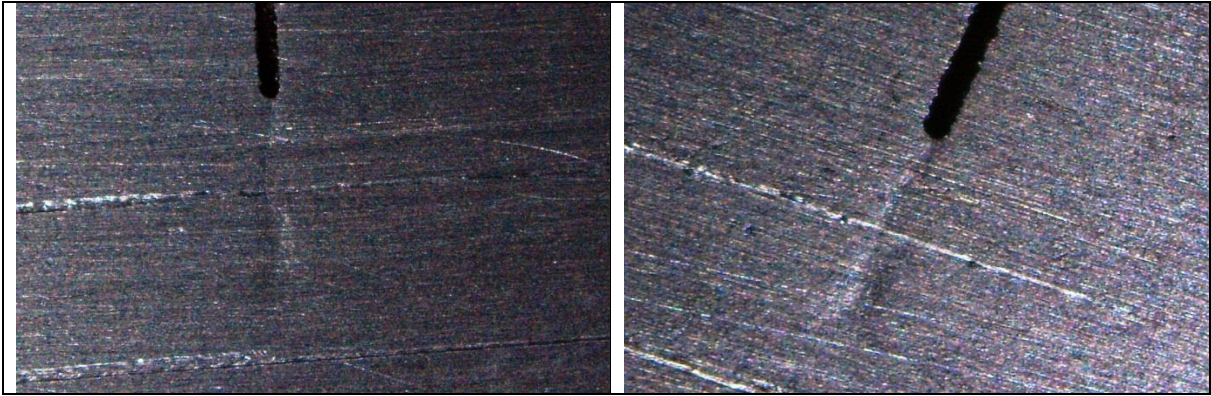


Figura C 69. Probeta D4 4



Figura C 70. Probeta D4 12

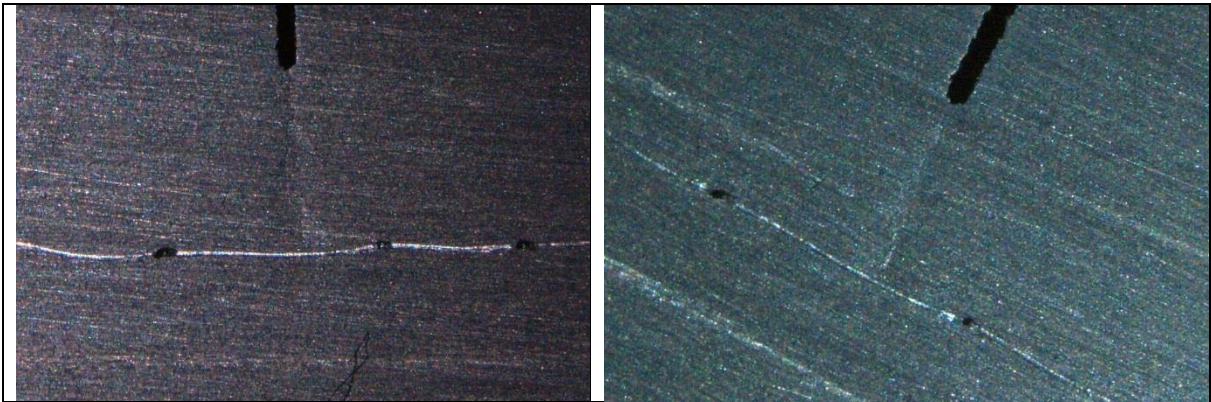


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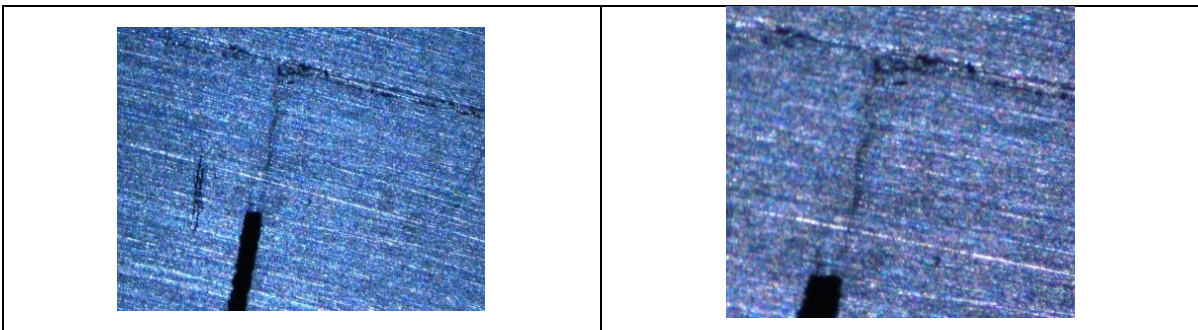


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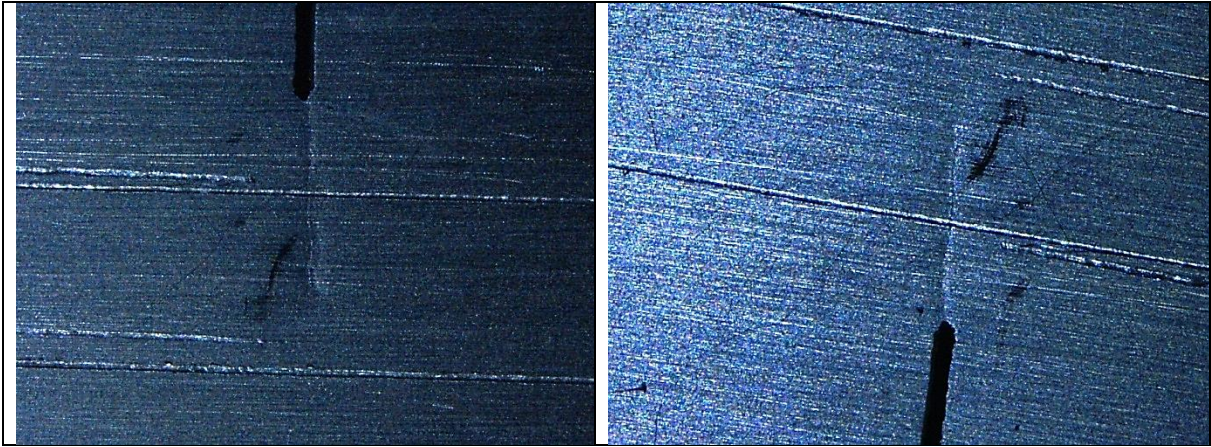


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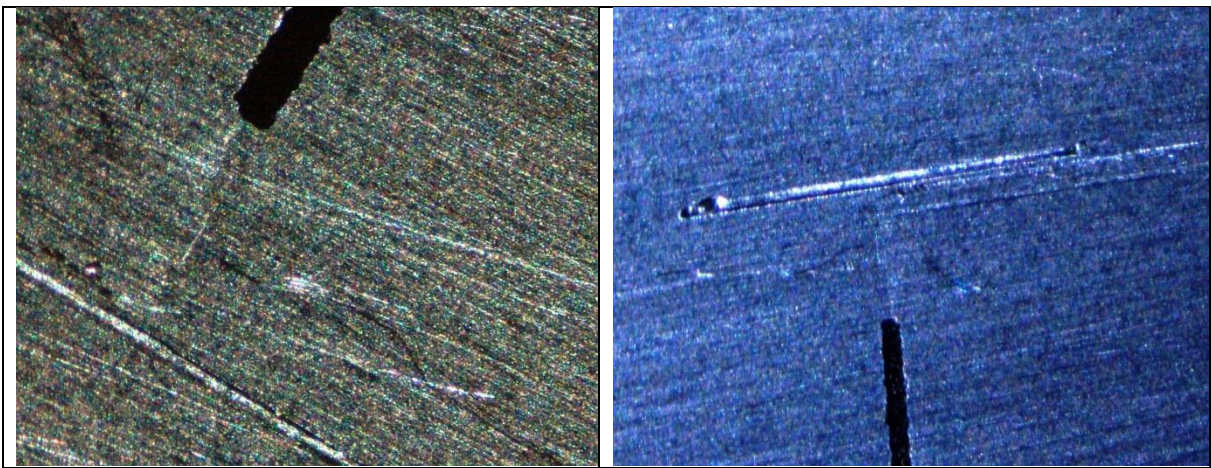


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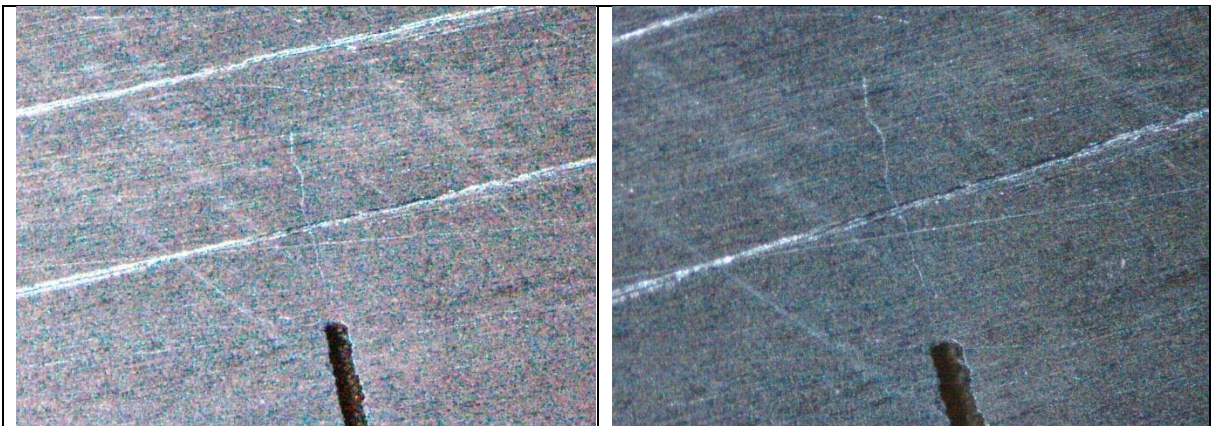


Figura C 75. Probeta D4 20

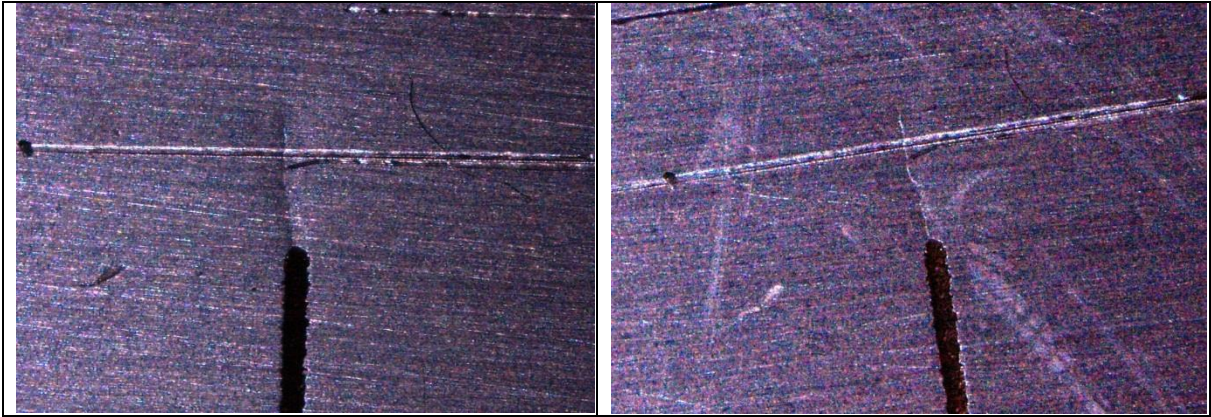


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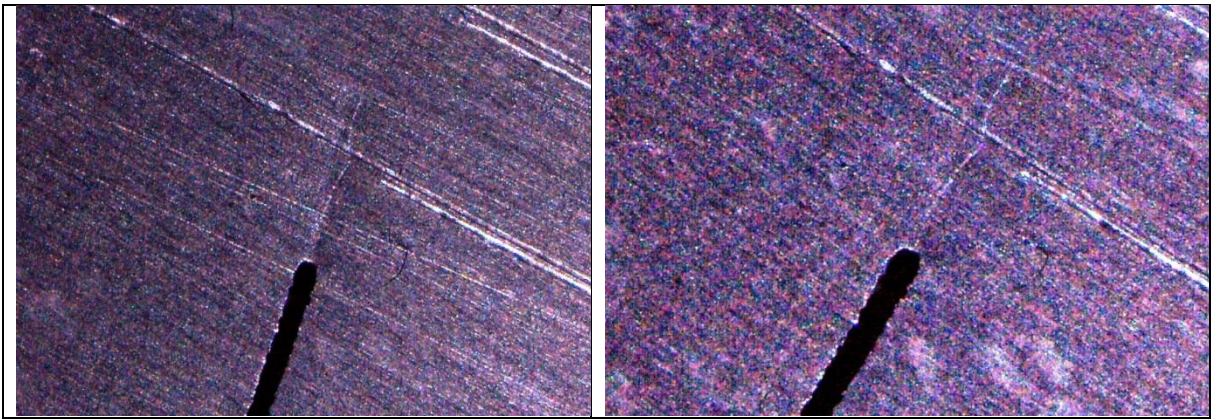


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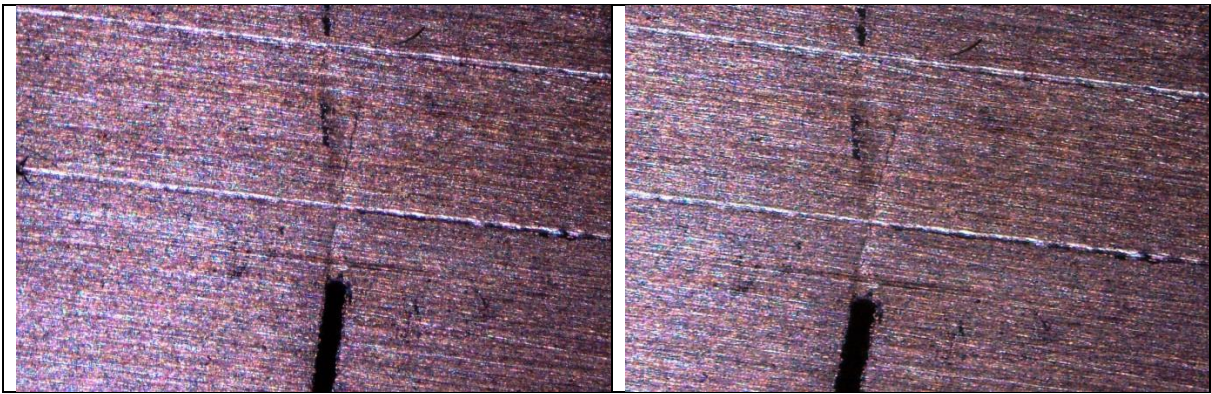


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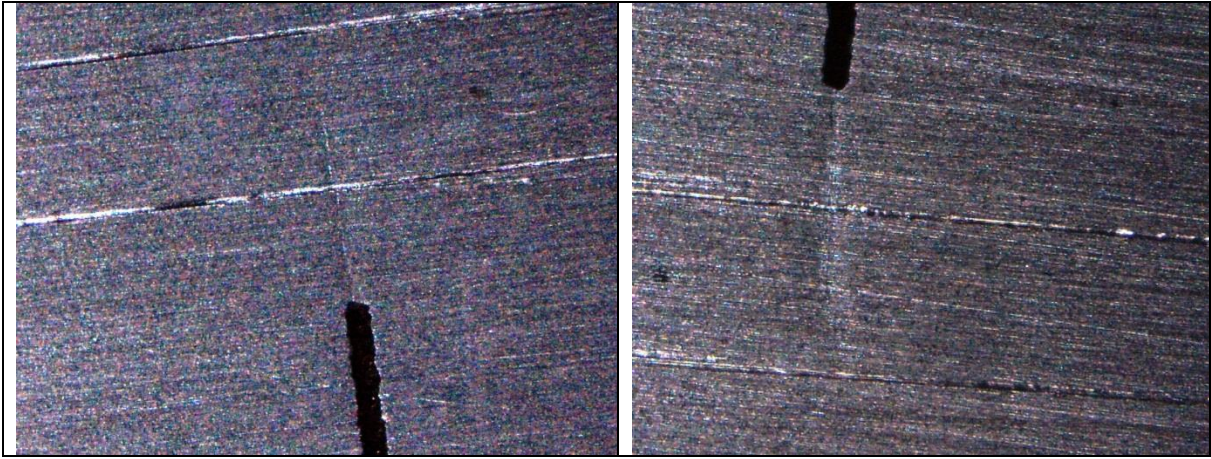


Figura C 79. Probeta D4 22

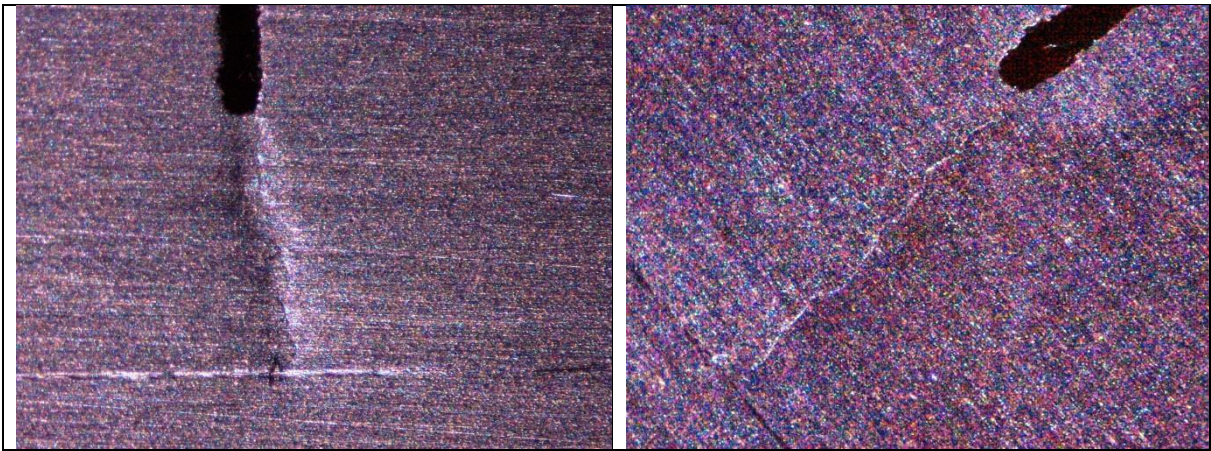


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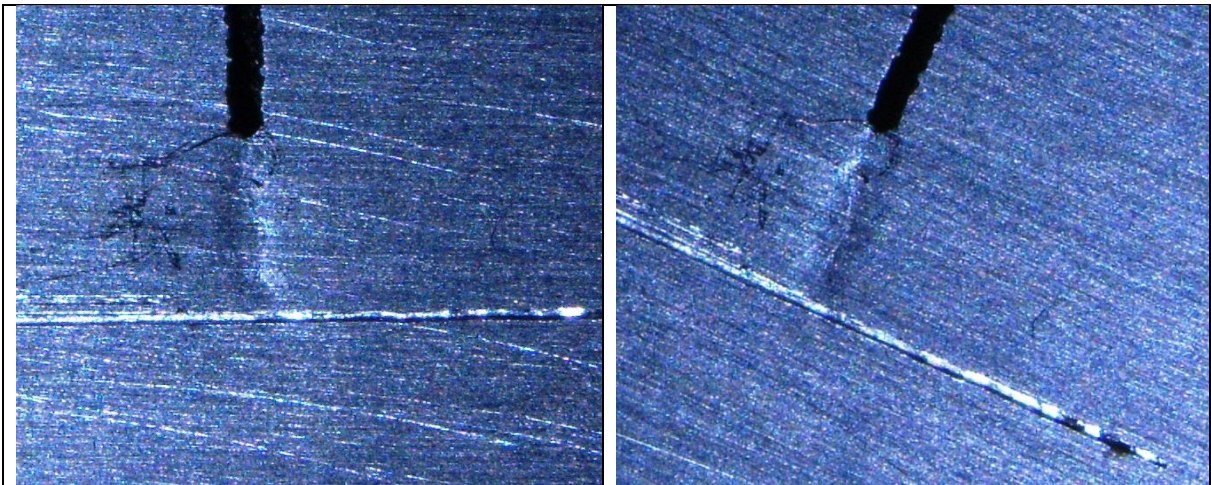


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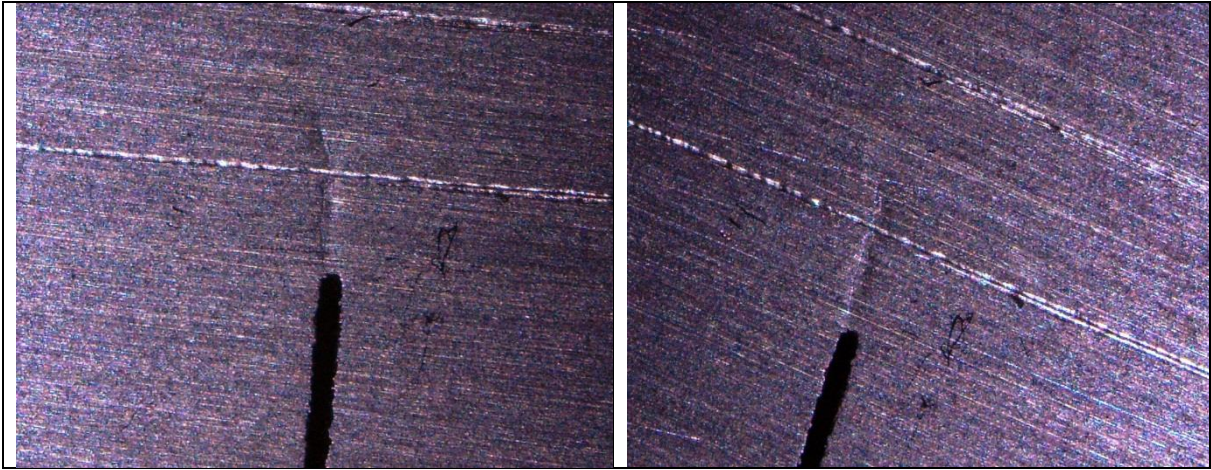


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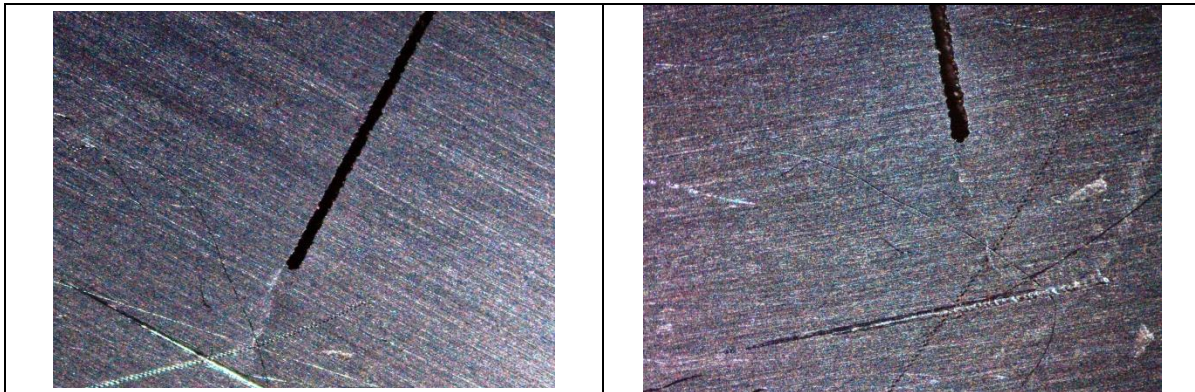


Figura C 83. Probeta D5 112

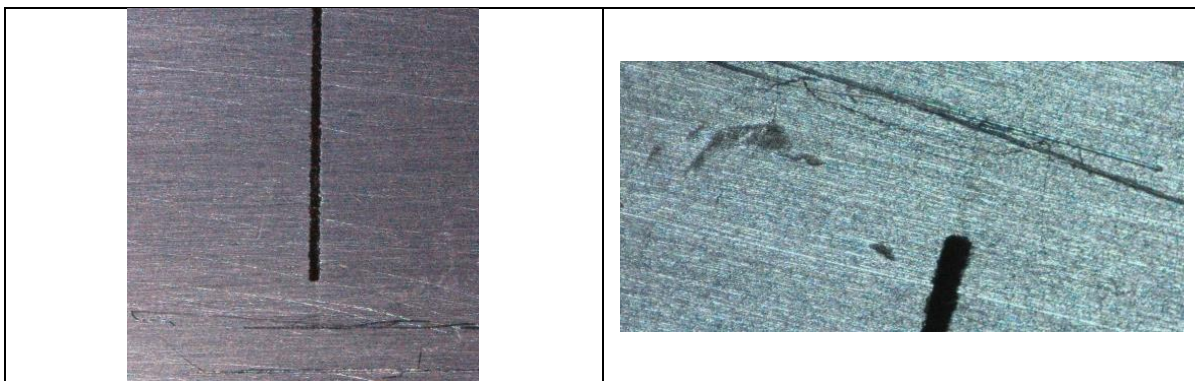


Figura C 84. Probeta D5 116

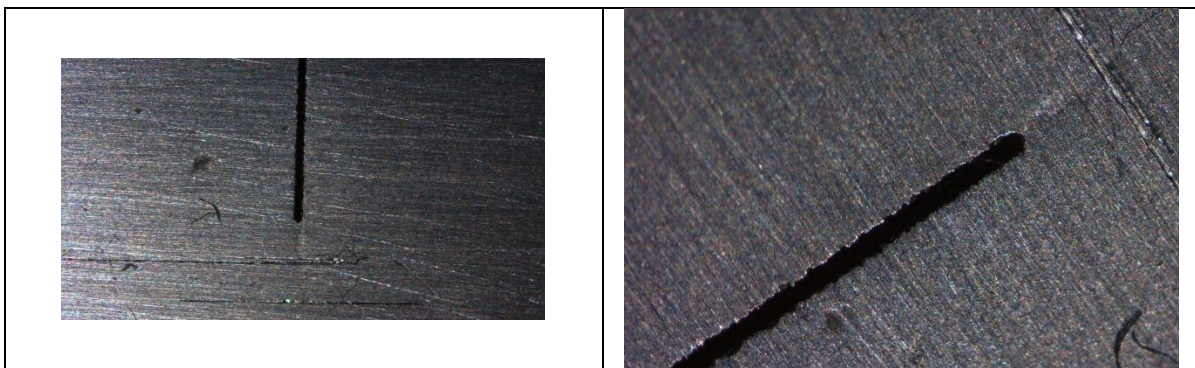


Figura C 85. Probeta D5 119



Figura C 86. Probeta D5 114

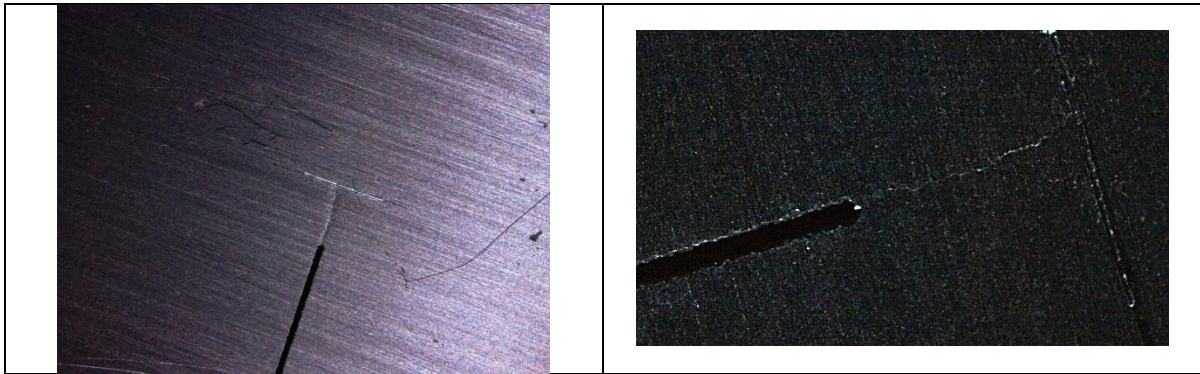


Figura C 87. Probeta D5 118

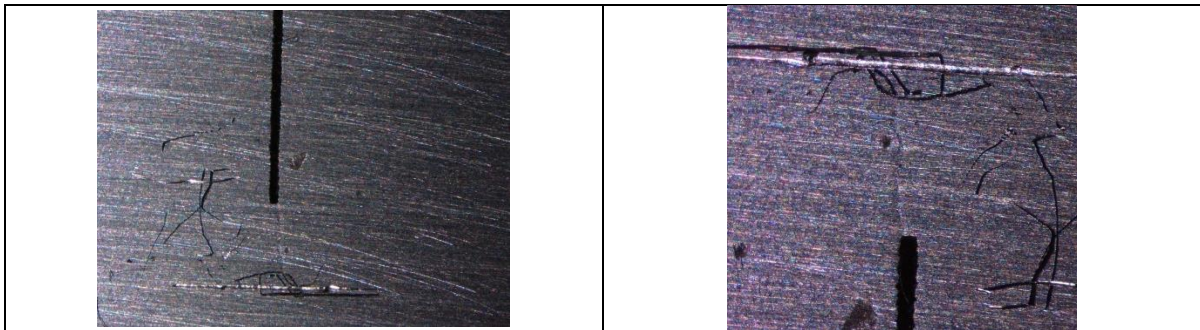


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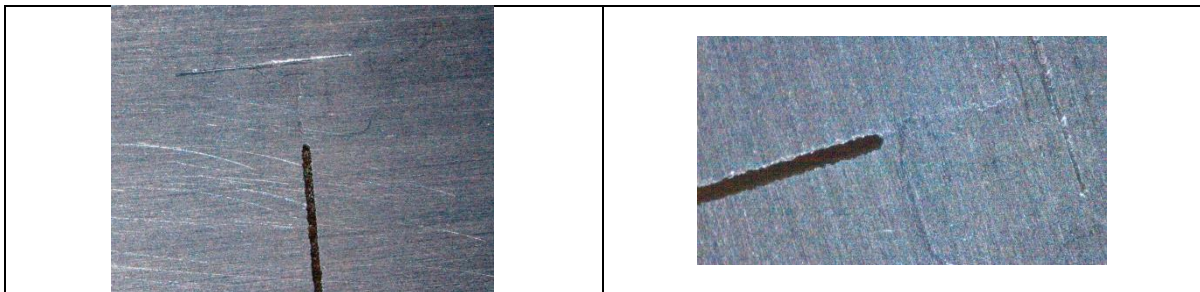


Figura C 89. Probeta D5 115

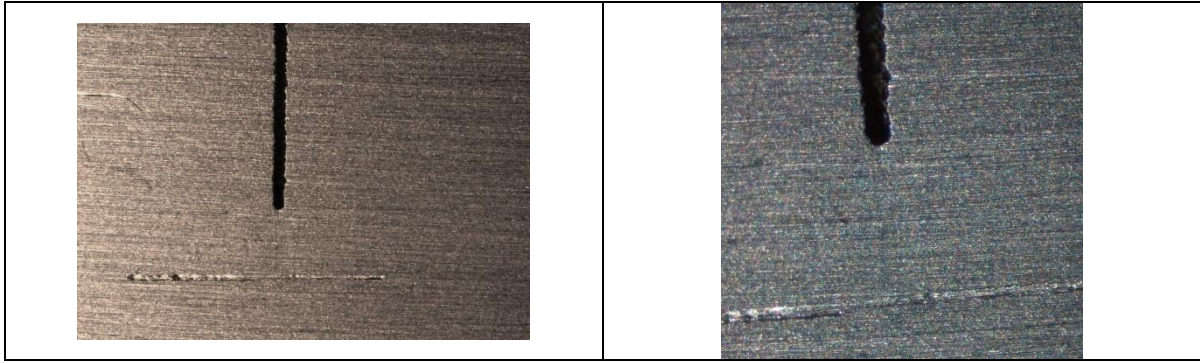


Figura C 90. Probeta D5 121

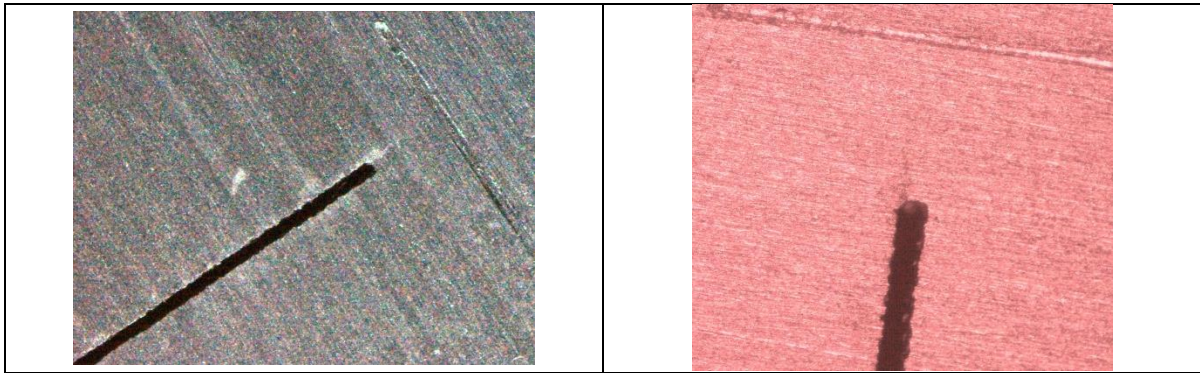


Figura C 91. Probeta D5 126



Figura C 92. Probeta D5 124

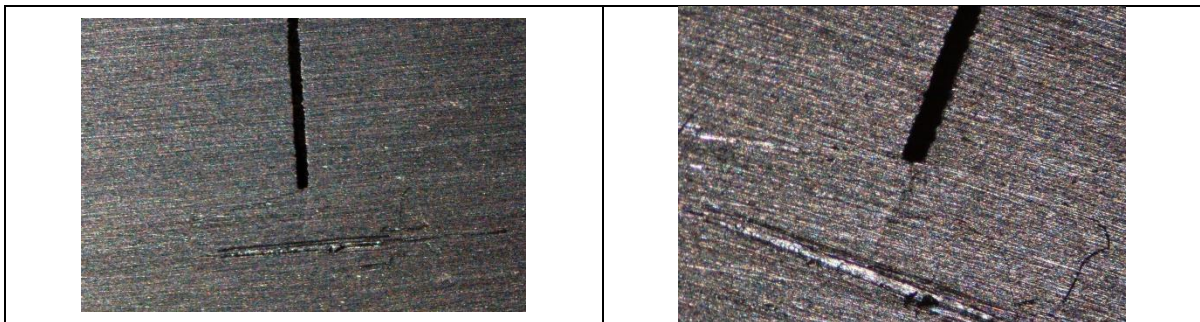


Figura C 93. Probeta D5 125

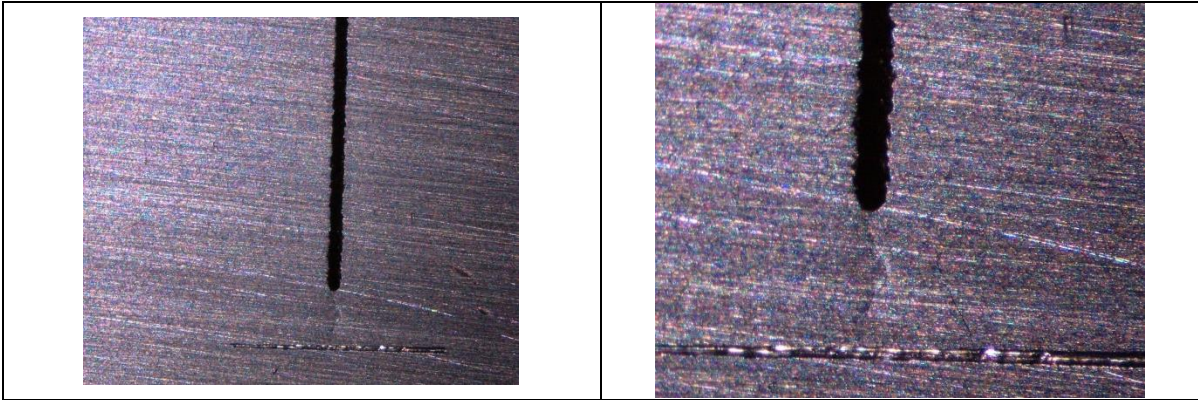


Figura C 94. Probeta D5 103

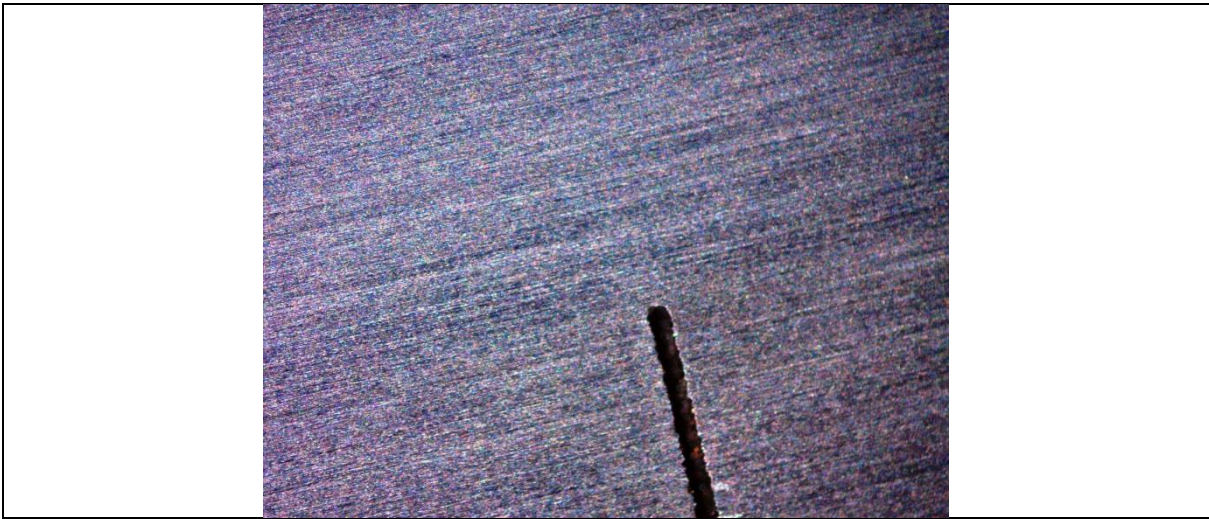


Figura C 95. Probeta D5 102

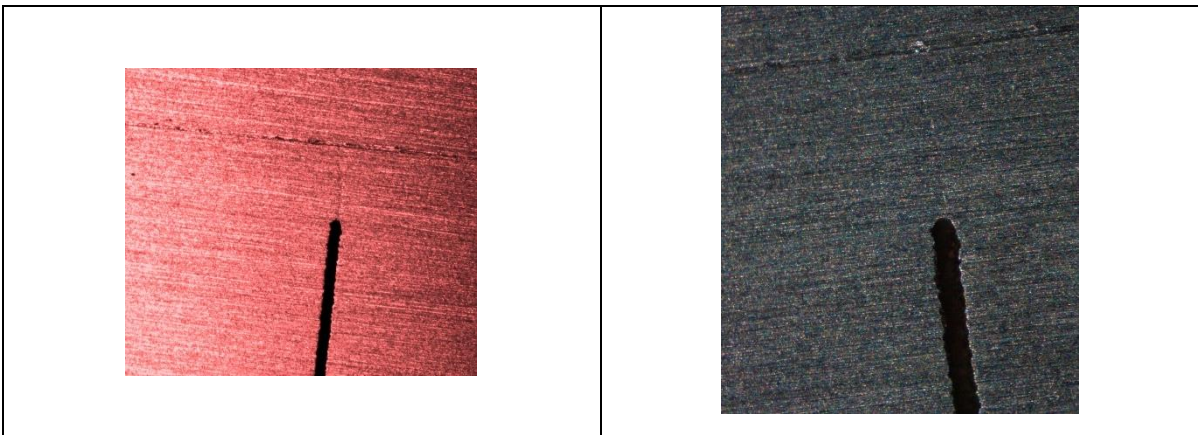


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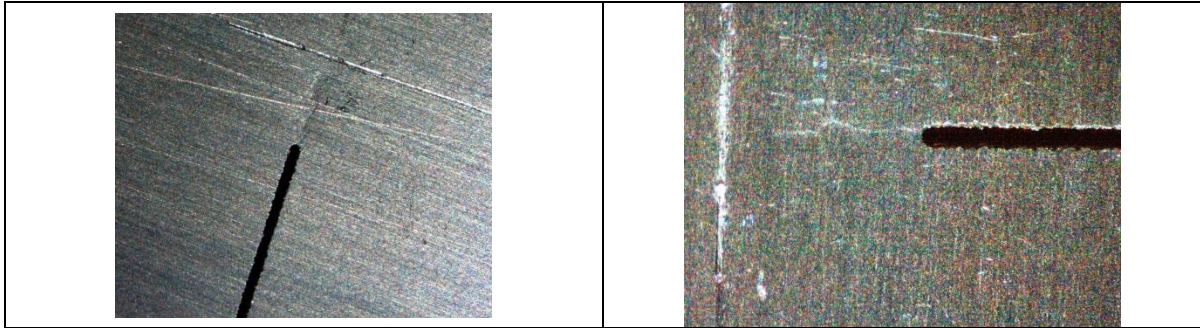


Figura C 97. Probeta D5 111



Figura C 98. Probeta D5 123

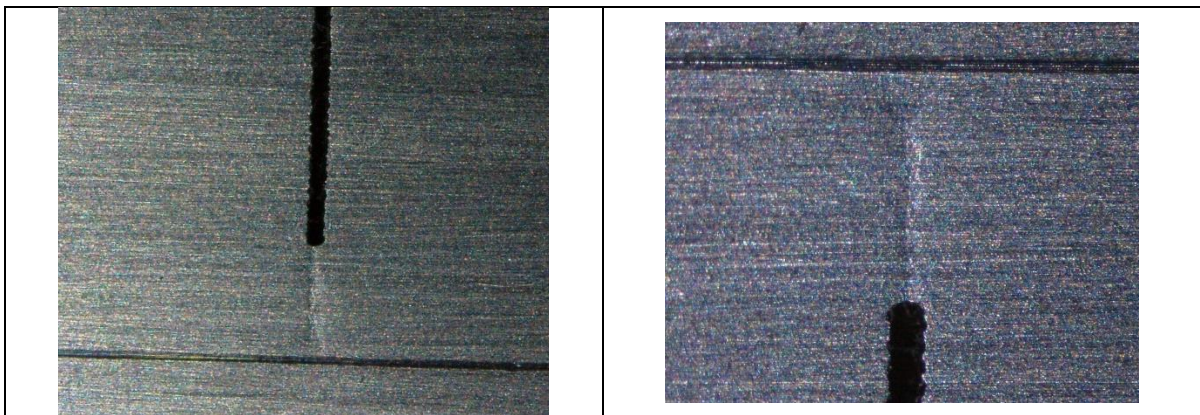


Figura C 99. Probeta D5 127

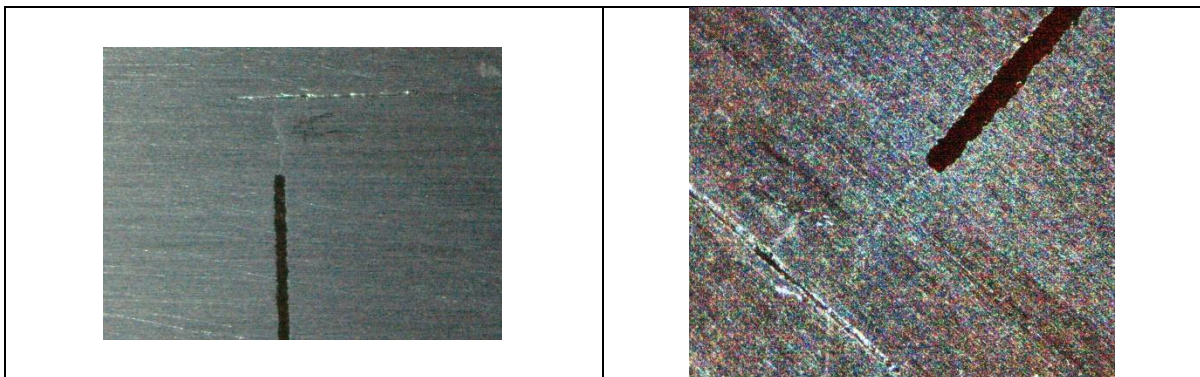


Figura C 100. Probeta D5 120

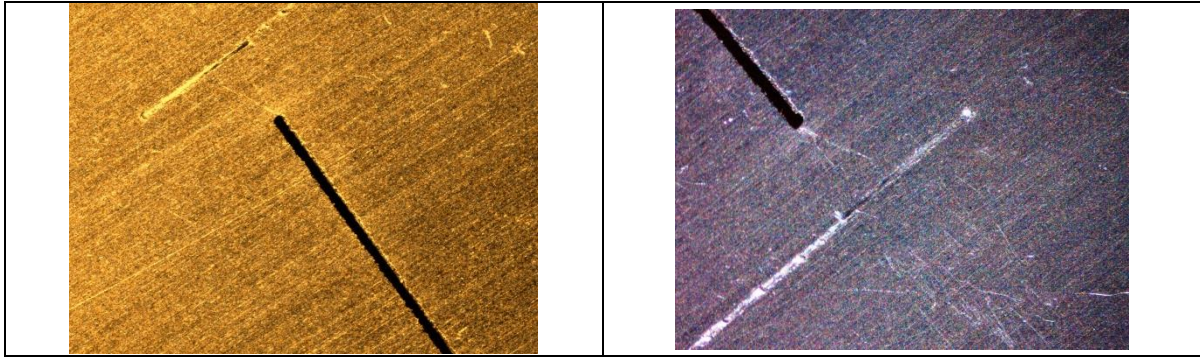


Figura C 101. Probeta D5 110

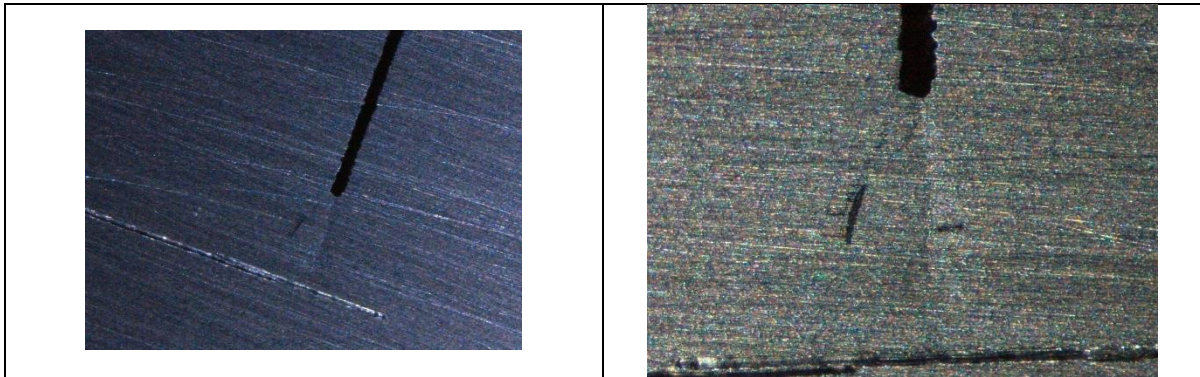


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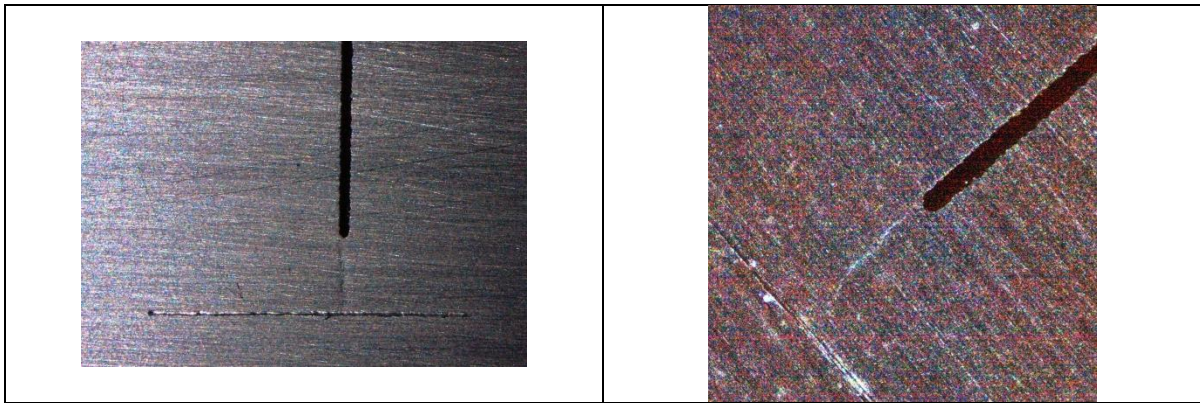


Figura C 103. Probeta D5 106



Figura C 104. Probeta D5 107

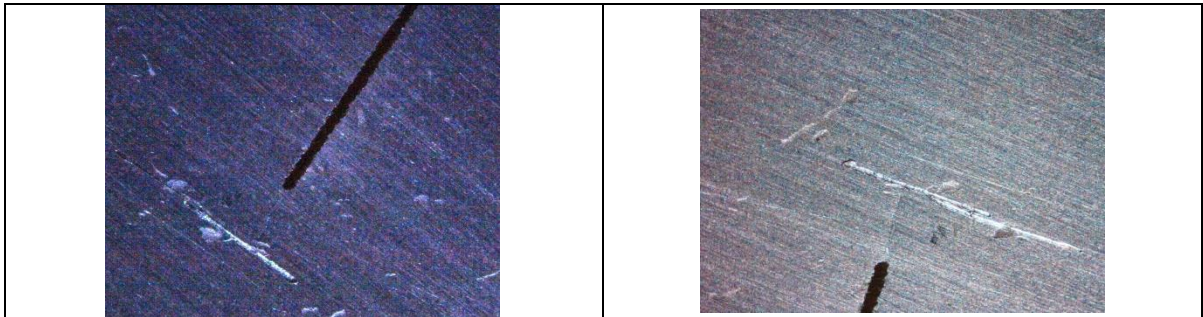


Figura C 105. Probeta D5 108

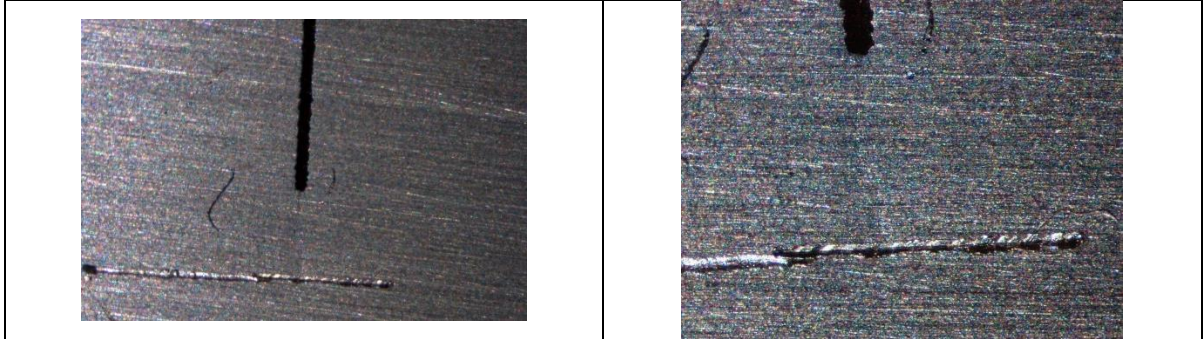


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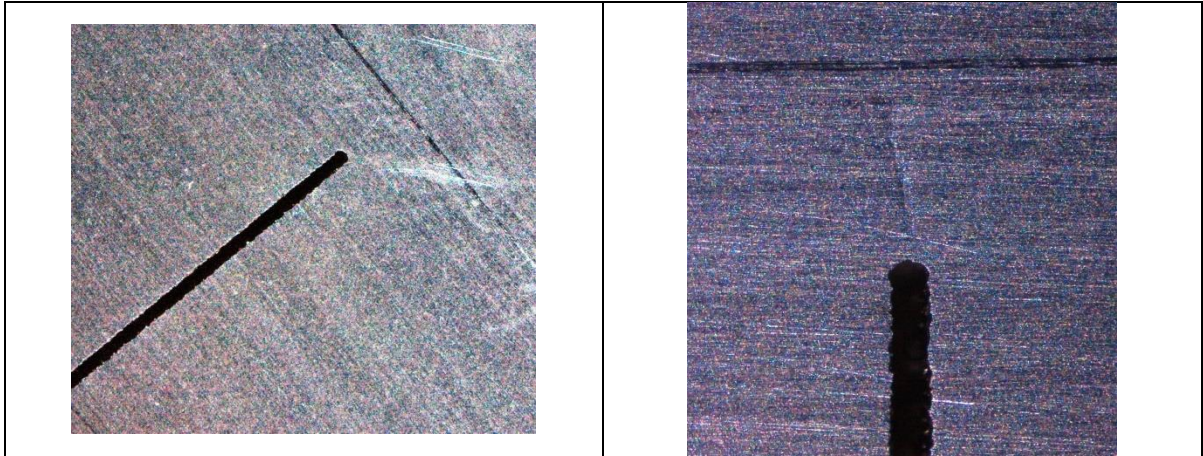


Figura C 107. Probeta D6 133



Figura C 108. Probeta D6 145

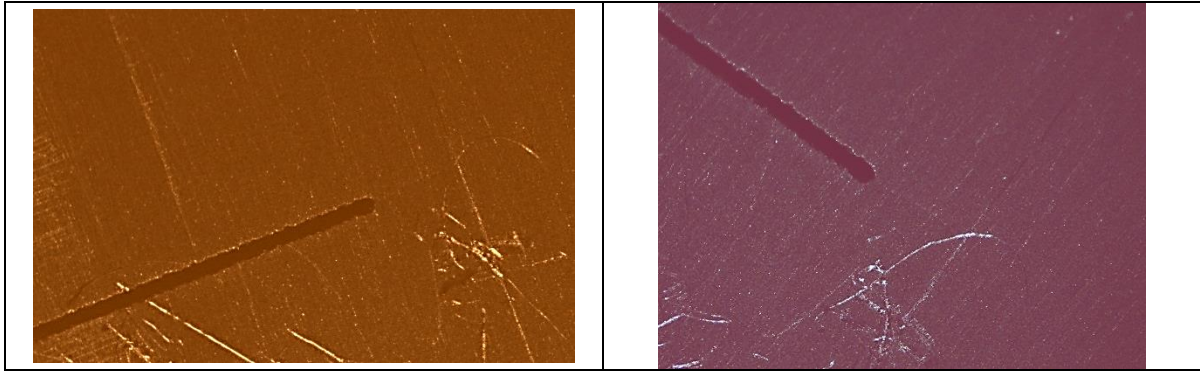


Figura C 109. Probeta D6 151

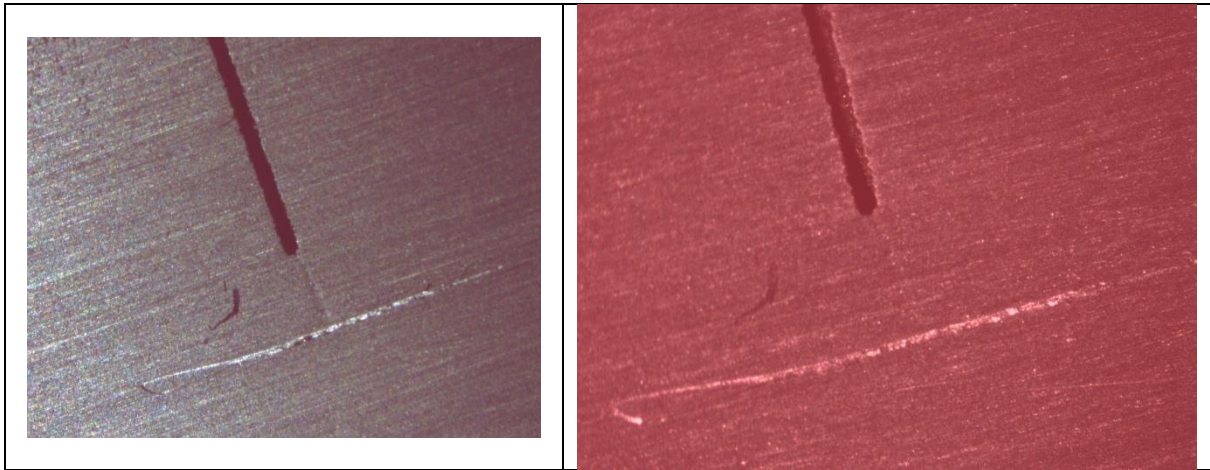


Figura C 110. Probeta D6 158



Figura C 111. Probeta D6 150

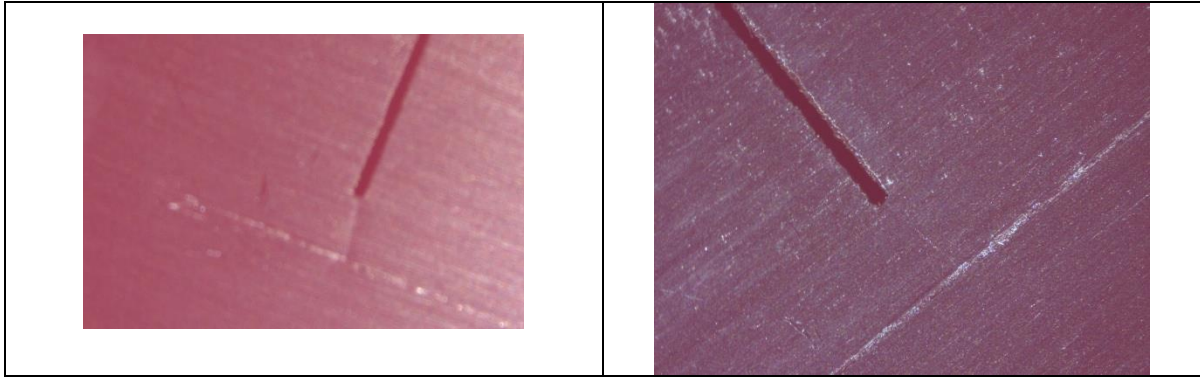


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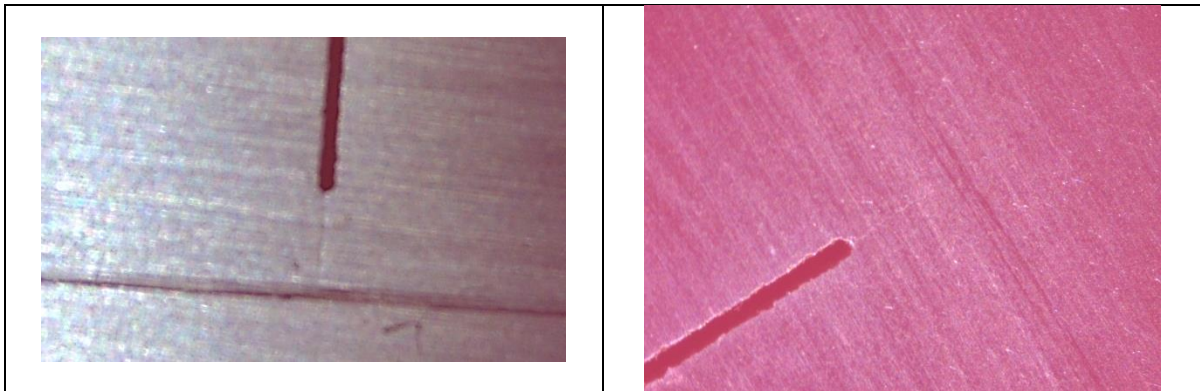


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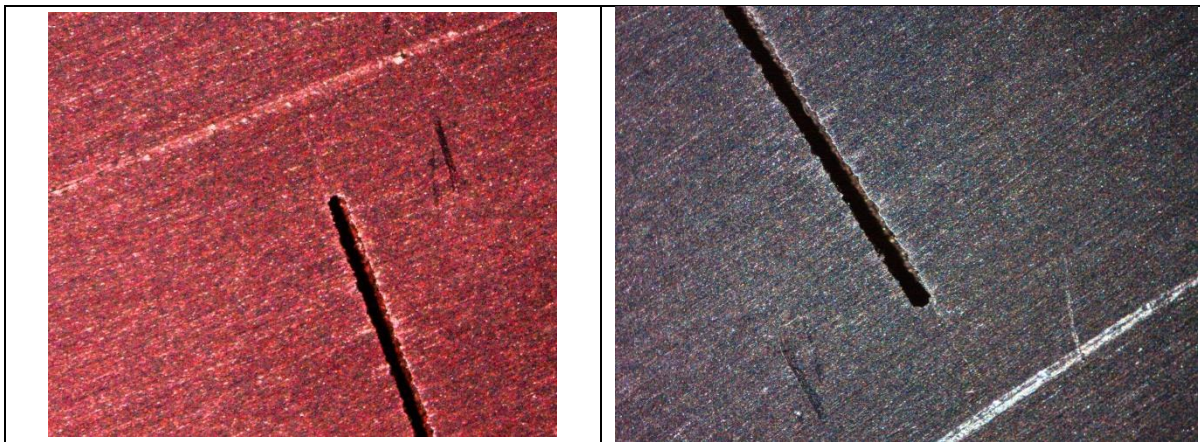


Figura C 114. Probeta D6 141



Figura C 115. Probeta D6 149

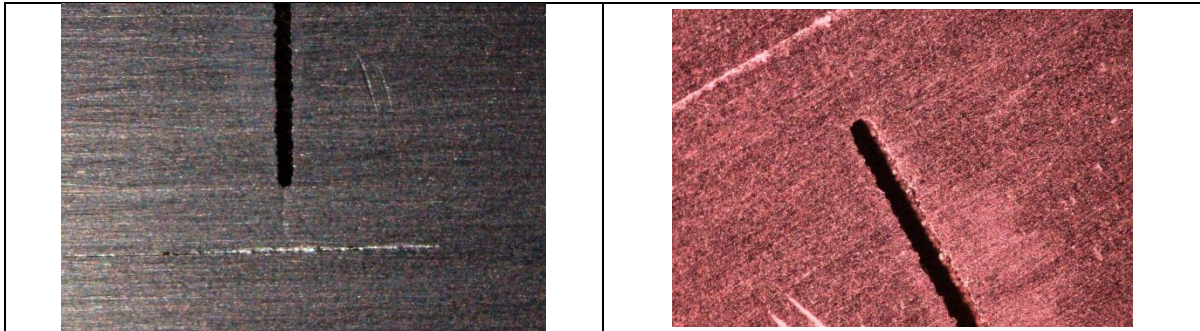


Figura C 116. Probeta D6 136

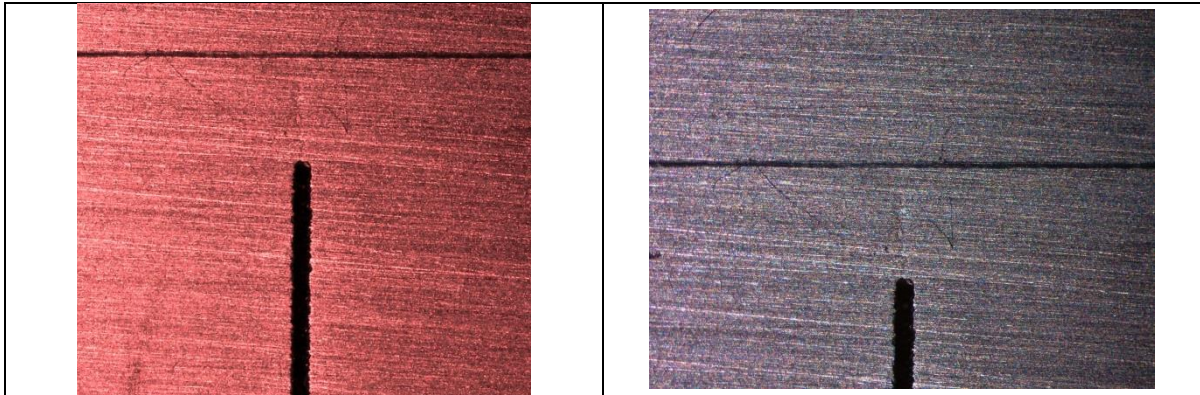


Figura C 117. Probeta D6 142



Figura C 118. Probeta D6 146

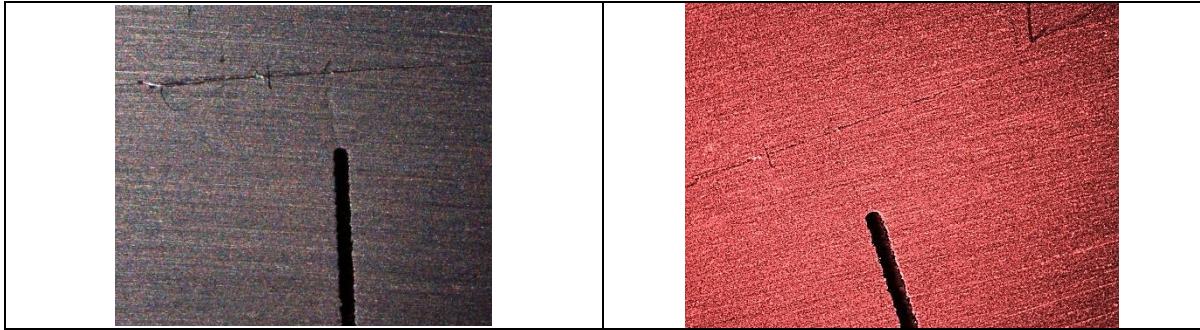


Figura C 119. Probeta D6 130

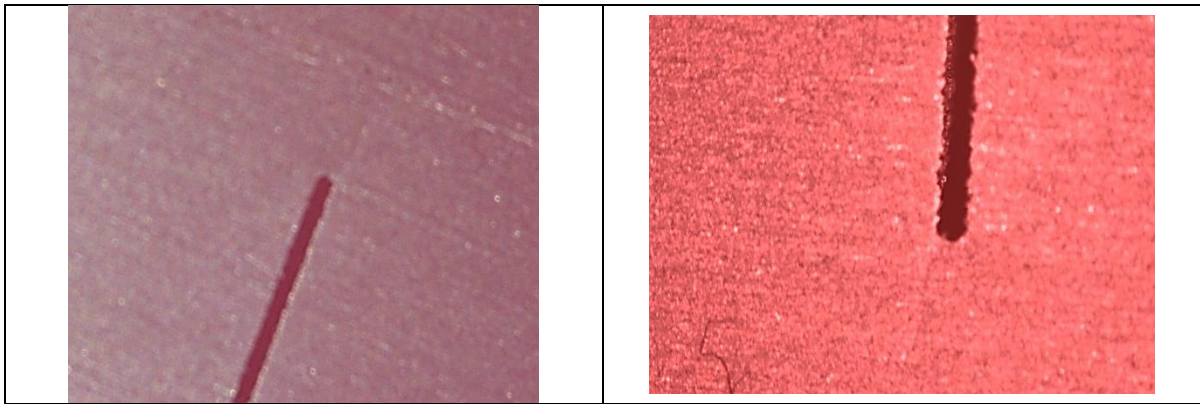


Figura C 120. Probeta D6 152



Figura C 121. Probeta D6 148

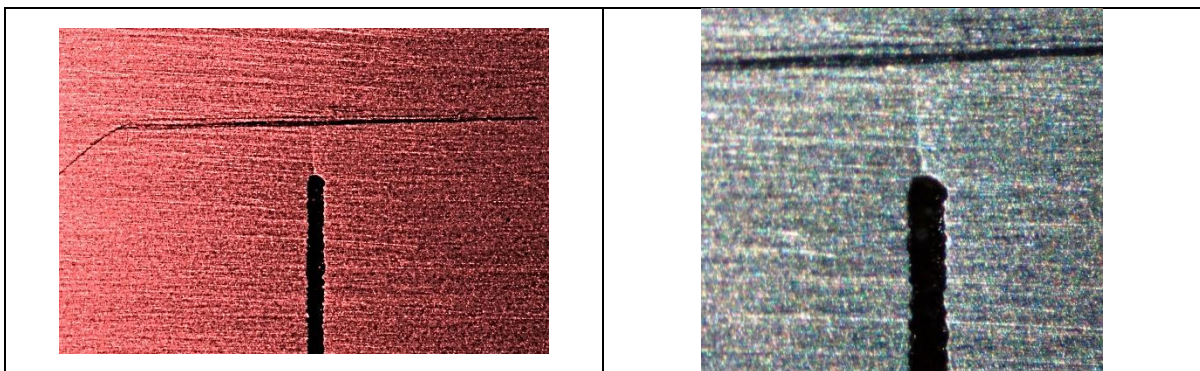


Figura C 122. Probeta D6 134

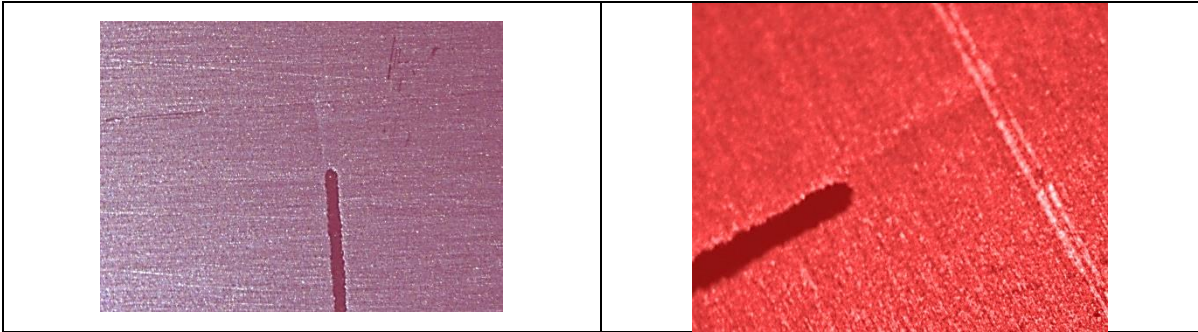


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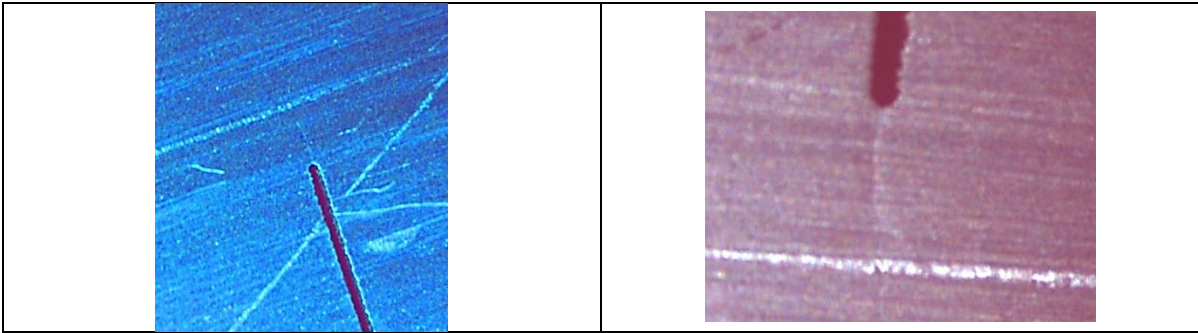


Figura C 124. Probeta D6 140

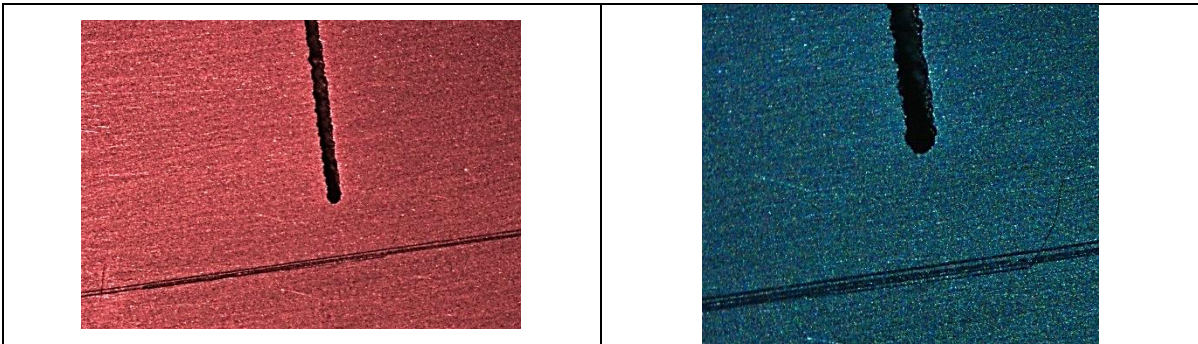


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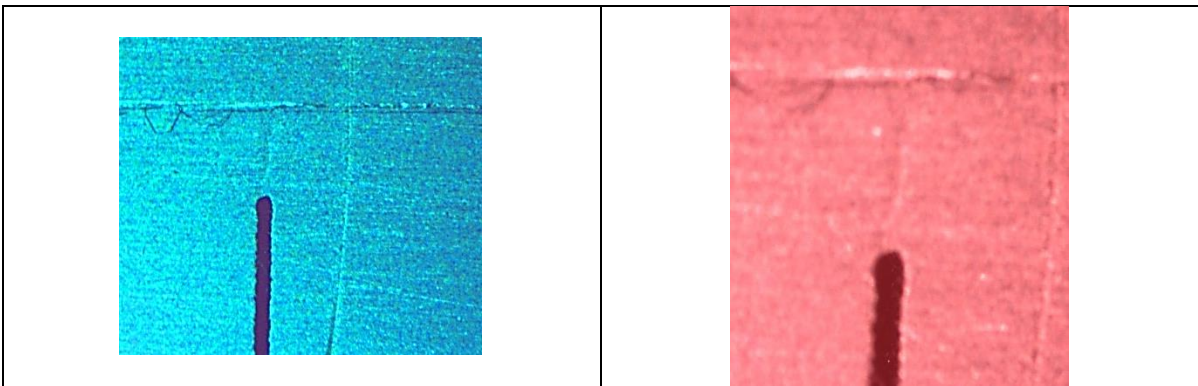


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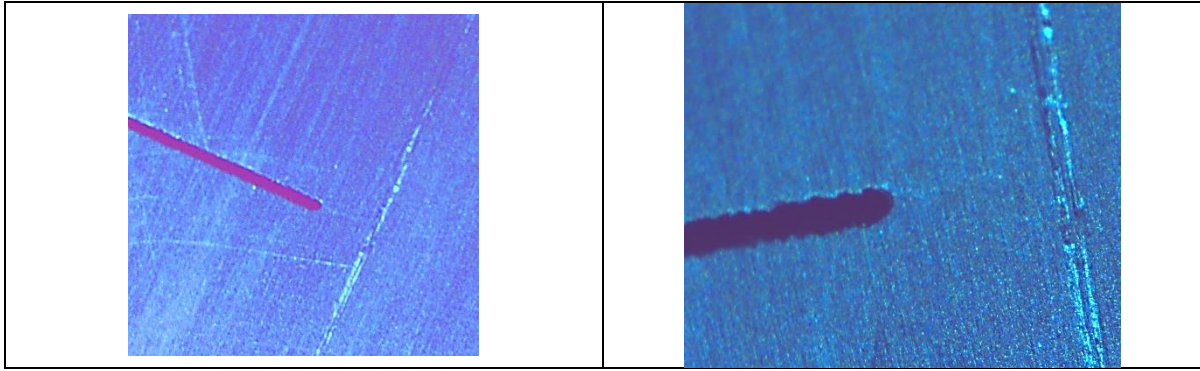


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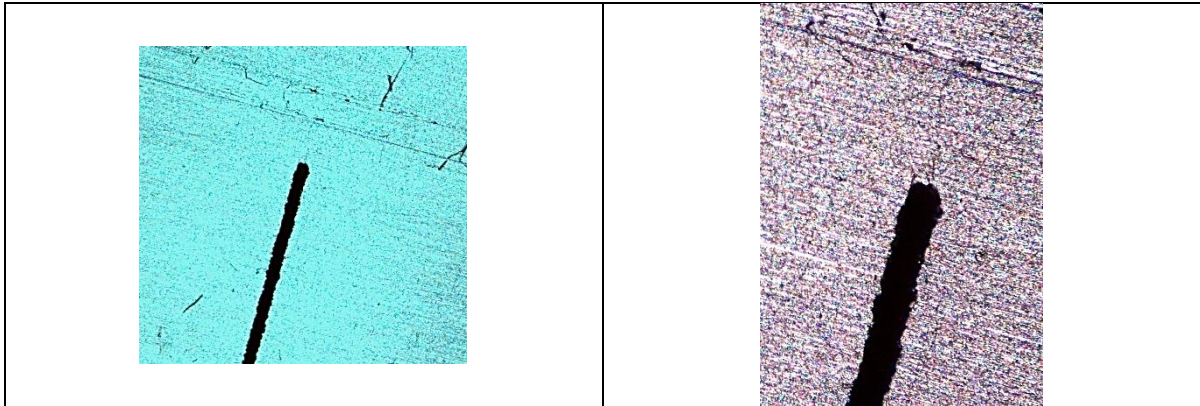


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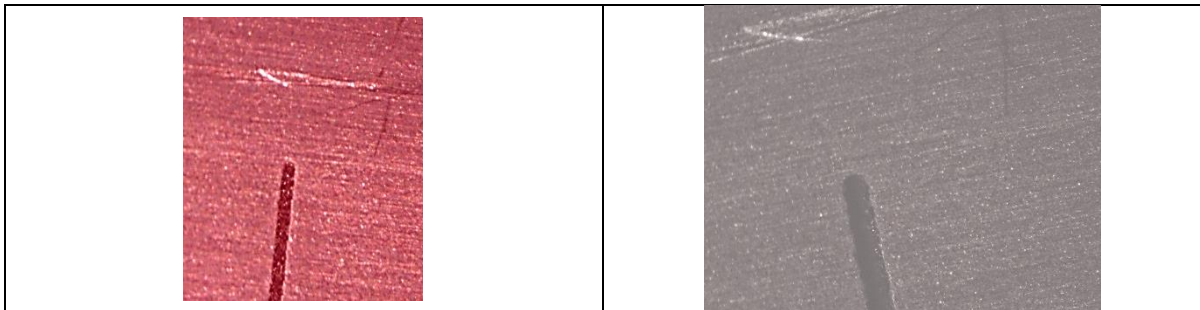


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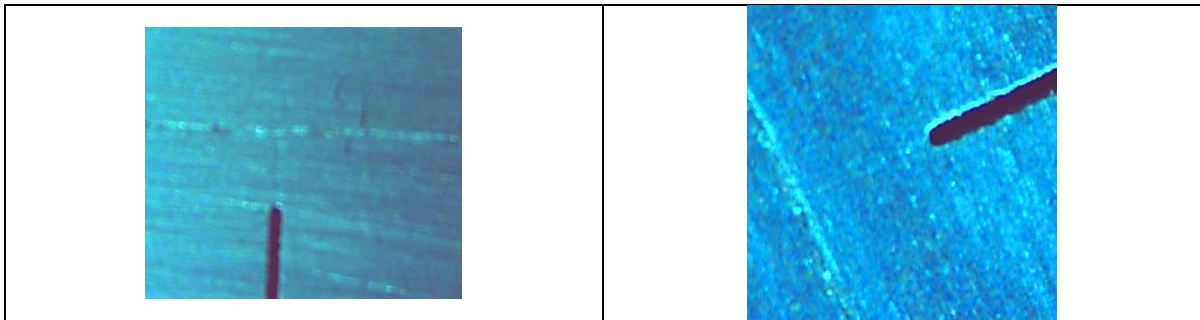


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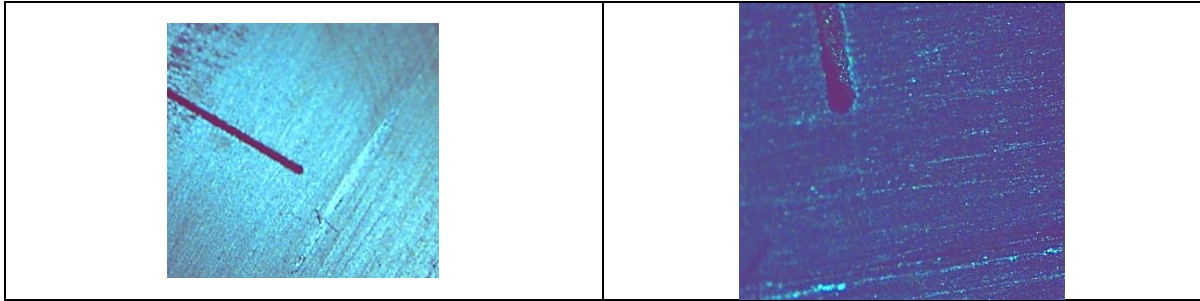


Figura C 131. Probeta D6 157

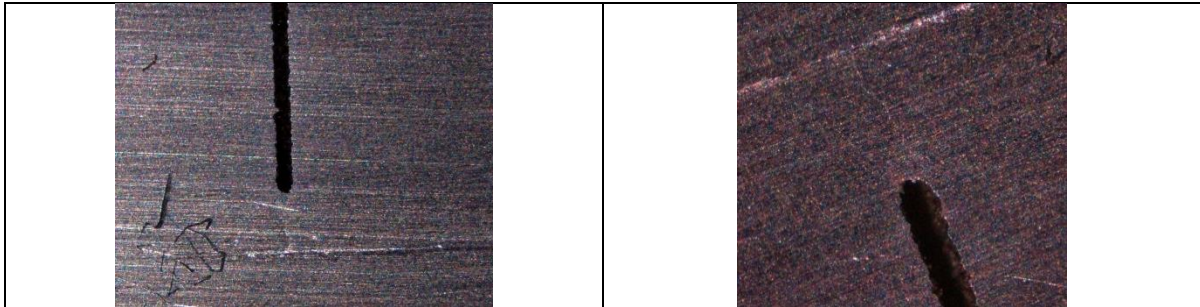


Figura C 132. Probeta D6 138

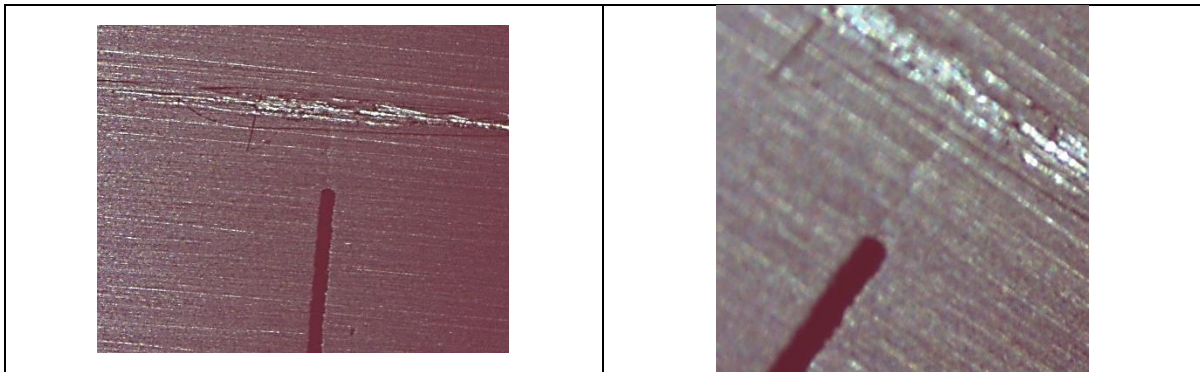


Figura C 133. Probeta D6 132

Anexo D

Tablas de datos de la prueba de flexión en tres puntos, carga máxima, esfuerzo máximo y energía.

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D152	307,5080	9,2253	139,1770	802,5710
D153	344,1540	10,3246	99,4494	387,0350
D154	356,9010	10,7070	81,9421	271,7000
D155	350,5270	10,5158	66,5460	194,1570
D161	350,5270	10,5158	66,5524	198,8970
D162	331,4080	9,9422	55,9585	205,0250
D163	348,9340	10,4680	64,3680	191,4230
D164	328,2210	9,8466	64,0764	201,1100
D168	379,2070	11,3762	75,5801	194,0810
D169	374,4270	11,2328	80,2134	224,2430
D170	396,7330	11,9020	87,3132	226,2570

Tabla D 1. Datos ensayo de flexión probetas D1

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D277	345,7480	10,3724	64,3074	185,3020
D278	333,0010	9,9900	62,3222	169,0340
D279	356,9010	10,7070	125,8170	658,3140
D280	336,1880	10,0856	72,8874	471,9490
D281	371,2400	11,1372	73,1200	289,5390
D286	301,1350	9,0341	50,0266	145,7110
D287	297,9480	8,9385	121,7810	712,7160
D288	305,9150	9,1775	48,4381	198,6330
D289	363,2740	10,8982	64,0525	158,1910
D290	334,5940	10,0378	58,5190	210,4420
D294	329,8140	9,8944	59,3522	202,3980
D295	334,5940	10,0378	60,6460	177,9980
D296	339,3740	10,1812	98,7755	522,7150
D297	313,8810	9,4164	47,5937	141,3850
D298	377,6140	11,3284	68,9249	195,3330

Tabla D 2. Datos ensayo de flexión probetas D2

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D324	403,1070	12,0932	104,0920	310,0420
D325	388,7670	11,6630	93,4522	239,7830
D326	331,4080	9,9422	61,8649	122,9830
D327	272,4550	8,1737	47,0727	125,7710
D329	283,6090	8,5083	44,1808	127,6110
D334	289,9820	8,6995	52,6492	126,0150
D335	336,1880	10,0856	62,9786	129,7640
D336	274,0490	8,2215	43,3571	95,4773
D337	320,2550	9,6076	59,6932	128,0160
D339	350,5270	10,5158	61,4937	127,3610
D344	299,5420	8,9863	49,6108	99,2232
D345	342,5610	10,2768	59,8382	110,9260
D346	353,7140	10,6114	88,3504	288,1420
D347	305,9150	9,1775	55,6781	108,7770
D348	302,7280	9,0819	57,7590	113,5790

Tabla D 3. Datos ensayo de flexión probetas D3

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D41	286,7950	8,6039	42,8982	88,5257
D42	229,4360	6,8831	34,6560	75,1277
D43	304,3220	9,1297	48,9384	86,5022
D44	285,2020	8,5561	51,9179	88,6755
D45	267,6760	8,0303	41,7861	84,1250
D48	310,6950	9,3208	50,1509	94,4083
D49	256,5220	7,6957	38,2680	87,1747
D410	253,3360	7,6001	45,1814	93,1208
D411	274,0490	8,2215	47,2591	106,2290
D412	320,2550	9,6076	59,0336	116,1270
D415	348,9340	10,4680	70,0354	166,0720
D416	289,9820	8,6995	65,2507	214,8000
D417	320,2550	9,6076	62,5437	152,3040
D418	417,4460	12,5234	94,2553	245,1540
D419	317,0680	9,5120	77,1065	173,0500

Tabla D 4. Datos ensayo de flexión probetas D4

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D5103	266,0820	7,9825	43,9816	66,8998
D5104	266,0820	7,9825	39,5363	54,3493
D5106	235,8090	7,0743	32,1736	45,8076
D5107	248,5560	7,4567	44,6556	75,2917
D5108	258,1160	7,7435	35,8845	48,2756
D5112	215,0960	6,4529	26,7580	45,5702
D5114	199,1630	5,9749	25,5582	42,1716
D5115	234,2160	7,0265	32,0271	45,5654
D5116	259,7090	7,7913	36,8962	51,6582
D5117	286,7950	8,6039	44,3863	65,1121
D5121	242,1830	7,2655	31,2973	65,5216
D5123	243,7760	7,3133	31,6957	48,4238
D5124	216,6900	6,5007	27,5658	43,5961
D5125	248,5560	7,4567	34,6098	54,8878
D5126	264,4890	7,9347	35,0432	50,1875

Tabla D 5. Datos ensayo de flexión probetas D5

	Carga Máxima	Esfuerzo Máximo	Energía al máximo	Energía
Probeta	kgf	kgf/mm2	kgf.mm	kgf.mm
D6130	235,8090	7,0743	29,2308	48,8826
D6131	254,9290	7,6479	37,8729	68,7065
D6132	208,7230	6,2617	28,3943	59,7888
D6134	246,9630	7,4089	33,6012	53,2451
D6137	192,7900	5,7837	27,9912	49,3813
D6140	210,3160	6,3095	29,3312	53,1846
D6141	223,0630	6,6919	28,5871	59,0591
D6142	246,9630	7,4089	34,9396	47,1762
D6144	227,8430	6,8353	28,1553	38,6807
D6145	226,2500	6,7875	29,9940	39,1029
D6150	227,8430	6,8353	30,6711	48,3186
D6151	213,5030	6,4051	25,1950	47,7880
D6152	200,7570	6,0227	27,4415	46,6297
D6153	223,0630	6,6919	29,8936	48,7201
D6154	218,2830	6,5485	28,9711	42,3931

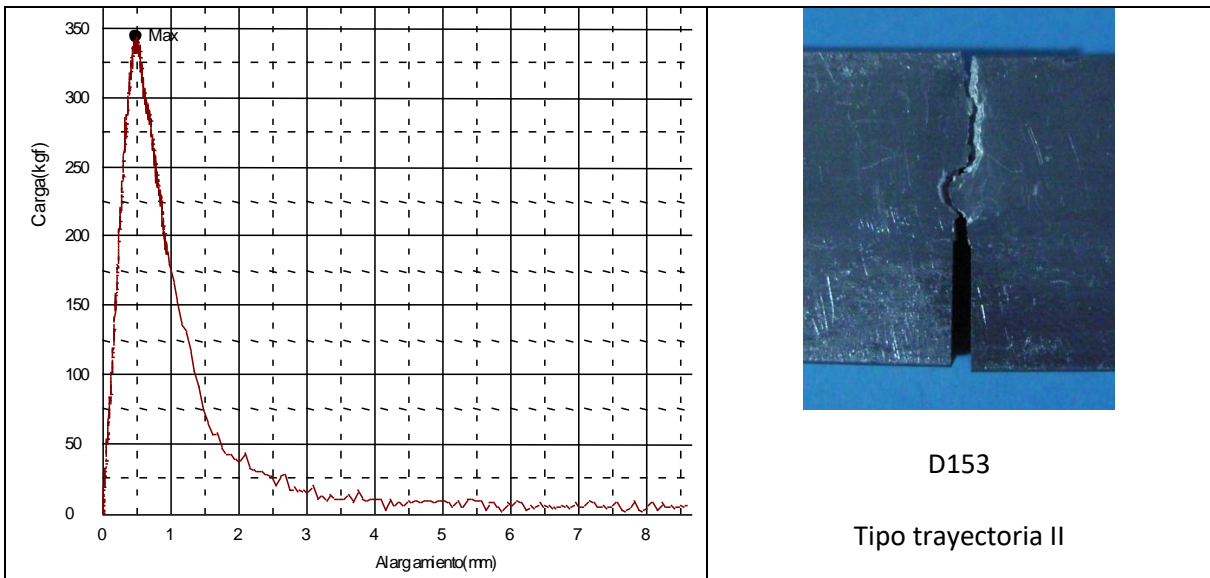
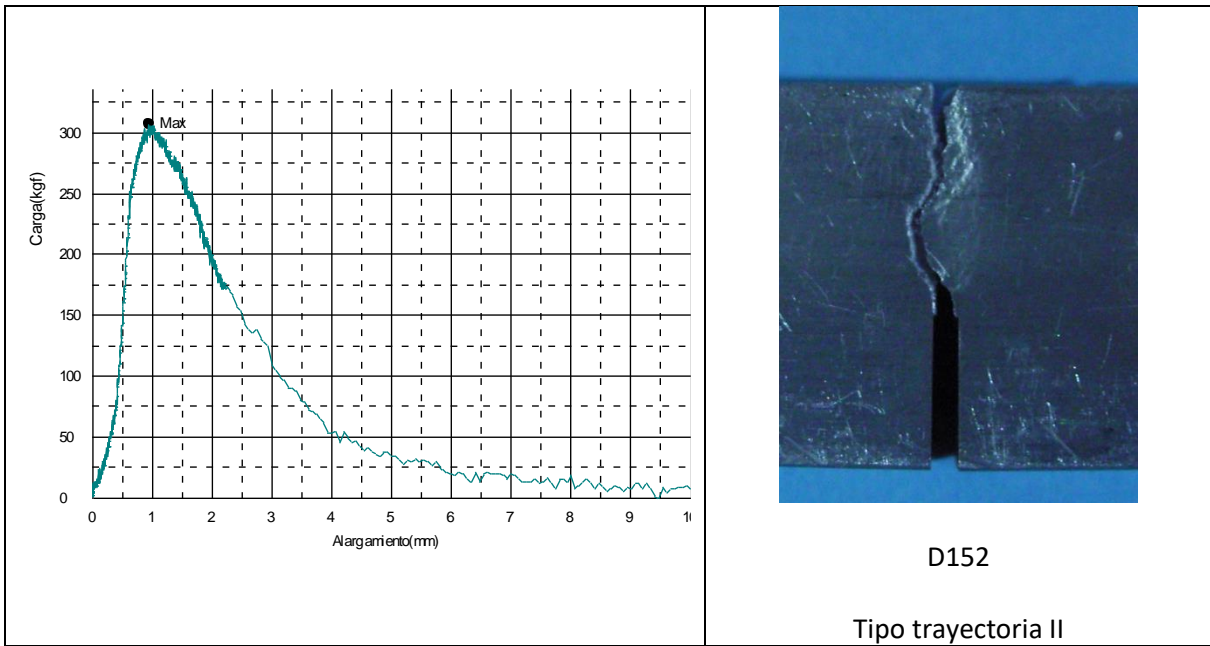
Tabla D 6. Datos ensayo de flexión probetas D6

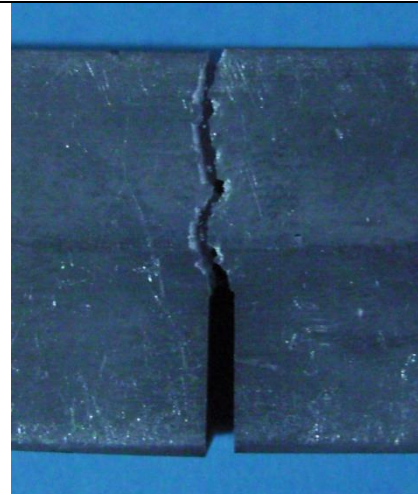
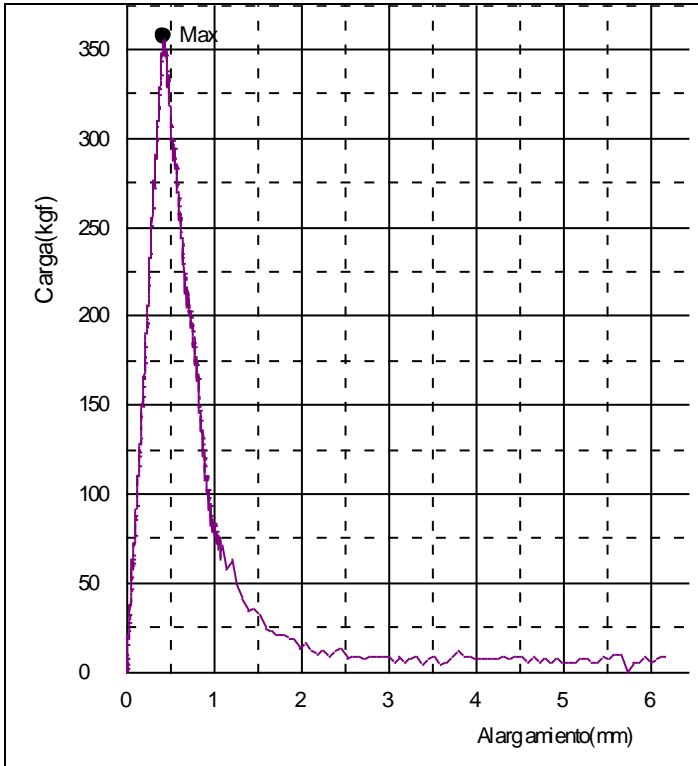
Anexo E

Gráficas carga Vs. deformación, obtenidas en la máquina universal de ensayos del ensayo de flexión en tres puntos

Tipografías trayectorias de grietas

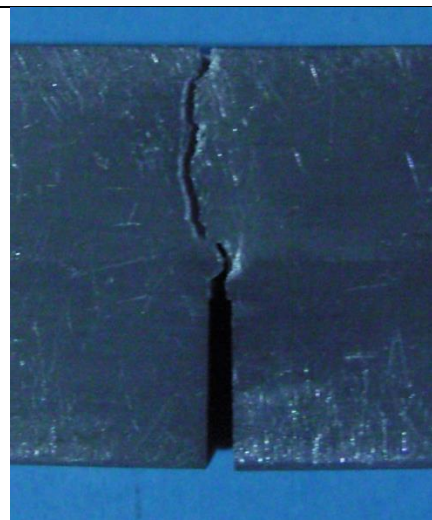
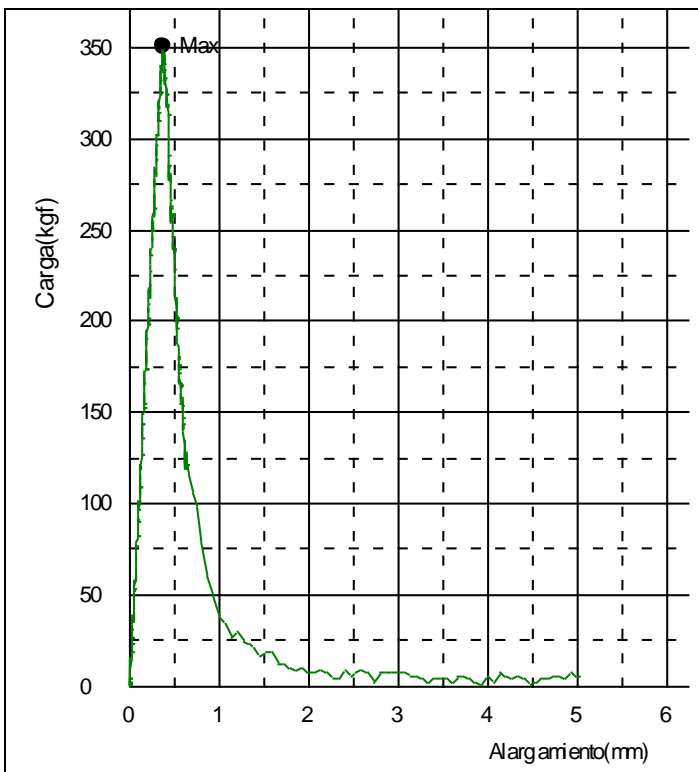
Figura E 1. Figuras ensayo de flexión, probetas D1 temperatura de envejecimiento 167°C





D154

Tipo trayectoria II

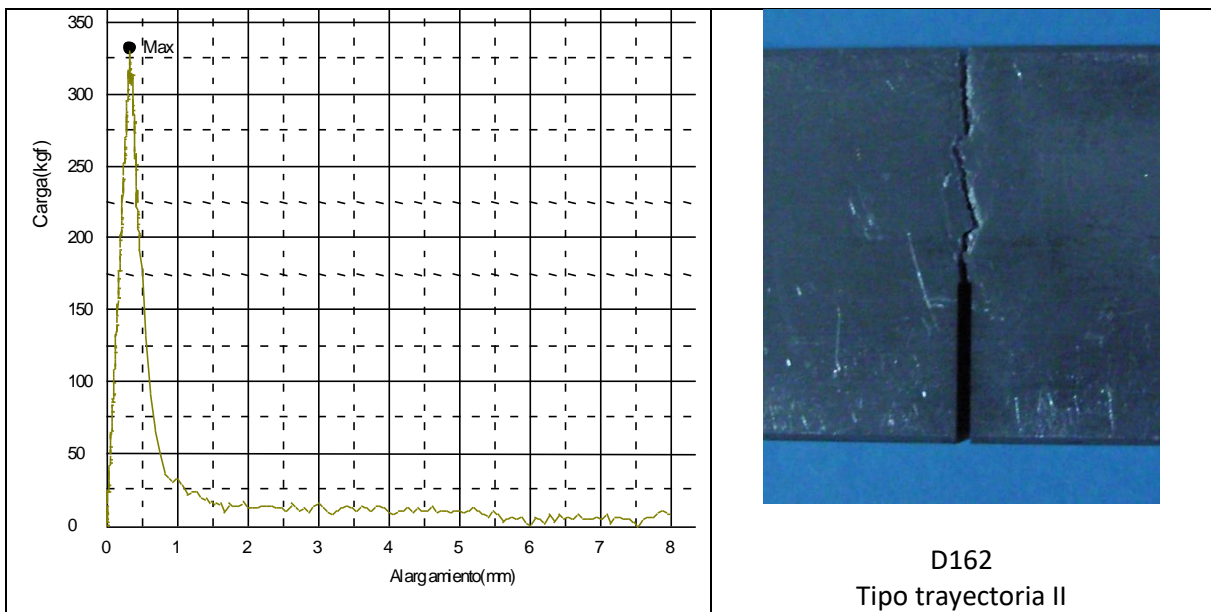
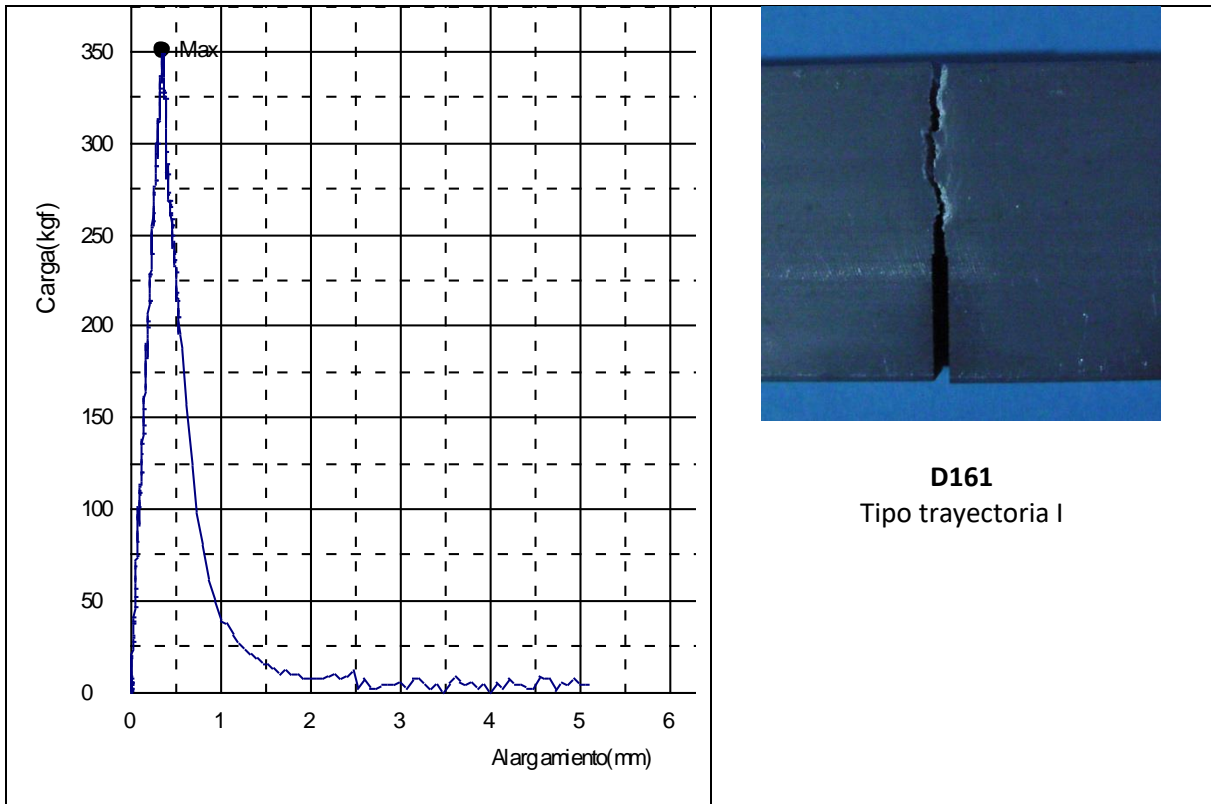


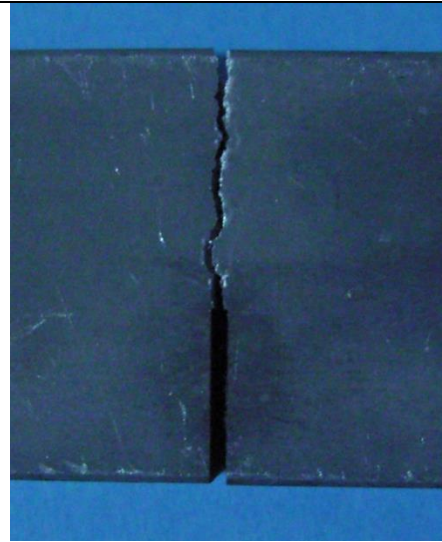
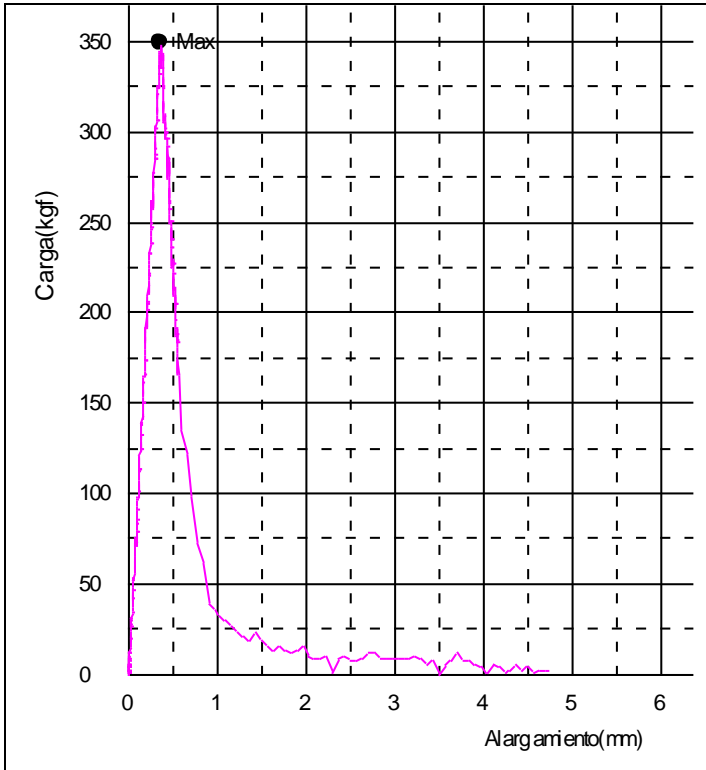
D155

Tipo trayectoria II

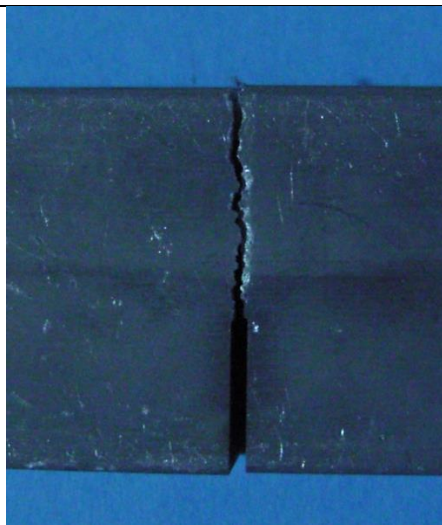
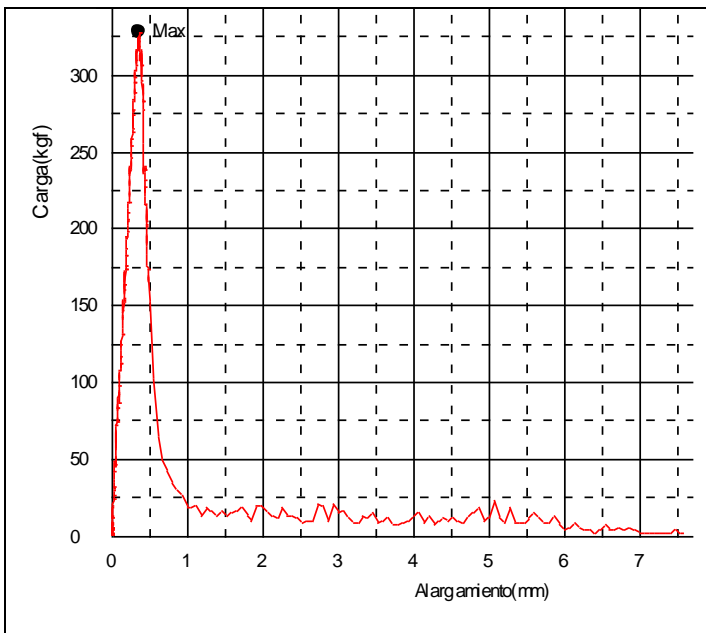
Temperatura de envejecimiento	Probeta	Tipo de gráfica
167 °C	D152	D
	D153	D
	D154	L
	D155	L

Figura E 2. Figuras ensayo de flexión, probetas D1 temperatura de envejecimiento 177°C





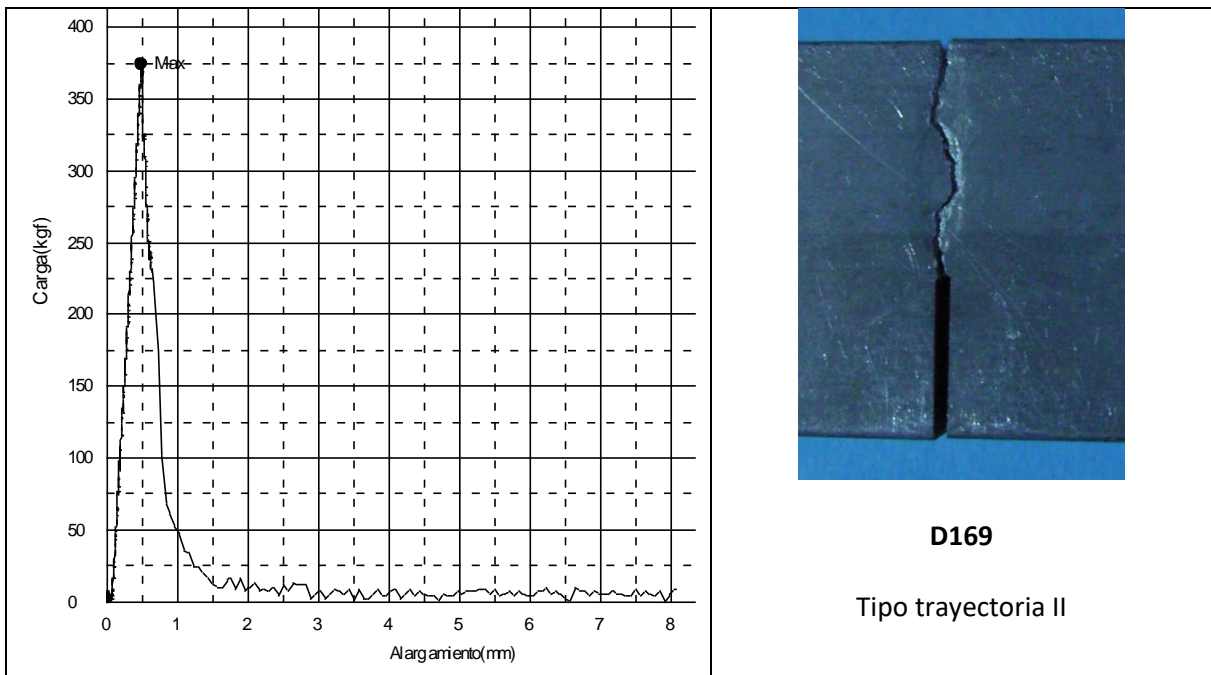
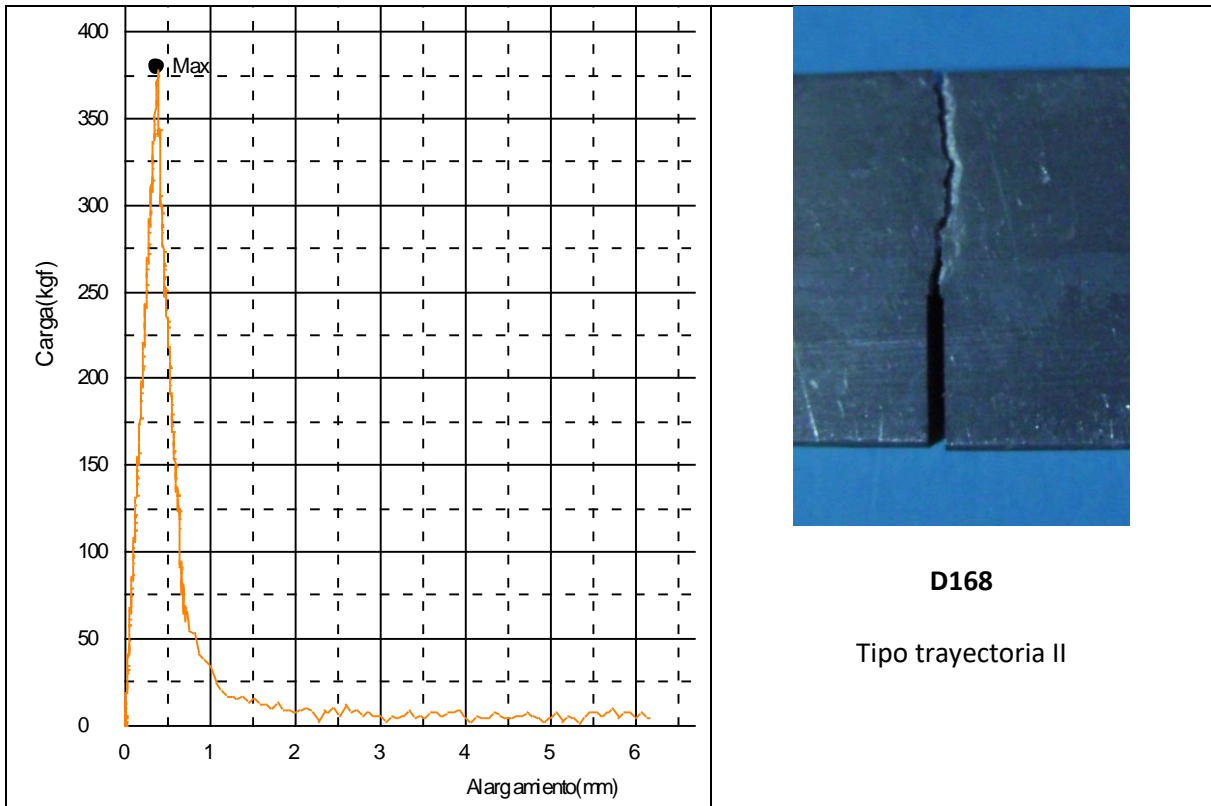
D163
Tipo trayectoria I

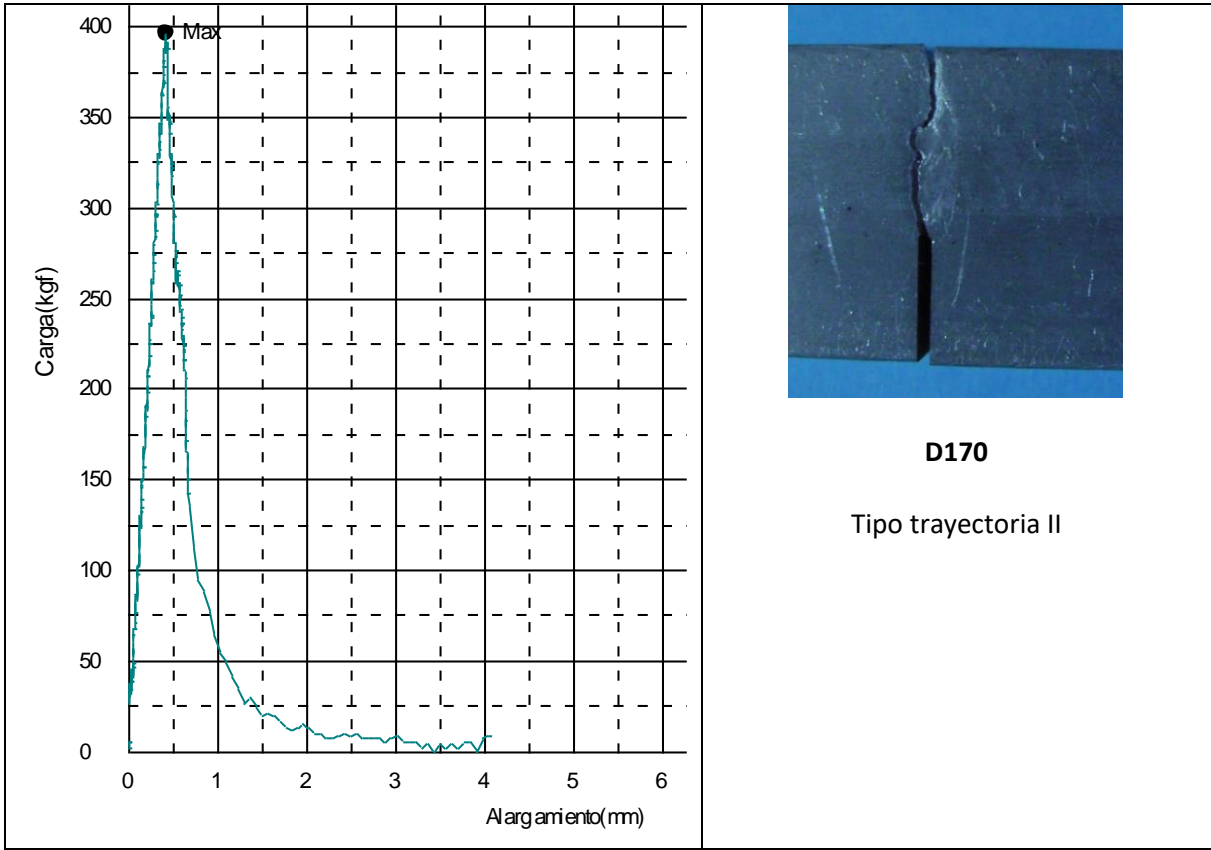


D164
Tipo trayectoria I

Temperatura de envejecimiento	Probeta	Tipo de gráfica
177 °C	D161	L
	D162	L
	D163	L
	D164	L

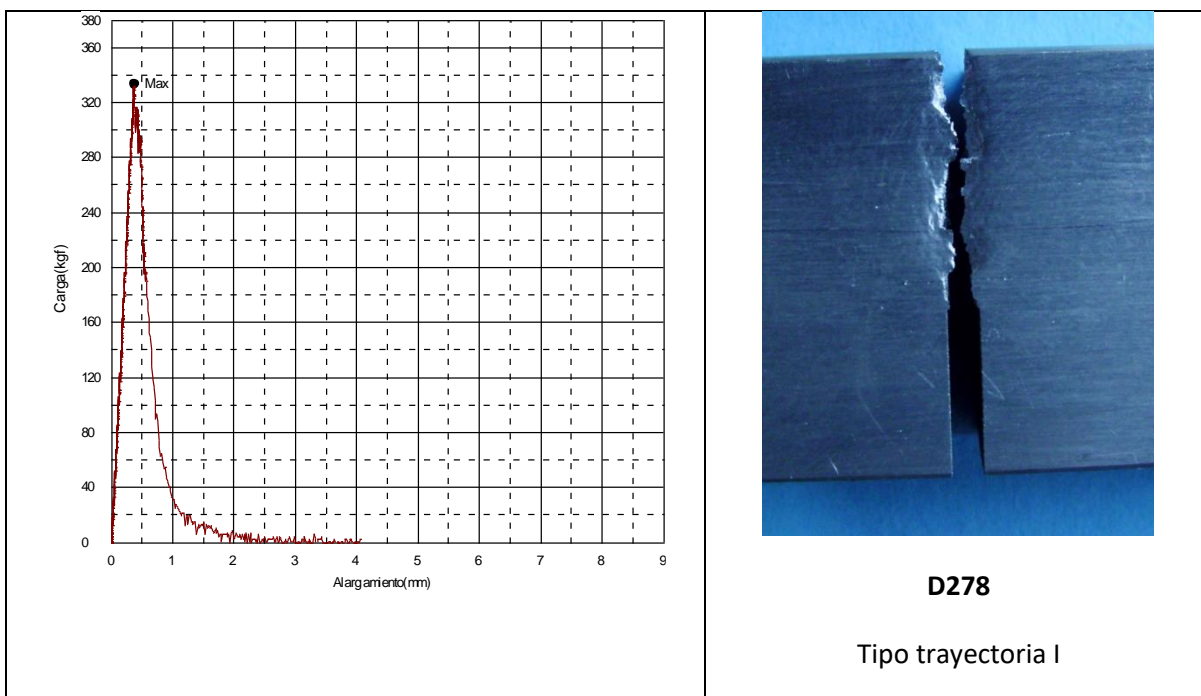
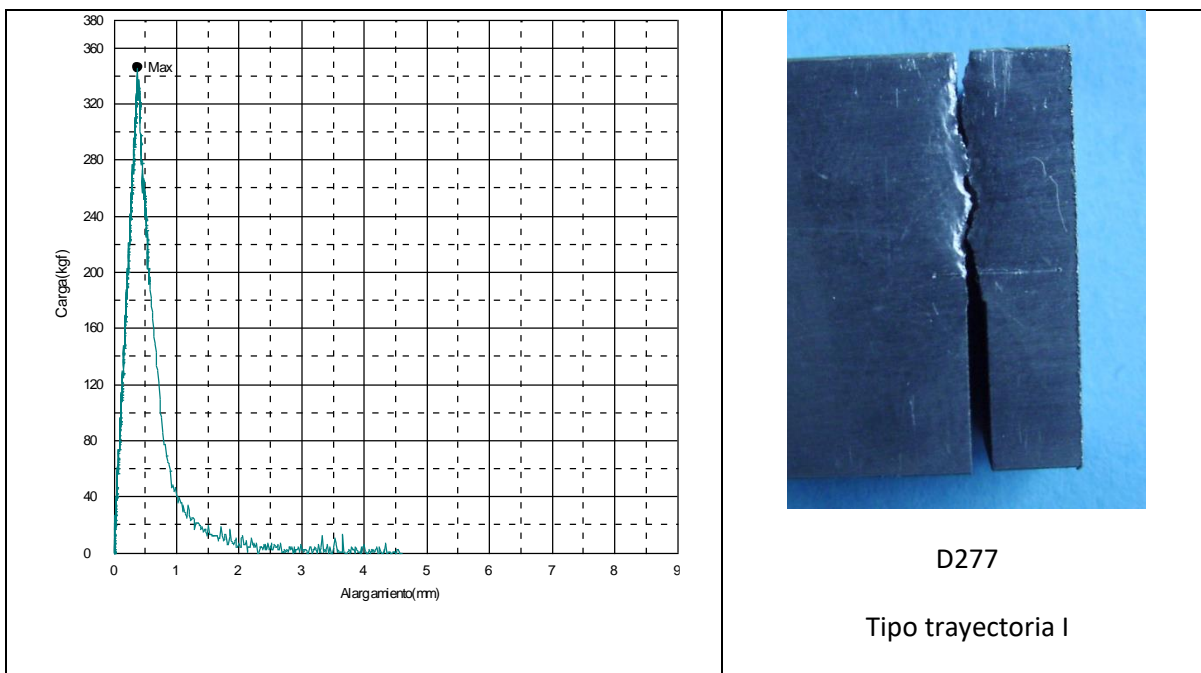
Figura E 3. Graficas ensayo de flexión, probetas D2 temperatura de envejecimiento 187°C

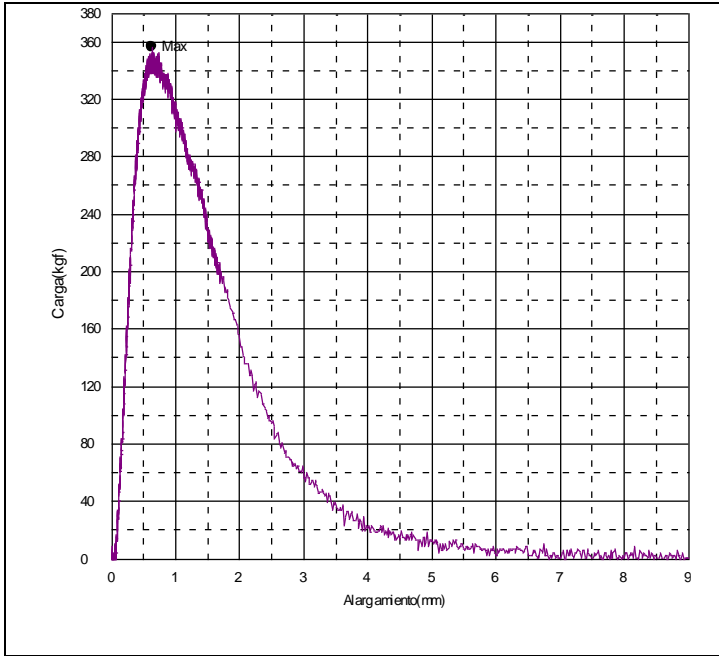




Temperatura de envejecimiento	Probeta	Tipo de gráfica
187 °C	D168	L
	D169	L
	D170	L

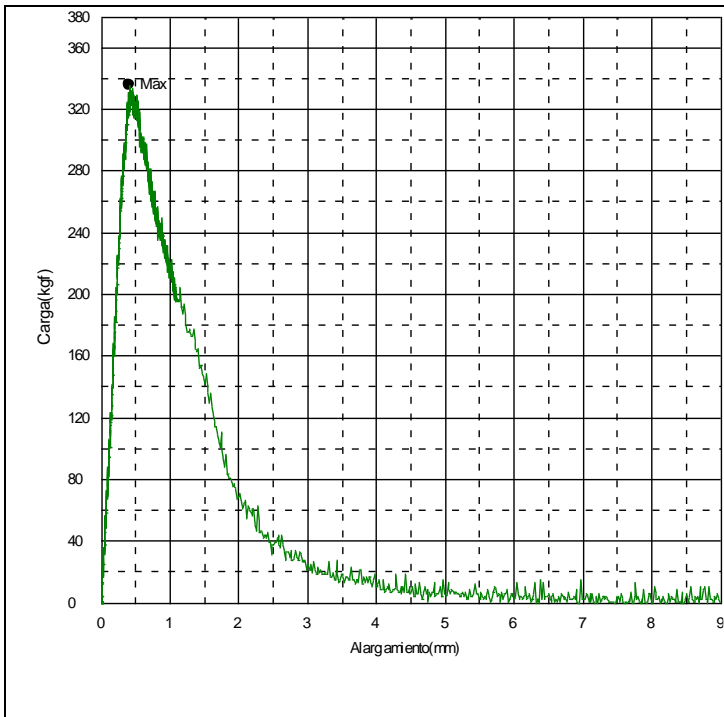
Figura E 4. Graficas ensayo de flexión, probetas D2 temperatura de envejecimiento 167°C





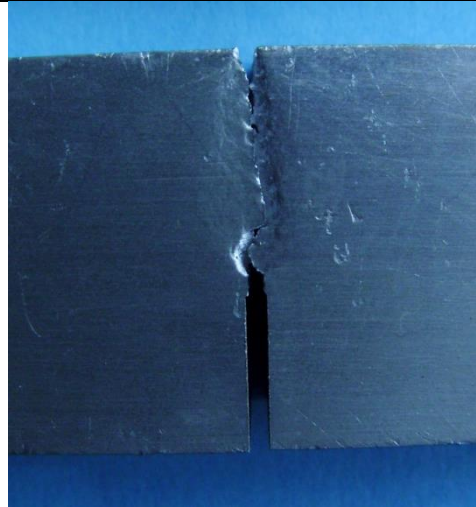
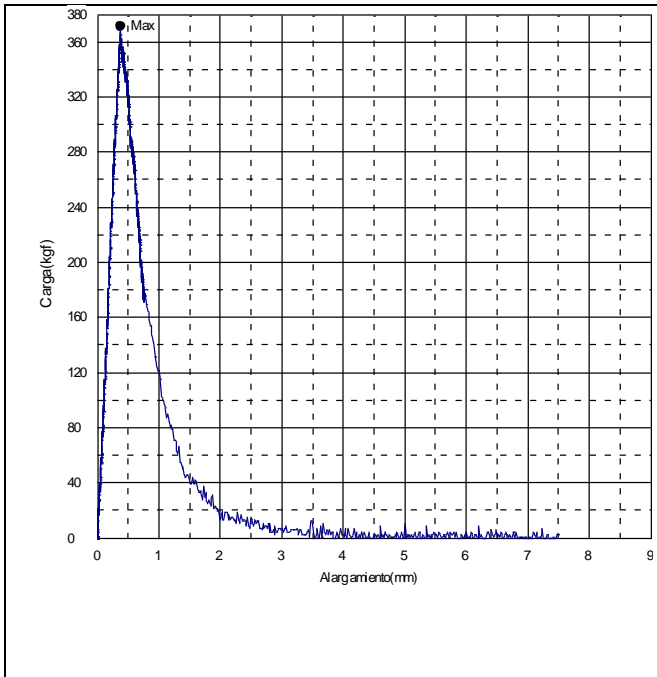
D279

Tipo trayectoria II



D280

Tipo trayectoria II

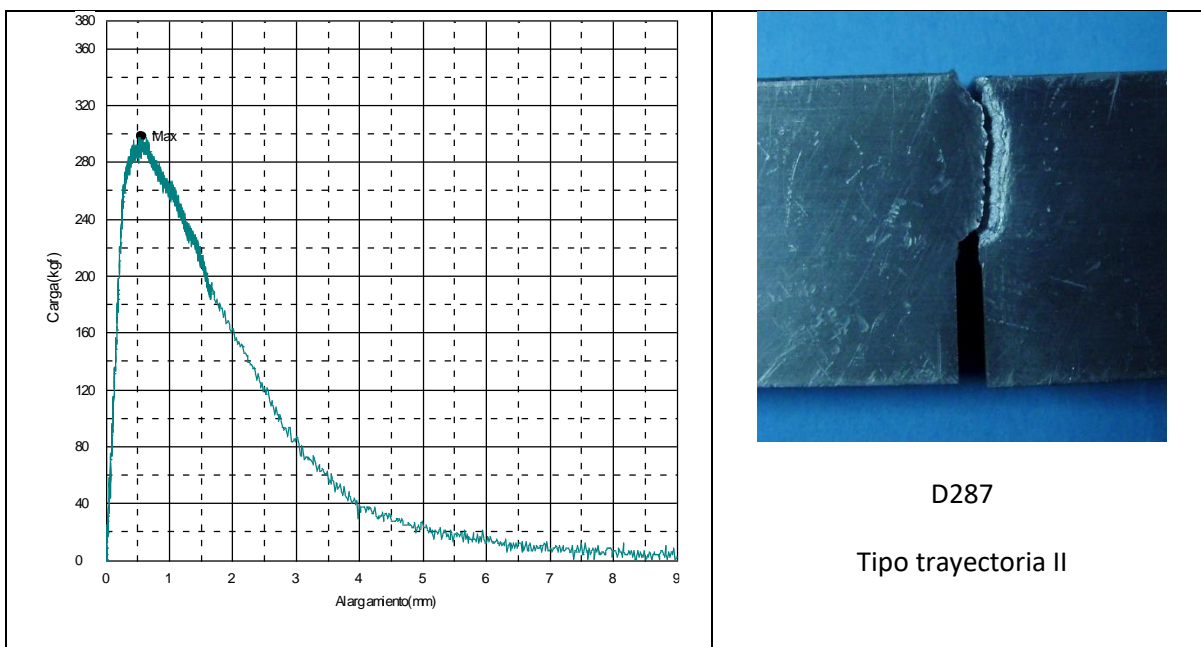
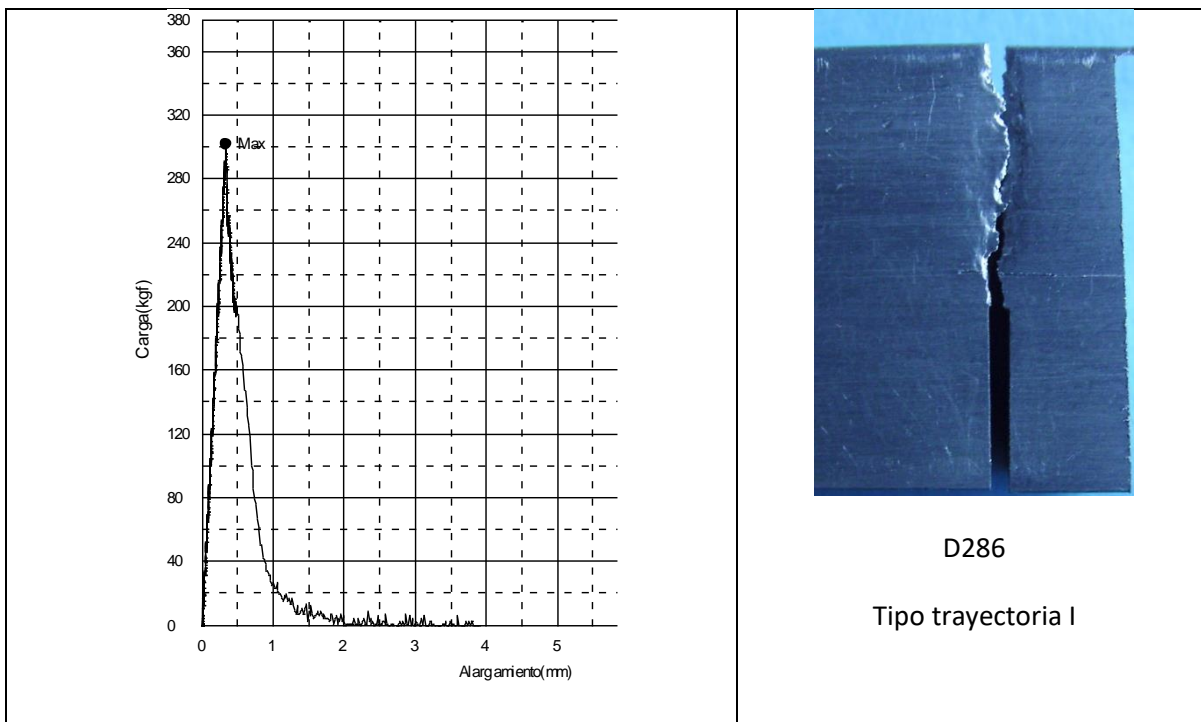


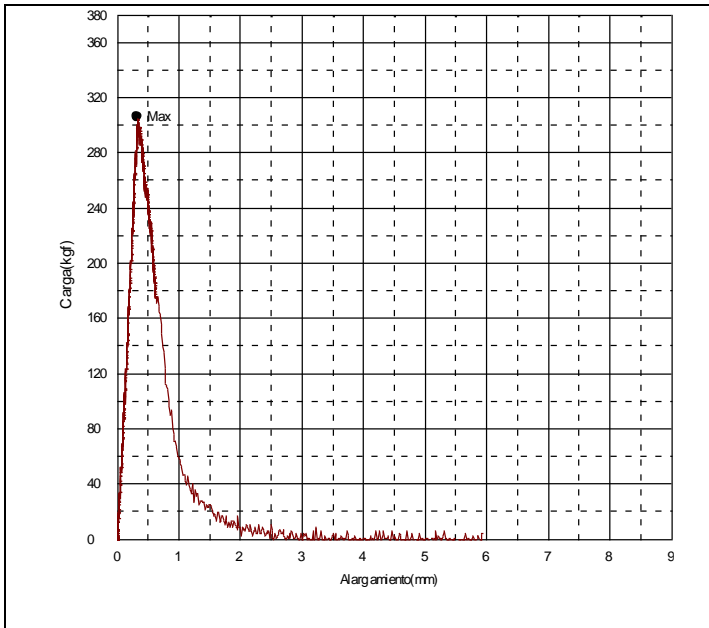
D281

Tipo trayectoria II

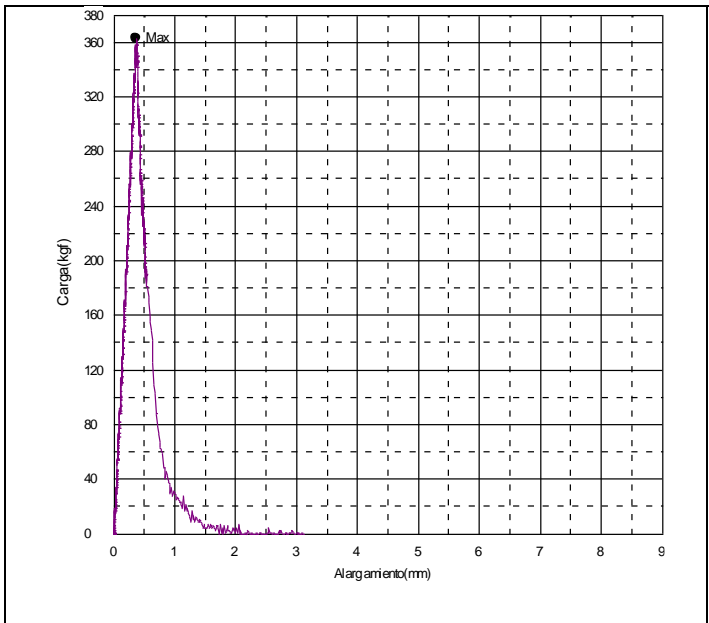
Temperatura de envejecimiento	Probeta	Tipo de gráfica
167 °C	D277	L
	D278	L
	D279	D
	D280	D
	D281	L

Figura E 5. Graficas ensayo de flexión, probetas D2 temperatura de envejecimiento 177°C

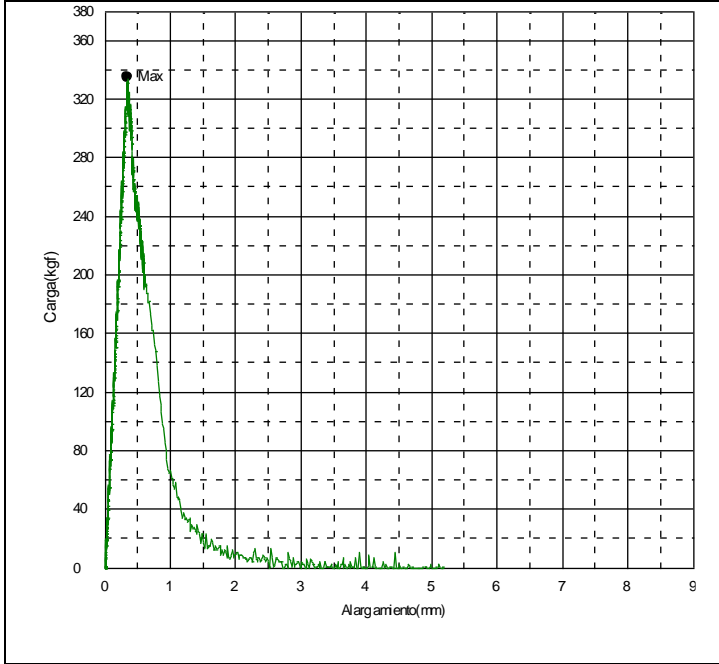




D288
Tipo trayectoria II



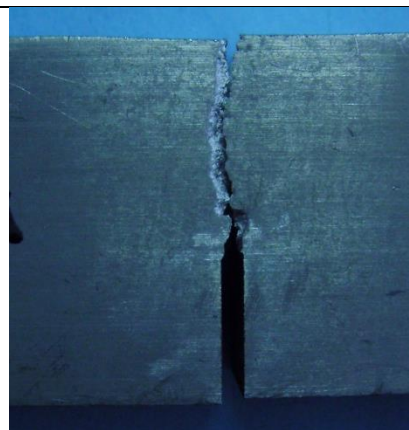
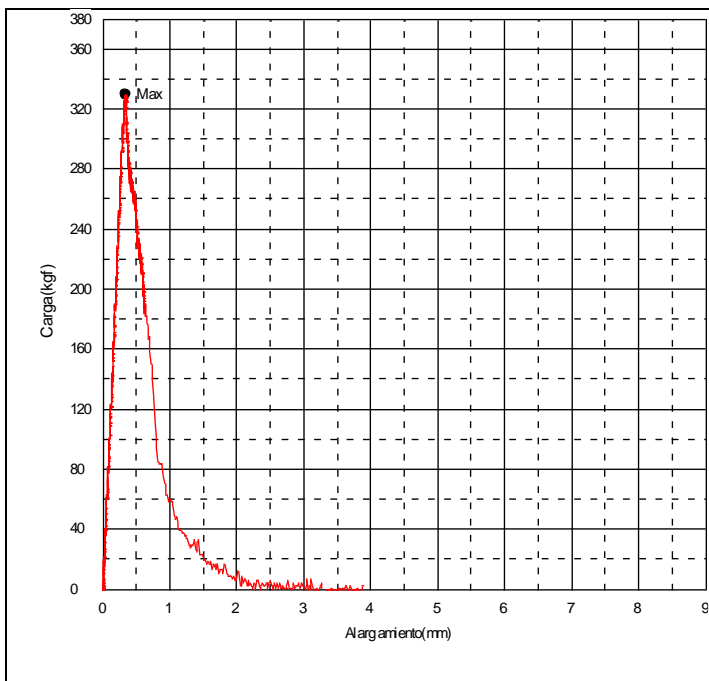
D289
Tipo trayectoria II



D290
Tipo trayectoria I

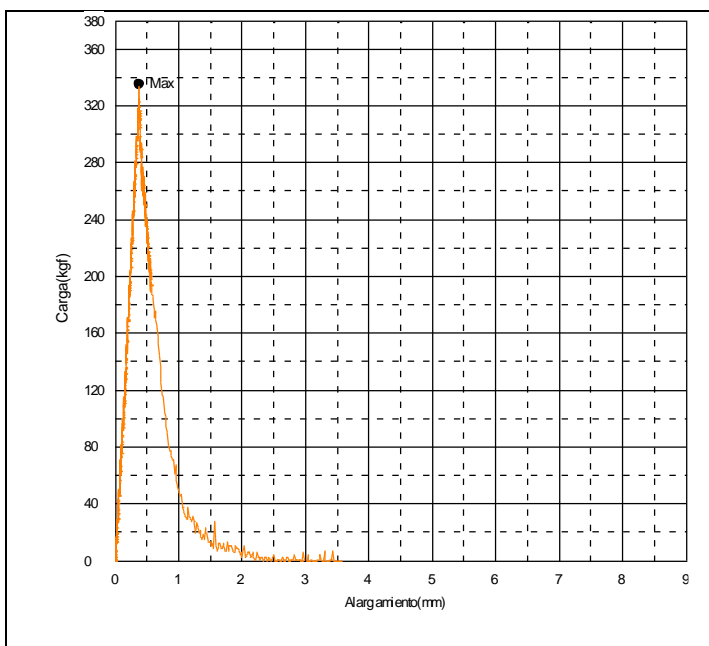
Temperatura de envejecimiento	Probeta	Tipo de gráfica
177 °C	D286	L
	D287	D
	D288	L
	D289	L
	D290	L

Figura E 6. Graficas ensayo de flexión, probetas D2 temperatura de envejecimiento 187°C



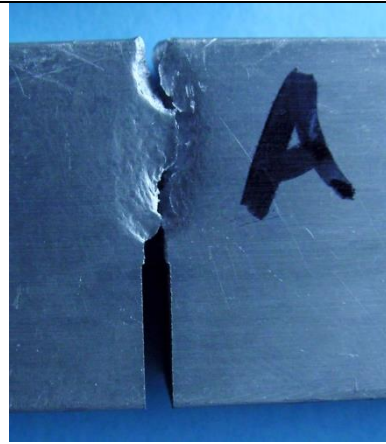
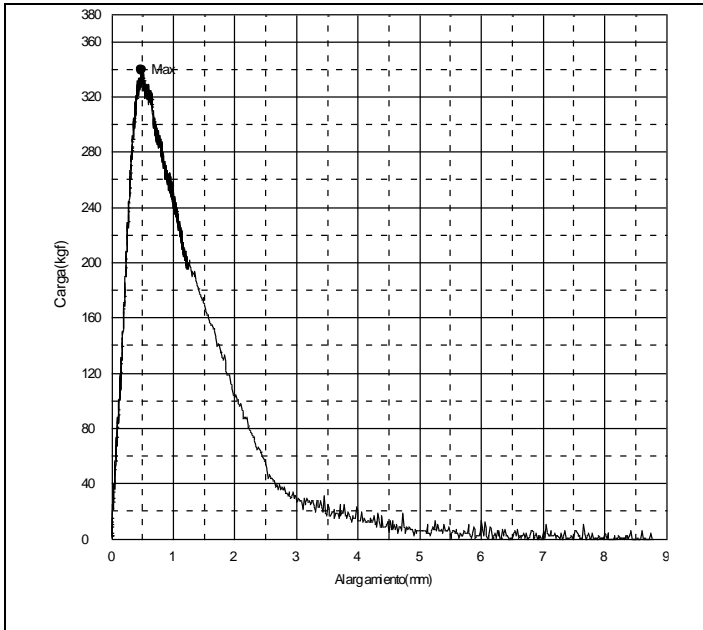
D294

Tipo trayectoria II



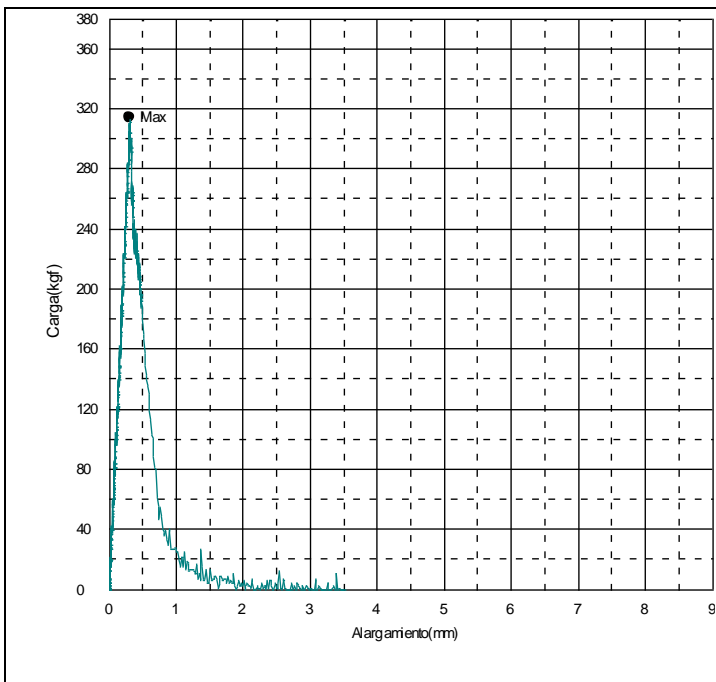
D295

Tipo trayectoria II



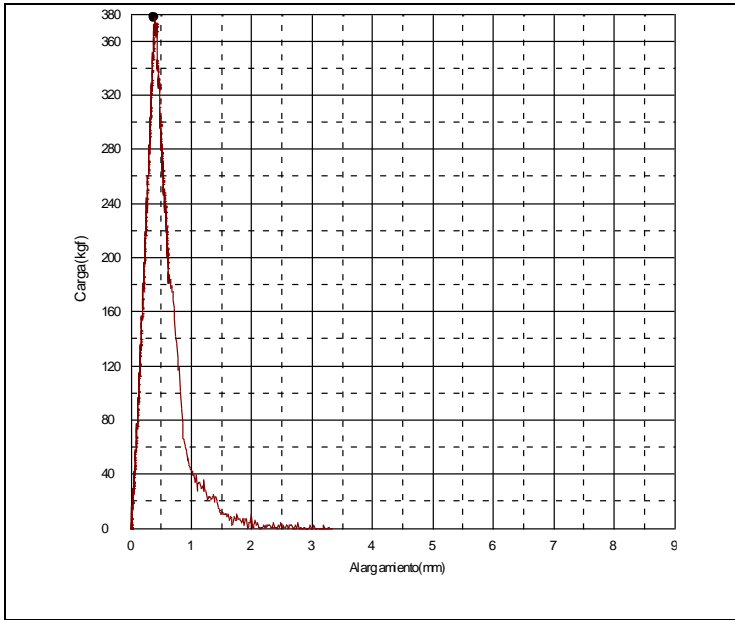
D296

Tipo trayectoria II



D297

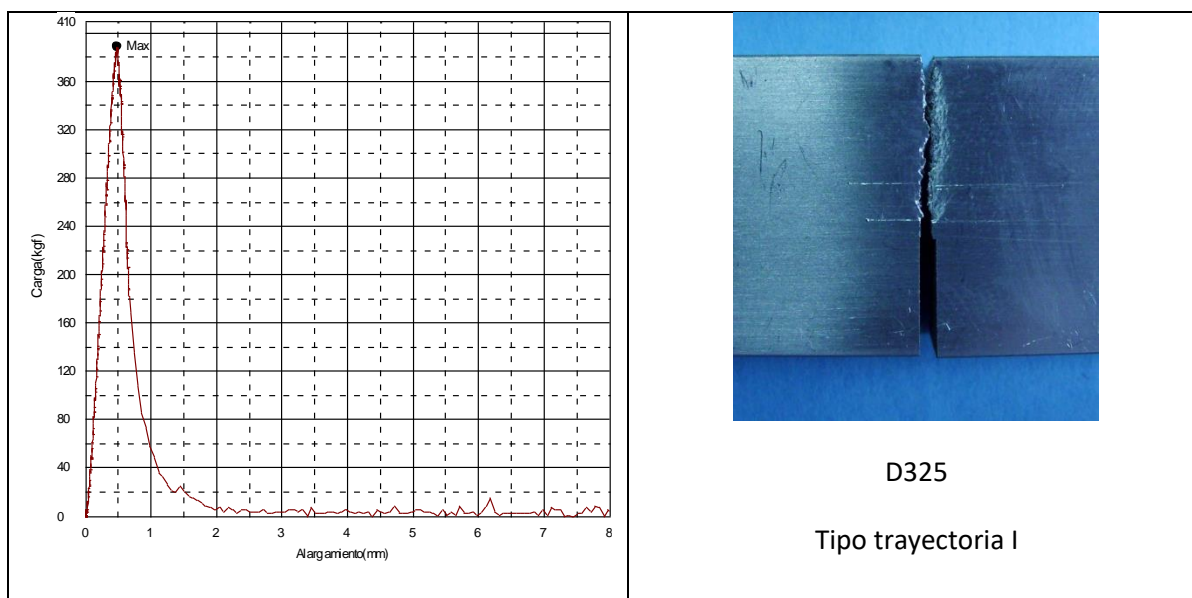
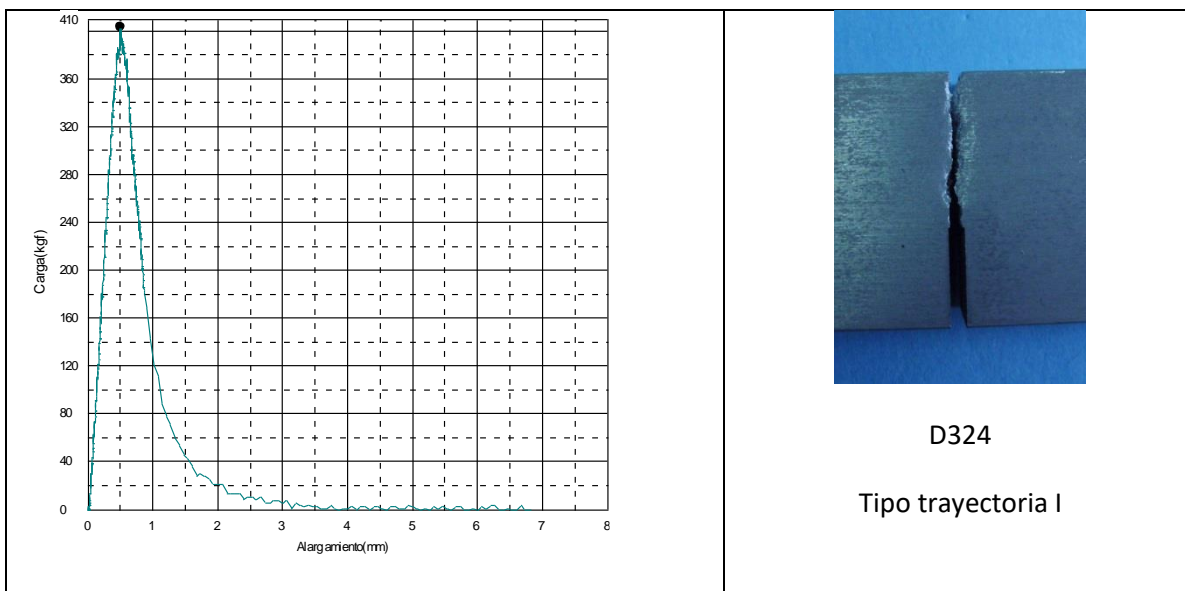
Tipo trayectoria I

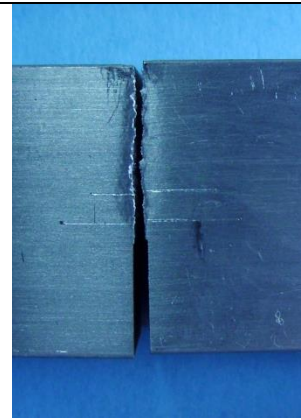
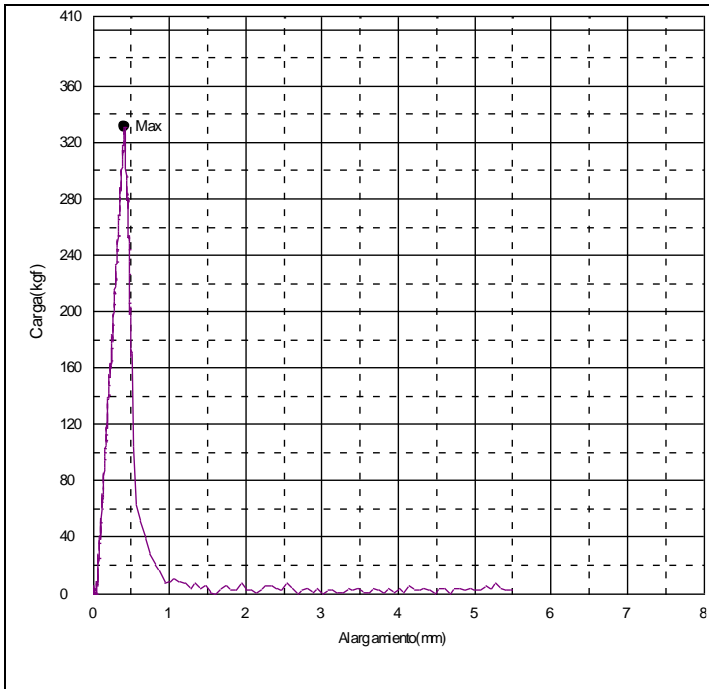


D298
Tipo trayectoria II

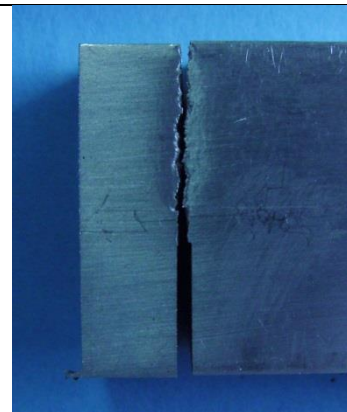
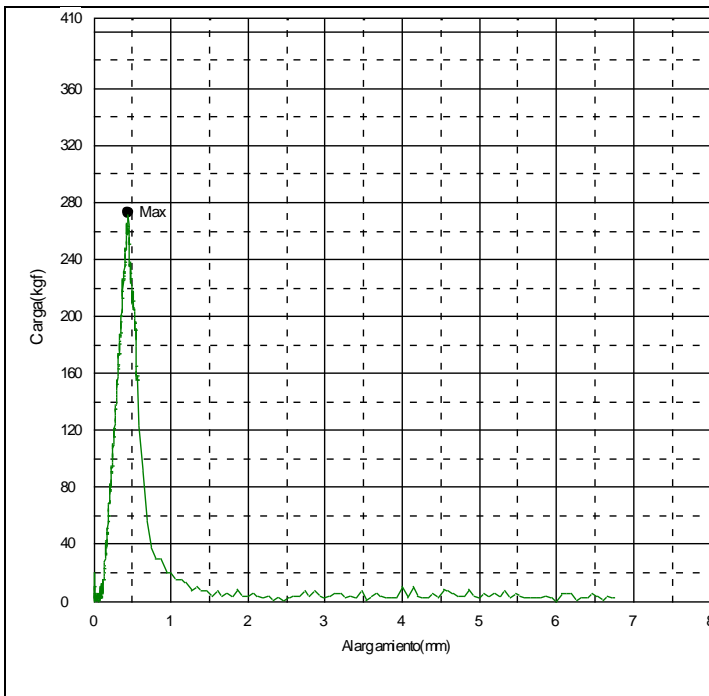
Temperatura de envejecimiento	Probeta	Tipo de gráfica
187 °C	D294	L
	D295	L
	D296	D
	D297	L
	D298	L

Figura E 7. Graficas ensayo de flexión, probetas D3 temperatura de envejecimiento 150°C

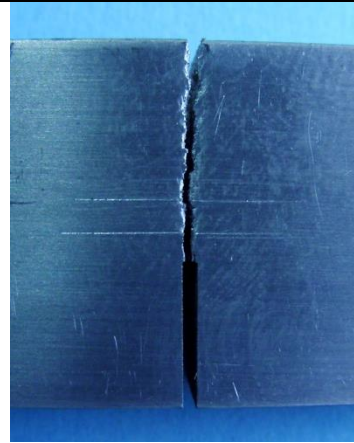
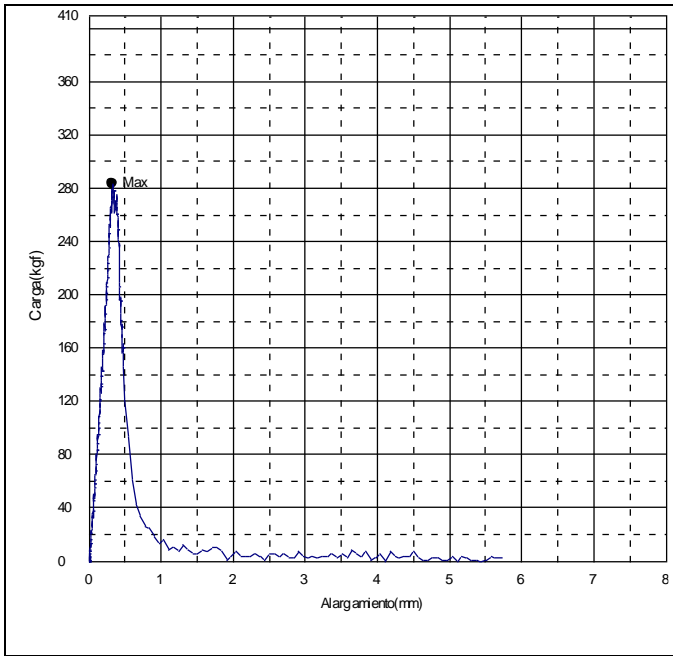




D326
Tipo trayectoria I



D327
Tipo trayectoria I

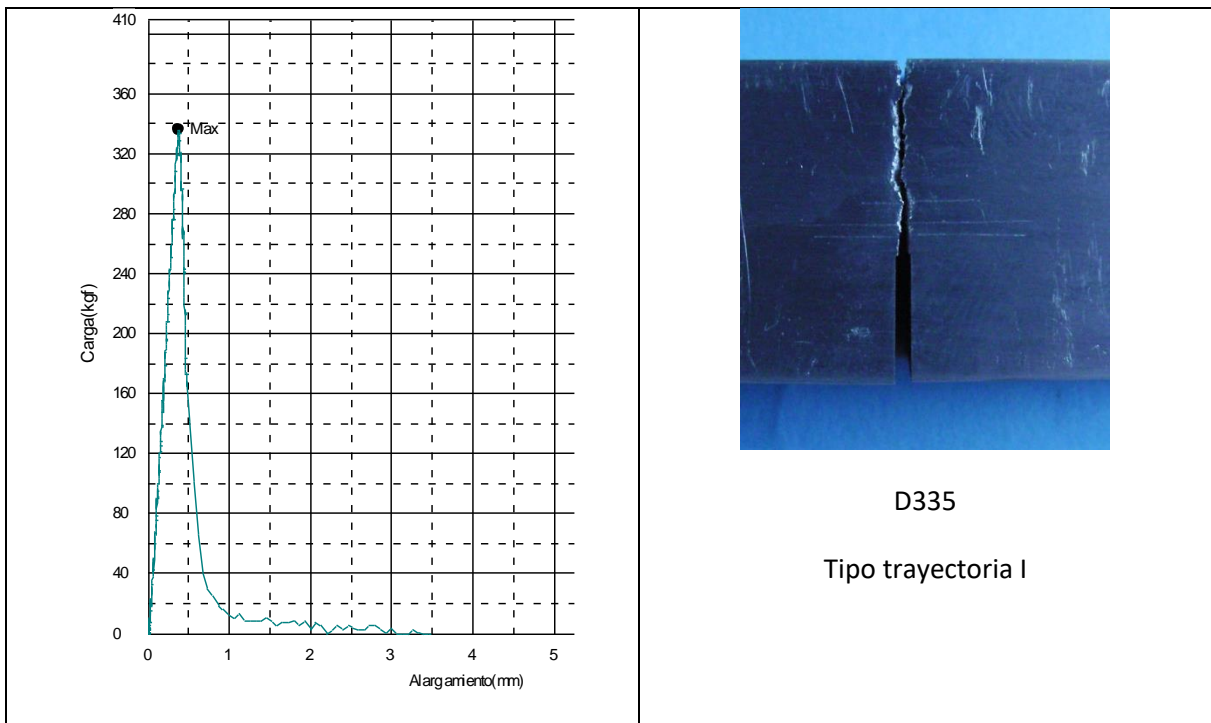
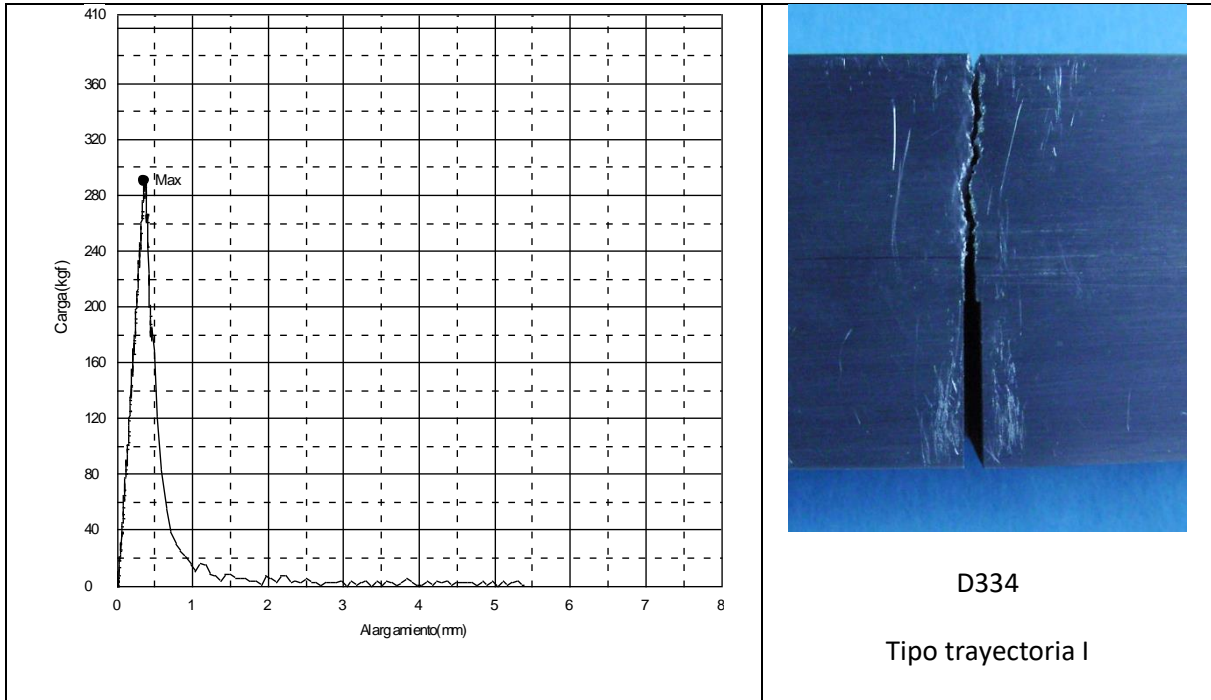


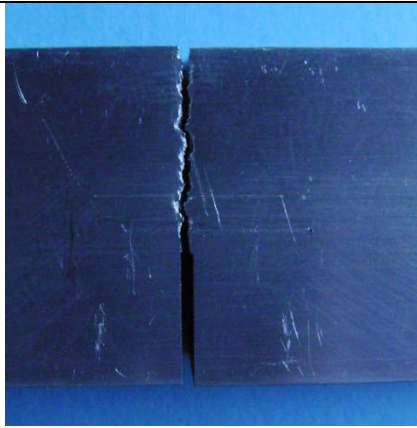
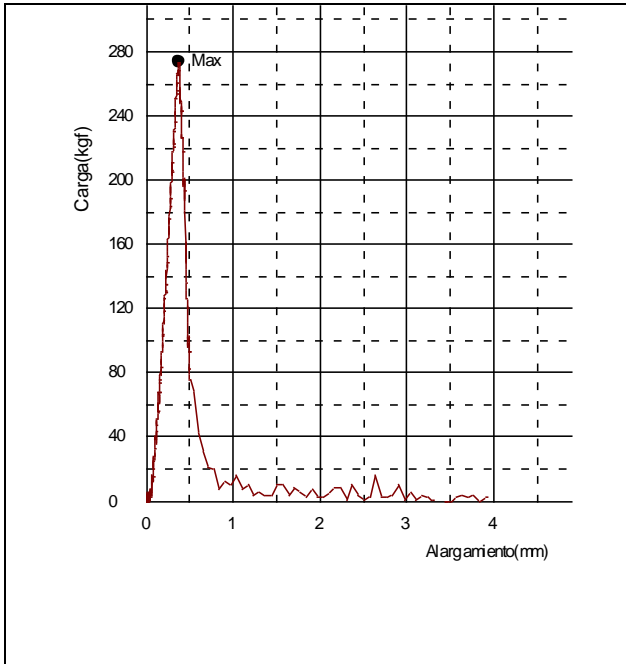
D329

Tipo trayectoria I

Temperatura de envejecimiento	Probeta	Tipo de gráfica
150 °C	D324	D
	D325	L
	D326	L
	D327	L
	D329	L

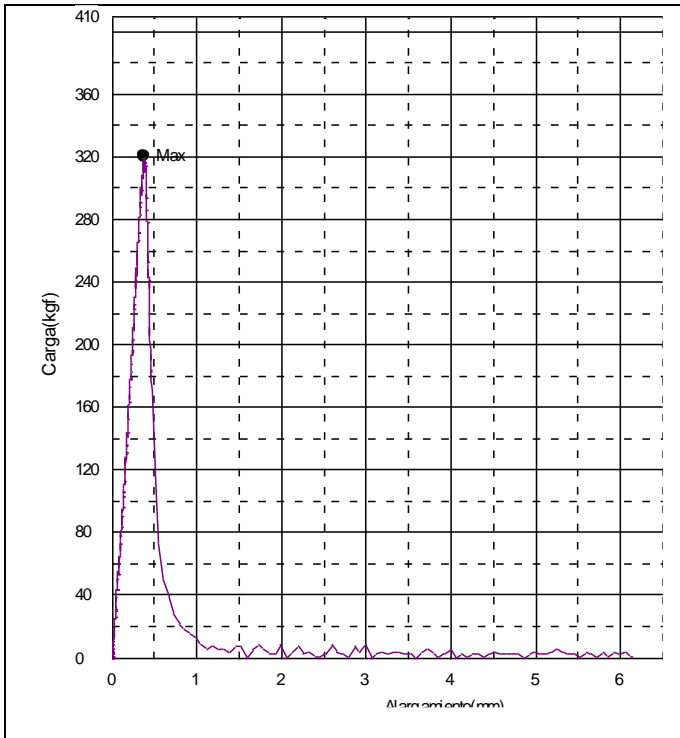
Figura E 8. Graficas ensayo de flexión, probetas D3 temperatura de envejecimiento 160°C





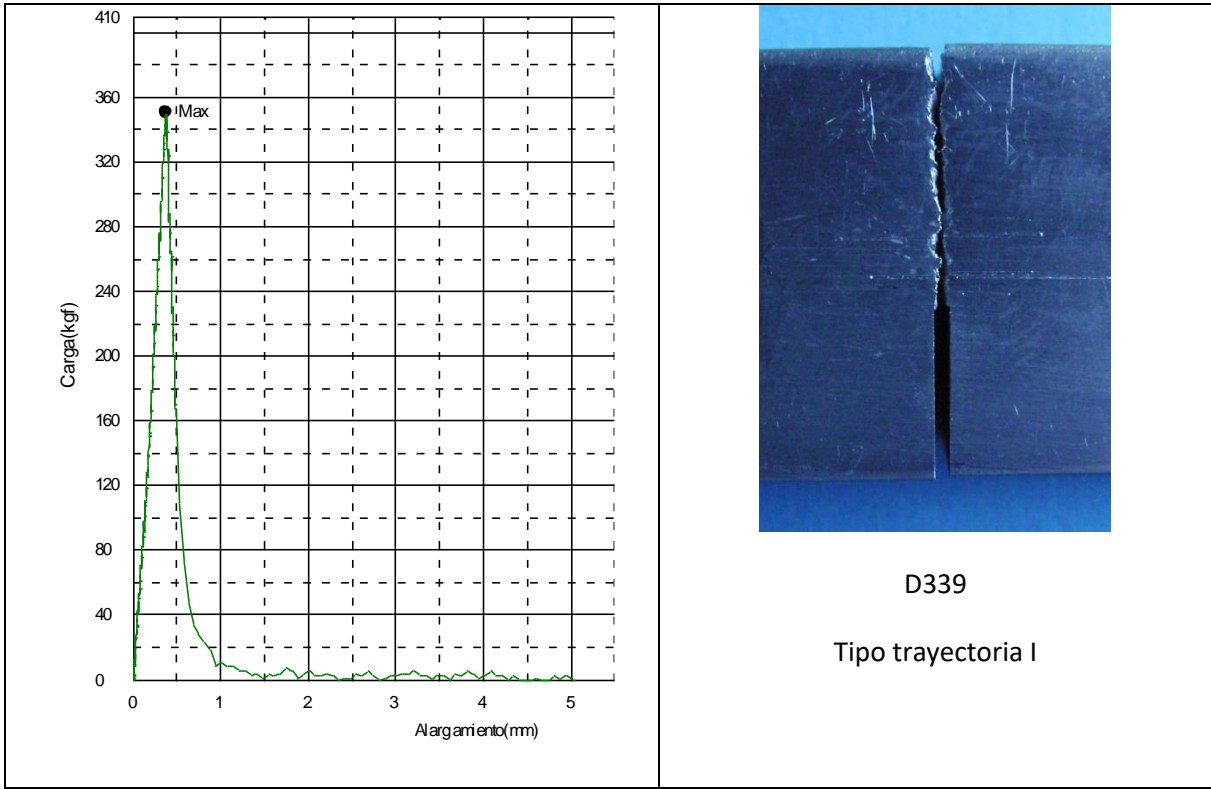
D336

Tipo trayectoria I



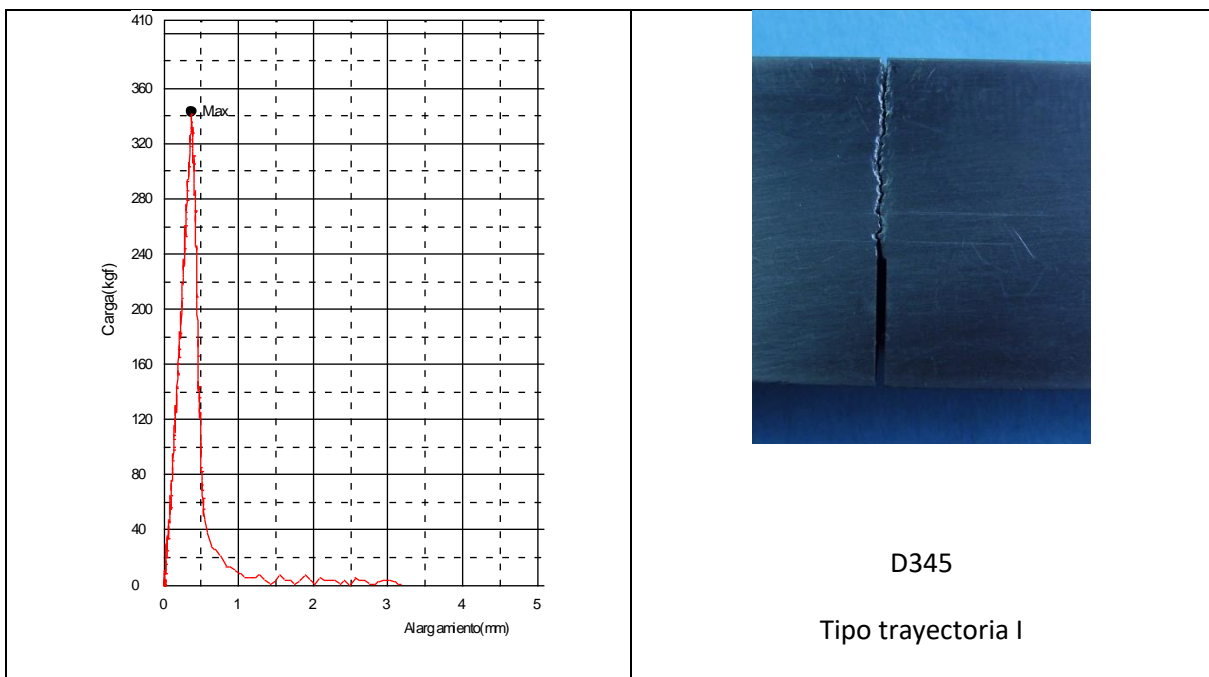
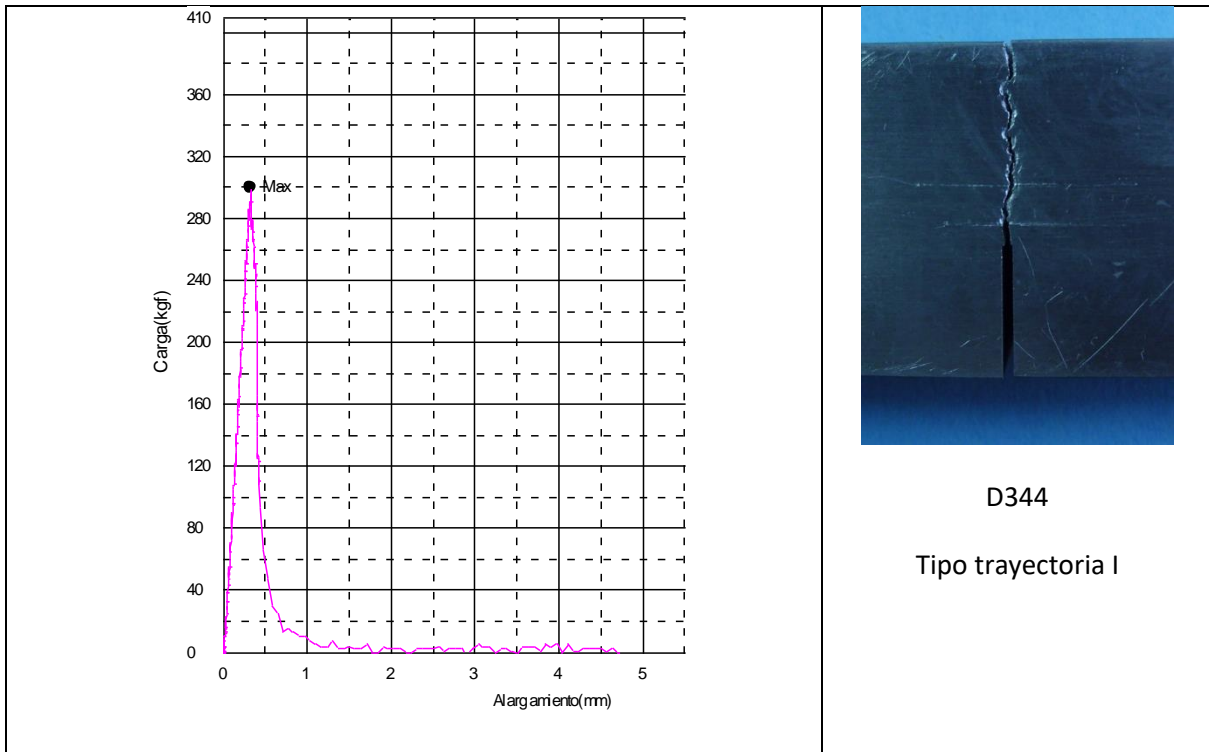
D337

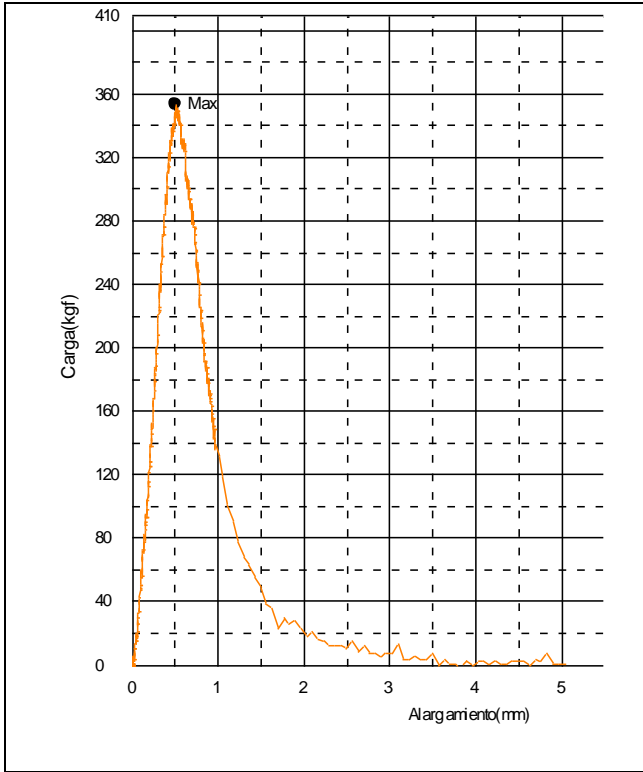
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
160 °C	D334	L
	D335	L
	D336	L
	D337	L
	D339	L

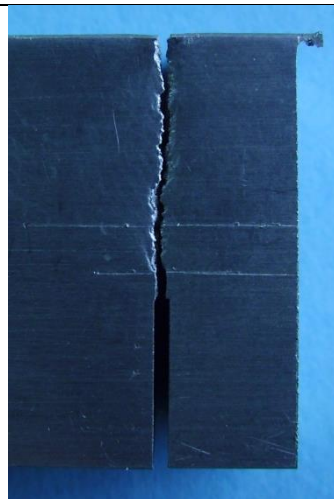
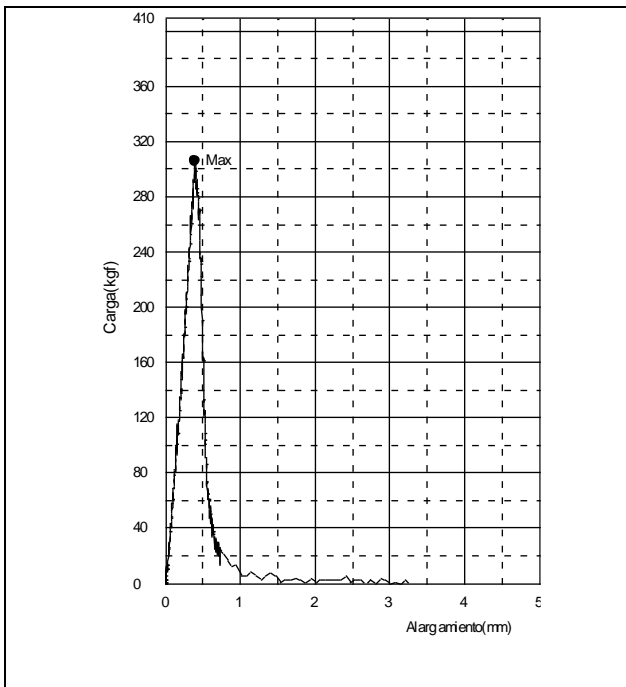
Figura E 9. Graficas ensayo de flexión, probetas D3 temperatura de envejecimiento 170°C





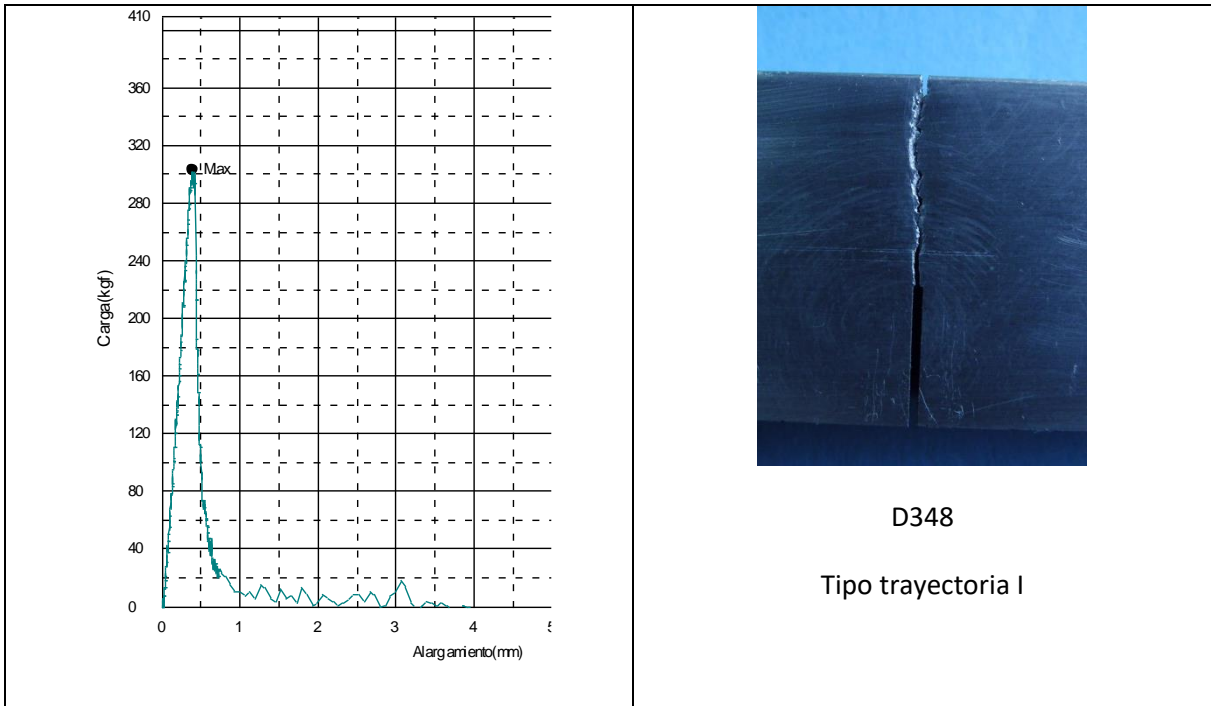
D346

Tipo trayectoria I



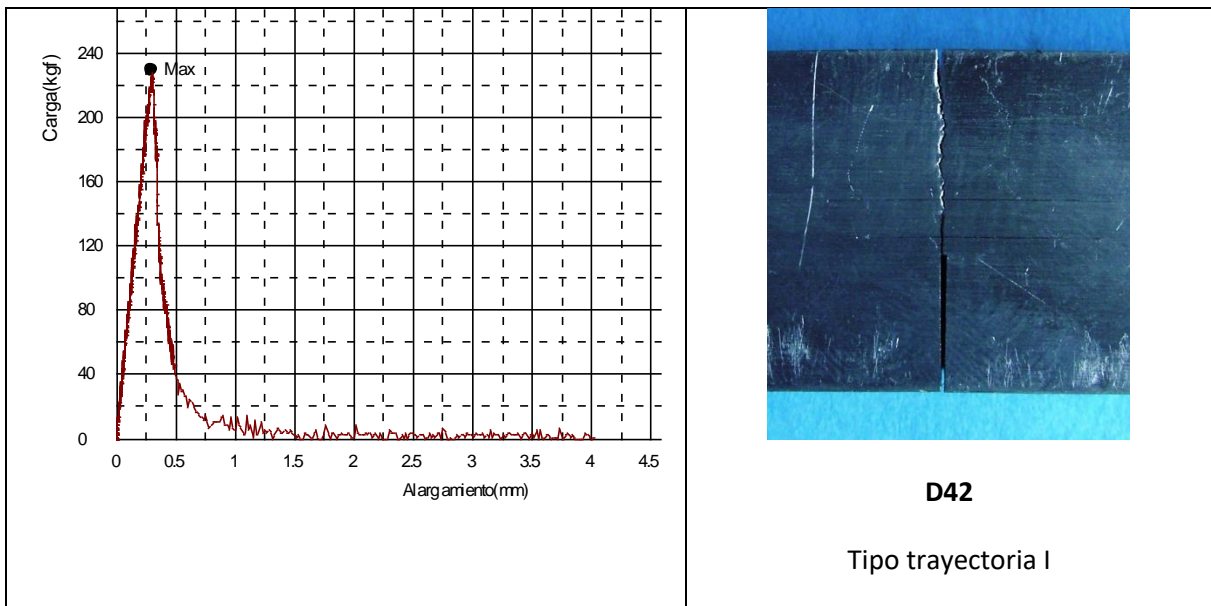
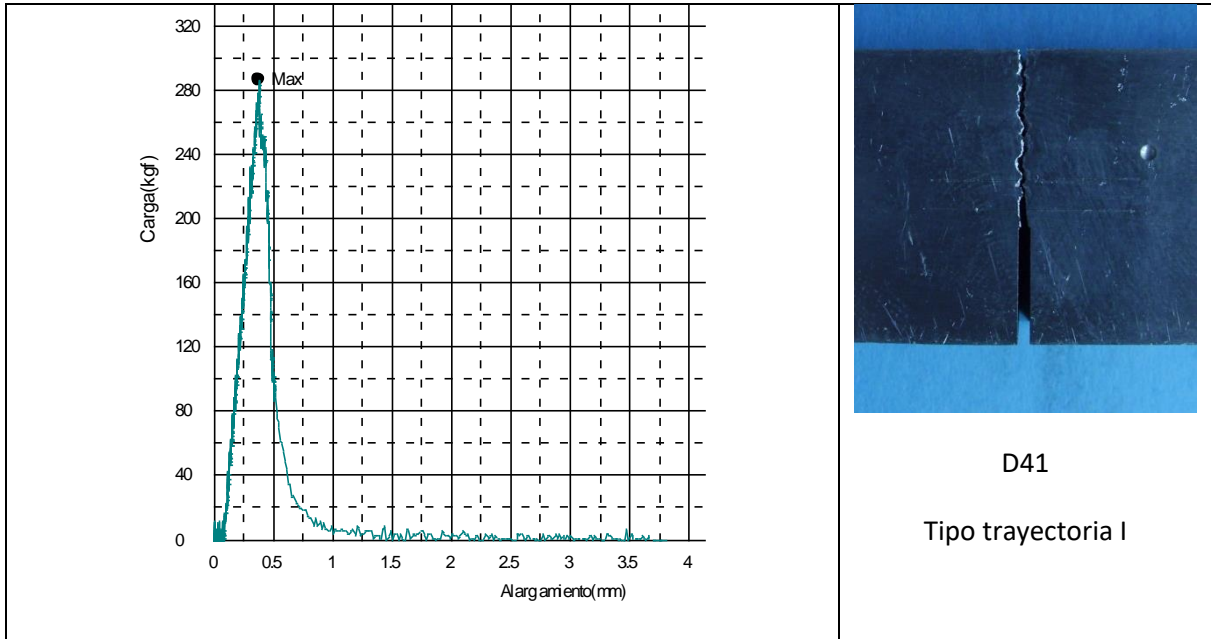
D347

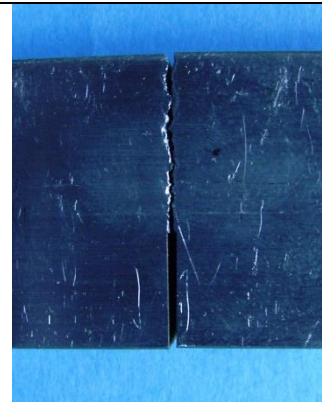
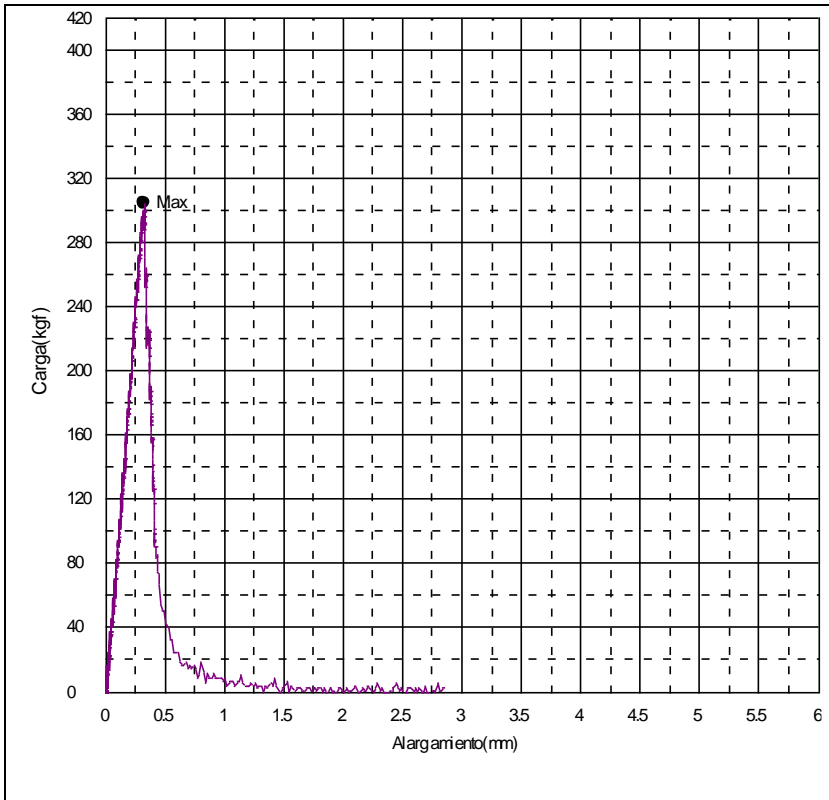
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
170 °C	D344	L
	D345	L
	D346	D
	D347	L
	D348	L

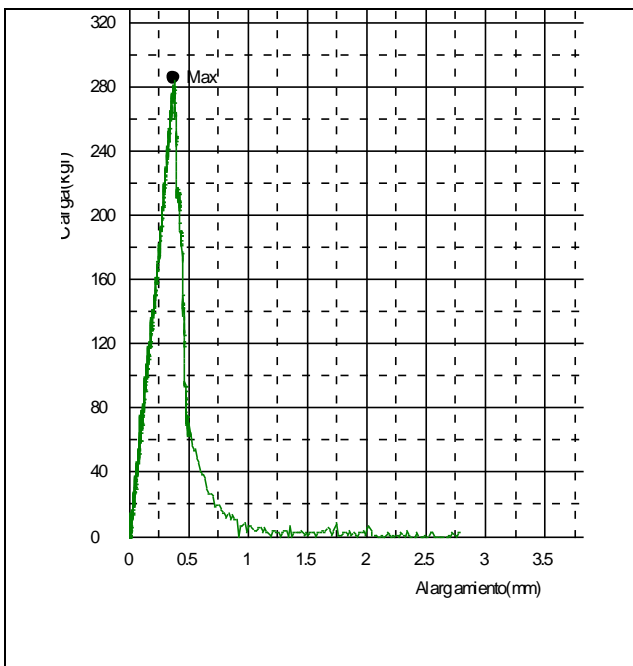
Figura E 10. Graficas ensayo de flexión, probetas D4 temperatura de envejecimiento 150°C





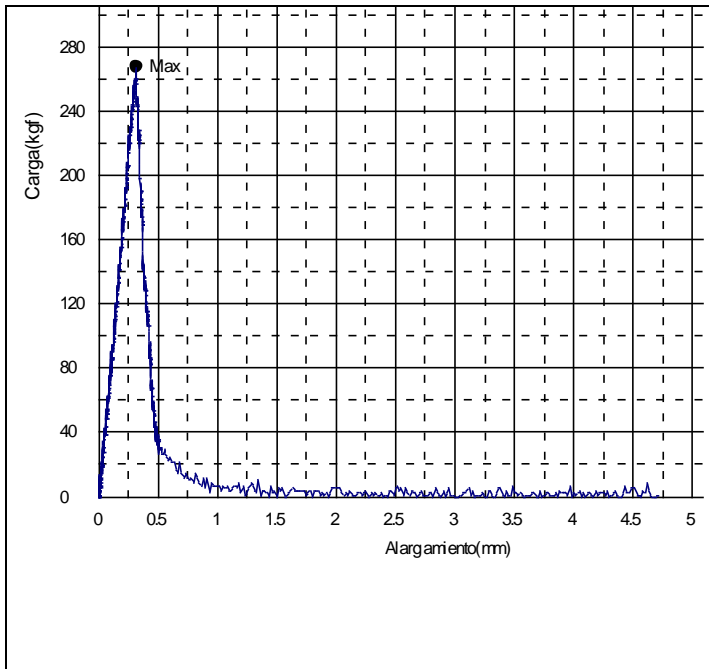
D43

Tipo trayectoria I



D44

Tipo trayectoria I

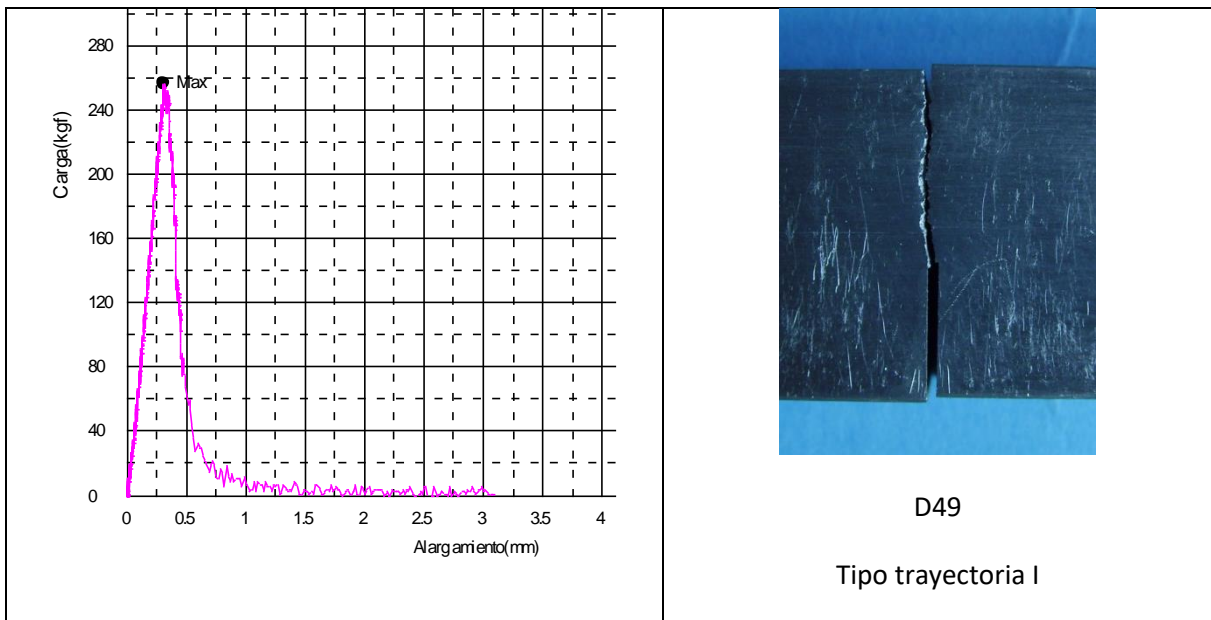
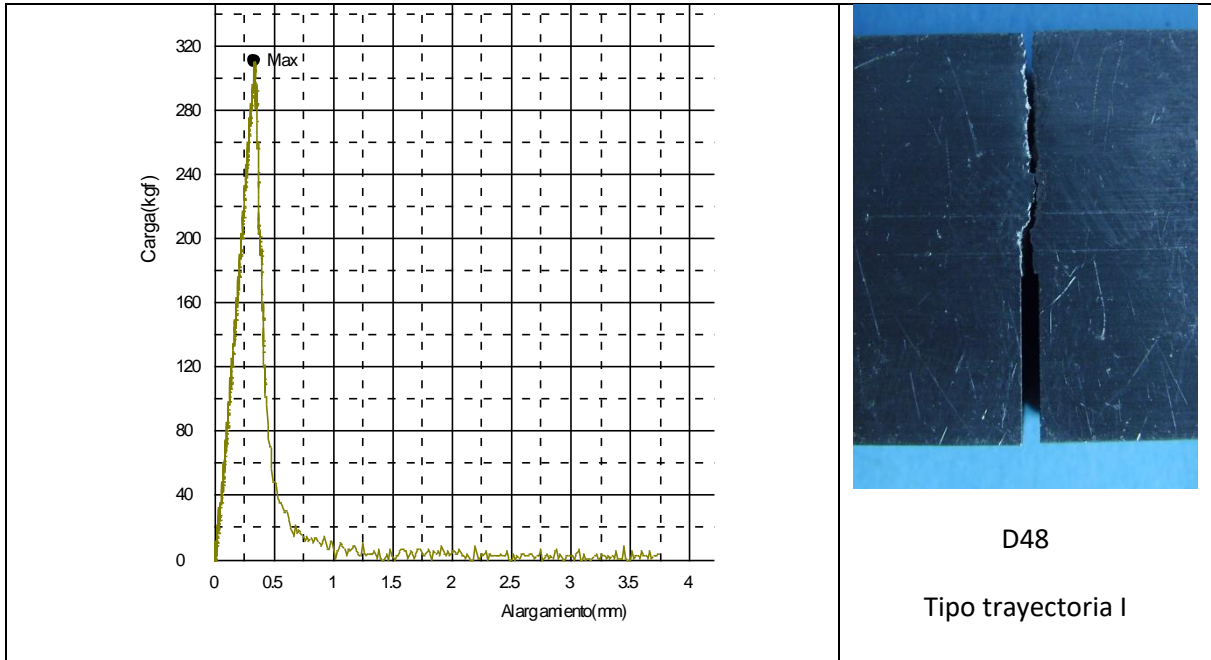


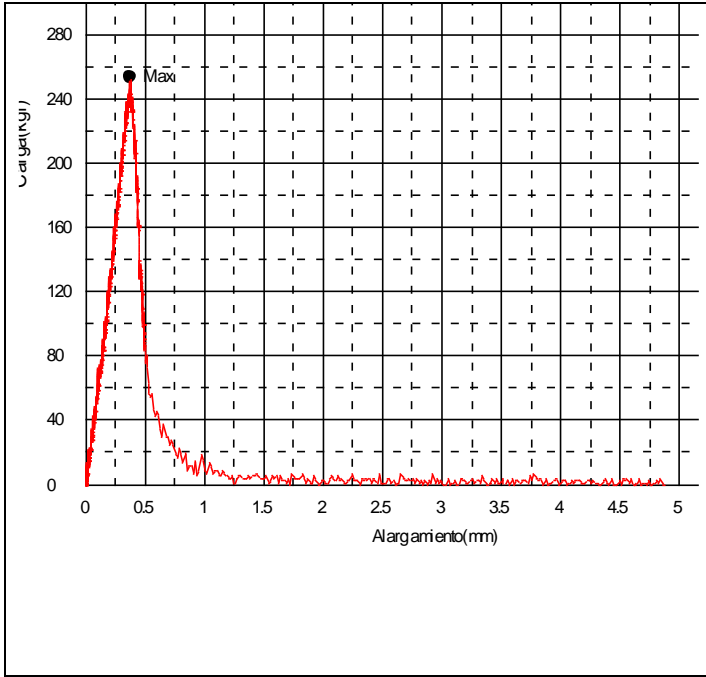
D45

Tipo trayectoria I

Temperatura de envejecimiento	Probeta	Tipo de gráfica
150 °C	D41	L
	D42	L
	D43	L
	D44	L
	D45	L

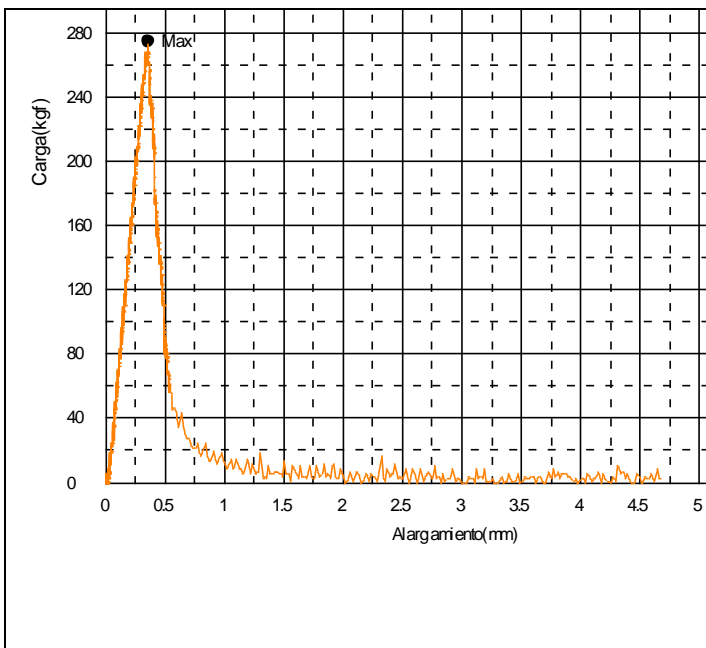
Figura E 11. Graficas ensayo de flexión, probetas D4 temperatura de envejecimiento 160°C





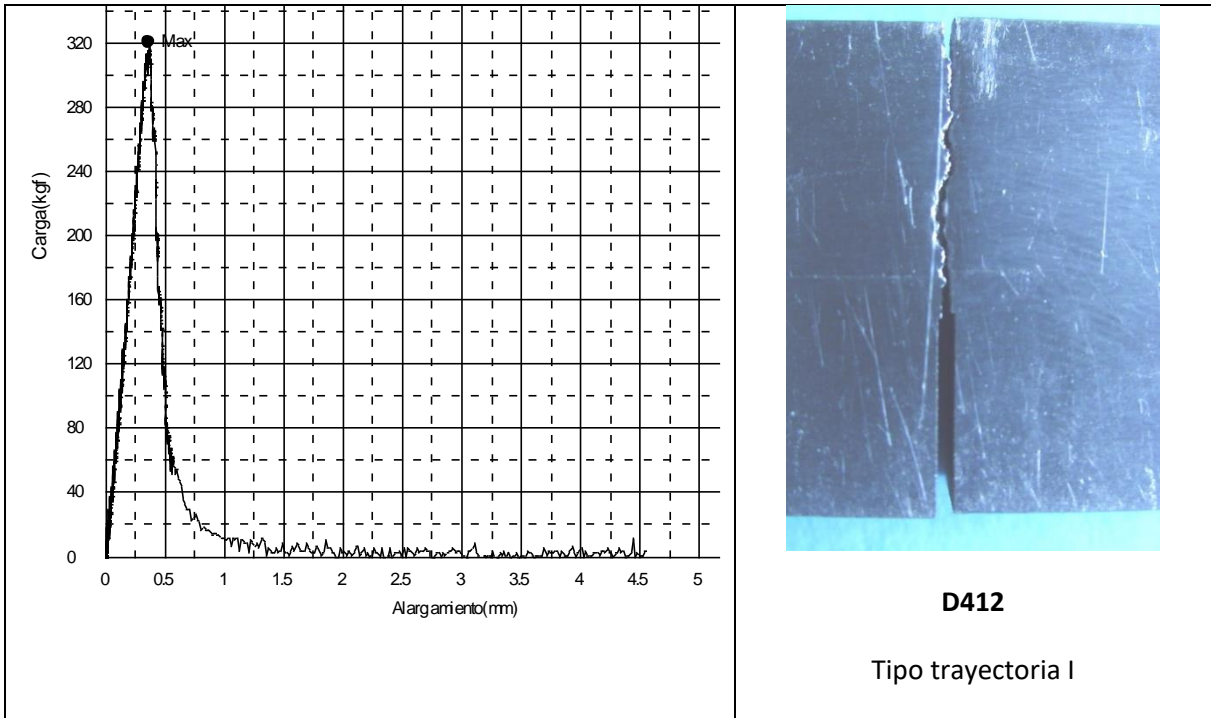
D410

Tipo trayectoria I



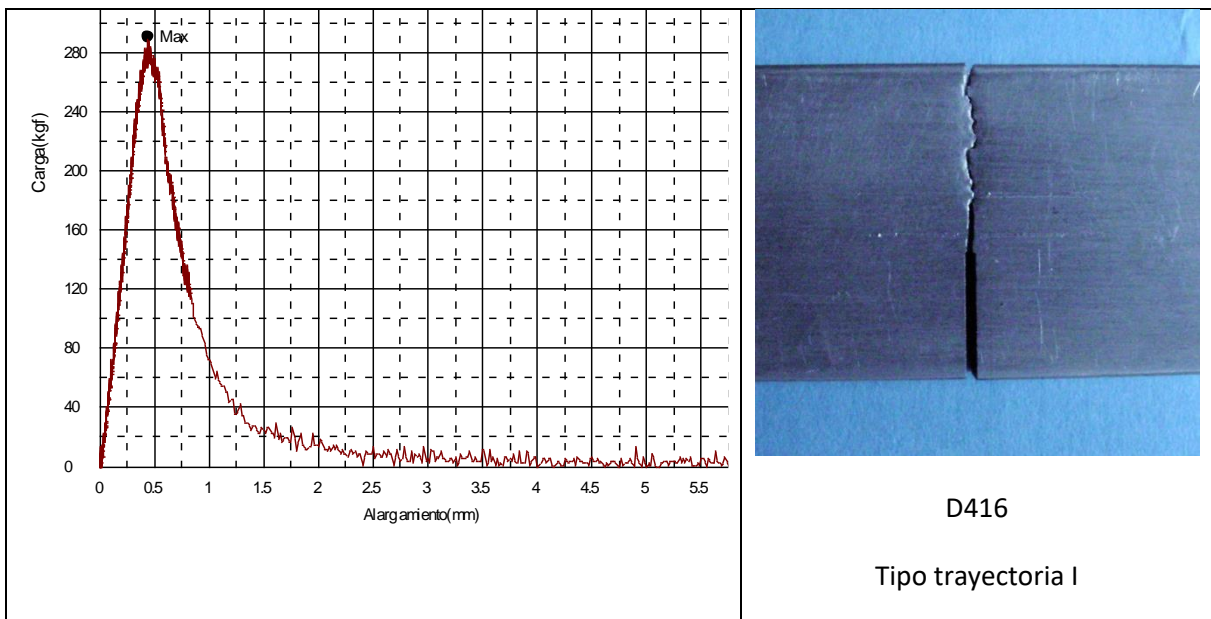
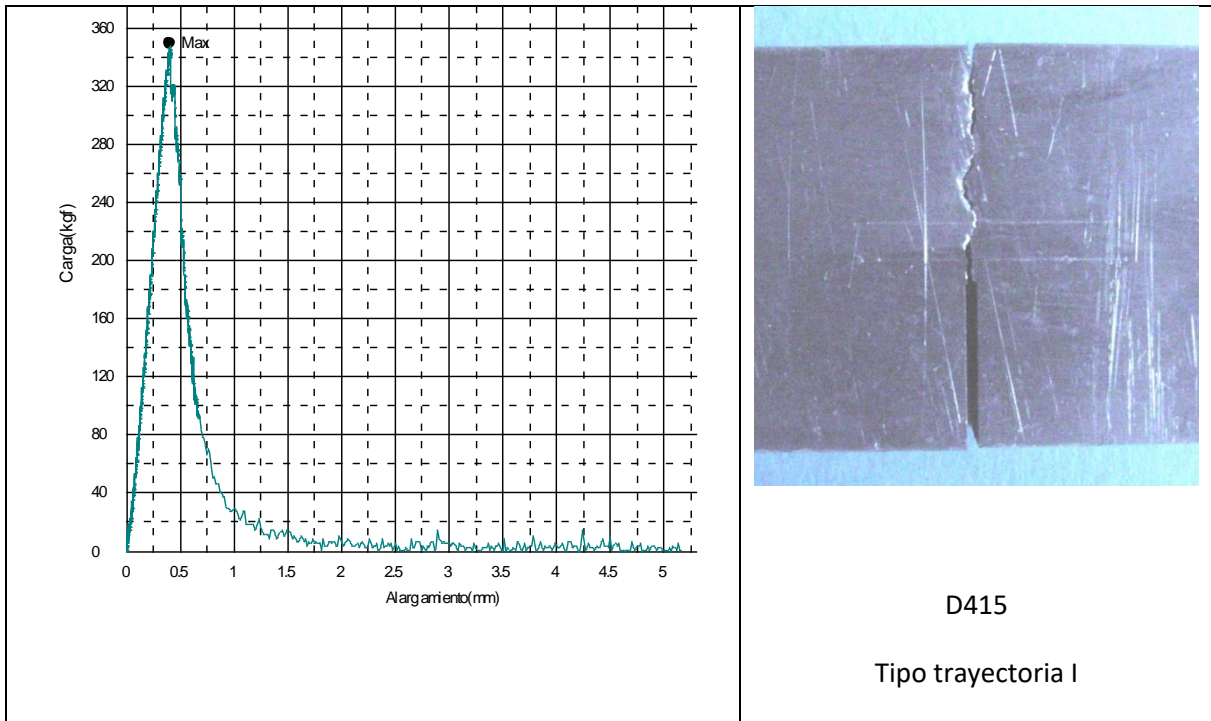
D411

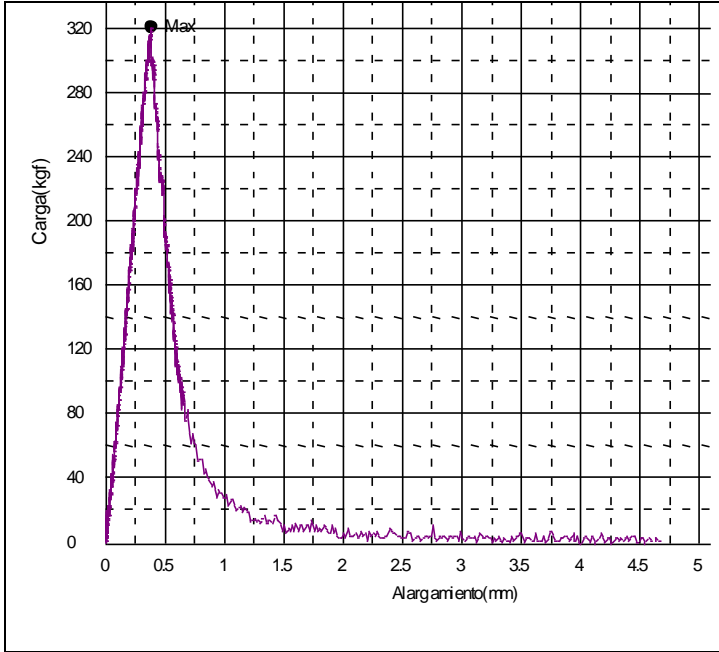
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
160 °C	D48	L
	D49	L
	D410	L
	D411	L
	D412	L

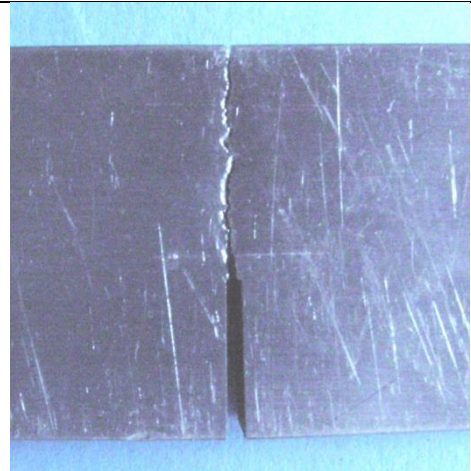
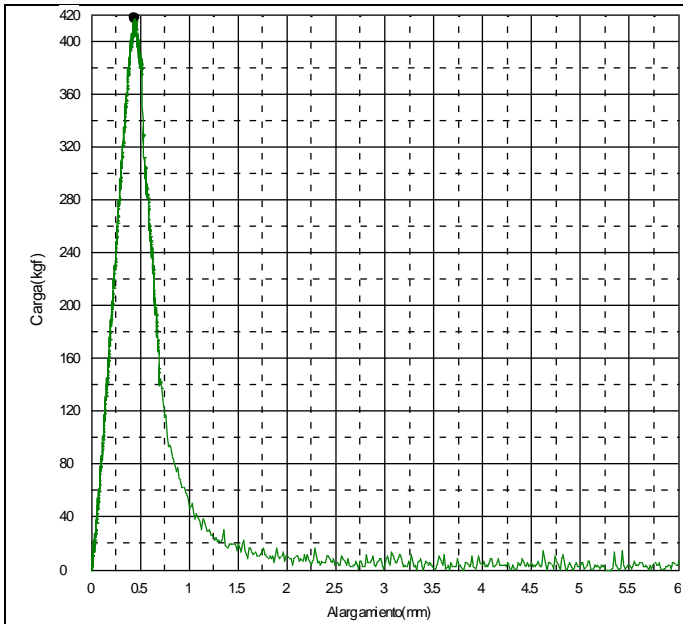
Figura E 12. Graficas ensayo de flexión, probetas D4 temperatura de envejecimiento 170°C





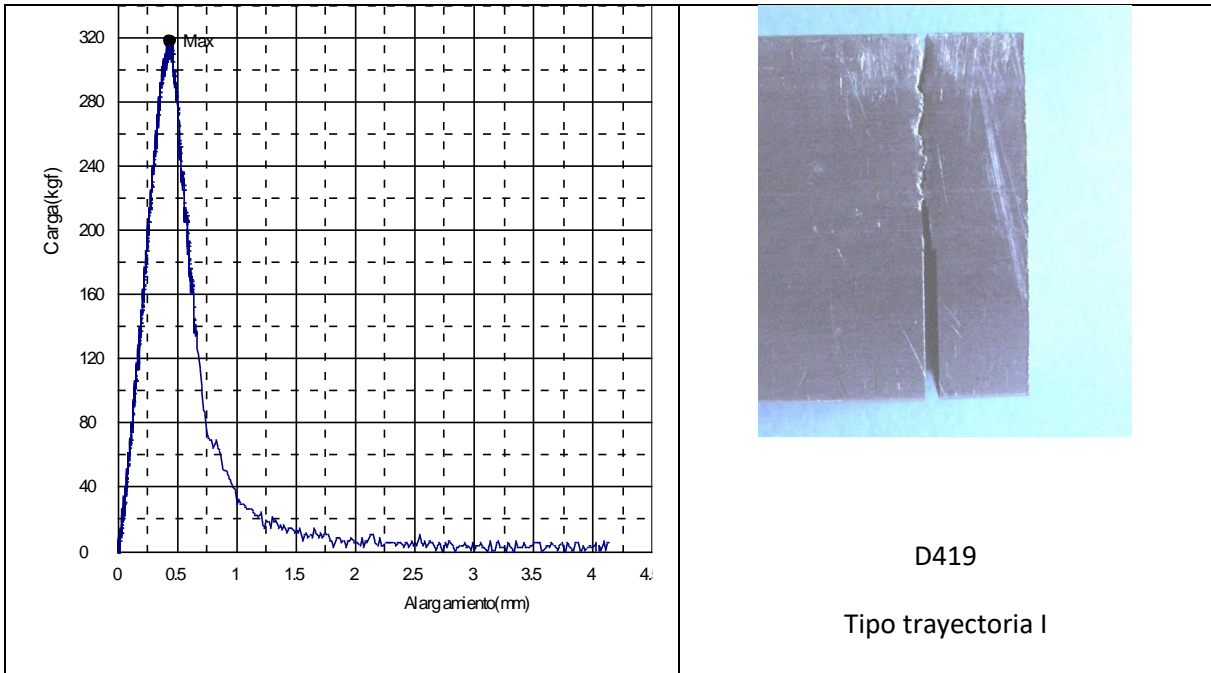
D417

Tipo trayectoria I



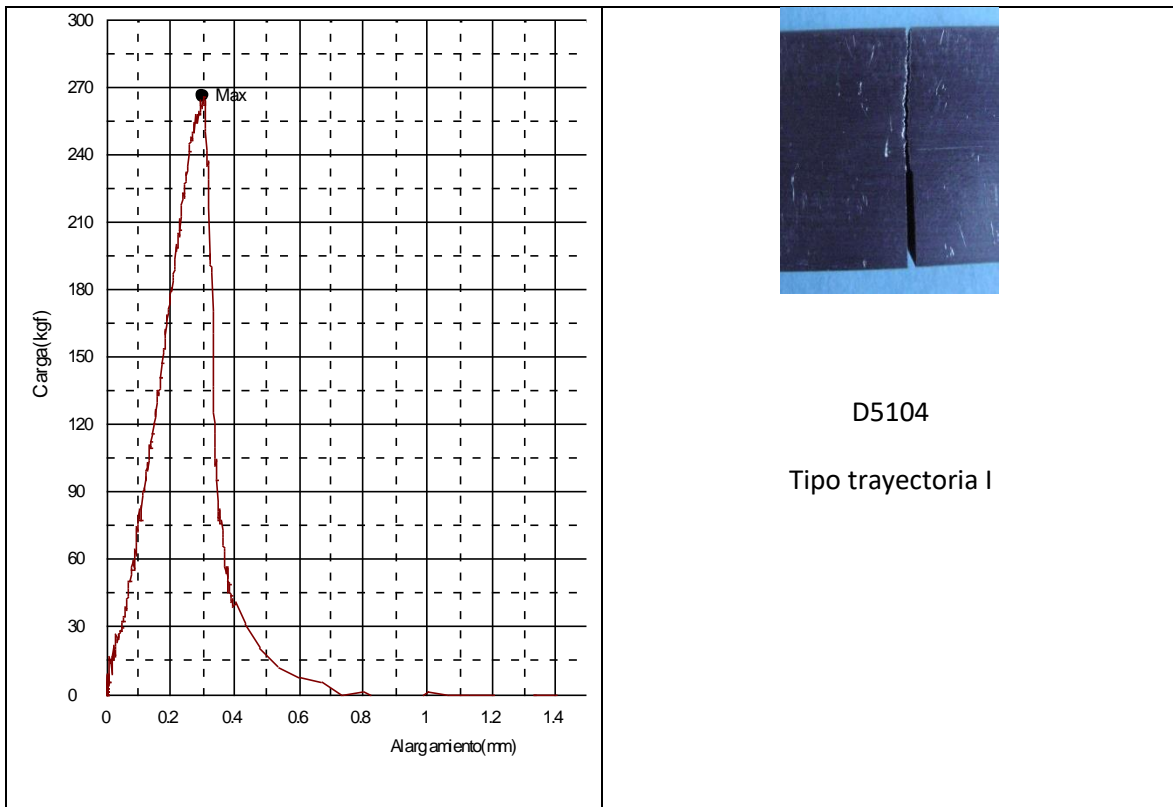
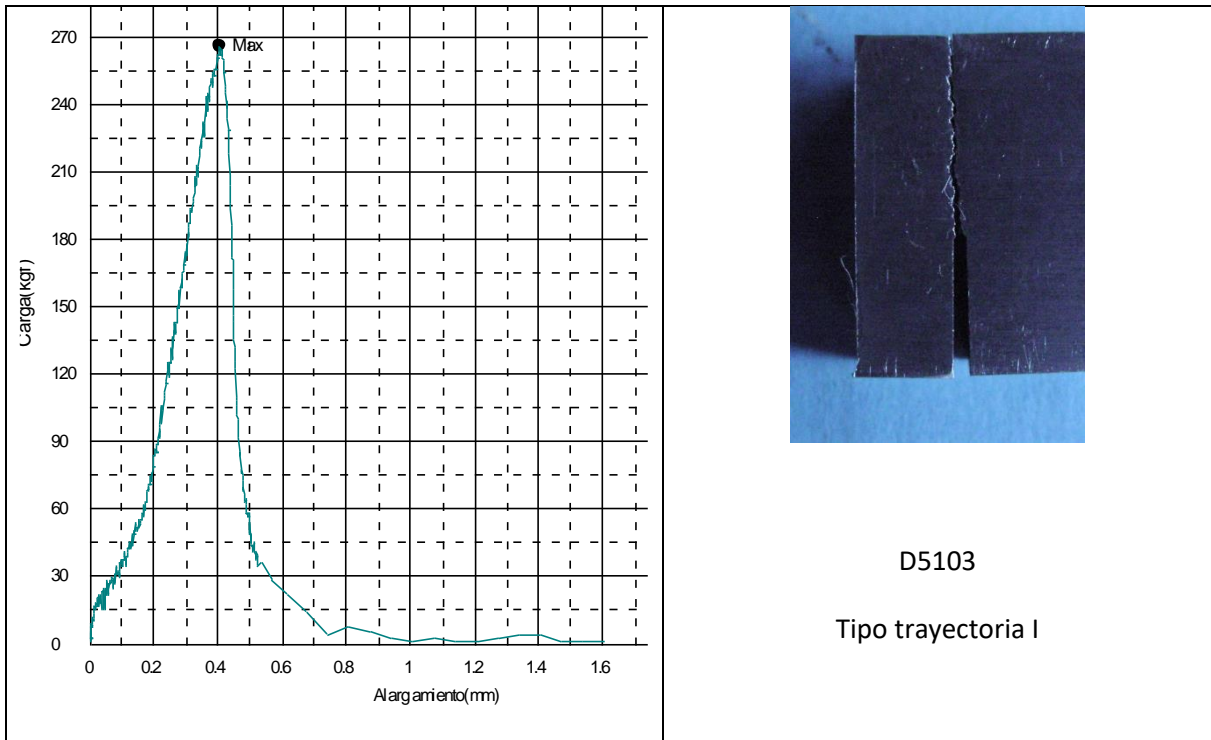
D418

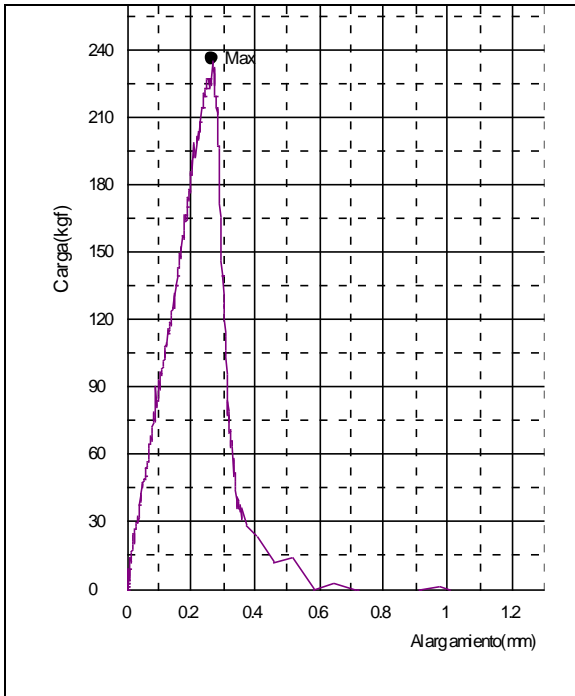
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
170 °C	D415	L
	D416	D
	D417	L
	D418	L
	D419	L

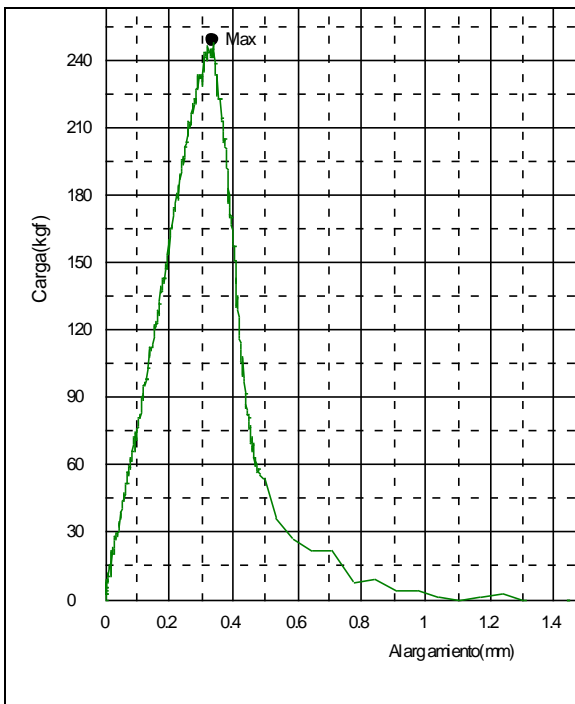
Figura E 13. Graficas ensayo de flexión, probetas D5 temperatura de envejecimiento 181°C





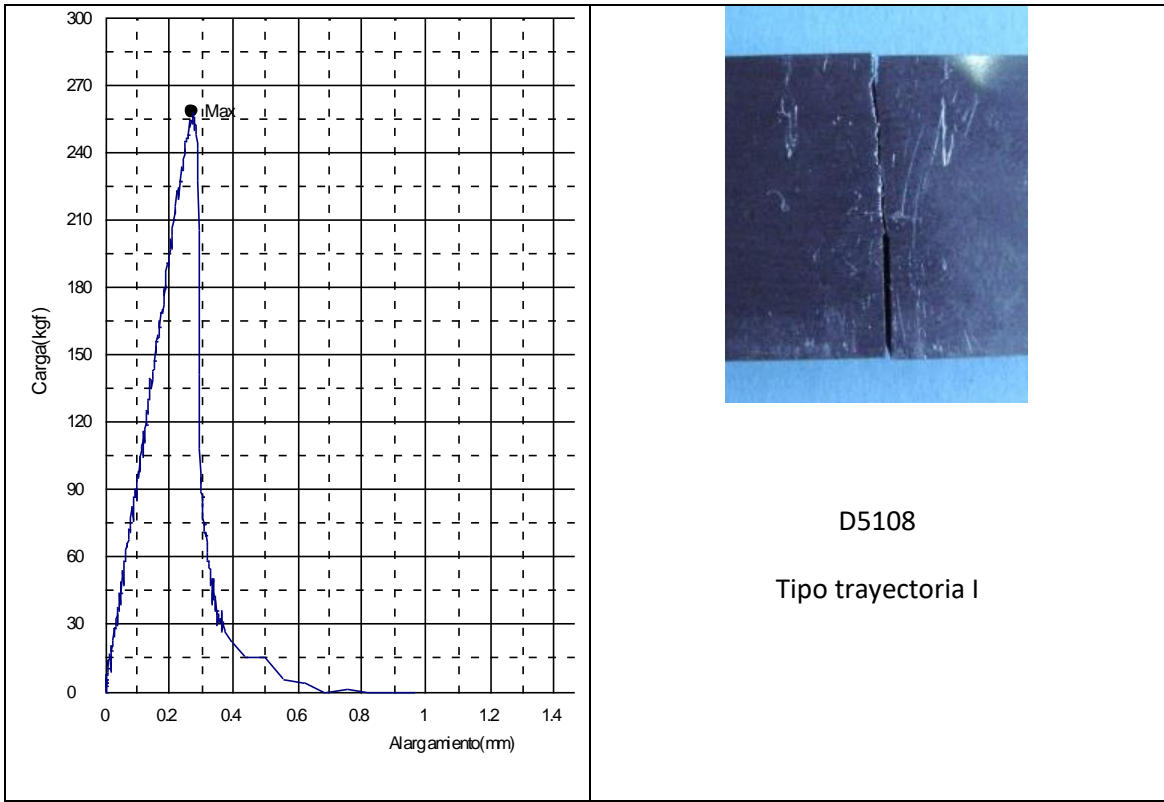
D5106

Tipo trayectoria I



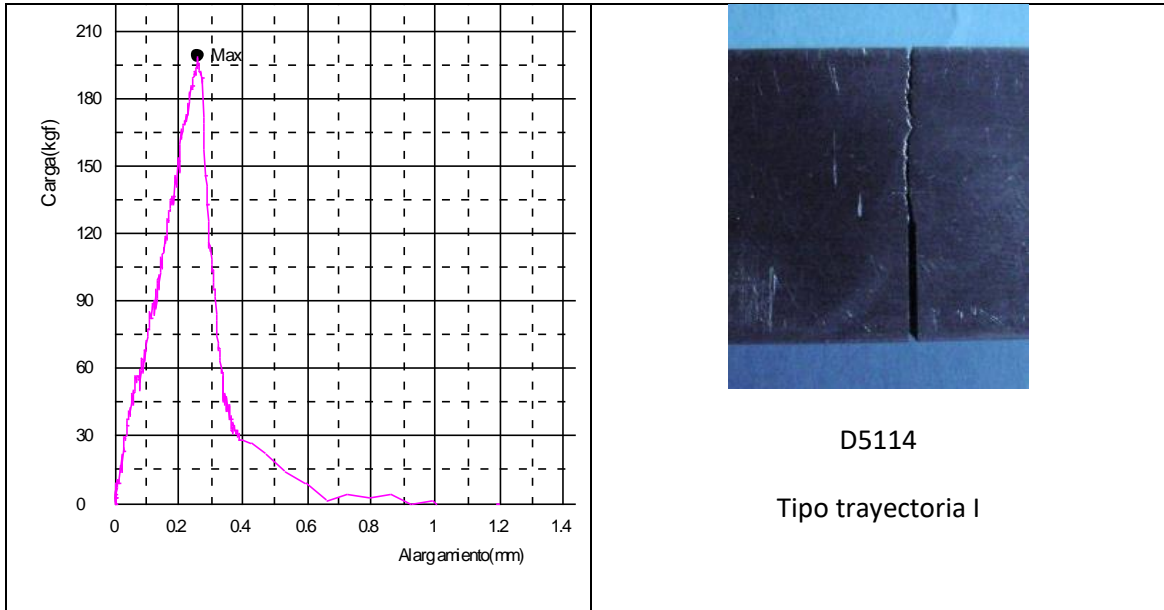
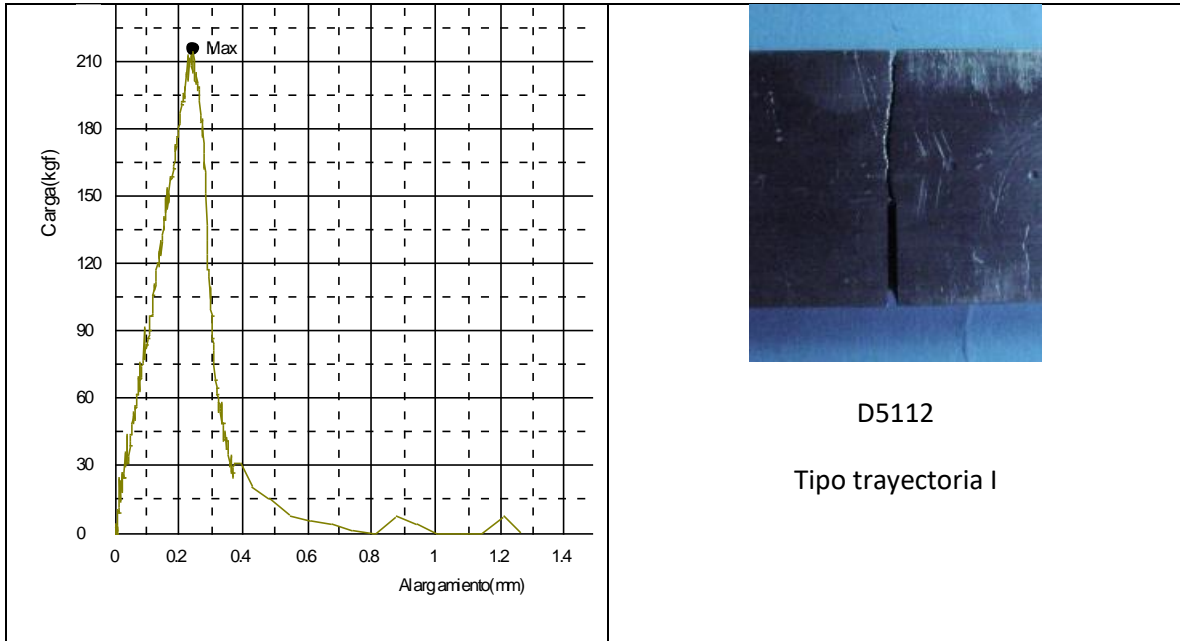
D5107

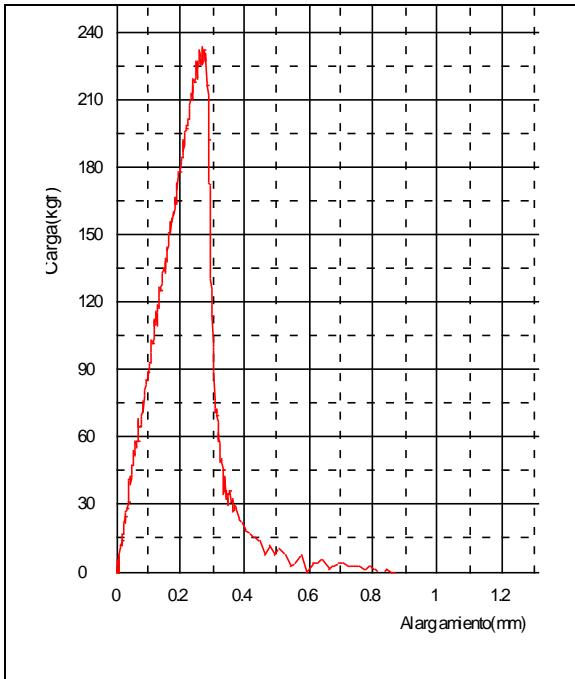
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
181 °C	D5103	L
	D5104	L
	D5106	L
	D5107	L
	D5108	L

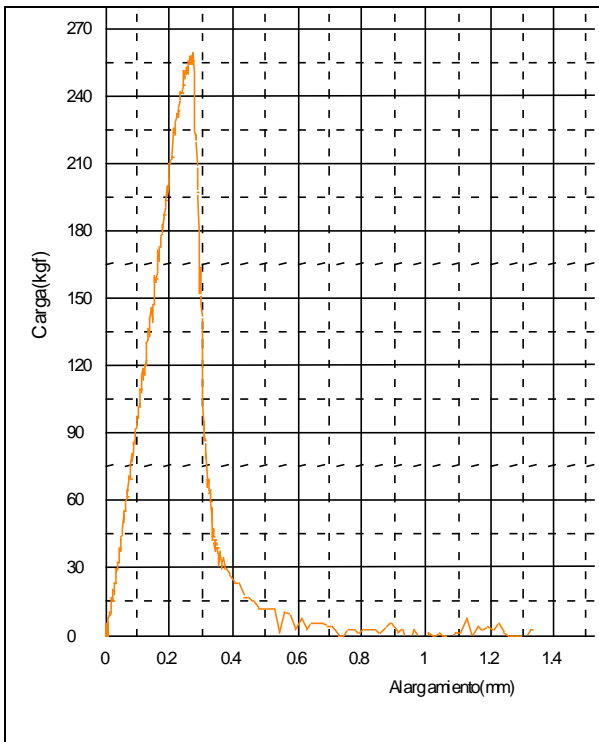
Figura E 14. Graficas ensayo de flexión, probetas D5 temperatura de envejecimiento 191°C





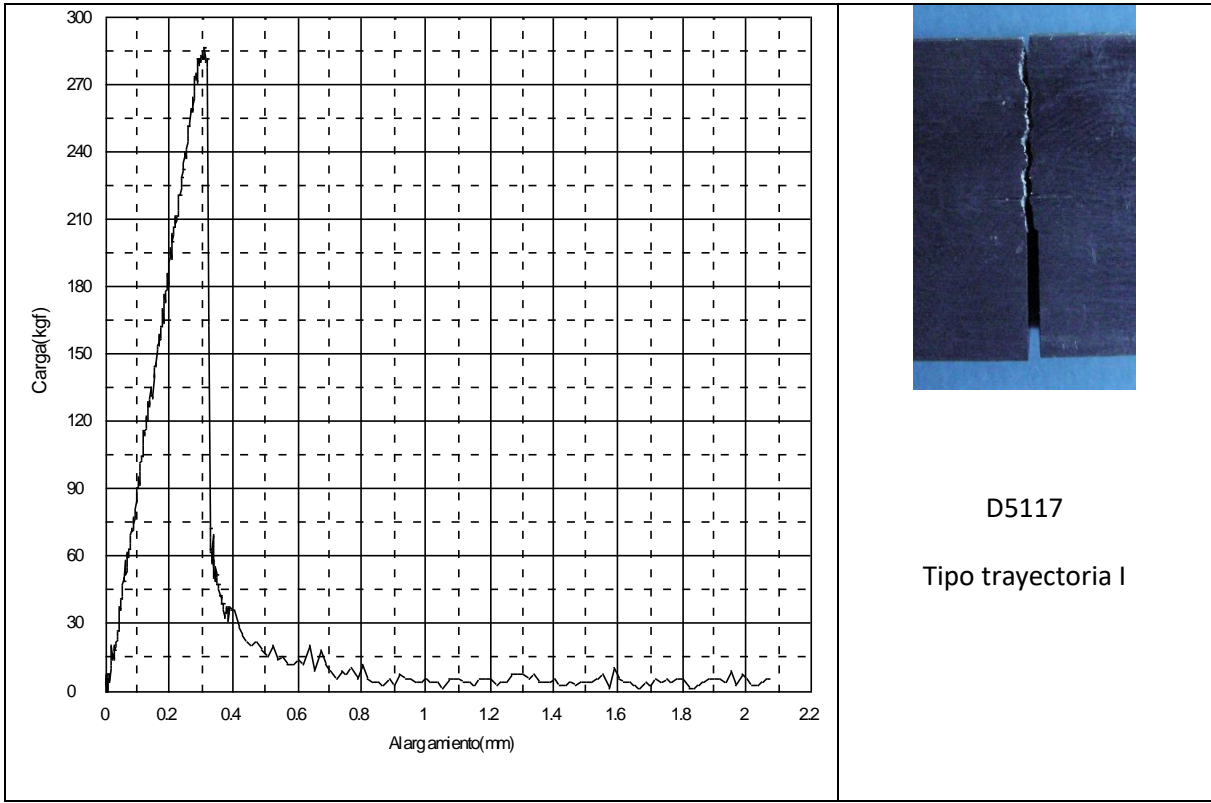
D5115

Tipo trayectoria I



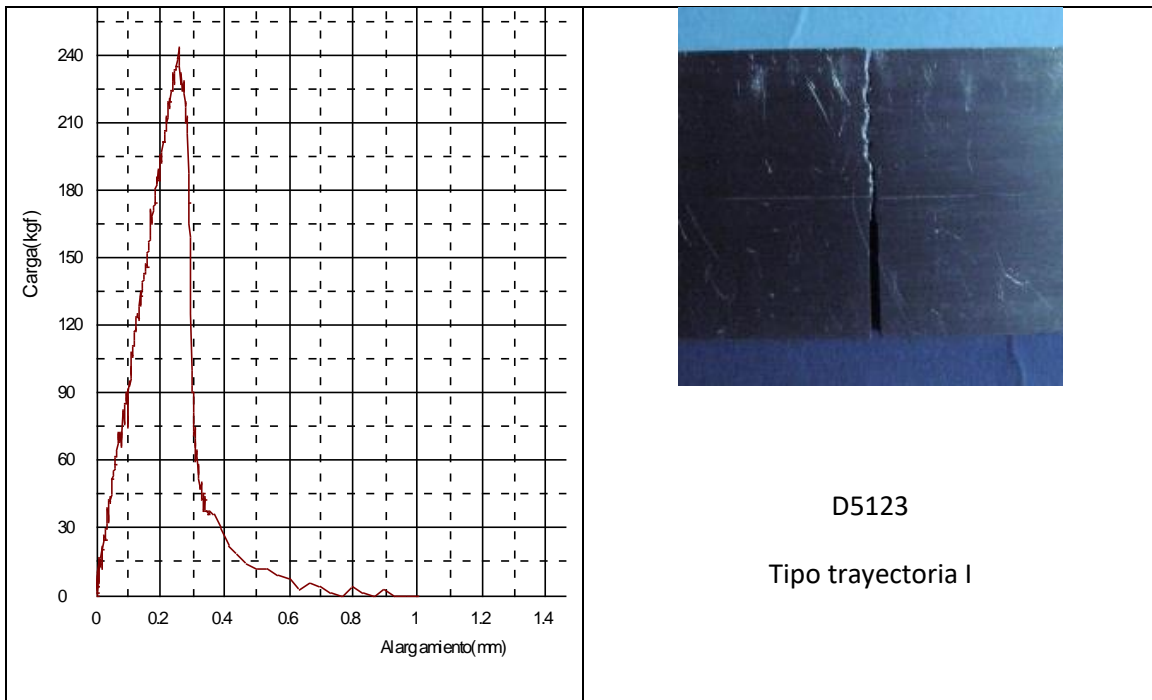
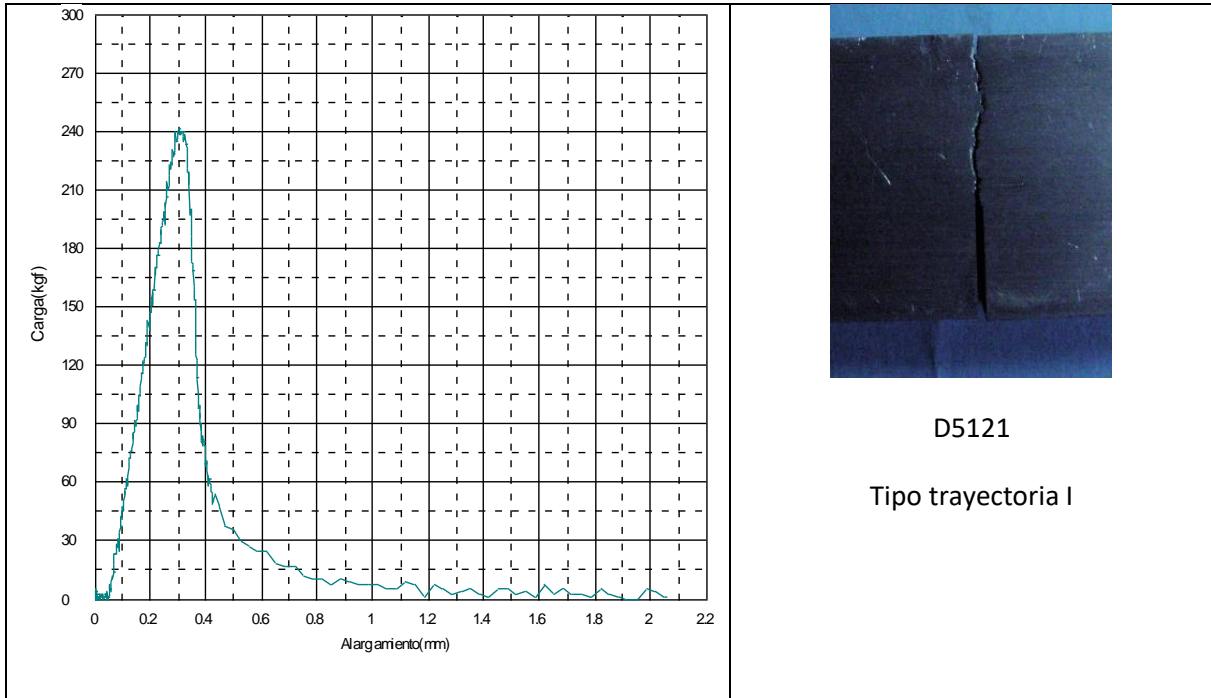
D5116

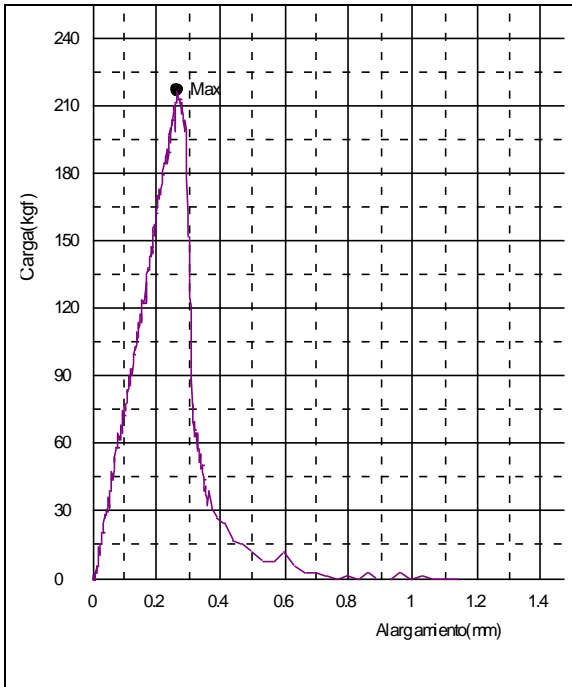
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
191 °C	D5112	L
	D5114	L
	D5115	L
	D5116	L
	D5117	L

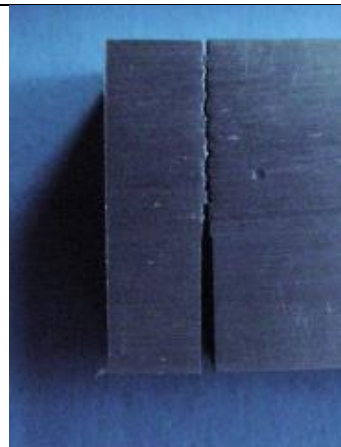
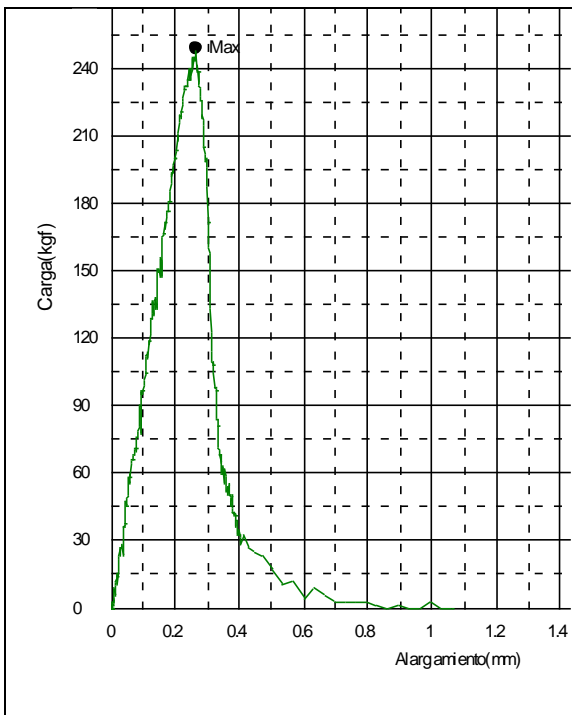
Figura E 15. Graficas ensayo de flexión, probetas D5 temperatura de envejecimiento 201°C





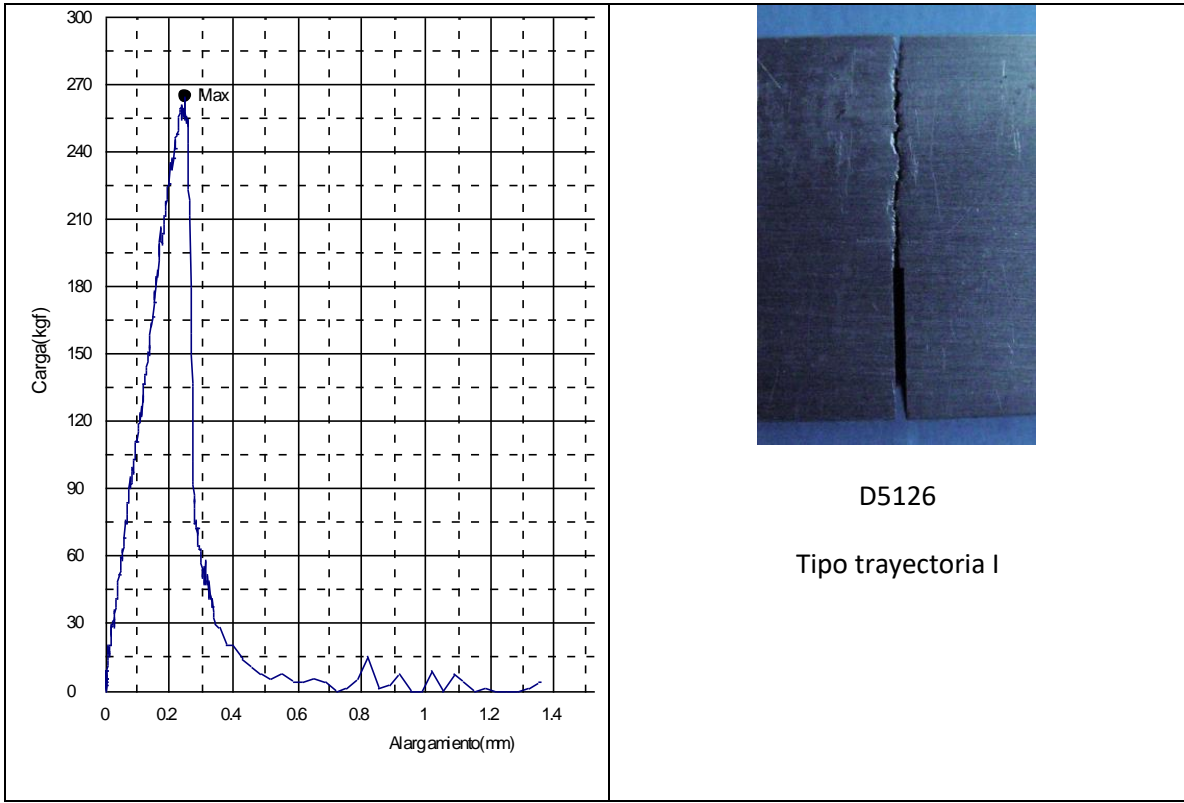
D5124

Tipo trayectoria I



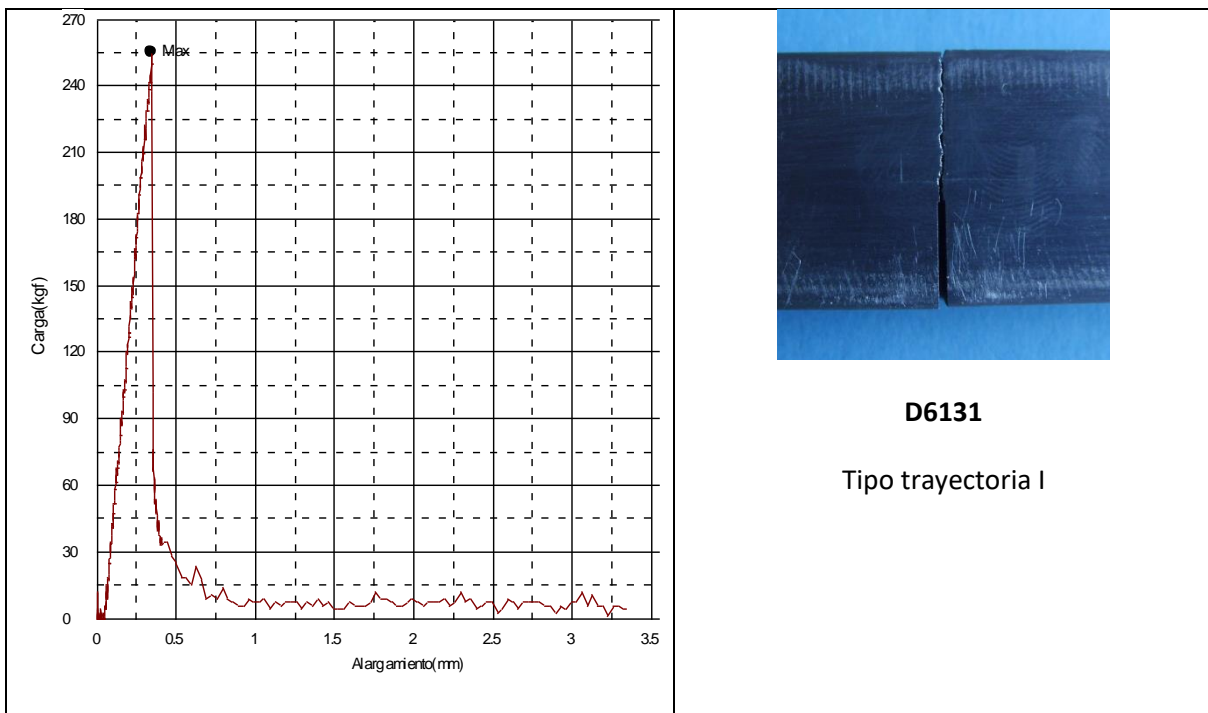
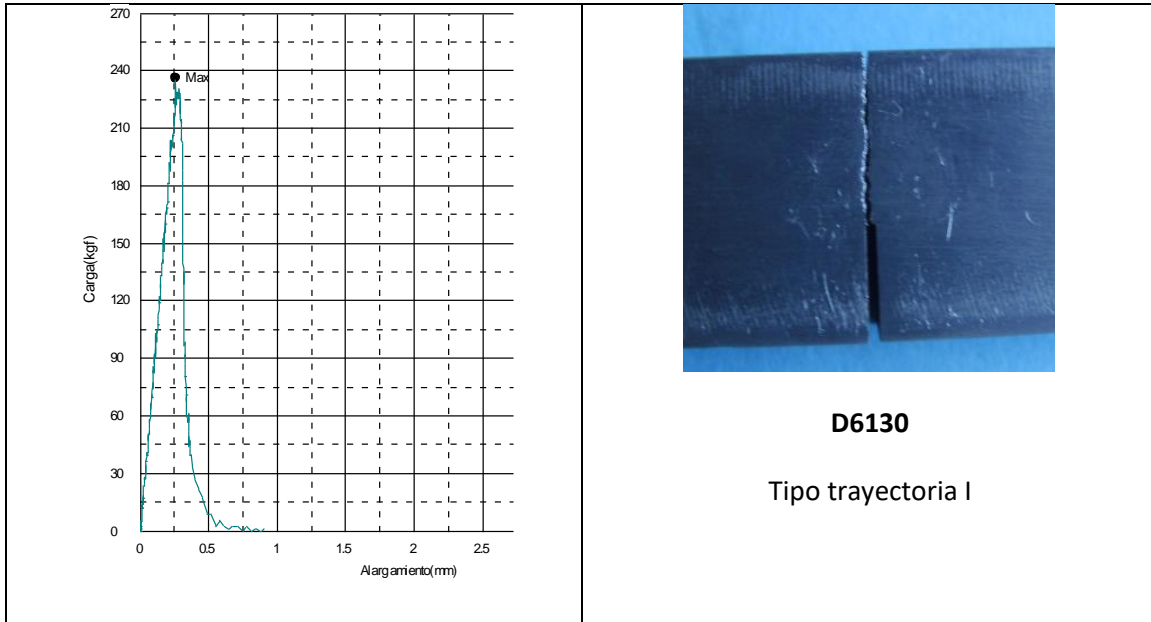
D5125

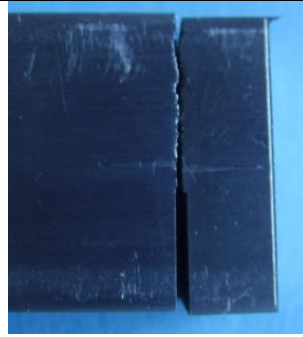
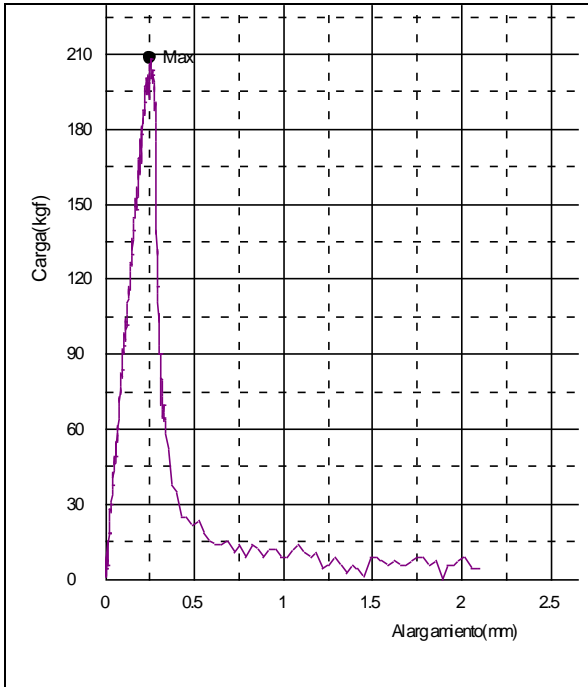
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
201 °C	D5121	L
	D5123	L
	D5124	L
	D5125	L
	D5126	L

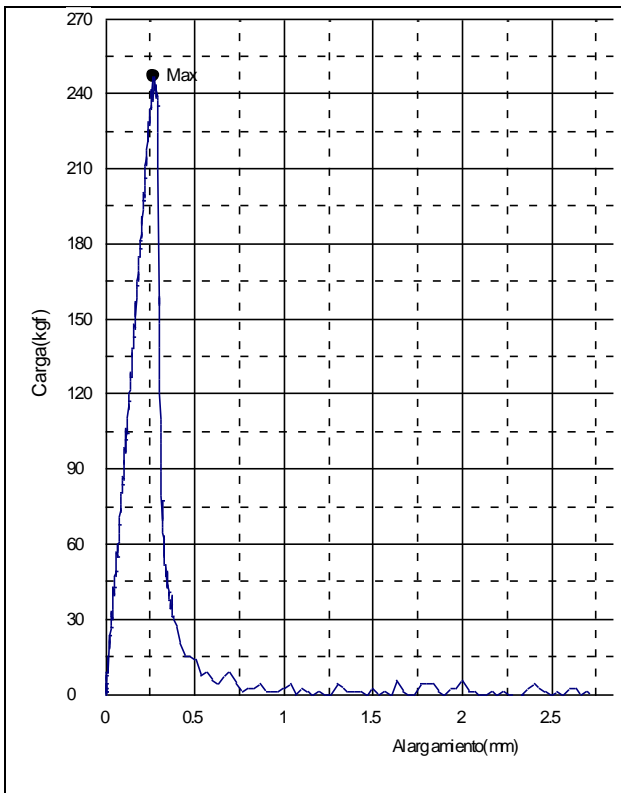
Figura E 16. Graficas ensayo de flexión, probetas D6 temperatura de envejecimiento 181°C





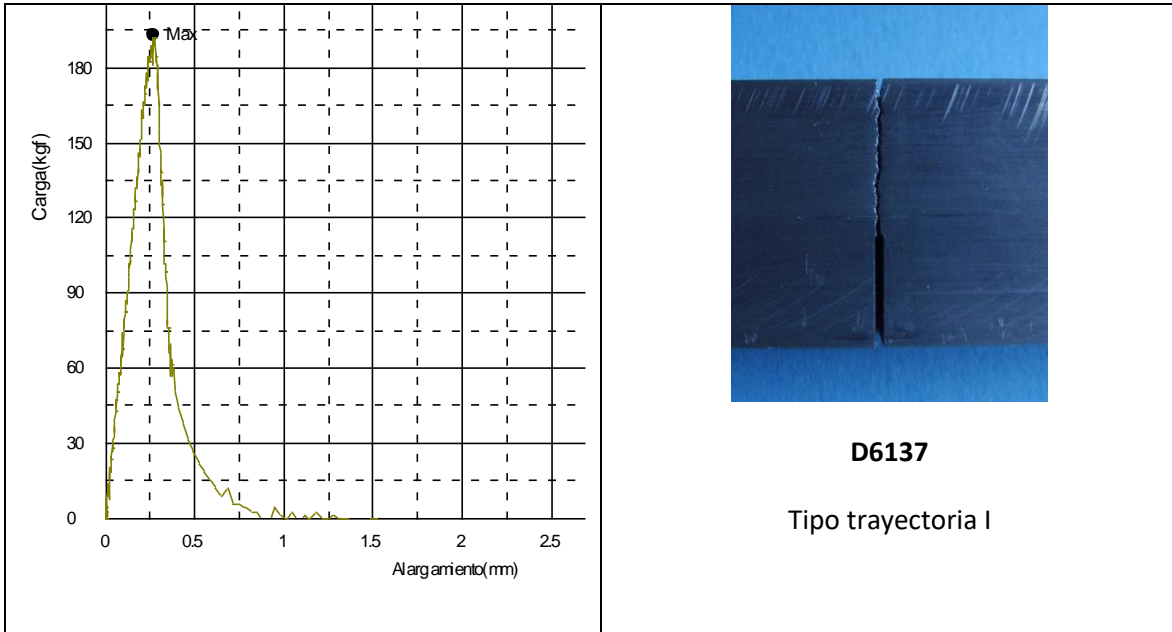
D6132

Tipo trayectoria I



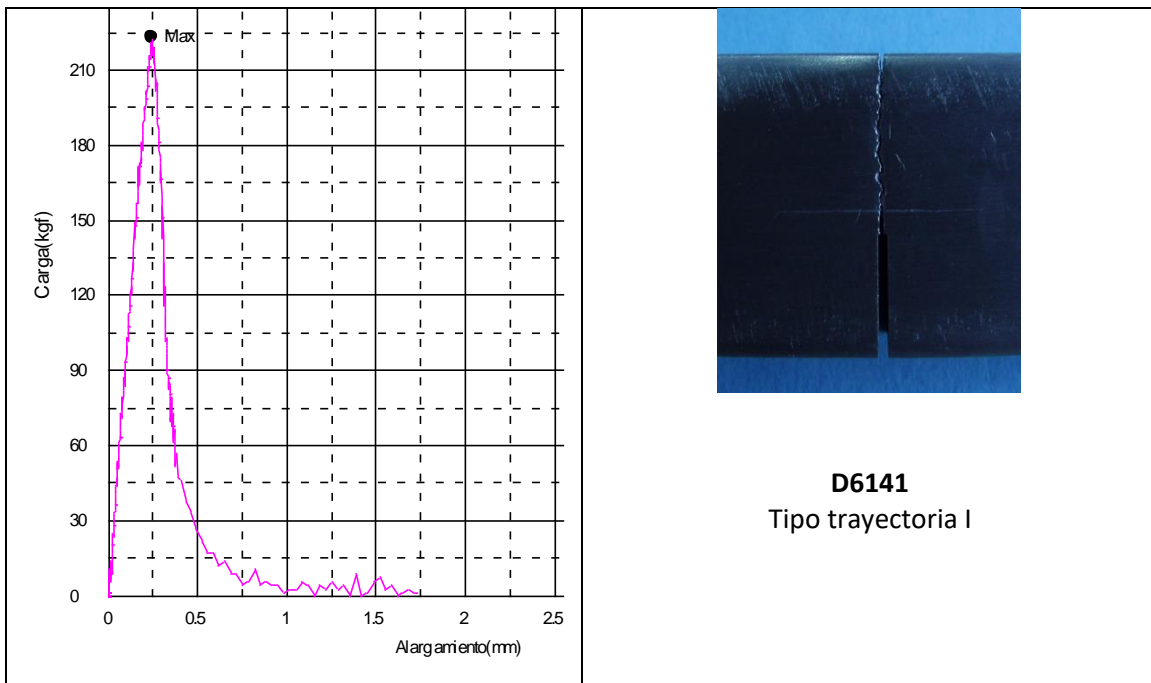
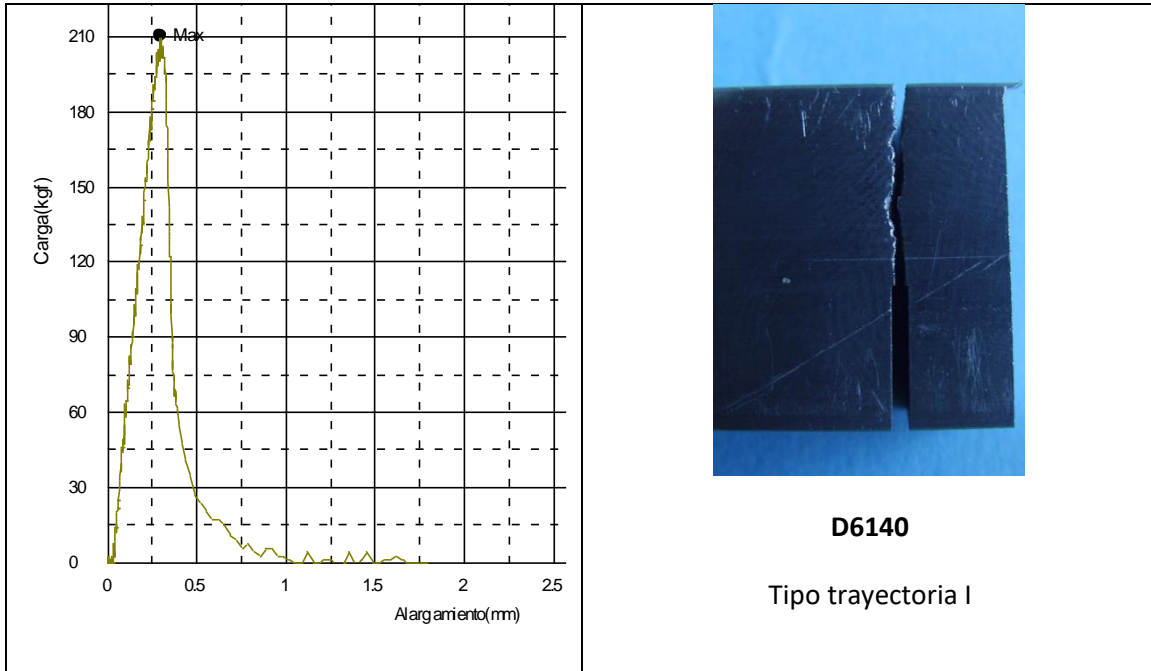
D6134

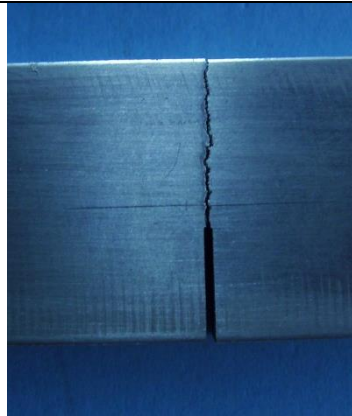
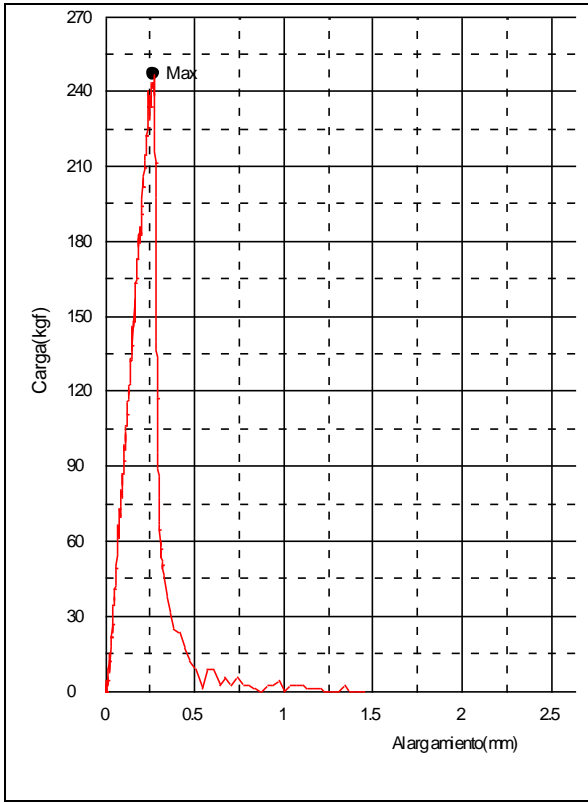
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
181 °C	D6130	L
	D6131	L
	D6132	L
	D6134	L
	D6137	L

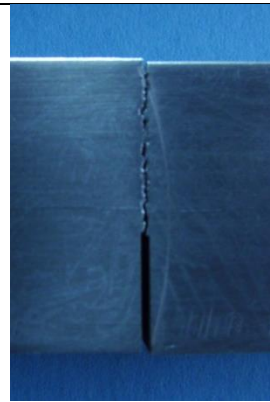
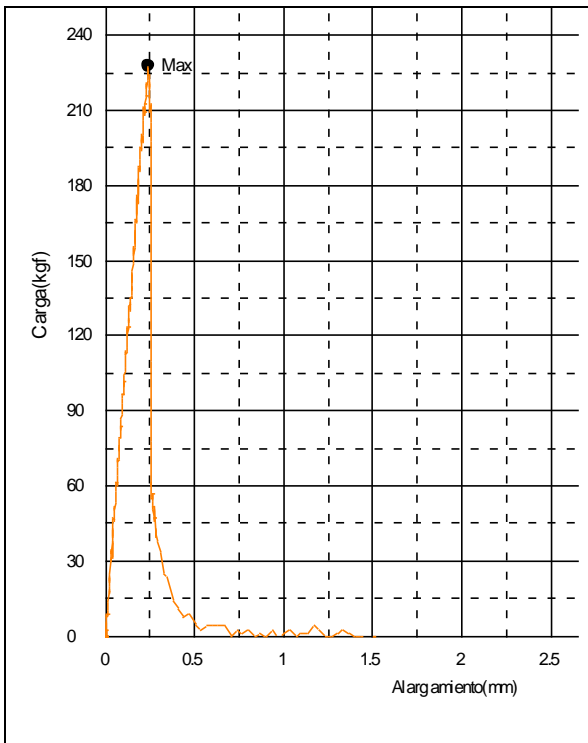
Figura E 17. Graficas ensayo de flexión, probetas D6 temperatura de envejecimiento 191°C





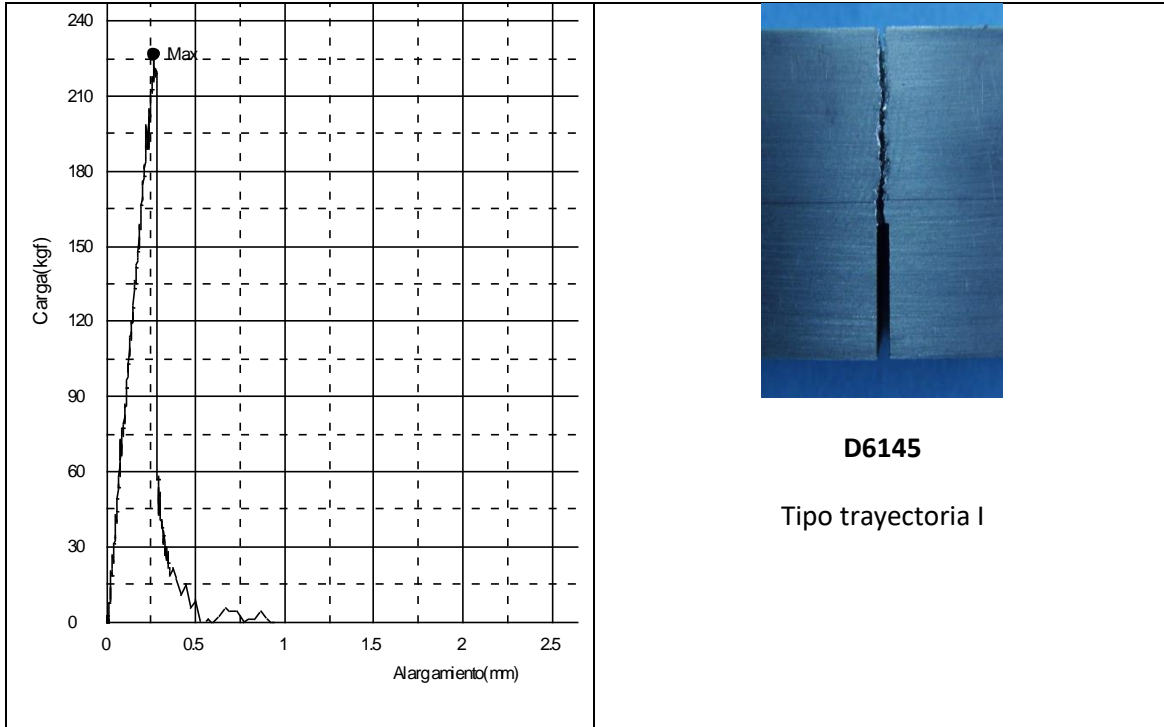
D6142

Tipo trayectoria I



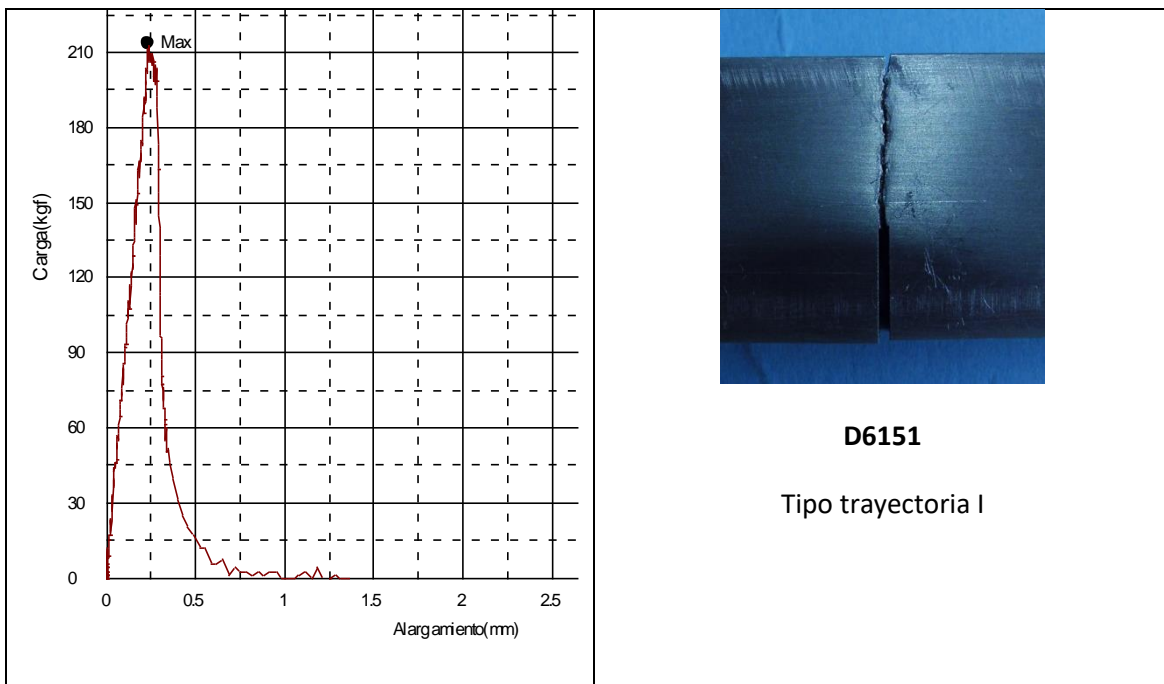
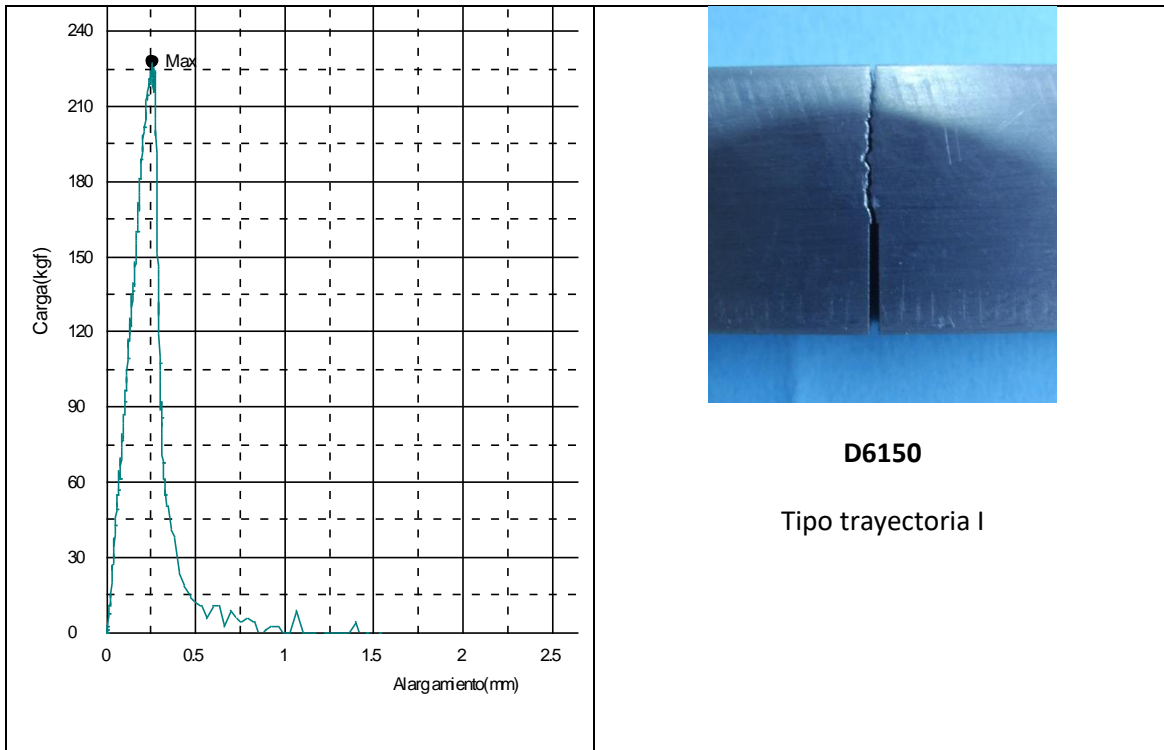
D6144

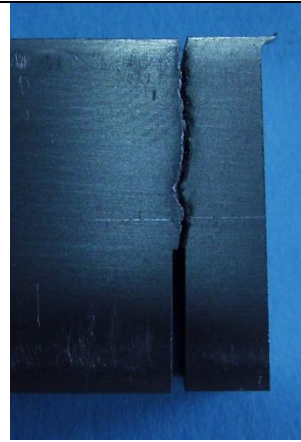
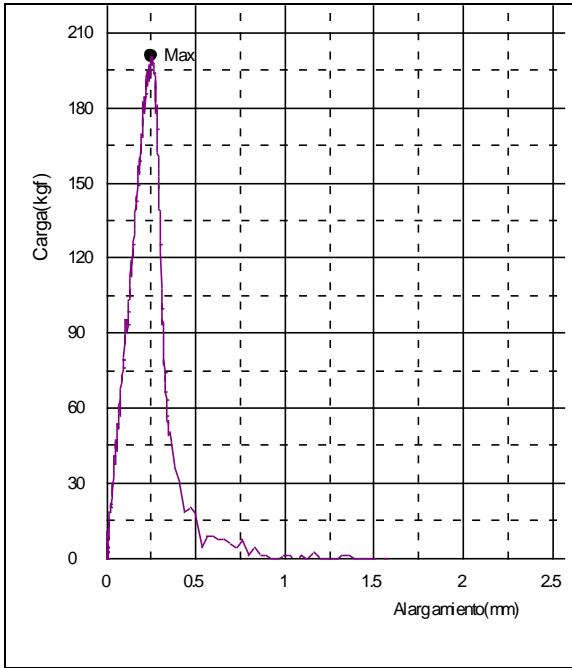
Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
191 °C	D6140	L
	D6141	L
	D6142	L
	D6144	L
	D6145	L

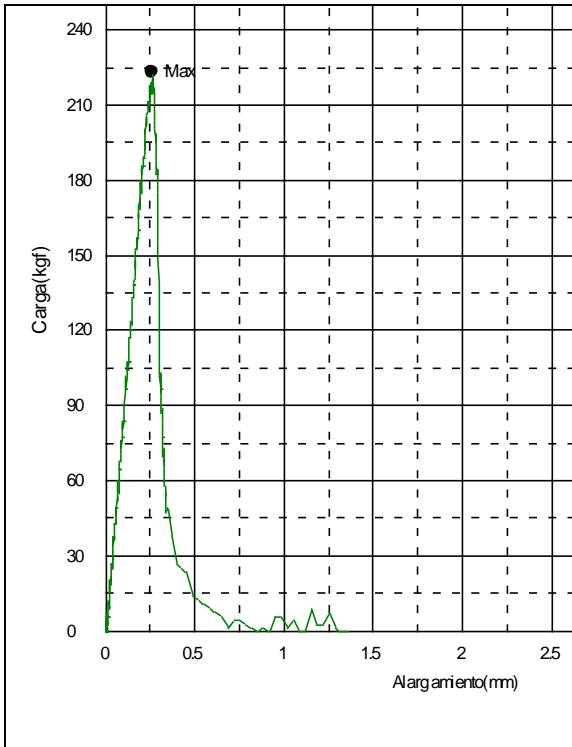
Figura E 18. Graficas ensayo de flexión, probetas D6 temperatura de envejecimiento 201°C





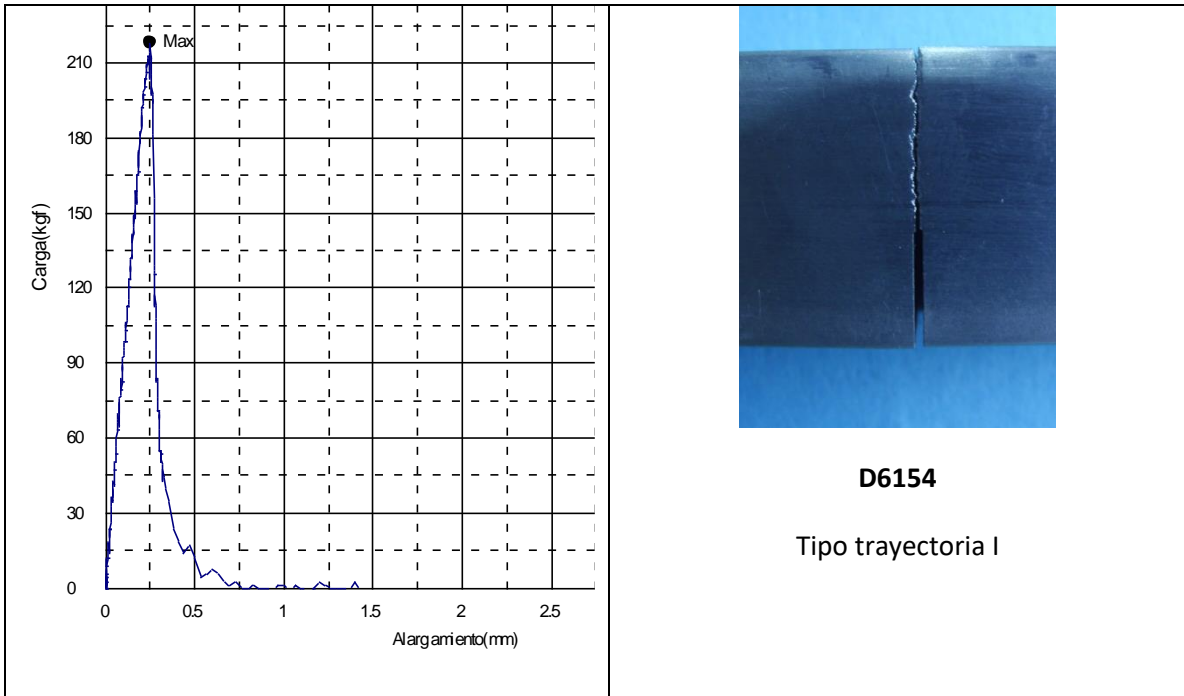
D6152

Tipo trayectoria II



D6153

Tipo trayectoria I



Temperatura de envejecimiento	Probeta	Tipo de gráfica
191 °C	D6150	L
	D6151	L
	D6152	L
	D6153	L
	D6154	L

Anexo F

Selección de probetas para análisis de metalografía, SEM, fractografía, dureza, difracción de rayos X y corrosión

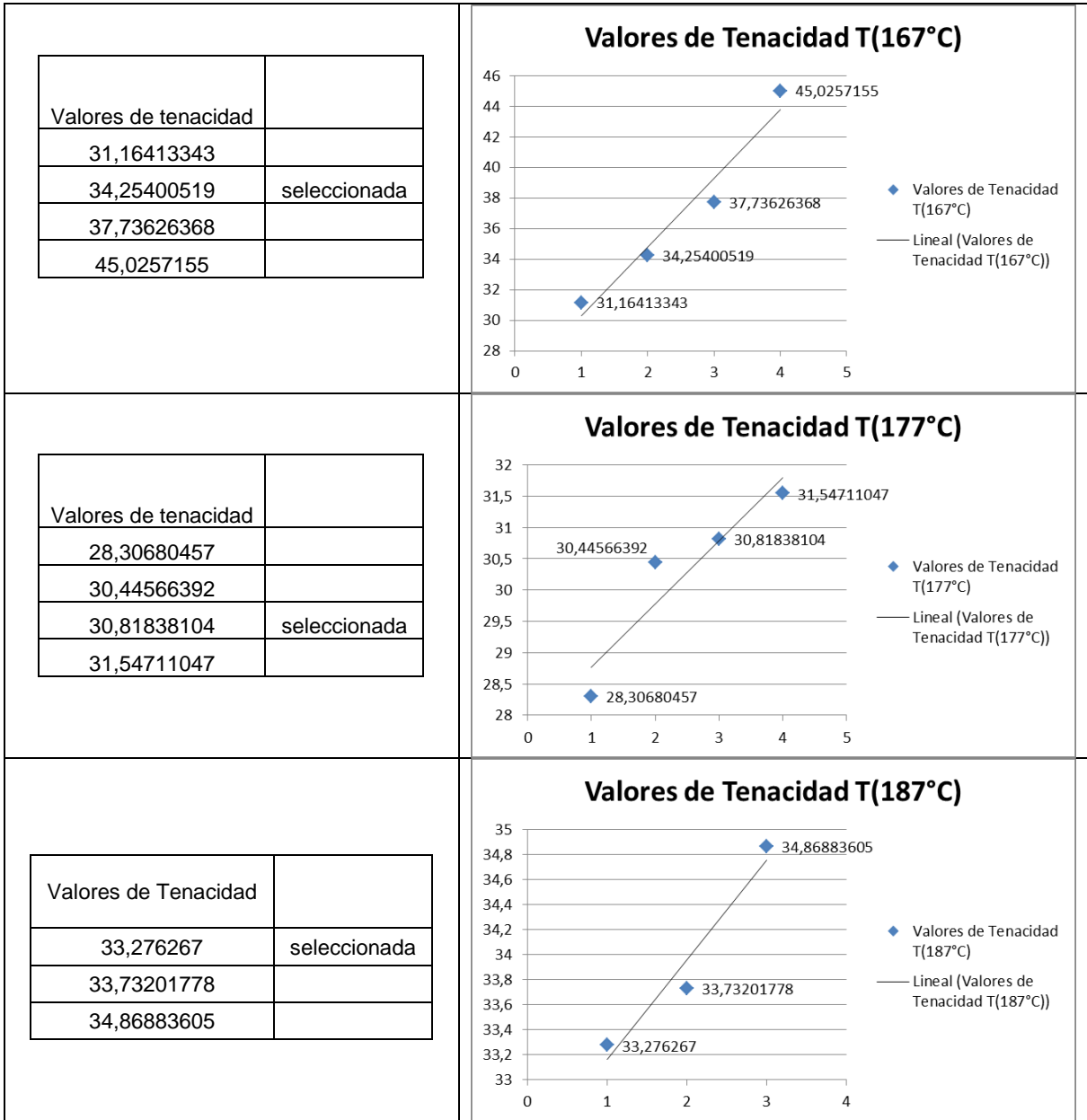


Tabla F 1. Selección probetas D1

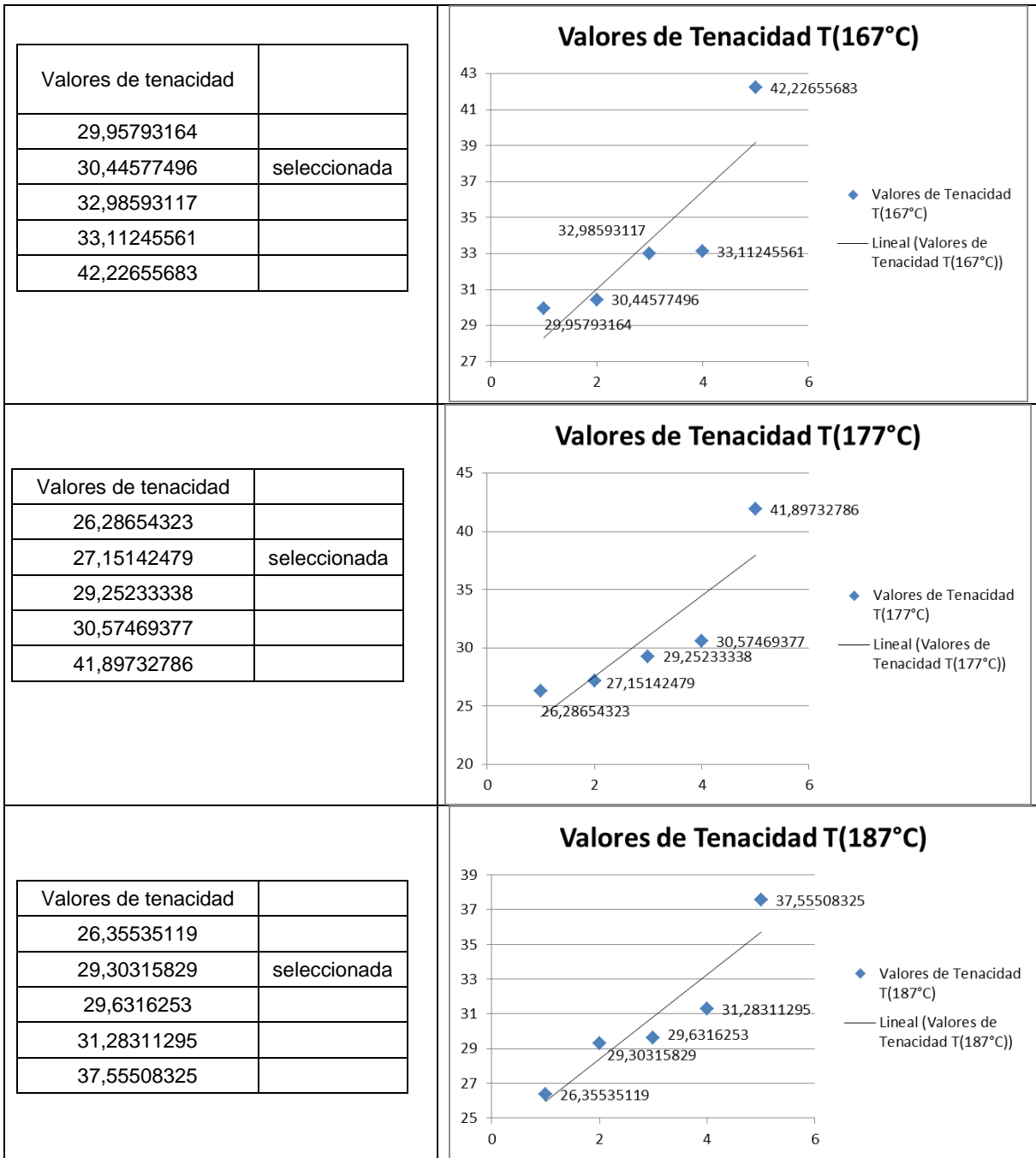


Tabla F 2. Selección probetas D2

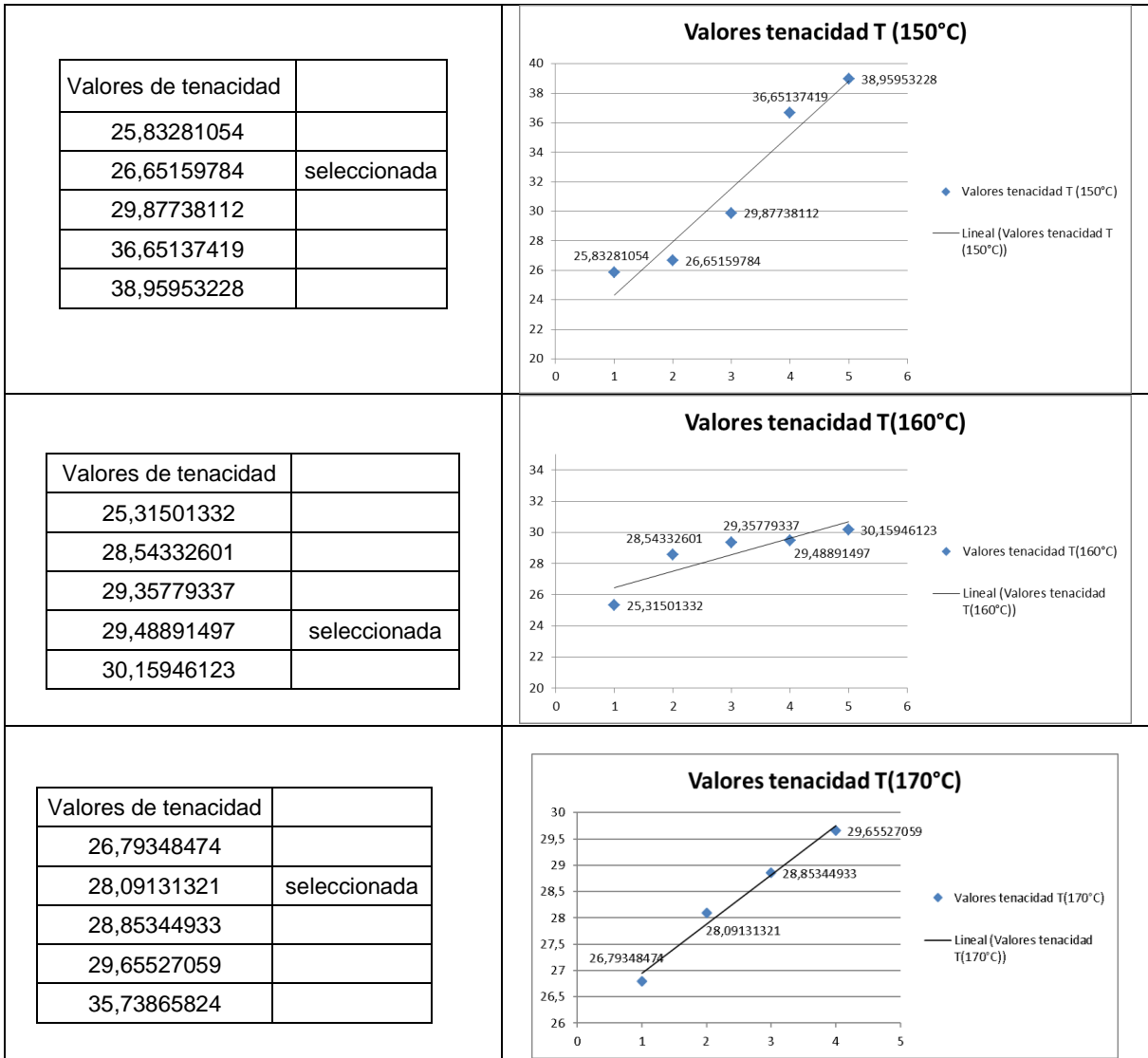


Tabla F 3. Selección probetas D3

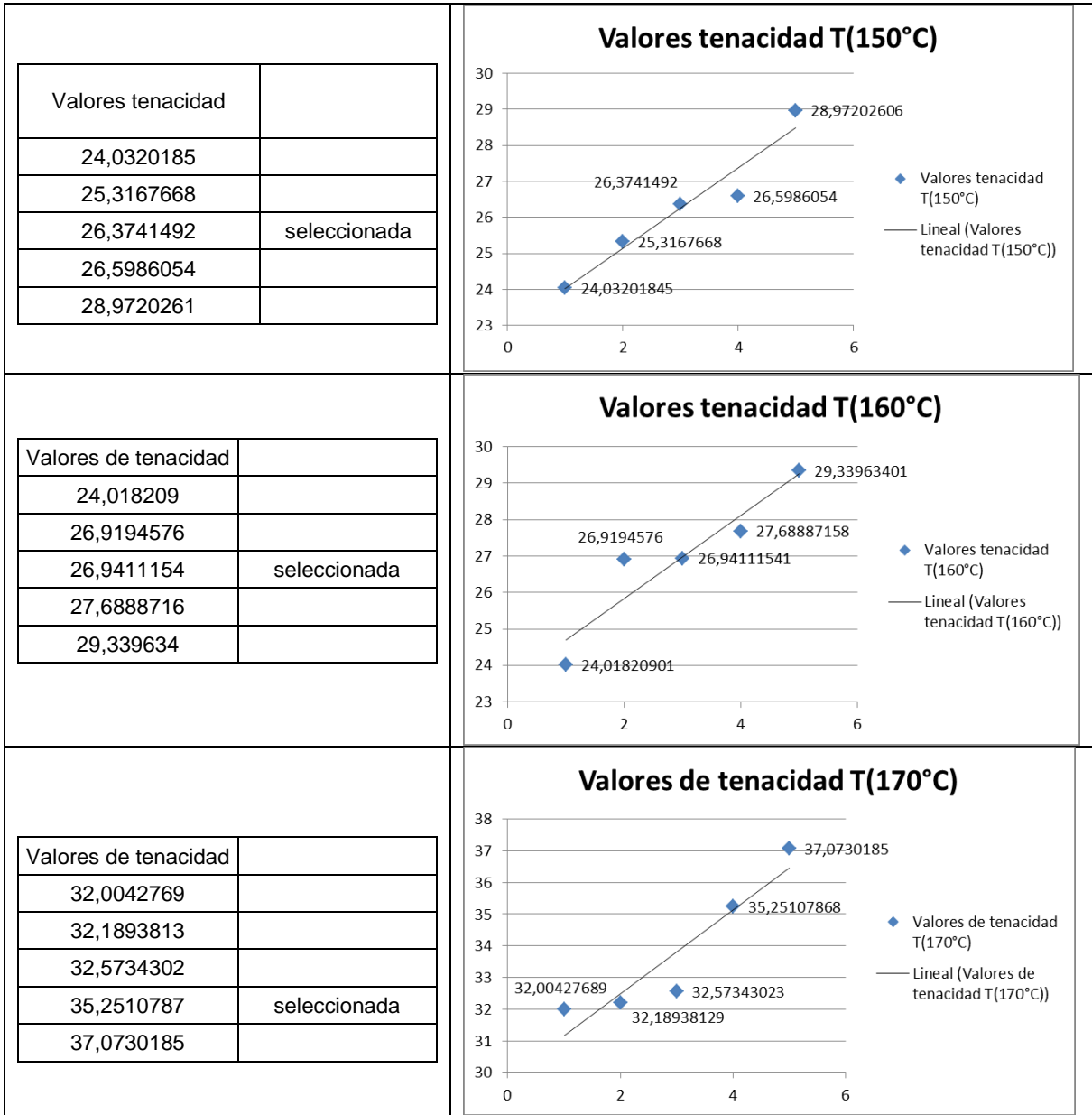


Tabla F 4. Selección probetas D4

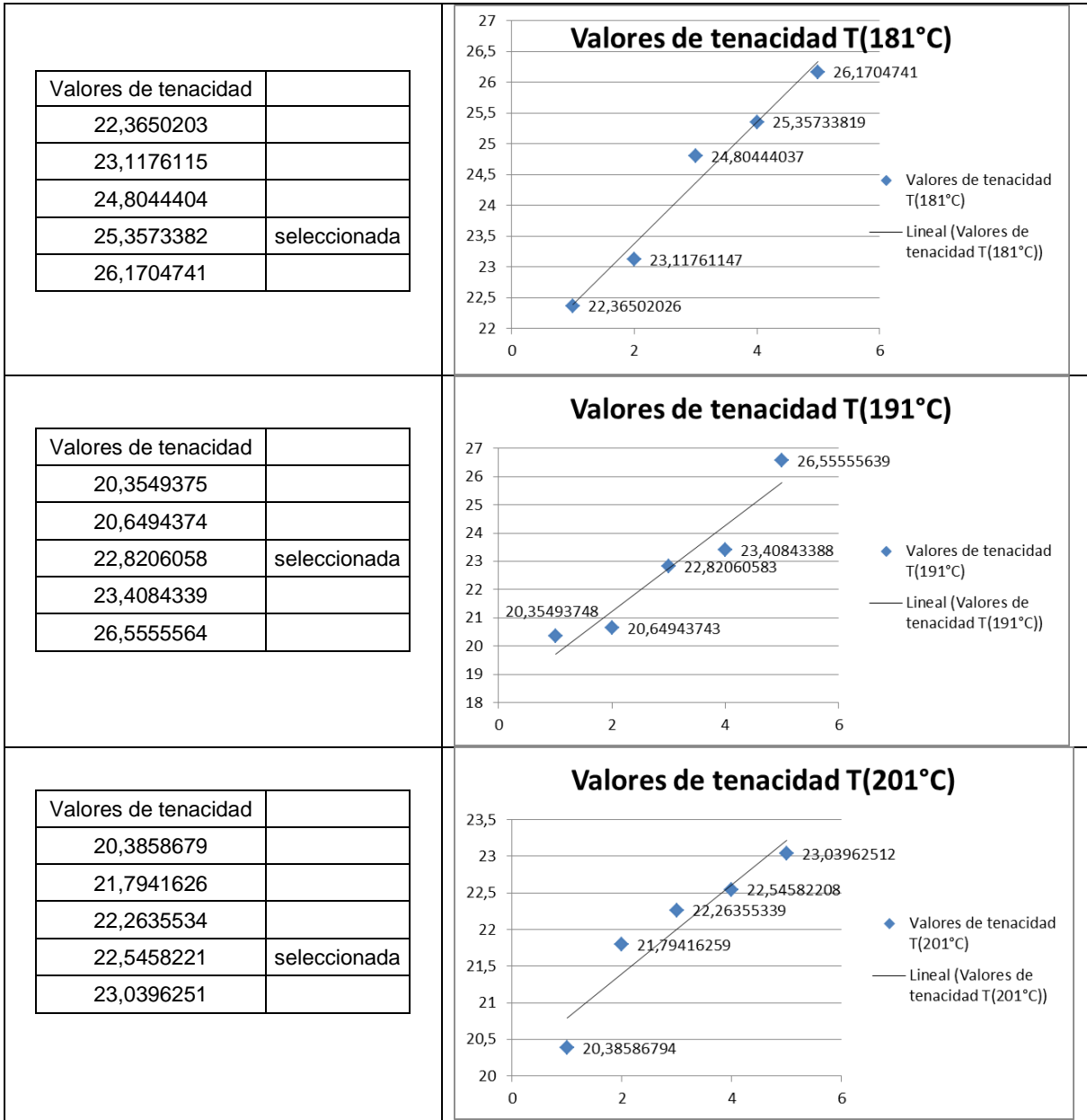


Tabla F 5. Selección probetas D5

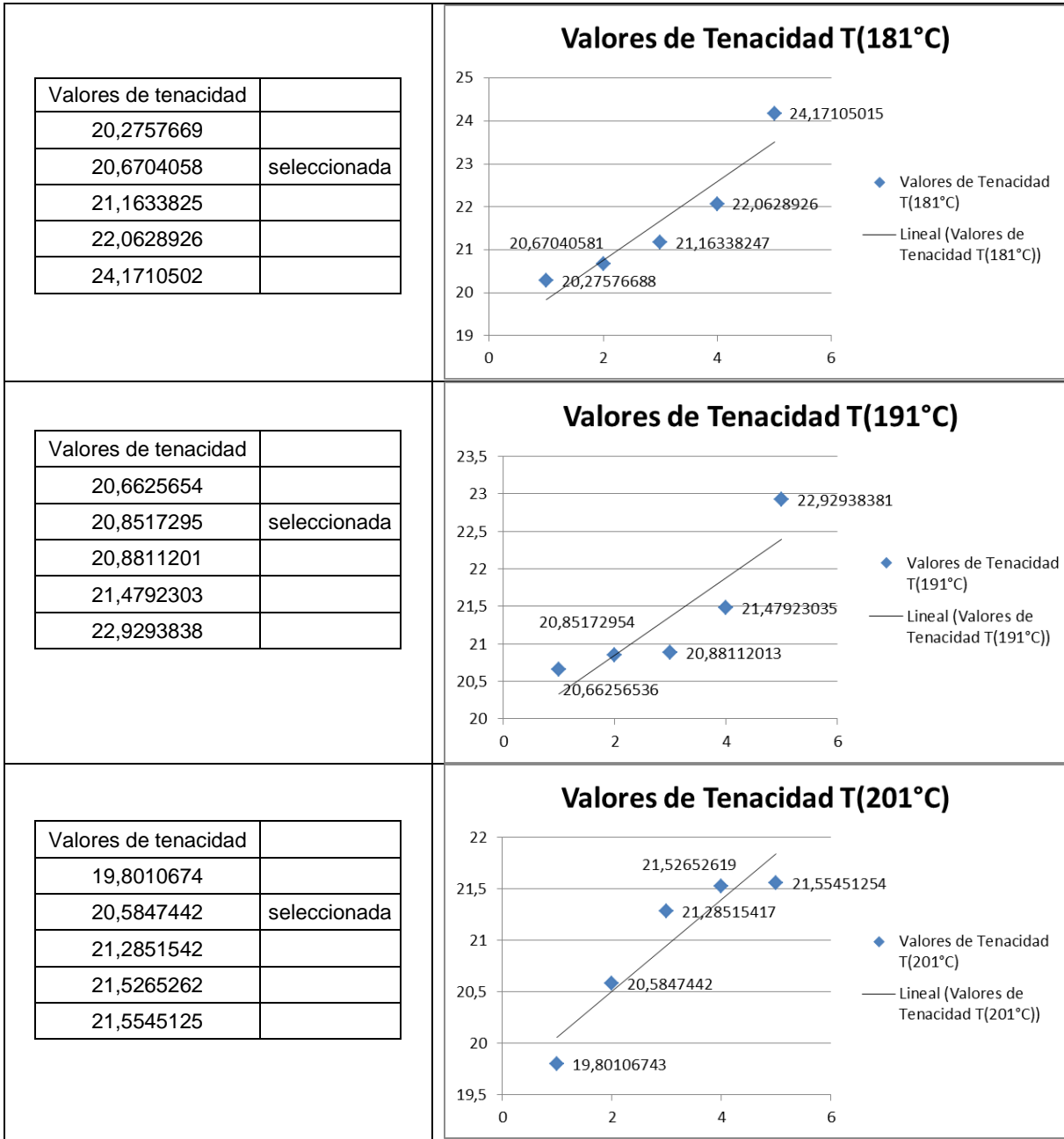


Tabla F 6. Selección probetas D6

Anexo G

Tipo de superficie de fractura

Dependiendo de la topografía


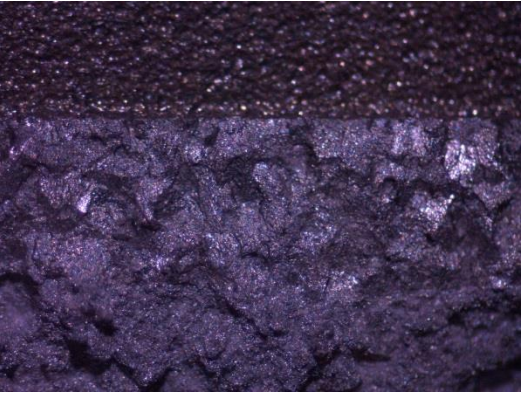



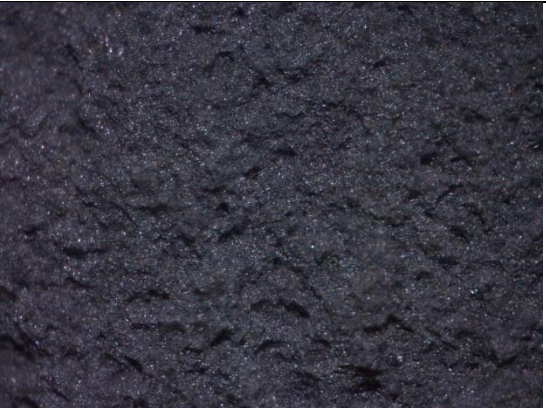
 <p>D154</p>	
 <p>D164</p>	
 <p>D168</p>	

Tabla G 1. Tipo de superficie de fractura, probetas D1

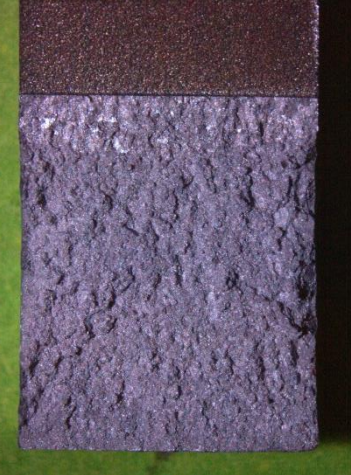

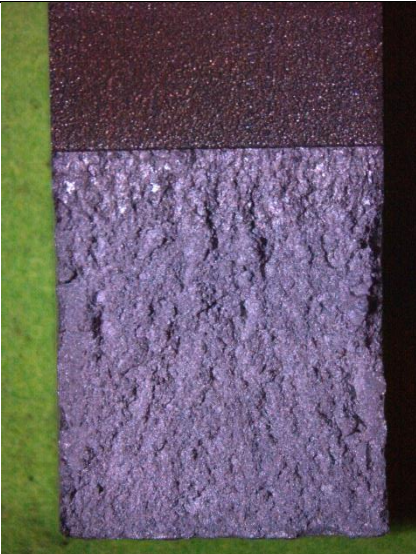
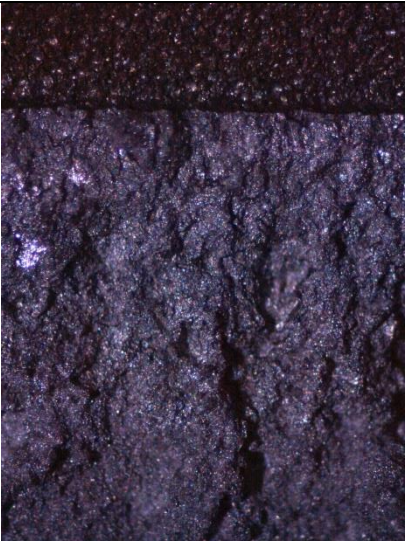


 <p>D277</p>	
 <p>D286</p>	
 <p>D295</p>	

Tabla G 2. Tipo de superficie de fractura, probetas D2

TEMPERATURA DE ENVEJECIMIENTO (°C)	PROBETA	TIPO DE SUPERFICIE
167	D2 (Probeta 77)	Tipo 1
177	D2 (Probeta 86)	Tipo 1
187	D2 (Probeta 95)	Tipo 1

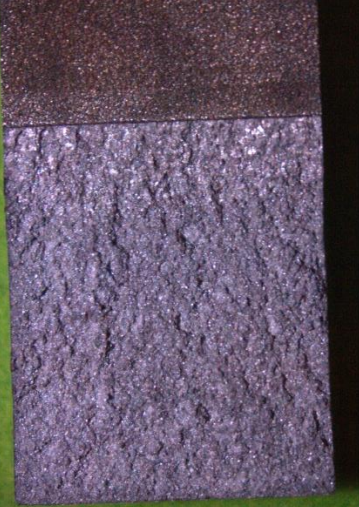

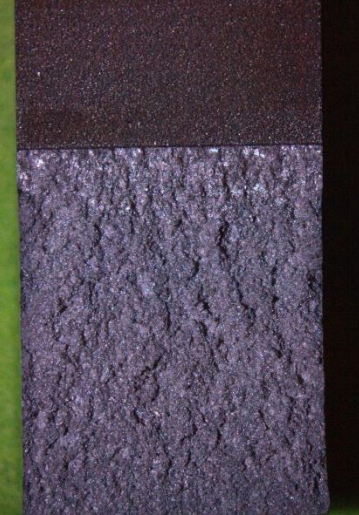



	<p>D327</p>		
	<p>D337</p>		
	<p>D347</p>		

Tabla G 3. Tipo de superficie de fractura, probetas D3

TEMPERATURA DE ENVEJECIMIENTO (°C)	PROBETA	TIPO DE SUPERFICIE
150	D3(Probeta 27)	Tipo 1
160	D3 (Probeta 37)	Tipo 1
170	D3 (Probeta 47)	Tipo 1




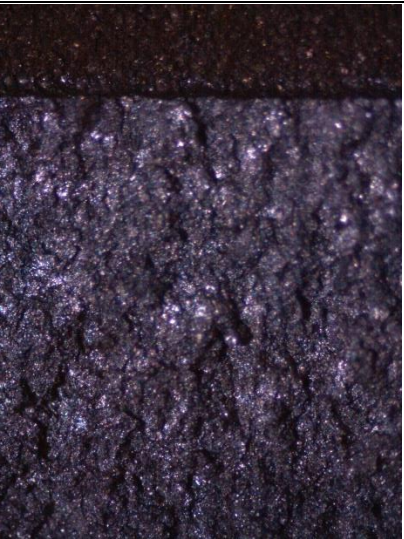

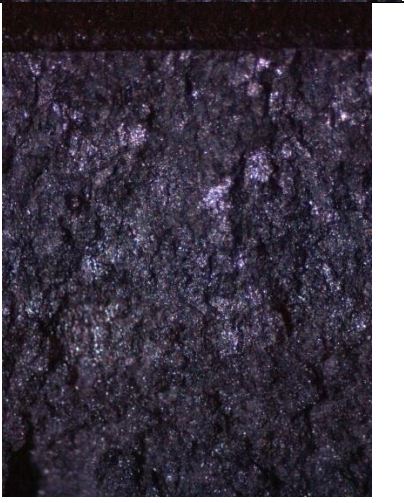
	<p>D45</p>		
	<p>D410</p>		
	<p>D419</p>		

Tabla G 4. Tipo de superficie de fractura, probetas D4

TEMPERATURA DE ENVEJECIMIENTO (°C)	PROBETA	TIPO DE SUPERFICIE
150	D4(Probeta 5)	Tipo 1
160	D4(Probeta 10)	Tipo 1
170	D4(Probeta 19)	Tipo 1






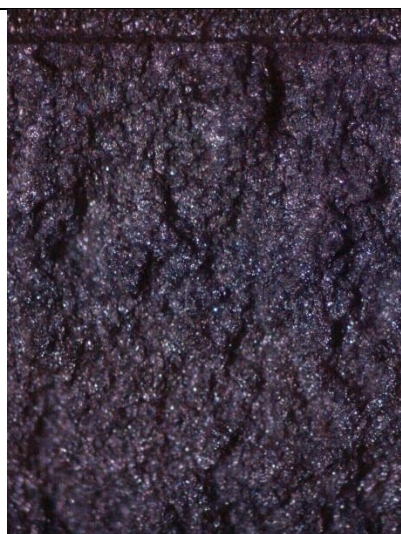
	<p>D5103</p>	
	<p>D5115</p>	
	<p>D5125</p>	

Tabla G 5. Tipo de superficie de fractura, probetas D5

TEMPERATURA DE ENVEJECIMIENTO (°C)	PROBETA	TIPO DE SUPERFICIE
181	D5(Probeta 103)	Tipo 1
191	D5(Probeta 115)	Tipo 1
201	D5(Probeta 125)	Tipo 1






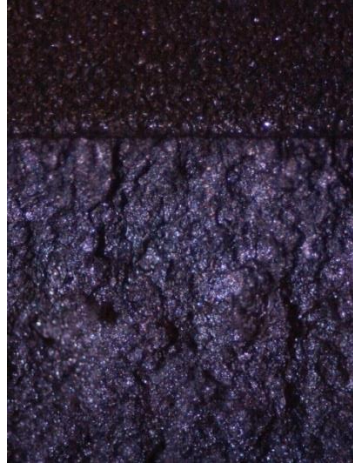
 <p>D6132</p>	
 <p>D6140</p>	
 <p>D6152</p>	

Tabla G 6. Tipo de superficie de fractura, probetas D6

TEMPERATURA DE ENVEJECIMIENTO (°C)	PROBETA	TIPO DE SUPERFICIE
181	D6(Probeta 132)	Tipo 1
191	D6(Probeta 140)	Tipo 1
201	D6(Probeta 152)	Tipo 1

Anexo H

Tipo de fractura microscópica en microscopio electrónico de barrido – SEM

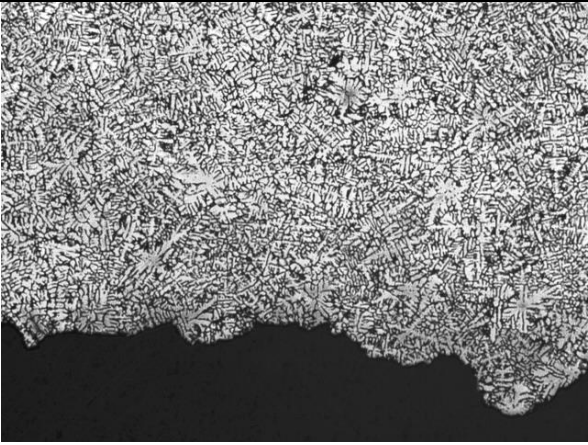
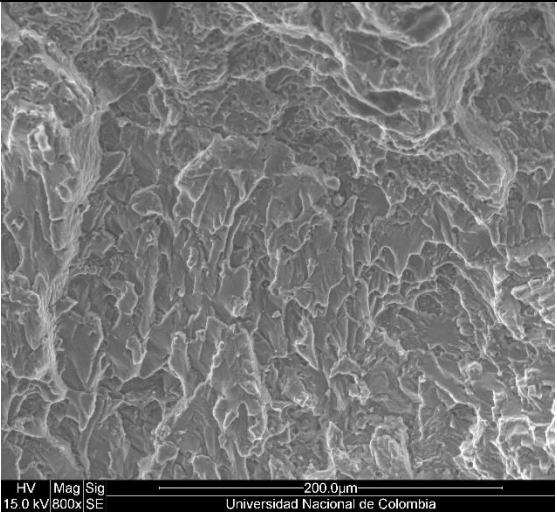
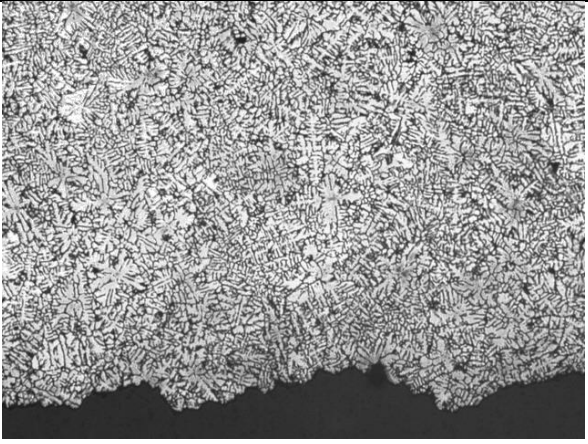
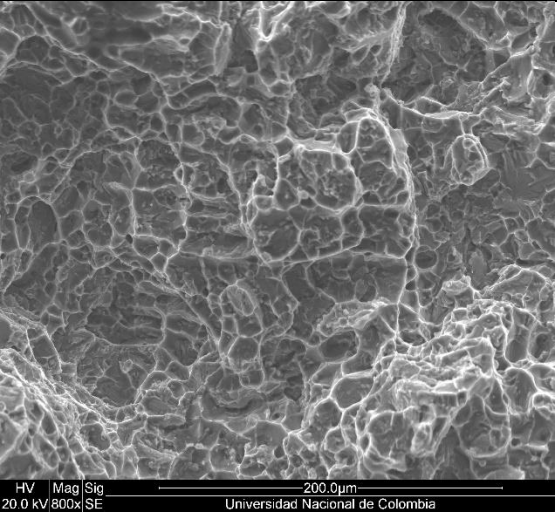
 <p>(A)</p>	 <p>(A)</p>
 <p>(B)</p>	 <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 1. Dirección D1, temperatura 167°C, probeta 54

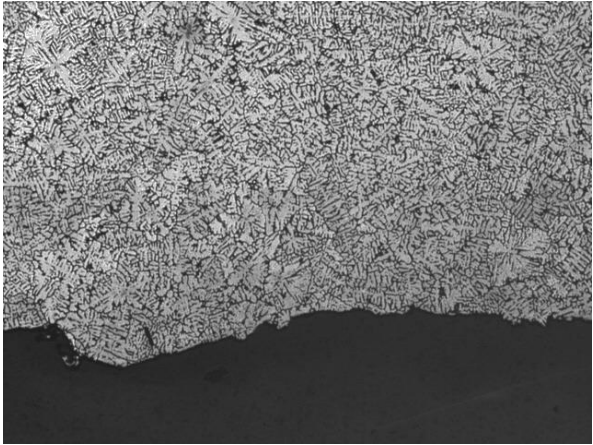
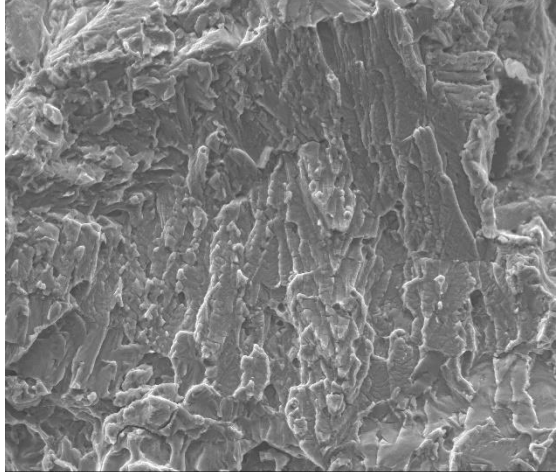
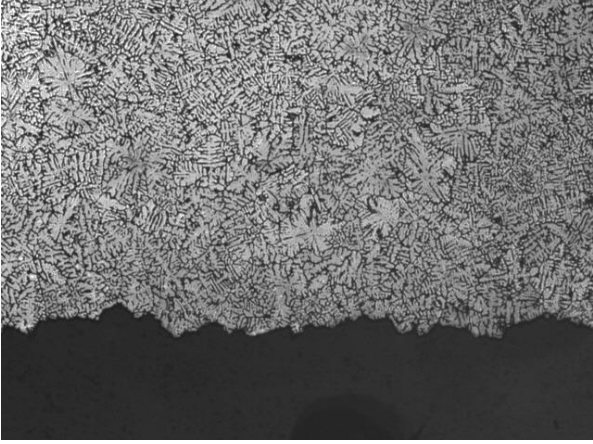
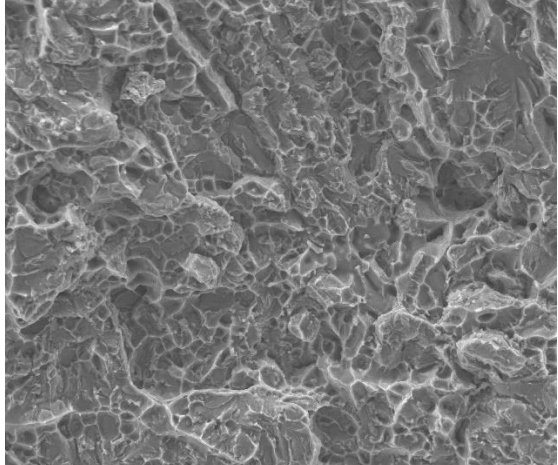
 <p>(A)</p>	 <p>HV Mag Sig 200.0µm 20.0 kV 800x SE Universidad Nacional de Colombia</p> <p>(A)</p>
 <p>(B)</p>	 <p>HV Mag Sig 200.0µm 20.0 kV 800x SE Universidad Nacional de Colombia</p> <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 2. Dirección D1, temperatura 177°C, probeta 64

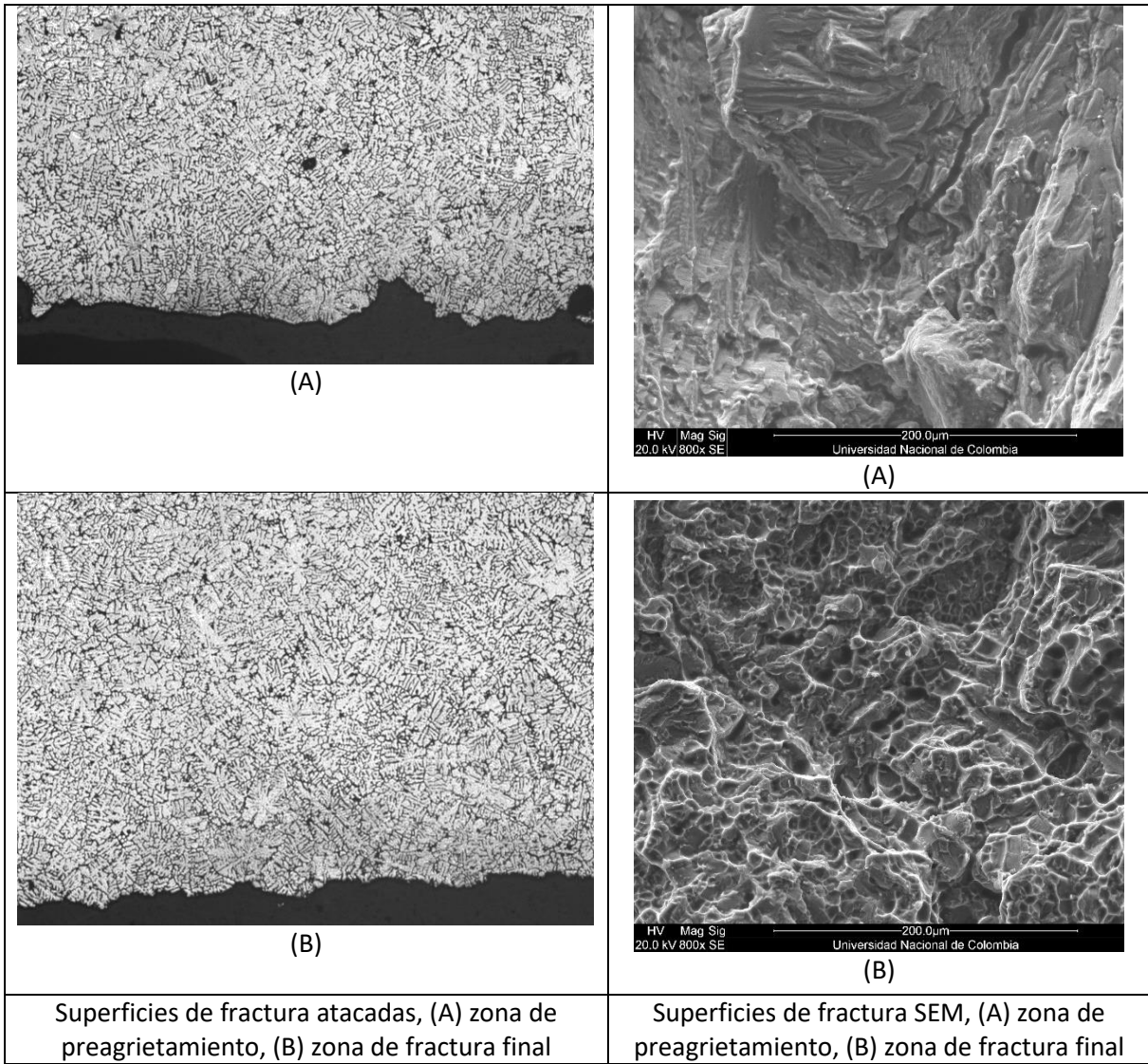


Tabla H 3. Dirección D1, temperatura 187°C, probeta 68

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D1	167	54	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	177	64	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	187	68	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos

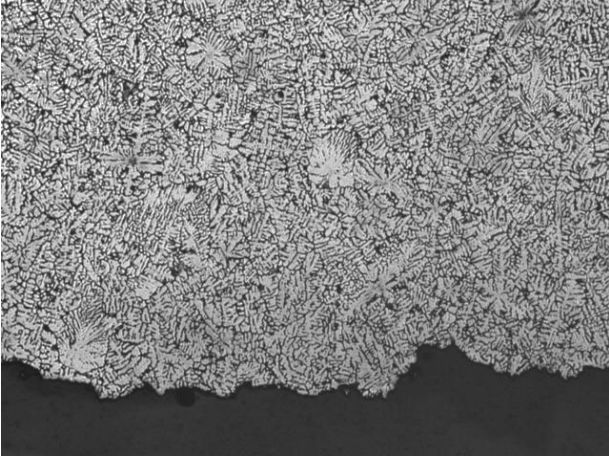
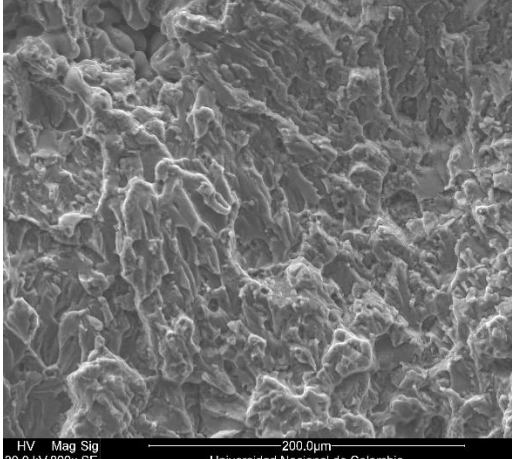
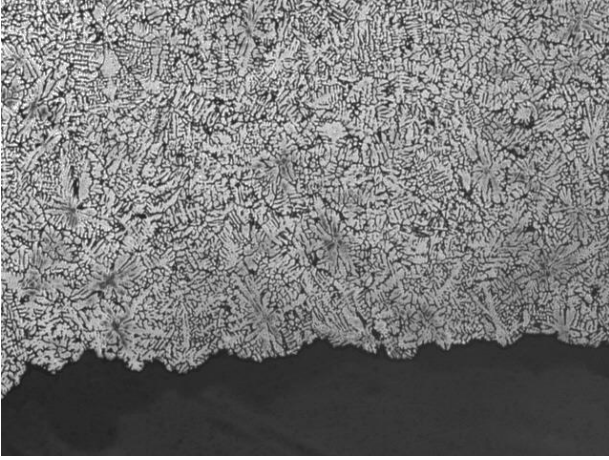
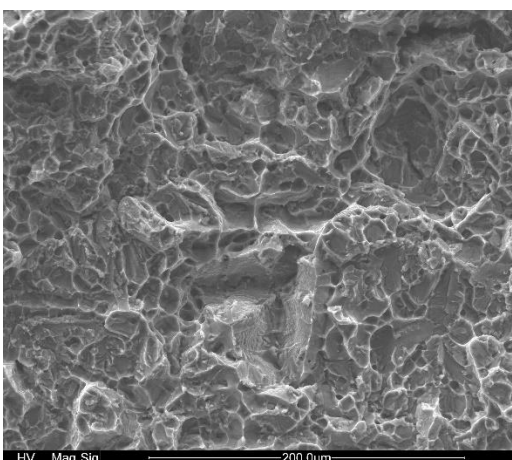
 <p>(A)</p>	 <p>HV Mag Sig 20.0 kV 800x SE 200.0µm Universidad Nacional de Colombia</p> <p>(A)</p>
 <p>(B)</p>	 <p>HV Mag Sig 20.0 kV 800x SE 200.0µm Universidad Nacional de Colombia</p> <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 4. Dirección D2, temperatura 167°C, probeta 77

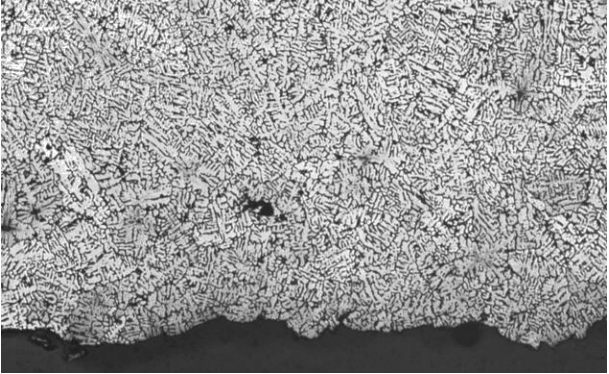
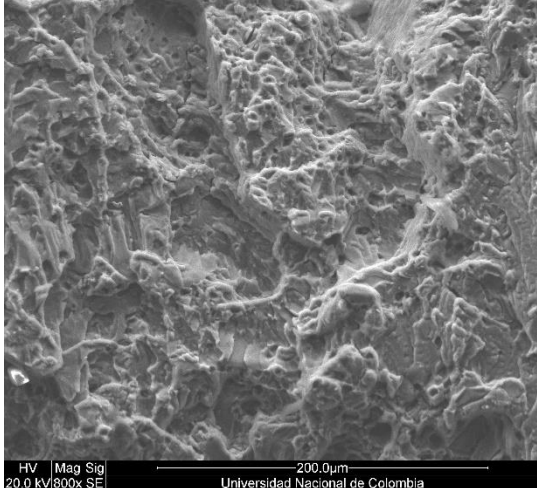
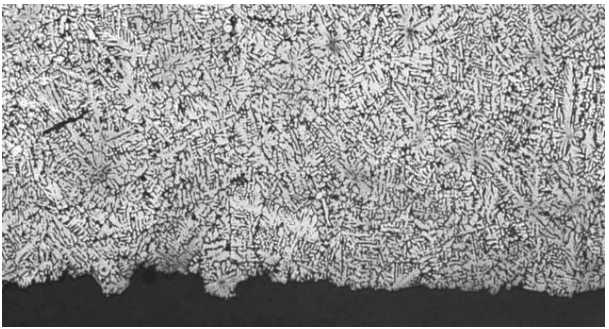
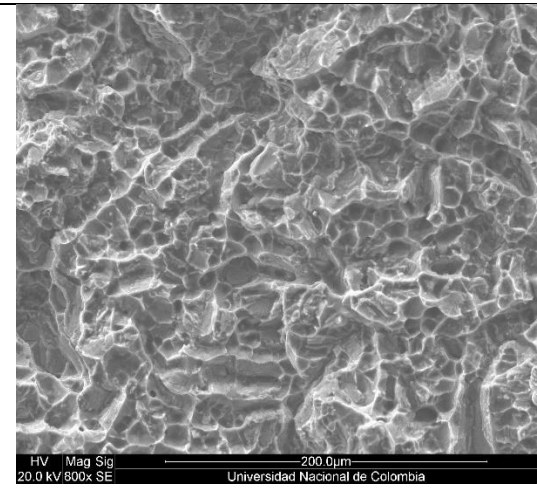
 <p>(A)</p>	 <p>HV Mag Sig 20.0 kV 800x SE 200.0µm Universidad Nacional de Colombia</p> <p>(A)</p>
 <p>(A)</p>	 <p>HV Mag Sig 20.0 kV 800x SE 200.0µm Universidad Nacional de Colombia</p> <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 5. Dirección D2, temperatura 177°C, probeta 86

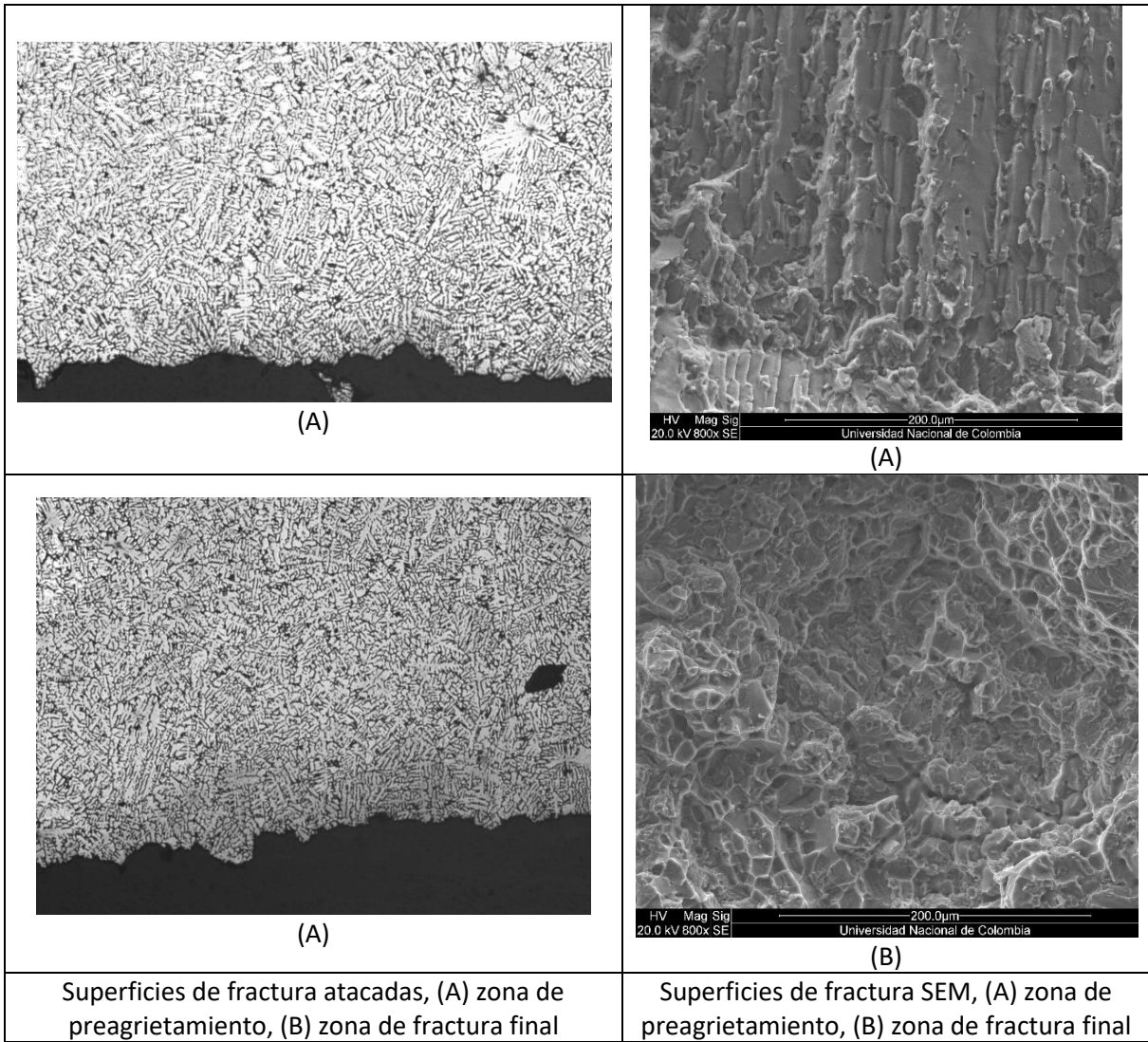


Tabla H 6. Dirección D2, temperatura 187°C, probeta 95

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D2	161	77	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	177	86	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	187	95	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos

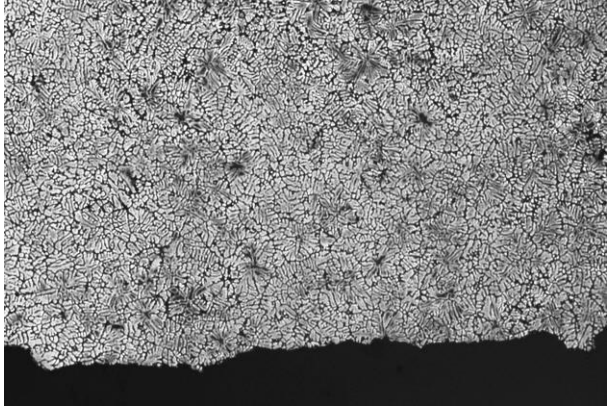
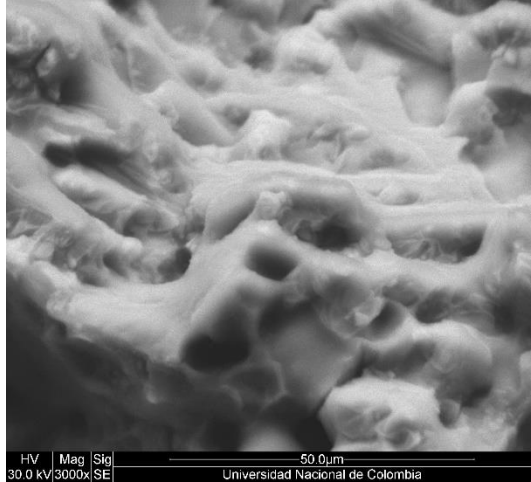
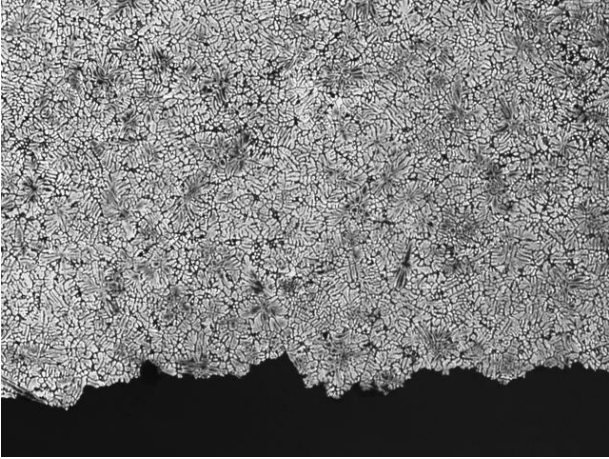
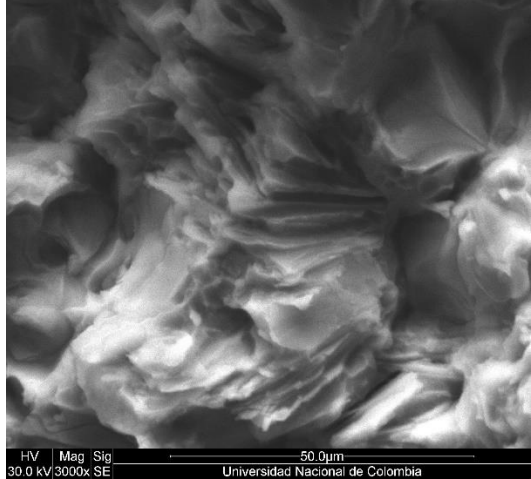
 <p>(A)</p>	 <p>(A)</p>
 <p>(B)</p>	 <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 7. Dirección D3, temperatura 150°C, probeta 27

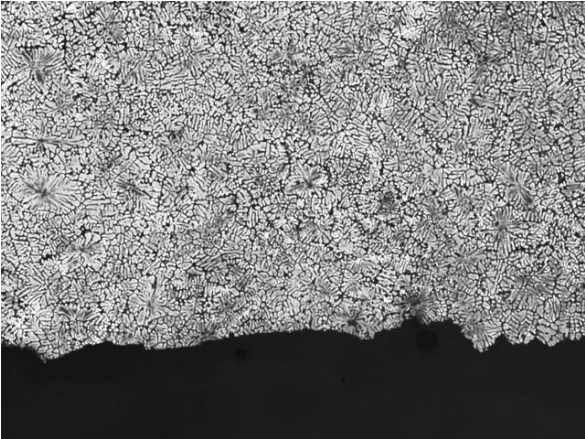
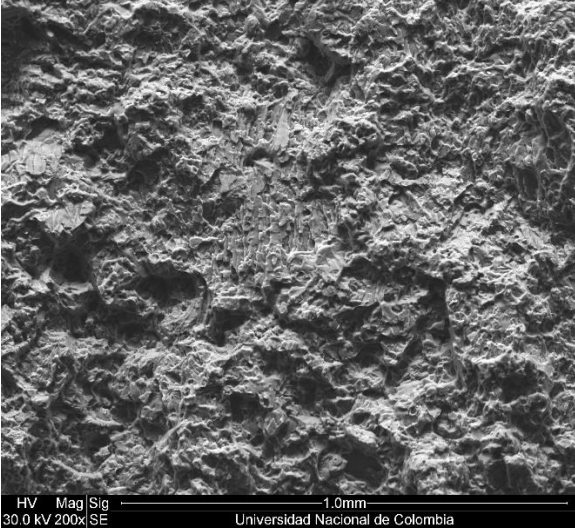
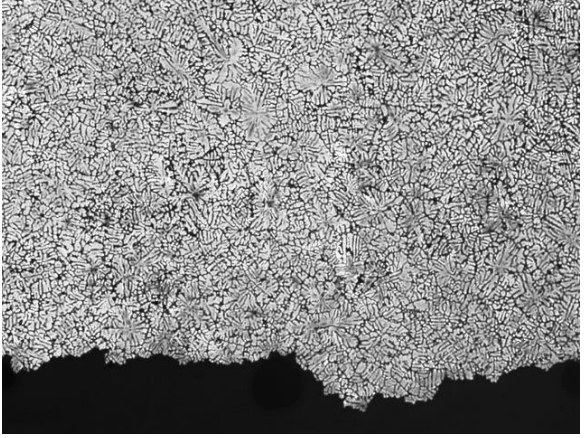
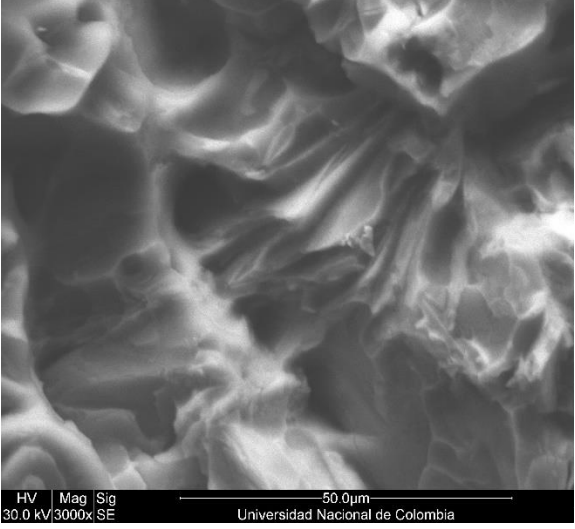
 <p>(A)</p>	 <p>HV Mag Sig 30.0 kV 200x SE 1.0mm Universidad Nacional de Colombia</p> <p>(A)</p>
 <p>(B)</p>	 <p>HV Mag Sig 30.0 kV/3000x SE 50.0µm Universidad Nacional de Colombia</p> <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 8. Dirección D3, temperatura 160°C, probeta 37

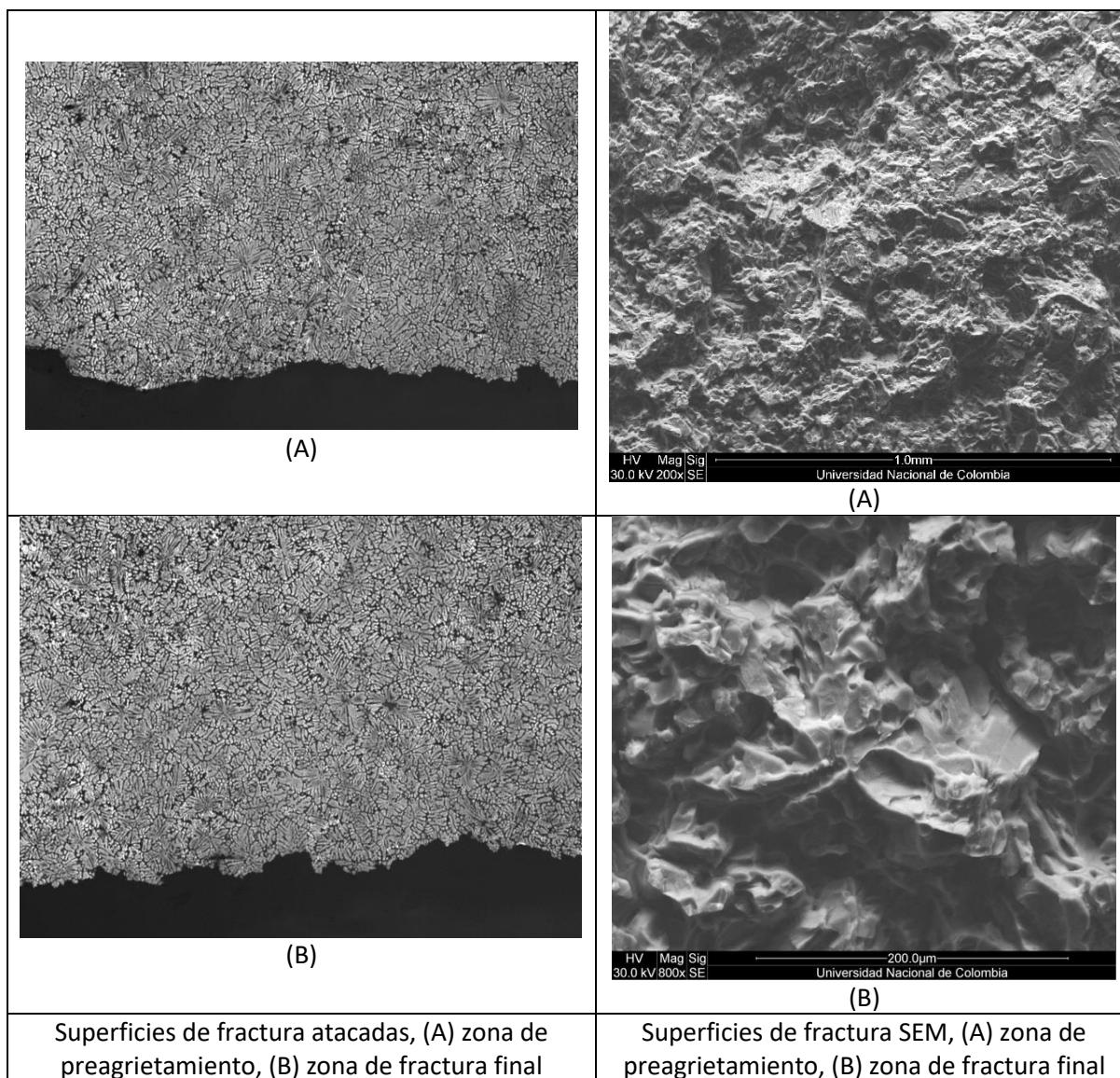


Tabla H 9. Dirección D3, temperatura 170°C, probeta 47

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D4	150	27	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	160	37	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	170	47	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos

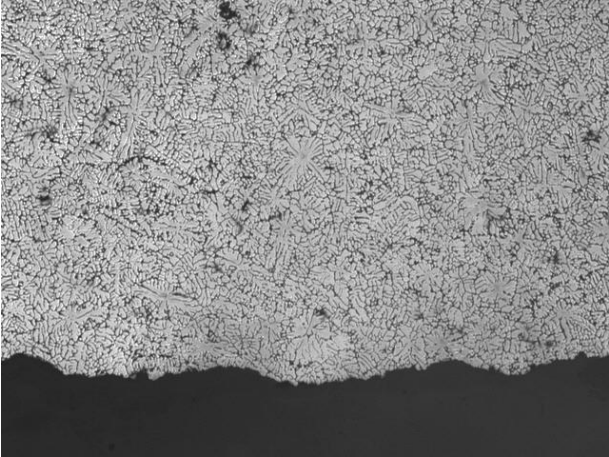
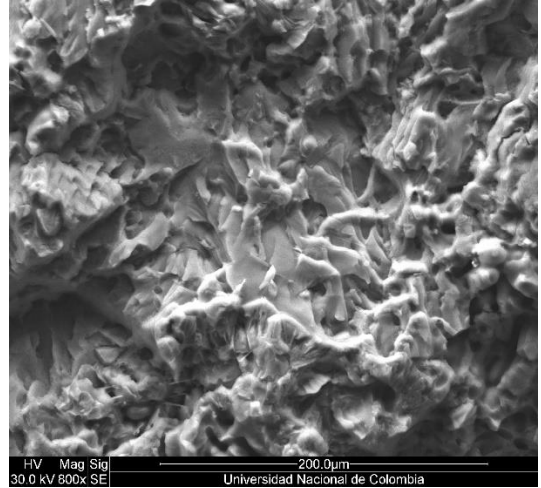
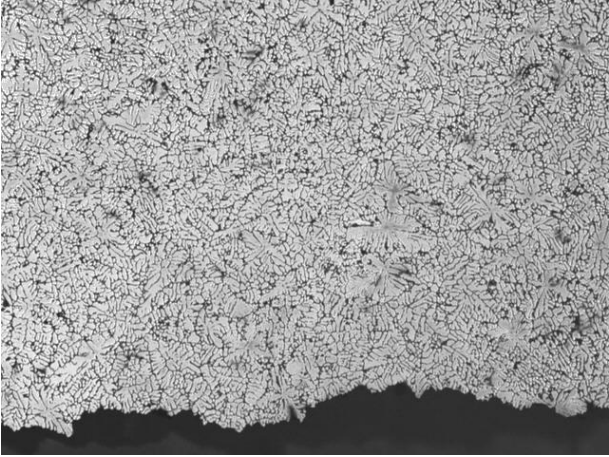
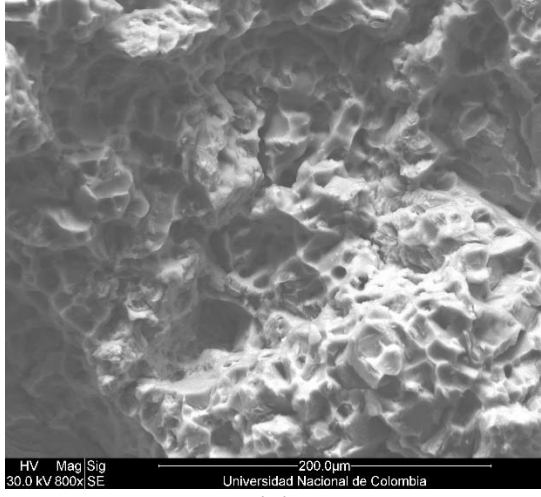
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(A)</p>
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 10. Dirección D4, temperatura 150°C, probeta 5

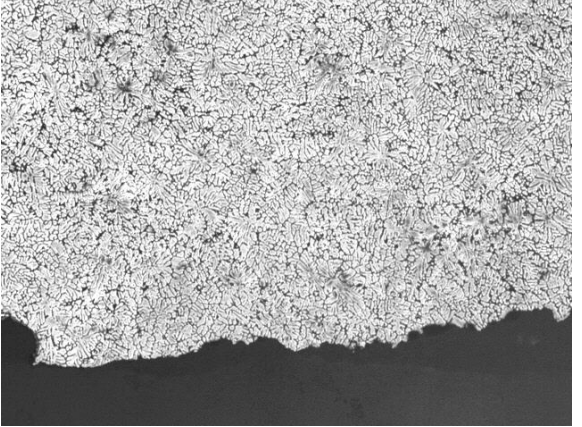
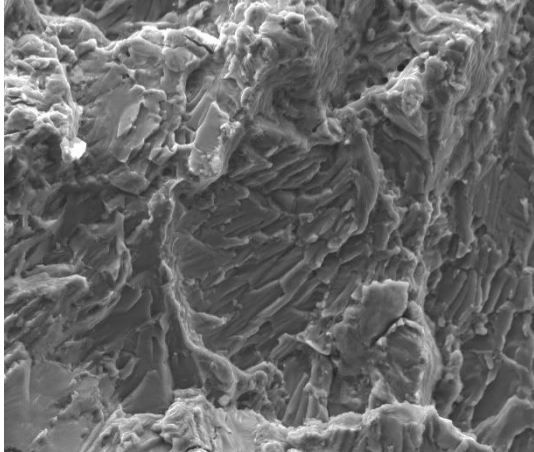
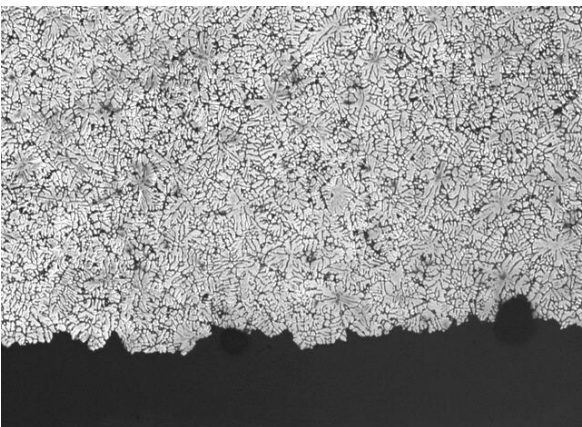
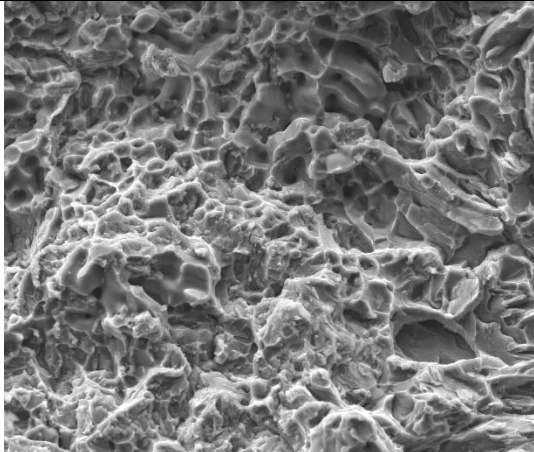
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(A)</p> <p style="text-align: center;"> <small>HV Mag Sig</small> <small>25.0 kV 800x SE</small> <small>200.0µm</small> <small>Universidad Nacional de Colombia</small> </p>
 <p style="text-align: center;">(B)</p>	 <p style="text-align: center;">(B)</p> <p style="text-align: center;"> <small>HV Mag Sig</small> <small>25.0 kV 800x SE</small> <small>200.0µm</small> <small>Universidad Nacional de Colombia</small> </p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 11. Dirección D4, temperatura 160°C, probeta 10

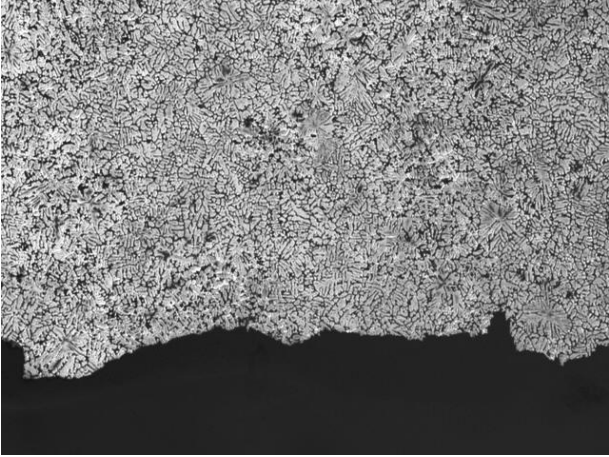
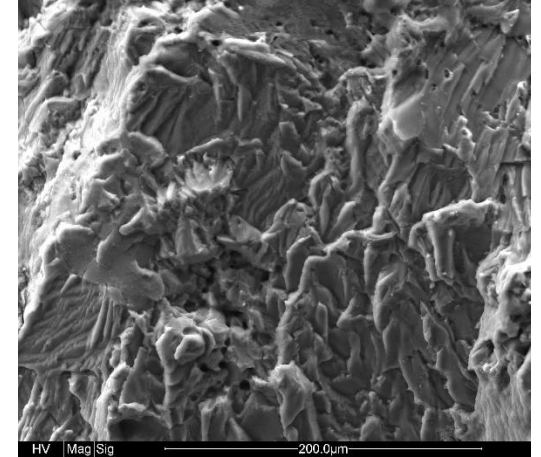
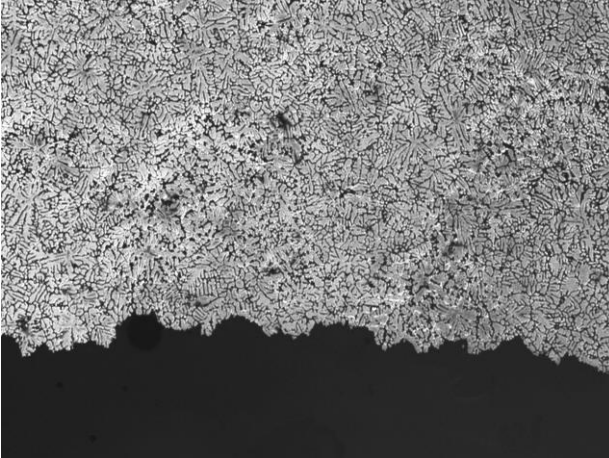
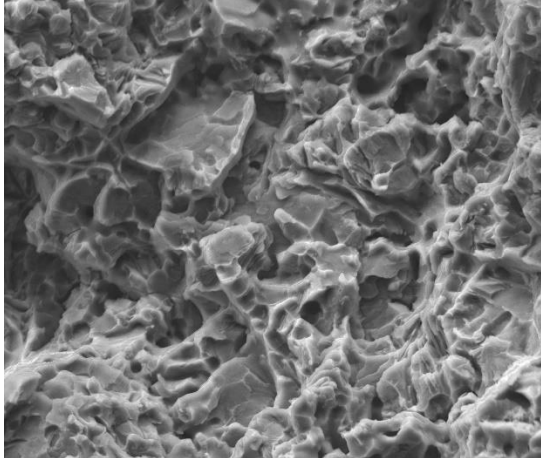
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(A)</p>
 <p style="text-align: center;">(B)</p>	 <p style="text-align: center;">(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 12. Dirección D4, temperatura 170°C, probeta 19

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D4	150	5	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	160	10	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos
	170	19	Preagrietamiento	Transgranular
			Fractura final	Transgranular + microvacíos

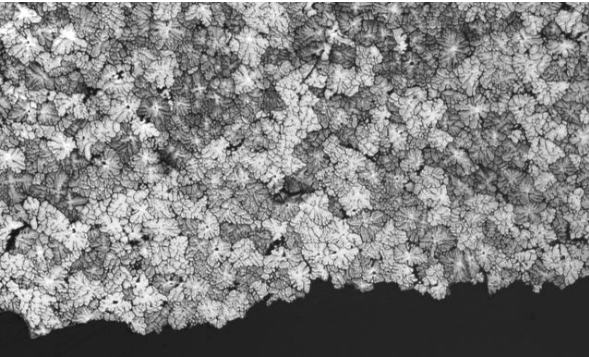
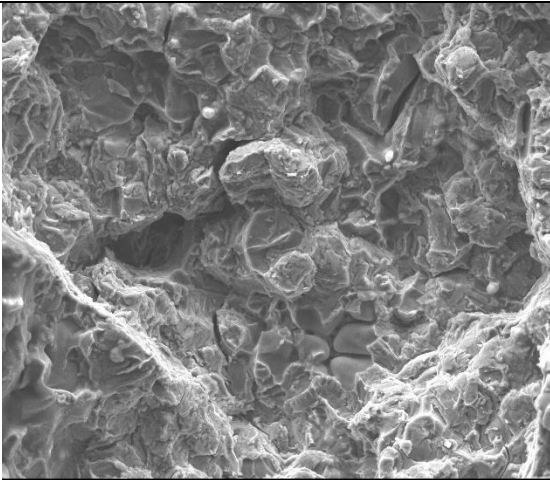
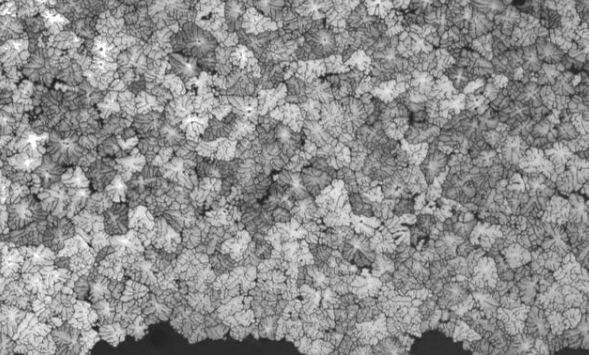
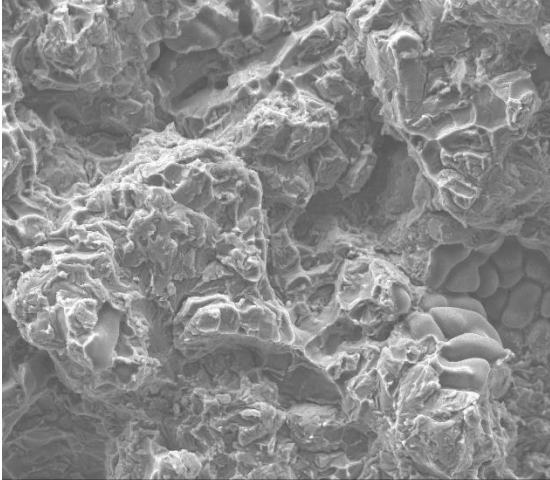
 <p>(A)</p>	 <p>(A)</p>
 <p>(B)</p>	 <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 13. Dirección D5, temperatura 181°C, probeta 103

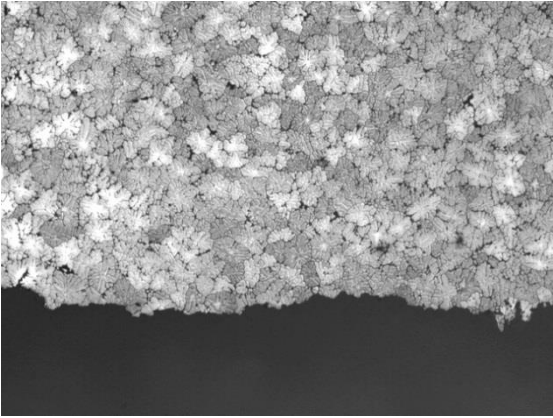
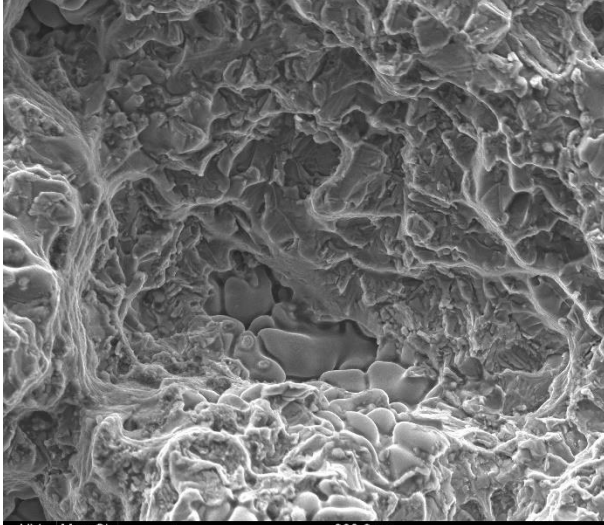
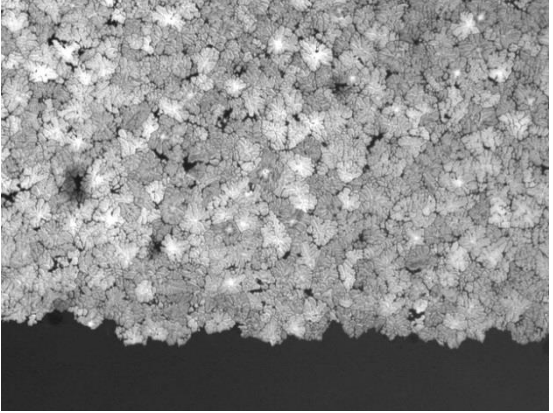
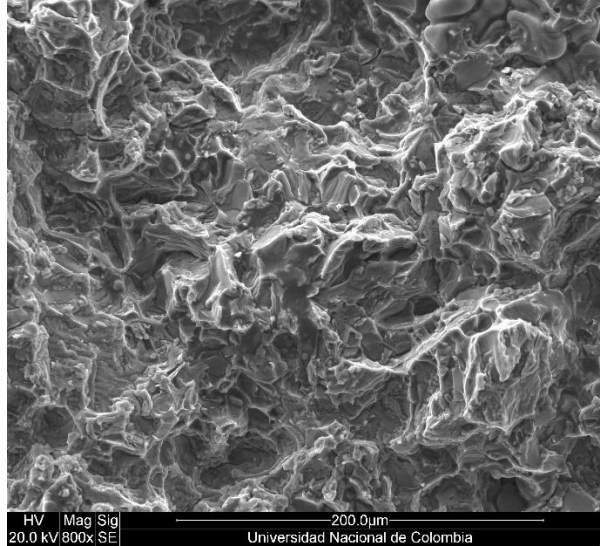
 <p>(A)</p>	 <p>HV Mag Sig 200.0µm 20.0 kV/800x SE Universidad Nacional de Colombia</p> <p>(A)</p>
 <p>(B)</p>	 <p>HV Mag Sig 200.0µm 20.0 kV/800x SE Universidad Nacional de Colombia</p> <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 14. Dirección D5, temperatura 191°C, probeta 115

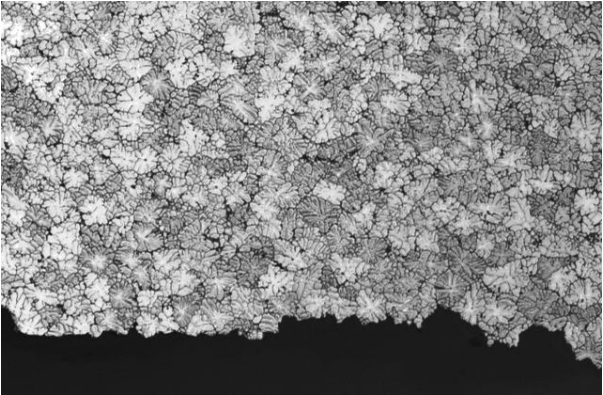
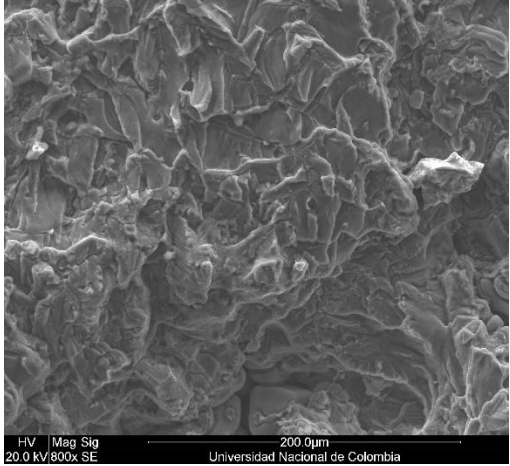
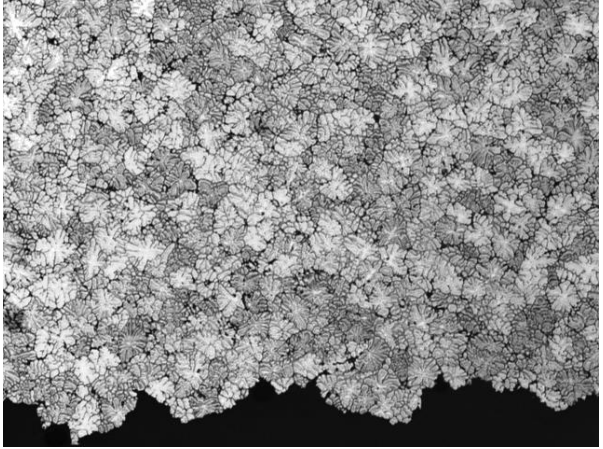
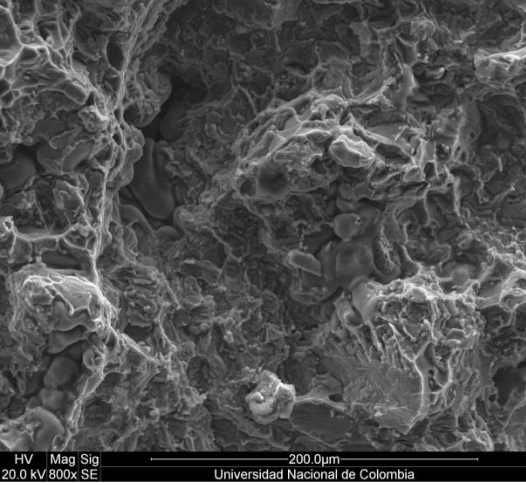
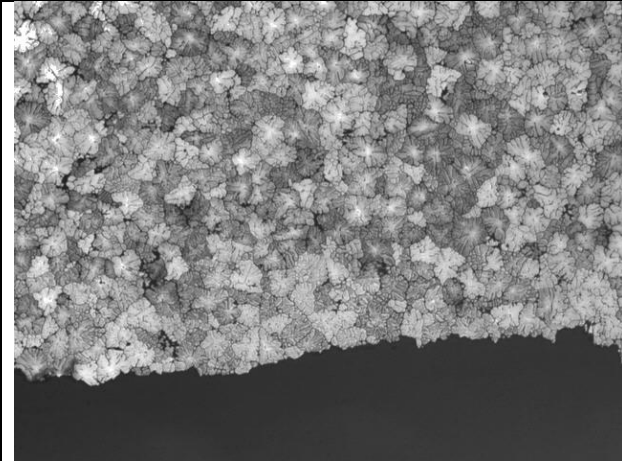
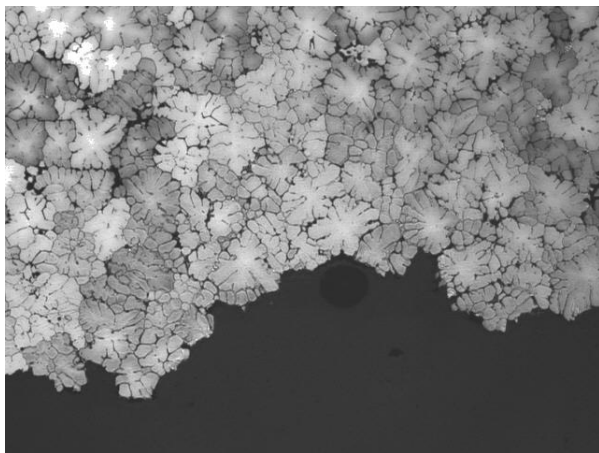
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(A)</p>
 <p style="text-align: center;">(B)</p>	 <p style="text-align: center;">(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 15. Dirección D5, temperatura 201°C, probeta 125

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D5	181	103	Preagrietamiento	Intergranular
			Fractura final	Intergranular
	191	115	Preagrietamiento	Intergranular
			Fractura final	Intergranular
	201	125	Preagrietamiento	Intergranular
			Fractura final	Intergranular

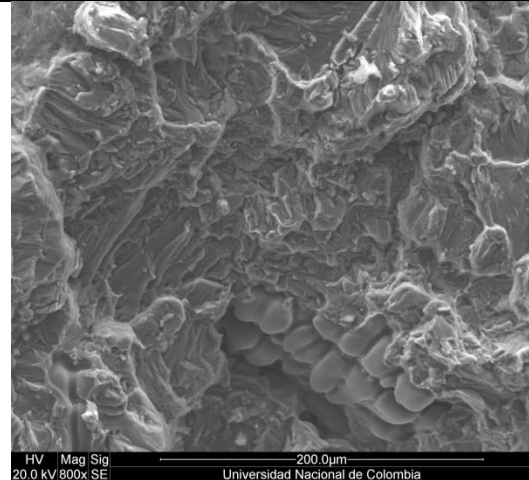


(A)



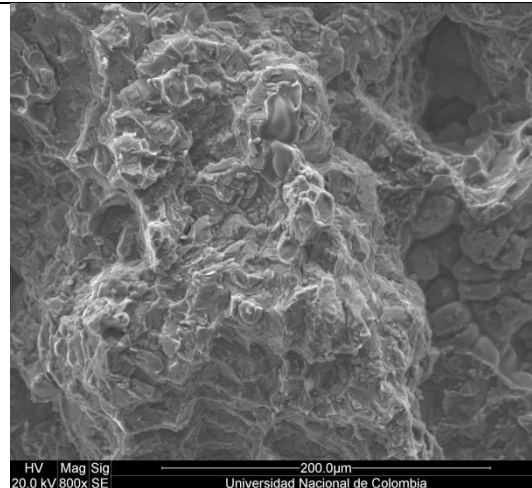
(B)

Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final



HV Mag Sig 200.0µm
20.0 kV/800x SE Universidad Nacional de Colombia

(A)



HV Mag Sig 200.0µm
20.0 kV/800x SE Universidad Nacional de Colombia

(B)

Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final

Tabla H 16. Dirección D6, temperatura 181°C, probeta 132

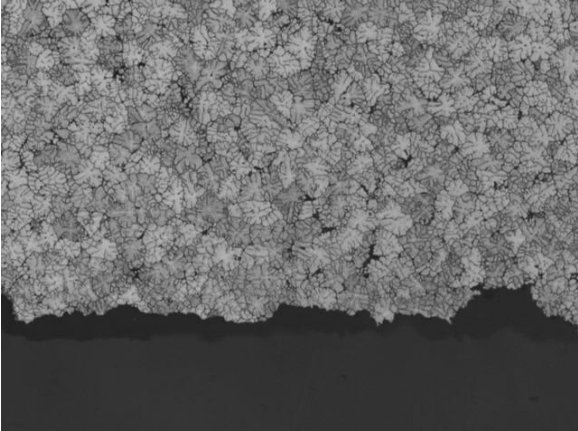
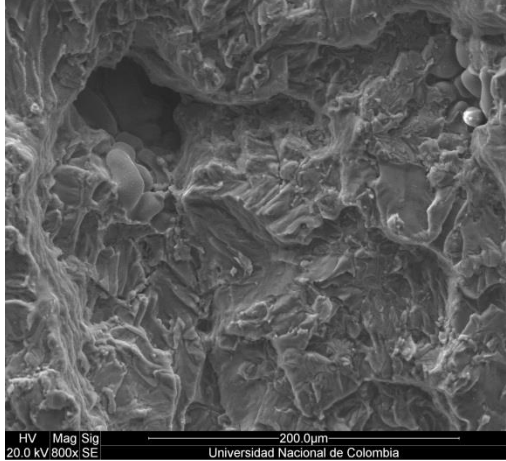
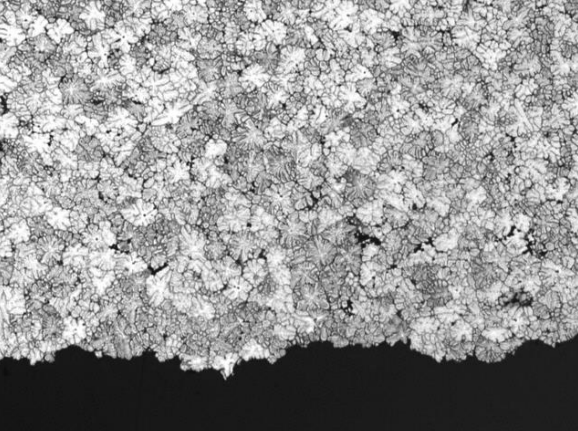
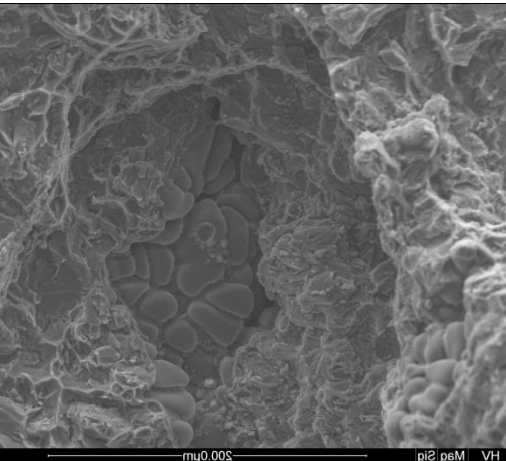
 <p>(A)</p>	 <p>(A)</p>
 <p>(B)</p>	 <p>(B)</p>
<p>Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p>Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 17. Dirección D6, temperatura 191°C, probeta 140

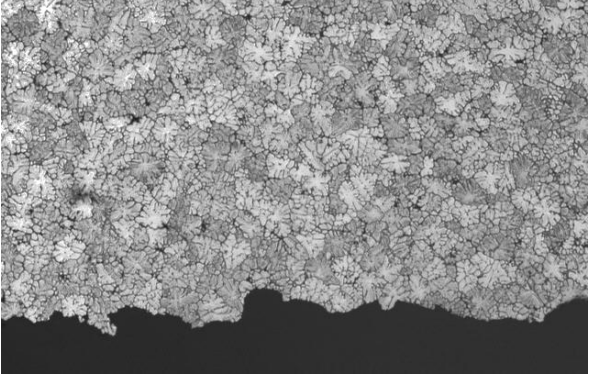
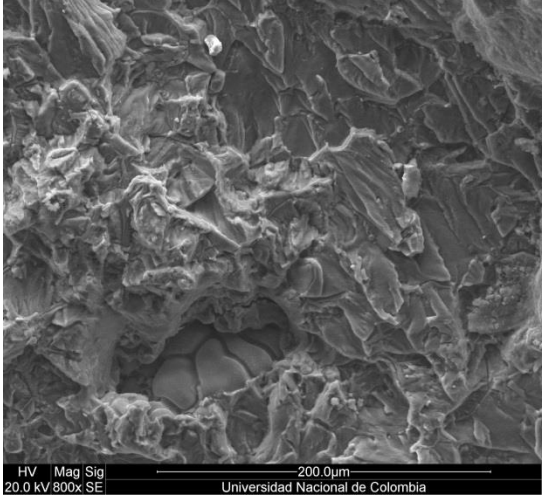
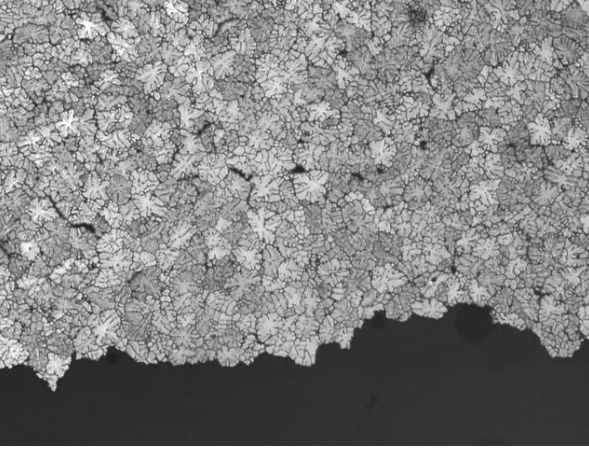
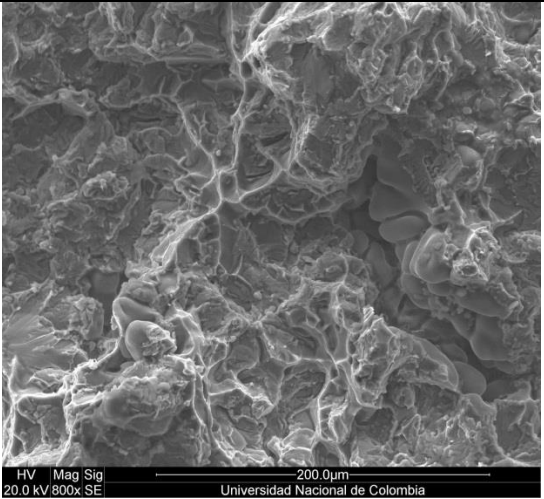
 <p style="text-align: center;">(A)</p>	 <p style="text-align: center;">(B)</p>
 <p style="text-align: center;">(B)</p>	 <p style="text-align: center;">(B)</p>
<p style="text-align: center;">Superficies de fractura atacadas, (A) zona de preagrietamiento, (B) zona de fractura final</p>	<p style="text-align: center;">Superficies de fractura SEM, (A) zona de preagrietamiento, (B) zona de fractura final</p>

Tabla H 18. Dirección D6, temperatura 201°C, probeta 152

Dirección	Temperatura de envejecimiento	Probeta	Zona de análisis	Tipo de superficie de fractura
D6	181	132	Preagrietamiento	Intergranular
			Fractura final	Intergranular
	191	140	Preagrietamiento	Intergranular
			Fractura final	Intergranular
201	152	Preagrietamiento	Intergranular	
		Fractura final	Intergranular	

Anexo I

Porcentaje de discontinuidades

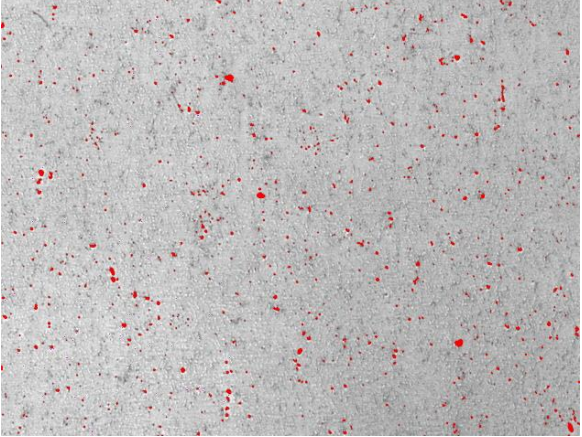
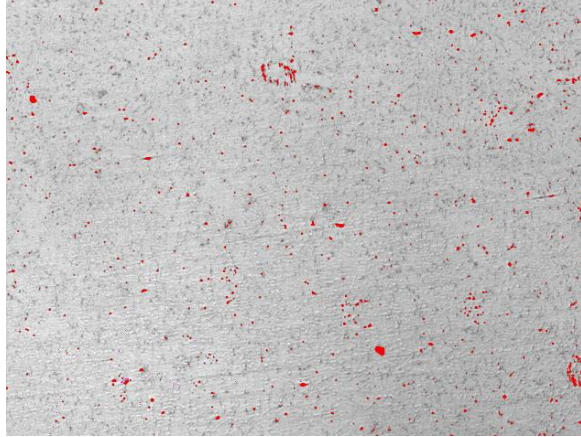
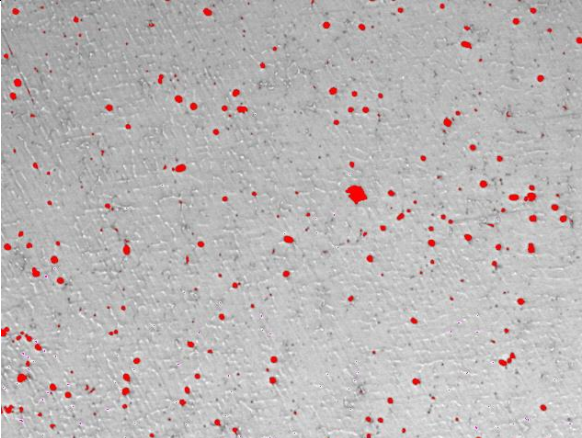
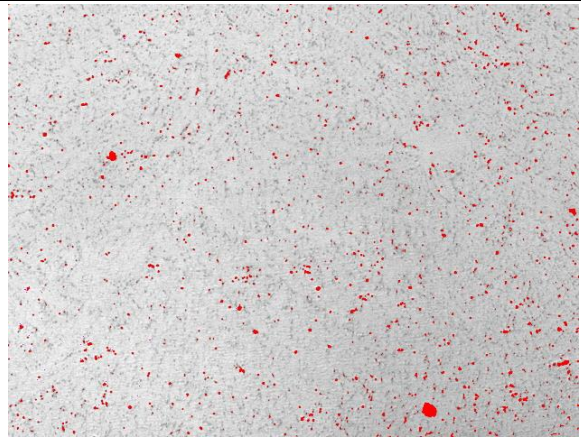
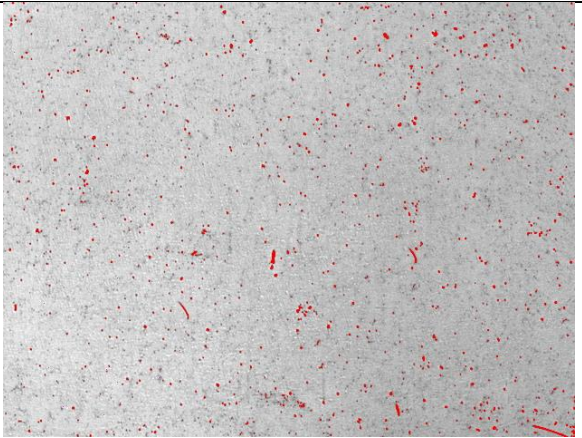
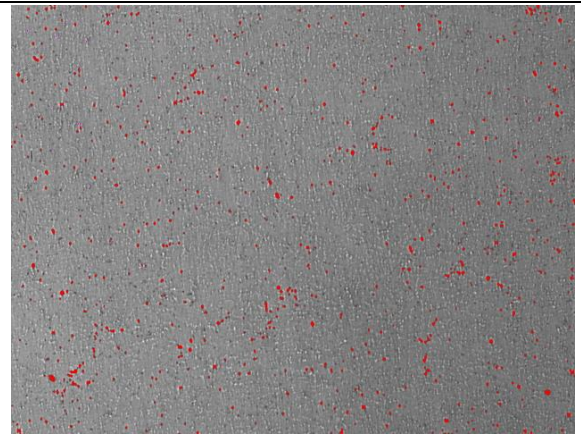
					
Probeta 54 D1			Probeta 64 D1		
					
Probeta 68 D1			Probeta 77 D2		
					
Probeta 86 D2			Probeta 95 D2		
Temperatura de envejecimiento	Probeta	Promedio % de discontinuidades		Probeta	Promedio % de discontinuidades
167	54	1,2		77	1,3
177	64	0,7		86	0,9
187	68	1,4		95	1,3

Tabla I 1. Porcentaje de discontinuidades direcciones D1 y D2

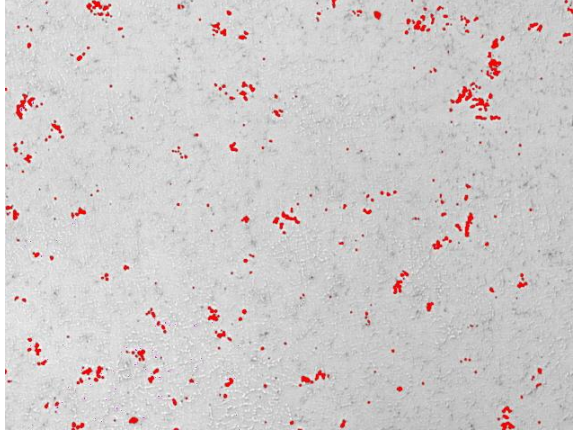
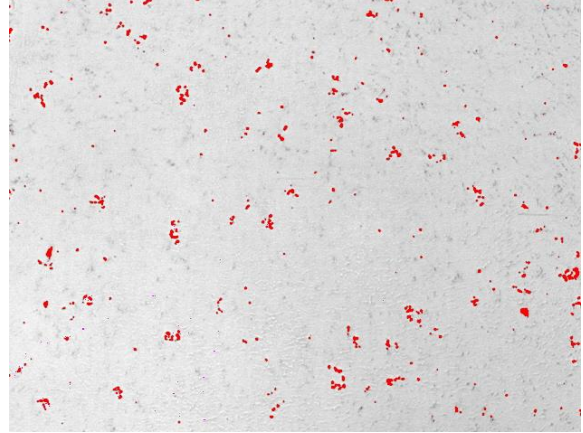
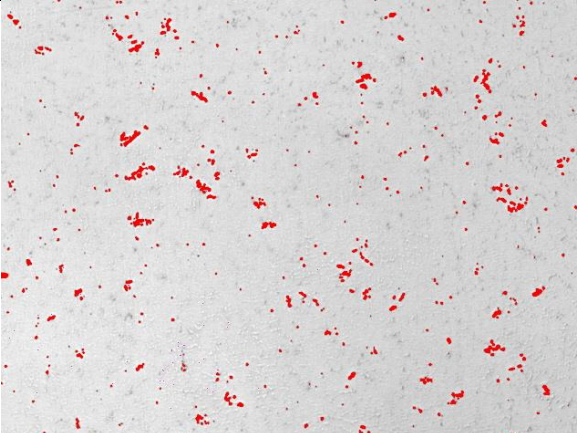
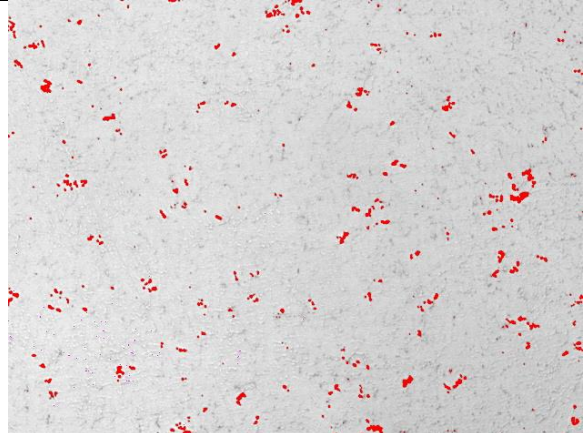
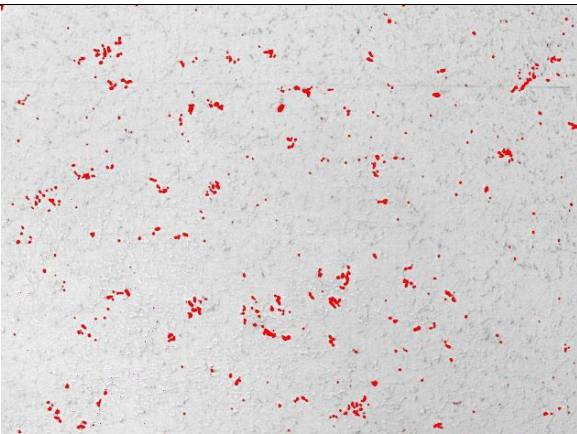
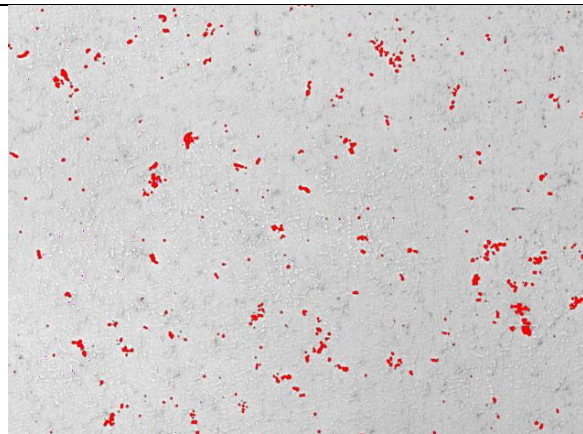
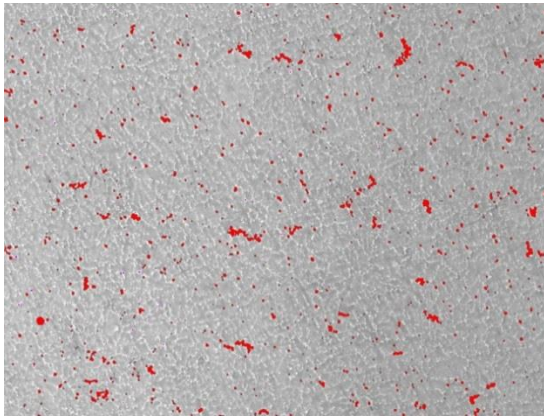
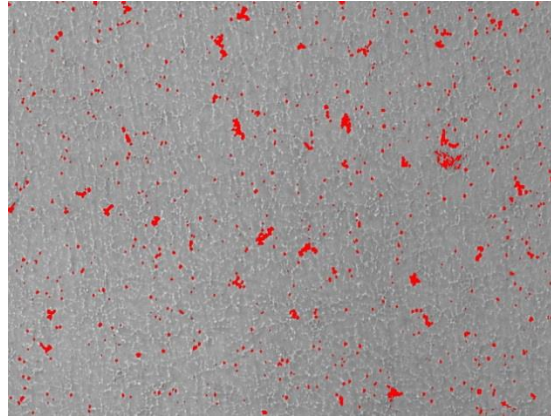
					
Probeta 27 D3			Probeta 37 D3		
					
Probeta 47 D3			Probeta 5 D4		
					
Probeta 10 D4			Probeta 19 D4		
Temperatura de envejecimiento	Probeta	Promedio % de discontinuidades		Probeta	Promedio % de discontinuidades
150	27	1,5		5	1,4
160	37	1,1		10	1,3
170	47	1,5		19	1,7

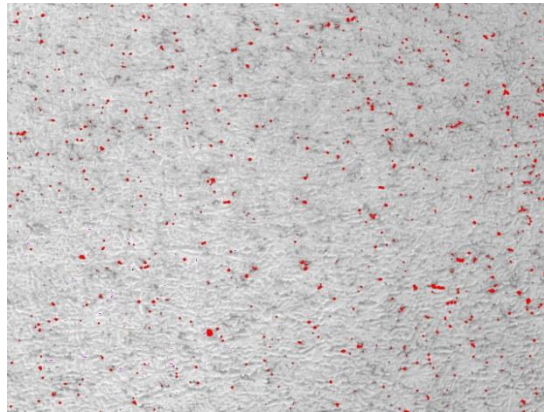
Tabla I 2. Porcentaje de discontinuidades direcciones D3 y D4



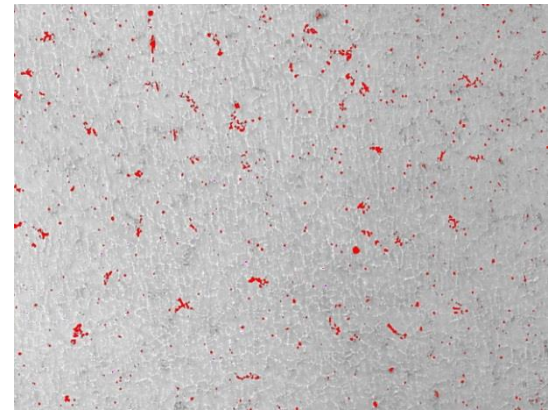
Probeta 103 D5



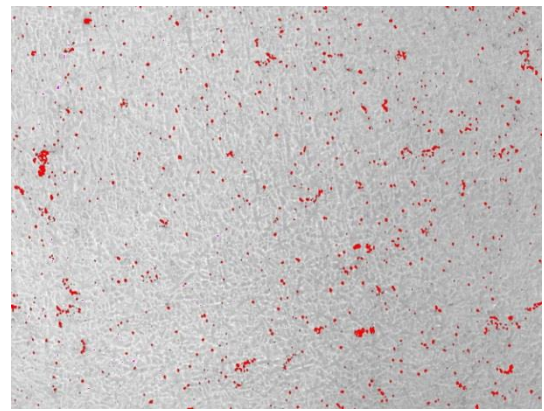
Probeta 115 D5



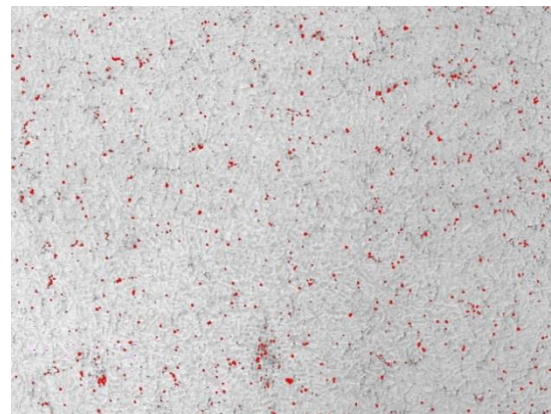
Probeta 125 D5



Probeta 132 D6



Probeta 140 D6



Probeta 152 D6

Temperatura de envejecimiento	Probeta	Promedio % de discontinuidades		Probeta	Promedio % de discontinuidades
181	103	1,4		132	1,15
191	115	2,1		140	1,10
201	125	0,9		152	0,96

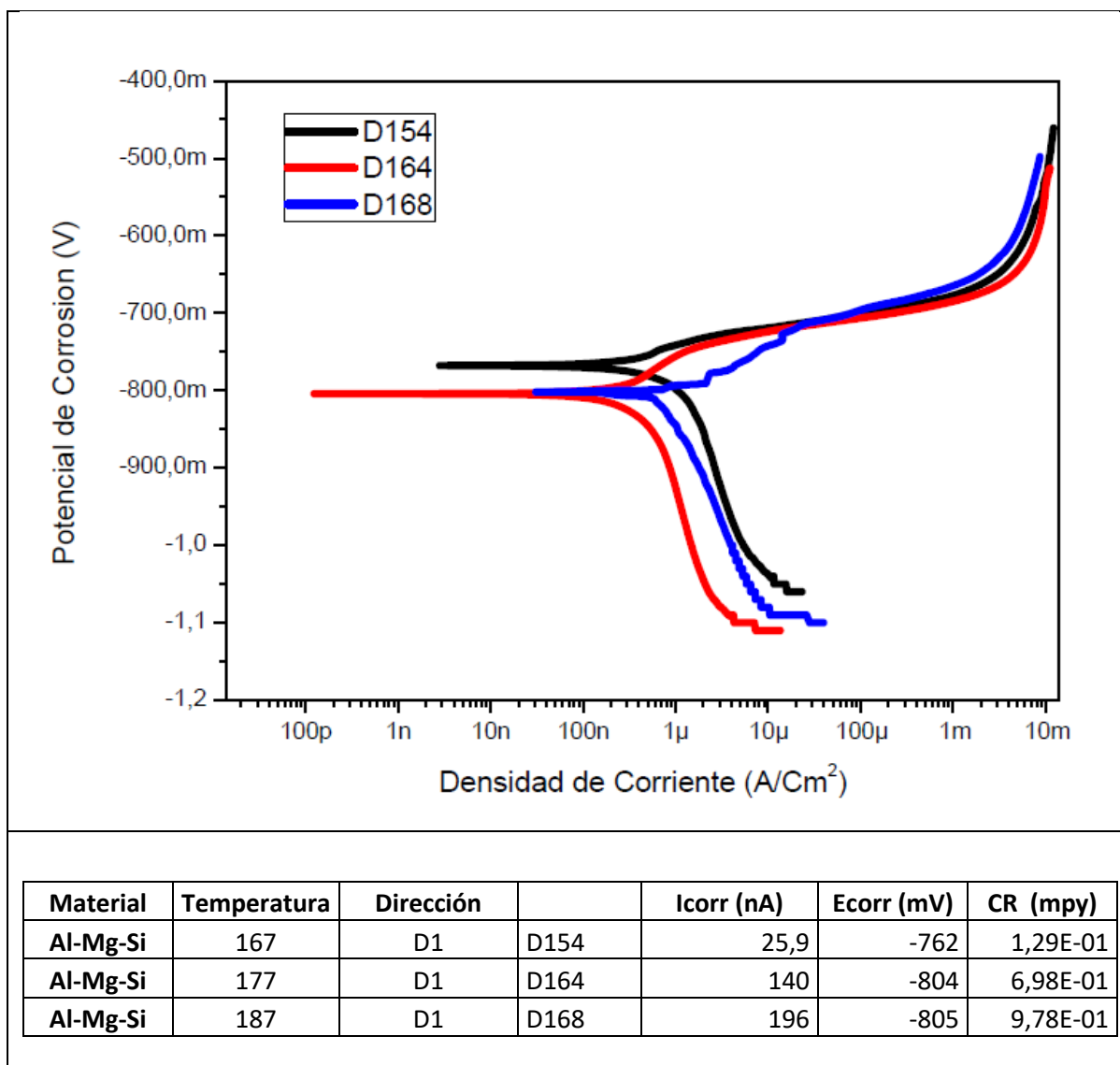
Tabla I 3. Porcentaje de discontinuidades direcciones D5 y D6

Anexo J

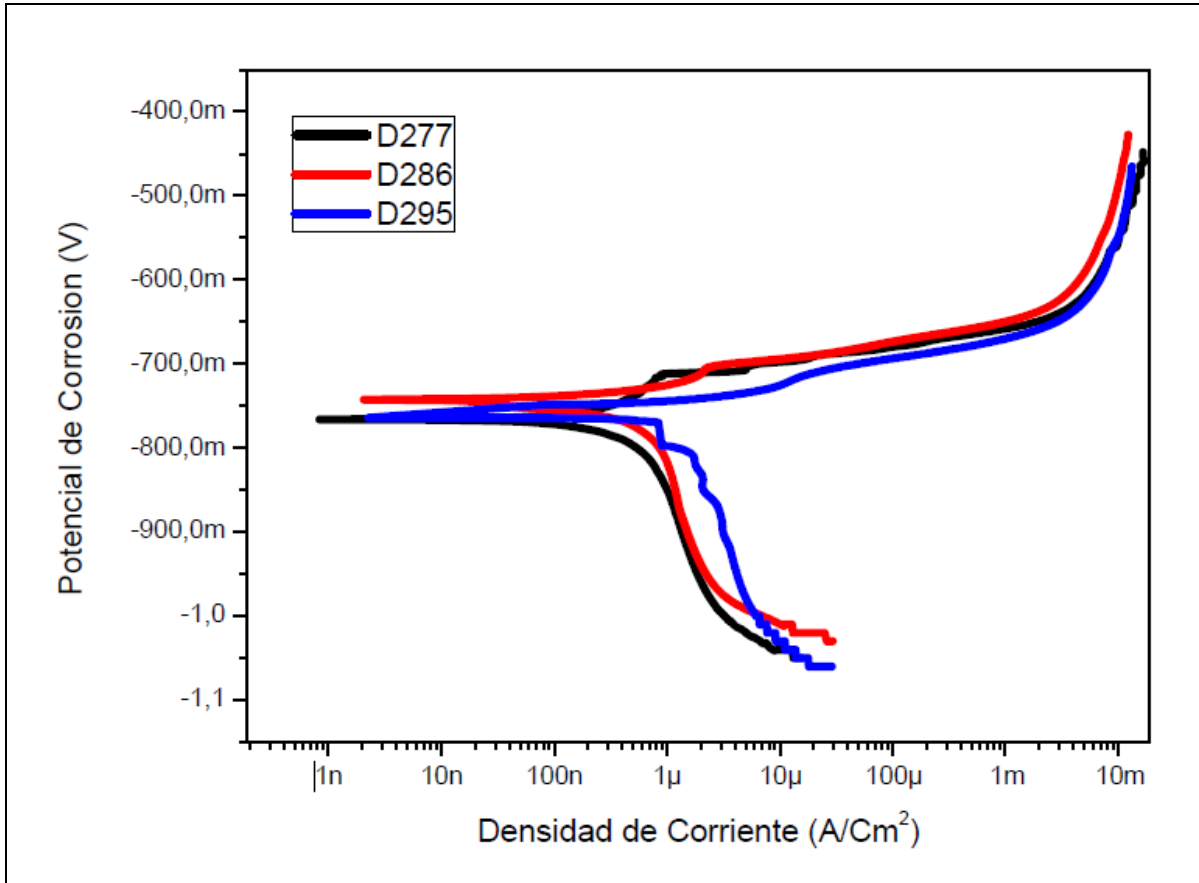
Graficas Ensayo Tafel

Para cada una de las curvas por dirección del lingote se encuentran los valores de corriente de corrosión dada en nano amperios (nA), potencial de corrosión dado en milivoltios (mV) y velocidad de corrosión de corrosión.

Curvas ensayo Tafel dirección D1

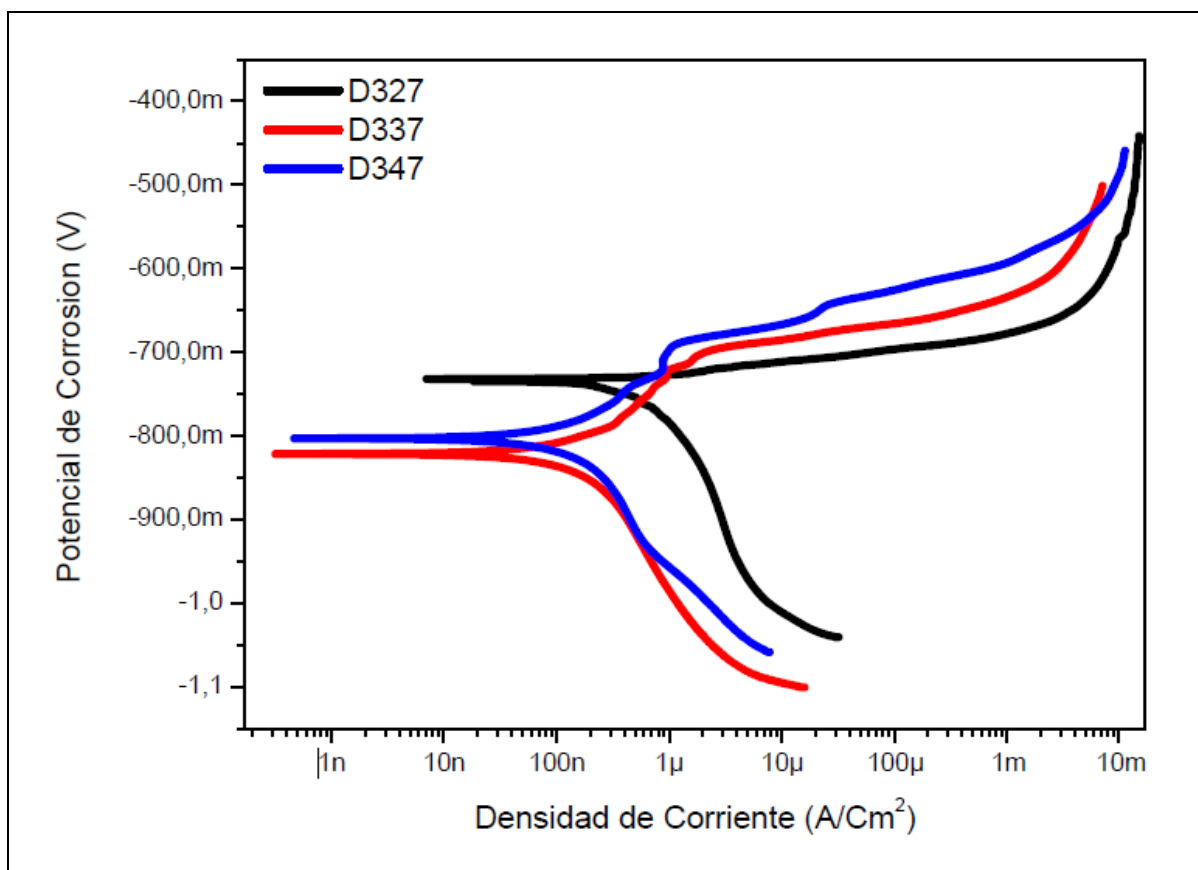


Curvas ensayo Tafel dirección D2



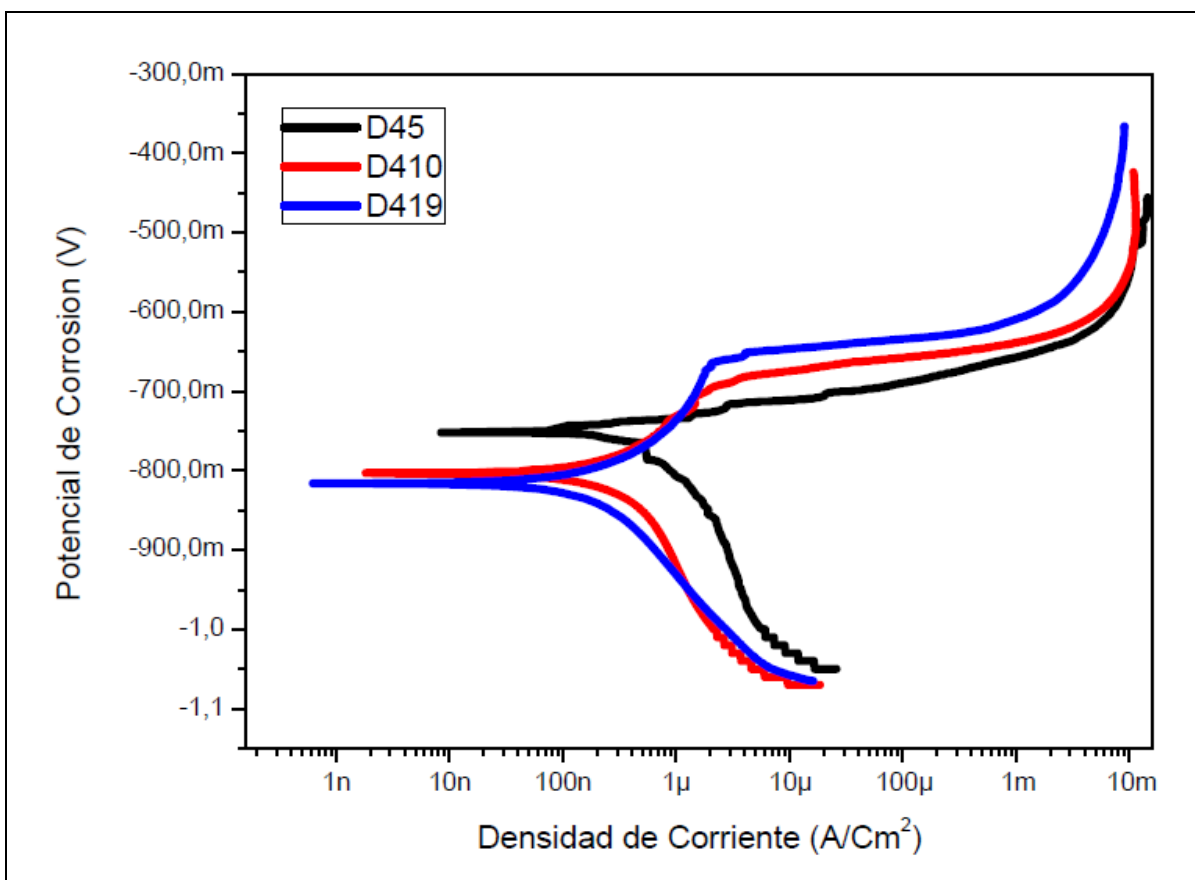
Material	Temperatura	Dirección		I _{corr} (nA)	E _{corr} (mV)	CR (mpy)
Al-Mg-Si	167	D2	D277	201	-765	1
Al-Mg-Si	177	D2	D286	36,8	-747	1,83E-01
Al-Mg-Si	187	D2	D295	52,2	-763	2,60E-01

Curvas ensayo Tafel dirección D3



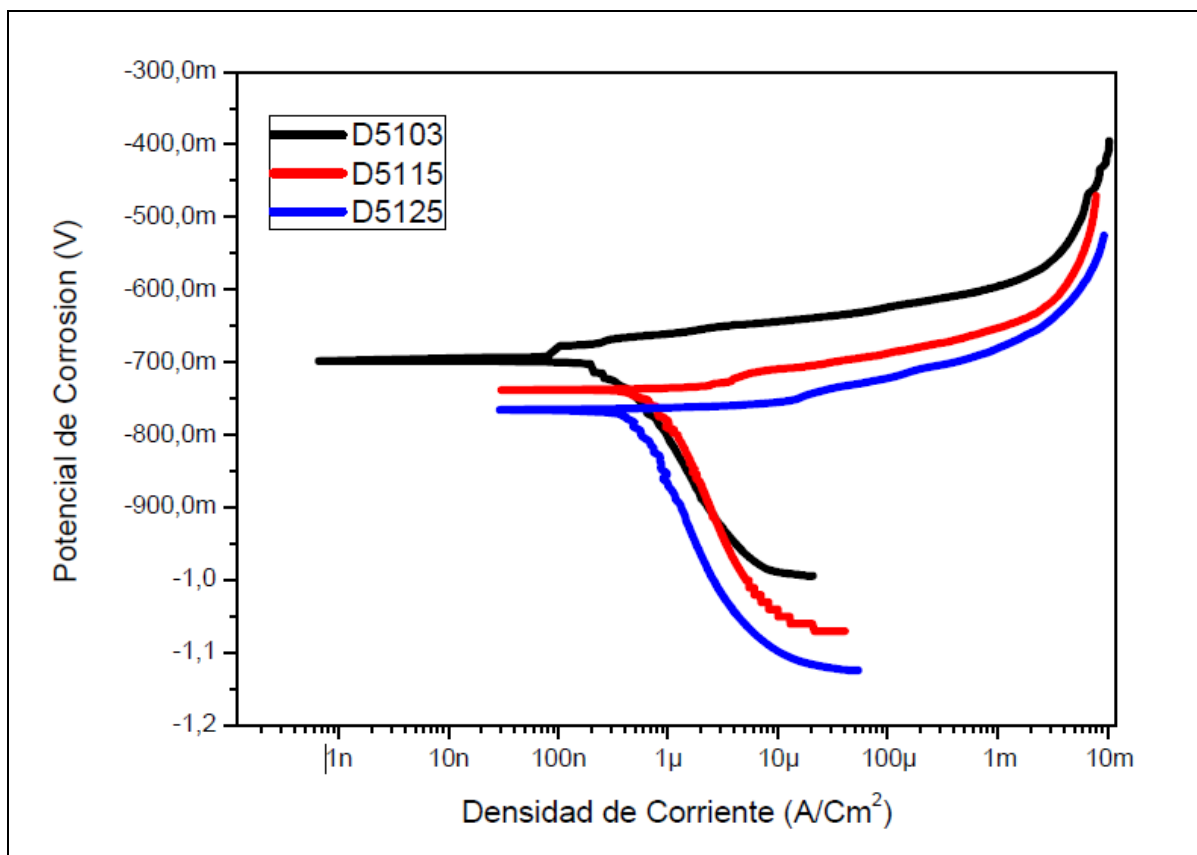
Material	Temperatura	Dirección		I _{corr} (nA)	E _{corr} (mV)	CR (mpy)
Al-Si	150	D3	D327	52,7	-734	2,56E-01
Al-Si	160	D3	D337	54	-821	2,62E-01
Al-Si	170	D3	D347	66,2	-803	3,21E-01

Curvas ensayo Tafel dirección D4



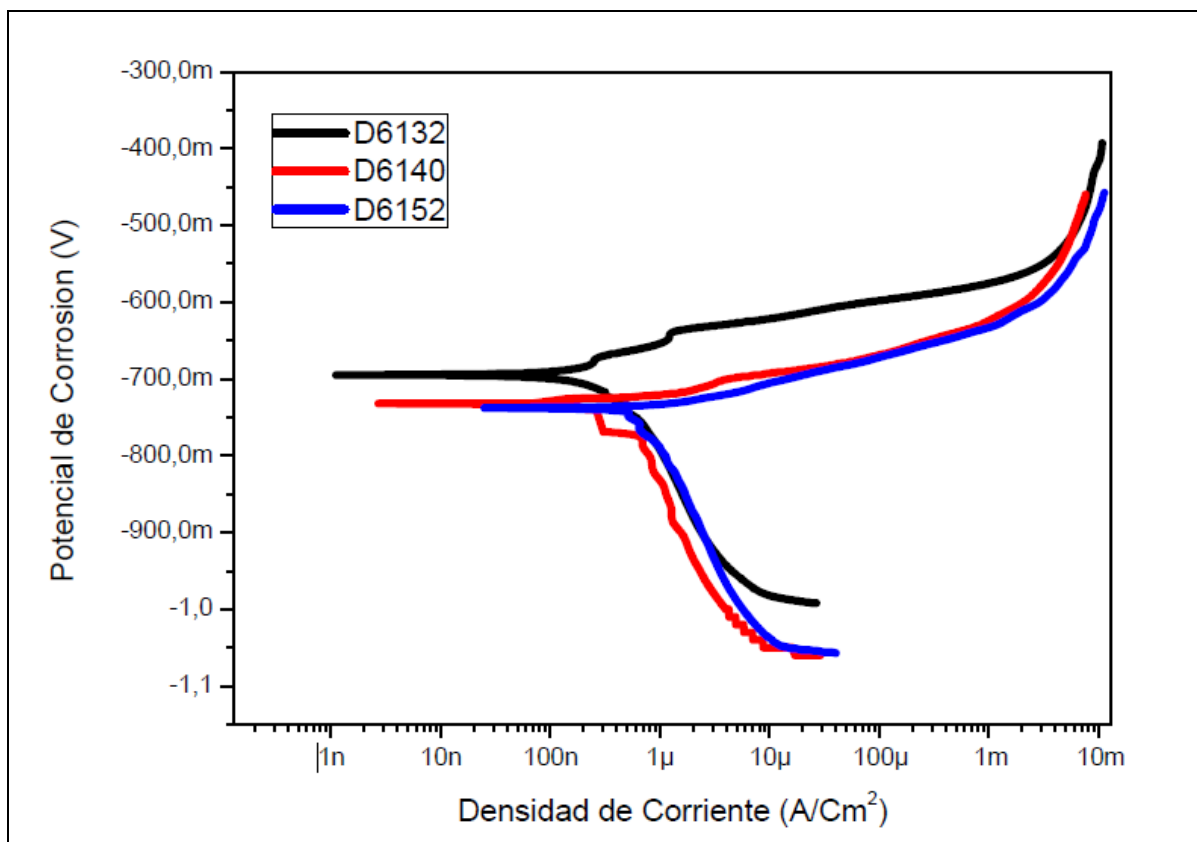
Material	Temperatura	Dirección		I _{corr} (nA)	E _{corr} (mV)	CR (mpy)
Al-Si	150	D4	D45	24,8	-746	1,20E-01
Al-Si	160	D4	D410	142	-804	6,88E-01
Al-Si	170	D4	D419	56,3	-816	2,73E-01

Curvas ensayo Tafel dirección D5



Material	Temperatura	Dirección		I _{corr} (nA)	E _{corr} (mV)	CR (mpy)
Al-Cu-Si	181	D5	D5103	8,4	-683	4,26E-02
Al-Cu-Si	191	D5	D5115	108	-740	5,47E-01
Al-Cu-Si	201	D5	D5125	73	-766	3,70E-01

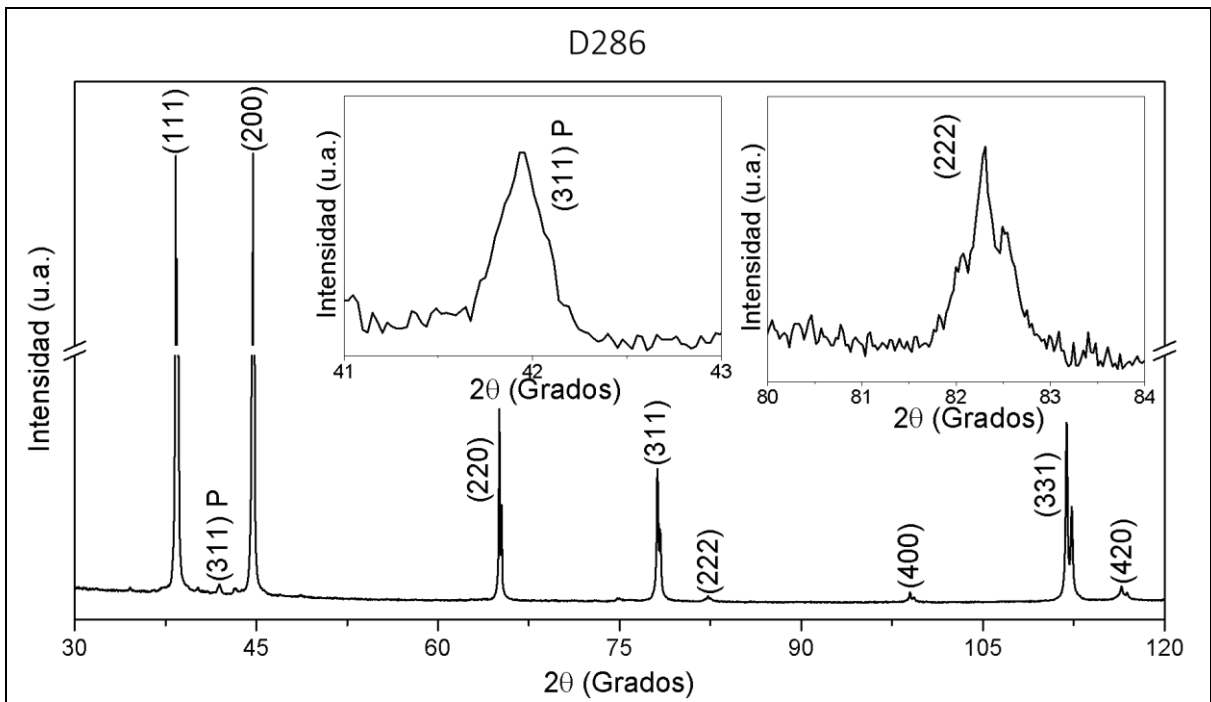
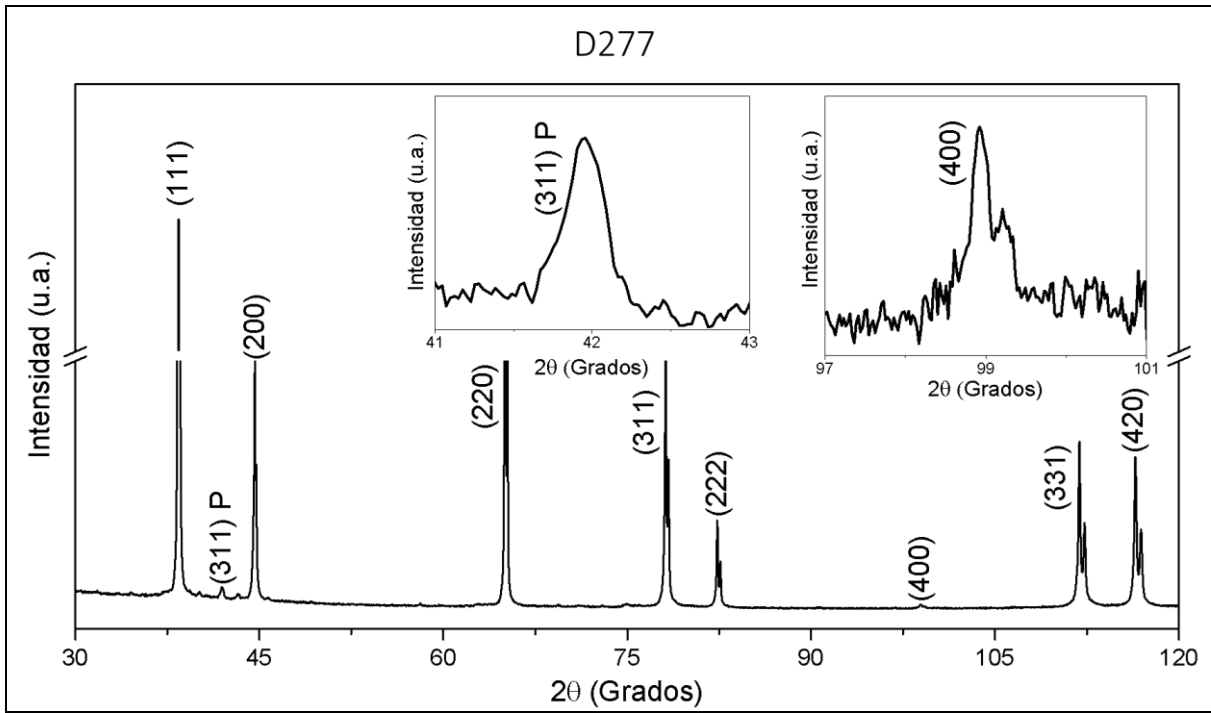
Curvas ensayo Tafel dirección D6

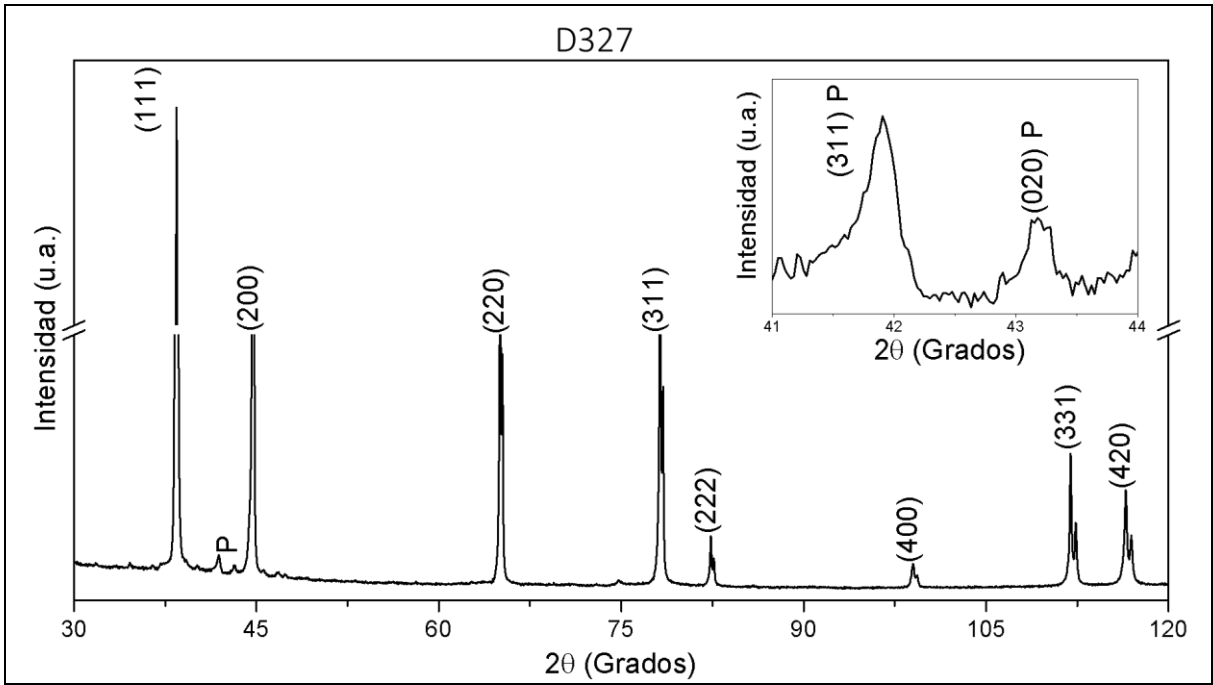
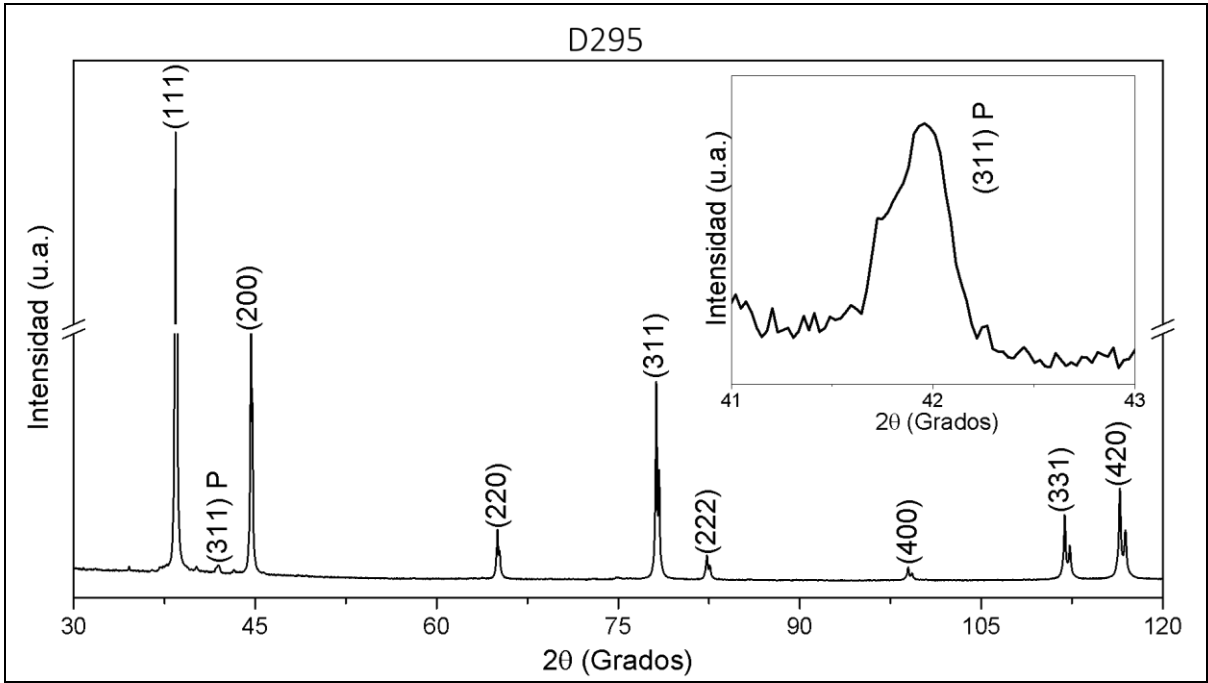


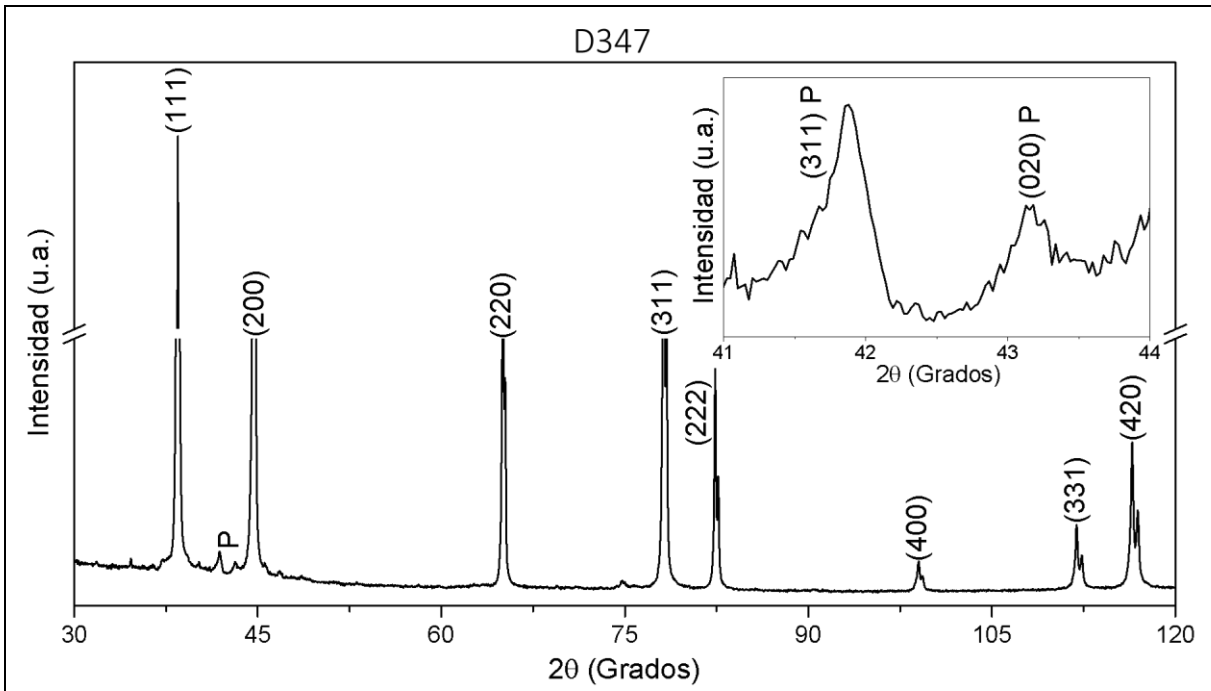
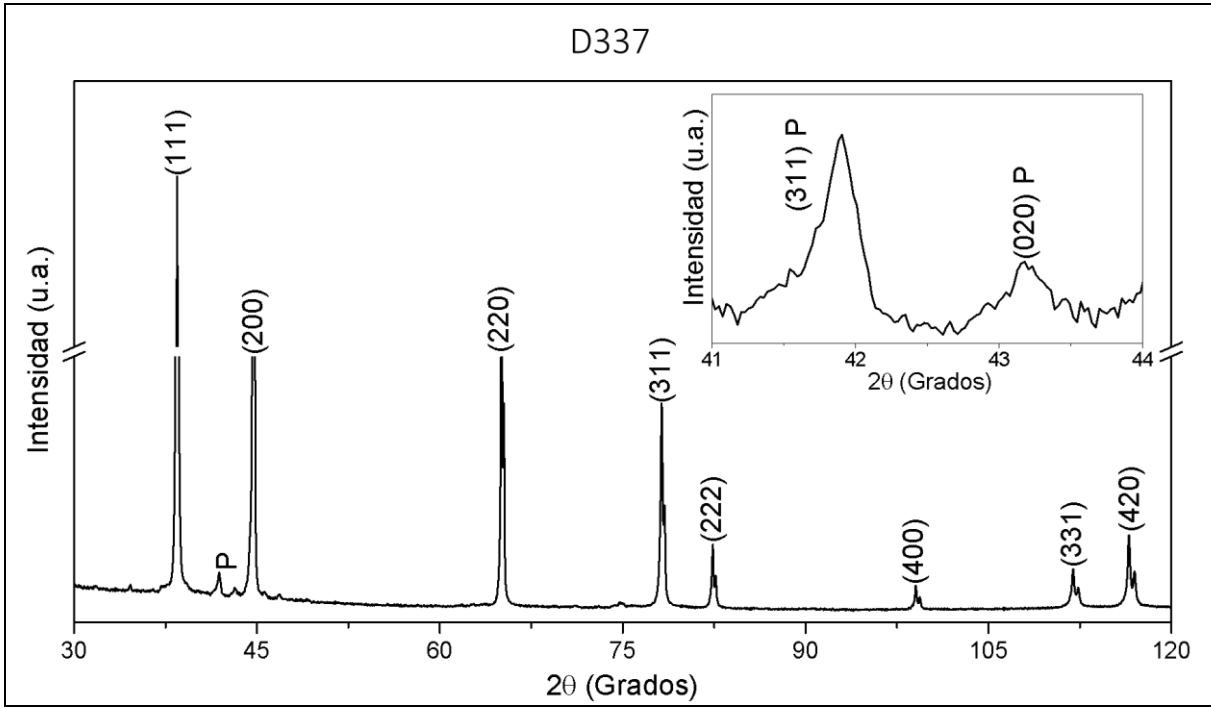
Material	Temperatura	Dirección		I _{corr} (nA)	E _{corr} (mV)	CR (mpy)
Al-Cu-Si	181	D6	D6132	36,2	-693	1,83E-01
Al-Cu-Si	191	D6	D6140	37,4	-734	1,90E-01
Al-Cu-Si	201	D6	D6152	154	-740	7,79E-01

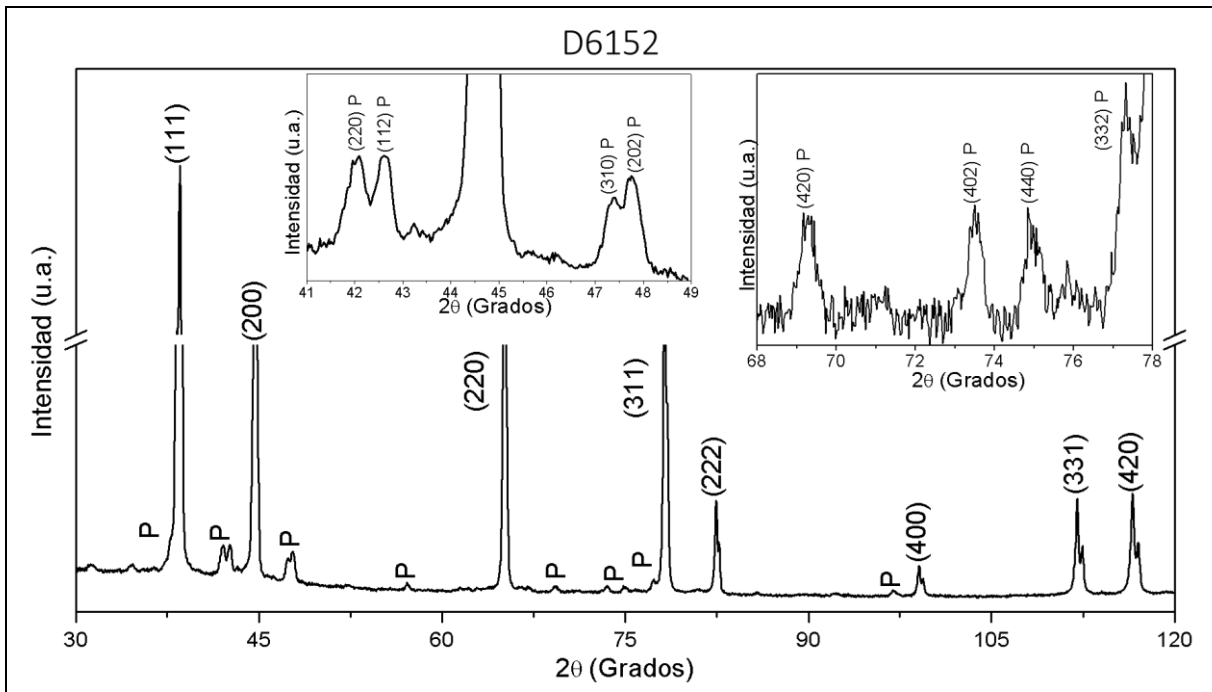
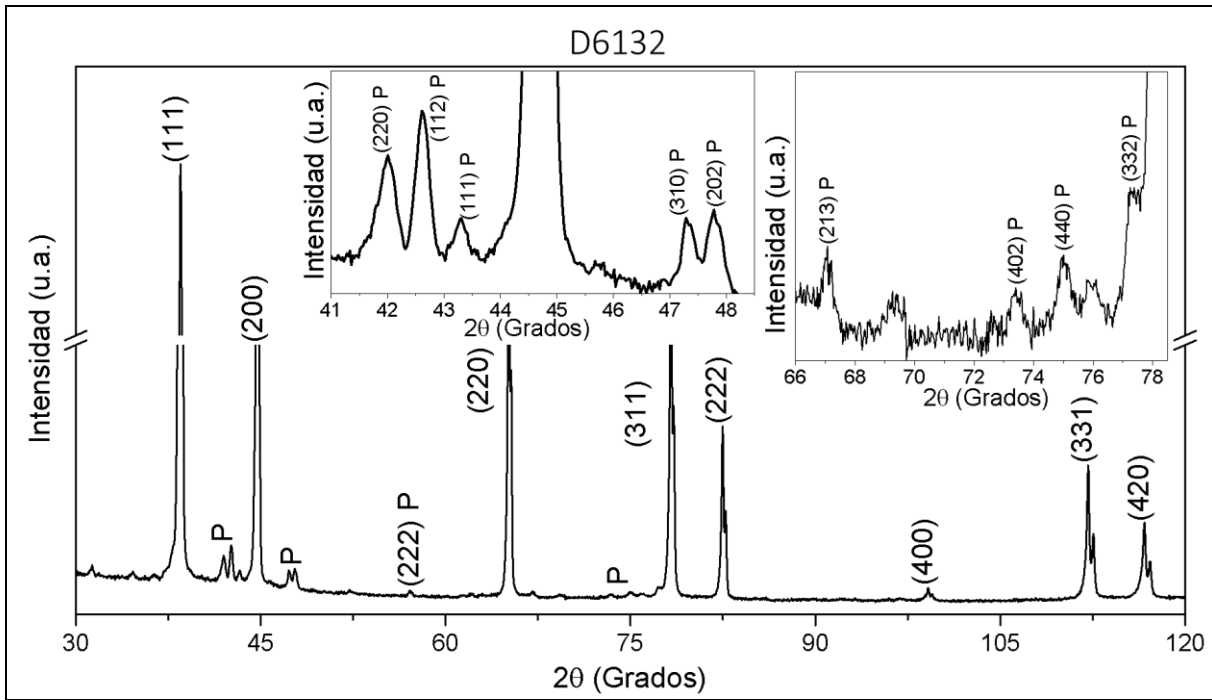
Anexo K

Difractogramas materiales ensayados









Para cada uno de los difractogramas obtenidos se realizó una tabla resumen, indicando como información principal, los tipos de compuestos encontrados y así relacionarlos con la tenacidad y la resistencia a la corrosión de los materiales bajo estudio.

Material Al-Mg-Si

Probeta D277

No.	Pos. [$^{\circ}2\theta$]	d-spacing [\AA]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,42	3,96	444	96-901-1647	Si	2	0	0	Orthorhombic	C m c a
2	26,51	3,3615	198	96-433-4345	Al-Mg-Si	0	2	0	Tetragonal	P 4/n c c
3	38,4058	2,34194	62414,67	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
4	40,1385	2,2525	256	96-433-4345	Al-Mg-Si	0	0	6	Tetragonal	P 4/n c c
5	41,9255	2,15667	842	96-901-6682	Fe-Si	0	1	2	Hexagonal	P 63/m c m
6	43,2771	2,10017	315	96-433-4345	Al-Mg-Si	1	3	1	Tetragonal	P 4/n c c
7	44,6226	2,02903	16864,43	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
8	45,7482	1,98	162	96-901-1647	Si	4	0	0	Orthorhombic	C m c a
9	65,0396	1,43287	37373,72	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
10	75,06	1,26893	174	96-433-4345	Al-Mg-Si	5	1	2	Tetragonal	P 4/n c c
11	78,1252	1,22237	21343,31	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
12	82,3376	1,17017	6595,63	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
13	98,9288	1,01355	273,55	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
14	111,8671	0,92988	12777,44	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
15	116,436	0,90617	11714,96	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Probeta D286

No.	Pos. [$^{\circ}2\theta$]	d-spacing [\AA]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,37	3,96	458	96-901-1647	Si	2	0	0	Orthorhombic	C m c a
2	38,3705	2,34402	68172,26	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
3	40,196	2,24227	319	96-433-4345	Al-Mg-Si	2	2	2	Tetragonal	P 4/n c c
4	41,95	2,15667	923	96-901-6682	Fe-Si	0	1	2	Hexagonal	P 63/m c m
5	43,21	2,10017	448	96-433-4345	Al-Mg-Si	1	3	1	Tetragonal	P 4/n c c
6	44,6997	2,02571	72093,96	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
7	65,0676	1,43232	16289,31	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
8	74,84	1,26541	228	96-433-4345	Al-Mg-Si	1	5	3	Tetragonal	P 4/n c c
9	78,1255	1,22237	11538,18	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
10	82,2616	1,17106	291,59	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
11	98,9749	1,0132	778,59	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
12	111,9089	0,92965	16233,42	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
13	116,4198	0,90625	1015,08	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Probeta D295

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,36	3,96	627	96-901-1647	Si	2	0	0	Orthorhombic	C m c a
2	26,55	3,3615	240	96-433-4345	Al-Mg-Si	0	2	0	Tetragonal	P 4/n c c
3	38,416	2,34134	215748,4	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
4	40,1296	2,24609	626	96-433-4345	Al-Mg-Si	1	2	4	Tetragonal	P 4/n c c
5	42,024	2,15667	1306	96-901-6682	Fe-Si	0	1	2	Hexagonal	P 63/m c m
6	43,23	2,10017	502	96-433-4345	Al-Mg-Si	1	3	1	Tetragonal	P 4/n c c
7	44,6556	2,02761	44694,63	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
8	65,0205	1,43325	7002,83	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
9	74,84	1,26541	280	96-433-4345	Al-Mg-Si	1	5	3	Tetragonal	P 4/n c c
10	78,1504	1,22204	30148,81	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
11	82,3244	1,17032	3318,66	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
12	98,957	1,01334	1842,97	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
13	111,9039	0,92967	9939,7	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
14	116,4578	0,90607	14078,03	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Material Al-Si

Probeta D327

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,35	3,92453	663	96-200-5763	Al-Fe-Si	0	2	2	Orthorhombic	C m c m
2	34,58	2,56746	300	96-210-1146	Al-Fe	3	1	-2	Monoclinic	C 1 2/c 1
3	38,4159	2,34135	67634,3	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
4	40,15	2,24609	200	96-433-4345	Al-Mg-Si	1	2	4	Tetragonal	P 4/n c c
	41,94	2,16871	1023	96-901-6188	Fe-Si	0	1	2	Tetragonal	P 4/n c c
5	43,19	2,09841	407	96-901-1645	Si	3	1	1	Orthorhombic	C m c a
6	44,6799	2,02656	21459,91	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
7	45,58	1,98946	383	96-901-6188	Fe-Si	1	2	1	Hexagonal	P 63/m c m
8	46,77	2,02805	249	96-210-1146	Al-Fe	7	1	-2	Monoclinic	C 1 2/c 1
9	65,0483	1,4327	24762,5	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
10	74,75	1,26838	273	96-200-5763	Al-Fe-Si	0	0	8	Orthorhombic	C m c m
11	78,1932	1,22148	21331,53	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
12	82,3681	1,16981	2699,75	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
13	98,9754	1,0132	1241,97	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
14	111,9523	0,92941	7335,89	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
15	116,4759	0,90598	5135,22	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Probeta D337

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,35	3,92453	575	96-200-5763	Al-Fe-Si	0	2	2	Orthorhombic	C m c m
2	34,62	2,56746	372	96-210-1146	Al-Fe	3	1	-2	Monoclinic	C 1 2/c 1
3	37,14	2,41255	317	96-200-5763	Al-Fe-Si	1	3	2	Orthorhombic	C m c m
4	38,4295	2,34055	63532,06	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
5	41,89	2,16871	1241	96-433-4345	Fe-Si	0	1	2	Tetragonal	P 4/n c c
6	43,2	2,09841	415	96-901-1645	Si	3	1	1	Orthorhombic	C m c a
7	44,6847	2,02636	29040,58	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
8	45,61	1,98946	447	96-901-6188	Fe-Si	1	2	1	Hexagonal	P 63/m c m
9	46,82	2,02805	256	96-210-1146	Al-Fe	7	1	-2	Monoclinic	C 1 2/c 1
10	65,0636	1,4324	21160,73	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
11	74,86	1,26838	226	96-200-5763	Al-Fe-Si	0	0	8	Orthorhombic	C m c m
12	78,183	1,22161	10597,97	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
13	82,3743	1,16974	3240,53	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
14	99,0367	1,01273	1260,04	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
15	111,9305	0,92953	2025,62	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
16	116,5142	0,90579	3872,23	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Probeta D347

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	22,35	3,92453	673	96-200-5763	Al-Fe-Si	0	2	2	Orthorhombic	C m c m
2	34,63	2,56746	385	96-210-1146	Al-Fe	3	1	-2	Monoclinic	C 1 2/c 1
3	36,41	2,46262	145	96-210-1146	Al-Fe	7	1	-1	Monoclinic	C 1 2/c 1
4	37,18	2,41255	360	96-200-5763	Al-Fe-Si	1	3	2	Orthorhombic	C m c m
5	38,4547	2,33908	133189	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
	40,15	2,24609	251	96-433-4345	Al-Mg-Si	1	2	4	Tetragonal	P 4/n c c
6	41,89	2,16871	1471	96-433-4345	Fe-Si	0	1	2	Tetragonal	P 4/n c c
7	43,15	2,09841	600	96-901-1645	Si	10	0	0	Monoclinic	C 1 2/c 1
8	44,6623	2,02732	58903,29	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
9	45,62	1,98946	870	96-901-6188	Fe-Si	1	2	1	Hexagonal	P 63/m c m
10	46,75	2,02805	299	96-210-1146	Al-Fe	7	1	-2	Monoclinic	C 1 2/c 1
11	65,0273	1,43311	18372,88	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
12	74,76	1,26838	342	96-200-5763	Al-Fe-Si	0	0	8	Orthorhombic	C m c m
13	78,1699	1,22178	23934,92	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
14	82,3826	1,16964	10278,68	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m
15	98,9878	1,0131	1274,03	ICDD 03-065-2869	Al	4	0	0	Cubic	Fm-3m
16	111,9191	0,92959	2963,21	ICDD 03-065-2869	Al	3	3	1	Cubic	Fm-3m
17	116,4579	0,90606	6809,67	ICDD 03-065-2869	Al	4	2	0	Cubic	Fm-3m

Material Al-Cu-Si

Probeta D6132

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	20,5617	4,29002	765	96-901-2197	CuAl ₂	1	1	0	Tetragonal	I 4/m c m
2	22,3818	3,96	396	96-901-1647	Si	2	0	0	Orthorhombic	C m c a
3	26,58	3,3615	151	96-433-4345	Alx-Mgy-Siz	0	2	0	Tetragonal	P 4/n c c
4	29,46	3,0335	604	96-901-2197	CuAl ₂	0	2	0	Tetragonal	I 4/m c m
5	34,61	2,59083	348	96-101-0632	Cu-Si	1	2	3	Cubic	I -4 3 d
6	38,5022	2,3363	59122,62	ICDD 03-065-2869	Al	1	1	1	Cubic	Fm-3m
7	41,9815	2,15037	1259	COD 96-901-2197	CuAl ₂	2	2	0	Tetragonal	I 4/m c m
8	42,6121	2,11999	1560	COD 96-901-2197	CuAl ₂	1	1	2	Tetragonal	I 4/m c m
9	43,3	2,07516	486	96-901-1647	Si	3	1	1	Orthorhombic	C m c a
10	44,81	2,02098	15114	ICDD 03-065-2869	Al	2	0	0	Cubic	Fm-3m
11	47,2714	1,92133	864	COD 96-901-2197	CuAl ₂	3	1	0	Tetragonal	I 4/m c m
12	47,76	1,90313	1029	COD 96-901-2197	CuAl ₂	2	0	2	Tetragonal	I 4/m c m
13	57,094	1,61118	283	COD 96-901-2197	CuAl ₂	2	2	2	Tetragonal	I 4/m c m
14	65,1551	1,43061	22411,65	ICDD 03-065-2869	Al	2	2	0	Cubic	Fm-3m
15	66,98	1,39463	240	COD 96-901-2197	CuAl ₂	2	1	3	Tetragonal	I 4/m c m
16	73,38	1,28868	170	COD 96-901-2197	CuAl ₂	4	0	2	Tetragonal	I 4/m c m
17	75,01	1,26541	225	96-901-1647	Si	1	5	3	Orthorhombic	C m c a
18	77,22	1,23441	418	COD 96-901-2197	CuAl ₂	3	3	2	Tetragonal	I 4/m c m
19	78,2858	1,22026	17992,88	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
20	82,4891	1,1684	8402,54	ICDD 03-065-2869	Al	2	2	2	Cubic	Fm-3m

Probeta D6152

No.	Pos. [°2θ]	d-spacing [Å]	Height [cts]	PDF	Compuesto	h	k	l	Estructura	Grupo espacial
1	20,78	4,29002	1629	96-901-2197	CuAl ₂	1	1	0	Tetragonal	I 4/m c m
2	22,42	4,012	232	96-901-1645	Si	2	0	0	Orthorhombic	C m c a
3	26,48	3,3615	166	96-433-4345	Alx-Mgy-Siz	0	2	0	Tetragonal	P 4/n c c
4	29,36	3,0335	730	96-901-2197	CuAl ₂	0	2	0	Tetragonal	I 4/m c m
5	34,61	2,59083	364	96-101-0632	Cu-Si	1	2	3	Cubic	I -4 3 d
6	38,5176	2,33541	40437,56	ICDD 03-065-2869	Al	1	1	1	Cubic	I 4/m c m
7	41,9815	2,15037	1457	COD 96-901-2197	CuAl ₂	2	2	0	Tetragonal	I 4/m c m
8	42,71	2,11999	1560	COD 96-901-2197	CuAl ₂	1	1	2	Tetragonal	I 4/m c m
9	44,6411	2,02824	20866,9	ICDD 03-065-2869	Al	2	0	0	Cubic	I 4/m c m
10	47,32	1,92133	1156	COD 96-901-2197	CuAl ₂	3	1	0	Tetragonal	I 4/m c m
11	47,77	1,90313	1553	COD 96-901-2197	CuAl ₂	2	0	2	Tetragonal	I 4/m c m
12	57,1223	1,61118	399	COD 96-901-2197	CuAl ₂	2	2	2	Tetragonal	I 4/m c m
13	65,1414	1,43088	9959,16	ICDD 03-065-2869	Al	2	2	0	Cubic	I 4/m c m
14	69,23	1,35662	350	96-901-2197	CuAl ₂	2	4	0	Tetragonal	I 4/m c m
15	73,45	1,28793	335	COD 96-901-2197	CuAl ₂	0	4	2	Tetragonal	I 4/m c m
16	74,94	1,26541	282	96-901-1647	Si	1	5	3	Orthorhombic	C m c a
17	77,27	1,23441	615	COD 96-901-2197	CuAl ₂	3	3	2	Tetragonal	I 4/m c m
18	78,2068	1,2213	17791,82	ICDD 03-065-2869	Al	3	1	1	Cubic	Fm-3m
19	80,91	1,18615	100	96-433-4345	Alx-Mgy-Siz	2	4	7	Tetragonal	P 4/n c c
20	82,4265	1,16913	4771,26	ICDD 03-065-2869	Al	2	2	2	Cubic	I 4/m c m