REALTIME MEASUREMENT OF (PM-10) DUST LEVELS IN A CARPETED AND NON-CARPETED SCHOOL GYM ROOM

WA Turner[1,4 *], SC Caulfield[1], T Ellis[2] , R Lewia [3]

[1]Turner Building Science, LLC, The H.L. Turner Group Inc. Concord, NH, USA
[2]Collins & Aikman Floorcoverings, Dalton, GA, USA
[3]Maine Administrative School District #71, Kennebunk, ME, USA
[4]Air Diagnostics & Engineering Inc., Harrison, ME, USA

ABSTRACT
During the snow-covered period real-time (10-min. avg.) particle data were collected in two school gyms for fifteen weeks in Kennebunk, Maine, USA. VCT (Vinyl Composition Tile) floor covering was installed in one facility and VCTT (Vinyl Cushioned Tufted Textile) floor covering, referred to as a specialty high-grade commercial "carpet", was in the other. Intensive one-minute data was also collected during three "experiments" which evaluated the measured effect of typical sweeping, vacuuming, and burnishing of VCT. From the data it can be concluded that advances to contain breathable dust during burnishing activities are needed and that modern vacuum cleaning devices likely produce the least impact on indoor air quality. In the two rooms studied,,monitored (PM-10) dust levels were similar in the hard and soft-surface floors. The data points to a need to further understand factors that affect particle exposures in schools.

INDEX TERMS
PM-10, Dust Exposure, Floor Coverings, Cleaning, Carpet, VCT, Floor Maintenance

INTRODUCTION
It has generally been reported, and widely accepted, that many parameters affect the level of inhalable-sized (PM-10) dusts that are observed in a facility, (Turner1996). Data reported from the US EPA BASE study revealed average indoor (PM-10) levels generally less than one-half of outdoor levels vs. data reported in recent US school studies having average indoor levels greater than two (2) times the outdoor levels, (Ligman 1999). In recent years, the use of carpets or hard-surface flooring in school facilities has become a controversial topic for many school facility decision makers and health and safety personnel. The general controversy often involves conflicting perceived information regarding both the health of the occupants and maintenance personnel, and the cost benefits and drawbacks of hard-surface floors such as vinyl-composition tile (VCT) vs. a textile-type floor covering commonly referred to as commercial grade carpet. One specific concern that has been previously observed by one of the authors was surprising levels of airborne inhalable (PM-10) dusts levels observed to be as high as 200 μgm^3 above background during reported "dust mop cleaning" activities in a very dry classroom with VCT floor coverings, (Turner 1998). The mission undertaken within this pilot study was twofold. First, to begin to understand the impact that various common

[*] Contact author email: wturner@hlturner.com

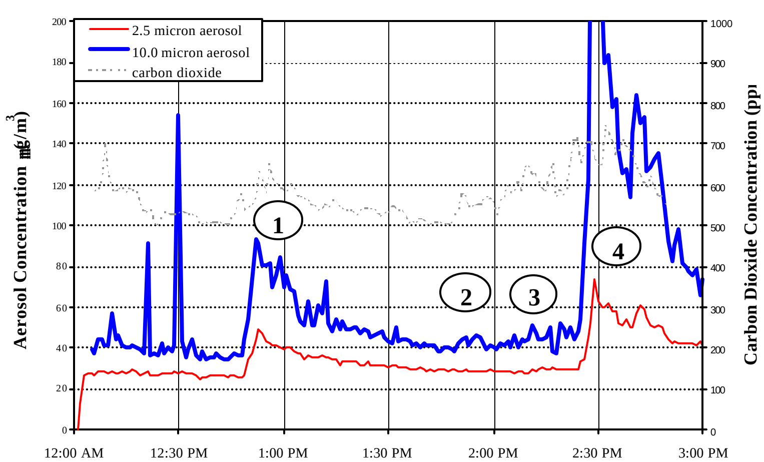
cleaning activities on VCT floors have on airborne breathable dust levels. Second, to begin to understand observed real-time PM-10 dust levels in comparable school spaces, one with a with a hard-surface VCT floor covering, the other with a specialty VCTT soft-surface floor covering.

METHODS

We will define the twofold pilot efforts as Experiment #1 - Cleaning, and Experiment #2 - Multi-day Flooring Comparison. In order to minimize the impact of the "outdoor" aerosol on these "indoor" experiments in real buildings (not a laboratory setting), the experiments were specifically scheduled climatologically during a time of year when the ground outside the facility location had continuous snow cover and thus outdoor levels would have minimum impact on indoor PM-10 levels.

Experiment #1 - Cleaning: The purpose of this experiment was to begin to understand the immediate effects of various types of non-powered, commonly-used push-device cleaning activities normally undertaken on VCT floors on airborne breathable particles. This experiment was set up in a normally occupied school hallway 37.2m (122ft) by 2.7m (8.8ft) with a 2.4m (8ft) ceiling height, on a day when occupants were not present. The hallway was allowed to accumulate dirt for a one-week period prior to cleaning. The hallway was divided into four equal lengthwise test strips.

Test #A on January 19, 2001. For this "cleaning" evaluation, four (4) different typical techniques were utilized: 1) a push broom with a commercial sweeping compound; 2) a clean dust mop treated with a commercial dust mop oil spray; 3) an used untreated dust mop; and 4) a plain old dry sweeping with a push broom with no sweeping compound. The dust levels were observed and then allowed to decay after each test strip was cleaned. Real time (PM-10) and (PM-2.5) dust levels were monitored (utilizing a TSI Dust trak device) with a one (1)-minute averaging period. In accordance with the manufacturers instructions, the real time (PM-10) data has been previously been correlated to four hour (PM-10) gravimeteric methods in schools utilizing an impactor often referred to as the Harvard Impactor suplied by Air Diagnostics & Engineering Inc. Carbon Dioxide, temperature, and relative humidity were also noted during the test runs for consistency.. Data from



this test is reported in Figure #1.

Figure 1. Experiment #1, Test "A" - School hallway with VCT during sweeping/dust-mopping operations on January 19, 2001.

Test #B on December 28, 2000. After allowing the hallway to accumulate dirt for one week, three different types of electric rotary burnishing devices were utilized: (#1) a state-of-the-art, battery-powered 2500-rpm device, (#2) a new plug-in 1500-rpm unit, and (#3) an older plug-in 1,000-rpm device. New pads were used for each test. All burnishing devices were utilized with a manufacturer-supplied dust collector bag. The same parameters were monitored as in Test #A. Data is reported in Figure#2.

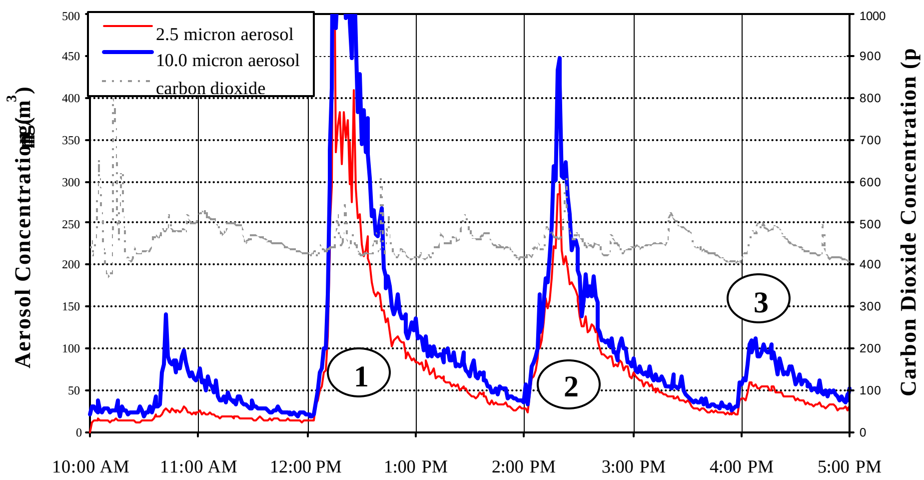


Figure 2. Experiment #1 - Test "B": School hallway with VCT during sweeping/ vacuuming/burnishing operations on December 28, 2000.

Test #C on January 26, 2001. The VCT hallway area above, and a 44m (143ft) by 3m (10ft) hallway with VCTT floor covering were utilized. Test (#1) on VCT, vacuum sweeper (battery-powered) with no brush; (#2) VCT, vacuum sweeper with brush; (#3) VCTT, backpack vacuum with HEPA; (#4) VCTT, vacuum sweeper with no brush on; (#5) vacuum sweeper with brush on VCTT. Data is reported in Figure# 3.

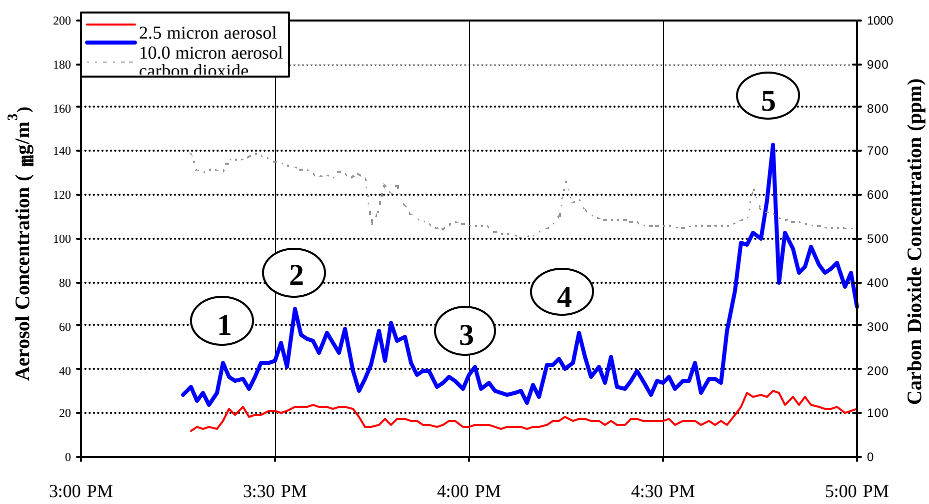


Figure 3. Experiment #1, Test "C" - School hallway with VCT (1,2) and VCTT (3-5) during sweeping/vacuuming operations on January 26, 2001.

Experiment #2 - Multi-day Flooring Comparison: The purpose of this experiment was to begin to understand observed real-time (ten min. avg.) (PM-10) dust levels experienced in comparable use spaces, one with a hard-surface VCT floor covering, the other with a VCTT soft-surface floor covering with a waterproof monolithic cushioned backing. After considerable review of available facilities within the district, two multipurpose type areas were identified for monitoring. The VCT room was 18.3m (60ft) by 30.5m (100ft) with an average ceiling height of 6.4m (21ft). The facility selected with the VCTT soft-surface flooring was 10.7m (35ft) by 18.3m (60ft) with a ceiling height of 7m (23ft). Room ventilation rates were determined via an average of several tracer decays to be 0.1ACH and 0.2 ACH respectively. For testing purposes, both rooms continued to be utilized for their normal activities and initially normal routine cleaning activities were conducted. Neither rooms had air recirculation devices which cleaned the air. Representative CO2 monitoring was conducted simultaneously in each location with a ten (10)-minute averaging period, as a general indicator of comparable occupancy and to quantify ventilation rates via tracer decay calculations. Real-time (PM-10) dust levels were monitored with a ten (10)-minute averaging period in both locations a two meter (seven foot) height for a total of 15 weeks of measurements excluding two holiday periods. Results of representative monitoring periods are graphically displayed and summarized in Figure # 4

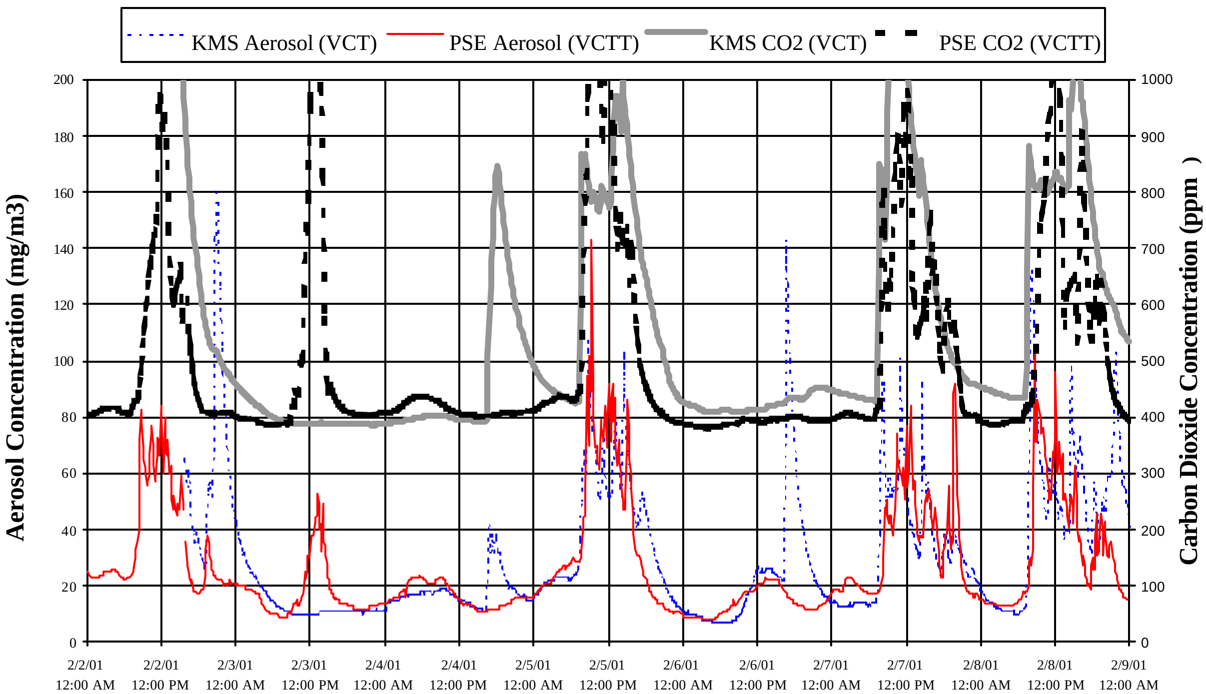


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Figure 4. Aerosol and carbon dioxide concentrations in two school gymnasiums (one with VCT flooring, one with VCTT flooring) recorded over a one-week period.

RESULTS AND DISCUSSION

Figure #1: VCT Floor Cleaning

This figure displays the results of the dry techniques used to clean the VCT . It can be observed that in this experiment sweeping utilizing a commercial sweeping compound and push broom had an impact on the airborne (PM–10) levels, as they doubled from 40 to 80 μgm^3 while the activity was occurring. This was much less of an impact than sweeping with a push broom with no compound in use, where the (PM-10 & PM-2.5) data both increased dramatically during the sweeping activity with the (PM-10) increasing to over five (5) times the background level of 40 μgm^3. From this data it is observed that dry mopping at room condition of 22% RH and normal room temperature had little impact on the measured airborne (PM-10 & PM-2.5).

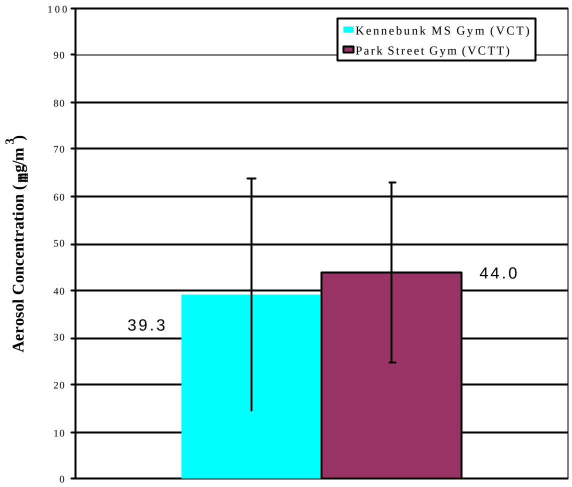

Figure 5. Average PM_{10} values recorded over a 15-week period, with one standard deviation error bars shown.

FIGURE #2: VCT Floor Burnishing

This figure displays the results of common rotary burnishing techniques typically required in a routine maintenance procedure on VCT. It can clearly be observed that in this experiment the higher burnishing speeds of the more modern units lead to higher (PM-10 & PM-2.5) levels in the air. In the worst case, the use of the most modern 2500 rpm equipment lead to levels elevated at ten (10) times the background level of 20–30 μgm^3 for a considerable time period after only 10 min. of burnishing.

Figure #3: Floor Vacuuming with Wide-body Sweeper Vacuum and Backpack Vacuum

Figure #3 displays the results of the use of a modern, convenient battery-powered wide-body vacuum/sweeper with a medium-efficiency exhaust filter on both VCT and VCTT soft-surface floor covering. It can clearly be observed that the wide-body vacuum sweeper had similar minor impact on the airborne levels for both hard and soft-surface materials until the optional external rotary brush feature (for edges) was utilized. The (PM-10) levels increase three (3) times when the edge brush was used on soft-surface flooring.

Figure #4: Comparison (PM-10) Data for One Week

This figure displays (PM-10) and Carbon Dioxide data for a one-week time period. It can be seen that CO_2 levels and daily patterns, as well as (PM-10) patterns are similar for the two different monitored rooms. Of particular interest is the evening (PM-10) spikes in the VCT room, where there is little elevation in the CO_2 data. At first it was expected these spikes might be related to a dance or basketball game. However, the CO_2 data does not confirm significant occupancy.

Figure #5 Comparison PM-10 Mean Data for 15 Weeks

This figure displays the mean data in the VCT and VCTT soft-surface room over a period of 15 weeks only during occupied periods of the day from 9 AM to 3 PM. From this data, it can be observed that the mean data, and variance of the means, for rooms with very different floor coverings are similar. It is likely that the slightly higher mean level in the VCTT soft-surface space is primarily driven by the greater occupant density of the facility at the noontime lunch hour.

CONCLUSIONS AND IMPLICATIONS

From these pilot study results of the VCT and VCTT soft-surface floor covering experiments, it can be suggested that several cleaning activities commonly utilized in school facilities could be exacerbating particle levels that have been observed by other studies in the United States. These methods include both dry "push broom" sweeping and common use of rotary electric high-speed burnishing devices. The elemental or chemical make-up of the observed significant levels of breathable dusts related to the burnishing of the VCT may be of interest regarding custodial worker health exposures. However, the determination of the heavy metal content or other chemical content of this material was beyond the scope of this study. The dusts observed to be kicked up by the external rotary corner cleaning brush on the vacuum sweeper could likely be reduced significantly by enclosing part of the brush within the vacuum airflow such as inside a suitable elastomeric boot.

In general, this cleaning experiment data suggests that use of the vacuum devices tested (vacuum sweepers and backpack vacuums) with sufficient exhaust filters (as equipped) would clean the floors and not be expected to exacerbate breathable (PM-10) particle exposures in schools. Review of the 15-week (PM-10) data set for the VCT and VCTT soft-surface floor covering suggests similar mean exposure levels for similar use. Again, the composition of the breathable particles was beyond the scope of this study.

The data from this study supports the need for additional particle exposure research in schools as it demonstrates that the (PM-10) particle levels may be either significantly exacerbated or reduced by modern cleaning techniques currently utilized in schools.

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REFERENCES

Ligman B, Casey M, Braganza F, *et al*. 1999. Airborne Particulate Matter Within School Environments in the United States, *Indoor Air '99*, Vol.4,p.255-260_

Turner WA, McKnight F, Bearg DW, *et al*. 1996. Indoor, PM –2.5, and Laser Optics Particle Sampling: How the Building Operator Can Benefit from this Type of Information, IAQ 96, /*Pathways to Better Building Environments/Poster Presentation*, pp. 210-217.

Turner WA. 1998. Unpublished data.