Appendix D3

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

List of Figures

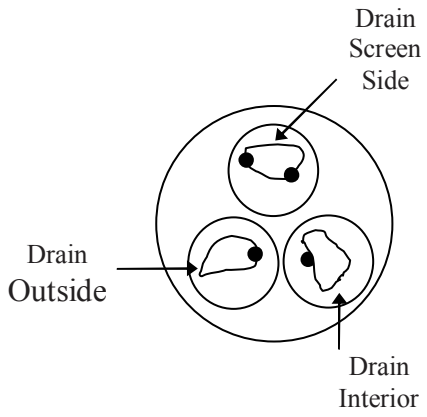
List of Tables

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 loss of coolant accident. 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 via ESEM and SEM/EDS the fiberglass samples recovered from the drain collar 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, environmental SEM (ESEM) was employed 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.

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

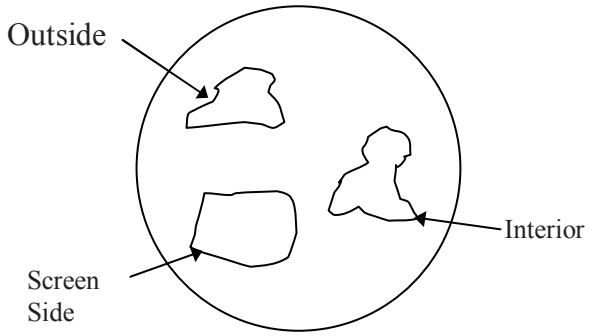
Note: *Very difficult to get EDS spectrum of particles. The particles are very thin and react under the beam. EDS18 and EDS19 are simply replicates at slightly different sample locations.

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 ×	1st area	Figure D3-24
	T2D30DI8	150 ×	Different area	Figure D3-25
	T2D30DI9	1000 ×	Same as above	Figure D3-26

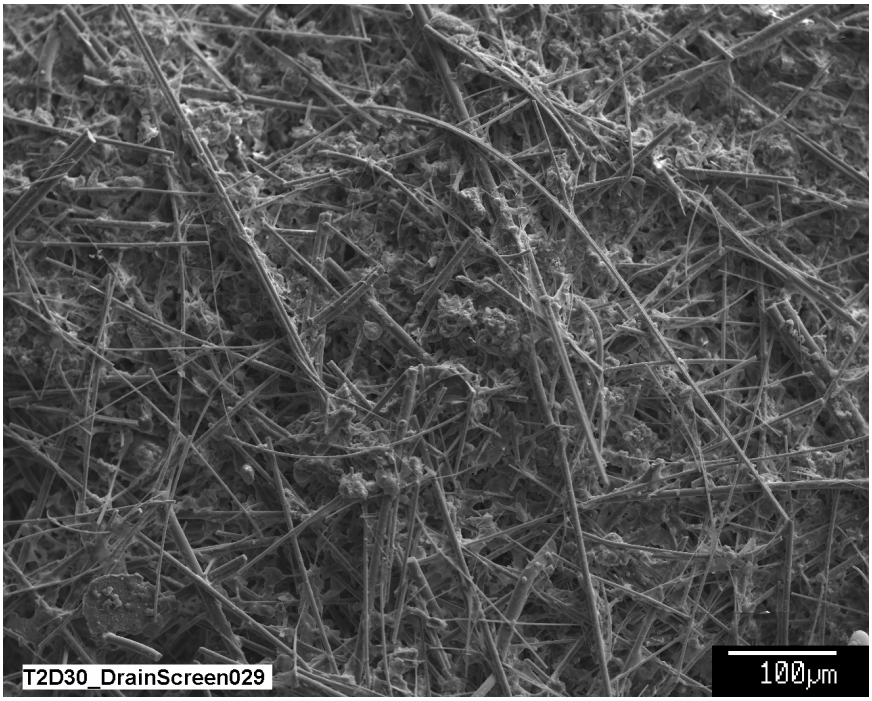


Figure D3-1. SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen029).

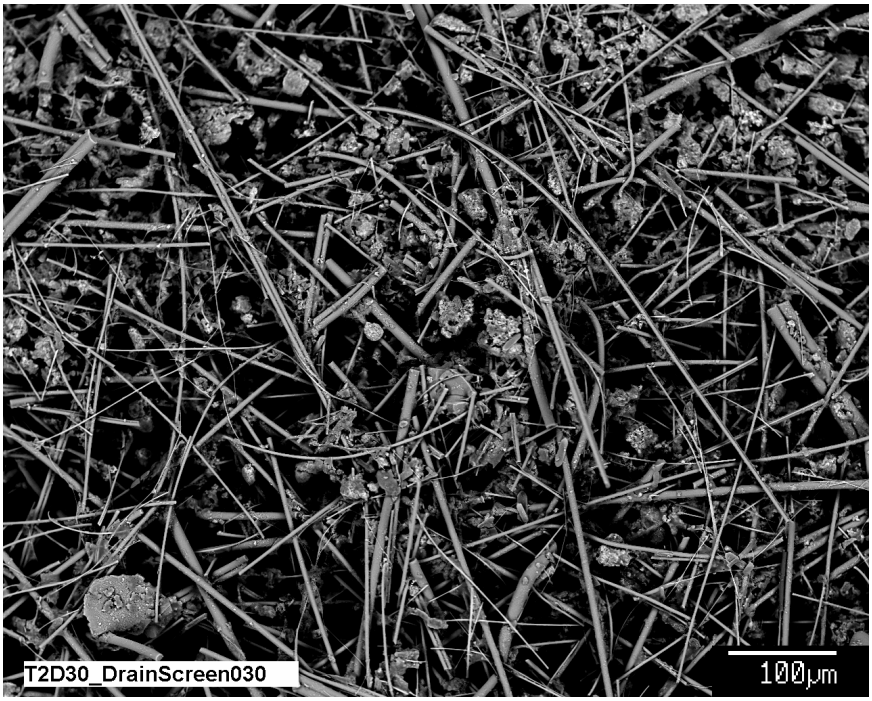


Figure D3-2. Backscattered SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen, illustrating that deposits have a similar atomic number to fiberglass (T2D30_DrainScreen030).

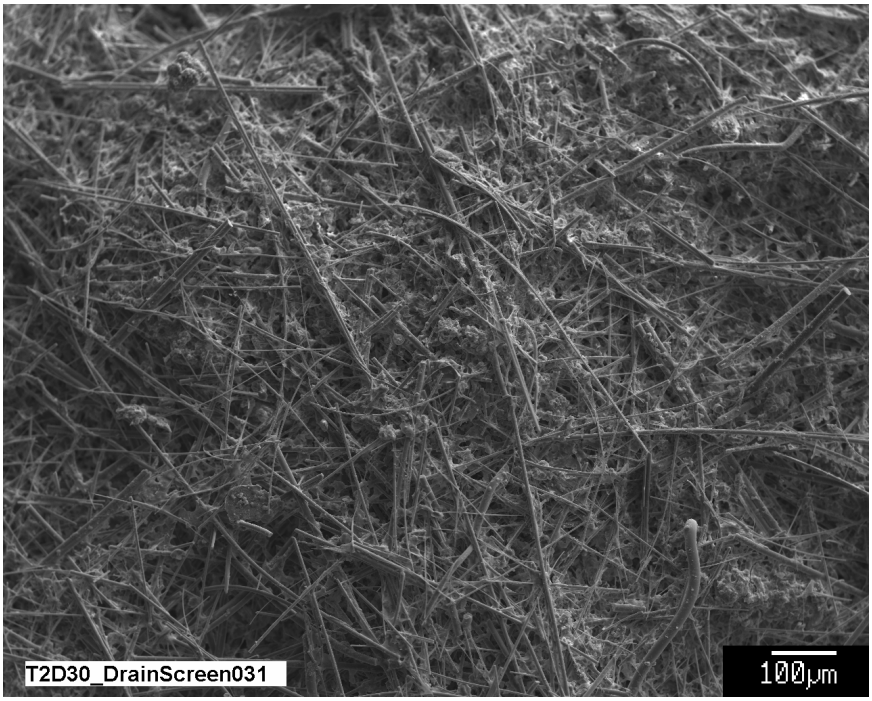


Figure D3-3. SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen031).

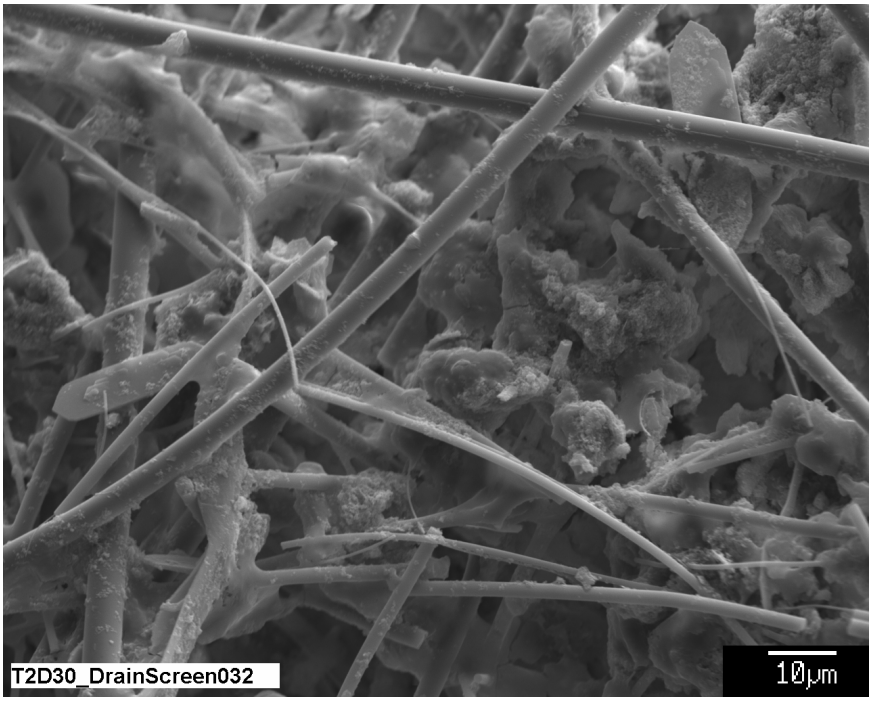


Figure D3-4. SEM image at 1000× magnification for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen032).

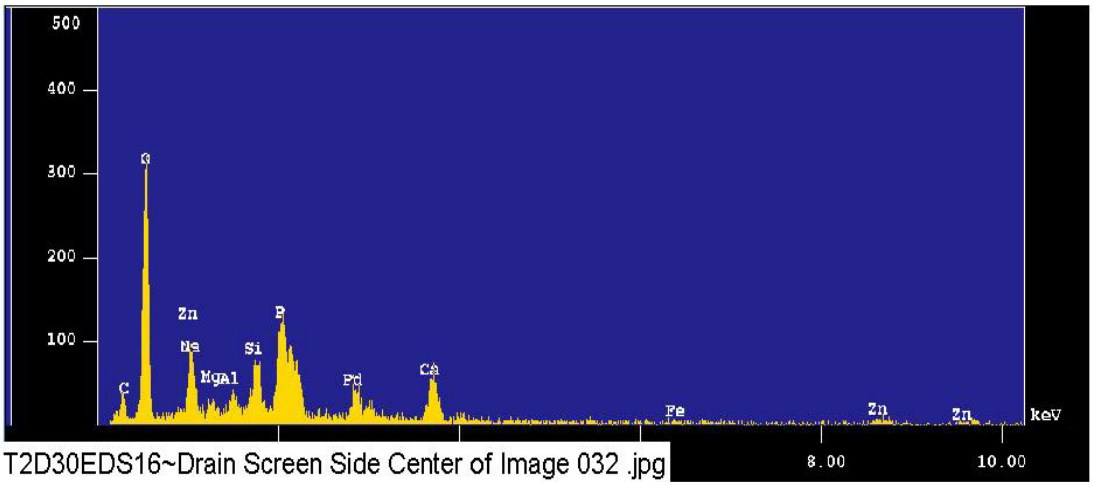


Figure D3-5. EDS counting spectrum for the center of the image shown in Figure D3-4 (T2D30EDS16~Drain Screen Side Center of Image 032).

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 Si, O, Al, Na, and Ca (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
```

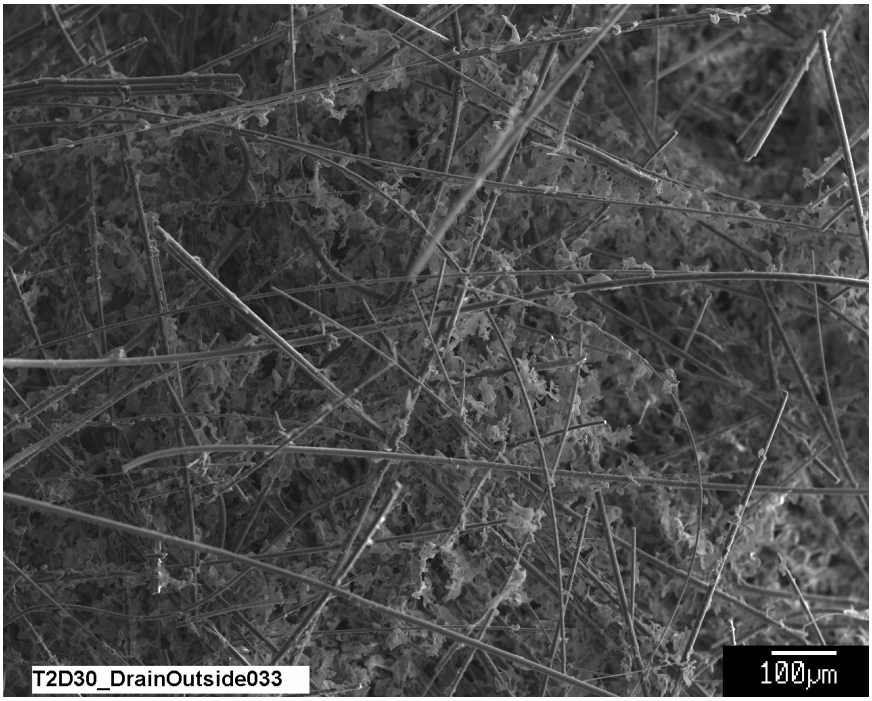


Figure D3-7. SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar (away from the drain screen) showing deposits or growth on fiberglass (T2D30_DrainOutside033).

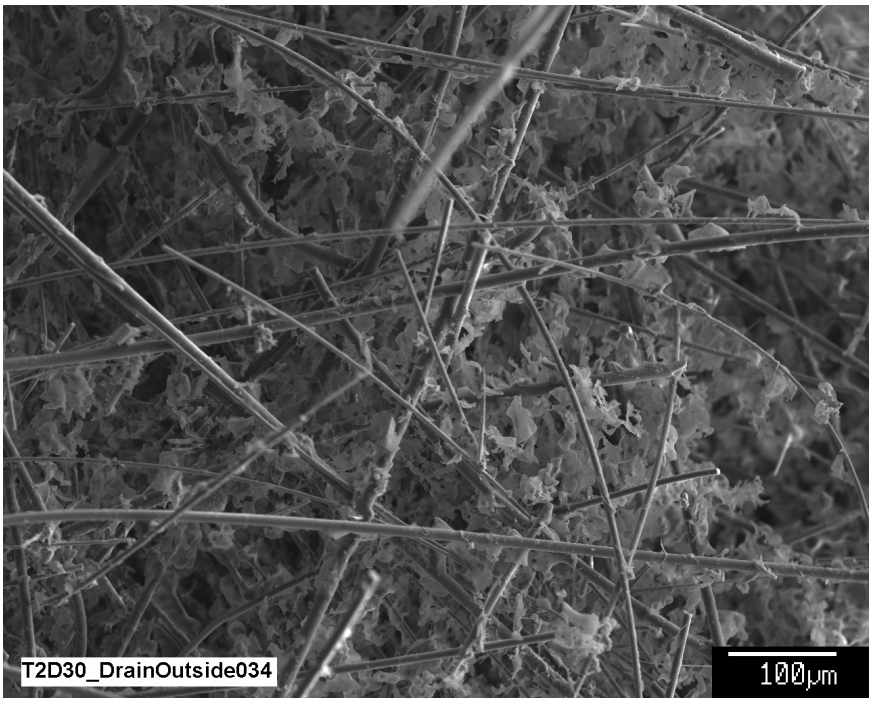


Figure D3-8. SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass (T2D30_DrainOutside034).

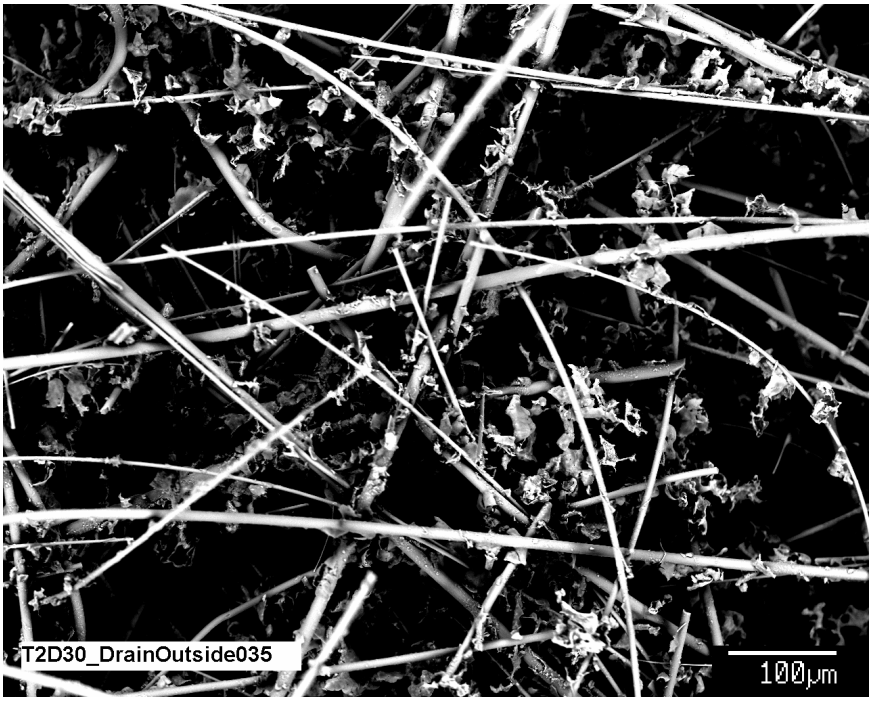


Figure D3-9. Backscattered SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar (T2D30_DrainOutside035).

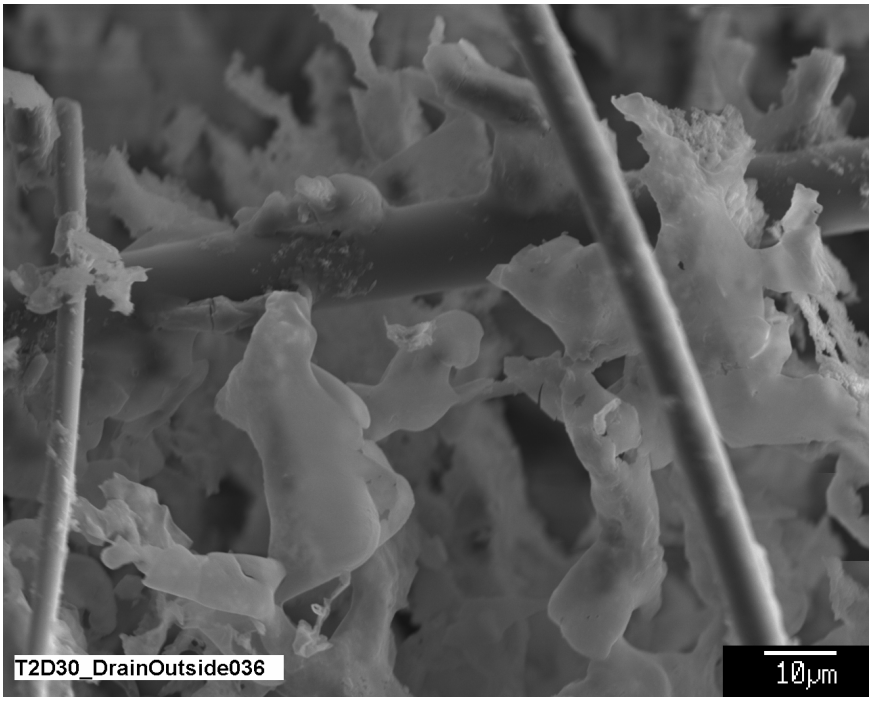


Figure D3-10. SEM image at a higher magnification for a Test-2 Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass (T2D30_DrainOutside036).

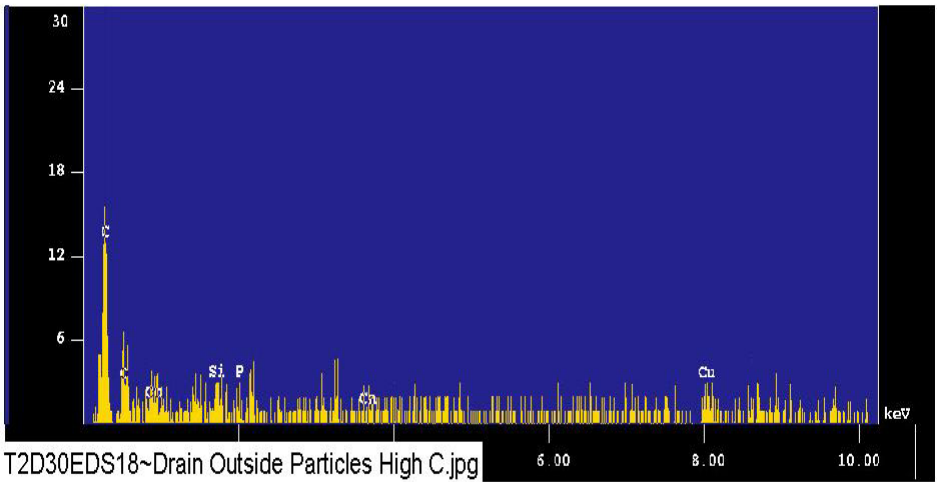


Figure D3-11. EDS counting spectrum for deposits or growth on fiberglass. The deposits contain a significant amount of C (T2D30EDS18~Drain Outside Particles High C).

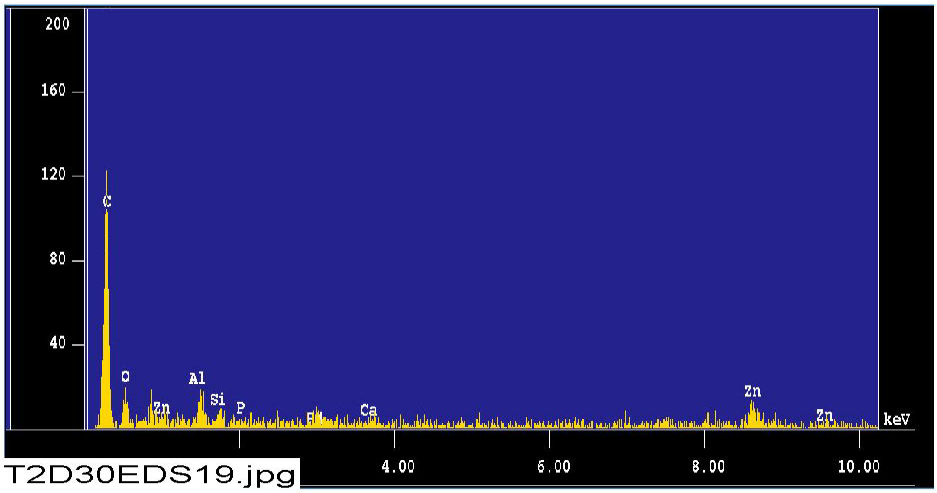


Figure D3-12. EDS counting spectrum for a deposit or growth on fiberglass. The deposit contains a significant amount of C (T2D30EDS19).

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).

```
Mar  9 16:58 2005  /tmp/eds_pout.log Page 1


 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
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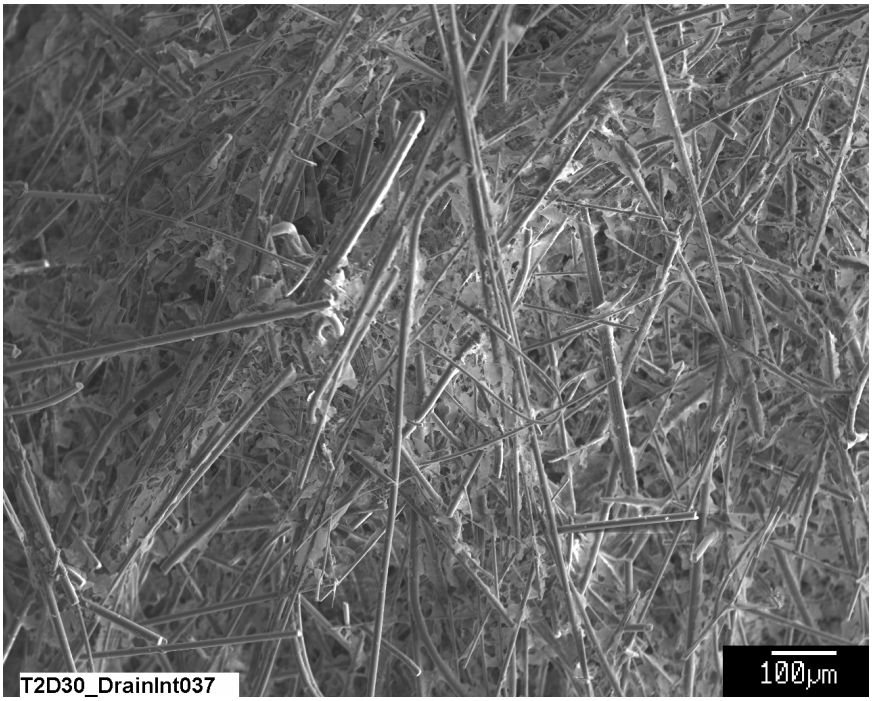

Figure D3-13. SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt037).

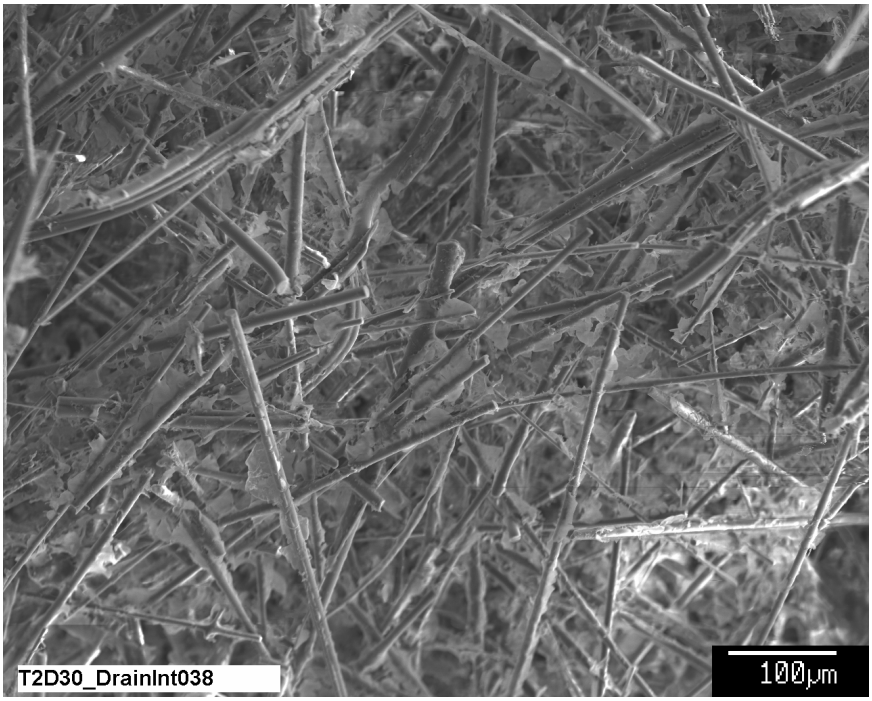

Figure D3-14. SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt038).

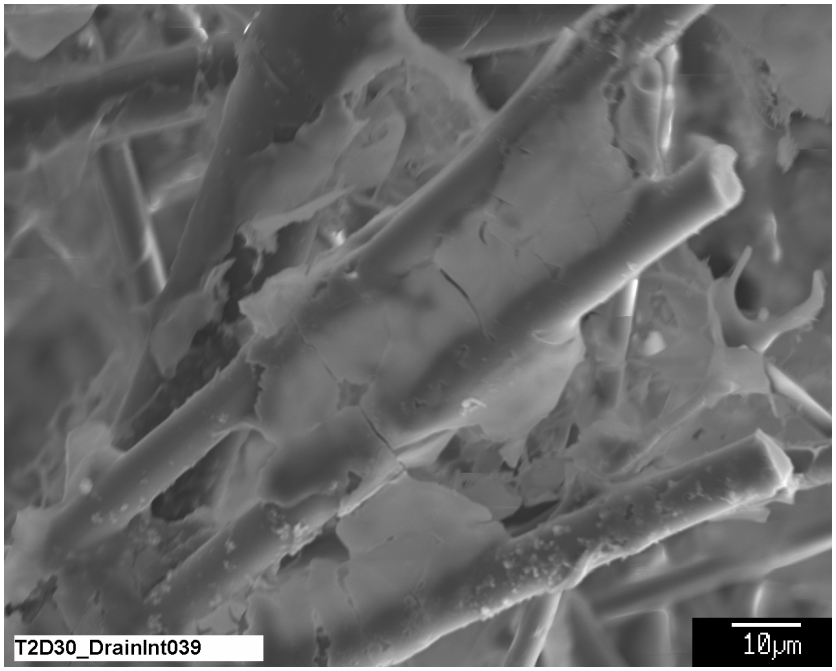

Figure D3-15. SEM image of a higher magnification for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt039).

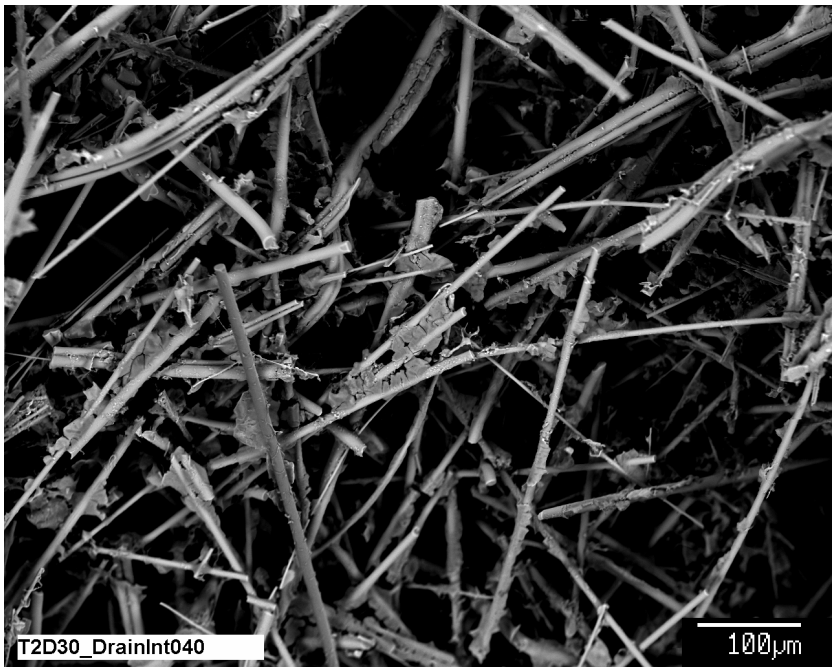

Figure D3-16. Backscattered SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Deposits appear to have a similar or lower atomic number than fiberglass (T2D30_DrainInt040).

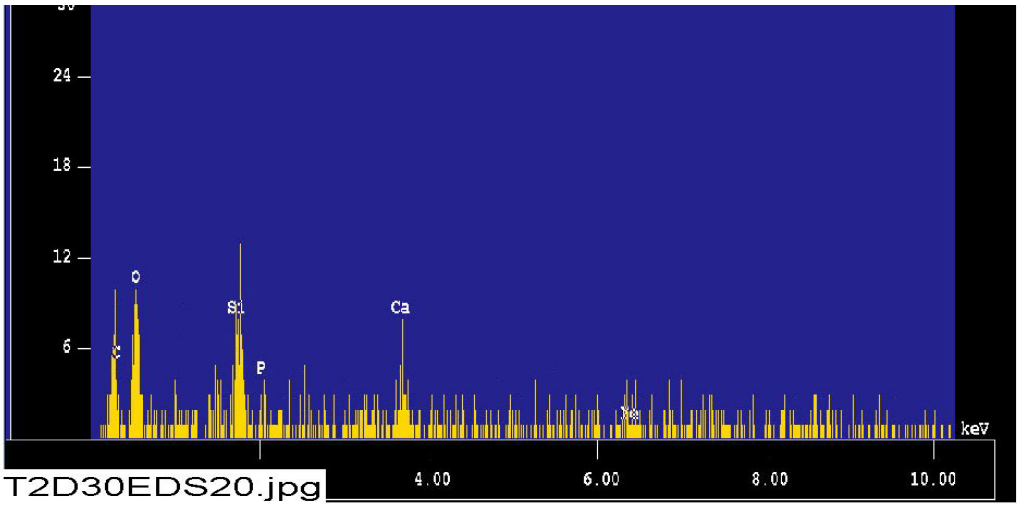

Figure D3-17. EDS counting spectrum for the deposits or growth on fiberglass. The deposits are rich in Si, C, O, and Ca. The deposits are very thin, thus it was difficult to obtain high-quality EDS spectra (T2D30EDS20).

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
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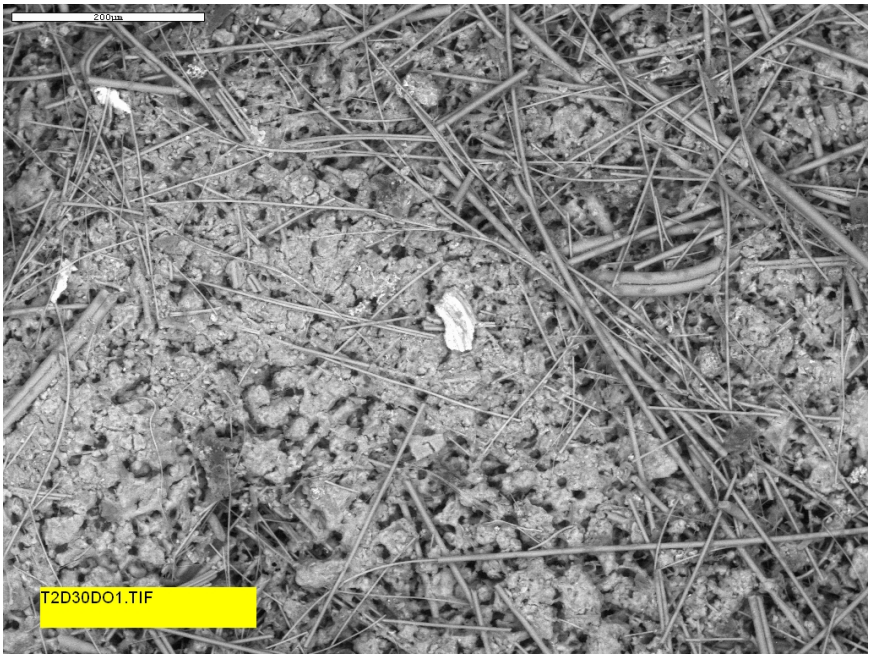

Figure D3-18. ESEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO1).

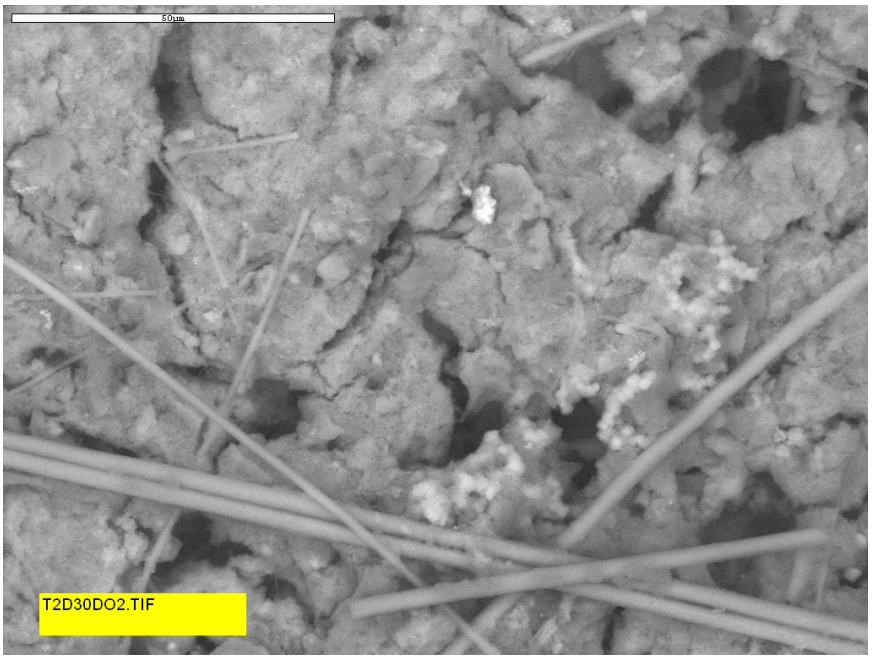

Figure D3-19. ESEM image of a higher magnification for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO2).

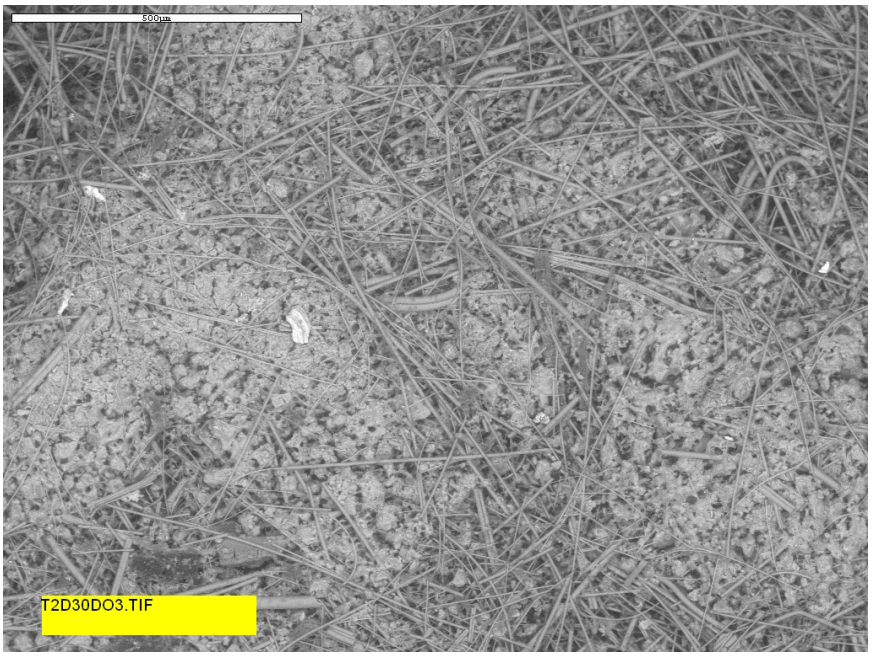

Figure D3-20. ESEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO3).

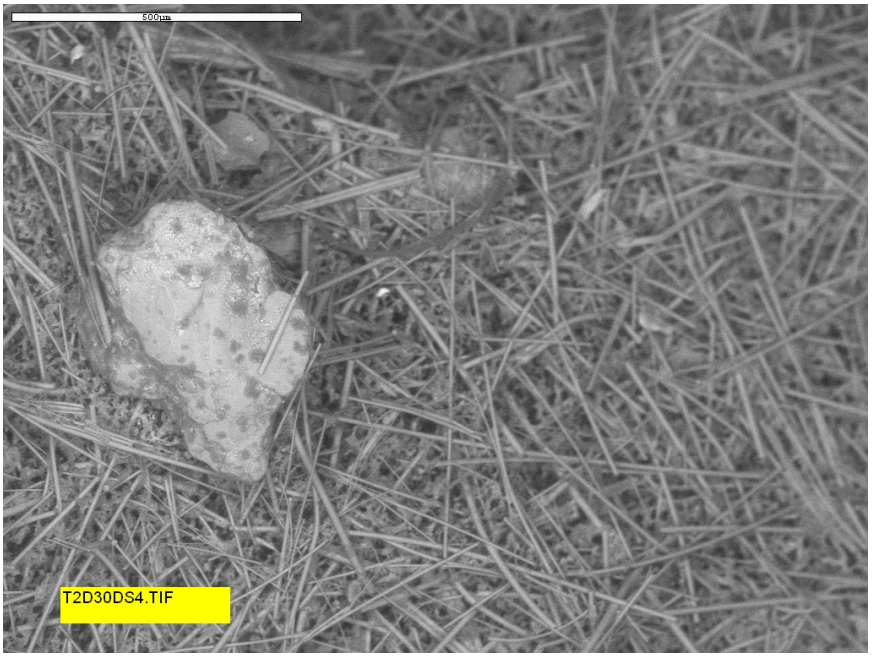

Figure D3-21. ESEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS4).

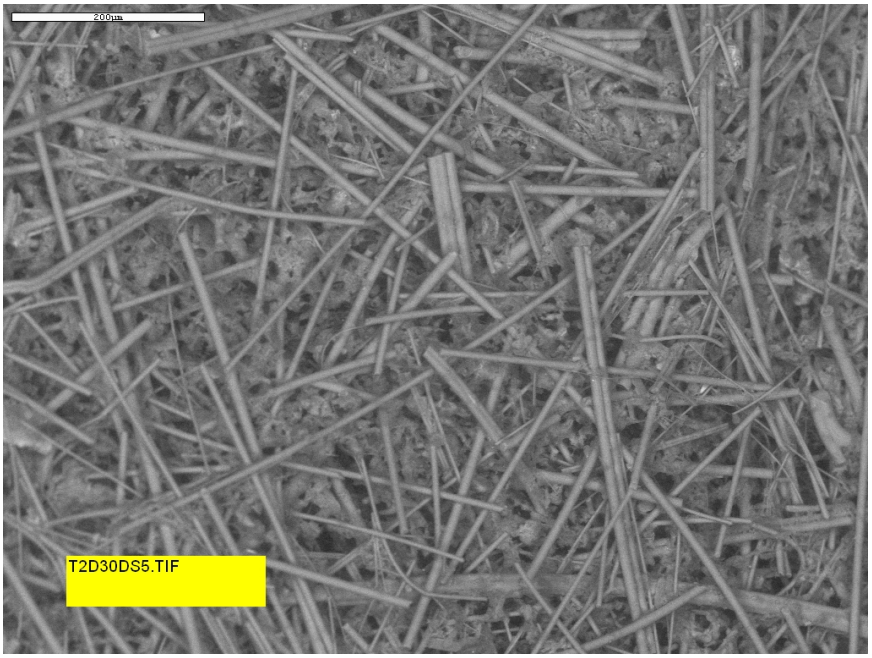

Figure D3-22. ESEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS5).

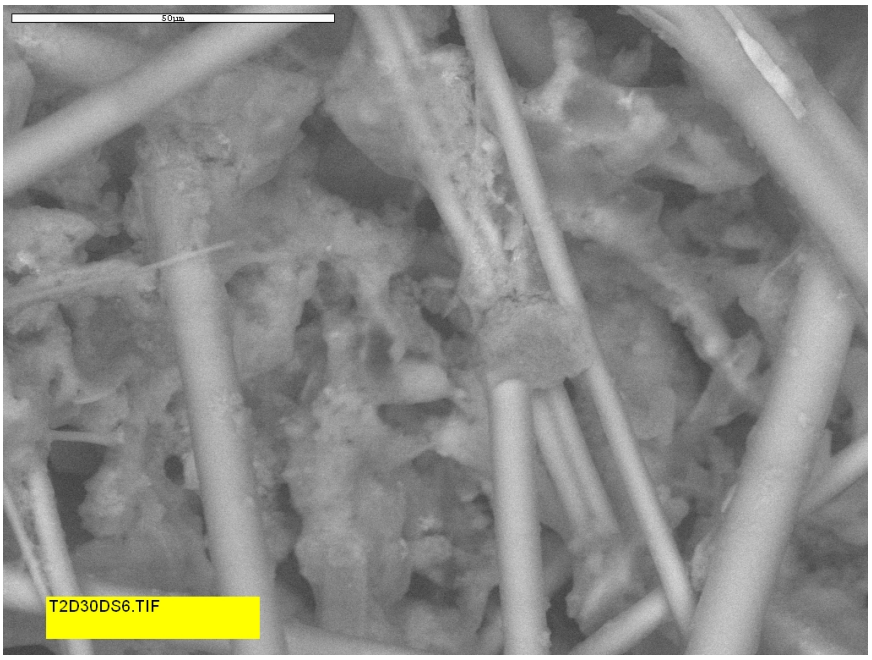

Figure D3-23. ESEM image of a higher magnification for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS6).

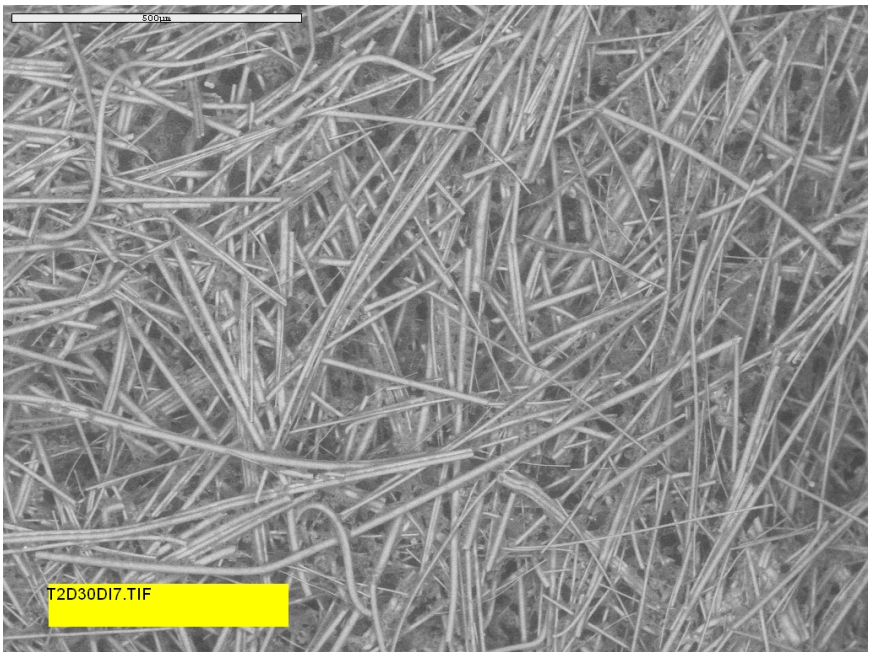

Figure D3-24. ESEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image suggests that interior fiberglass was relatively clean compared to exterior (T2D30DI7).

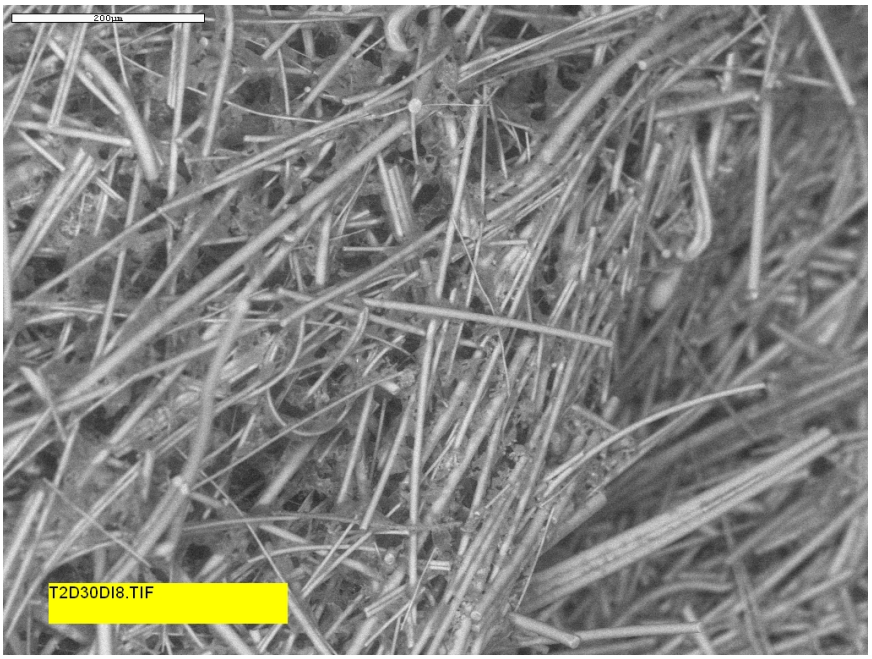

Figure D3-25. ESEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar (T2D30DI8).

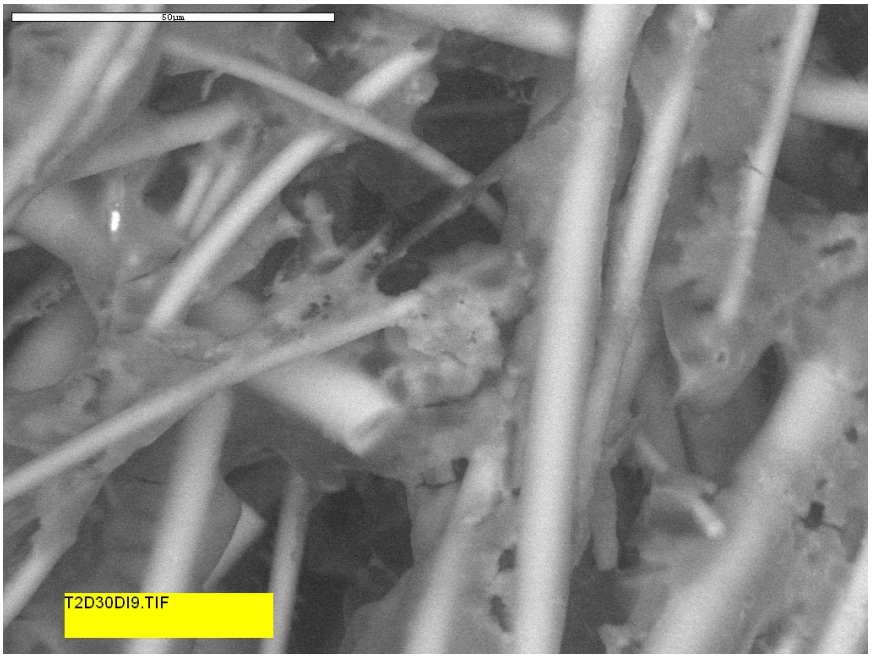

Figure D3-26. ESEM image of a higher magnification for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on the interior fiberglass, although the quantity was less than for exterior samples (T2D30DI9).

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