

# MICROBIOLOGY REPORT



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Date: July 7, 2020  
Test Type: Multi-Pass Organism Removal

Test Requested By: Alen Corp  
Contact: Russ Baldinger

### Scope

Alen Corporation provided three Alen BreatheSmart 45i air cleaners, three Alen BreatheSmart 75i air cleaners, and prototype air filters for all air cleaners for multi-pass efficiency testing with MS-2 bacteriophage (ATCC 15597-B1) as the challenge aerosol contaminant.

### Method

The multi-pass efficiency tests were conducted in a 1050 ft<sup>3</sup> stainless-steel test chamber. The organisms were grown on appropriate media, harvested, and resuspended in saline to 4x10<sup>9</sup> pfu/ml. Suspensions of the organisms were then aerosolized into the test chamber using a nebulizer for 10-minute periods prior to powering each test air cleaner. The test chamber air was sampled at 0-minutes, 5-minutes, 10-minutes, and 20-minutes using a SKC Bio-Sampler Bioaerosol Collection Device. After incubating the collection plates for 24-hours, the recovered plaque-forming units (PFU) were enumerated.

**Test Device Information**

Air Cleaner Manufacturer: Alen Corp  
Air Cleaner Model: BreatheSmart 45i  
Air Cleaner Serial Numbers: I-04-22-2019-1148  
I-04-22-2019-0986  
I-04-22-2019-0960

Filter Size: 11" x 14" x 2"  
Filter Prototype Numbers: PR-20-089-1  
PR-20-089-2  
PR-20-089-3

**Table 1. Alen 45i air cleaner and filter pairings**

Test ID	Air Cleaner Serial #	Filter Prototype #
45i #1	I-04-22-2019-1148	PR-20-089-1
45i #2	I-04-22-2019-0986	PR-20-089-2
45i #3	I-04-22-2019-0960	PR-20-089-3



**Figure 1. Alen BreatheSmart 45i with filter**

Air Cleaner Manufacturer: Alen Corp  
Air Cleaner Model: BreatheSmart 75i  
Air Cleaner Serial Numbers: I-06-25-0646  
I-06-25-1041  
I-06-25-0673

Filter Size: 14.5" x 19.25" x 1.75"  
Filter Prototype Numbers: EP-20-078 #1  
EP-20-078 #2  
EP-20-078 #3

**Table 2. Alen 75i air cleaner and filter pairings**

Test ID	Air Cleaner Serial #	Filter Prototype #
75i #1	I-06-25-0646	EP-20-078 #3
75i #2	I-06-25-1041	EP-20-078 #2
75i #3	I-06-25-0673	EP-20-078 #1



**Figure 2. Alen BreatheSmart 75i with filter**

**Test Conditions**

Environmental Conditions: 71 °F and 44% RH

**Equipment**

1050 ft<sup>3</sup> Stainless-Steel Test Chamber  
SKC Bio-Sampler Bioaerosol Collection Device  
TSI Scanning Mobility Particle Sizer (SMPS) 3938

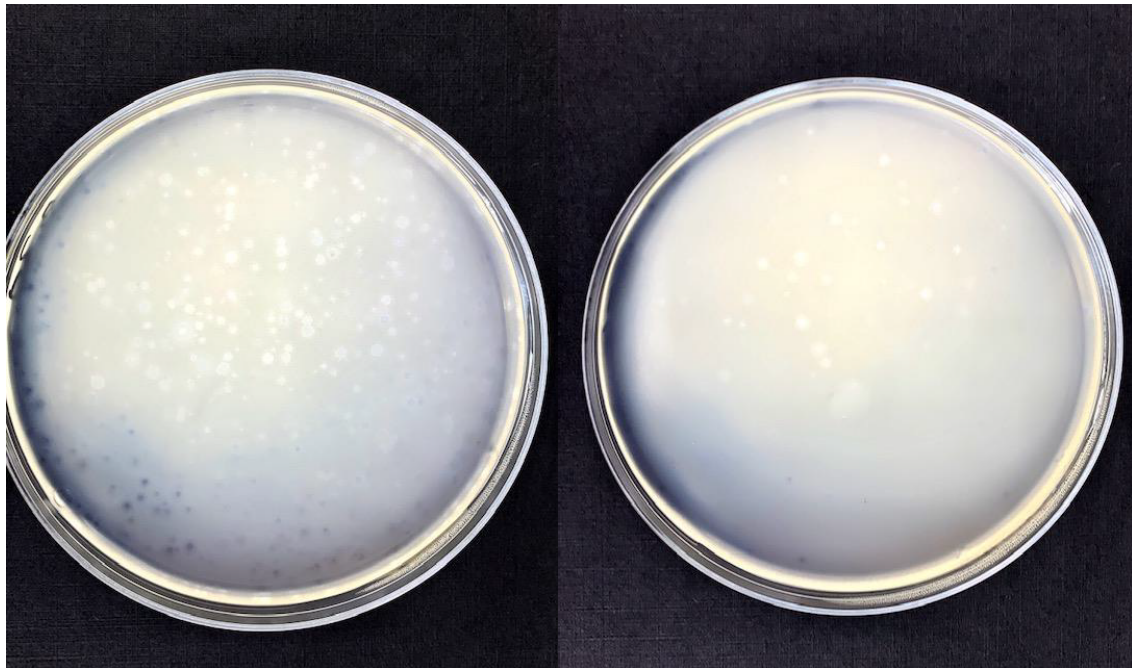
**Data**

**PFU Results**

The number of plaque-forming units from plating SKC Bio-Sampler samples for all tests are shown in Table 3.

**Table 3. MS-2 plaque forming units results**

Test Sequence	Number of Plaque-Forming Units (PFUs)				Removal Efficiencies (Adjusted for Natural Chamber Decay)		
	0-minutes	5-minutes	10-minutes	20-minutes	5-minutes	10-minutes	20-minutes
Natural Chamber Decay	144000	121200	90000	52600	N/A	N/A	N/A
Alen 75i #1	133200	22300	6000	360	80.1%	92.8%	99.3%
Alen 75i #2	136500	23400	6300	320	79.6%	92.6%	99.4%
Alen 75i #3	129800	21800	5800	340	80.0%	92.9%	99.3%
Alen 45i #1	216000	43200	19200	3600	76.2%	85.8%	95.4%
Alen 45i #2	187500	37600	18100	3150	76.2%	84.6%	95.4%
Alen 45i #3	208000	41400	19200	3350	76.4%	85.2%	95.6%



**Figure 3. Representative photos of MS-2 plates at time=0 (left) and time=20 (right)**

### Particulate Results

Figure 5 through Figure 10 show the particle size distribution data for the empty chamber test and each of the air cleaner tests.

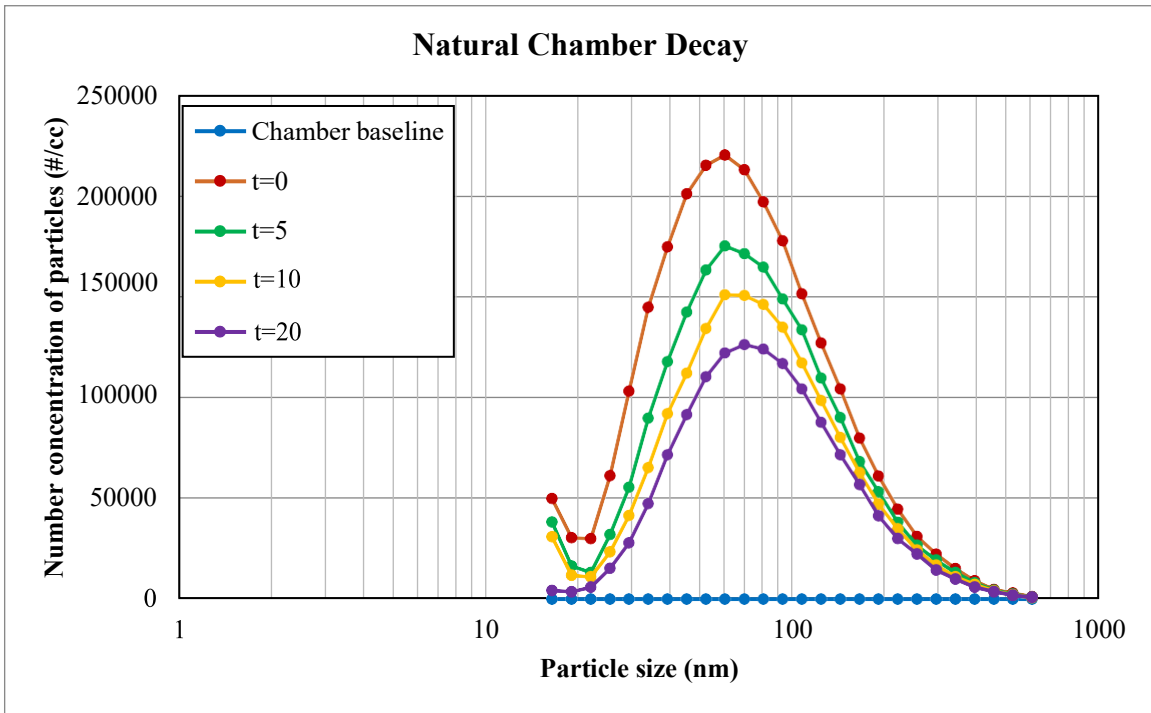


Figure 4. Empty chamber: TSI SMPS particle size data

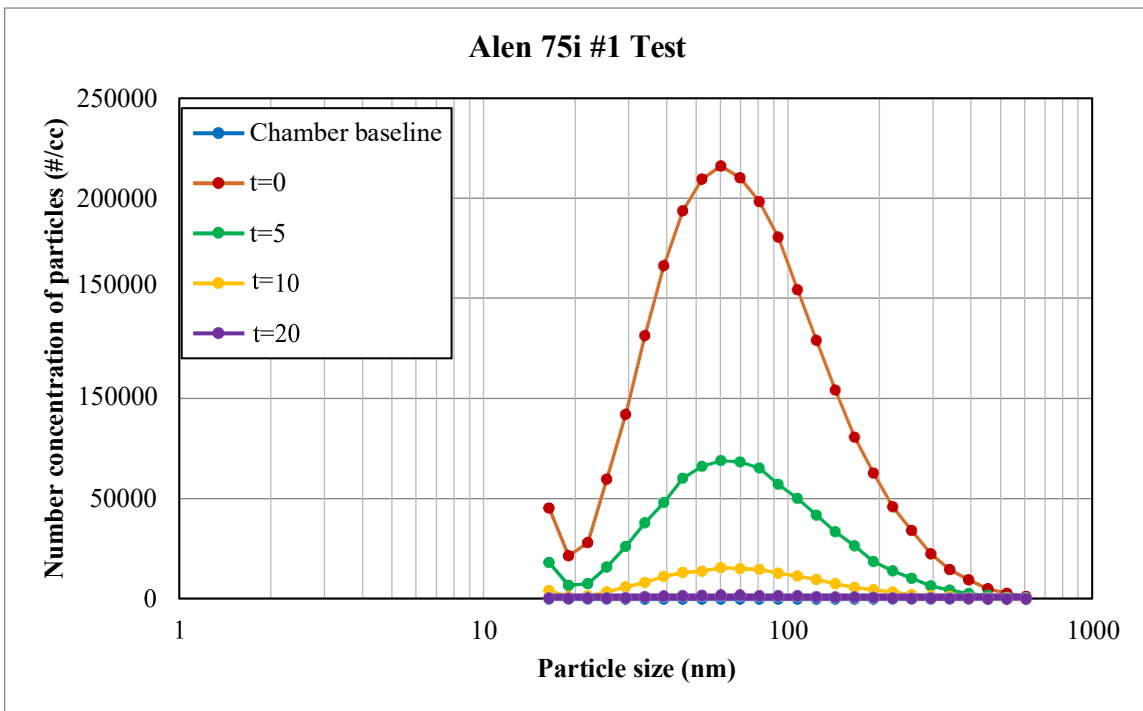


Figure 5. Alen 75i #1: TSI SMPS particle size data

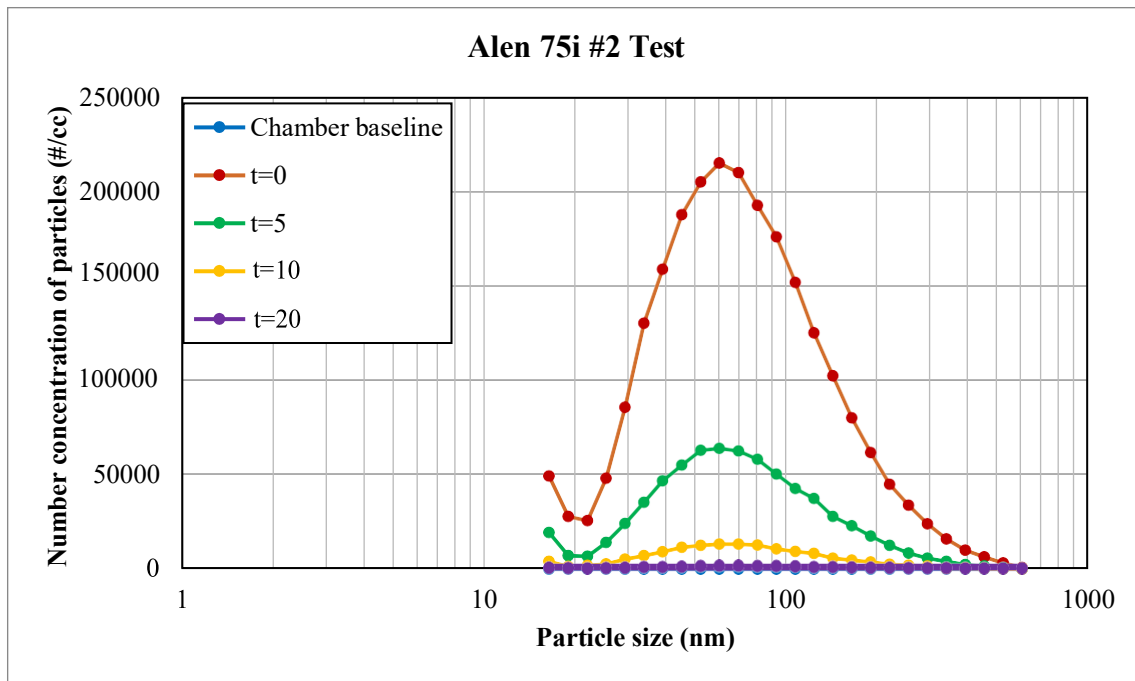


Figure 6. Alen 75i #2: TSI SMPS particle size data

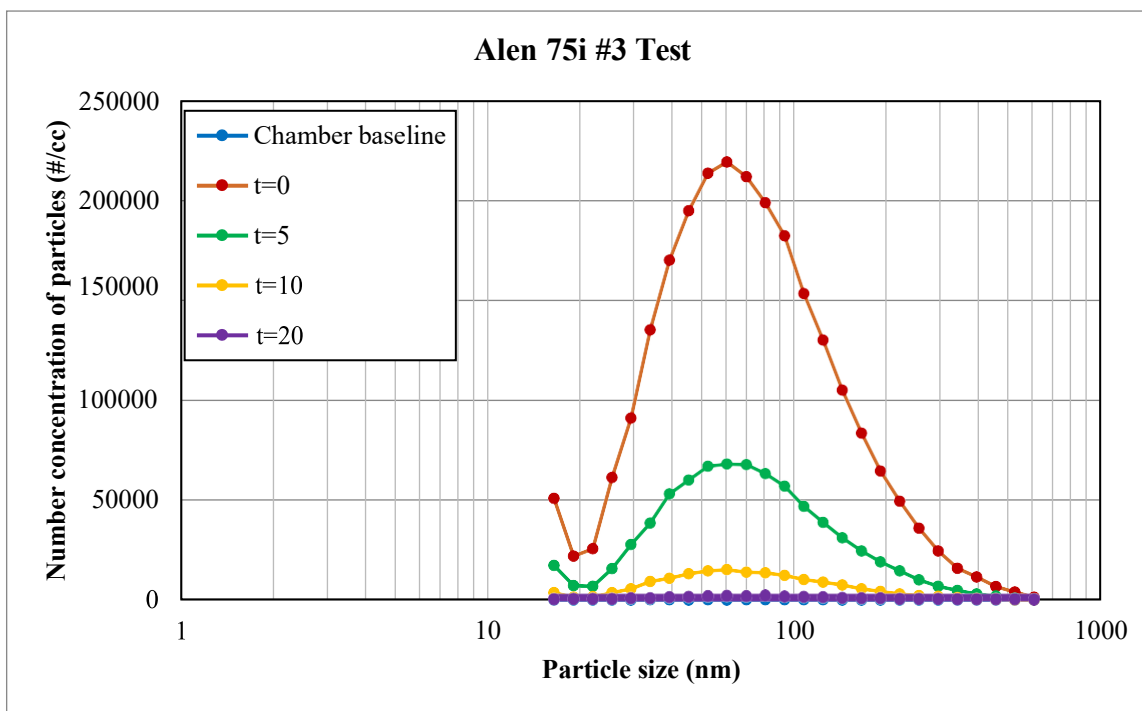


Figure 7. Alen 75i #3: TSI SMPS particle size data

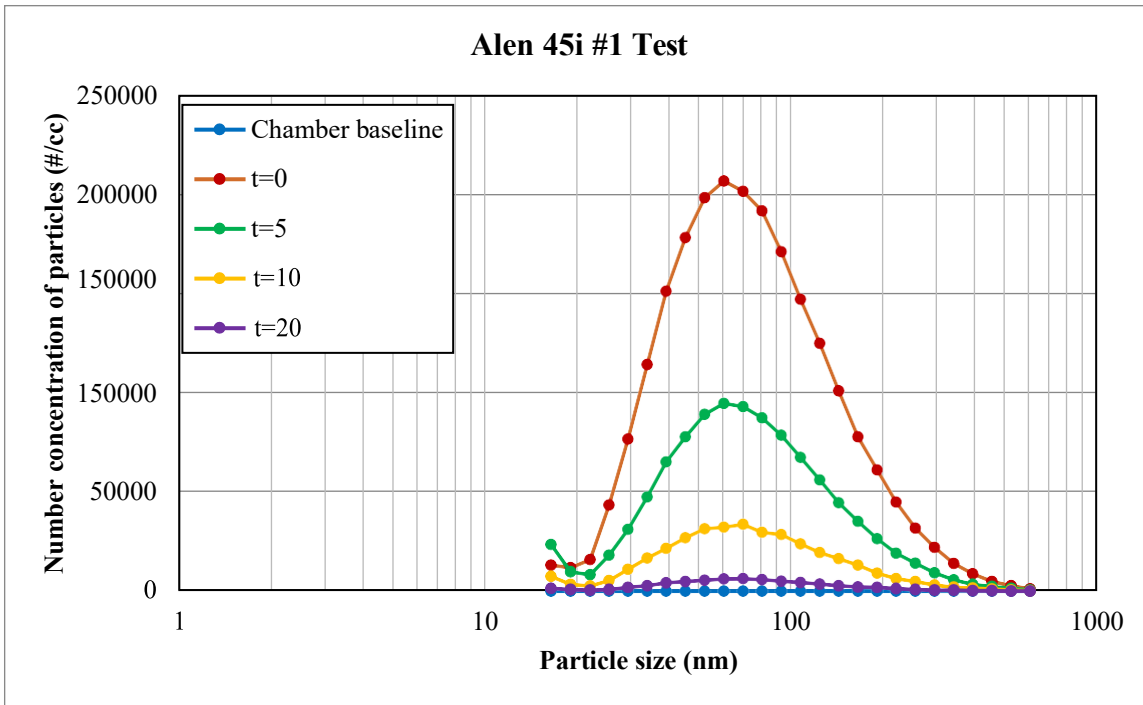


Figure 8. Alen 45i #1: TSI SMPS particle size data

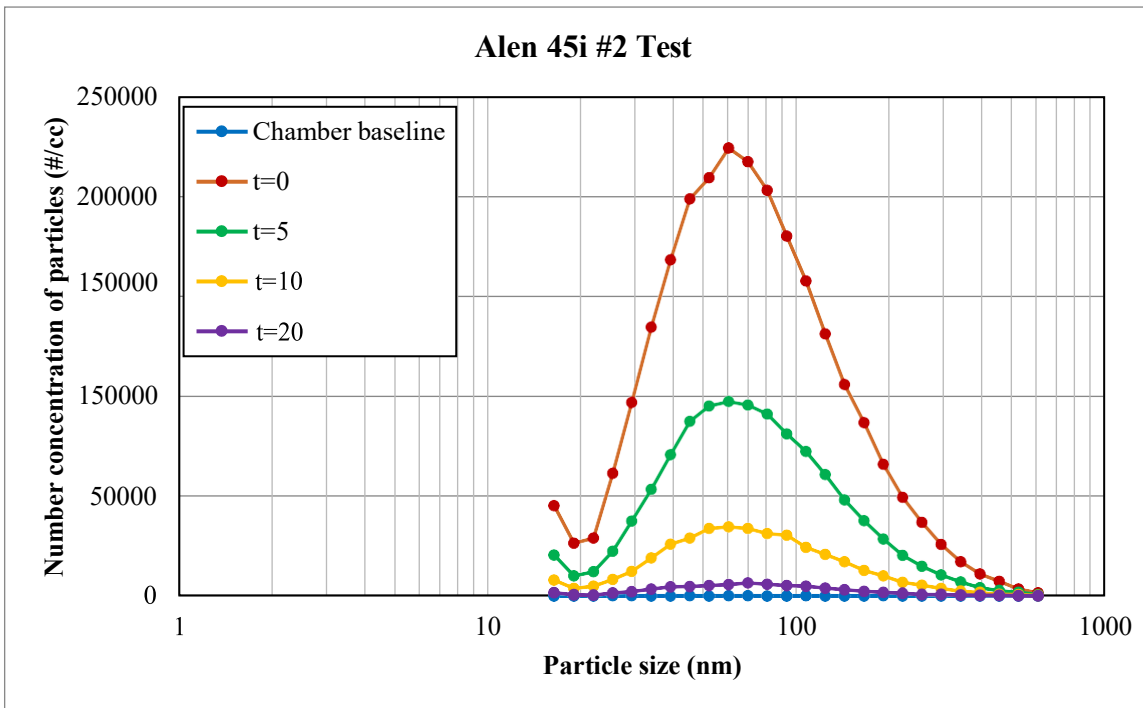


Figure 9. Alen 45i #2: TSI SMPS particle size data

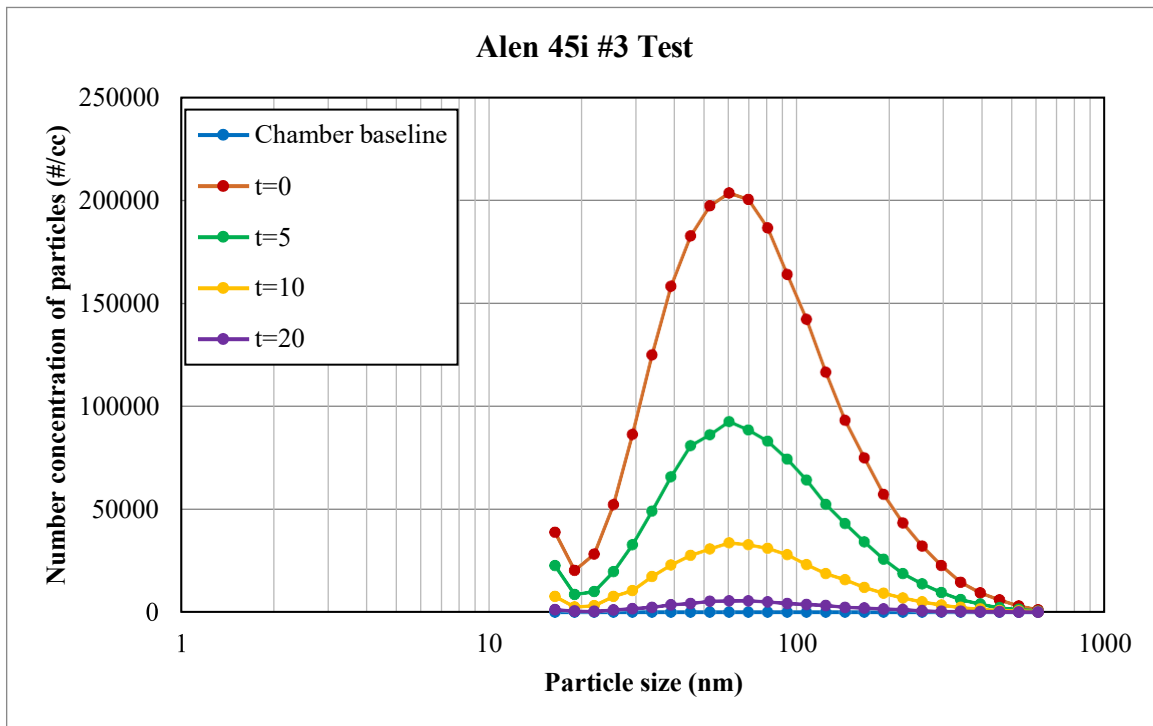


Figure 10. Alen 45i #3: TSI SMPS particle size data

The cumulative particle concentration data from the TSI SMPS in the size range of 16.5nm to 604.3nm were plotted for the full duration of all Alen 75i (Figure 11) and Alen 45i (Figure 12) tests. The k-values were determined from exponential regression of these data. The clean air delivery rates (CADR) were calculated based on the following equation with a total test chamber volume of 1050 ft<sup>3</sup>.

$$CADR = V(k_{air\_cleaner} - k_{empty})$$



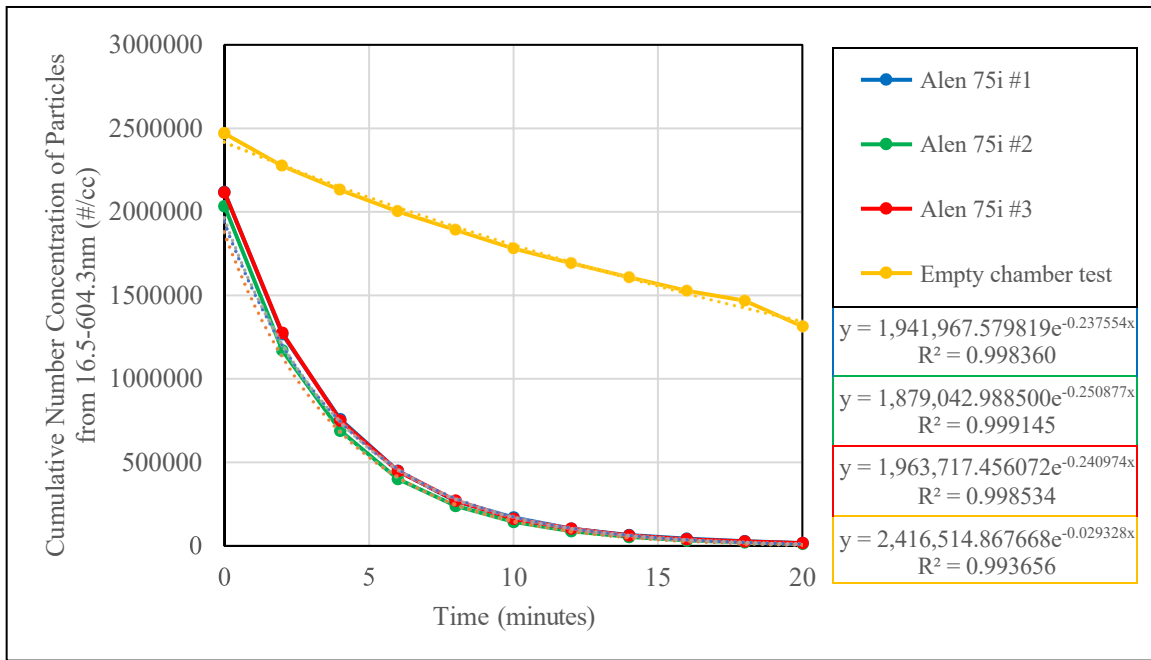


Figure 11. TSI SMPS number particle concentration decay rates for all Alen 75i tests

Table 4. CADR results based on SMPS data for all Alen 75i tests

	Alen 75i #1	Alen 75i #2	Alen 75i #3	Empty chamber test
k-value	0.237554	0.250877	0.240974	0.029328
R <sup>2</sup>	0.998	0.999	0.999	0.994
CADR (cfm)	218.6	232.6	222.2	N/A

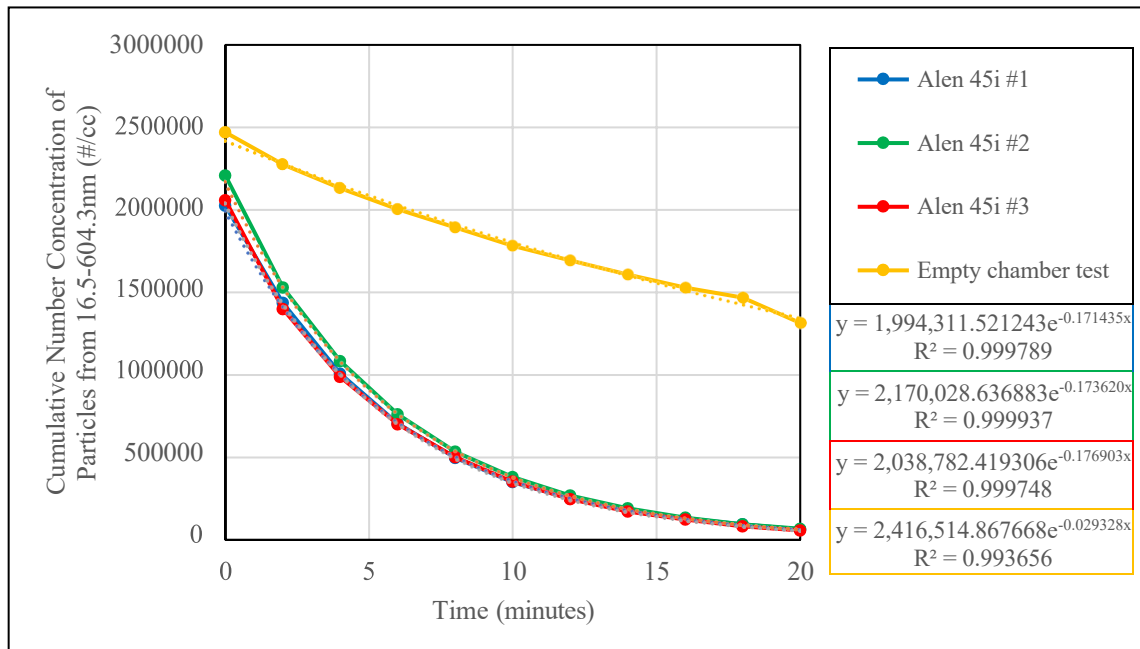


Figure 12. TSI SMPS number particle concentration decay rates for all Alen 45i tests

Table 5. CADR results based on SMPS data for all Alen 45i tests

	Alen 45i #1	Alen 45i #2	Alen 45i #3	Empty chamber test
k-value	0.171435	0.173620	0.176903	0.029328
R <sup>2</sup>	0.999	0.999	0.999	0.994
CADR (cfm)	149.2	151.5	155.0	N/A