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An Exposure Assessment of Paper Dust in a Coupon Manufacturing Facility

Danny C. Fink
University of South Florida, dcfink12@gmail.com

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by

Danny C. Fink

A thesis submitted in partial fulfillment
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Major Professor: Rene R. Salazar, Ph.D.
Yehia Y. Hammad, Sc.D.
Steven P. Mlynarek, Ph.D.

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Dedication

I would like to dedicate this thesis to my grandma Clarice and my mother Linda. Thank you, both for providing me with a better life and supporting me through graduate school. Without you two I would not be as accomplished as I am today.

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A special thank you to Dr. Salazar for being a great professor and advisor throughout my undergraduate and graduate studies here at the College of Public Health. I also thank Dr. Mlynarek, Dr. Hammad, Dr. Bernard, and Dr. Smyth for the bulk of acquired skills and knowledge regarding industrial hygiene.

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List of Abbreviations and Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
AHU	Air Handling Unit
AIHA-LAP	American Industrial Hygiene Association – Laboratory Accreditation Programs
ARU	Air-Rotation Unit
DNG	Disposable Nitrile Gloves
IDLH	Immediately Dangerous to Life or Health
IPM	Inhalable Particulate Mass
NIST	National Institute of Standards and Technology
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
PNOR	Particulates Not Otherwise Regulated
PVC	Polyvinyl Chloride
PW	Pre-Weighted
RPM	Respirable Particulate Mass
TLV	Threshold Limit Value
TPM	Thoracic Particulate Mass
TWA	Time Weighted Average

Abstract

Purpose. Exposures to paper dust, classified as Particulates Not Otherwise Regulated (PNOR), in an industrial setting can cause irritation to the eyes, skin, throat and upper respiratory tract. An exposure assessment was conducted to evaluate the paper dust exposures in the coupon manufacturing facility during a normal production working period. ***Methods.*** Total and respirable personal dust sampling was performed according to NIOSH 0500 and 0600 methods. Six total dust samples and seven respirable dust samples were taken within the sampling areas where airborne paper dust was produced to evaluate the Time Weighted Average (TWA) of the exposed employees. ***Results.*** Results showed that the TWAs for total dust within the three sampling areas ranged from 0.4% to 4.7% of the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) and 0.5% to 7.1% of the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), except sample RD-4 in the Baler Room. TWAs for respirable dust within the Press Room and Collation Area ranged from 0.8% to 0.9% of the OSHA PEL for all samples and 1.4% to 1.5% of the ACGIH TLV. Descriptive statistics showed the sample standard deviation for both total and respirable dust to be below 1.0. The coefficient of variation for TWAs of total dust in the Press Room was 32.7% while all other total dust and respirable dust coefficient of variations for TWA ranged from 1.3% to 3.4%. ***Conclusion.*** Exposures to paper dust ranged from 0.4% to 7.1% of either the OSHA PEL or ACGIH TLV with an exception of sample RD-4 in the Baler Room which was 34% of the OSHA PEL and

56.7% of the ACGIH TLV. Identical respirable dust data and variable total dust data in the Press Room and Collation Area suggest that the dust being generated is of a larger particle size and therefore affects the nose, throat, and upper lungs. The engineering and administrative controls present appeared to be adequate based on the sampling data. Respiratory Personal Protective Equipment (PPE) was not considered a requirement but should be permitted if requested. Present workplace practices also appeared adequate based on the sampling data.

Chapter 1

Introduction

Inhalation is the most common route of exposure in an industrial setting (Jayjock, Lynch, Nelson & American Industrial Hygiene Association, 2000). Evaluation of exposures to airborne particulates, such as paper dust, is commonly done by performing total and/or respirable dust sampling. High total and/or respirable dust concentrations in the workplace can be an indicator of poor workplace hygiene and a need to improve engineering controls. An absence of literature on exposure to paper dust in a coupon manufacturing facility gives value to this exposure assessment.

Background

In the 470,000-square foot couponing manufacturing facility, workers were exposed to paper dust daily. The areas that received the largest number of complaints regarding paper dust exposure were the Press Room, Baler Room, and Collation Area. The facility was producing coupons 24 hours a day with three working shifts. Collaboration from the managers at the facility was solicited to perform the personal sampling during the days and shifts that had the highest production.

A dust exposure assessment had been performed by a certified industrial hygienist in 2008 for both the Press Room and the Baler Room. Descriptions of the Press Room, Baler Room, and Collation Area are based on the observations of a normal working shift.

Press Room

There were two large presses, Press #1 and Press #2, that were identical in design and one small press, Press #3, in the Press Room. The printed paper was folded and cut multiple times before being turned into a coupon. When the paper was cut, paper dust was produced. Paper dust is defined as Particulates Not Otherwise Regulated (PNOR) for sampling purposes. Around the press areas dust was visibly present, with higher levels of visible dust accumulation on the upper levels of the presses. Employees working the presses were generally not on the upper levels of the presses while the presses were running. Ventilation in this area consisted of supply air and return air vents. The two larger Air Handling Units (AHUs) each had been programmed to supply an air flow rate of 42,000 cubic feet per minute (cfm). The smaller AHU had been programmed to supply an air flow rate of 15,000 cfm.

Baler Room

The Baler Room contained paper balers and dust collection systems that used duct conveyances to collect paper scraps and paper dust from multiple locations inside the plant. Paper scraps were compressed and bound by wire in the large baler. Paper scraps on the floor left from the baler were swept by an employee with a broom and dustpan periodically. Three dust collectors operating in the Baler Room filtered out paper dust into a total of seven collection bins underneath the dust collectors. Collection bins were aluminum, 55-gallon drums that were lined with large bag liners. Drum bag liners were emptied by an employee periodically, leaving visible dust in the air when doing so. Employees wore National Institute for Occupational Safety and Health (NIOSH) N95 Particulate Respirators by Moldex while changing the collection bins.

There was no direct duct work in the Baler room, just a large fan that was not active at the time of the observation and the door leading outside was open often.

Collation Area

The Collation Area contained a series of conveyor systems and packing areas that took printed coupons and prepared them for shipping via boxes and totes. Some areas of the conveyor lines were covered to protect the employees from the machinery and prevent airborne paper dust. On part-1 of the collators, there was a build-up paper dust on the equipment. Employees reported concerns about the amount of dust exposure on the collators, in the folding section, and the imprinting section. Employees sometimes wore Disposable Nitrile Gloves (DNG) by ULINE while monitoring the coupon conveyor line. Safety glasses were available if needed by employees. Four Air-Rotation Units (ARUs) had been programmed to supply an air flow rate of 109,000 cfm each to ventilate the Collation Area.

SGS Galson Laboratories was used to rent all sampling equipment and analyze all sample media. Galson Laboratories has been accredited by the American Industrial Hygiene Association – Laboratory Accreditation Programs, LLC (AIHA-LAP) for 37 years. The accredited programs include industrial hygiene, environmental lead, and environmental microbiology. See Appendix C for laboratory reports and certification.

The purpose of the dust exposure assessment was to evaluate the paper dust exposures in the couponing manufacturing facility during a normal production working period.

Research Questions

The following research questions guided this assessment:

1) Does the TWA of employees exposed to total dust exceed the OSHA PEL and/or the ACGIH TLV?
2) Does the TWA of employees exposed to respirable dust exceed the OSHA PEL and/or the ACGIH TLV?
3) How do present paper dust exposure levels compare to the previous assessment in the Press Area and Baler Room?

Chapter 2

Literature Review

Exposures to Paper Dust

Currently, there is a lack of scientific studies in occupational settings that are exposed to paper dust daily. A cross-sectional study from 1976 to 1980 and 1981 to 1983 examined the concentration of paper dust in multiple areas of a soft tissue paper mill to determine if soft paper tissue dust exposure caused respiratory issues or reduced lung function. Three hundred and fifty-five individuals were classified as being exposed to low (<1 milligram per cubic meter (mg/m^3)), moderate (1-5 mg/m^3), or heavy (>5 mg/m^3) levels of dust. Of those exposed, a questionnaire was completed assessing the gender, smoking habits, years of employment, and respiratory symptoms. Results showed that paper dust being produced was of larger particle size and therefore affected the upper respiratory tract. Most symptoms reported were deposits in the nose along with a dry, irritated throat and coughing with or without phlegm. Heavily exposed employees reported symptoms more often than employees with low exposure (Ericsson, Jarvholm & Norin, 1988).

A similar study compared 37 employees with exposure to paper dust in a Swedish soft paper mill to 36 controls that were not exposed. The purpose was to determine if exposure to paper dust increased the risk of rhinitis. A questionnaire was given to all participating employees and all subjects were examined for weight, height, lung and nasal function, nasal transit time via mucociliary clearance, and personal dust

exposure via personal dust sampling. Smoking habits and years of employment were also assessed. With smoking being controlled for through statistical analysis, there was an increase in nasal deposits and obstruction among those exposed to paper dust. Symptoms were reported to also reduce the sense of smell. Results also showed that exposure to paper dust with an average inhalable dust exposure of 3.9 mg/m^3 was not linked with increased rates of rhinitis (Hellgren et al., 2001).

Paper Composition

Paper making has been around for well over a thousand years and today is used worldwide for manufacturing purposes. The components of modern paper pulp are α-cellulose, hemicellulose, lignin, extractives, minerals, and trace inorganic compounds. The lignins serve as an adhesive to cement the wood fibers together. Extractives include fats, alcohols, aromatic acids, alkaloids, and pigments. Paper pulp and fibers primarily come from softwoods, hardwoods, straw, bamboo, and cotton. Other paper additives are talc, titanium dioxide, alum ($Al_2(SO_4)_3$), rosin, clay, starch, dyes, and latex (International Labour Office, n.d.).

Particulate Matter

According to ACGIH, particles can be categorized into Respirable Particulate Mass (RPM), Thoracic Particulate Mass (TPM), and Inhalable Particulate Mass (IPM). RPM is composed of particles 10 micrometers (µm) or smaller in aerodynamic diameter and have a 50% aerodynamic diameter cut-point, also known as average particle size, of 4.0 µm. Respirable particles are capable of traveling to and depositing in the non-ciliated portion of the lower lungs where gas exchange takes place. TPM is composed of particles 25 µm or smaller in aerodynamic diameter and have a 50% aerodynamic

diameter cut-point of 10.0 µm. Thoracic particles travel to past the larynx and deposit in the upper lungs. IPM is composed of larger particles that have a 50% aerodynamic diameter cut-point of 100 µm. Inhalable particles enter in the nose and mouth (Plog & Quinlan, 2012).

The cyclones used in respirable dust sampling create a vortex and inertial separation that causes the larger particles to fall into the grit pot and selectively collect particles that are in the respirable fraction. Total dust sampling collects particles that vary in size and there is no clearly defined 50% aerodynamic diameter cut-point. Total dust particles can deposit anywhere in the respiratory tract.

The size of the particles, among other properties, will determine the site of deposition in the respiratory tract. The anatomy of the human respiratory tract contains nasal passages, oral passages, pharynx, larynx, trachea-bronchial tree, and the alveolar region. When inhaling through the nose, air passes through the hairs inside the nasal cavity to the nasopharynx. Impaction and sedimentation prevent a portion of the particles from going any further. Mucus produced inside the nasal cavity and pharynx helps carry the trapped particles. Particles that accumulate in the non-ciliated parts of the nasal cavity, including those in the nose hairs, are evacuated through sneezing, blowing, and wiping the nose. In the trachea-bronchial tree, particles can be collected via impact if the particle size is too large to travel the curves down the tree. Some particles will deposit in the smaller airways and the smallest will do so via diffusion. Many particles are cleared through the mucociliary escalator, others enter the esophagus and travel out the gastrointestinal tract. At the alveolar region, gas exchange occurs, and particles are cleared much slower due to lack of cilia and mucus. A portion

of the particles are captured by phagocytic cells and transported to the mucociliary escalator while another portion enters the lymphatic system via breaking through the wall of the alveoli. Yet another portion of the particles in this region will dissolve where deposited (Lippmann, 1970).

PNOR

OSHA and The American Conference of Governmental Industrial Hygienists (ACGIH) have exposure limits on PNOR for both total and respirable dust sampling. The OSHA 8-hour PEL for total and respirable dust classified as PNOR is 15 mg/m^3 and 5 mg/m^3 respectively. The ACGIH 8-hour TLV for total and respirable dust is 10 mg/m^3 and 3 mg/m^3 respectively. Exposures to paper dust, which is classified as PNOR or nuisance dust, can result in irritation to the eyes, skin, and upper respiratory system. The target organs that are associated with the symptoms are the eyes, skin, and respiratory system. There are no standards set for the NIOSH Immediately Dangerous to Life or Health (IDLH) concentration. The primary exposure route is inhalation in this situation and the secondary route is contact with the skin. Recommended first aid for respiratory symptoms is breathing fresh air and first aid for eye symptoms is to irrigate immediately (National Institute for Occupational Safety and Health, 2007).

Ventilation

AHUs treat the air before it is supplied to building(s) through ventilation ducts. Treatment of the air includes filtering, temperature control, and humidity control (AHU Magazine, 2015). ARUs are designed to deliver conditioned air to areas by circulating air at a low velocity. The ARUs retrieve return air from the vents located at the bottom of the ARU using a fan system, the air is checked for the correct temperature before being

released near the ceiling. The ARUs used in the couponing manufacturing facility are made by Johnson Air-Rotation System. Each of the ARUs by Johnson Air-System has the capacity to heat up to 150,000 square feet and/or cool 125,000 square feet and is unique because it does not require duct work (Johnson Air-Rotation, n.d.).

Dust Collectors

For air cleaning purposes, there are two primary types of cleaning devices: air filters and dust collectors. A dust collector is designed to be able to handle substantially higher loads than an air filter. Typically, the dust collector must have the ability to handle 100 to 200,000 times more dust than an air filter found in ventilation systems. Dry materials, such as the paper dust, can be collected with dry dust collection equipment. The collector can be unloaded into bags, covered drums, covered totes, pneumatic conveyors, and screw conveyors. Dry dust collectors can also have discharge valves which can be categorized as manual or continuous. Manual discharge valves include a dust door, dust gate, and slide gate. Continuous valves include trickle valve, rotary lock, and double dump valve (American Conference of Governmental Industrial Hygienists, 2004).

Chapter 3

Methods

Total & Respirable Dust in the Press Room

The purpose of doing total and respirable dust sampling was to measure the dust exposure of employees in the press room during a normal working shift.

Sampling occurred on June 28, 2016. The ambient pressure was 762.8 millimeters of mercury (mm Hg). The ambient temperature was 23.1˚C. The ambient relative humidity was 52.5%. Sampling also occurred on June 29, 2016. The ambient pressure was 762 mm Hg. The ambient temperature was 22.5˚C. The ambient relative humidity was 51.1%.

Figure 1 shows the front end of Press #2. The presses are where the printed paper was folded and cut multiple times before being turned into a coupon. Paper dust was produced during the paper cutting process. Figure 2 shows the front end side view of Press #3. This press was the most recently added press and noticeably smaller in size. Figure 3 shows the floor plan of the Press Room.

Figure 1. The front end of Press #2.

Figure 2. The front end side view of Press #3.

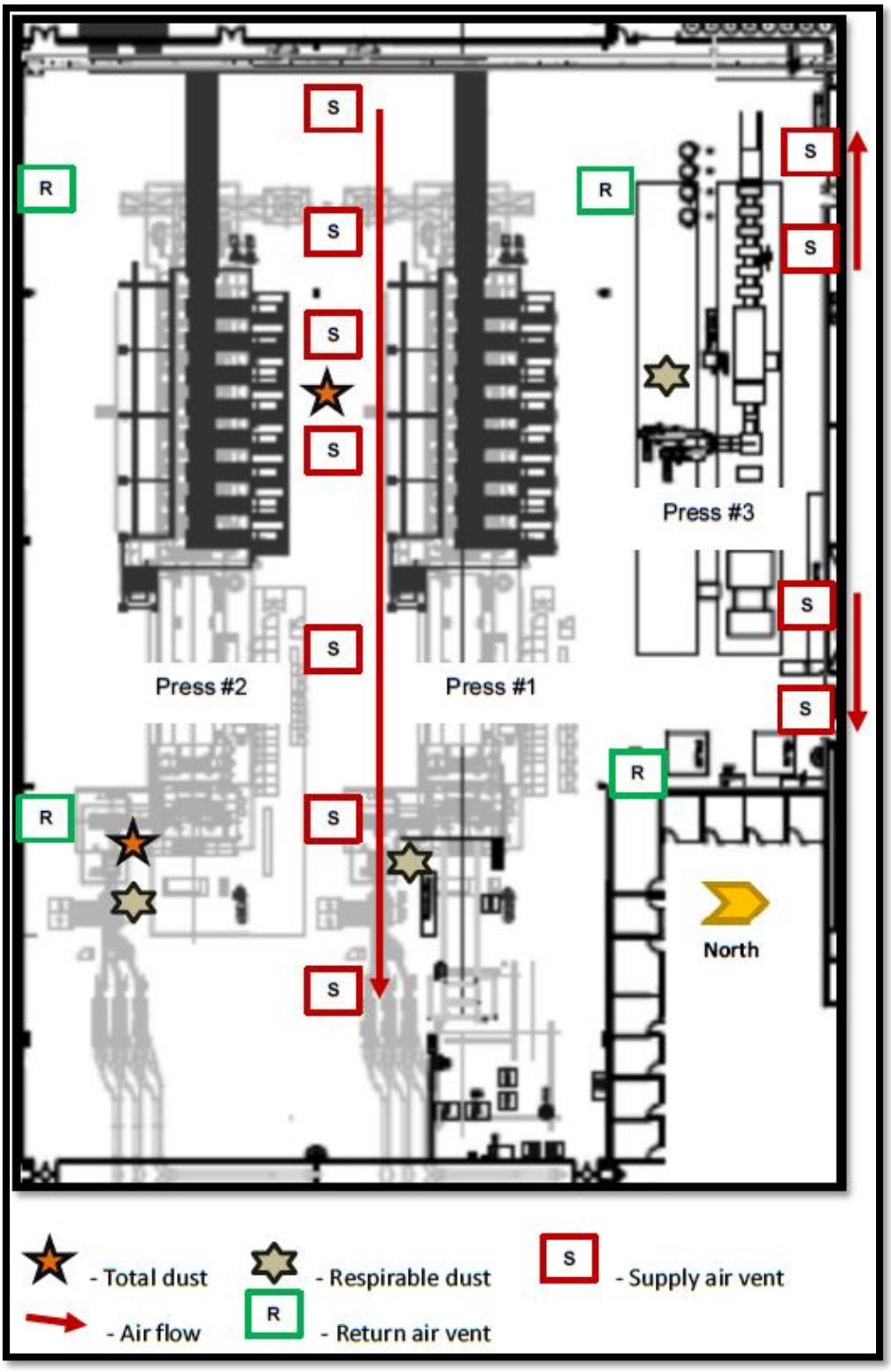

Figure 3. The floor plan for the Press Room.

As shown in Figure 3, the sampling took place near printing presses in the Press Room. Both Press #1 and Press #2 were identical in design while Press #3 was a smaller press with a different design. Calibration began by using a National Institute of Standards and Technology (NIST) Certified, Defender 510-M Primary Flow Meter (Brandt Instruments Inc., Prairieville, LA) to calibrate five AirChek 52 Personal Sampling Pumps (SKC Inc., PA). For total dust, the pumps were calibrated to the recommended 2.0 Liters per minute (Lpm). For respirable dust, Aluminum Cyclones (SGS Galson Laboratories, East Syracuse, NY) were used and the flow rate was calibrated to the recommended 2.5 Lpm.

Two Pre-Weighted (PW) Polyvinyl Chloride (PVC) 37 mm dia., 5 µm pore size, 2-piece cassette and filter sets (SGS Galson Laboratories, East Syracuse, NY) used for total dust sampling were labeled TD-1 and TD-2. One field blank was labeled TD Blank 1. Three PW PVC 37 mm dia., 5 µm pore size, 3-piece cassette and filter sets (SGS Galson Laboratories, East Syracuse, NY) used for respirable dust sampling were labeled RD-1, RD-2, and RD-3. One field blank was labeled RD Blank 1.

TD-1 and RD-2 were placed near Press #1.TD-2 and RD-1 were placed at Press #2 (see Figure 1). RD-3 was placed at Press #3 (see Figure 2).

NIOSH sampling methods 0500 and 0600 were used for total and respirable dust sampling (National Institute for Occupational Safety and Health, 1998). Ambient temperature and relative humidity were measured in the sampling area using a 971 Temperature Humidity Meter (Fluke Corporation, Singapore). Employees were in the sampling locations the entire shift and had the AirChek 52 Personal Sampling Pumps on during their breaks from the area. After the sampling period ended, the sampling times were recorded, sample media were stored properly, and a post-calibration was performed on the AirChek 52 Personal Sampling Pumps using the Defender 510-M Primary Flow Meter.

Total & Respirable Dust in the Baler Room

The purpose of doing total and respirable dust sampling was to measure the amount of total and respirable dust exposure of employees during a normal work shift.

Sampling occurred on June 29, 2016. The ambient pressure was 762 mm Hg. The ambient temperature was 25˚C. The ambient relative humidity was 51.1%.

Figure 4 shows the Baler Room work area. This was where the paper waste was formed into bales before it was sent off for recycling. Figure 5 shows Dust Collector #1. This was one of three dust collector spots. Dust Collectors #1 and #2 had three collection bins underneath, while Dust Collector #3 had one collection bin. Figure 6 shows the floor plan for sampling in the Baler Room. This figure illustrates the sampling points, fan location, and dust collectors.

Figure 4. The Baler Room work area.

Figure 5. Dust Collector #1.

Figure 6. The floor plan for sampling in the Baler Room.

As shown in Figure 4, the Baler Room is an area that holds paper scraps. As shown in Figure 5, collection bins under the dust collectors were emptied during the sampling period. Calibration began by using a NIST Certified, Defender 510-M Primary Flow Meter to calibrate two AirChek 52 Personal Sampling Pumps. For total dust, the pump was calibrated to the recommended 2.0 Lpm. For respirable dust, an Aluminum Cyclone was used and the flow rate was calibrated to the recommended 2.5 Lpm.

One PW PVC 37 mm dia., 5 µm pore size, 2-piece cassette and filter set used for total dust sampling was labeled TD-3 and one field blank was labeled TD Blank 2. One PW PVC 37 mm dia., 5 µm pore size, 3-piece cassette and filter set used for respirable dust sampling was labeled RD-4 and one field blank was labeled RD Blank 2.

TD-3 was placed at Dust Collector #1 and RD-4 was placed at Dust Collectors #2 and #3 (see Figure 6).

Ambient temperature and relative humidity were measured in the sampling area using a 971 Temperature Humidity Meter. Employees had the AirChek 52 Personal Sampling Pumps on during their entire working shift and during their breaks from the area. Two collection bins were emptied from Dust Collector #1, one bin was emptied from Dust Collector #2, and one bin was emptied from Dust Collector #3. After the sampling period ended, the sampling times were recorded, sample media were stored properly, and post-calibration was performed on the AirChek 52 Personal Sampling Pumps using the Defender 510-M Primary Flow Meter.

Total & Respirable Dust in the Collation Area

The purpose of doing total and respirable dust sampling was to measure the amount of total and respirable dust exposure of employees in the Collation Area during a normal working shift.

Sampling occurred on July 27, 2016. The ambient pressure was 763.5 mm Hg. The ambient temperature was 22.6˚C. The ambient relative humidity was 55.9%.

Figure 7 shows a folding section of the Collation Area. The folding section was where the coupons were folded with the assistance of machines. Complaints of airborne dust in this section occurred often. Figure 8 shows an imprinting section in the Collation Area. The imprinting section was where the coupon packets were imprinted on and fanned to prevent them from sticking together. Complaints of airborne dust occurred often during the fanning of the coupons. Figure 9 shows part-1 of a collator. This part of the collator prepared the coupons down the conveyor system. Complaints of airborne dust occurred in this part of the collator. Figure 10 shows part-2 of a collator. This part of the collator placed coupons in postal totes and prepared them to be shipped. Figure 11 shows the floor plan of the Collation Area. This floor plan illustrates the sampling points and ventilation design.

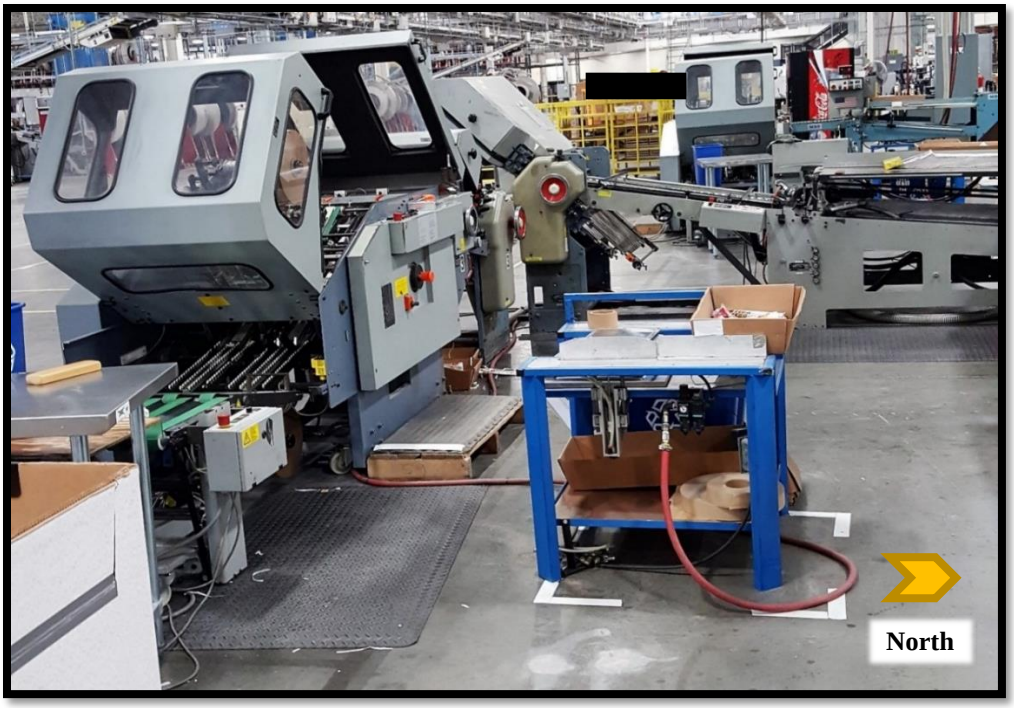

Figure 7. A folding section of the Collation Area.

Figure 8. An imprinting section of the Collation Area.

Figure 9. Part-1 of a collator.

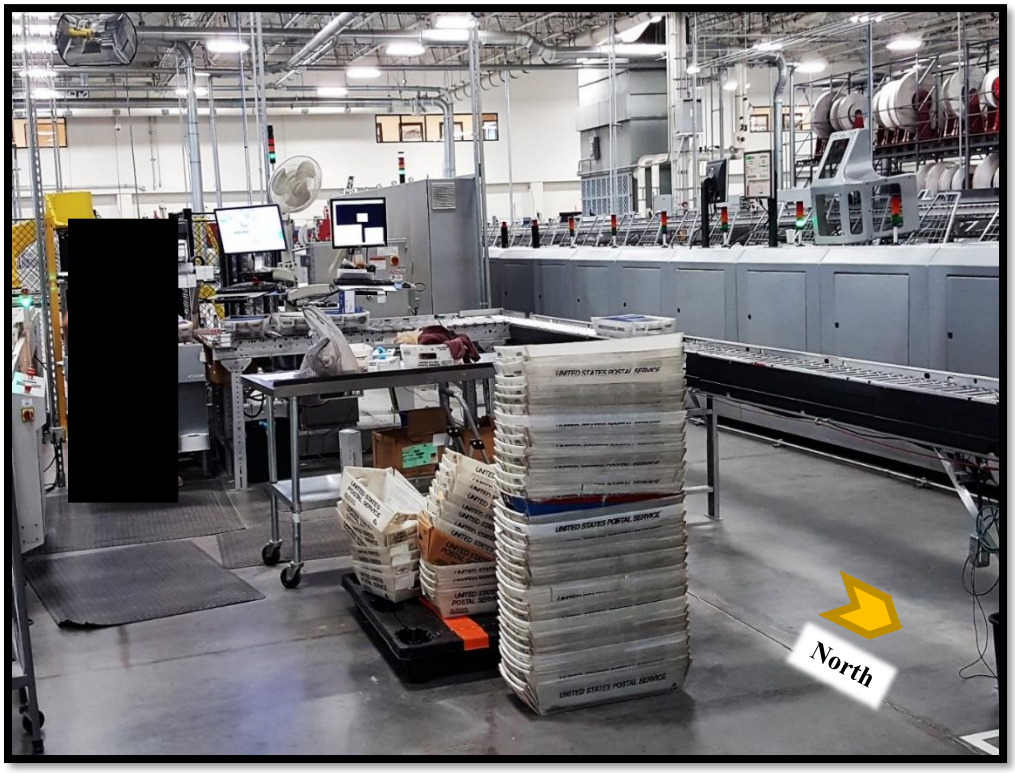

Figure 10. Part-2 of a collator.

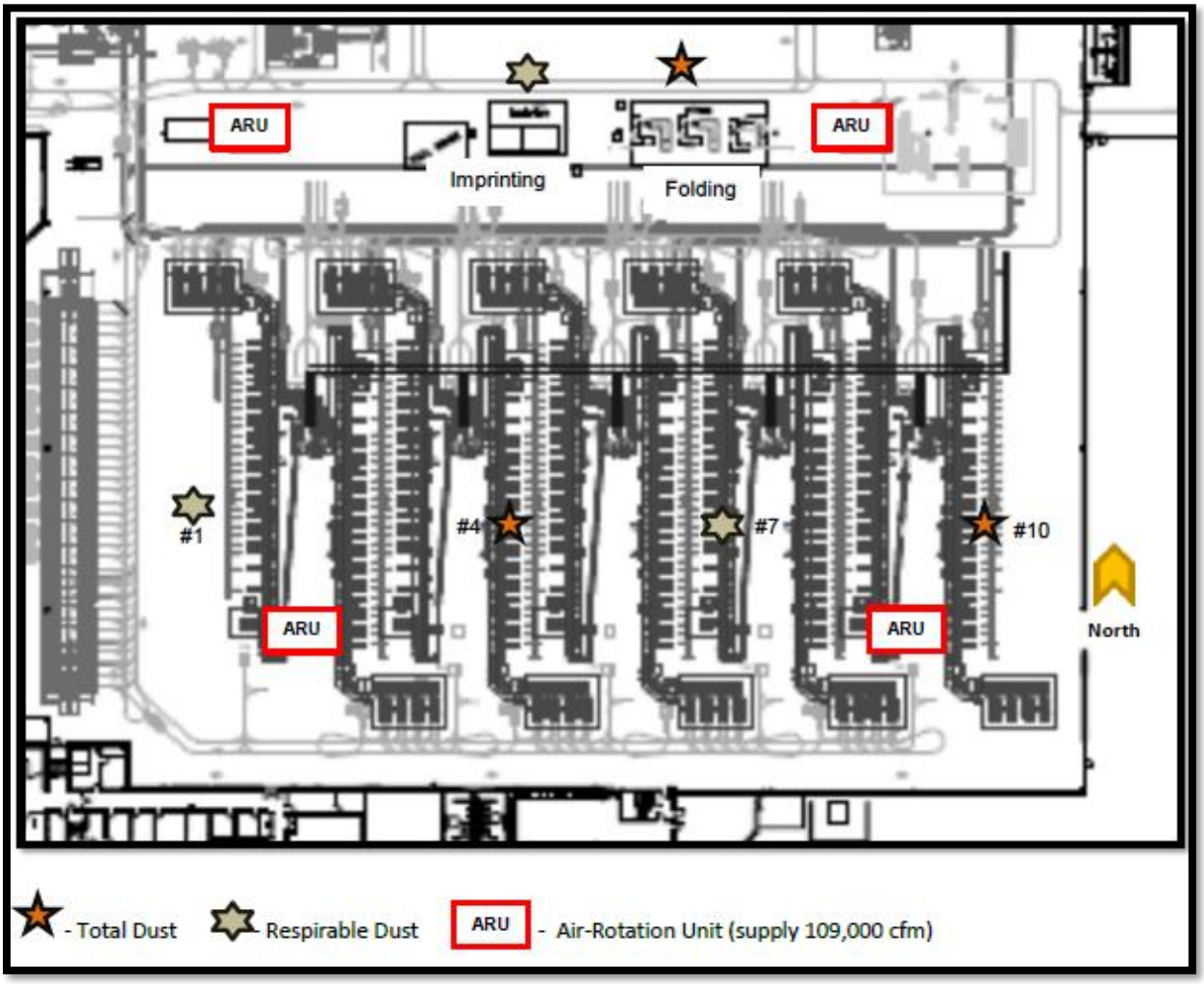

Figure 11. The floor plan of the Collation Area.

As shown in Figures 7-10, there are multiple sections of the Collation Area that required employees to perform different tasks. Calibration began using a NIST Certified, DryCal DCL-M Primary Flow Meter (Bios International Corporation, Butler, NJ) to calibrate six GilAir3 Personal Air Samplers (Sensidyne Inc., Clearwater, FL).

For total dust, the pumps were calibrated to the recommended 2.0 Lpm. For respirable dust, Aluminum Cyclones were used and the flow rate was calibrated to the recommended 2.5 Lpm.

Three PW PVC 37 mm dia., 5 µm pore size, 2-piece, close-faced cassette and filter sets (SGS Galson Laboratories, East Syracuse, NY) used for total dust sampling were labeled TD-1, TD-2, and TD-3. Two field blanks were labeled TD Blank 1 and TD Blank 2. Three PW PVC 37 mm dia., 5 µm pore size, 3-piece cassette and filter sets used for respirable dust sampling were labeled RD-1, RD-2, and RD-3. Two field blanks were labeled RD Blank 1 and RD Blank 2.

TD-1 was placed at Collator #4, TD-2 was placed at the folding section (see Figure 7), and TD-3 was placed at Collator #10. RD-1 was placed at Collator #1, RD-2 was placed at Collator #7, and RD-3 was placed at the imprinting section (see Figure 8).

Ambient temperature and relative humidity were measured in the sampling area using a 971 Temperature Humidity Meter. Employees were in the sampling locations the entire shift and had the GilAir3 Personal Air Samplers on during their breaks from the area. After the sampling period ended, the sampling times were recorded, sample media were stored properly, and post-calibration was performed on the GilAir3 Personal Air Samplers using the DryCal DCL-M Primary Flow Meter.

Chapter 4

Results

Press Room

Results in Table 1 present total dust - PNOR in the Press Room. Table 2 presents respirable dust - PNOR in the Press Room. Table 3 presents the past and present total dust comparison in the Press Room.

Table 1. Total Dust - PNOR in the Press Room

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
TD-1	2.02	2.02	499	1008	0.075	0.075	15	0.5%	10	0.7%
TD-2	2.03	1.99	486	977	0.12	0.12	15	0.8%	10	1.2%

Note: See Methods for the designated area of each sample.

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA | / 8-hr OSHA PEL or ACGIH TLV)) x 100

Table 2. Respirable Dust - PNOR in the Press Room

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
RD-1	2.52	2.47	444	1110	0.045	0.045	5	0.9%	3	1.5%
RD-2	2.51	2.42	449	1109	0.045	0.045	5	0.9%	3	1.5%
RD-3	2.51	2.44	458	1136	0.044	0.044	5	0.9%	3	1.5%

Note: See Methods for the designated area of each sample.

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA| / 8-hr OSHA PEL or ACGIH TLV)) x 100

Table 3. Past and Present Total Dust Comparison in Press Room

Sample #	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)
Average of TD-1&TD-2[3]	493	993	0.098	0.098
080313-01[3]	590	1246	0.16	0.16
% Difference[2]	16.4%	20.3%	38.8%	38.8%

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % Difference = (|Avg. of Present Samples - Past Sample| / Past Sample) x 100

[3] TD-1 & TD-2 were sampled June 28, 2016; 080313-01 was sampled March 13, 2008

Baler Room

Results in Table 4 present total dust - PNOR in the Baler Room. Table 5 presents respirable dust - PNOR in the Baler Room. Table 6 presents the past and present total dust comparison in the Baler Room.

Table 4. Total Dust - PNOR in the Baler Room

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
TD-3	2.05	2.05	470	964	0.71	0.71	15	4.7%	10	7.1%

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA |/ 8-hr OSHA PEL or ACGIH TLV)) x 100

Table 5. Respirable Dust - PNOR in the Baler Room

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
RD-4[3]	2.51	2.48	12	30	1.7	1.7	5	34.0%	3	56.7%

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA |/ 8-hr OSHA PEL or ACGIH TLV)) x 100

[3] RD-4 experienced pump failure. See Discussion for details.

Table 6. Past and Present Total Dust Comparison in Bailer Room

Sample #	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)
TD-3[3]	470	964	0.71	0.71
080222-01[3]	542	1103	0.16	0.16
% Difference[2]	13.3%	12.6%	343.8%	343.8%

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % Difference = (|Present Samples - Past Sample| / Past Sample) x 100

[3] TD-3 was sampled June 29, 2016; 080222-01 was sampled February 22, 2008

Collation Area

Results in Table 7 present total dust - PNOR in the Collation Area. Table 8 presents respirable dust - PNOR in the Collation Area.

Table 7. Total Dust - PNOR in the Collation Area

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
TD-1	2.02	1.98	460	920	0.054	0.054	15	0.4%	10	0.5%
TD-2[3]	2.03	1.93	444	879	0.057	0.057	15	0.4%	10	0.6%
TD-3[4]	2.02	1.69	447	831	0.057	0.057	15	0.4%	10	0.6%

Note: See Methods for the designated area of each sample.

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA |/ 8-hr OSHA PEL or ACGIH TLV)) x 100

[3] TD-2 experienced pump failure and was promptly reset to resume sampling. See Discussion for details.

[4] TD-3 appeared to restart itself sometime during the end of the sampling period. See Discussion for details.

Table 8. Respirable Dust - PNOR in the Collation Area

Sample #	Pre-Sampling Flow Rate (Lpm)	Post-Sampling Flow Rate (Lpm)	Sample Time (min)	Sample Volume (L)	Sample Conc. (mg/m^3)	TWA[1] (mg/m^3)	OSHA 8-hr PEL (mg/m^3)	% of Exposure Limit[2]	ACGIH 8-hr TLV (mg/m^3)	% of Exposure Limit[2]
RD-1	2.51	2.66	458	1186	0.042	0.042	5	0.8%	3	1.4%
RD-2	2.50	2.42	451	1109	0.045	0.045	5	0.9%	3	1.5%
RD-3	2.50	2.41	458	1127	0.044	0.044	5	0.9%	3	1.5%

Note: See Methods for the designated area of each sample.

[1] TWA = (1 / total time) * ($conc_1$*$time_1$ + $conc_2$*$time_2$ + …. + $conc_n$*$time_n$)

[2] % of Exposure Limit = (1 - (| 8-hr OSHA PEL or ACGIH TLV - TWA |/ 8-hr OSHA PEL or ACGIH TLV)) x 100

Descriptive Statistics

From the Press Room and the Collation Area, Table 9 presents the descriptive statistics for the TWA in the Press Room. Table 10 presents the descriptive statistics for the TWA in the Collation Area.

Table 9. Descriptive Statistics for TWA in the Press Room

Sampling procedure	Sample size	Sample mean (mg/m^3)	Sample standard deviation[1] (mg/m^3)	Coefficient of variation[2]
Total dust	2	0.098	0.032	32.7%
Respirable dust	3	0.045	0.00058	1.3%

[1] Sample standard deviation (mg/m^3) = $\sqrt{[\sum (Sample_x - Sample\ mean)^2] / (Sample\ size - 1)}$

[2] Coefficient of variation = (Sample standard deviation (mg/m^3) / Sample mean (mg/m^3))

Table 10. Descriptive Statistics for TWA in the Collation Area

Sampling procedure	Sample size	Sample mean (mg/m^3)	Sample standard deviation[1] (mg/m^3)	Coefficient of variation[2]
Total dust	3	0.056	0.0017	3.0%
Respirable dust	3	0.044	0.0015	3.4%

[1] Sample standard deviation (mg/m^3) = $\sqrt{[\sum (Sample_x - Sample\ mean)^2] / (Sample\ size - 1)}$

[2] Coefficient of variation = (Sample standard deviation (mg/m^3) / Sample mean (mg/m^3))

Chapter 5

Discussion

The following research questions were used to guide the process of completing a successful dust exposure assessment in the couponing manufacturing facility.

1) Does the TWA of employees exposed to total dust exceed the OSHA PEL and/or the ACGIH TLV?
2) Does the TWA of employees exposed to respirable dust exceed the OSHA PEL and/or the ACGIH TLV?
3) How do present paper dust exposure levels compare to the previous assessment in the Press Area and Baler Room?

Research Question One

There was a total of six total dust samples. All sampling blanks for total dust sampling were below the level of quantitation. See Appendix C for details.

Press Room. Table 1 shows the percent of exposure limit for total dust to be 0.5 to 0.8% of the OSHA PEL and 0.7% to 1.2% of the ACGIH TLV.

There were no known or observed systematic errors that occurred. No known or observed gross errors occurred.

Baler Room. Table 4 shows the percent of exposure limit for total dust to be 4.7% of the OSHA PEL and 7.1% of the ACGIH TLV.

There were no known or observed systematic errors that occurred. No known or observed gross errors occurred.

Collation Area. Table 7 shows the percent of exposure limit for all samples to be exactly 0.4% of the OSHA PEL and range from 0.5% to 0.6%% of the ACGIH TLV.

A known systematic error occurred when the pump with sample TD-2 failed approximately four hours into sampling as noticed by the employee. There was no likely or known cause for the sampling pump failure. I promptly reset the sampling pump and sampling resumed within 20 minutes. The pump for sample TD-3 also appeared to reset itself during the sampling period even though it was working the whole shift. For TD-3, the 447-minute work shift was used for sampling calculations. The cause of the sampling pump restarting itself was unknown. No known or observed gross errors occurred.

Research Question Two

There was a total of seven respirable dust samples. All sampling blanks for respirable dust sampling were below the limit of quantitation. See Appendix C for details.

Press Room. Table 2 shows the percent of exposure limit for all samples to be exactly 0.9% of the OSHA PEL and 1.5% of the ACGIH TLV.

There were no known or observed systematic errors that occurred. No known or observed gross errors occurred.

Baler Room. Table 5 the percent of exposure limit to be 34.0% of the OSHA PEL and 56.7% of the ACGIH TLV. Sample RD-4 likely had a higher percent of the exposure limit due to the systematic error explained in the following paragraph.

A systematic error occurred because there was a pump failure for sample RD-4 during the shift. The cause of the failure was unknown and the actual sampling time was unknown so the 12-minute sampling time recorded by the pump was used due to this error. The pump was likely running longer than 12-minutes but there was no way to determine how many times the sampling pump had reset itself. No known or observed gross errors occurred.

Collation Area. Table 8 shows the percent of exposure limit ranged from 0.8% to 0.9% of the OSHA PEL and 1.4% to 1.5% of the ACGIH TLV.

There were no known or observed systematic errors that occurred. No known or observed gross errors occurred.

Research Question Three

Press Room. Table 3 shows the percent difference, which is the comparison between the two experimental values, of total dust in 2008 yielded a TWA that was 38.8% higher than the average of the total dust samples done in this exposure assessment.

Baler Room. Table 6 shows the percent difference of the total dust sample from this exposure assessment yielded a TWA that was 343.8% higher than the sample done in 2008. The more than 3-fold difference could have been due to the dust collector bins

being a quarter of the way full, causing dust to disperse in the air because the workers were working to get the task done as soon as possible. Wear and tear on the equipment over eight years could have also contributed to the difference in sampling results.

Descriptive Statistics

Tables 9 and 10 show that the sample standard deviation for both total dust and respirable dust is well under 1.0, indicating an extremely small variation among the samples. The coefficient of variation indicates the spread of the sample results, with the largest coefficient of variation at 32.7%. The other three coefficient of variations shown in the Tables 9 and 10 range from 1.3% to 3.4%. The small percentage indicates a very small spread of sample results. As a rule of thumb, the smaller the standard deviation and coefficient of variation, the greater the precision.

Limitations

Limited financial resources and time lead to a small sample size. The small sample size included six total dust samples and seven respirable dust samples. Having a small sample size lead to having statistics that were insufficient to be representative of the sample population. Another limitation would be the literature of paper dust exposure in facilities that create coupons or that have similar processes.

Chapter 6

Conclusion

Exposures to paper dust ranged from 0.4% to 7.1% of either the OSHA PEL or ACGIH TLV with an exception of sample RD-4 in the Baler Room which was 34% of the OSHA PEL and 56.7% of the ACGIH TLV. The exposure to paper dust was not over the exposure limit and was low based on the data. The respirable dust samples from the Press Room and Collation Area ranged from 0.8% to 0.9% of the OSHA PEL and 1.4% to 1.5% of the ACGIH TLV. Identical respirable dust data and variable total dust data in the Press Room and Collation Area suggest that the dust being generated is of a larger particle size and therefore affects the nose, throat, and upper lungs. The engineering and administrative controls present at the time appeared to be adequate based on the sampling data. Respiratory Personal Protective Equipment (PPE) was not required but should be permitted if employees choose to wear it. Employees were educated on the results of the assessment and how it affects them. Present workplace hygiene practices, which included vacuuming, sweeping, maintaining a clutter-free work area, and performing maintenance on working equipment appeared adequate based on the sampling data.

Future Research

Increasing the sample size large enough to be representative of the sample population working at the facility would be better for statistical significance. Performing an exposure assessment in other couponing facilities or facilities with similar exposures

and processes would be beneficial for contributing to the general body of literature. Long-term cross-sectional studies, like those mentioned in the literature review, would be great to assess and evaluate the long-term health effects of workers exposed to paper dust frequently.

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Appendices

Appendix A: Equipment List

Cassette and Filter sets, PW PVC 37 mm dia., 5 µm pore size, 2-piece
SGS Galson Laboratories
6601 Kirkville Road,
East Syracuse, NY 1305, USA
Quantity – 10

Cassette and Filter sets, PW PVC 37 mm dia., 5 µm pore size, 3-piece
SGS Galson Laboratories
6601 Kirkville Road,
East Syracuse, NY 1305, USA
Quantity – 10

Cyclones, Aluminum
SGS Galson Laboratories
6601 Kirkville Road,
East Syracuse, NY 1305, USA
Quantity – 6

Personal Air Sampler
Sensidyne, Inc.
16333 Bay Vista Drive
Clearwater, FL 33760, USA
Model – GilAir3
Serial No. – 20160503020, 20160601001, 2016061002, 20160601004, 20160601005, 2016061008
Quantity – 6

Personal Sampling Pumps
SKC, Inc.
863 Valley View Road,
Eighty Four, PA 15330, USA
Model – AirChek 52
Model No. – 224-52
Serial No. – 849303, 632499, 787492, 876116, 787107, 815590, 784883
Quantity – 7

Primary Flow Meter
Bios International Corporation, Mesa Laboratories Certified
10 Park Place,
Butler, NJ 07405, USA
Model – DCL-M
Serial No. – 106996
Cert. No. – 82436

Primary Flow Meter
Brandt Instruments, Inc., Mesa Laboratories Certified
18568 Oak Grove Pkwy,
Prairieville, LA 70768, USA
Model – Defender 510-M
Serial No. – 119362
Cert. No. - 97898

Temperature Humidity Meter
Fluke Corporation
Fluke South East Asia Pte Ltd
1 Clementi Loop, #06-02/03/04
Singapore 129808
Model – 971

Tubing
Saint-Gobain Performance Plastics Corporation
2664 Gilchrist Road,
Akron, OH 44305, USA
Model – Tygon S3 E-3603

Appendix B: IRB Approval

USF
UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813)974-7091

November 28, 2016

Danny Fink
Environmental and Occupational Health
Tampa, FL 33612

RE: **Not Human Subjects Research Determination**
IRB#: Pro00028564
Title: An Exposure Assessment and Characterization of Paper Dust in a Coupon Manufacturing Facility

Dear Mr. Fink:

The Institutional Review Board (IRB) has reviewed your application and determined the activities do not meet the definition of human subjects research. Therefore, this project is not under the purview of the USF IRB and approval is not required. If the scope of your project changes in the future, please contact the IRB for further guidance.

All research activities, regardless of the level of IRB oversight, must be conducted in a manner that is consistent with the ethical principles of your profession. Please note that there may be requirements under the HIPAA Privacy Rule that apply to the information/data you will utilize. For further information, please contact a HIPAA Program administrator at 813-974-5638.

We appreciate your dedication to the ethical conduct of research at the University of South Florida. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

Kristen Salomon, Ph.D., Vice Chairperson
USF Institutional Review Board

Appendix C: Laboratory Documents

The following documents have been edited to remove employer information.

AIHA Laboratory Accreditation Programs, LLC

acknowledges that

SGS Galson Laboratories, Inc.

6601 Kirkville Road, East Syracuse, NY 13057
Laboratory ID: 100324

along with all premises from which key activities are performed, as listed above, has fulfilled the requirements of the AIHA Laboratory Accreditation Programs (AIHA-LAP), LLC accreditation to the ISO/IEC 17025:2005 international standard, *General Requirements for the Competence of Testing and Calibration Laboratories* in the following:

LABORATORY ACCREDITATION PROGRAMS

✓	**INDUSTRIAL HYGIENE**	Accreditation Expires: October 1, 2016
✓	**ENVIRONMENTAL LEAD**	Accreditation Expires: October 1, 2016
✓	**ENVIRONMENTAL MICROBIOLOGY**	Accreditation Expires: October 1, 2016
☐	**FOOD**	Accreditation Expires:
☐	**UNIQUE SCOPES**	Accreditation Expires:

Specific Field(s) of Testing (FoT)/Method(s) within each Accreditation Program for which the above named laboratory maintains accreditation is outlined on the attached **Scope of Accreditation**. Continued accreditation is contingent upon successful on-going compliance with ISO/IEC 17025:2005 and AIHA-LAP, LLC requirements. This certificate is not valid without the attached **Scope of Accreditation**. Please review the AIHA-LAP, LLC website (www.aihaaccreditedlabs.org) for the most current Scope.

Gerald R Schultz

Gerald Schultz, CIH
Chairperson, Analytical Accreditation Board

Cheryl O. Morton

Cheryl O. Morton
Managing Director, AIHA Laboratory Accreditation Programs, LLC

Revision 14: 03/26/2014

Date Issued: 02/24/2016

SGS GALSON

[redacted]

July 11, 2016

DOH ELAP #11626
AIHA-LAP #100324

[redacted]

[redacted]

Enclosed are the analytical results for the samples received by our laboratory on July 01, 2016. All test results meet the quality control requirements of AIHA-LAP and NELAC unless otherwise stated in this report. All samples on the chain of custody were received in good condition unless otherwise noted.

Results in this report are based on the sampling data provided by the client and refer only to the samples as they were received at the laboratory. Unless otherwise requested, all samples will be discarded 14 days from the date of this report, with the exception of IOMs, which will be cleaned and disposed of after seven calendar days.

Current Scopes of Accreditation can be viewed at www.galsonlabs.com in the accreditations section under the "about Galson" tab.

Please contact [redacted] if you would like any additional information regarding this report. Thank you for using SGS Galson Laboratories.

Sincerely,

SGS Galson Laboratories

Lisa Swab
Laboratory Director

Enclosure(s)

Galson Laboratories, Inc. is now a part of SGS, the world's leading inspection, verification, testing, and certification company. As part of our transition to SGS, you will begin to see some formatting changes with reports that will improve the presentation of data and allow for the transition to the new logo.

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6601 Kirkville Road
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FAX: (315) 437-0571
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LABORATORY ANALYSIS REPORT

[redacted]

Date Sampled : 28-JUN-16 - 29-JUN-16
Date Received : 01-JUL-16

Date Analyzed : 03-JUL-16
[redacted]

Respirable Dust

Sample ID	Lab ID	Air Vol liter	Total mg	Conc mg/m3
RD1	L379249-9	1110	<0.050	<0.045
RD2	L379249-10	1122.5	<0.050	<0.045
RD3	L379249-11	1145	<0.050	<0.044
RD4	L379249-12	30	<0.050	<1.7
RD BLANK 1	L379249-13	NA	<0.050	NA
RD BLANK 2	L379249-14	NA	<0.050	NA

COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: 0.050 mg
Analytical Method : mod. NIOSH 0600; Gravimetric
OSHA PEL : PNOR 5 mg/m3 (TWA)
Collection Media : PVC PW 37mm

Submitted by: DCB
Approved by : KRK
Date : 11-JUL-16 NYS DOH # : 11626
Supervisor: KRK QC by: TJB

< -Less Than mg -Milligrams m3 -Cubic Meters kg -Kilograms NA -Not Applicable ND -Not Detected
> -Greater Than ug -Micrograms l -Liters NS -Not Specified ppm -Parts per Million

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FAX: (315) 437-0571
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LABORATORY ANALYSIS REPORT

[redacted]

Date Sampled : 28-JUN-16 - 29-JUN-16
Date Received : 01-JUL-16

Date Analyzed : 03-JUL-16
[redacted]

Total Dust

Sample ID	Lab ID	Air Vol liter	Total mg	Conc mg/m3
TD 1	L379249-19	998	0.075	0.075
TD 2	L379249-20	972	0.12	0.12
TD 3	L379249-21	940	0.67	0.71
TD BLANK 1	L379249-22	NA	<0.050	NA
TD BLANK 2	L379249-23	NA	<0.050	NA

COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: 0.050 mg
Analytical Method : mod. NIOSH 0500; Gravimetric
OSHA PEL : PNOR 15 mg/m3 (TWA)
Collection Media : PVC PW 37mm

Submitted by: DCB
Approved by : KRK
Date : 11-JUL-16 NYS DOH # : 11626
Supervisor: KRK QC by: TJB

< -Less Than mg -Milligrams m3 -Cubic Meters kg -Kilograms NA -Not Applicable ND -Not Detected
> -Greater Than ug -Micrograms l -Liters NS -Not Specified ppm -Parts per Million

SGS GALSON

[redacted]

LABORATORY FOOTNOTE REPORT

6601 Kirkville Road
East Syracuse, NY 13057
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FAX: (315) 437-0571
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Date Sampled : 28-JUN-16 - 29-JUN-16
Date Received: 01-JUL-16
Date Analyzed: 03-JUL-16 - 07-JUL-16

[redacted]

Unless otherwise noted below, all quality control results associated with the samples were within established control limits or did not impact reported results.

Note: The findings recorded within this report were drawn from analysis of the sample(s) provided to the laboratory by the Client (or a third party acting at the Client's direction). The laboratory does not have control over the sampling process. The findings herein constitute no warranty of the samples' representativeness of any sampled environment and strictly relate to the samples as they were presented to the laboratory.

Unrounded results are carried through the calculations that yield the final result and the final result is rounded to the number of significant figures appropriate to the accuracy of the analytical method. Please note that results appearing in the columns preceeding the final result column may have been rounded and therefore, if carried through the calculations, may not yield an identical final result to the one reported.

The stated LOQs for each analyte represent the demonstrated LOQ concentrations prior to correction for desorption efficiency (if applicable).

Unless otherwise noted below, reported results have not been blank corrected for any field blank or method blank.

[redacted]

< -Less Than	mg -Milligrams	m3 -Cubic Meters	kg -Kilograms	ppm -Parts per Million		
> -Greater Than	ug -Micrograms	l -Liters	NS -Not Specified	ND -Not Detected	NA -Not Applicable	

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[redacted]

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(315) 432-5227
FAX: (315) 437-0571
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Date Sampled : 28-JUN-16 - 29-JUN-16
Date Received: 01-JUL-16
Date Analyzed: 03-JUL-16 - 07-JUL-16

[redacted]

[redacted]

L379249 (Report ID: 944489):
SOPs: GRAV-SOP-5(16), GRAV-SOP-6(15)
Gravimetric analytical accuracy of the sampling media is -0.001 +/- 0.006 mg (average blank weight change +/- 95% confidence interval or k=2). The estimated uncertainly applies to the media, technology, and SOP(s) referenced in this report and does not account for any uncertainty associated with the sampling process.

L379249 (Report ID: 944478):
SOPs: GRAV-SOP-5(16), GRAV-SOP-6(15)
Gravimetric analytical accuracy of the sampling media is -0.001 +/- 0.006 mg (average blank weight change +/- 95% confidence interval or k=2). The estimated uncertainly applies to the media, technology, and SOP(s) referenced in this report and does not account for any uncertainty associated with the sampling process.
PNOR = Particulates Not Otherwise Regulated.

L379249 (Report ID: 944459):
SOPs: GRAV-SOP-5(16), GRAV-SOP-6(15)
Gravimetric analytical accuracy of the sampling media is -0.001 +/- 0.006 mg (average blank weight change +/- 95% confidence interval or k=2). The estimated uncertainly applies to the media, technology, and SOP(s) referenced in this report and does not account for any uncertainty associated with the sampling process.
PNOR = Particulates Not Otherwise Regulated.

< -Less Than	mg -Milligrams	m3 -Cubic Meters	kg -Kilograms	ppm -Parts per Million		
> -Greater Than	ug -Micrograms	l -Liters	NS -Not Specified	ND -Not Detected	NA -Not Applicable	

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Comments :

Sample ID * (Maximum of 20 Characters)	Date Sampled *	Collection Medium	Sample Volume Sample Time Sample Area *	Liters Minutes in², cm², ft² *	Analysis Requested	Method Reference ^	Hexavalent Chromium Process (e.g., welding, plating, painting, etc.)
[redacted]							
Calibration Filter	—	3pc 37mm PW PVC	N/A	N/A	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD 1	6/28/16	3pc 37mm PW PVC	444	min @2.5 LPM	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD2	6/28/16	3pc 37mm PW PVC	449	min	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD3	6/29/16	3pc 37mm PW PVC	458	min	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD 4	6/29/16	3pc 37mm PW PVC	→ Broken arrow Ø12	min	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD Blank 1	6/28/16	3pc 37mm PW PVC	—	—	Dust, respirable	mod. NIOSH 0600; Gravimetric	

☐ ^ If the method(s) indicated on the COC are not our routine/preferred method(s), we will substitute our routine/preferred methods. If this is not acceptable, check here to have us contact you.

Chain of Custody	Print Name / Signature		Date	Time		Print Name / Signature		Date	Time
Relinquished By :					Received By :				
Relinquished By :					Received By :	M. Kraus	M. Kraus	7/1/16	0754

*** You must fill in these columns for any samples which you are submitting.**

Samples received after 3pm will be considered as next day's business.

[redacted]

Draft : 6/23/2016 12:03:12 PM

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SGS GALSON CHAIN OF CUSTODY

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Comments :

Sample ID * (Maximum of 20 Characters)	Date Sampled *	Collection Medium	Sample Volume Sample Time Sample Area *	Liters Minutes in², cm², ft² *	Analysis Requested	Method Reference ^	Hexavalent Chromium Process (e.g., welding, plating, painting, etc.)
RD Blank 2	6/29/16	3pc 37mm PW PVC	—	—	Dust, respirable	mod. NIOSH 0600; Gravimetric	
[redacted]							
TD 1	6/28/16	37mm, 5um PW PVC, 2pc	499	min	Dust, Total	NIOSH 0500	
TD 2	6/28/16		486	min			
TD 3	6/29/16		470	min			
TD Blank 1	6/28/16		—	—	07/1/16		
TD Blank 2	6/29/16		—	—			

☐ ^ If the method(s) indicated on the COC are not our routine/preferred method(s), we will substitute our routine/preferred methods. If this is not acceptable, check here to have us contact you.

Chain of Custody	Print Name / Signature		Date	Time		Print Name / Signature		Date	Time
Relinquished By :	Danny Fink	Danny Fink	6/30/16	9:45AM	Received By :				
Relinquished By :					Received By :	M. Krause	M. Krause	7/1/16	0754

*** You must fill in these columns for any samples which you are submitting.**

Samples received after 3pm will be considered as next day's business.

[redacted]

Draft : 6/23/2016 12:03:12 PM

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SGS GALSON

[redacted]

August 08, 2016

DOH ELAP #11626
AIHA-LAP #100324

[redacted] [redacted]

[redacted]

Enclosed are the analytical results for the samples received by our laboratory on August 01, 2016. All test results meet the quality control requirements of AIHA-LAP and NELAC unless otherwise stated in this report. All samples on the chain of custody were received in good condition unless otherwise noted.

Results in this report are based on the sampling data provided by the client and refer only to the samples as they were received at the laboratory. Unless otherwise requested, all samples will be discarded 14 days from the date of this report, with the exception of IOMs, which will be cleaned and disposed of after seven calendar days.

Current Scopes of Accreditation can be viewed at www.galsonlabs.com in the accreditations section under the "about Galson" tab.

Please contact [redacted] if you would like any additional information regarding this report. Thank you for using SGS Galson Laboratories.

Sincerely,

SGS Galson Laboratories

Lisa Swab
Laboratory Director

Enclosure(s)

Galson Laboratories, Inc. is now a part of SGS, the world's leading inspection, verification, testing, and certification company. As part of our transition to SGS, you will begin to see some formatting changes with reports that will improve the presentation of data and allow for the transition to the new logo.

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East Syracuse, NY 13057
(315) 432-5227
FAX: (315) 437-0571
www.galsonlabs.com

LABORATORY ANALYSIS REPORT

[redacted]

Date Sampled : 27-JUL-16
Date Received : 01-AUG-16

[redacted]

Date Analysed : 04-AUG-16

[redacted]

Respirable Dust

Sample ID	Lab ID	Air Vol liter	Total mg	Conc mg/m3
RD-1	L381911-1	1186	<0.050	<0.042
RD-2	L381911-2	1109	<0.050	<0.045
RD-3	L381911-3	1127	<0.050	<0.044
RD BLANK 1	L381911-4	NA	<0.050	NA
RD BLANK 2	L381911-5	NA	<0.050	NA

COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: 0.050 mg
Analytical Method : mod. NIOSH 0600; Gravimetric
OSHA PEL : PNOR 5 mg/m3 (TWA)
Collection Media : PVC PW 37mm

Submitted by: KBD/PAH
Approved by : KRK
Date : 08-AUG-16 NYS DOH # : 11626
Supervisor: KRK QC by: AMD

< -Less Than mg -Milligrams m3 -Cubic Meters kg -Kilograms NA -Not Applicable ND -Not Detected
> -Greater Than ug -Micrograms l -Liters NS -Not Specified ppm -Parts per Million

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LABORATORY ANALYSIS REPORT

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[redacted]

Date Sampled : 27-JUL-16
Date Received : 01-AUG-16

[redacted]

Date Analyzed : 04-AUG-16

[redacted]

Total Dust

Sample ID	Lab ID	Air Vol liter	Total mg	Conc mg/m3
TD-1	L381911-6	920	<0.050	<0.054
TD-2	L381911-7	879	<0.050	<0.057
TD-3	L381911-8	881.64	<0.050	<0.057
TD BLANK 1	L381911-9	NA	<0.050	NA
TD BLANK 2	L381911-10	NA	<0.050	NA

COMMENTS: Please see attached lab footnote report for any applicable footnotes.

Level of quantitation: 0.050 mg
Analytical Method : mod. NIOSH 0500; Gravimetric
OSHA PEL : PNOR 15 mg/m3 (TWA)
Collection Media : PVC PW 37mm

Submitted by: KBD/PAH
Approved by : KRK
Date : 08-AUG-16 NYS DOH # : 11626
Supervisor: KRK QC by: AMD

< -Less Than mg -Milligrams m3 -Cubic Meters kg -Kilograms NA -Not Applicable ND -Not Detected
> -Greater Than ug -Micrograms l -Liters NS -Not Specified ppm -Parts per Million

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LABORATORY FOOTNOTE REPORT

Date Sampled : 27-JUL-16
Date Received: 01-AUG-16
Date Analyzed: 04-AUG-16

[redacted]

Unless otherwise noted below, all quality control results associated with the samples were within established control limits or did not impact reported results.

Note: The findings recorded within this report were drawn from analysis of the sample(s) provided to the laboratory by the Client (or a third party acting at the Client's direction). The laboratory does not have control over the sampling process. The findings herein constitute no warranty of the samples' representativeness of any sampled environment and strictly relate to the samples as they were presented to the laboratory.

Unrounded results are carried through the calculations that yield the final result and the final result is rounded to the number of significant figures appropriate to the accuracy of the analytical method. Please note that results appearing in the columns preceeding the final result column may have been rounded and therefore, if carried through the calculations, may not yield an identical final result to the one reported.

The stated LOQs for each analyte represent the demonstrated LOQ concentrations prior to correction for desorption efficiency (if applicable).

Unless otherwise noted below, reported results have not been blank corrected for any field blank or method blank.

L381911 (Report ID: 948922):
SOPs: GRAV-SOP-5(16), GRAV-SOP-6(15)
Gravimetric analytical accuracy of the sampling media is -0.001 +/- 0.006 mg (average blank weight change +/- 95% confidence interval or k=2). The estimated uncertainty applies to the media, technology, and SOP(s) referenced in this report and does not account for any uncertainty associated with the sampling process.
PNOR = Particulates Not Otherwise Regulated.

L381911 (Report ID: 948923):
SOPs: GRAV-SOP-5(16), GRAV-SOP-6(15)
Gravimetric analytical accuracy of the sampling media is -0.001 +/- 0.006 mg (average blank weight change +/- 95% confidence interval or k=2). The estimated uncertainty applies to the media, technology, and SOP(s) referenced in this report and does not account for any uncertainty associated with the sampling process.
PNOR = Particulates Not Otherwise Regulated.

< -Less Than	mg -Milligrams	m3 -Cubic Meters	kg -Kilograms	ppm -Parts per Million		
> -Greater Than	ug -Micrograms	l -Liters	NS -Not Specified	ND -Not Detected	NA -Not Applicable	

[redacted]
Date:08/01/16
Shipper:FEDEX
Initials:DTE
Prep:UNKNOWN
[redacted]

[redacted]LSON CHAIN OF CUSTODY

76

You may edit and complete this COC electronically by logging in to your Client Portal account at https://portal.galsonlabs.com/

Turn[redacted]arge	
☑ Standard	0%
☐ 4 Business Days	35%
☐ 3 Business Days	50%
☐ 2 Business Days	75%
☐ Next Day by 6pm	100%
☐ Next Day by Noon	150%
☐ Same Day	200%

☑ Samples submitted using the FreePumpLoan™ Program

☐ Samples submitted using the FreeSamplingBadges™ Program

[redacted]

☐ Card on File (enter the last five digits on the line below)

Comments: Pumps were calibrated pre & post by me. Recieved equipment 7/26/16
- Please See Field Pump data Sheet
- TD-3 [PG930] was working entire Shift yet recorded 51 min. of Sample time & flow rate ~~calib.~~ redued Post ~~Sample~~ calib.
*474 min. total per client ZK 8/1

State Sampled: FL

Please indicate which OEL(s) this data will be used for: ☑ OSHA PEL ☐ ACGIH TLV ☐ MSHA ☐ Cal OSHA ☐ IAQ: ______ Specify Limit(s) ☐ Other: ______ Specify Other

S[redacted]

Project:

Sampled By: Danny Fink

List description of industry or Process/interferences present in sampling area:

Sample ID * (Maximum of 20 Characters)	Date Sampled *	Collection Medium	Sample Volume Sample Time Sample Area *	Liters Minutes in², cm², ft² *	Analysis Requested	Method Reference ^	Hexavalent Chromium Process (e.g., welding, plating, painting, etc.)
RD-1	7/27/16	3pc 37mm PW PVC	1186	L	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD-2	7/27/16	3pc 37mm PW PVC	1109	L	Dust, respirable	mod. NIOSH 0600; Gravimetric	

☐ ^ If the method(s) indicated on the COC are not our routine/preferred method(s), we will substitute our routine/preferred methods. If this is not acceptable, check here to have us contact you.

Chain of Custody	Print Name / Signature		Date	Time		Print Name / Signature	Date	Time
Relinquished By:	Danny Fink	Danny Fink	7/28/16	7:00 AM	Received By:	Zachary King [signature]	8/1/16	9:09
Relinquished By:					Received By:			

*** You must fill in these columns for any samples which you are submitting.**

Samples received after 3pm will be considered as next day's business.

[redacted]

Draft : 7/22/2016 3:46:24 PM

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Comments :

Sample ID * (Maximum of 20 Characters)	Date Sampled *	Collection Medium	Sample Volume Sample Time Sample Area *	Liters Minutes in², cm², ft² *	Analysis Requested	Method Reference ^	Hexavalent Chromium Process (e.g., welding, plating, painting, etc.)
RD-3	7/27/16	3pc 37mm PW PVC	1127	L	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD Blank 1	↓	3pc 37mm PW PVC	—	—	Dust, respirable	mod. NIOSH 0600; Gravimetric	
RD Blank 2	↓	3pc 37mm PW PVC	—	—	Dust, respirable	mod. NIOSH 0600; Gravimetric	
Calibration	—	3pc 37mm PW PVC	—	—	Dust, respirable	mod. NIOSH 0600; Gravimetric	
TD-1	7/27/16	2pc 37mm PW PVC	920	L	Dust, Total	mod. NIOSH 0500; Gravimetric	
TD-2	↓	2pc 37mm PW PVC	879	L	Dust, Total	mod. NIOSH 0500; Gravimetric	
TD-3	↓	2pc 37mm PW PVC	95	L	Dust, Total	mod. NIOSH 0500; Gravimetric	
TD Blank 1	7/27/16	2pc 37mm PW PVC	—	—	Dust, Total	mod. NIOSH 0500; Gravimetric	
TD Blank 2	7/27/16	2pc 37mm PW PVC	—	—	Dust, Total	mod. NIOSH 0500; Gravimetric	
Calibration	—	2pc 37mm PW PVC	—	—	Dust, Total	mod. NIOSH 0500; Gravimetric	

☐ ^ If the method(s) indicated on the COC are not our routine/preferred method(s), we will substitute our routine/preferred methods. If this is not acceptable, check here to have us contact you.

Chain of Custody	Print Name / Signature		Date	Time		Print Name / Signature		Date	Time
Relinquished By :	Danny Fink	Danny Fink	7/28/16	7:00 AM	Received By :	Zachary King		8/1/16	9:09
Relinquished By :					Received By :				

*** You must fill in these columns for any samples which you are submitting.**

Samples received after 3pm will be considered as next day's business.

[redacted]

Draft : 7/22/2016 3:46:24 PM

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This should NOT be used as a Chain of Custody

Field Pump Data Sheet

[redacted]

Employee: _____ Job Title: _____

ID Number: _____ Date Of Sampling: 7/27/16

Sampled By: Danny Fink

Field Sampling Data **Contaminant(s)**

Sample ID	Sample Media (PW PVC, etc.)	Pump Number	Rotameter Number	Pre-Sample Flow Rate (LPM) *1 or *2	Time On	Time Off	Duration (mins.)	Post-Sample Flow Rate (LPM) *1	Average of Pre- and Post-Sample Flow Rates	Adjusted (TRUE) Flow Rate (see sample *3)	Final (TRUE) Air Volume (in Liters) (Duration times TRUE Flow Rate)
RD-1	3pc 37mm PW PVC	PG934	—	2.51	6:51		458	2.66	2.59	—	1186
RD-2	"	PG938	—	2.50	6:56		451	2.42	2.46	—	1109
RD-3	"	PG939	—	2.50	7:01		458	2.41	2.46	—	1127
TD-1	2pc 37mm PW PVC	PG 913	—	2.02	6:48		460	1.98	2.0	—	920
TD-2	"	PG932	—	2.03	6:53		444	1.93	1.98	—	879
TD-3	"	PG930	—	2.02	7:03		51	1.69	1.86	—	95

1 Flow Rate as indicated on Rotameter ***2 Or use results on Page 1, 3rd column***

*3 SAMPLE: If the Pre-Sample Flow Rate was 2.00 LPM, and the Post-Sample Flow Rate was 2.1 LPM and the Rotameter's Correction Formula was "Y= 0.93 X +0.142" , (This is a an example formula ONLY, please use formula on supplied rotameter)
CALCULATE as such: 2.00 + 2.1 divided by 2. Plug THAT figure (2.05) into the formula as "X": 0.93 times 2.05 + 0.142.
The result (in this case): 2.0485 Liters per minute.