

## Appendix D3

# ESEM and SEM/EDS Data for Test #2, Day-30 Drain Collar Fiberglass

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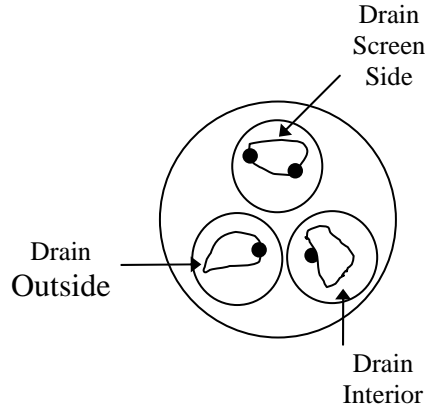
Chemical deposits accumulated on fiberglass during ICET testing are of great interest because they may cause additional head loss during recirculation of the coolant following a LOCA. The drain collar placed in the test tank represents an area of higher flow velocity, where water continually flows through any accumulated debris. This condition of continual water flow is similar to that found on the face of a recirculation sump screen, so it is important to examine the fiberglass samples recovered from the drain collar via ESEM and SEM/EDS and compare the results with similar examinations of fiberglass from alternative flow regimes.

Fiberglass samples from the drain collar were extracted on the date that Test #2 was shut down (March 7, 2005). Samples located at the outside exterior (away from the drain screen), the inside exterior (next to the drain screen), and the interior of the collar were examined. Microprobe SEM was used to examine the fiberglass samples after they were dried in air at room temperature and coated with carbon. In addition to microprobe SEM, ESEM was used to analyze the wet fiberglass samples. ESEM was performed without any required coating under a low-vacuum condition (80 Pa) to minimize any modification of the sample that might occur through the drying process. Microprobe SEM/EDS and ESEM results of the Test #2, Day-30 drain collar fiberglass samples were obtained on March 9, 2005.

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## Transcribed Laboratory Log

Microprobe laboratory session from March 9, 2005  
 T2D30 samples from fiberglass drain collar



Conditions: 15-kV, 1-nA beam current, Aperture=2  
 Note: Bold spots on sketch denote carbon glue used to secure the samples.

### Sample: Drain Screenside

Image:	T2D30_DrainScreen029	150 ×	SE	Figure D3-1
	T2D30_DrainScreen030	150 ×	BSE	Figure D3-2
	T2D30_DrainScreen031	90 ×	SE	Figure D3-3
	T2D30_DrainScreen032	1000×	SE	Figure D3-4
EDS:	T2D30EDS16		Center of image 032	Figure D3-5
	T2D30EDS17		Film on fiberglass	Figure D3-6

### Sample: Drain Outside

Image:	T2D30_DrainOutside033	90 ×	SE	Figure D3-7
	T2D30_DrainOutside034	150 ×	SE same area	Figure D3-8
	T2D30_DrainOutside035	150 ×	BSE same area	Figure D3-9
	T2D30_DrainOutside036	1000 ×	SE same area	Figure D3-10
EDS:	T2D30EDS18		Particles on fiberglass, high C content	Figure D3-11
	T2D30EDS19		Particle on fiberglass, high C content	Figure D3-12

Note: \*Very difficult to get EDS spectrum of particles. The particles are very thin and react under the beam. EDS18 and EDS19 are simply replicates at slightly different sample locations.

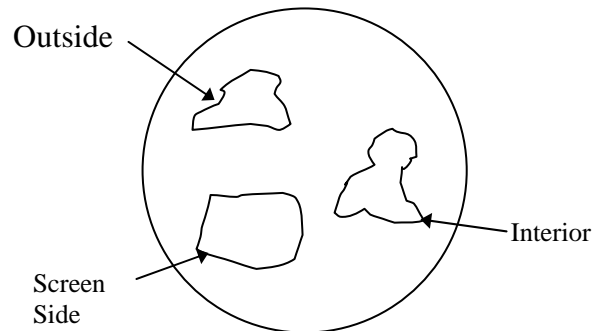
**Sample: Drain Interior**

Image:	T2D30_DrainInt037	90 ×	SE	Figure D3-13
	T2D30_DrainInt038	150 ×	SE new area	Figure D3-14
	T2D30_DrainInt039	1000 ×	SE same area	Figure D3-15
	T2D30_DrainInt040	150 ×	BSE same area	Figure D3-16
EDS:	T2D30EDS20		Particles on fiberglass	Figure D3-17

**Transcribed Laboratory Log**

ESEM laboratory session from March 9, 2005

T2D30 NRC - Fiberglass on Drain Collar ESEM



Conditions: 20-kV, 12-mm Working Distance, 80 Pa pressure

**Outside Sample**

Image:	T2D30DO1	150 ×	BSE Overview	Figure D3-18
	T2D30DO2	1000 ×	Same area	Figure D3-19
	T2D30DO3	90 ×	Same area	Figure D3-20



**Screen-Side Sample**

Image: T2D30DS4	90 ×	Overview	Figure D3-21
T2D30DS5	150 ×	Same area	Figure D3-22
T2D30DS6	1000 ×	Same area as above	Figure D3-23

**Interior Sample**

Image: T2D30DI7	90 ×	1 <sup>st</sup> area	Figure D3-24
T2D30DI8	150 ×	Different area	Figure D3-25
T2D30DI9	1000 ×	Same as above	Figure D3-26

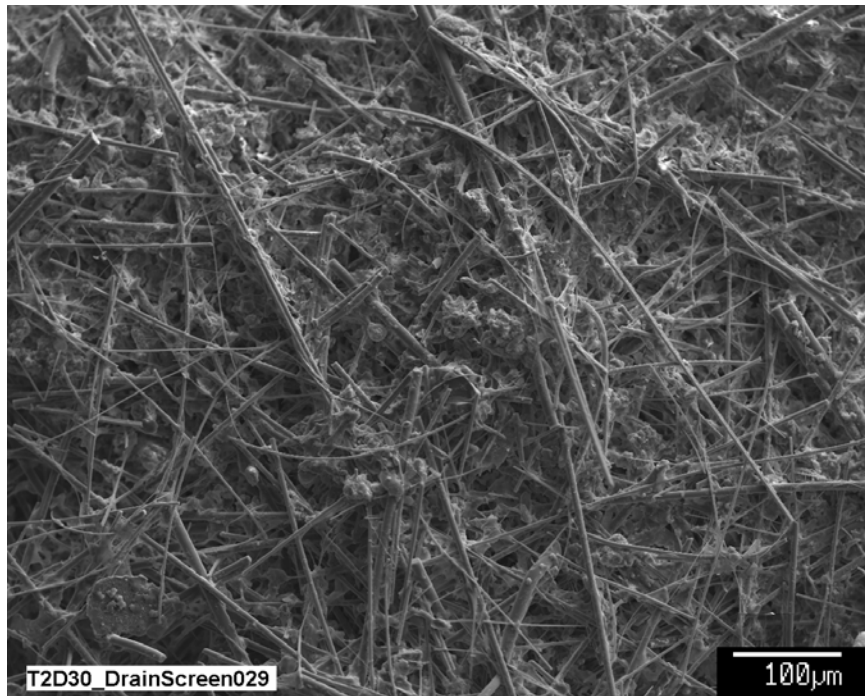


Figure D3-1. SEM image for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30\_DrainScreen029)

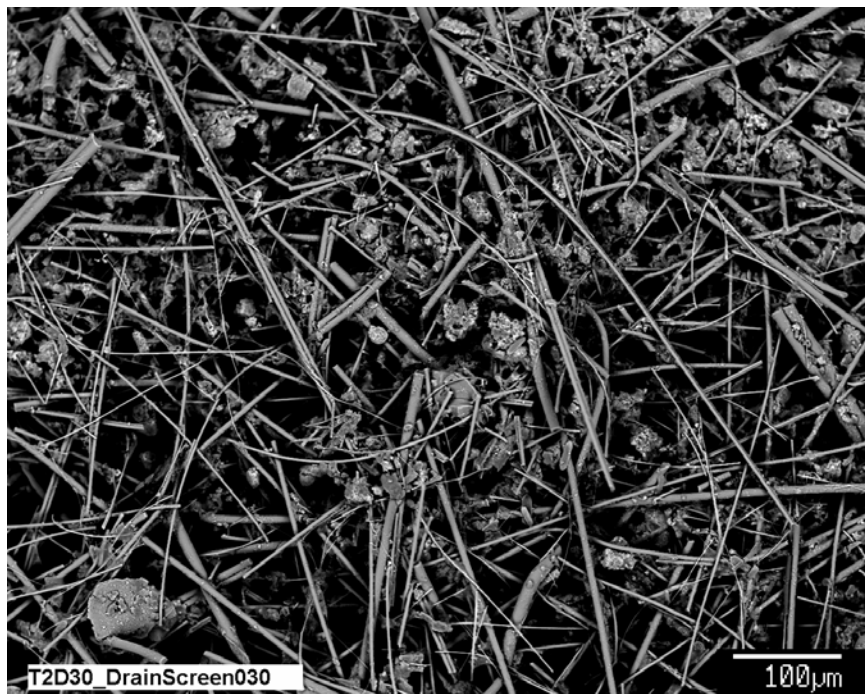


Figure D3-2. Backscattered SEM image for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen, illustrating that deposits have a similar atomic number to fiberglass. (T2D30\_DrainScreen030)

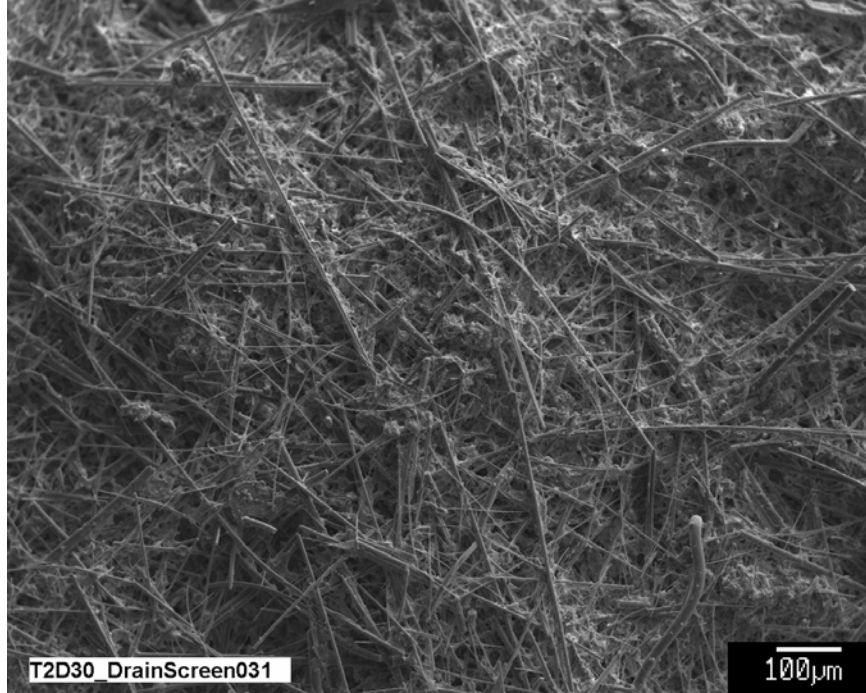


Figure D3-3. SEM image for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30\_DrainScreen031)

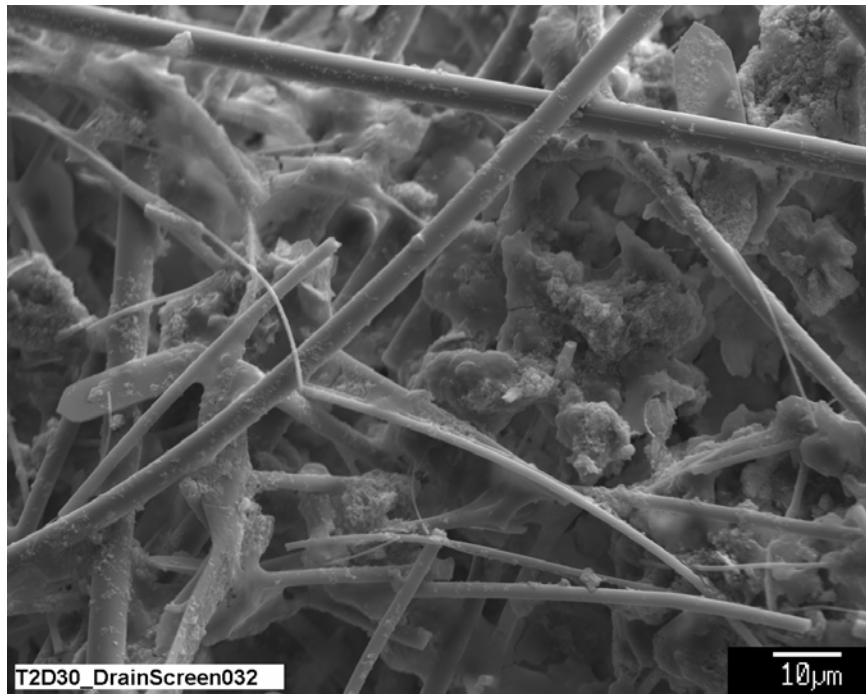
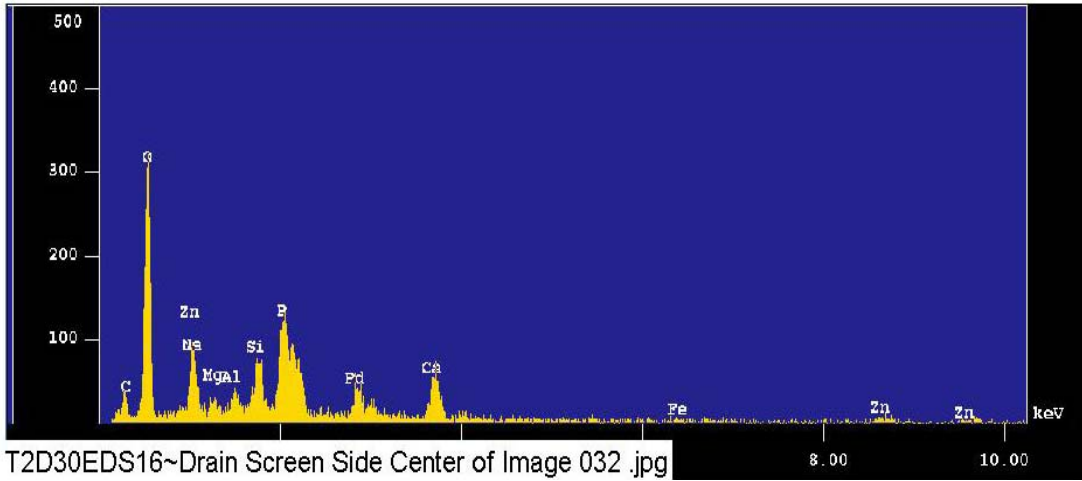


Figure D3-4. SEM image at 1000× magnification for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30\_DrainScreen032)



**Figure D3-5. EDS counting spectrum for the center of the image shown in Figure D3-4. (T2D30EDS16~Drain Screen Side Center of Image 032)**

The results from the chemical composition analysis for T2D30EDS16 are given in Table D3-1.

**Table D3-1. The Chemical Composition for T2D30EDS16 (Figure D3-5)**

Mar 9 17:18 2005 /tmp/eds\_pout.log Page 1

```

Group       : NRC
Sample      : T2D30 ID# : 16
Comment     : drain screen side
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=75.582 Y=53.863 Z=10.627
              Acq. Date  : Wed Mar 9 16:16:45 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
C K	Normal	0.09- 0.46	0.0000	0.0000	0 /	27
O K	Normal	0.25- 0.77	88.9796	0.0022	2775 /	22
Na K	Normal	0.83- 1.28	2.1316	0.0068	209 /	19
Al K	Normal	1.26- 1.78	1.4306	0.0004	211 /	53
Si K	Normal	1.50- 2.07	3.5171	0.0007	520 /	73
P K	Normal	1.75- 2.38	13.8624	0.0024	1032 /	44
Ca K	Normal	3.40- 4.30	9.2372	0.0047	722 /	7
Zn K	Normal	8.22-10.03	10.8880	0.0035	98 /	3

-----  
Chi\_square = 2.8663

Element	Mass%	Atomic%	ZAF	Z	A	F
C	0.000	0.0000	4.3367	1.0203	4.2504	0.9999
O	65.359	81.5376	0.9412	0.9731	0.9672	1.0000
Na	2.262	1.9637	1.3596	0.9772	1.3894	1.0013
Al	1.422	1.0518	1.2735	0.9851	1.2952	0.9981
Si	3.163	2.2478	1.1523	0.9730	1.1881	0.9968
P	9.891	6.3735	0.9142	1.1728	0.7798	0.9996
Ca	7.056	3.5137	0.9787	0.9855	0.9933	0.9998
Zn	10.847	3.3119	1.2765	1.2799	0.9973	1.0000

-----  
Total 100.000 100.0000  
Normalization factor = 0.7805



**Figure D3-6.** EDS counting spectrum for the film between fibers shown in Figure D3-4. The film is rich in silicon, oxygen, aluminum, sodium, and calcium. (T2D30EDS17~Drain Screen Side Film on Fiber Glass)

The results from the chemical composition analysis for T2D30EDS17 are given in Table D3-2.

**Table D3-2. The Chemical Composition for T2D30EDS17 (Figure D3-6)**

Mar 9 17:20 2005 /tmp/eds\_pout.log Page 1

```

Group       : NRC
Sample      : T2D30 ID# : 17
Comment     : film on fiberglass
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 60.000 sec   Aperture #   : 1
              Acc. Volt  : 15.0 KV      Probe Current : 1.001E-09 A
              Stage Point: X=75.684 Y=53.977 Z=10.627
              Acq. Date  : Wed Mar 9 16:21:30 2005
    
```

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
O K	Normal	0.25- 0.77	7.9629	0.0018	1866 /	12
Na K	Normal	0.83- 1.28	0.4017	0.0037	296 /	15
Al K	Normal	1.26- 1.78	0.8589	0.0006	954 /	93
Si K	Normal	1.50- 2.07	2.1743	0.0011	2413 /	84
P K	Normal	1.75- 2.38	0.6172	0.0018	345 /	129
Ca K	Normal	3.40- 4.30	0.6433	0.0037	378 /	6
Fe K	Normal	6.04- 7.40	0.0946	0.0232	18 /	2

-----  
 Chi\_square = 2.9399

Element	Mass%	Atomic%	ZAF	Z	A	F
O	59.959	73.0617	0.9746	0.9921	0.9824	1.0000
Na	3.492	2.9608	1.1249	0.9964	1.1283	1.0006
Al	7.333	5.2984	1.1051	1.0045	1.1064	0.9944
Si	18.694	12.9763	1.1128	0.9923	1.1231	0.9986
P	4.794	3.0176	1.0055	1.1961	0.8408	0.9998
Ca	4.994	2.4289	1.0048	1.0056	0.9992	1.0000
Fe	0.734	0.2562	1.0038	1.0013	1.0018	1.0008

-----  
 Total 100.000 100.0000  
 Normalization factor = 7.7260



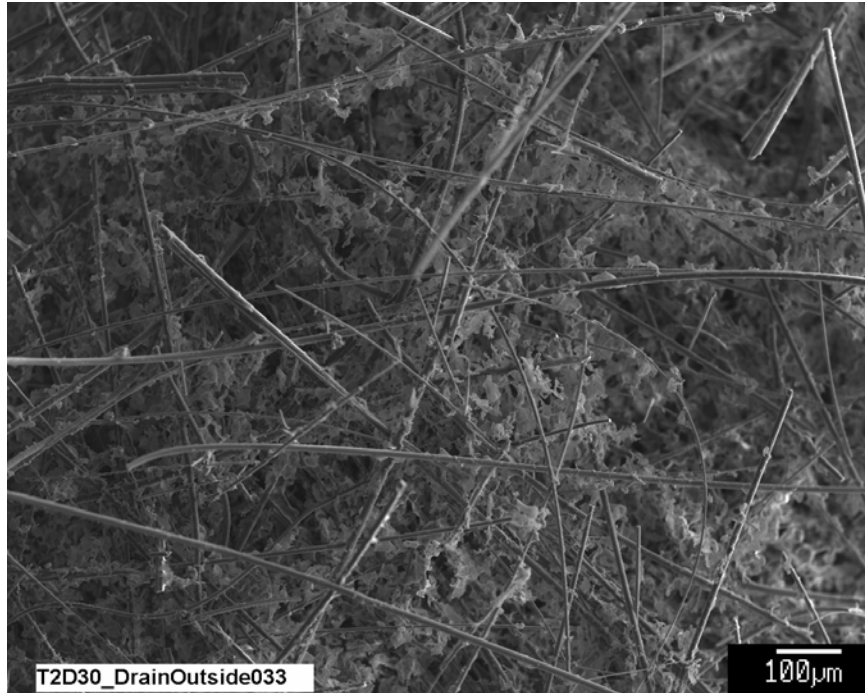


Figure D3-7. SEM image for a Test #2, Day-30 exterior fiberglass sample on the drain collar (away from the drain screen) showing deposits or growth on fiberglass. (T2D30\_DrainOutside033)

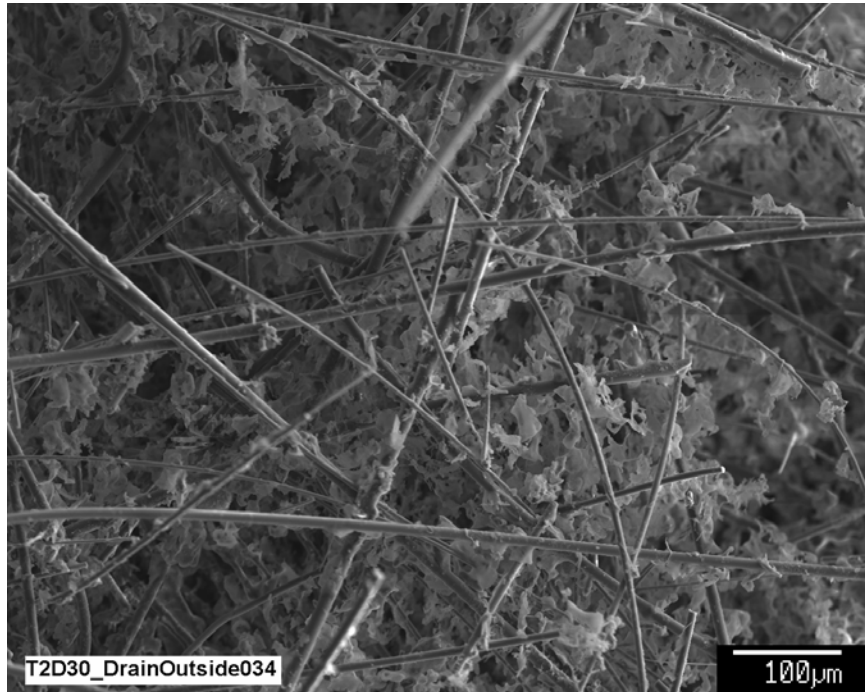


Figure D3-8. SEM image for a Test #2, Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass. (T2D30\_DrainOutside034)



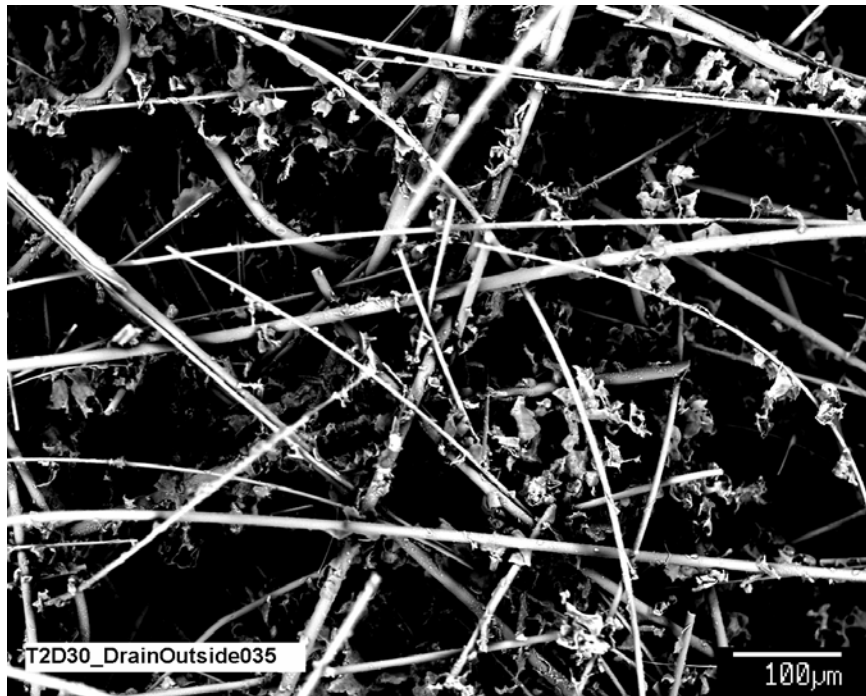


Figure D3-9. Backscattered SEM image for a Test #2, Day-30 exterior fiberglass sample on the drain collar. (T2D30\_DrainOutside035)

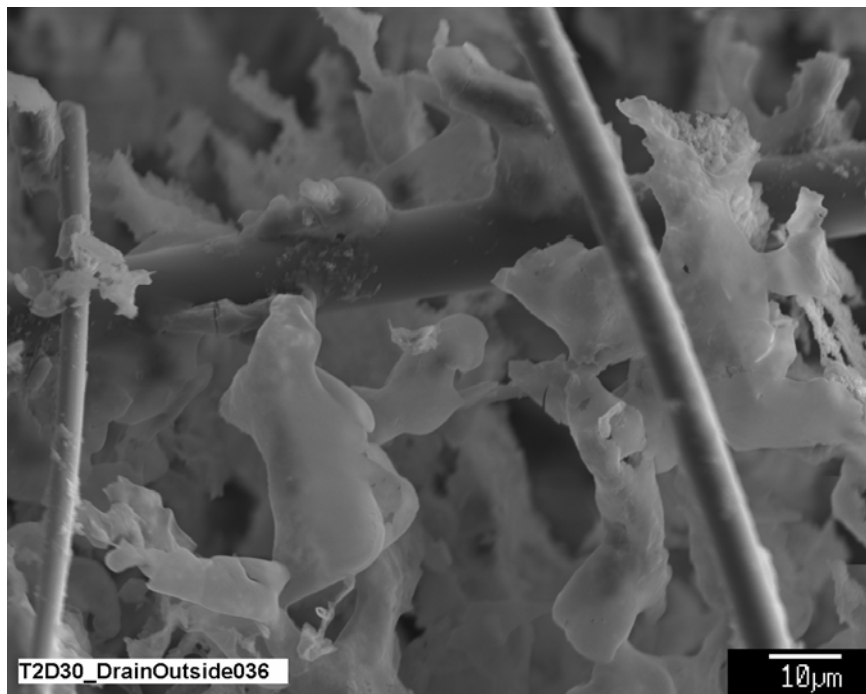
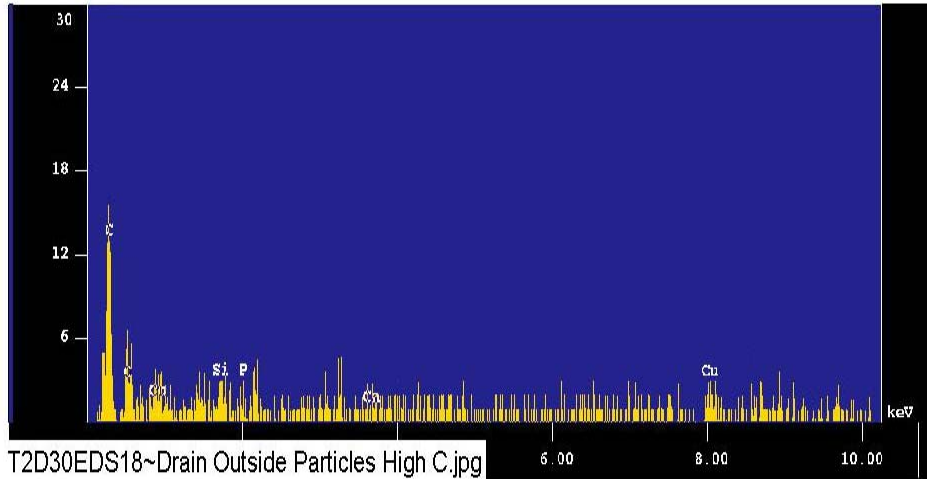
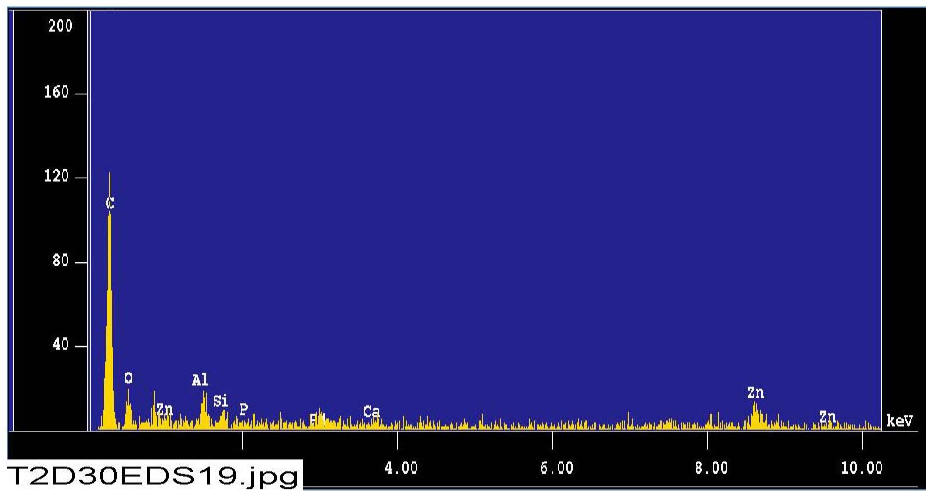


Figure D3-10. SEM image at a higher magnification for a Test #2, Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass. (T2D30\_DrainOutside 036)



**Figure D3-11. EDS counting spectrum for deposits or growth on fiberglass. The deposits contain a significant amount of carbon. (T2D30EDS18~Drain Outside Particles High C)**



**Figure D3-12. EDS counting spectrum for a deposit or growth on fiberglass. The deposit contains a significant amount of carbon. (T2D30EDS19)**

The results from the chemical composition analysis for T2D30EDS19 are given in Table D3-3.

**Table D3-3. The Chemical Composition for T2D30EDS19 (Figure D3-12)**

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Group : NRC  
 Sample : T2D30 ID# : 19  
 Comment : particles on fiberglass  
 Condition : Full Scale : 20KeV(10eV/ch,2Kch)  
           Live Time : 120.000 sec Aperture # : 1  
           Acc. Volt : 15.0 KV Probe Current : 9.749E-09 A  
           Stage Point : X=81.088 Y=63.027 Z=10.627  
           Acq. Date : Wed Mar 9 16:55:59 2005

Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
C K	Normal	0.09- 0.46	0.1138	0.0002	771 /	2
O K	Normal	0.25- 0.77	0.0359	0.0006	164 /	44
Al K	Normal	1.26- 1.78	0.0048	0.0002	104 /	6
Si K	Normal	1.50- 2.07	0.0033	0.0003	71 /	11
Zn K	Normal	8.22-10.03	0.1099	0.0036	145 /	2
Ca K	Normal	3.40- 4.30	0.0038	0.0018	44 /	4

-----  
 Chi\_square = 3.5725

Element	Mass%	Atomic%	ZAF	Z	A	F
C	59.630	79.7022	2.7985	0.9722	2.8786	1.0000
O	12.718	12.7615	1.8946	0.9274	2.0429	1.0000
Al	1.176	0.6998	1.3104	0.9398	1.3945	0.9998
Si	0.710	0.4060	1.1613	0.9286	1.2506	1.0000
Zn	25.102	6.1648	1.2204	1.2263	0.9952	1.0000
Ca	0.664	0.2658	0.9225	0.9421	0.9800	0.9991

-----  
 Total 100.000 100.0000

Normalization factor = 187.2003

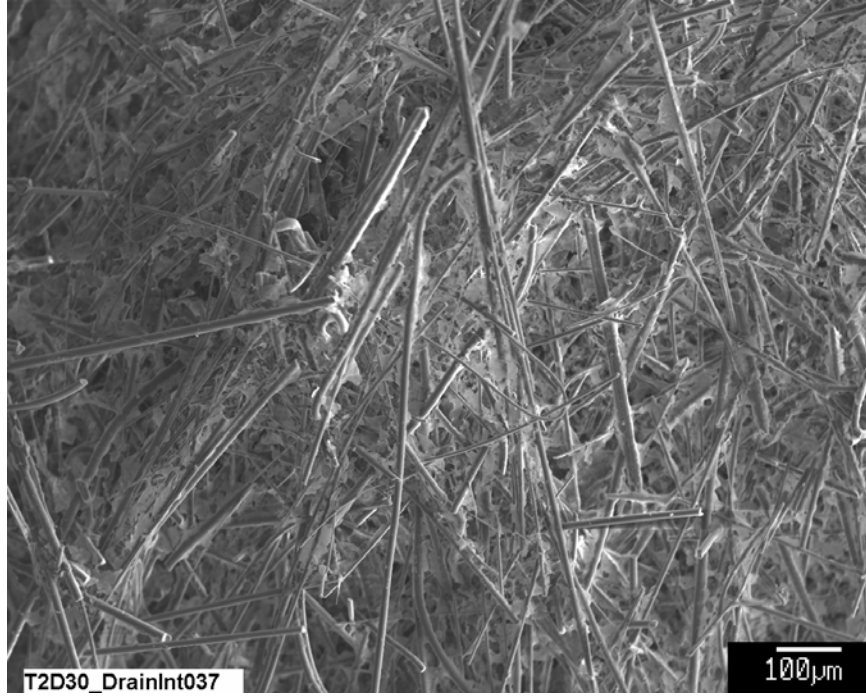


Figure D3-13. SEM image for a Test #2, Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass. (T2D30\_DrainInt037)

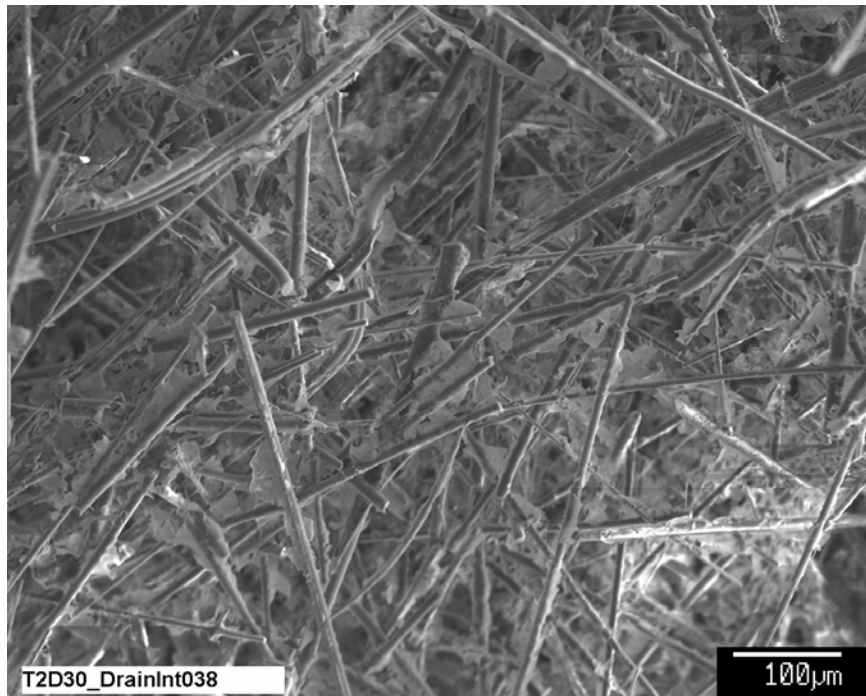


Figure D3-14. SEM image for a Test #2, Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass. (T2D30\_DrainInt038)

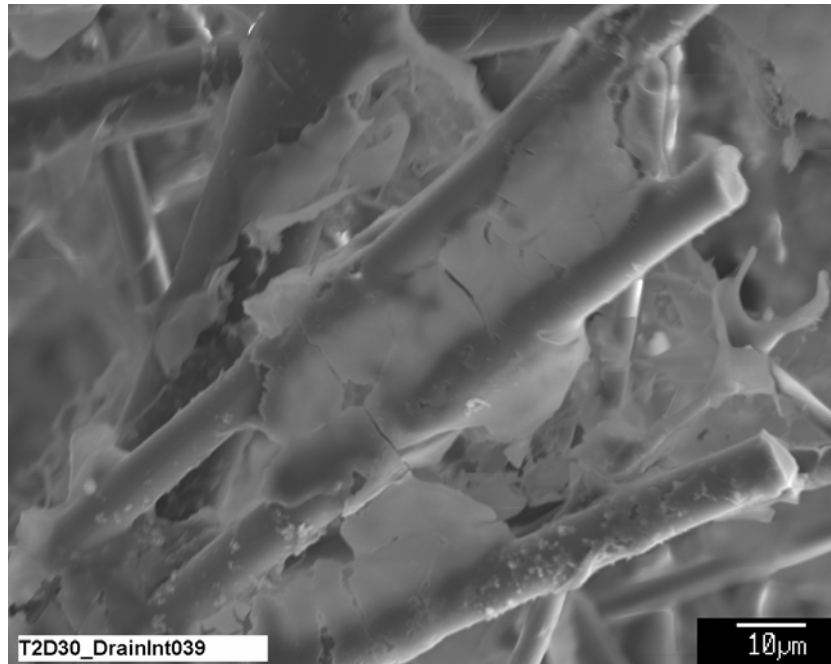


Figure D3-15. SEM image of a higher magnification for a Test #2, Day-30 interior fiberglass sample on the drain collar. The image shows deposits or growth on fiberglass. (T2D30\_DrainInt039)

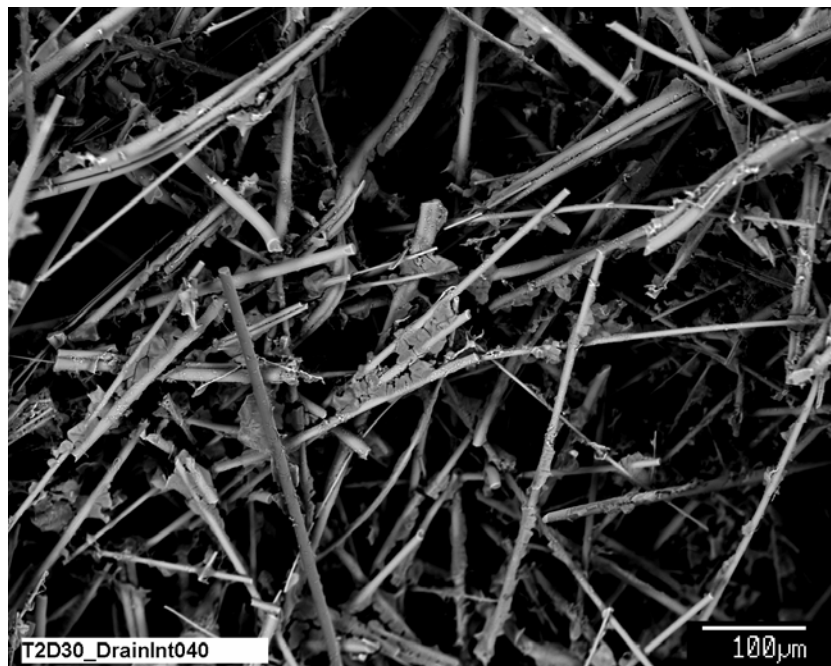
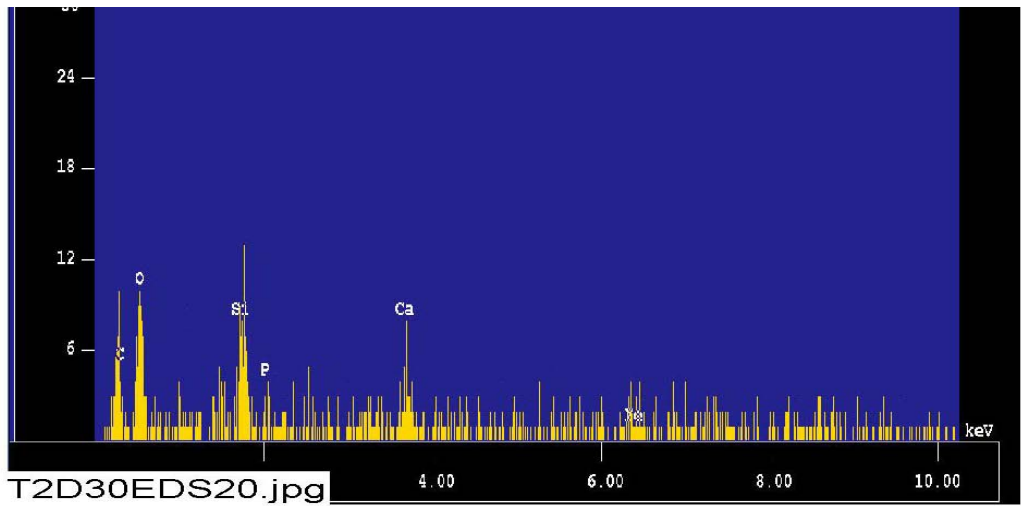


Figure D3-16. Backscattered SEM image for a Test #2, Day-30 interior fiberglass sample on the drain collar. Deposits appear to have a similar or lower atomic number as compared with fiberglass. (T2D30\_DrainInt040)



**Figure D3-17. EDS counting spectrum for the deposits or growth on fiberglass. The deposits are rich in silicon, carbon, oxygen, and calcium. The deposits are very thin, and thus it was difficult to obtain high-quality EDS spectra. (T2D30EDS20)**

The results from the chemical composition analysis for T2D30EDS20 are given in Table D3-4.

**Table D3-4. The Chemical Composition for T2D30EDS20 (Figure D3-17)**

Mar 9 17:16 2005 /tmp/eds\_pout.log Page 1

```

Group       : NRC
Sample      : T2D30 ID# : 20
Comment     : particles on fiberglass
Condition   : Full Scale : 20KeV(10eV/ch,2Kch)
              Live Time  : 120.000 sec   Aperture #   : 1
              Acc. Volt  : 15.0 KV       Probe Current  : 1.375E-09 A
              Stage Point : X=68.013 Y=68.140 Z=10.627
              Acq. Date   : Wed Mar 9 17:14:10 2005
    
```

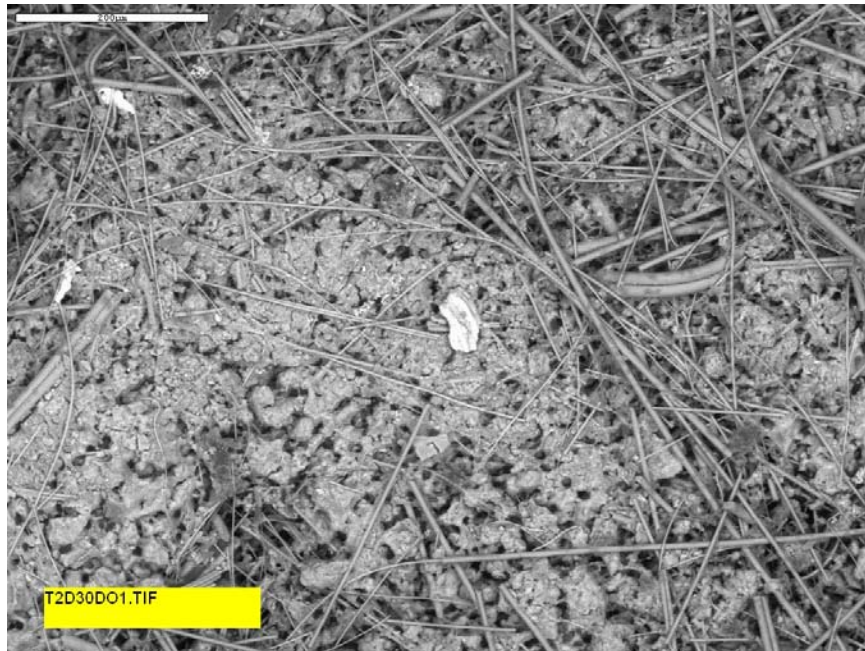
Element	Mode	ROI (KeV)	K-ratio(%)	+/-	Net/Background	
C K	Normal	0.09- 0.46	0.0420	0.0001	40 /	2
O K	Normal	0.25- 0.77	0.1425	0.0005	92 /	3
Si K	Normal	1.50- 2.07	0.0292	0.0002	89 /	2
Ca K	Normal	3.40- 4.30	0.0225	0.0013	36 /	1

-----  
 Chi\_square = 0.7730

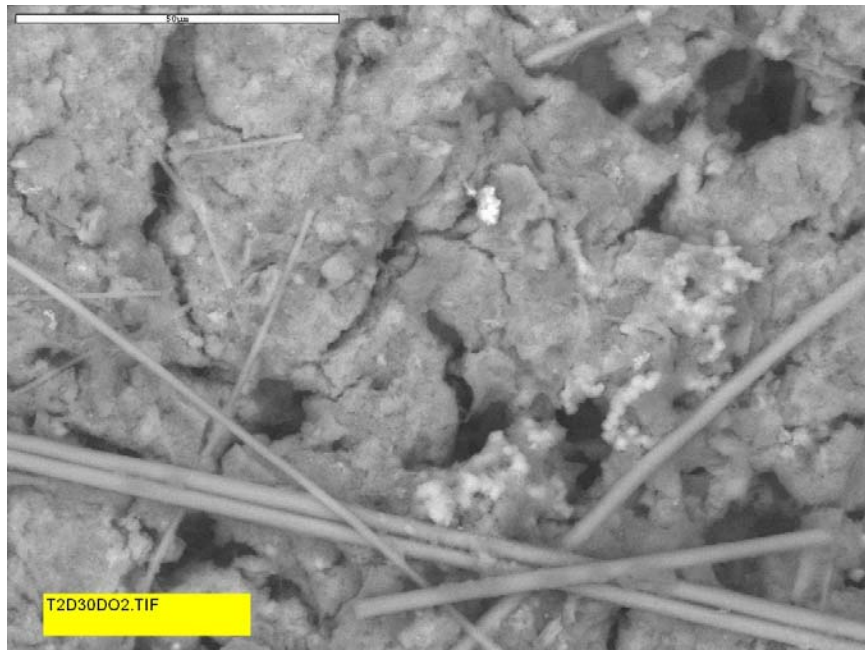
Element	Mass%	Atomic%	ZAF	Z	A	F
C	30.132	39.0987	2.5156	1.0305	2.4412	0.9999
O	55.239	53.8107	1.3590	0.9832	1.3822	1.0000
Si	8.443	4.6849	1.0136	0.9850	1.0293	0.9998
Ca	6.187	2.4058	0.9650	1.0007	0.9642	1.0001

-----  
 Total 100.000 100.0000  
 Normalization factor = 285.2892





**Figure D3-18. ESEM image for a Test #2, Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass. (T2D30DO1)**

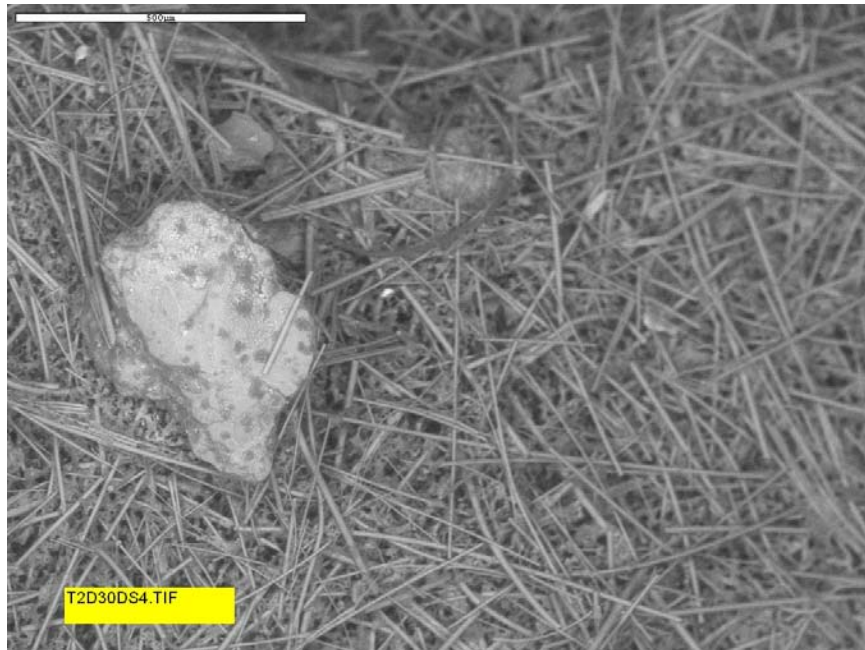


**Figure D3-19. ESEM image of a higher magnification for a Test #2, Day-30 exterior fiberglass sample on the drain collar. The image shows particulate deposits or growth on fiberglass. (T2D30DO2)**

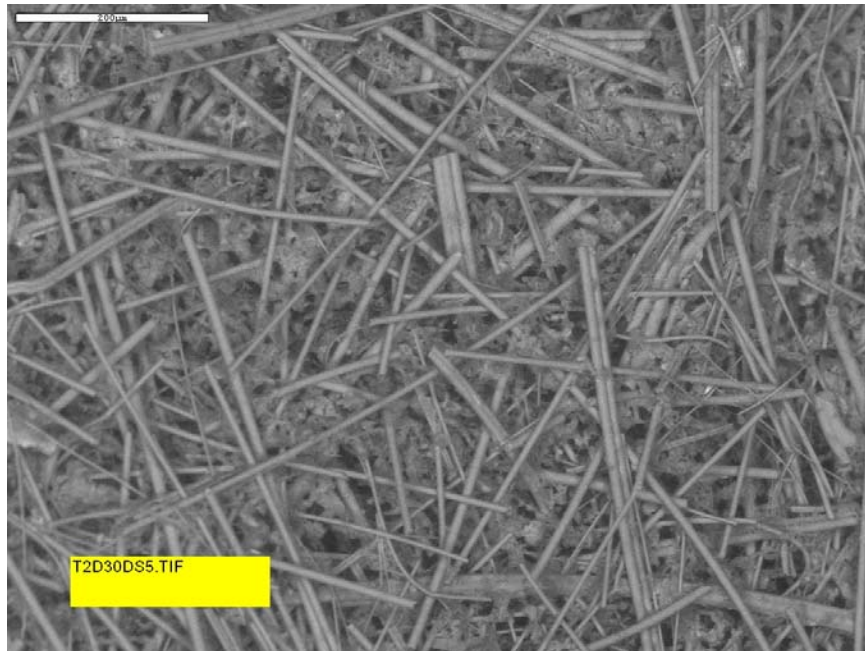




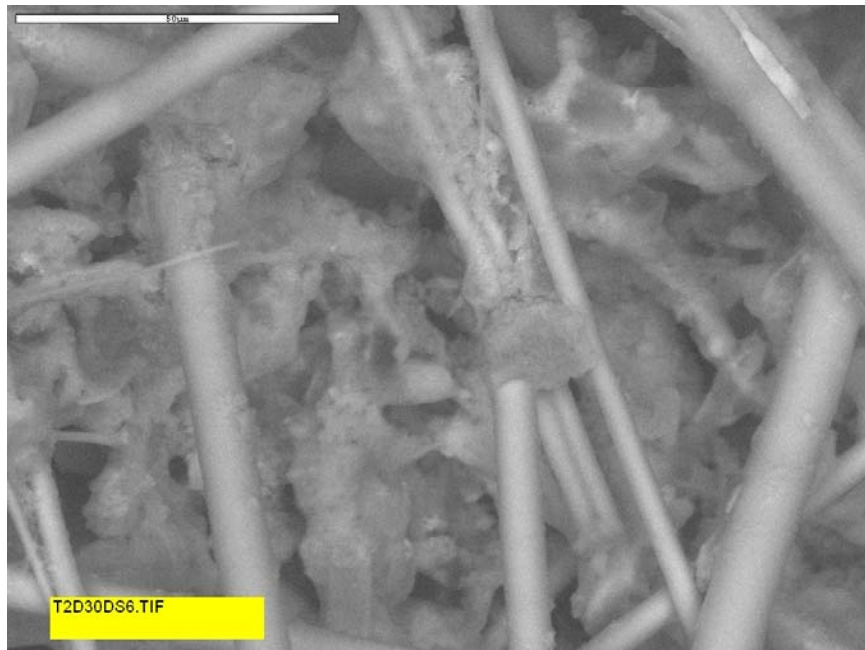
**Figure D3-20. ESEM image for a Test #2, Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass. (T2D30DO3)**



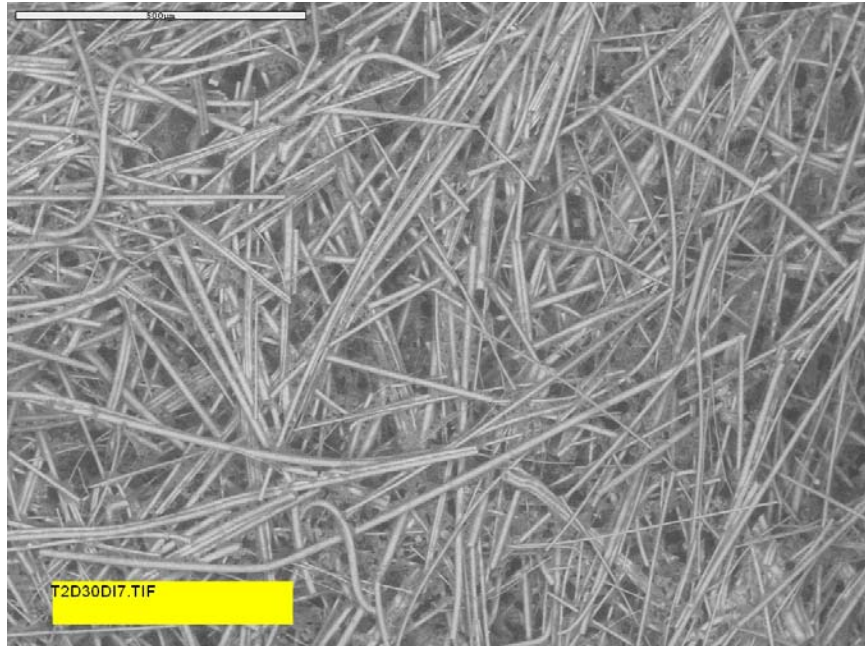
**Figure D3-21. ESEM image for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30DS4)**



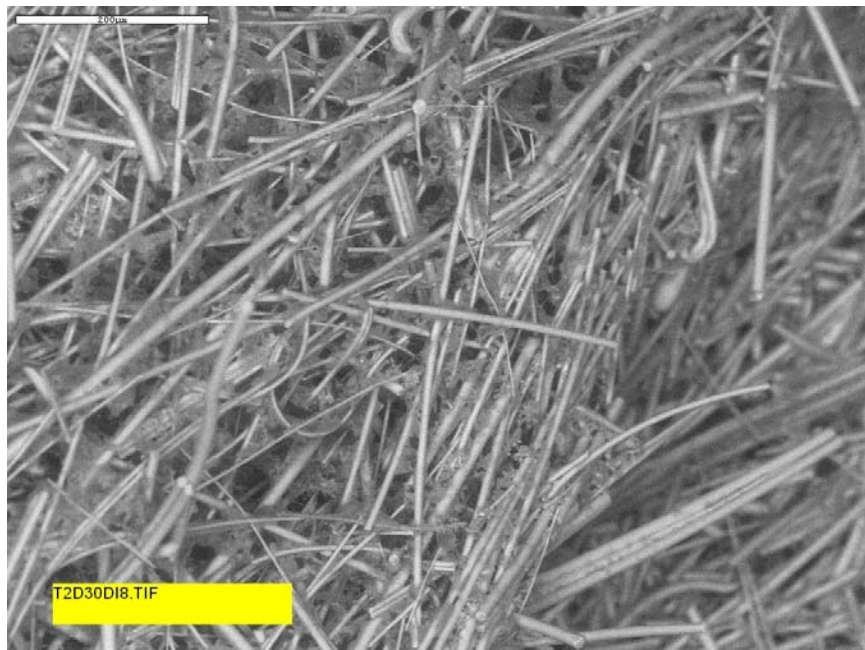
**Figure D3-22. ESEM image for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30DS5)**



**Figure D3-23. ESEM image of a higher magnification for a Test #2, Day-30 fiberglass sample on the drain collar next to the drain screen. (T2D30DS6)**

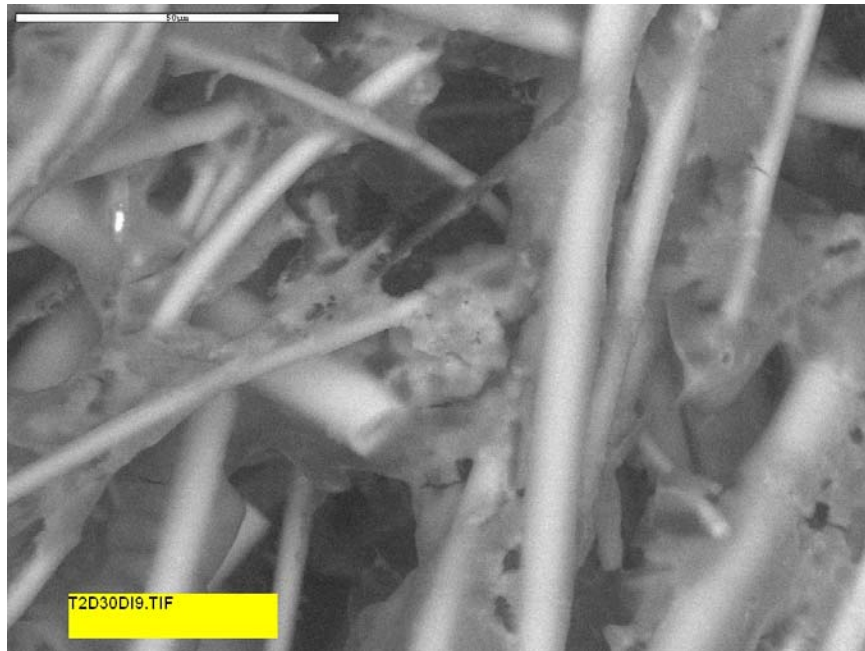


**Figure D3-24. ESEM image for a Test #2, Day-30 interior fiberglass sample on the drain collar. Image suggests that interior fiberglass was relatively clean as compared with exterior. (T2D30DI7)**



**Figure D3-25. ESEM image for a Test #2, Day-30 interior fiberglass sample on the drain collar. (T2D30DI8)**





**Figure D3-26. ESEM image of a higher magnification for a Test #2, Day-30 interior fiberglass sample on the drain collar. The image shows deposits or growth on the interior fiberglass, although the quantity was less than for exterior samples. (T2D30DI9)**