Report Date: October 3, 2005

TEST REPORT

Job J-00019881
Customer Number 1X780

All Testing Performed at:
NSF International Headquarters

Test Sample:
Air Deflector comprised of 4 pieces of
clear plastic that snaps together received; in mint condition.

Proposed Benefits:
To reduce the accumulation of dirt on ceiling tiles adjacent
to air diffusers.

Date Sample received:
The SMMA sample on April 12, 2005
The Polycarbonate Sample on September 6, 2005

Client:
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Report Authorized By: Sal Aridi
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DN: CN = Sal Aridi, C = US, O = NSF International
Date: 2005.10.03 17:31:35 -04'00'

Sal Aridi, PE Manager

Executive Summary Table:

Section Number	*Test or Evaluation Performed*	*Result*
3.1	Airflow Metrics[1]	The changes in airflow velocity are insignificant at two feet from the diffuser in either direction after the addition of the deflector.
3.2	Noise and Vibration[1]	The deflector does not have an impact on the noise level from the diffuser or on the vibration produced.
4	Fog Patterns[1]	Demonstrated the shift in airflow patterns.
6	Dust Accumulation[1] Test Results	It took 4 times more dust with the deflector installed to get the tiles to look like the ones used with no deflector.
7	Grid Compatibility[1&2]	Fits with commonly used $^{9}/_{16}$ and $^{15}/_{16}$ 'exposed' style grid. The sample, as supplied to NSF, does not fit the 1.5" grid.
8	Chemical Analysis[2]	The material was identified using an FTIR analysis as Polycarbonate based on 88% match with a library sample.
8.2	Service Life[2]	The material has good physical properties but may be incompatible with some aggressive cleaning chemicals.
9	Flammability[2]	The polycarbonate material used is resistant to burning and performed well under the flammability test.
[1]- SMMA material received on April 12, 2005. [2]- Polycarbonate material received on September 6, 2005		

1 Sample Description

Section 1,8 and 9 were performed on 2 types of materials. The first material was SMMA and the data for it was reported on July 5, 2005. The data in this report is for the second material which is polycarbonate.
The Airtech air deflector is made up of four pieces of clear plastic that snap together to form a square frame that is placed around the air diffuser. The sample (Figures 1-3), as tested, is 23 X 23 inch with a 3/8-inch lip on all four sides.
The sample was tested using a 15/16-inch wide exposed edge ceiling grid manufactured by USG, with a 23 3/4-inch air diffuser holding the deflector in place.

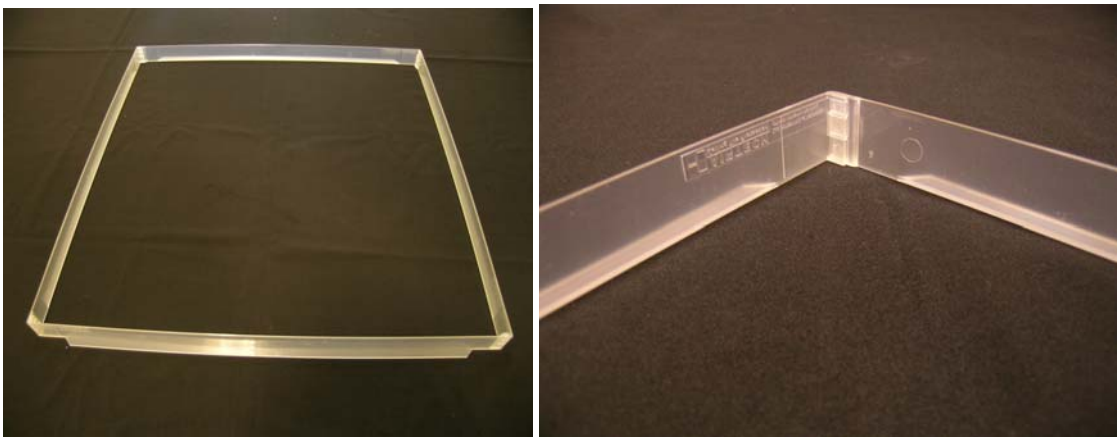

Figure 1: The Air Deflector Sample and a close up

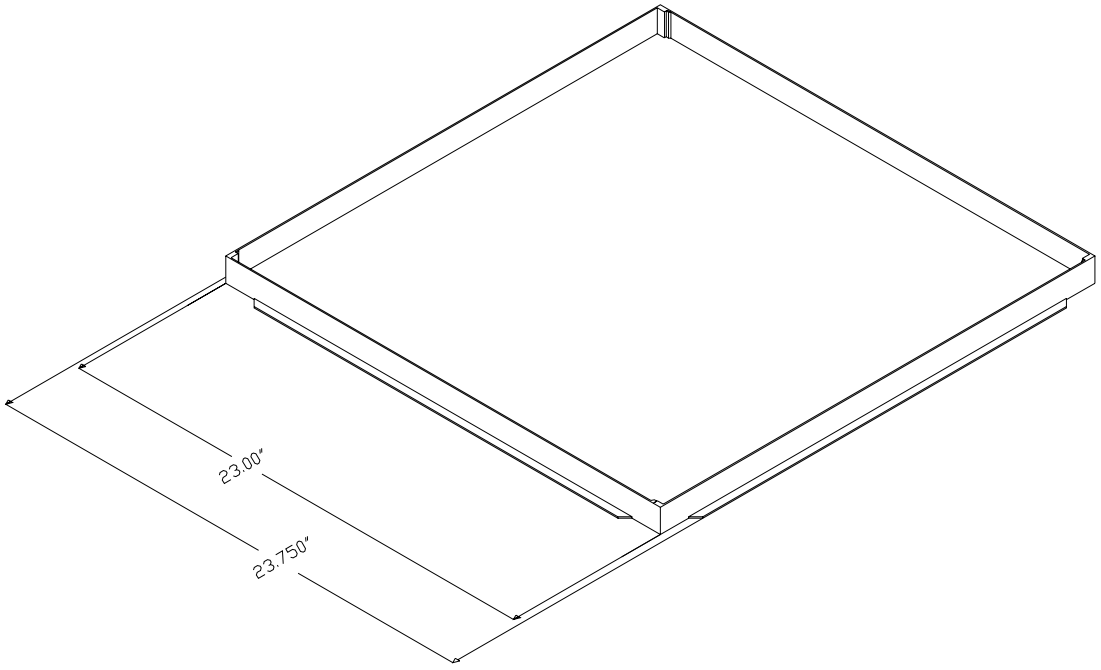

Figure 2: Air Deflector Dimensions (isometric view)

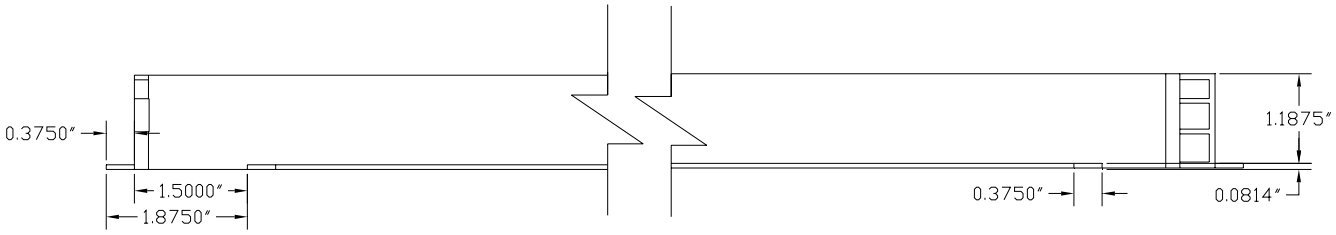

Figure 3: Air deflector dimensions (side view)

2 Functional/Performance Testing

2.1 Test Room

The functionality of the deflector was evaluated using a test room (Figures 4-5). The test room was built with a suspended ceiling consisting of one air vent with a diffuser and eight surrounding 2' X 2' tiles. The room is 75 X 75 inch with a ceiling 7'2" above the floor. The commonly supplied 17.75 inch, square, horizontally installed, ceiling air diffuser (Titus model Omni-AA) was centrally located and surrounded by eight, 22.5 X 22.5 inch acoustical tiles (textured) supported by a hanging frame.

Figure 5: Test Setup: 6' X 6' simulated room with 7' suspended ceiling

Figure 4: Air diffuser set-up: Centered air vent with eight surrounding 2' X 2' ceiling tiles

The four sides of the room were covered using 2 and 4 mils thick transparent plastic film, which served as walls to the room. The film was secured and sealed so that only a minimal amount of dust could escape the room during testing. Additionally, the room was equipped with two, 20 X 70 inch dust filters located on two sides near the floor to allow for ventilation.

3 Airflow Measurements

Prior to dust testing, airflow, noise, and vibration measurements were performed with and without the air deflector in place. Airflow measurements were taken before the installation of test room walls. This was to allow for free-field (un-encumbered) velocity and flow measurements. The northward facing diffuser discharge slot was selected for evaluation of air velocity and flow.

The noise and vibration measurements were taken following the installation of the walls.

3.1 Airflow Metrics

All volumetric airflow measurements were made in the local density mode on the Shortridge air data multimeter. The air speed was measured with a thermal anemometer placed at the locations identified in Note 1 following Table 2. The air volume was set to deliver a certain SCFM per the left column of Table 1 and Table 2, then the air velocities were measured at two horizontal and five vertical distances from the diffuser. The data is presented in Tables 1 and 2.

SCFM Actual	Static Pressure (in.wc.)	Horiz. (1) (fpm)	Horiz. (2) (fpm)	Vertical (3) (fpm)	Vertical (4) (fpm)	Vertical (5) (fpm)	Vertical (6) (fpm)	Vertical (7) (fpm)
48	0.0063	96	4	21	5	6	4	4
123	0.0364	182	16	33	12	14	28	24
175	0.0731	316	16	44	34	27	33	28

Table 1: Air measurements without deflector at various locations; see Note 1 for nomenclature.

SCFM Actual	Static Pressure (in.wc.)	Horiz. (1) (fpm)	Horiz. (2) (fpm)	Vertical (3) (fpm)	Vertical (4) (fpm)	Vertical (5) (fpm)	Vertical (6) (fpm)	Vertical (7) (fpm)
50	0.0068	13	6	154	58	10	1	0
123	0.0382	25	20	302	99	23	24	10
174	0.0695	21	21	482	239	95	36	12

Table 2: Air measurements with deflector at various locations; see Note 1 for nomenclature.

Note 1: Nomenclature

(1) Horizontal one foot from north oriented discharge slot @ 0.562 inches down from ceiling tile

(2) Horizontal two feet from north oriented discharge slot @ 5.0 inches down from ceiling tile

(3) Vertical 3.5 inches down from north oriented discharge slot @ 2.25 inches out horizontally from diffuser edge

(4) Vertical 8.75 inches down from north oriented discharge slot @ 2.25 inches out horizontally from diffuser edge

(5) Vertical 12.0 inches down from north oriented discharge slot @ 2.25 inches out horizontally from diffuser edge

(6) Vertical 24.0 inches down from north oriented discharge slot @ 2.25 inches out horizontally from diffuser edge

(7) Vertical 36.0 inches down from north oriented discharge slot @ 2.25 inches out horizontally from diffuser edge

Conclusion

Figures 6 and 7 indicate that the flow of air decreases significantly at a horizontal distance of 1 foot from the deflector and is actually slightly higher at a distance of 2 feet when the deflector is installed. Figures 8-10 show that vertical air velocities increase at the five vertical distances when the deflector is installed. At 50 cfm and 125 cfm, the air velocities become comparable at 12” below the discharge slot. At 175 cfm, this distance increases to 24”. Additionally, the column titled Static Pressure in Tables 1 and 2 indicate that no significant change in backpressure (as measured in the diffuser supply duct) has occurred after the deflector was installed.

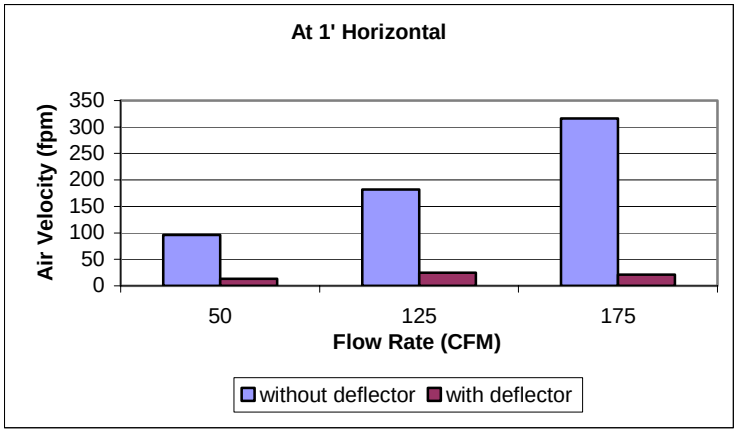

Figure 6: Horizontal airflow measurements at one foot from the north-oriented discharge slot @ 0.562 inches down from ceiling tile

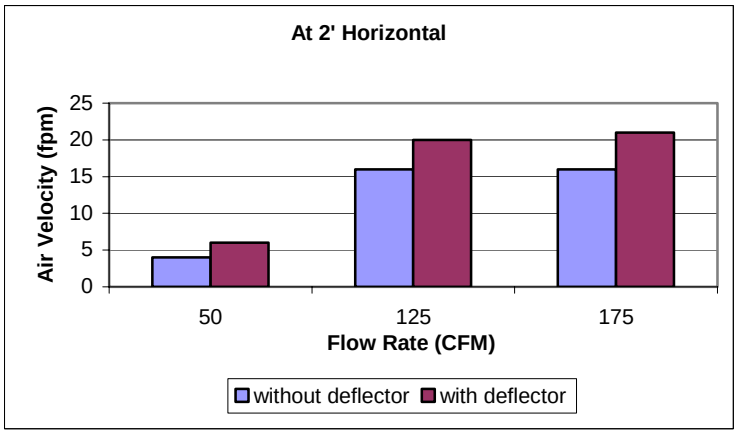

Figure 7: Horizontal airflow measurements at two feet from north-oriented discharge slot @ 5.0 inches down from ceiling tile

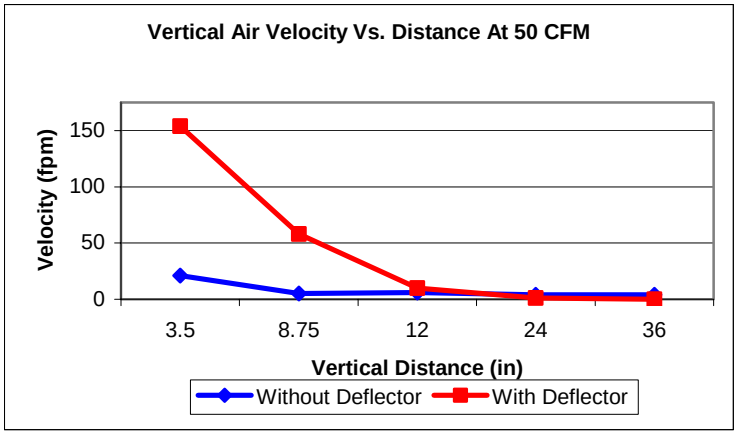

Figure 8: Airflow measurements at 50 cfm at five vertical distances from ceiling

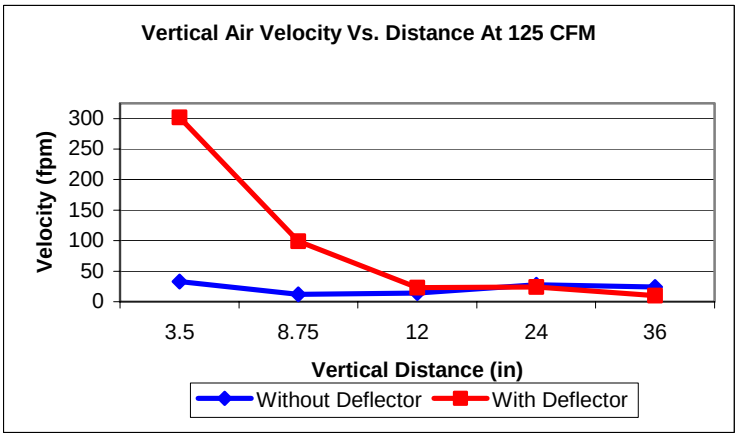

Figure 9: Airflow measurements at 125 cfm at five vertical distances from ceiling

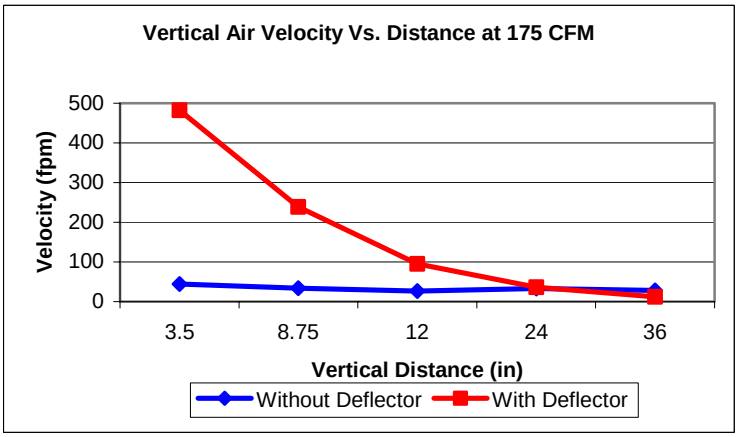

Figure 10: Airflow measurements at 175 cfm at five vertical distances from ceiling

3.2 Noise and Vibration Measurements

Noise and vibration measurements were taken over a range of air flow rates both with and without an air deflector installed. The flow rates shown in Table 3 are an average of three measurements and are corrected for the calibration curve of the instrument. The noise levels were measured using a Quest Model 1800 sound level meter. The meter was field calibrated immediately prior to making the measurements. Vibration was measured using a Quest Model 1800 sound level meter equipped with a VI-90 vibration integrator. Vibration measurements are reported with the background vibration level subtracted (net vibration).

Noise levels were measured with the microphone pointing up centered under the air diffuser, twenty-four inches below the air diffuser. The background noise level was measured at 48 decibels both with and without the deflector installed. As shown in Table 3, noise levels did not rise significantly above the ambient level until the flow rate reached 150 CFM. There was no significant difference between the noise level with the deflector installed and the level without it installed at any airflow point measured.

Flow Rate	Noise Level (dbA)		Net Vibration (inches rms amplitude)	
(CFM)	Without Deflector	With Deflector	Without Deflector	With Deflector
39	48	48	<0.0001	<0.0001
78	49	49	<0.0001	<0.0001
113	50	49	0.0001	0.0001
150	52	52	0.0002	0.0002
168	55	55	0.0004	0.0004

Table 3: Noise and vibration measurements with and without deflector installed.

Vibration levels were measured at the center of the air diffuser, with the vibration pickup secured using double-sided tape. Net vibration at the first two points was below the reporting limit for the instrument. The measurements, shown in Table 3, show no significant difference between the vibration levels with the deflector installed and the levels without the deflector installed.

Conclusion

The deflector does not have an impact on noise level or vibration.

4 Fog Patterns

Fog testing was performed using an air diffuser both with and without the deflector in place in order to provide a visual image of discharging airflow patterns. A video of the fog test was made and Figures 9 and 10 were extracted from the video.

The fog was generated using dry ice that was placed in 140°F water. The resulting fog was fed into the inlet of the blower. The blower was set to deliver 140 CFM. As is evident in Figures 11 and 12, the airflow pattern hovers around the ceiling without the deflector whereas the pattern was directed down when the air deflector was in place.

Figure 11: Fog test without deflector.

Figure 12: Fog test with deflector

5 Dust Accumulation Test

The tile adjacent to the northward-facing diffuser discharge slot was selected for dust evaluation, allowing for a correlation of dust deposition to pre-dust test airflow measurements.

5.1 Without Deflector (Setup A)

Red ball clay fine powder (Rovin Ceramics Red Art #5) was used for the test. The powder was introduced into a variable frequency blower, 50.0±1.0g at a time, at an average rate of 21.2 grams per second (gps), for a total of 202.5 grams. The blower was set to a flow rate of 150 CFM. This will be known as Setup A. At the end of the process, the north tile was visually inspected and photographed as it was located in the ceiling, as well as separately, next to an unexposed tile, used as a control. Pictures of the north tile can be observed below, Figures 13-15.

5.2 With Deflector (Setup B & Setup C)

Having replaced all of the tiles, and with the deflector in place, the test was repeated in an identical manner. The red ball clay powder was introduced in the blower 50.0±1.0g at a time, at an average rate of 22.2gps, for a total of 201.7 grams. We will call this scenario Setup B. Post-testing, the diffuser, deflector, and north

tile were visually inspected and photographed in their testing locations. The north tile was also photographed separately, next to the control tile, and the north tile exposed without the deflector. Pictures of the tile can be seen below, Figures 16-18.

Further testing was conducted to determine how much more dust needs to be introduced in the system with the deflector installed to give the north tile an appearance similar to that of the north tile when tested with 202.5g of dust (setup A) without the deflector. Testing showed this amount to be 601.9g of additional ball clay powder, for a total of 803.6g, approximately four times the amount used in Setup A. This scenario is called Setup C. The result provides an estimate for how much longer tiles with a deflector installed would last compared to the traditional, no-deflector setup.

Table 4 gives a summary of the three different setups.

Setup	Deflector	Amount of Dust Dispersed
Setup A	No	202.5g
Setup B	Yes	201.7g
Setup C	Yes	803.6g

Table 4:Summary of Setups

6 Dust Accumulation Test Results

6.1 Without Deflector (Setup A)

Figures 11 through 13 show different aspects of the north tile in the traditional setup after having been exposed to 202.5g of red ball clay.

Figure 13: North tile after 202.5g of dispersed ball clay powder without a deflector

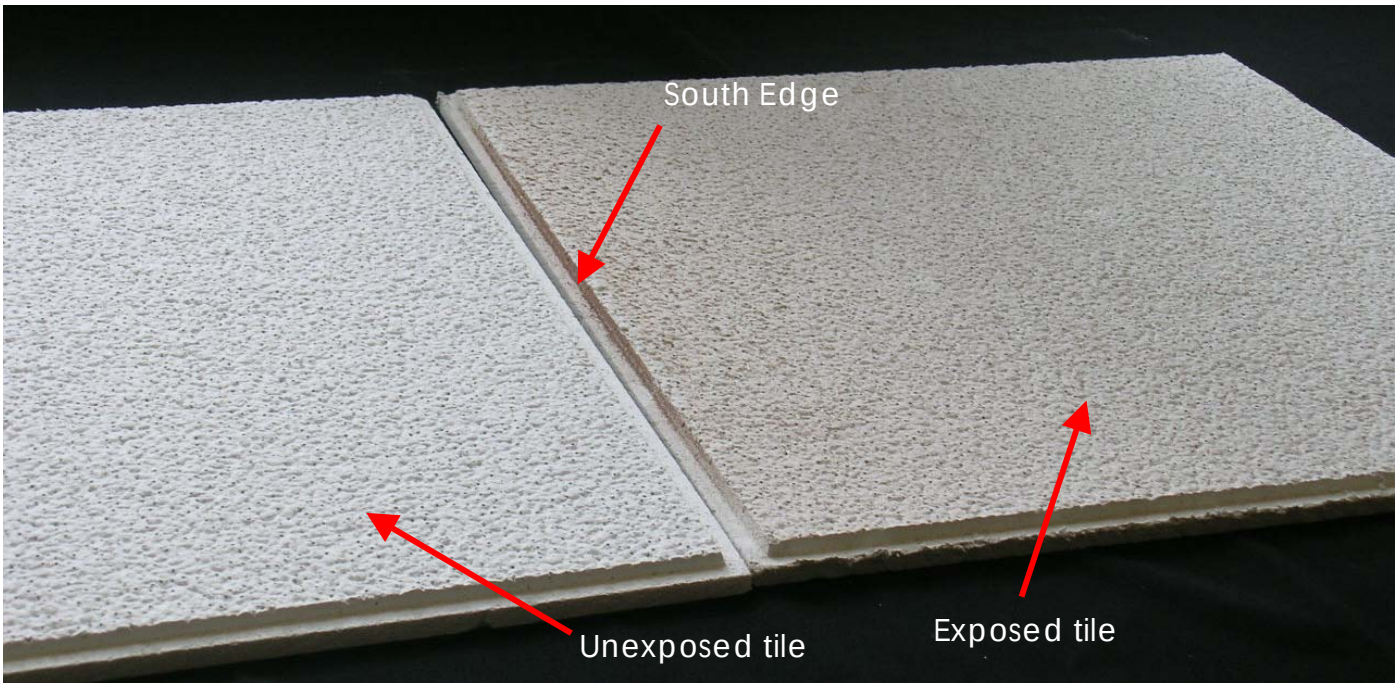

Figure 14: Unexposed tile (control) next to exposed north tile

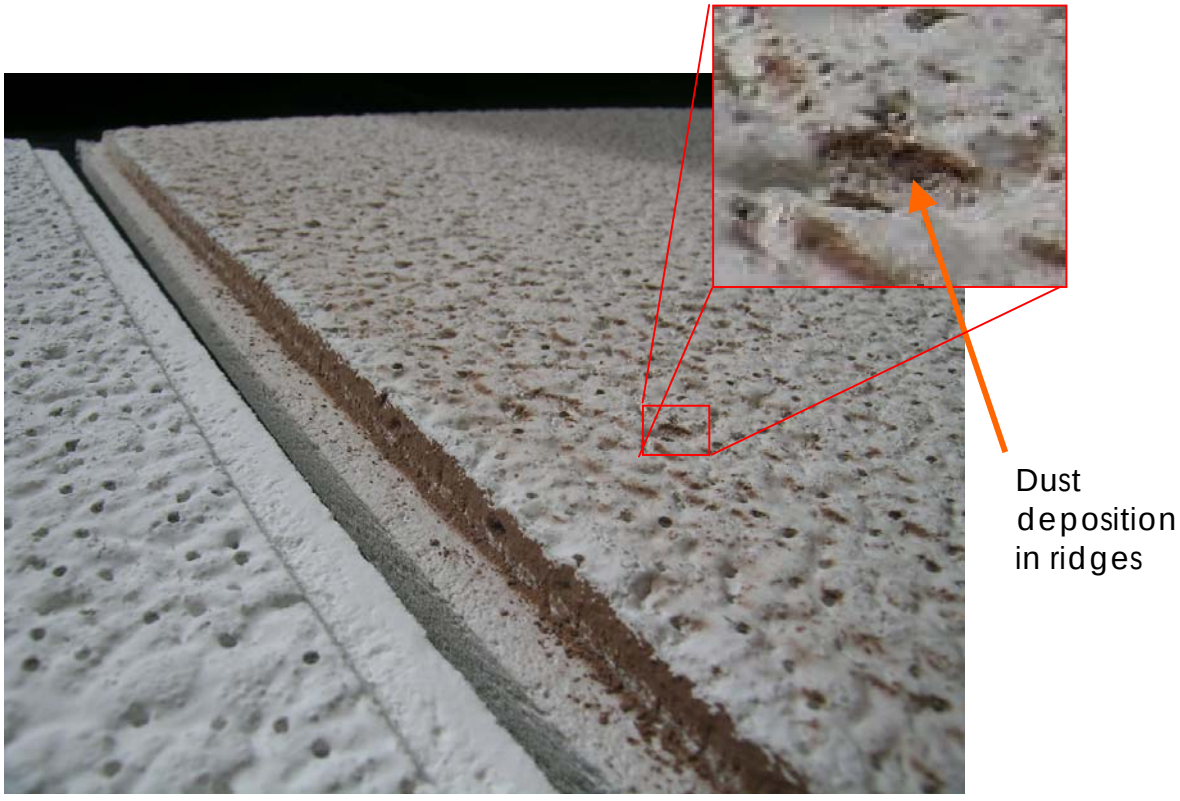

Figure 15: Dust accumulation on north tile, along south edge (edge shared with diffuser)

6.2 With Deflector (Setup B)

Figures 16 through 19 show different aspects of the north tile and deflector after having been exposed to 201.7g of red ball clay powder. It is important to notice that there is significant dust accumulation on the diffuser and the deflector itself.

Figure 16: North tile with deflector after 201.7g of dispersed ball clay powder

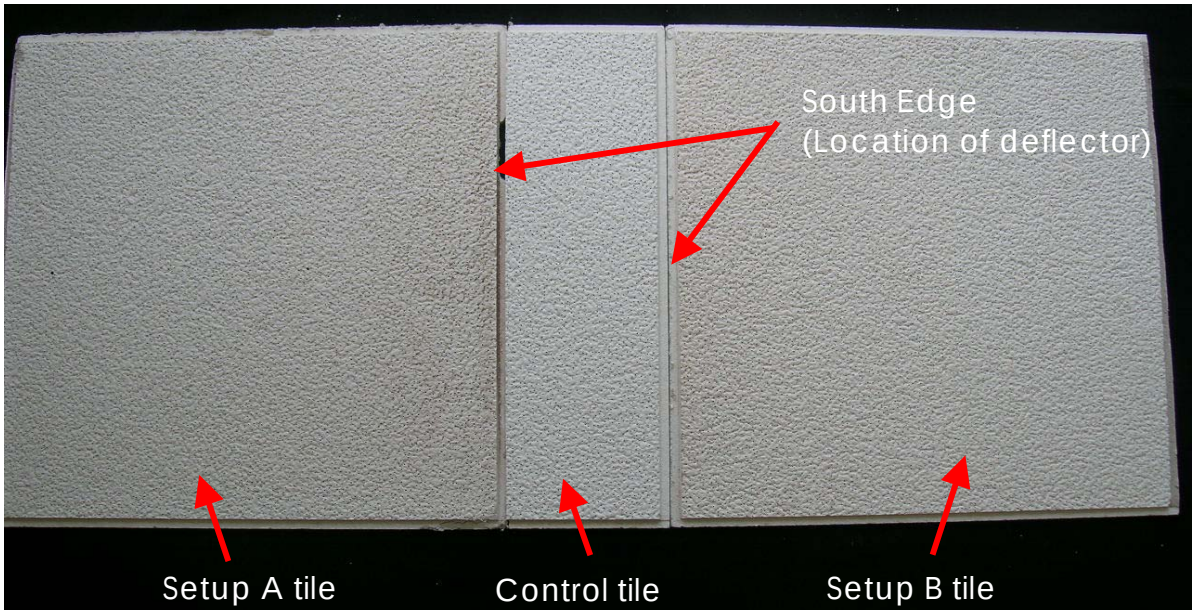

Figure 17: Comparison of north tile without deflector (left), control tile (center), and north tile with deflector (right) after 200g exposures

Figure 18: Dust accumulation in North East Corner of deflector

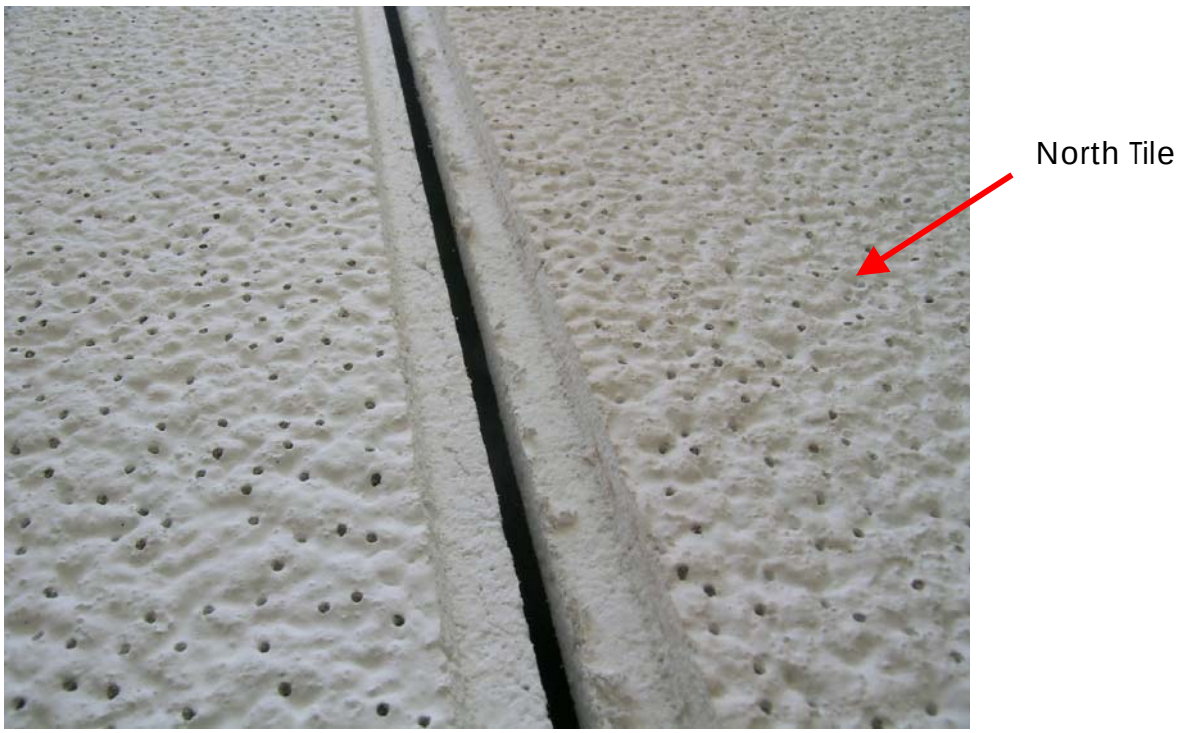

Figure 19: South edge of the north tile (location of deflector) after exposure (right)

in comparison to unexposed tile (left)

6.3 With Deflector (Setup C)

In order to determine the amount of dust that would be necessary to give the tile in Setup B a similar appearance to the tile in Setup A, a third test was conducted. In this test, additional dust was added until the coloration level of the tile reached a point that was similar to that when no deflector was used (Setup A) and 202.5 g of powder was fed into the system. The tile in Setup C reached this level of coloration, very similar to the tile in Setup A, after a total of 803.6 grams of dust was fed into the system, Figures 20 and 21 reveal this aspect.

To provide some quantitative measurement of the color change that the tiles underwent during exposure, a color analysis of the tiles was conducted in the form of image processing of the pictures taken. Scion Image, provided by Scion Corporation, is software that allows the user to analyze the color intensity and density of grayscale images. The software assigns a value between 0 and 256 to every pixel based on the amount of white and black color present in that pixel. Zero corresponds to a purely white pixel while 256 corresponds to a purely black pixel. A color analysis was performed on the images in Figures 17 and 20. The results are displayed in Figures 22 and 23.

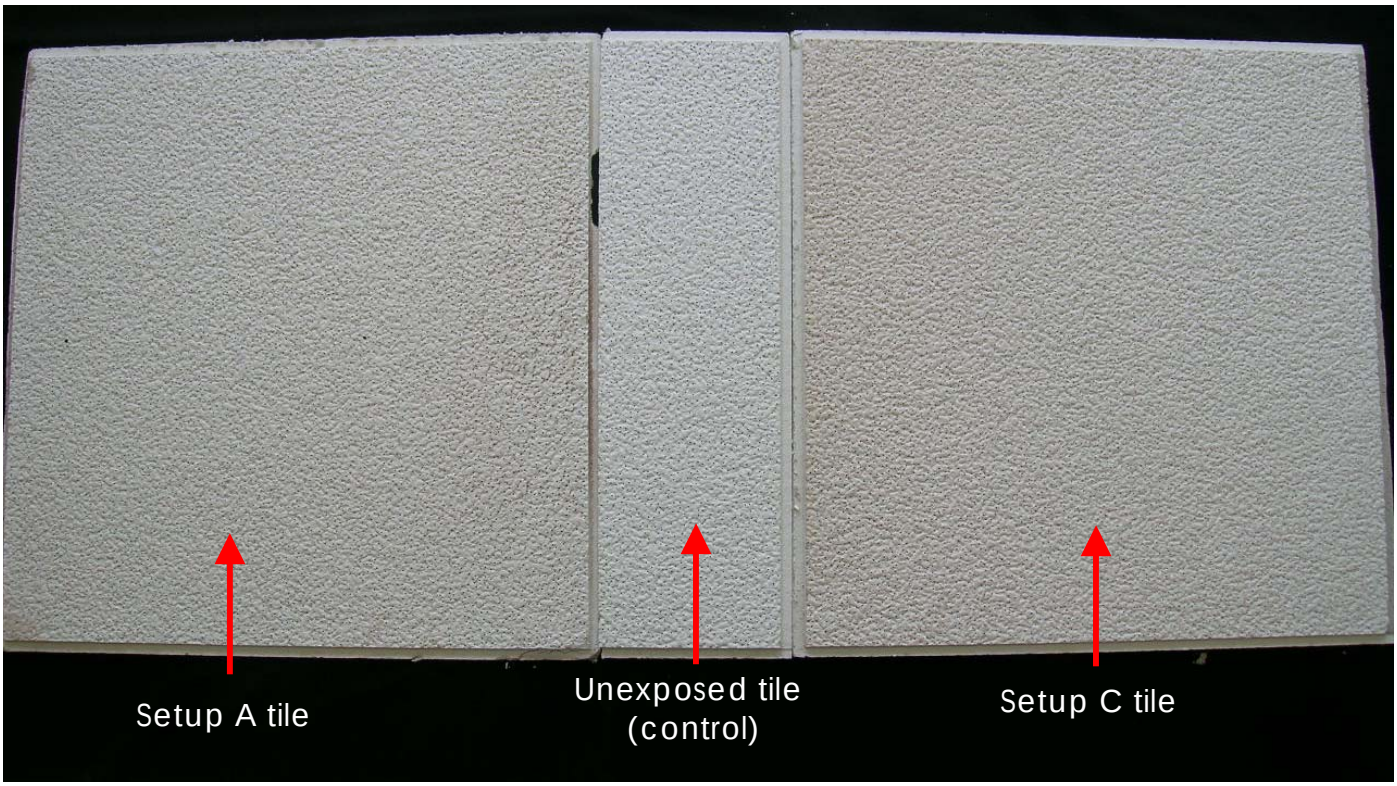

Figure 20: Comparison of Setups A and C to control tile

The top half in Figure 22 is a graph of the color values taken over the corresponding area in the bottom half. The three areas in the graph separated by the spikes correspond to the three tiles directly below the graph.

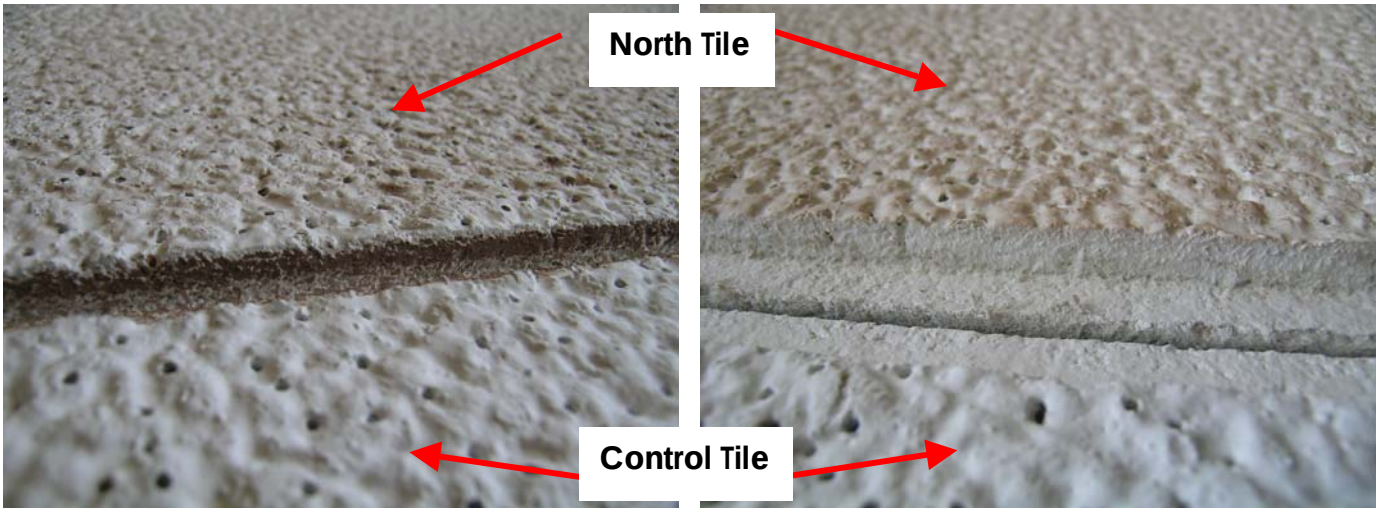

Figure 21:Comparison of dust accumulation along south edge of Setup A tile (left) and Setup C tile (right)

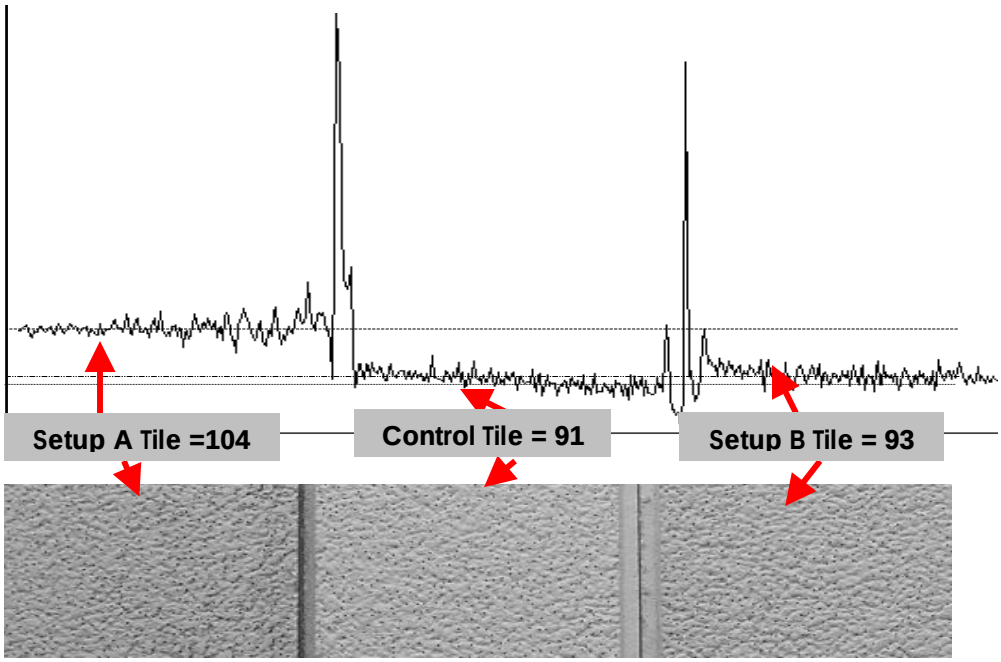

Figure 22: Average grayscale value comparison for Setup A tile, Setup B tile and Control tile.

The three values in Figure 22 were obtained by analyzing equally sized and shaped areas in the three regions of the image. The same process was repeated in the analysis of the image in Figure 20. The results are illustrated in Figure 23.

Figure 23 also shows that after approximately four times the amount of dust used in Setup A, the tile in Setup C has almost the same color index as that of Setup A (101 vs. 104, respectively).

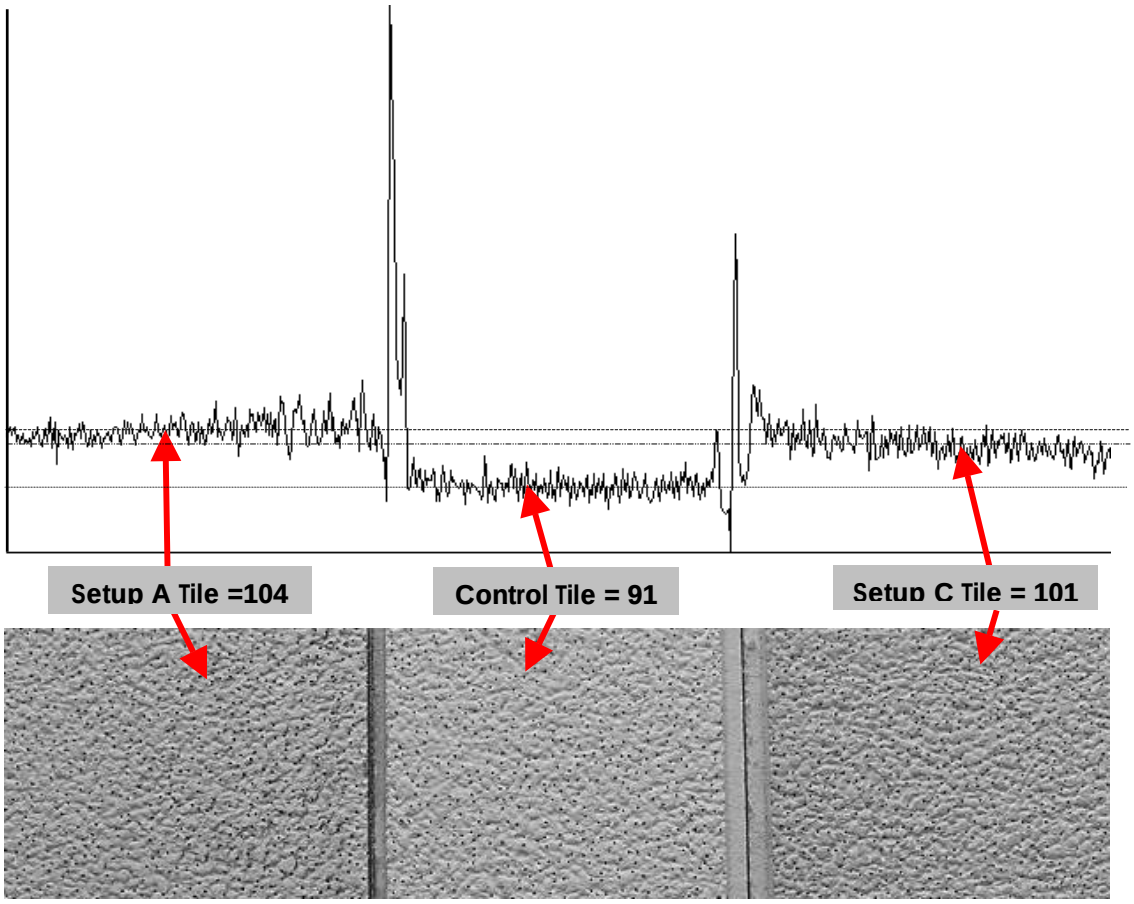

Figure 23: Average grayscale value comparison for Setup A tile, Setup C tile and Control tile.

7 Grid Compatibility

Ceiling grids are manufactured in a variety of sizes and profiles. However, there are three very common sizes and one most common profile. The common sizes of ceiling grids are; 1.5-inch, 15/16-inch and 9/16-inch, with an "exposed" grid profile. The grid size refers to the exposed width. The actual lip of a 15/16-inch grid that the deflector would sit on is about 50% of that total, or 0.468 inch (Figure 24).

It should be noted that air diffusers are matched to the specific grid opening created by various ceiling grid widths. The air deflector will not fit into the opening created by using a 1.5 inch grid because the four sides which create the square opening of the deflector cannot be reduced in size to accommodate a grid larger than 15/16. The tested air deflector would however fit into the opening created by the 15/16 or 9/16-inch size grid. Care must be taken to match the best fit between the air diffuser/grid and the air deflector especially since the 1.5-inch grid is mostly used in commercial buildings. One possible solution is that the air deflector be redesigned with breakaway tabs that will allow it to be easily modified in the field for use with different size grids.

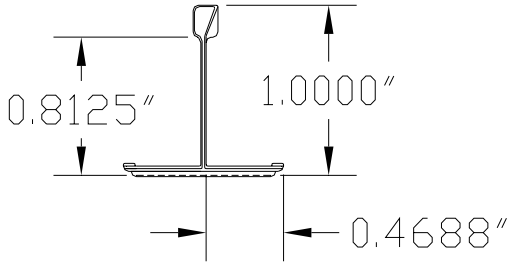

Figure 24: 15/16-inch grid support dimensions (end view).

8 Chemical Analysis

8.1 Method: An FTIR analysis was ran on the air deflector sample. The resulting curve is shown in the top half of Figure 25. A search was conducted from the scan library to determine the type of plastic. A match was found as shown in the bottom of Figure 25.

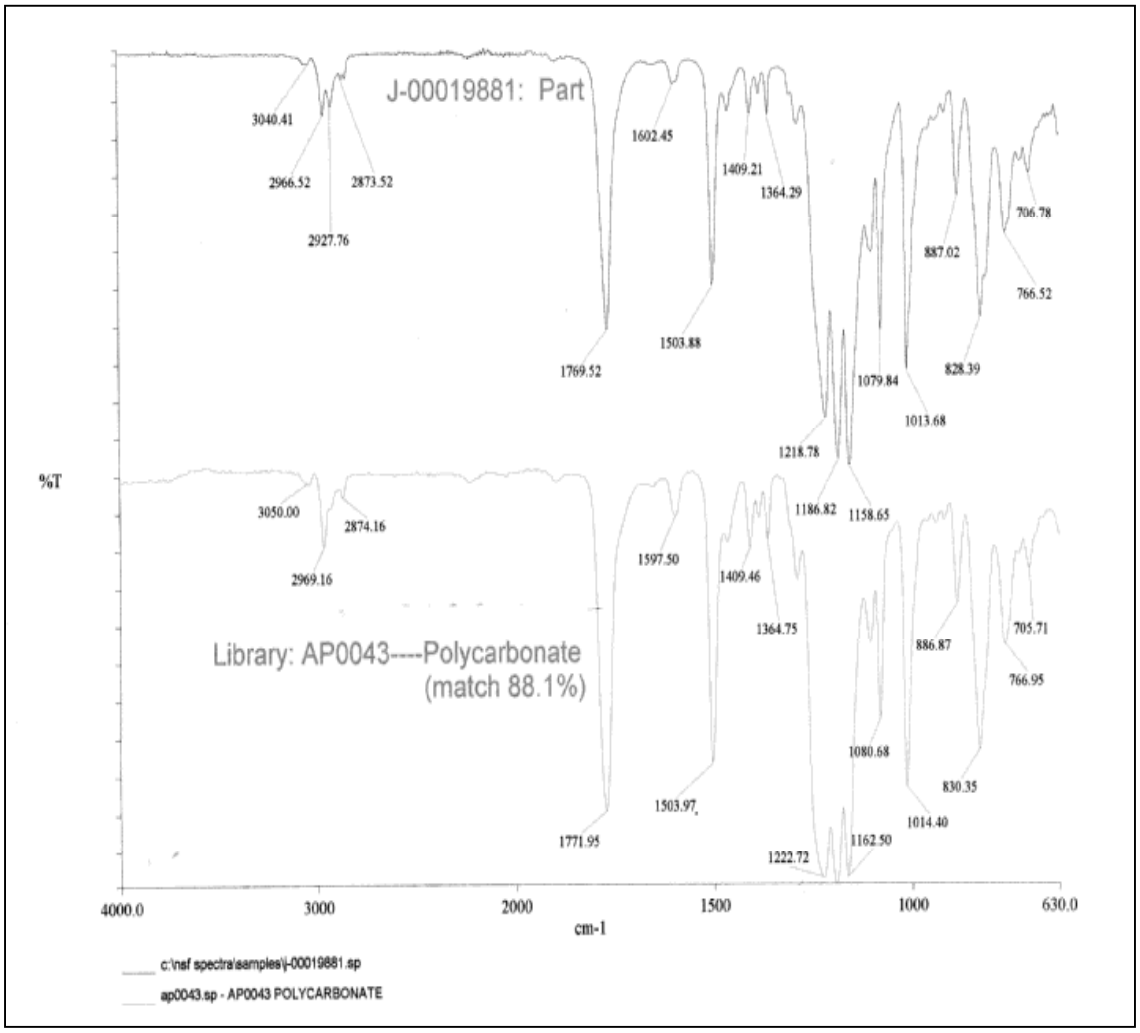

Figure 25: FTIR Scan of Air Deflector and Library Scan of Polycarbonate

8.2 Results

The Polycarbonate FTIR curve selected from the library had an 88% match with the FTIR curve obtained from the air deflector sample. Therefore the air deflector is determined to be a Polycarbonate material.

8.1 Service Life:

Table 5 summarizes the properties of Polycarbonate which appears to be a good material choice. Its mechanical and optical properties match the end use requirements. It is relatively strong and flexible – high tensile strength and high modulus. Of the materials reviewed, it had the lowest haze and highest transparency. Its only drawback is its poor chemical resistance to solvents.

Mechanical Properties	**PC**
Elongation at break	120-165 %
Tensile Strength	52-58 MPa
Flexural Modulus	1.9-2.2 GPa
Flexural Strength	76-87 MPa
Hardness	114-122
Izod Impact (J/cm)	1.1-9.5
Optical Properties	
Transparency	Clear
UV light resistance	Good
Chemical resistance	Poor (solvents) Good (acids)

Table 5: Physical Properties, PolyCarbonate.

8.2 Suggestion

In order to maximize the air deflector service life, it should not be directly exposed to sunlight. It will also require a good choice of cleaning agent – as mentioned above, aromatic hydrocarbons, halogenated compounds, oxygenated materials and concentrated acids will attack polycarbonate and reduce its service life. A window cleaning detergent or a sudsing dishwashing detergent may be used.

9. Flammability Analysis

9.1 Method:

The air deflector was evaluated for flammability according to ASTM Method D635. Flame was exposed to a specimen that was 0.5 inches wide, 4 inches long, and 0.08 inches thick as taken from a deflector. Flame exposure was for 30 seconds. After this time, the flame was removed and the time that the sample kept on burning as well as the flame travel distance was recorded, the data is presented in Table 6. A picture of the specimens after they had gone through the test is shown in Figure 26

9.2 Results:

Each of the five specimens tested did not burn after the flame was removed. During exposure to the flame, there was some melting and shrinking of the specimen. The specimens blackened with soot as a result of the flame exposure.

Sample Number	Flame Travel Distance (in)	Burning Rate (in/min)
1	0.19	0.38
2	0.16	0.33
3	0.35	0.69
4	0.36	0.71
5	0.29	0.59
6	0.24	0.47
7	0.50	1.00

Table 6: Flammability Test Specimen Results

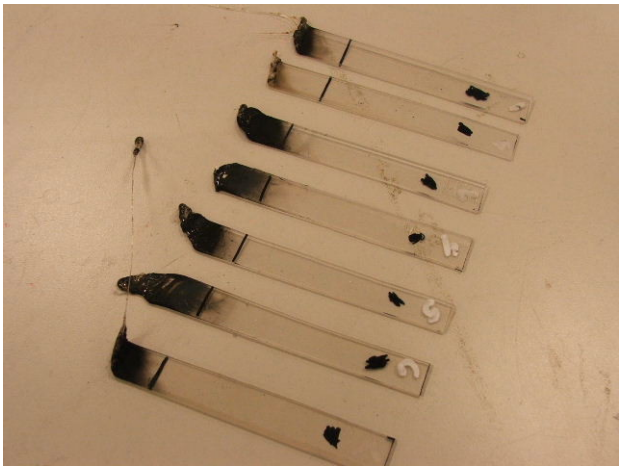

Figure 26: Samples After Flammability Test