Filtration and Drying Unit Operations- Generic Scenario for Estimating Occupational Exposures and Environmental Releases

-Draft-

U.S. Environmental Protection Agency
Office of Pollution Prevention and Toxics
Chemical Engineering Branch
1200 Pennsylvania Avenue
Washington, D.C. 20460

15 December 1995

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for Filtration and Drying Unit Operations
(Draft)

I. *Introduction*

Worker exposures and chemical releases associated with a plate and frame filter press and a stationary tray dryer were studied in a pilot plant.[1] The study, managed by ORD, was intended to evaluate the importance of physical properties, activities performed, and worker techniques in order to develop a predictive model that could be used to estimate worker exposures more generally. A major conclusion of the study was that development of a predictive model was an unreasonable goal. The study, however, provides limited monitoring data for these worker activities.

Of the 375 most recent IRERs prepared by CEB, during FY95 and FY96, thirteen cases involve the filtration and drying of a powdered PMN chemical substance during its production. In eight of these thirteen cases, the throughput rates were less than 100 kg/day. The occupational exposure assessments varied for these PMN cases with some based on the OSHA PEL while others were based on limited data available from textile dye weighing study or the above-mentioned ORD study of filtration and drying. Estimates based on the ORD data tend to be about an order of magnitude lower than those based on the OSHA PEL and 2-3 orders of magnitude higher than those based on the textile dye weighing scenario.

The purpose of this scenario is to standardize the approach used to assess potential dose rates for workers handling solid and dried powders during filtration and drying operations. Development of a general comprehensive model for particulate exposures is an ongoing CEB research effort, therefore, this scenario is intended to be an interim, generic approach for using the information collected by ORD. This information is most likely useful for relatively small volume chemicals handled in batch sizes on the order of 100 kg/batch.

II. *Background*

In the study, a slurry of calcium carbonate in water (about 90% water), was processed in a plate and frame filter resulting in a wet cake. The wet cake was loaded in 100 kg batches into trays and dried in a convection oven. The dried material was then loaded into containers. The drying experiment was repeated for powdered calcium carbonate. The tray loading and unloading areas were located in a room that had a moderately high air exchange rate (average of 8.7 changes/hr) and well-mixed air circulation (average of 1.03) but no local exhaust ventilation.

The experiments included two different size distributions of calcium carbonate.

Monitoring data was collected for different activities, namely: (1) removal of wet cake (defined as 10 to 30% moisture content); (2) loading dryer with wet cake; and (3) removal of dried solids (defined as <1% moisture content) from the dryer. To develop the scenario, an uncertainty range of the airborne concentrations has been derived from the experimental data for each activity (see Table 1). The low value of the uncertainty range is based on the geometric mean or central tendency of the experimental data while the high value of the range represents the highest measured data point. The highest measured data point was chosen because there are generally less than 10 data points per activity. Determination of the central tendency, the high end, or the bounding estimate was not possible given the limited amount of the experimental data. The 95% confidence intervals for the geometric mean have, however, been calculated by CEB (results are attached). The calculated confidence intervals indicate an order of magnitude uncertainty in the mean.

Table 1: Summary of Monitoring data collected by Activity

Activity	Number of samples	Geometric Mean (mg/m3)	95% Confidence Interval	Highest data point (mg/m3)
Removal of wet cake Workers empty the wet filter cake into a collection bin and scrape residual cake from each frame and filter cloth. Wet cake is defined as about 10 to 30% moisture.	4	0.3	+/- 3	0.8
Loading dryer/ wet cake Workers load wet cake (10 to 30% moisture) to tray dryer.	4	0.3	+/- 3	0.7
Loading dryer/ powder solids Workers load dry cake (<1% moisture) to tray drier.	4	1	+/- 10	2
Unloading dryer and packaging Workers dump solids into containers.	8	22	+/- 52	50

III. *Summary of Scenario*

To estimate the PDR from the airborne concentration several default parameters have been identified, including, breathing rate and duration of exposure. The default values for duration of exposure were based on the distribution of worker activity reported in the study. Because the sampling data and the default values may not be representative of all possible exposures, estimates of potential worker exposures based on the data should be characterized as a "what-if" scenarios.

In addition to collecting experimental data, the study also tried to identify the most important variables. For each worker activity, the variables found to be most highly correlated with the particulate airborne concentration levels were: outside humidity; time of day; and exhaust air barometric pressure. These variables, however, are generally unknown in CEB's evaluations and cannot be incorporated into estimating screening level estimates of potential exposure.

Table II summarizes the calculations and default assumptions for this scenario.

Example language for IRER:

Activity: removal of wet cake from filter, loading dryer, and unloading dryer

Inhalation: 10 to 40 mg/day (what-if based on monitoring data)
Basis: Limited experimental data collected for a pilot-scale operation involving plate and frame filtration of a calcium carbonate solution and is presented as an uncertainty range representing a best estimate of potential dose rates which may be encountered in the workplace.

150 mg/day (what-if based on OSHA PEL)
Basis: OSHA PEL of 15 mg/m3, 8-hr TWA for total particulates, not otherwise regulated

Table II: Summary of Scenario Calculations and Defaults

Activity	"What-if" Scenario: PDR based on Experimentally-derived Uncertainty Range1,3 (mg/day)	"What-if" Scenario: PDR based on OSHA PEL for total particulates, not otherwise regulated (mg/day)
Removal of Wet Cake from Filter	Calculation: (0.3 * Ys * b * d) to (0.8 * Ys * b *d) For default values: Ys = 1 b = 1.25 d = 5 hrs/day PDR= 2 to 5 mg/day	--
Loading Dryer with wet cake	Calculation: (0.3 * Ys * b * d) to (0.7 * Ys * b * d) For default values: Ys = 1 b = 1.25 d = 1.5 hrs/day PDR= 1 mg/day	
Removal from dryer	Calculation: (20 * Ys * b * d) to (50 * Ys * b * d) For default values: Ys = 1 b = 1.25 d = 0.5 hrs/day PDR= 10 to 30 mg/day	
Time-weighted exposure to total particulates for worker	Note that if the same worker performs all three activities, the cumulative exposures for all three activities would be the sum of the above calculations. -- For the above listed default values: PDRall activities= 10 to 40 mg/day	Note that if the same worker performs all three activities, the cumulative exposures for all three activities would be required to be within the OSHA PEL. Calculation: 150*Ys For default values: Ys = 1 PDR= 150 mg/day

IV. *Assumptions and Uncertainties*

The following is a summary of the assumptions and uncertainties in this approach. The scenarios and equations are described in the next section of this paper.

(A) Worker activities and workplace conditions are similar to those found in the study, namely, that the room air is well-mixed and that general exhaust ventilation is present but not local exhaust ventilation.

(B) Calcium carbonate is an adequate surrogate for the chemical of interest. The amount of airborne dust generated is likely to be a function of the physical properties of the chemical of interest as well as the handling of the material, including, particle diameter; particle size distribution; quantity of material handled; moisture content; height of particle when released into workplace; and terminal settling velocity. This approach assumes that properties and handling of chemical of interest are similar to the study.

(C). The lower end of the uncertainty range is assumed to be best represented by the geometric mean of the airborne concentration. Because the sample size is limited (<10 data points/worker activity), the higher end of the uncertainty range is assumed to be best represented by the highest reported value.

V. *Comparison of experimental data to other studies*

For the purpose of assessing the predictive capability of this generic approach, estimated worker exposure based on the approach has been compared to limited data set of measured airborne concentrations. This comparison of predicted airborne concentrations to limited inplant monitoring data demonstrate that the predictive equations may overestimate the PDR by about an order of magnitude. This comparison is attached. The data set is limited in several respects: (1) small number of samples (4 per worker activity) collected at one site; and (2) sampling may not be representative of all possible exposures since samples were only collected at one site over a few days. No NIOSH HHE's or additional studies were identified for filtration or drying activities.

Table III summarizes a comparison of the predictive approach to limited monitoring data. This evaluation provides limited evidence that the approach is within an order of magnitude of actual exposures.

Table III: Comparison of Scenario Prediction to OSHA PEL and to Other Montitoring Data

Activity	Predicted PDR Routine Range1,3 (mg/day)	Predicted PDR based on OSHA PEL for nuisance dust (mg/day)	PDR Based on Geometric Mean Airborne Concentration2 (mg/day)	High End Based on High End Airborne Concentration2 (mg/day)
Removal of Wet Cake from Filter	0.064 to 0.24	5	0.034	0.084
Loading Dryer with wet cake.	0.025 to 0.45	5	0.0045	0.0065
Removal from dryer	0.46 to 1	5	0.026	0.086

1The predicted routine PDR range is based on limited experimental data for a pilot-scale operation involving a plate and frame filtration of a calcium carbonate solution. Assumes that work practices and workplace conditions are similar to those in the study, including well-mixed rom air; general ventilation; and no local exhaust ventilation.

2Based on monitoring data collected in an electronics manufacturing facility for filtration of wastewater sludges generated from the treatment of industrial wastewater containing soluble metals. High ventilation rates were measured, no local exhaust ventilation was present. Measurements were taken for copper; the weight fraction of copper is reported to be 3.3%. Reference: Assessing Chemical Releases and Worker Exposure from a Filter Press, Prepared for USEPA by Southwest Research Institute, October, 1989, PB90-119587.

3Ys = 0.033

4 Duration (d) is assumed to be 5 hrs/day.

5 Duration (d) is assumed to be 1.5 hrs/day.

6 Duration (d) is assumed to be 0.5 hrs/day.

7 Note that if the same worker performs all three activities, the cumulative exposures for all three activities would be required to be within the OSHA PEL. For comparison, a PDR based on the OSHA PEL of 15 mg/m3, 8-hr TWA, and assuming 3.3 wt%, would be 5 mg/day. Similarly, a PDR based on the OSHA PEL of 1 mg/m3, 8-hr TWA for copper dust, and assuming 3.3 wt%, would be 0.3 mg/day.