

Appendix D3

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

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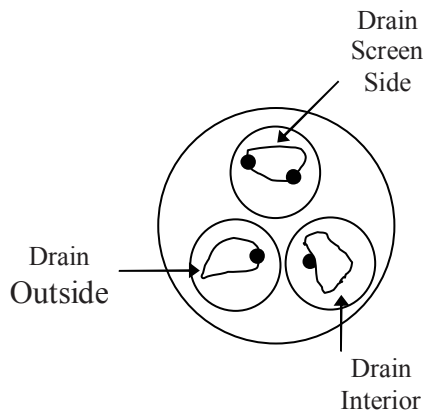
Chemical deposits accumulated on fiberglass during ICET testing are of great interest because they may cause additional head loss during recirculation of the coolant following a loss of coolant accident. The drain collar placed in the test tank represents an area of higher flow velocity where water continually 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.

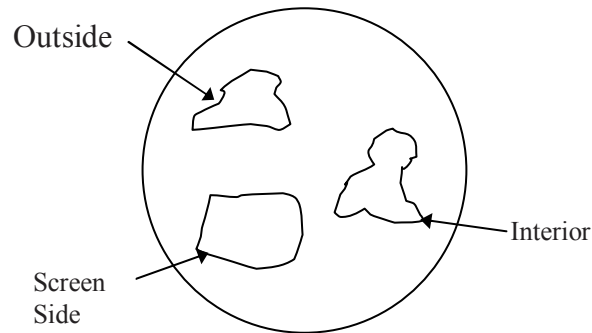
Sample: Drain Interior

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

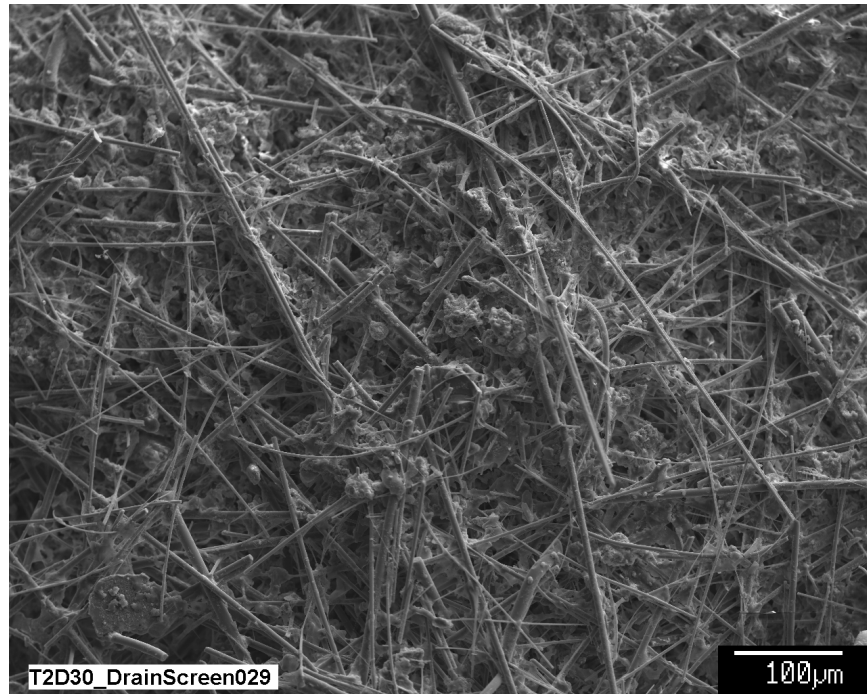


Figure D3-1. SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen029).

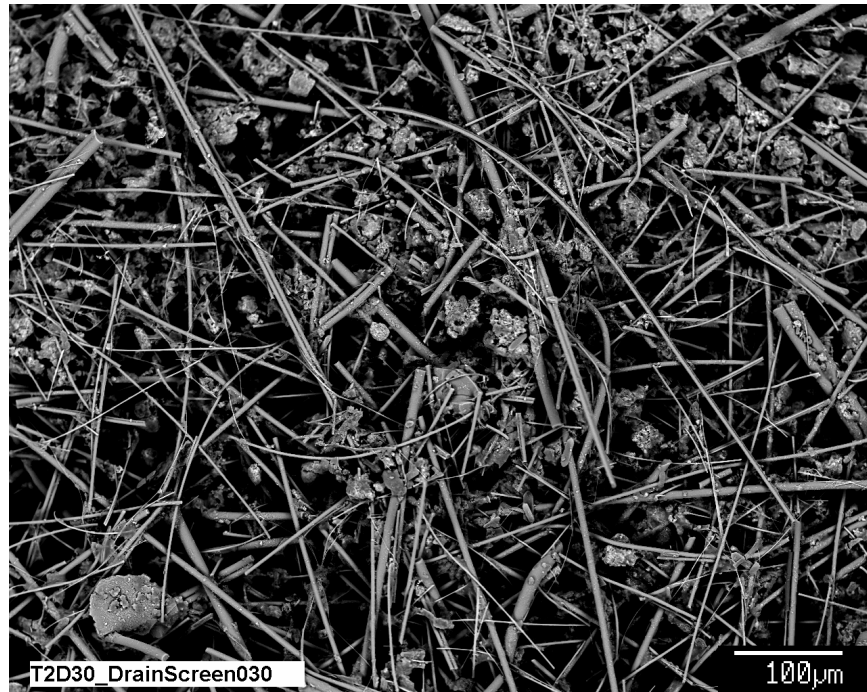


Figure D3-2. Backscattered SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen, illustrating that deposits have a similar atomic number to fiberglass (T2D30_DrainScreen030).

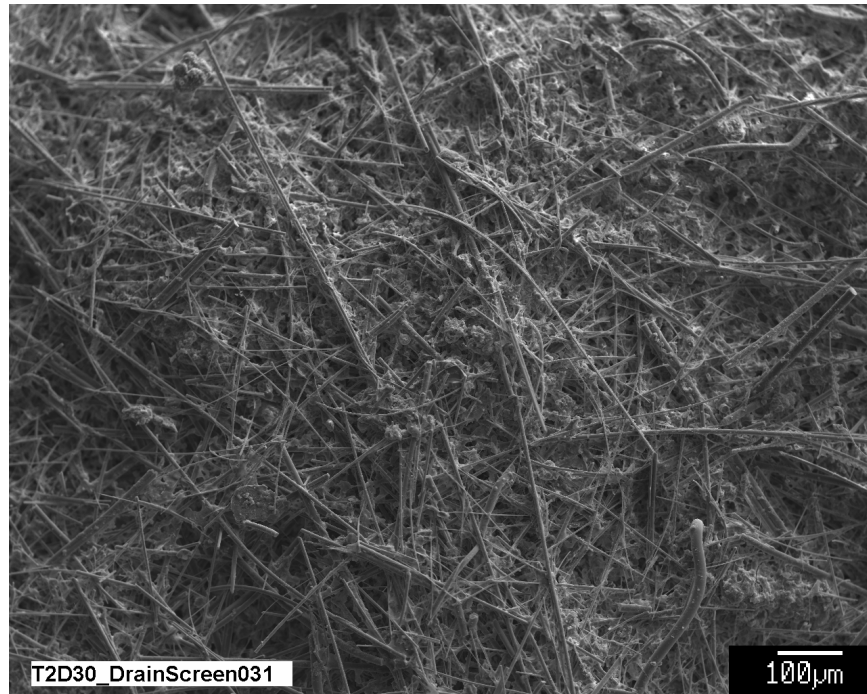


Figure D3-3. SEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen031).

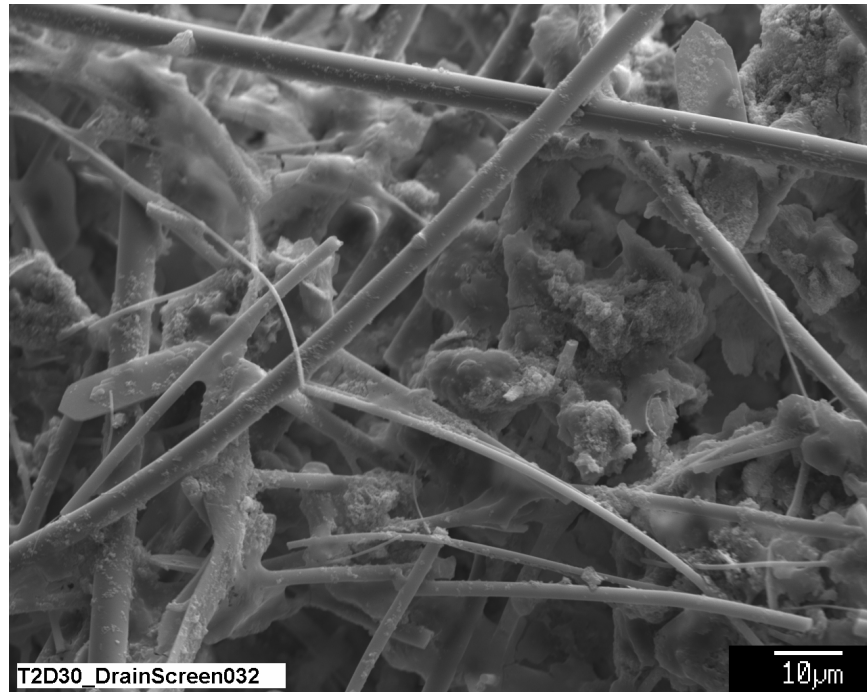


Figure D3-4. SEM image at 1000× magnification for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30_DrainScreen032).

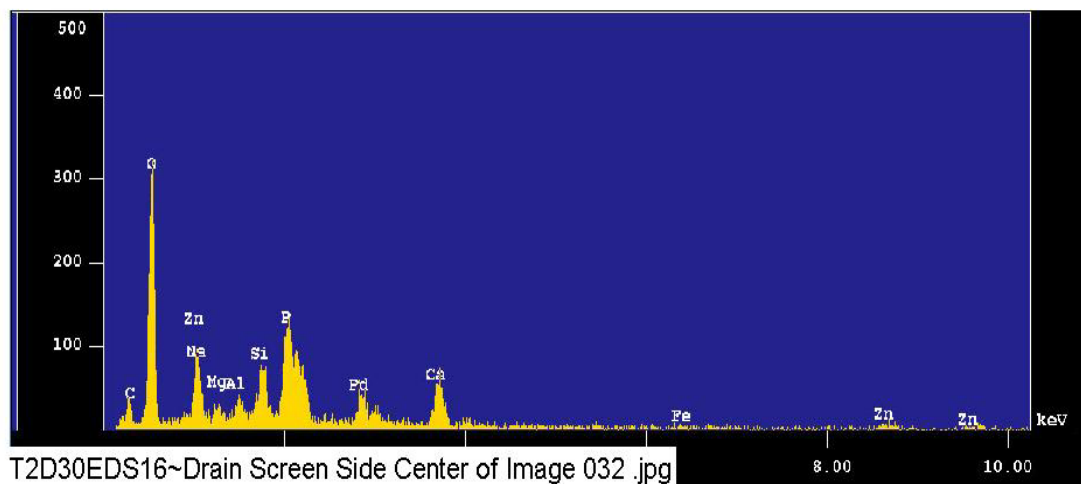


Figure D3-5. EDS counting spectrum for the center of the image shown in Figure D3-4 (T2D30EDS16~Drain Screen Side Center of Image 032).

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)

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```

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

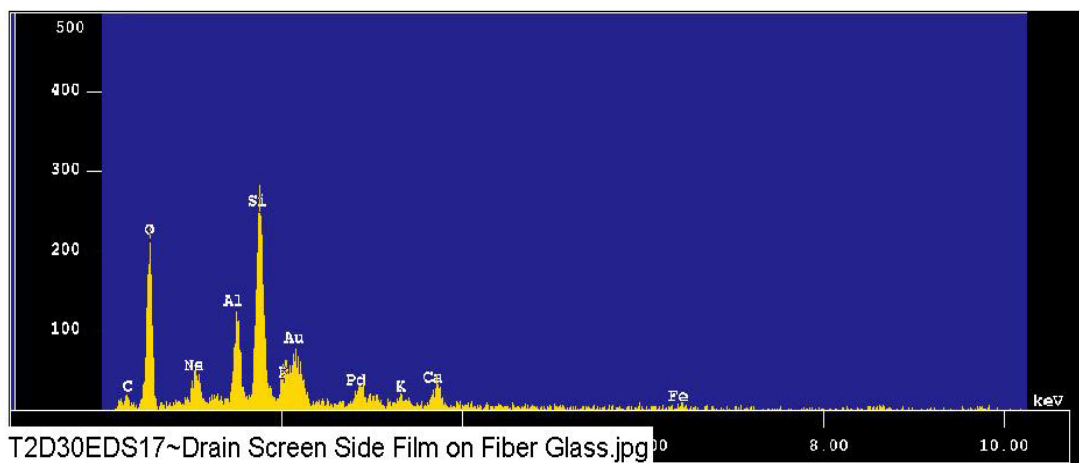


Figure D3-6. EDS counting spectrum for the film between fibers shown in Figure D3-4. The film is rich in Si, O, Al, Na, and Ca (T2D30EDS17~Drain Screen Side Film on Fiber Glass).

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)

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```

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

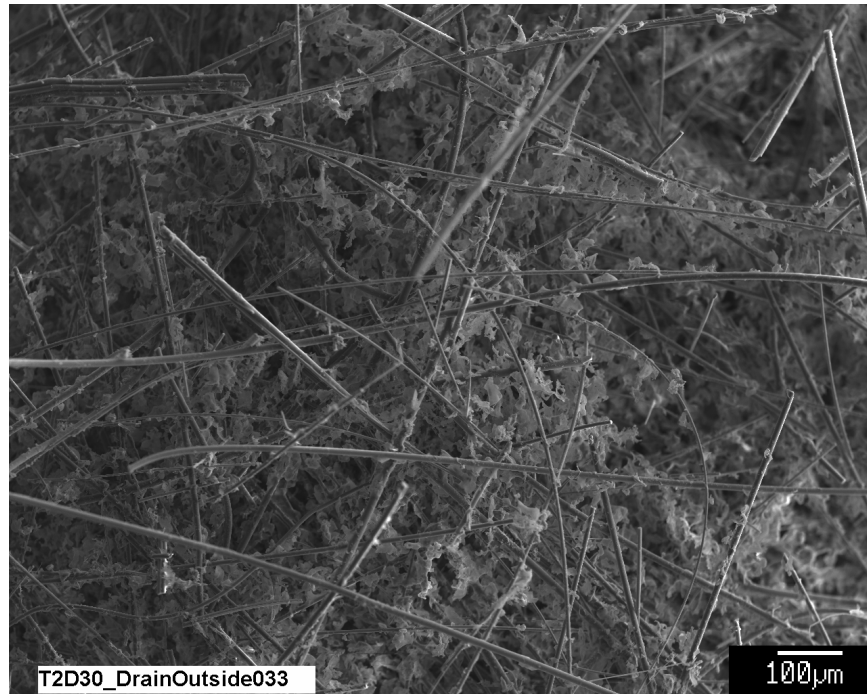


Figure D3-7. SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar (away from the drain screen) showing deposits or growth on fiberglass (T2D30_DrainOutside033).

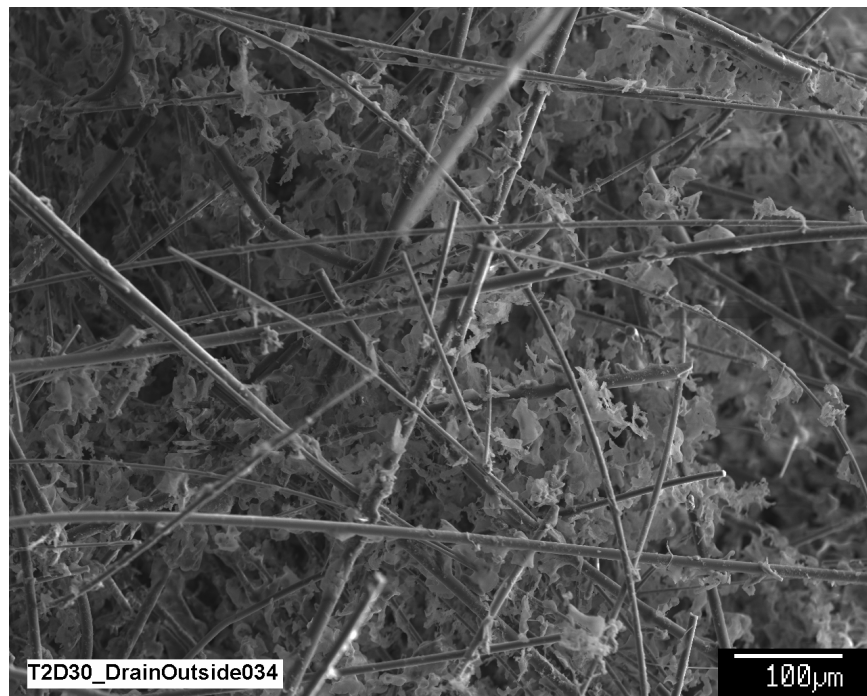


Figure D3-8. SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass (T2D30_DrainOutside034).

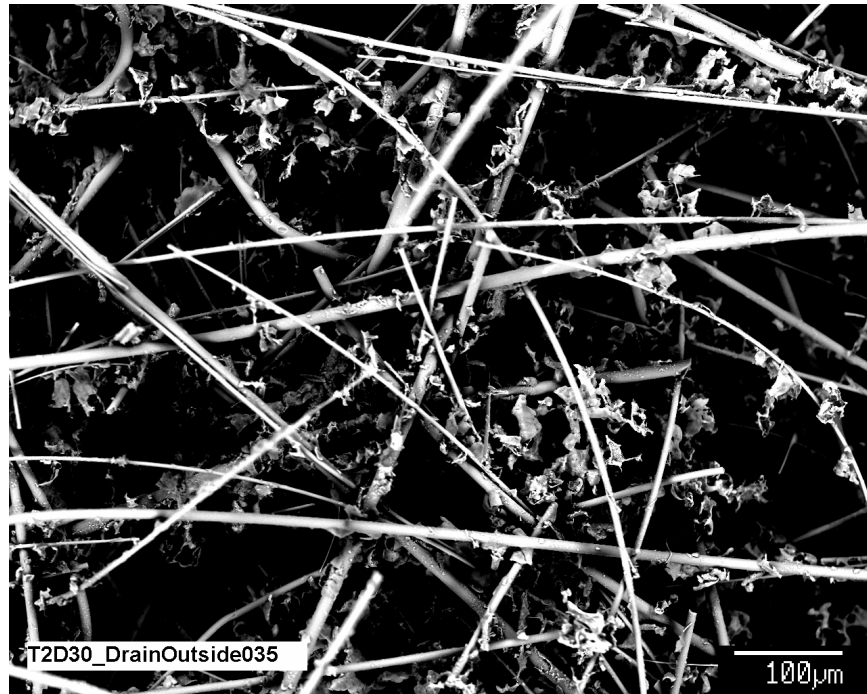


Figure D3-9. Backscattered SEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar (T2D30_DrainOutside035).

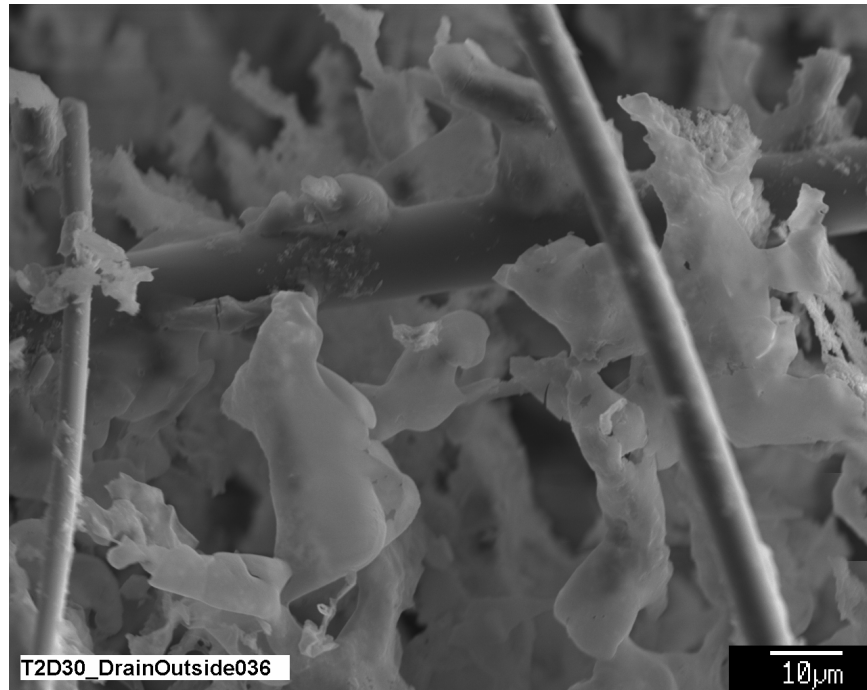


Figure D3-10. SEM image at a higher magnification for a Test-2 Day-30 exterior fiberglass sample on the drain collar showing deposits or growth on fiberglass (T2D30_DrainOutside036).

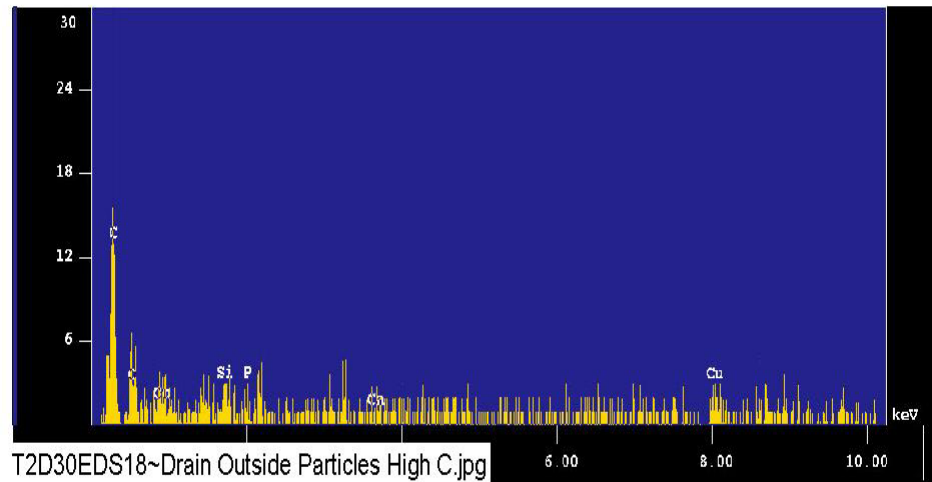


Figure D3-11. EDS counting spectrum for deposits or growth on fiberglass. The deposits contain a significant amount of C (T2D30EDS18~Drain Outside Particles High C).

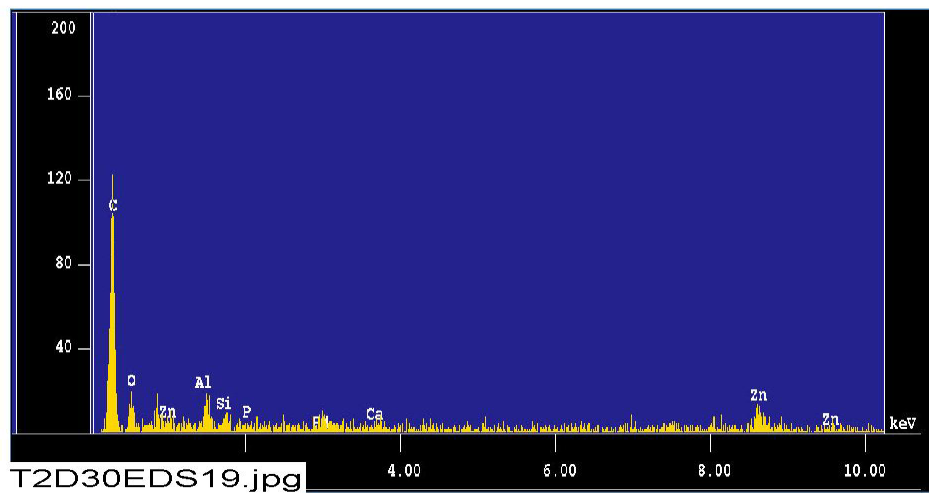


Figure D3-12. EDS counting spectrum for a deposit or growth on fiberglass. The deposit contains a significant amount of C (T2D30EDS19).

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).

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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

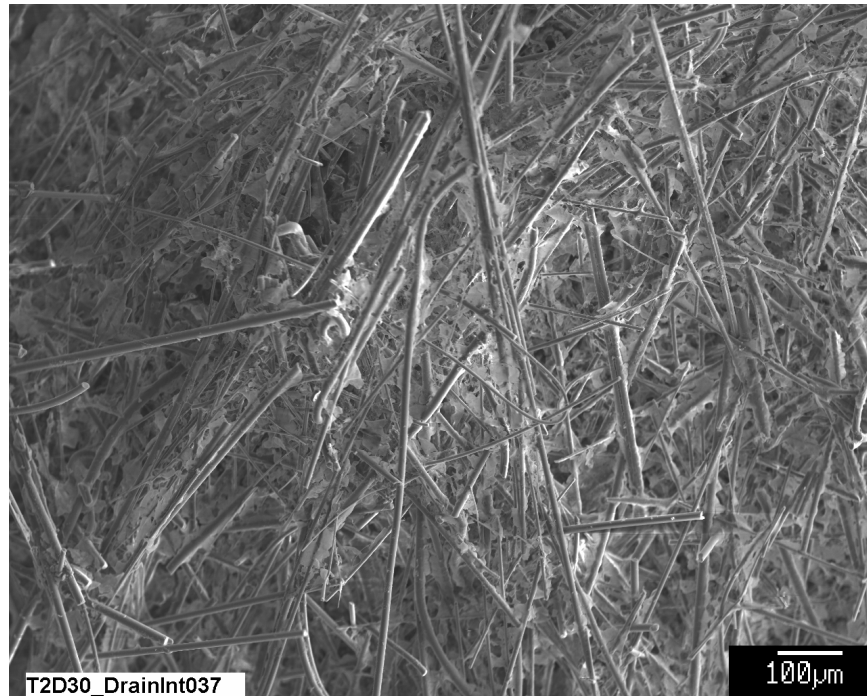


Figure D3-13. SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt037).

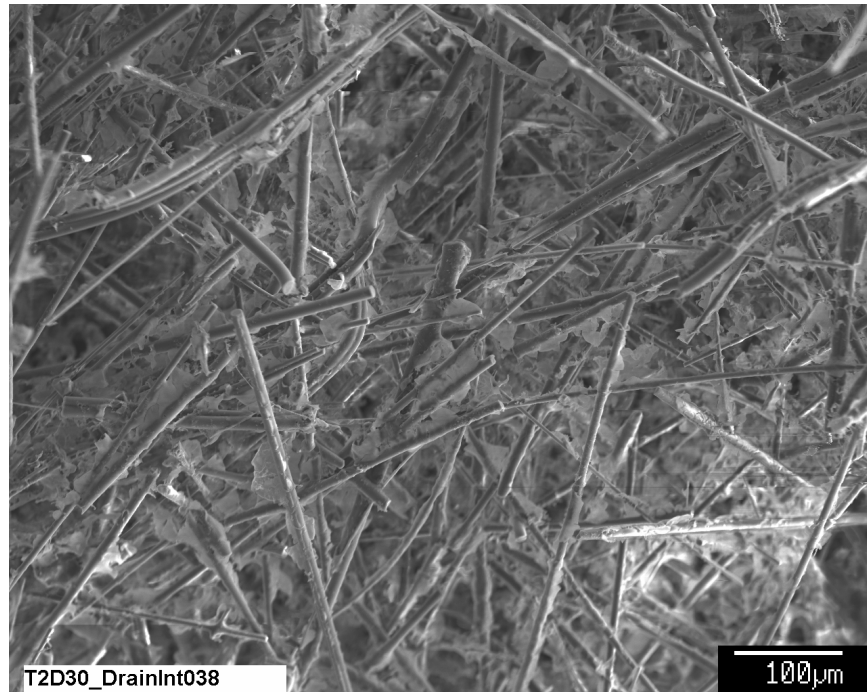


Figure D3-14. SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt038).

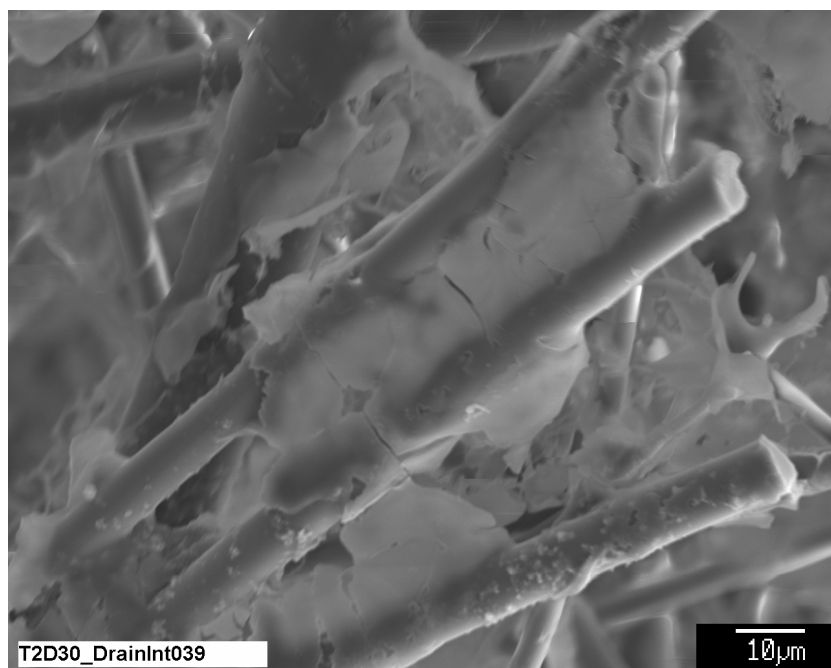


Figure D3-15. SEM image of a higher magnification for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on fiberglass (T2D30_DrainInt039).

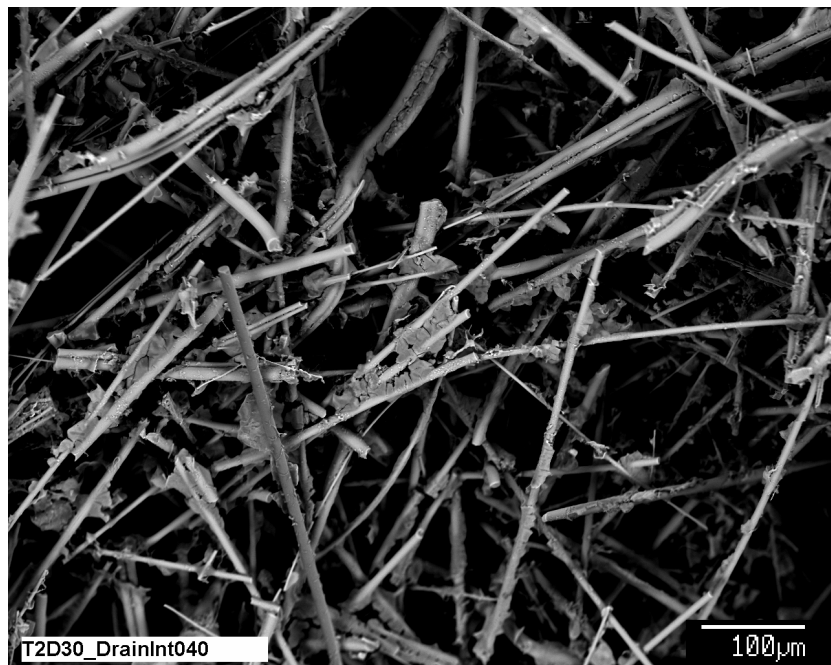


Figure D3-16. Backscattered SEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Deposits appear to have a similar or lower atomic number than fiberglass (T2D30_DrainInt040).

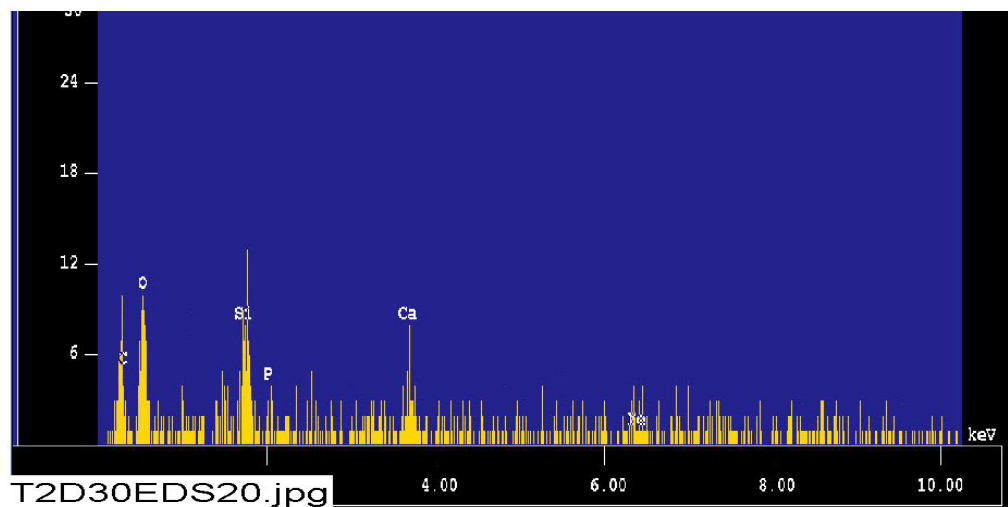


Figure D3-17. EDS counting spectrum for the deposits or growth on fiberglass. The deposits are rich in Si, C, O, and Ca. The deposits are very thin, thus it was difficult to obtain high-quality EDS spectra (T2D30EDS20).

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

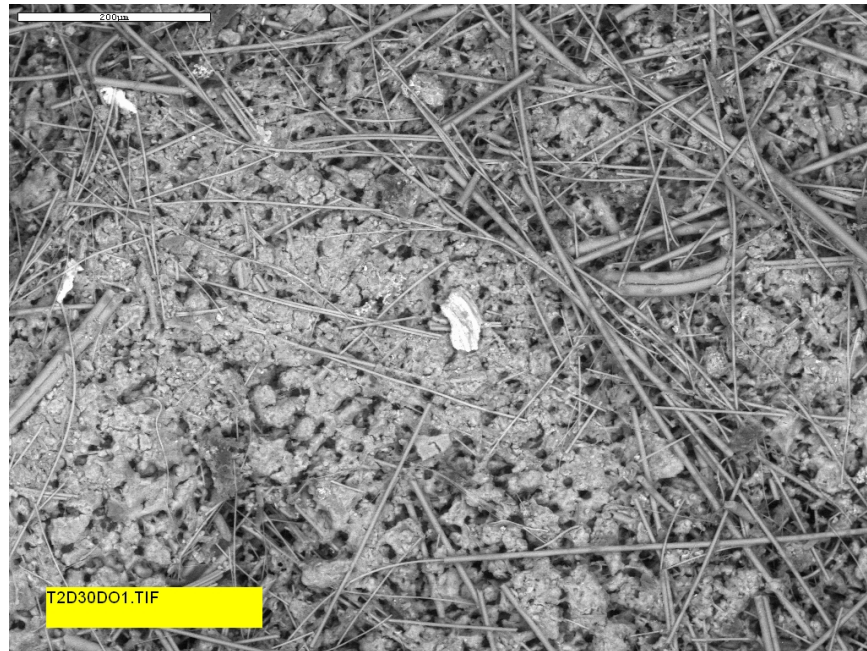


Figure D3-18. ESEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO1).

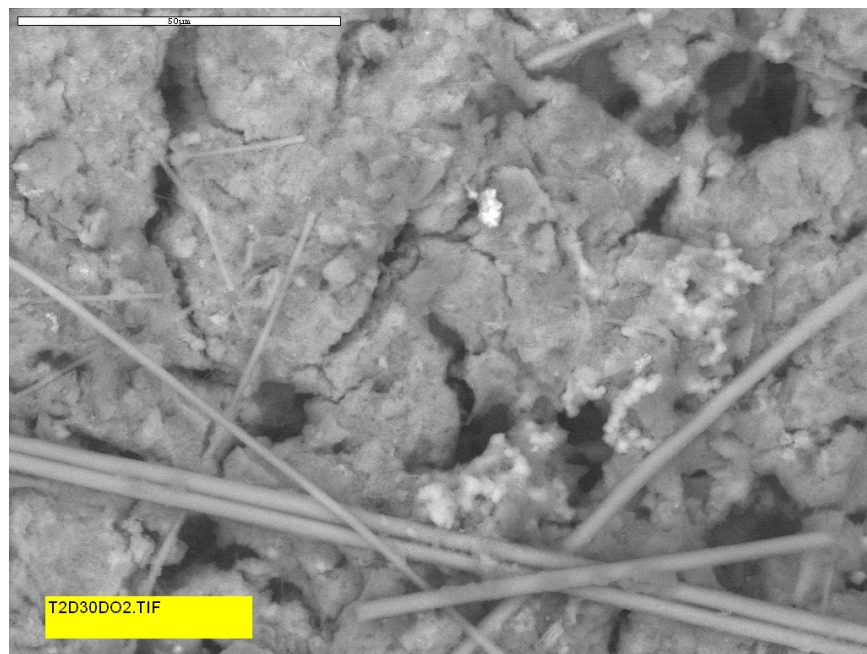


Figure D3-19. ESEM image of a higher magnification for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO2).

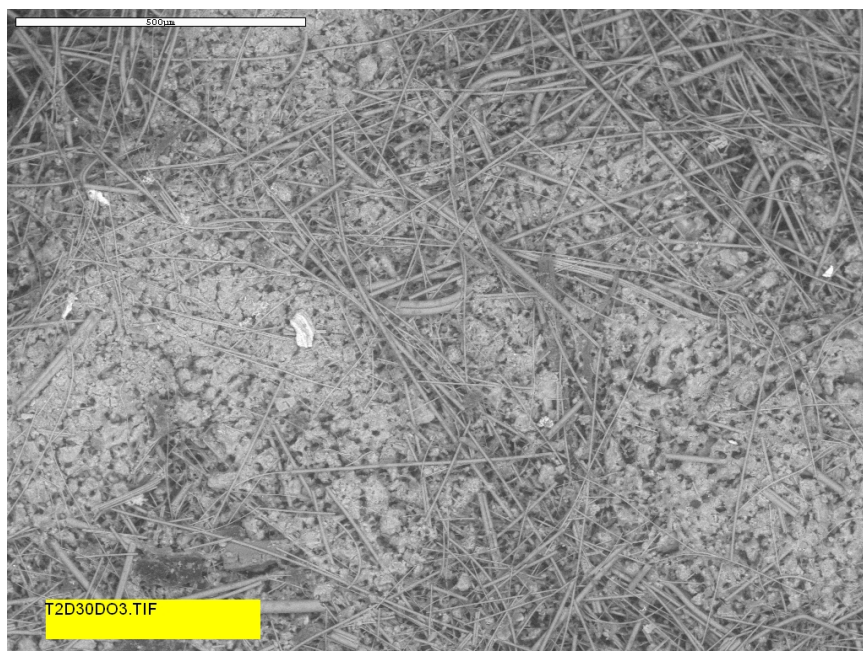


Figure D3-20. ESEM image for a Test-2 Day-30 exterior fiberglass sample on the drain collar. Image shows particulate deposits or growth on fiberglass (T2D30DO3).

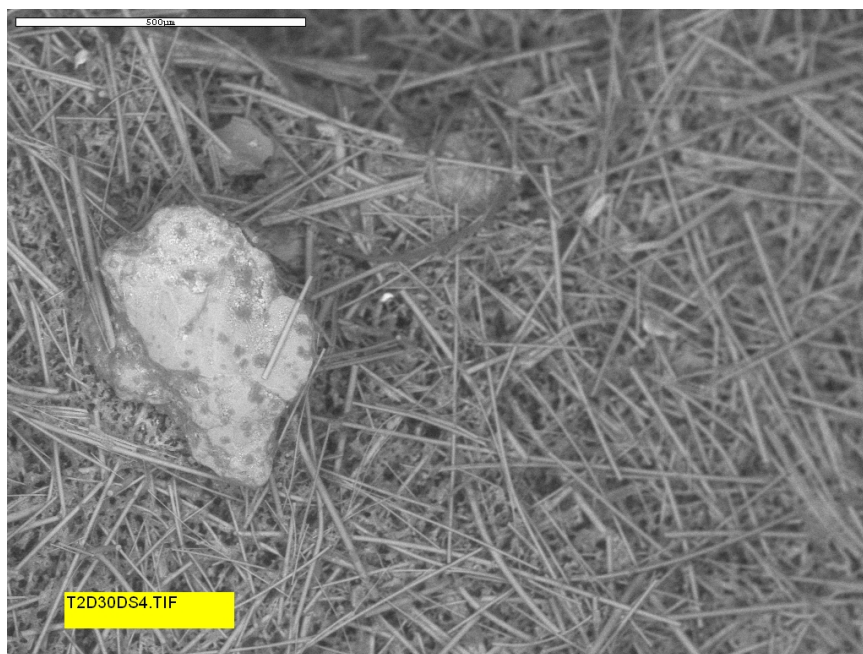


Figure D3-21. ESEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS4).

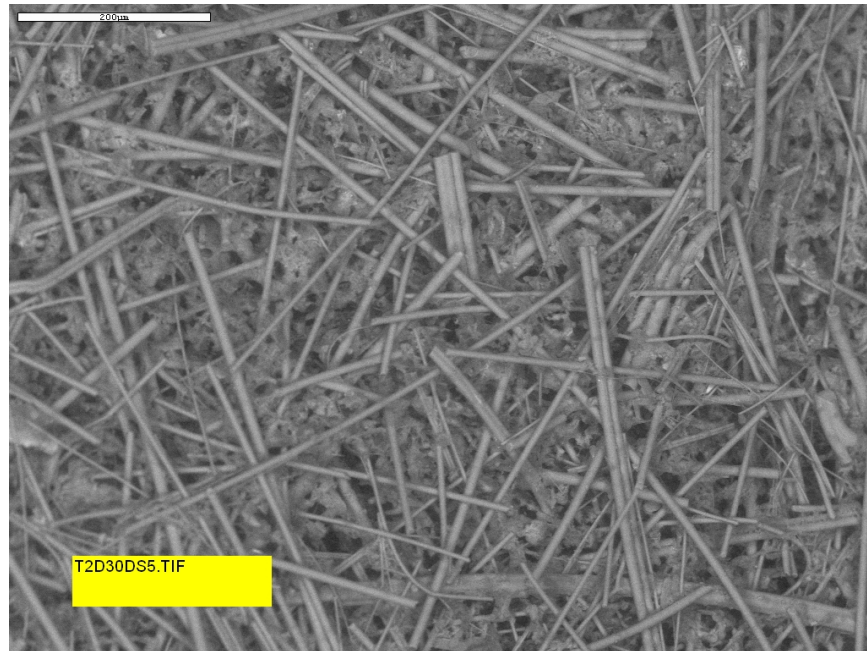


Figure D3-22. ESEM image for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS5).

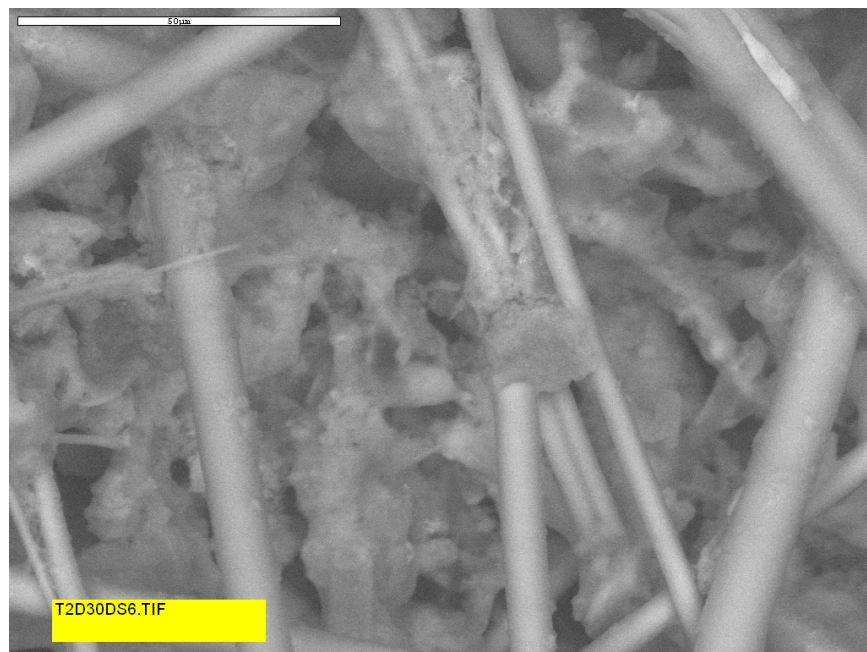


Figure D3-23. ESEM image of a higher magnification for a Test-2 Day-30 fiberglass sample on the drain collar next to the drain screen (T2D30DS6).

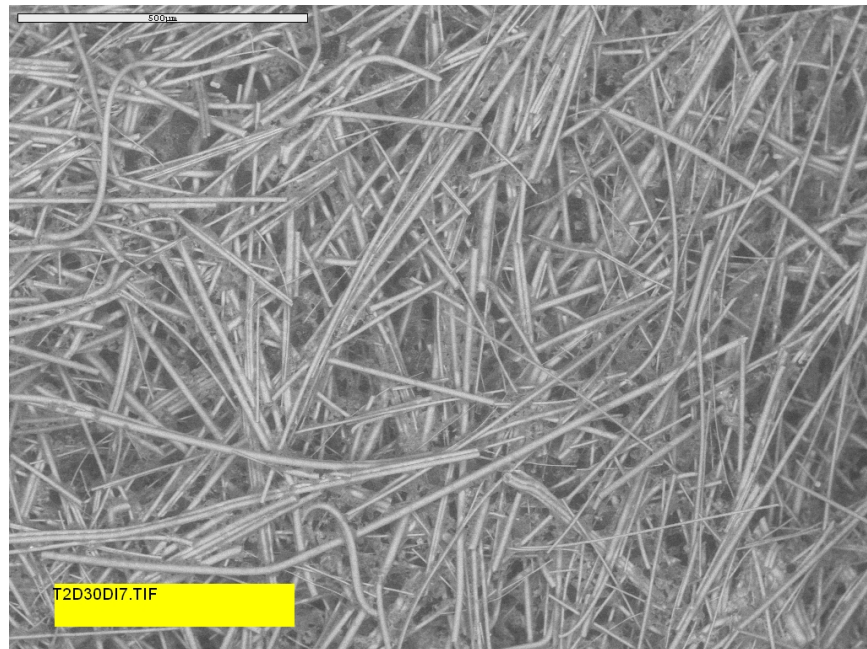


Figure D3-24. ESEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image suggests that interior fiberglass was relatively clean compared to exterior (T2D30DI7).

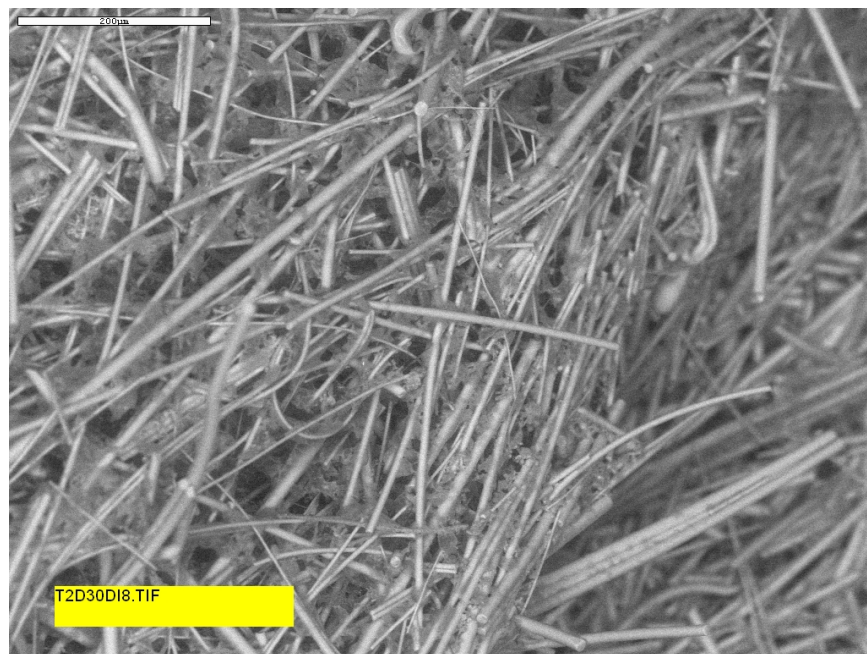


Figure D3-25. ESEM image for a Test-2 Day-30 interior fiberglass sample on the drain collar (T2D30DI8).

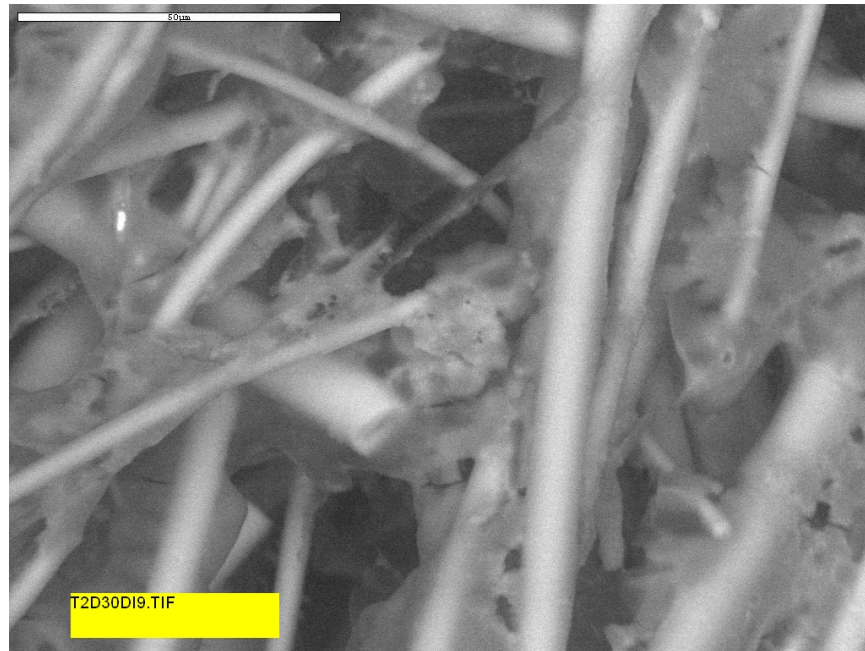


Figure D3-26. ESEM image of a higher magnification for a Test-2 Day-30 interior fiberglass sample on the drain collar. Image shows deposits or growth on the interior fiberglass, although the quantity was less than for exterior samples (T2D30DI9).

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