

Appendix E3

SEM/EDS Data for Test #5, Day-30 Galvanized Steel Coupons

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This appendix shows the SEM/EDS results for the metal galvanized steel coupons under two categories: (1) unsubmerged and (2) submerged. Unsubmerged coupons were contacted with the solution only during the initial 4-hour spray phase. In addition, the surface of the unsubmerged coupons may be affected during the test by the moist air in the tank gas space. Submerged refers to the coupons submerged in the solution during the test.

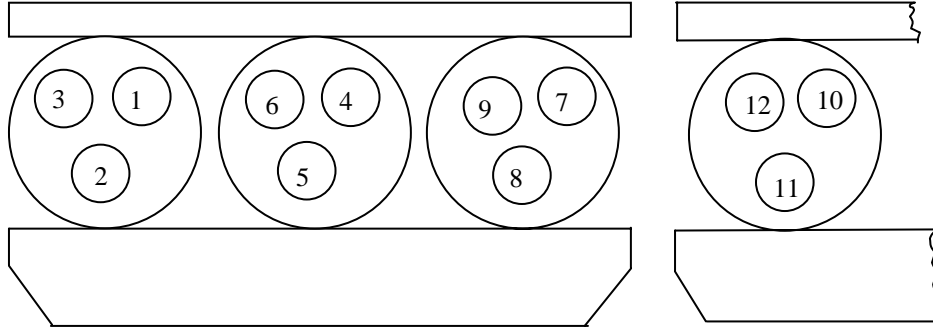
The coupon samples were collected on August 25, 2005 (the date Test #5 was shut down), and examined by SEM/EDS on August 30 and September 6, 2005. The galvanized steel coupon samples were dried in air before being coated with Au/Pd for SEM examination. SEM results present the surface condition of the galvanized steel coupons. In addition, EDS results provide a semi-quantitative elemental analysis of the coupon surface and the corrosion products.

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Transcribed Laboratory Log

Laboratory session from September 6, 2005.
SEM Test #5, Day-30 Galvanized Steel Coupons

Conditions: e=15.0kV, WD=11mm



1--Yellow Deposits on Submerged Rack	2--Sediment (T5D30)	3--Al-Unsubmerged
4--Al-Submerged	5--Gal-Steel Unsubmerged	6--Gal-Steel Submerged
7--Cu Unsubmerged	8--Cu-Submerged	9--Steel-Unsubmerged
10--Steel-Submerged	11--Drain Collar Interior	12--Drain Collar Outside Ext.

Unsubmerged Galvanized Steel Coupon

Image:	T5D30SuspGalsteel013	100 ×	SEM image	Figure E3-1
	T5D30SuspGalsteel014	1000 ×	SEM Annotated image	Figure E3-2
EDS:	T5D30Susp GS		On needle like crystal shown	Figure E3-3
	needle03		in image 014	
	T5D30 Susp GS		On cracked skin layer shown	Figure E3-4
	layer04		in image 014	

Submerged Galvanized Steel Coupon

Image:	T5D30SubmGalsteel015	100 ×	SEM image of fiberglass	Figure E3-5
	T5D30SubmGalsteel016	1000 ×	SEM image higher magnification	Figure E3-6
EDS:	T5D30Subm GS Particle05		On particles shown in image 016	Figure E3-7
	T5D30Subm GS Particle05		On particles shown in image 016	Figure E3-8

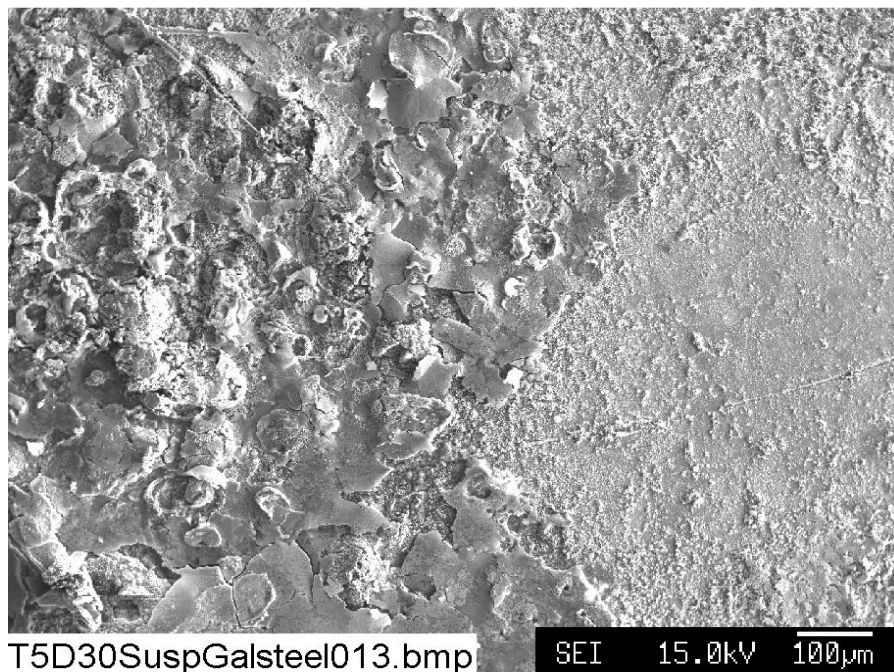


Figure E3-1. SEM image magnified 100 times for a Test #5, Day-30 unsubmerged galvanvanized steel coupon sample. (T5D30SuspGalsteel013.bmp)

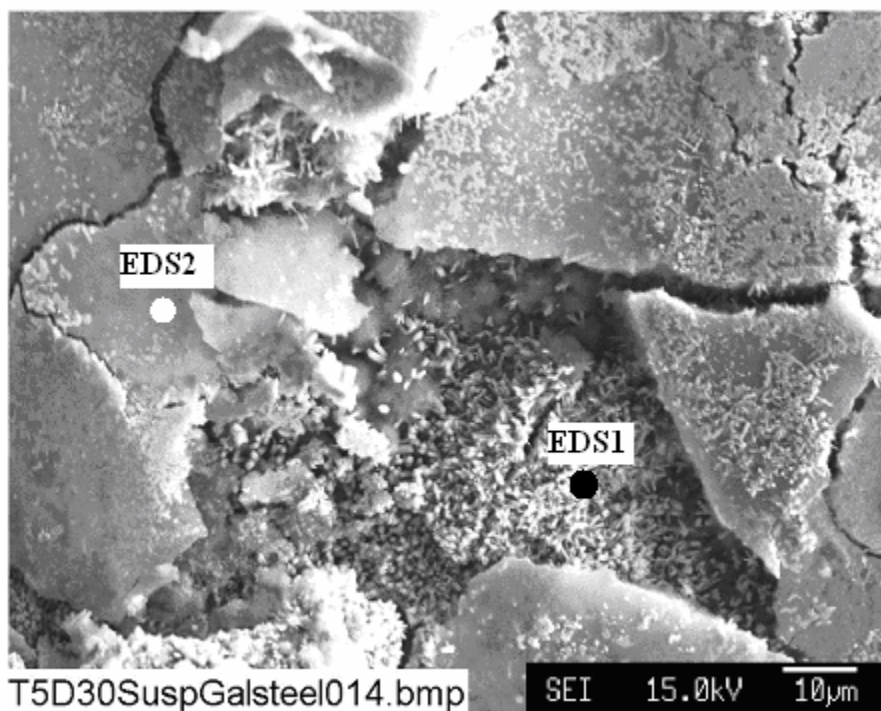


Figure E3-2. Annotated SEM image magnified 1000 times for a Test #5, Day-30 unsubmerged galvanvanized steel coupon sample. (T5D30SuspGalsteel014.bmp)

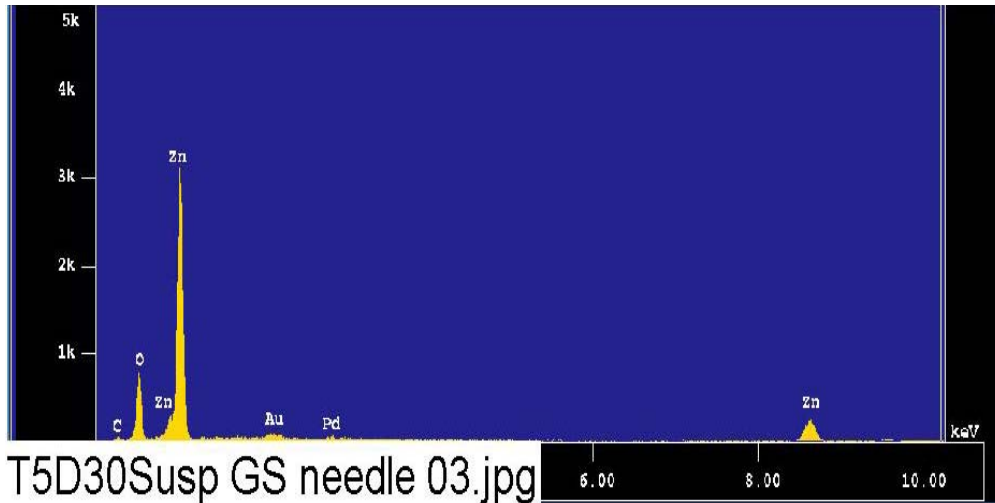


Figure E3-3. EDS counting spectrum for the needle-like crystal (EDS1) on the unsubmerged, galvanized steel coupon surface shown in Figure E3-2. (T5D30Susp GS needle 03.jpg)

The results from the chemical composition analysis for T5D30Susp GS needle 03.jpg are given in Table E3-1.

Table E3-1. Chemical Compositions for T5D30Susp GS needle 03.jpg, Figure E3-3

```

Group      : NRC
Sample     : T5D30 ID# : 9
Comment    : Needle crystal on suspended Gal-steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec      Aperture #   : 1
             Acc. Volt  : 15.0 KV         Probe Current : 1.005E-09 A
             Stage Point: X=44.601 Y=63.875 Z=11.848
             Acq. Date  : Tue Aug 30 14:27:56 2005
  
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Zn K	Normal	8.19-10.06	30.9955	0.0087	3521 / 5
O K	Normal	0.31- 0.74	24.2024	0.0125	22808 / 40
C K	Normal	0.11- 0.47	29.4584	0.0106	297 / 123

Chi_square = 7.1611

Element	Mass%	Atomic%	ZAF	Z	A	F
Zn	48.925	17.6401	1.1674	1.1710	0.9969	1.0000
O	36.525	53.8072	1.1161	0.9160	1.2184	1.0000
C	14.550	28.5527	0.3653	0.9195	0.3973	1.0000

Total 100.000 100.0000
Normalization factor = 1.3522

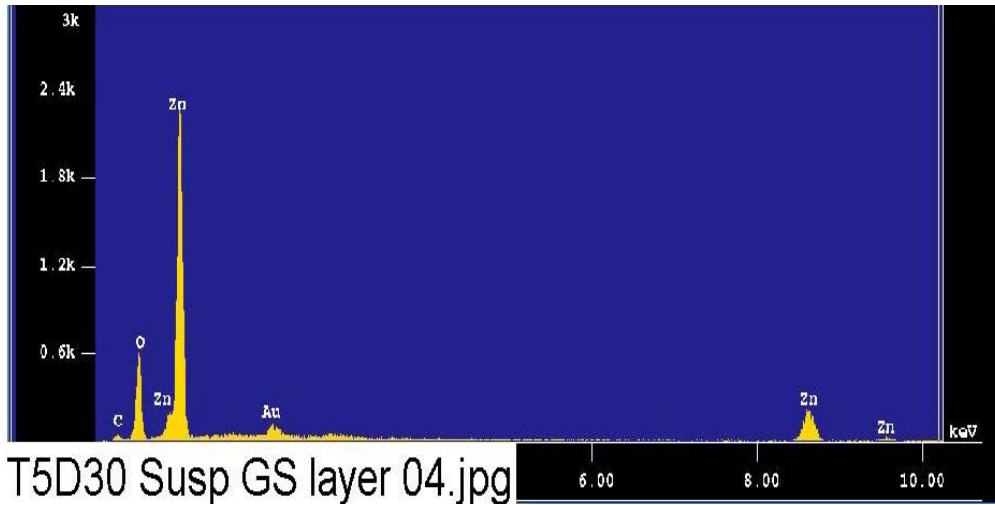


Figure E3-4. EDS counting spectrum for the cracked layer (EDS2) on the unsubmerged galvanized steel coupon surface shown in Figure E3-2. (T5D30 Susp GS layer 04.jpg)

The results from the chemical composition analysis for T5D30 Susp GS layer 04.jpg are given in Table E3-2.

Table E3-2. Chemical Compositions for T5D30 Susp GS layer 04.jpg, Figure E3-4

```

Group      : NRC
Sample    : T5D30 ID# : 10
Comment   : Cracked layer on suspended Gal-steel
Condition : Full Scale : 20KeV(10eV/ch,2Kch)
           Live Time  : 60.000 sec      Aperture #   : 1
           Acc. Volt  : 15.0 KV        Probe Current : 1.006E-09 A
           Stage Point: X=44.601 Y=63.875 Z=11.848
           Acq. Date  : Tue Aug 30 14:32:43 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Zn K	Normal	8.19-10.06	27.9430	0.0081	3177 / 6
C K	Normal	0.11- 0.47	29.1554	0.0102	294 / 100
O K	Normal	0.31- 0.74	19.0550	0.0110	17975 / 35

Chi_square = 4.1819

Element	Mass%	Atomic%	ZAF	Z	A	F
Zn	49.823	17.9813	1.1635	1.1671	0.9970	1.0000
C	16.397	32.2068	0.3670	0.9167	0.4003	1.0000
O	33.780	49.8119	1.1568	0.9133	1.2667	1.0000

Total 100.000 100.0000
Normalization factor = 1.5324

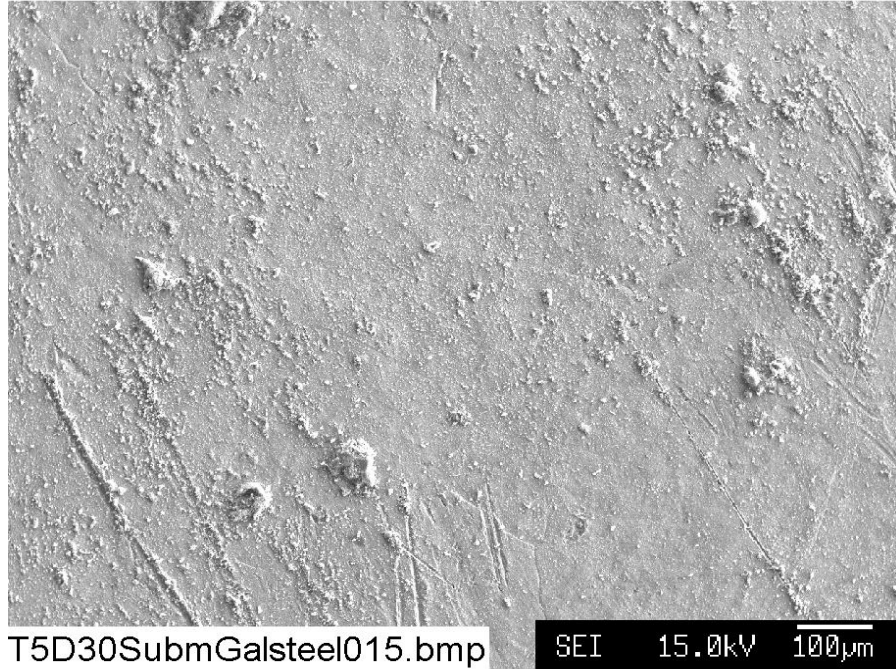


Figure E3-5. SEM image magnified 100 times for a Test #5, Day-30 submerged galvanized steel coupon sample. (T5D30SubmGalsteel015.bmp)

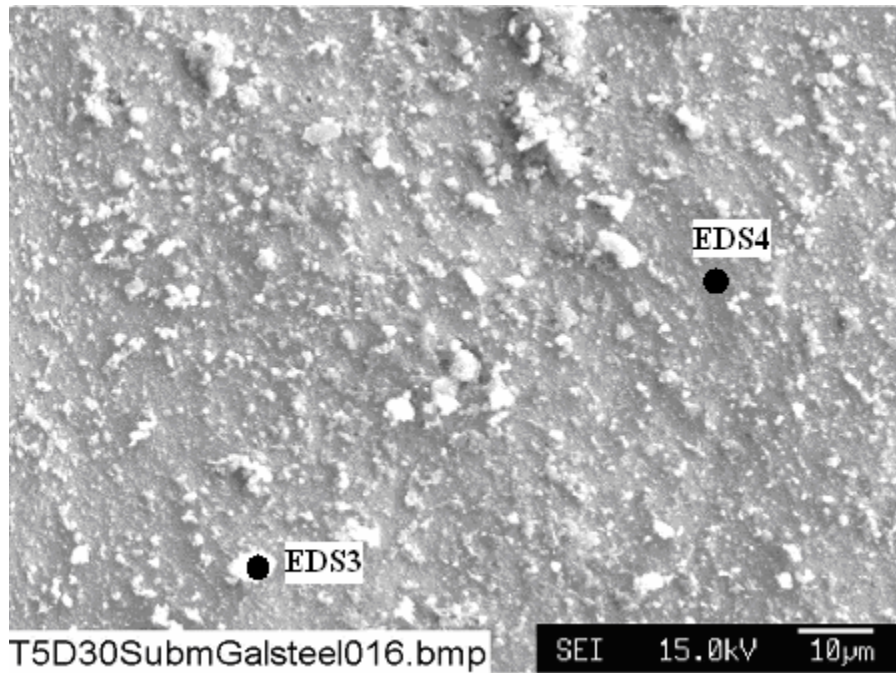


Figure E3-6. Annotated SEM image magnified 1000 times for a Test #5, Day-30 submerged galvanized steel coupon sample. (T5D30SubmGalsteel016.bmp)

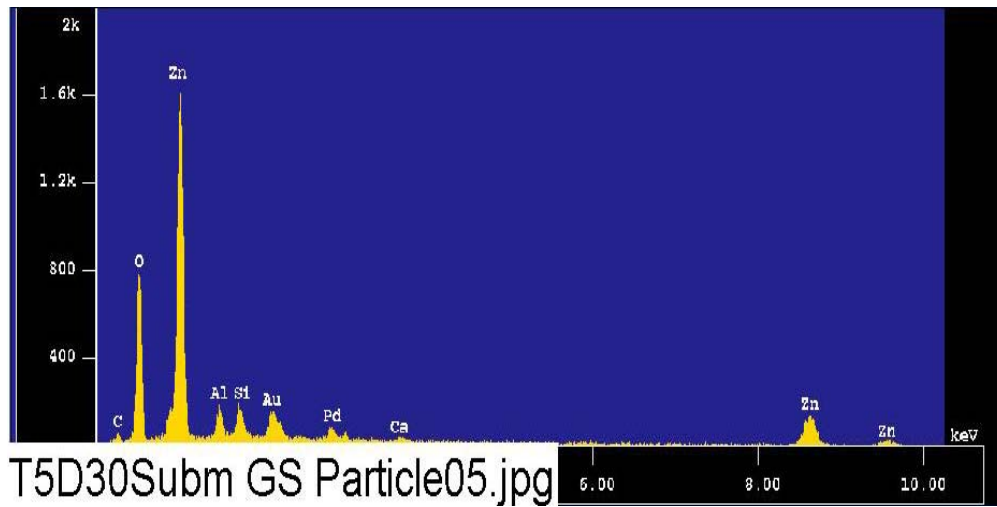


Figure E3-7. EDS counting spectrum for the light deposits (EDS3) on the submerged galvanized steel coupon surface shown in Figure E3-6. (T5D30Subm GS Particle05.jpg)

The results from the chemical composition analysis for T5D30Subm GS Particle05.jpg are given in Table E3-3.

Table E3-3. Chemical Compositions for T5D30Subm GS Particle05.jpg, Figure E3-7

```

Group      : NRC
Sample     : T5D30 ID# : 11
Comment    : Particles on submerged Gal_steel surface
Condition  : Full Scale : 20KeV(10ev/ch,2Kch)
            Live Time  : 60.000 sec   Aperture #   : 1
            Acc. Volt  : 15.0 KV      Probe Current : 1.005E-09 A
            Stage Point : X=56.678 Y=62.490 Z=11.848
            Acq. Date  : Tue Aug 30 14:47:04 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Al K	Normal	1.26- 1.78	0.9951	0.0008	1109 / 70
Si K	Normal	1.50- 2.07	0.9148	0.0005	1119 / 125
Ca K	Normal	3.40- 4.30	0.4234	0.0049	250 / 25
Zn K	Normal	8.19-10.06	17.3542	0.0070	1971 / 7
C K	Normal	0.11- 0.47	19.5680	0.0121	197 / 121
O K	Normal	0.31- 0.74	25.0700	0.0122	23626 / 28

Chi_square = 5.5084

Element	Mass%	Atomic%	ZAF	Z	A	F
Al	2.628	2.0964	1.5366	0.9406	1.6342	0.9996
Si	2.296	1.7594	1.4602	0.9328	1.5654	1.0000
Ca	0.685	0.3677	0.9409	0.9394	1.0025	0.9991
Zn	36.016	11.8565	1.2072	1.2114	0.9965	1.0000
C	12.092	21.6651	0.3595	0.9447	0.3805	1.0000
O	46.283	62.2547	1.0739	0.9412	1.1410	1.0000

Total 100.000 100.0000
 Normalization factor = 1.7191

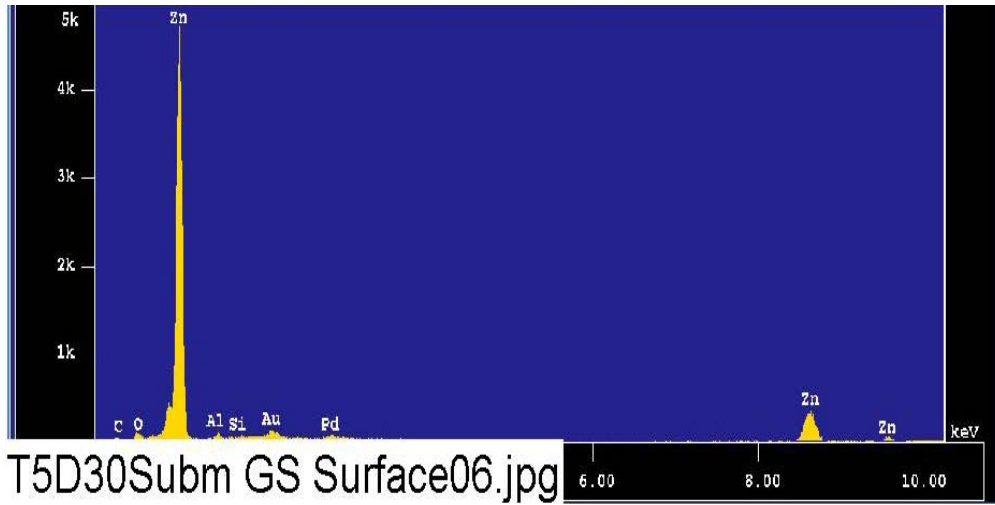


Figure E3-8. EDS counting spectrum for the grey coupon surface (EDS4) of the submerged galvanized steel shown in Figure E3-6. (T5D30Subm GS Surface06.jpg)

The results from the chemical composition analysis for T5D30Subm GS Surface06.jpg are given in Table E3-4.

Table E3-4. Chemical Compositions for T5D30Subm GS Surface06.jpg, Figure E3-8

```

Group      : NRC
Sample     : T5D30 ID# : 12
Comment    : Surface of submerged Gal_steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec      Aperture #    : 1
             Acc. Volt   : 15.0 KV        Probe Current  : 1.006E-09 A
             Stage Point : X=56.678 Y=62.490 Z=11.848
             Acq. Date   : Tue Aug 30 14:52:18 2005

```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
Al K	Normal	1.26- 1.78	0.4278	0.0007	477 /	58
Si K	Normal	1.50- 2.07	0.1268	0.0004	155 /	91
Zn K	Normal	8.19-10.06	45.4077	0.0105	5163 /	10
O K	Normal	0.31- 0.74	2.7433	0.0065	2588 /	58
C K	Normal	0.11- 0.47	21.6706	0.0104	219 /	36

Chi_square = 1.5563

Element	Mass%	Atomic%	ZAF	Z	A	F
Al	1.263	1.6261	1.8551	0.8522	2.1770	1.0000
Si	0.331	0.4087	1.6372	0.8446	1.9384	1.0000
Zn	77.389	41.1116	1.0705	1.0718	0.9988	1.0000
O	5.427	11.7800	1.2426	0.8547	1.4540	0.9999
C	15.590	45.0735	0.4519	0.8583	0.5265	1.0000

Total 100.000 100.0000
Normalization factor = 1.5921

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Appendix E4

SEM/EDS Data for Test #5, Day-30 Steel Coupons

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This appendix shows the SEM/EDS results for the metal steel coupons under two categories: (1) unsubmerged and (2) submerged. Unsubmerged coupons were contacted with the solution only during the initial 4-hour spray phase. In addition, the surface of the unsubmerged coupons may be affected during the test by the moist air in the tank gas space. Submerged refers to the coupons submerged in the solution during the test.

The coupon samples were collected on August 25, 2005 (the date Test #5 was shut down), and examined by SEM/EDS on August 30 and September 6, 2005. The steel coupon samples were dried in air before being coated with Au/Pd for SEM examination. SEM results present the surface condition of the steel coupons. In addition, EDS results provide a semi-quantitative elemental analysis of the coupon surface and the corrosion products.

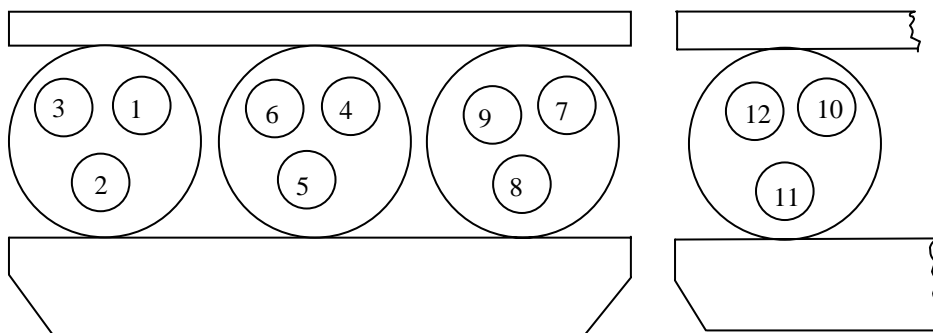
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Transcribed Laboratory Log

Laboratory session from September 6, 2005.

SEM Test #5, Day-30 Steel Coupons

Conditions: e=15.0kV, WD=11mm



- | | | |
|--------------------------------------|---------------------------|-------------------------------|
| 1--Yellow Deposits on Submerged Rack | 2--Sediment (T5D30) | 3--Al-Unsubmerged |
| 4--Al-Submerged | 5--Gal-Steel Unsubmerged | 6--Gal-Steel Submerged |
| 7--Cu Unsubmerged | 8--Cu-Submerged | 9--Steel-Unsubmerged |
| 10--Steel-Submerged | 11--Drain Collar Interior | 12--Drain Collar Outside Ext. |

Unsubmerged Steel Coupon

Image:	T5D30SuspSteel021	100 ×	SEM image	Figure E4-1
	T5D30SuspSteel022	1000 ×	SEM image higher magnification	Figure E4-2
EDS:	T5D30SuspSteel023	1000 ×	SEM annotated image	Figure E4-3
	T5D30Susp Steel Surface11		On smooth surface shown in image 023	Figure E4-4
	T5D30Susp Steel Particle12		On white particles shown in image 023	Figure E4-5

Submerged Steel Coupon

Image:	T5D30SubmSteel024	100 ×	SEM image of fiberglass	Figure E4-6
	T5D30SubmSteel025	1000 ×	SEM Annotated image	Figure E4-7
EDS:	T5D30Subm Steel light particle13		EDS of light particles in 025	Figure E4-8
	T5D30Subm Steel dark particle14		EDS of dark particle in 025	Figure E4-9
	T5D30Subm Steel Surface15		EDS of surface in 025	Figure E4-10

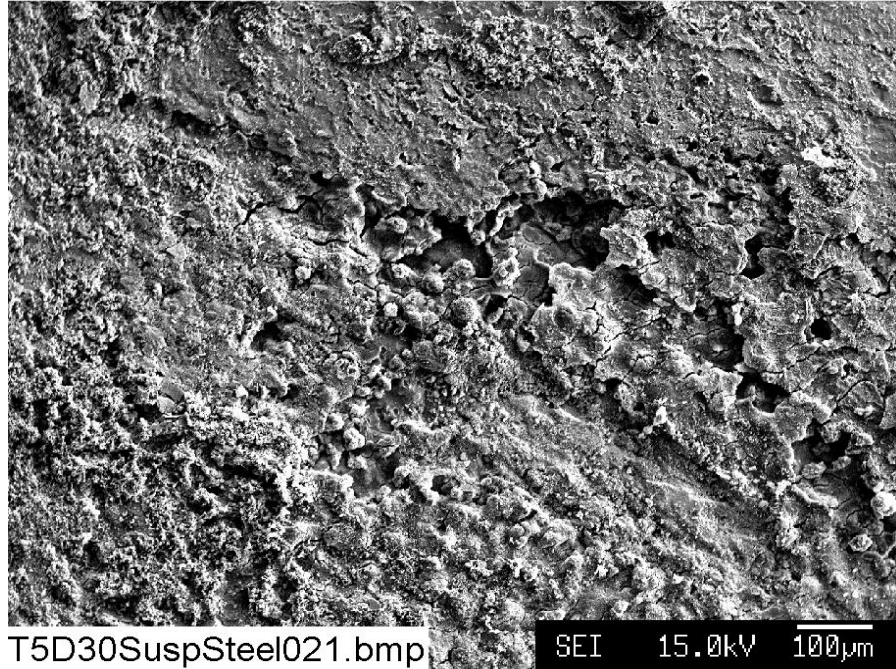


Figure E4-1. SEM image magnified 100 times for a Test #5, Day-30 unsubmerged steel coupon sample. (T5D30SuspSteel021.bmp)

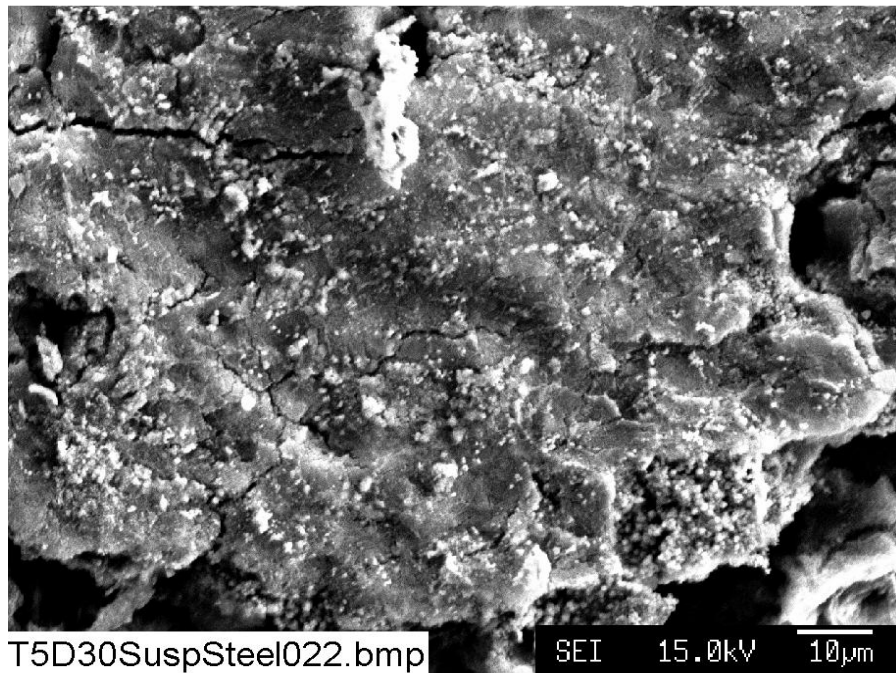


Figure E4-2. SEM image magnified 1000 times for a Test #5, Day-30 unsubmerged steel coupon sample. (T5D30SuspSteel022.bmp)

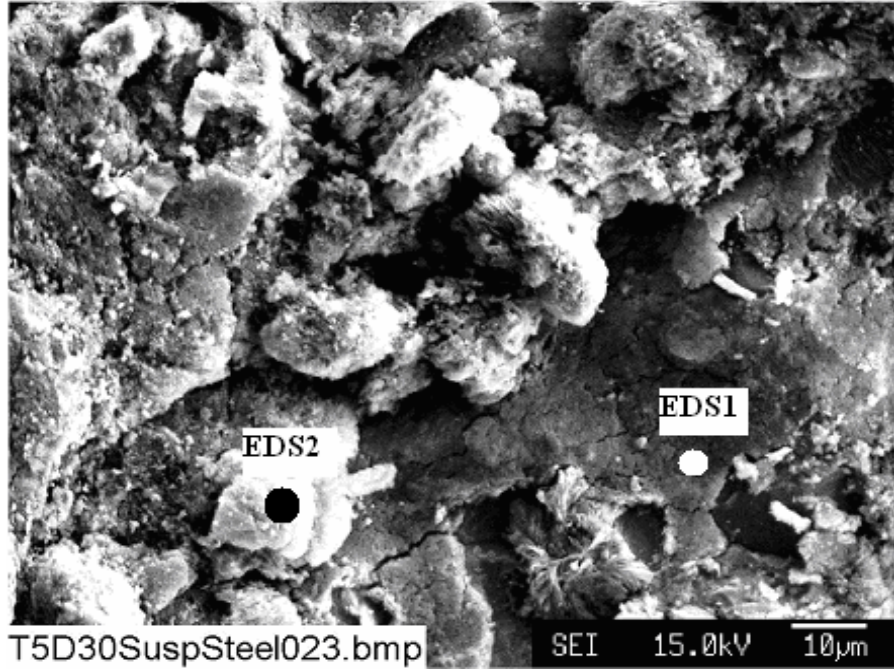


Figure E4-3. Annotated SEM image magnified 1000 times for a Test #5, Day-30 unsubmerged steel coupon sample. (T5D30SuspSteel023.bmp)

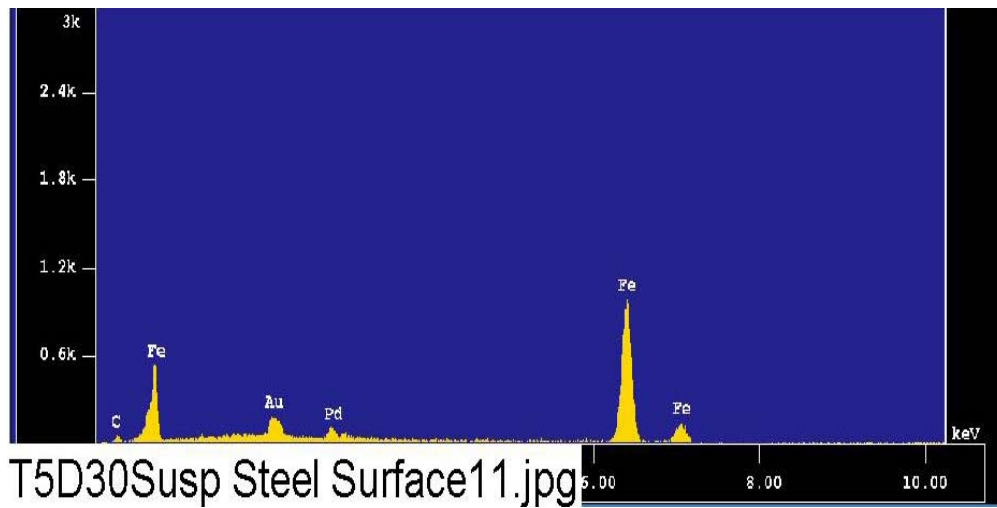


Figure E4-4. EDS counting spectrum for the dark coupon surface (EDS1) of the unsubmerged steel shown in Figure E4-3. (T5D30Susp Steel Surface11.jpg)

The results from the chemical composition analysis for T5D30Susp Steel Surface11.jpg are given in Table E4-1.

Table E4-1. Chemical Compositions for T5D30Susp Steel Surface11.jpg, Figure E4-4

```

Group      : NRC
Sample     : T5D30 ID# : 17
Comment    : Surface of Suspended Steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec      Aperture #   : 1
             Acc. Volt  : 15.0 KV        Probe Current : 1.004E-09 A
             Stage Point: X=21.743 Y=66.867 Z=11.848
             Acq. Date  : Tue Aug 30 15:38:16 2005

```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Fe K	Normal	6.04- 7.40	57.1720	0.0094	15164 / 18
C K	Normal	0.11- 0.47	25.4488	0.0098	256 / 25

Chi_square = 3.9338

Element	Mass%	Atomic%	ZAF	Z	A	F
Fe	89.763	65.3492	1.0215	1.0227	0.9989	1.0000
C	10.237	34.6509	0.2617	0.8592	0.3046	1.0000

Total 100.000 100.0000
Normalization factor = 1.5370

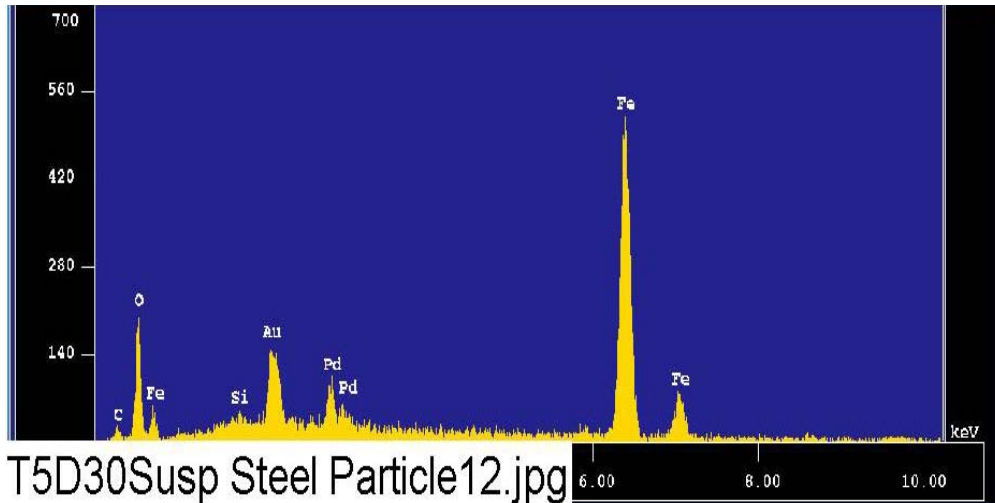


Figure E4-5. EDS counting spectrum for the light particle (EDS2) on the unsubmerged steel coupon surface shown in Figure E4-3. (T5D30Susp Steel Particle12.jpg)

The results from the chemical composition analysis for T5D30Susp Steel Particle12.jpg are given in Table E4-2.

Table E4-2. Chemical Compositions for T5D30Susp Steel Particle12.jpg, Figure E4-5

```

Group      : NRC
Sample     : T5D30 ID# : 18
Comment    : Particles on Suspended Steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 60.000 sec      Aperture #   : 1
             Acc. Volt  : 15.0 KV        Probe Current : 1.005E-09 A
             Stage Point : X=21.743 Y=66.867 Z=11.848
             Acq. Date   : Tue Aug 30 15:43:38 2005

Element    Mode      ROI (KeV)  K-ratio(%)  +/-      Net/Background
Si K       Normal    1.50- 2.07  0.1045     0.0003   128 / 47
Fe K       Normal    6.04- 7.40  29.4350    0.0070   7815 / 13
C K        Normal    0.11- 0.47  15.9559    0.0066   161 / 35
O K        Normal    0.31- 0.74  6.1537     0.0065   5799 / 21
-----
Chi_square = 2.8510

Element  Mass%   Atomic%   ZAF      Z      A      F
Si       0.348   0.4060   1.3604   0.8714 1.5612 0.9999
Fe       76.176  44.6485  1.0562   1.0587 0.9976 1.0000
C        10.179  27.7411  0.2604   0.8849 0.2942 1.0000
O        13.297  27.2045  0.8818   0.8813 1.0011 0.9995
-----
Total    100.000 100.0000
Normalization factor = 2.4503

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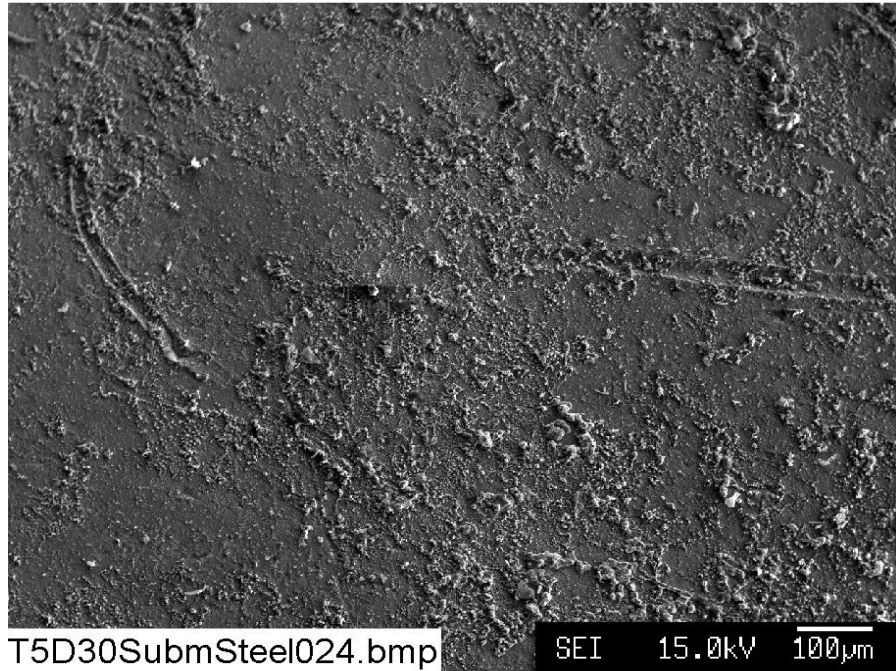


Figure E4-6. SEM image magnified 100 times for a Test #5, Day-30 submerged steel coupon sample. (T5D30SubmSteel024.bmp)

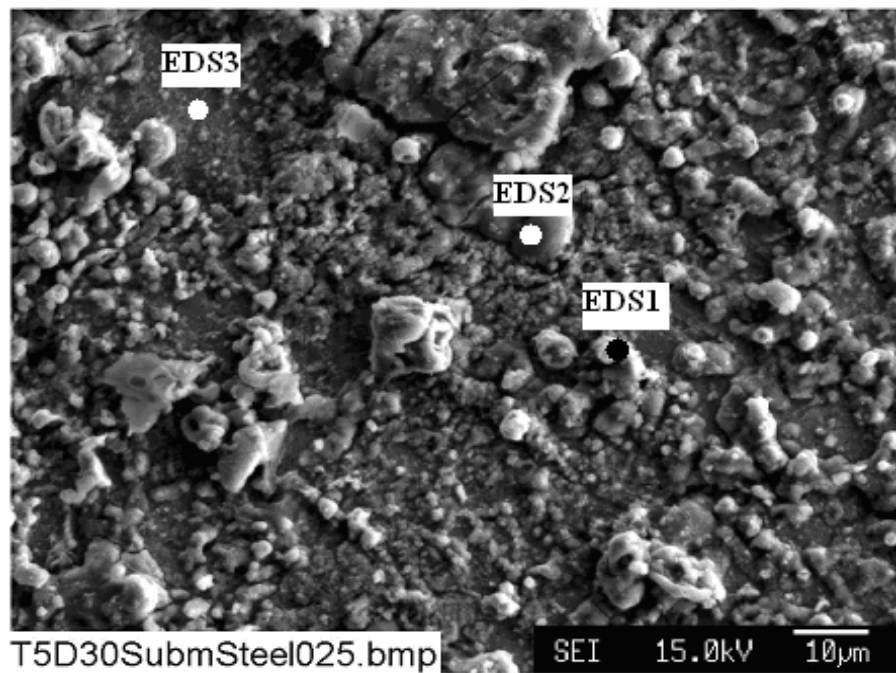


Figure E4-7. Annotated SEM image magnified 1000 times for a Test #5, Day-30 submerged steel coupon sample. (T5D30SubmSteel025.bmp)

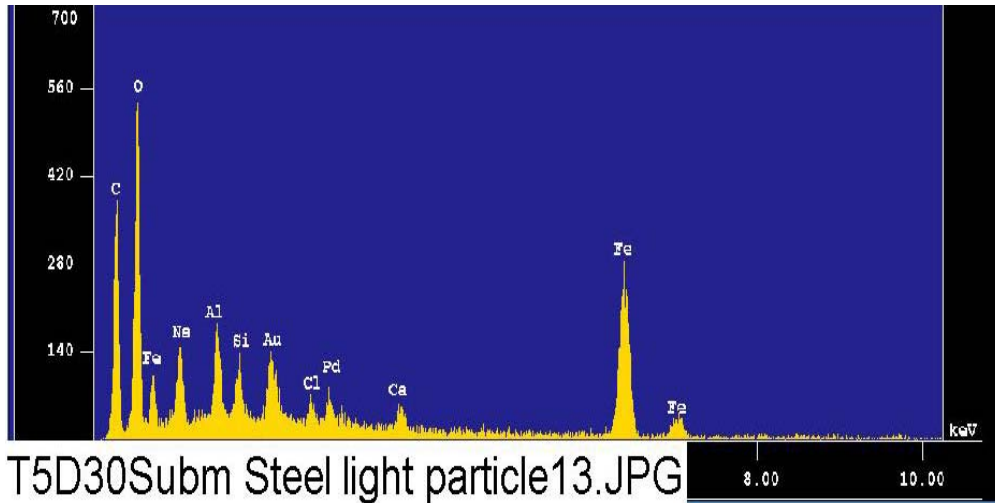


Figure E4-8. EDS counting spectrum for the light particle (EDS1) on the submerged steel coupon surface shown in Figure E4-7. (T5D30Subm Steel light particle13.JPG)

The results from the chemical composition analysis for T5D30Subm Steel light particle13.JPG are given in Table E4-3.

Table E4-3. Chemical Compositions for T5D30Subm Steel light particle13.JPG, Figure E4-8

Group	: NRC						
Sample	: T5D30 ID# : 19						
Comment	: Light particle on submerged Steel						
Condition	: Full Scale : 20KeV(10eV/ch,2Kch)						
	Live Time	: 60.000 sec	Aperture #	: 1			
	Acc. Volt	: 15.0 KV	Probe Current	: 1.003E-09 A			
	Stage Point	: X=76.455 Y=54.980 Z=11.000					
	Acq. Date	: Tue Aug 30 16:26:04 2005					
Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background		
C K	Normal	0.11- 0.47	255.6311	0.0237	2571 /	99	
O K	Normal	0.35- 0.72	14.1923	0.0039	3803 /	62	
Na K	Normal	0.83- 1.28	1.2501	0.0063	923 /	34	
Al K	Normal	1.26- 1.78	1.1529	0.0008	1283 /	66	
Si K	Normal	1.50- 2.07	0.6334	0.0009	704 /	119	
Cl K	Normal	2.32- 3.09	0.5137	0.0007	485 /	36	
Ca K	Normal	3.40- 4.30	0.8103	0.0053	477 /	27	
Fe K	Normal	6.04- 7.40	15.7888	0.0051	4184 /	6	

Chi_square = 3.2813							
Element	Mass%	Atomic%	ZAF	Z	A	F	
C	49.124	65.0147	0.1870	0.9620	0.1944	1.0000	
O	26.855	26.6826	1.8416	0.9574	1.9235	0.9999	
Na	1.678	1.1603	1.3065	0.9520	1.3704	1.0015	
Al	1.365	0.8042	1.1523	0.9602	1.2004	0.9998	
Si	0.695	0.3932	1.0673	0.9487	1.1251	0.9999	
Cl	0.522	0.2339	0.9882	1.0049	0.9842	0.9991	
Ca	0.770	0.3053	0.9247	0.9632	0.9661	0.9937	
Fe	18.991	5.4057	1.1706	1.1807	0.9915	1.0000	

Total	100.000	100.0000					
Normalization factor = 1.0275							

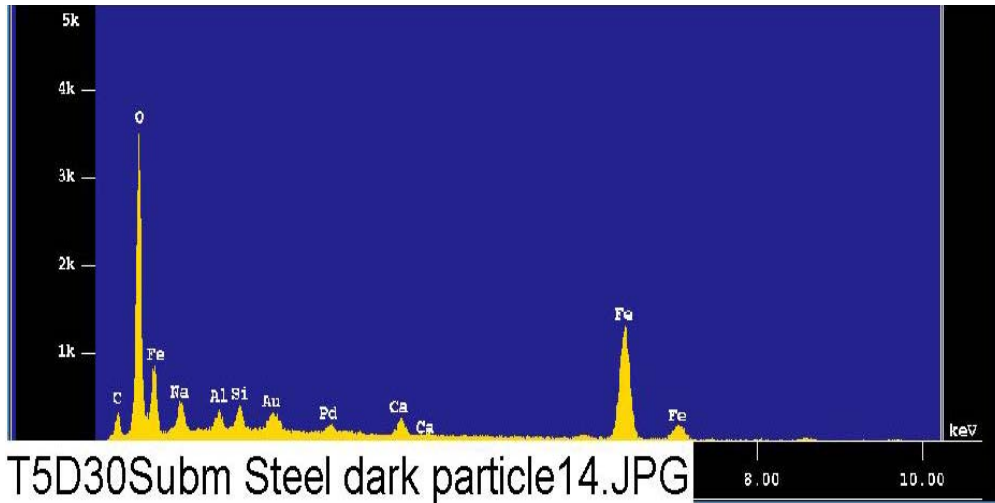


Figure E4-9. EDS counting spectrum for the dark particle (EDS2) on the submerged steel coupon surface shown in Figure E4-7. (T5D30Subm Steel dark particle14.JPG)

The results from the chemical composition analysis for T5D30Subm Steel dark particle14.JPG are given in Table E4-4.

Table E4-4. Chemical Compositions for T5D30Subm Steel dark particle14.JPG, Figure E4-9

```

Group      : NRC
Sample     : T5D30 ID# : 20
Comment    : Dark particle on submerged Steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 191.130 sec   Aperture #   : 1
             Acc. Volt   : 15.0 KV       Probe Current : 1.003E-09 A
             Stage Point : X=76.455 Y=54.980 Z=11.000
             Acq. Date   : Tue Aug 30 17:08:10 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Na K	Normal	0.83- 1.28	0.9443	0.0114	2221 / 116
Al K	Normal	1.26- 1.78	0.5316	0.0013	1884 / 212
Si K	Normal	1.50- 2.07	0.5549	0.0008	2159 / 284
Ca K	Normal	3.40- 4.30	1.2563	0.0109	2354 / 73
Fe K	Normal	6.04- 7.40	24.3440	0.0113	20548 / 36
O K	Normal	0.31- 0.74	33.9978	0.0267	101858 / 292
C K	Normal	0.11- 0.47	58.5353	0.0260	1876 / 551

Chi_square = 20.3524

Element	Mass%	Atomic%	ZAF	Z	A	F
Na	1.969	1.7446	1.6775	0.9412	1.7796	1.0015
Al	0.872	0.6582	1.3195	0.9486	1.3913	0.9998
Si	0.890	0.6453	1.2897	0.9408	1.3709	0.9999
Ca	1.439	0.7313	0.9214	0.9484	0.9798	0.9916
Fe	34.836	12.7034	1.1509	1.1573	0.9945	1.0000
O	43.074	54.8293	1.0190	0.9488	1.0741	0.9999
C	16.919	28.6879	0.2325	0.9522	0.2442	0.9999

Total 100.000 100.0000
Normalization factor = 1.2433

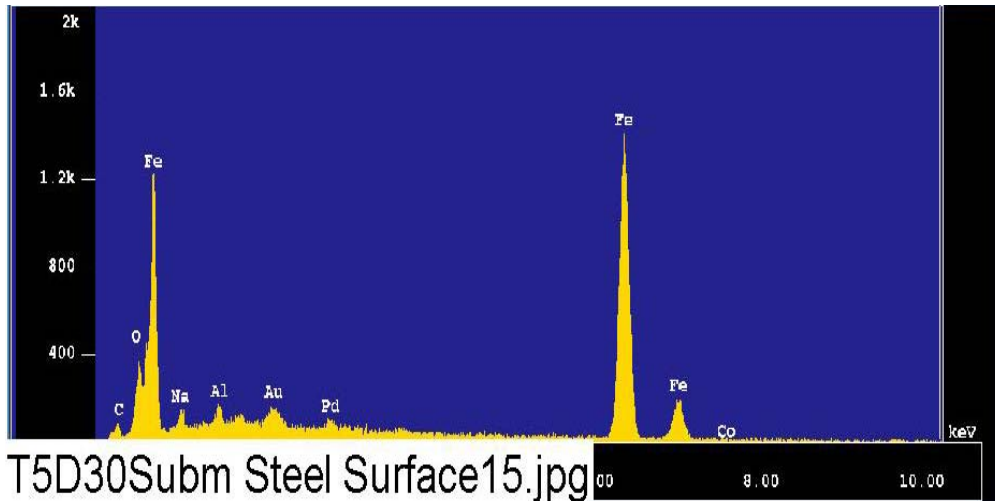


Figure E4-10. EDS counting spectrum for the submerged steel coupon surface (EDS3) shown in Figure E4-7. (T5D30Subm Steel Surface15.jpg)

The results from the chemical composition analysis for T5D30Subm Steel Surface15.jpg are given in Table E4-5.

Table E4-5. Chemical Compositions for T5D30Subm Steel Surface15.jpg, Figure E4-10

```

Group      : NRC
Sample     : T5D30 ID# : 21
Comment    : Surface of submerged Steel
Condition  : Full Scale : 20KeV(10eV/ch,2Kch)
             Live Time  : 83.100 sec   Aperture #   : 1
             Acc. Volt  : 15.0 KV      Probe Current : 1.003E-09 A
             Stage Point: X=76.455 Y=54.980 Z=11.000
             Acq. Date  : Tue Aug 30 17:15:50 2005
  
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background
Na K	Normal	0.83- 1.28	0.6403	0.0069	655 / 72
Fe K	Normal	6.04- 7.40	58.7678	0.0113	21567 / 30
Co K	Normal	6.53- 8.02	0.1879	0.0017	64 / 66
O K	Normal	0.31- 0.74	5.4760	0.0120	7133 / 270
C K	Normal	0.11- 0.47	28.0267	0.0128	390 / 86
Al K	Normal	1.26- 1.78	0.5087	0.0009	784 / 108

Chi_square = 8.3983

Element	Mass%	Atomic%	ZAF	Z	A	F
Na	1.768	2.7579	2.0987	0.8635	2.4268	1.0016
Fe	80.660	51.7984	1.0432	1.0450	0.9983	1.0000
Co	0.264	0.1607	1.0680	1.0710	0.9972	1.0000
O	6.395	14.3354	0.8877	0.8717	1.0189	0.9994
C	9.925	29.6345	0.2692	0.8754	0.3075	1.0000
Al	0.988	1.3132	1.4761	0.8693	1.6981	1.0000

Total 100.000 100.0000
Normalization factor = 1.3156