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Project Summary

Assessing Chemical Releases and Worker Exposures from a Filter Press

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Chemical releases and worker exposures associated with the filtration of an industrial wastewater sludge were characterized. The filter was a recessed chamber filter press with an open filtrate discharge system. Chemical releases and worker exposures for a selected chemical were measured over four operational cycles and various aspects of the filtration operation believed to influence the measurement values were documented. The filter press and ancillary systems are described as a reference for the measured releases and exposures. Bulk samples of the feed stream, filter cake, and filtrate effluent were taken together with the mass quantities for the batch filtration cycles to further define the operational conditions. The three sequential stage activities comprising each filtration operation are described along with worker exposures and durations for each stage. Ventilation patterns around the filter press were monitored.

The worker's time-weighted average exposures to total copper (low vapor pressure, highly insoluble form) during the 113-minute operational cycle ranged from 3.1 to 25 µg/m³. The sludge feed and filter cake copper concentrations were approximately 0.1 and 1.0 weight percent. A noticeable difference in worker techniques was observed which may account for the large range of inhalation exposures during the cake removal stage. During this stage, the inhalation exposures ranged from 11 µg/m³ to 130 µg/m³. The manual removal of filter cake comprised only 15% of the time in an average filtration cycle, but produced 72% of the worker's inhalation exposure.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

For the study summarized herein, inhalation and dermal worker exposures as well as chemical releases were characterized at an electronic manufacturing plant. The parameters (exposures and releases) were measured, and the aspects of the operation believed to influence these parameters were documented over four filtration cycles. Each cycle was composed of three stages: sludge filtering, filter cake drying, and filter cake removal.

This assessment study is part of a joint research effort undertaken by the U.S. Environmental Protection Agency and Southwest Research Institute. The overall goal of the cooperative agreement is to develop database models for use in predicting chemical releases and worker exposures from select filtration and drying unit operations. The database models developed will be applicable for the *Premanufacture Notice* (PMN) *review* system. For each study the chemical monitored is a surrogate for a hypothetical PMN new chemical in order to evaluate the worker exposures and chemical releases from the unit operation. Thus, there is no requirement to select an operation which has a toxic chemical, provided that the physical properties of the chemical can be extrapolated to the hypothetical PMN new chemical. The surrogate chemical at Plant 50 is total copper.

The sludge was from a metal rinse stream. Because the metal with the highest concentration was copper, total copper (both soluble and insoluble) was selected to evaluate worker exposures and chemical releases.

For each unit operation cycle, sludge was pumped from a storage tank to a recessed chamber filter press. In the sludge filtering stage, the solids (filter cake) were collected in the chambers of the press while filtrate exited the press through spigots on the side of each plate into an open collection trough. The filtrate further drained into a sump and was then pumped to an effluent storage tank. This process continued until the press was (approximately) filled with cake.

Once the press was filled, the cake was blown with compressed air (the filter cake drying stage). The air entered the press through the same port as the sludge and exited the press through the same spigots as the filtrate. The discharging compressed air created a mist in the vicinity of the press.

After the drying stage, the filter cake was removed. As the press was opened, one plate at a time, the filter cake dropped into a collection hopper. The filter cake was transported with a screw auger to a collection trailer. Cleaning the last chamber of the press completed the filter cake removal stage.

Two filter presses were housed in a separate room next to the main waste treatment area. The recessed chamber filter press used in this study had 23 plates (or 22 chambers), which were each approximately 1 m in length and width and 4.5 cm thick. (The other press did not operate during this study.) The total filtration surface area was 34.8 m^2, and the total filtration volume was 0.70 m^3. The overall size of the press was 5.0 m long by 1.6 m wide by 2.3 m tall. The press was equipped with a hydraulic ram closure mechanism and an automatic plate shifting device.

Procedure

All data were categorized according to the three filtration stages mentioned above. Worker exposures were assessed during four cycles of the filtration operation, and chemical release measurements were taken during the first three cycles. The emissions from sealing points were evaluated during the sludge filtering stage in the fourth cycle. For all four cycles, the sludge came from a single, isolated storage tank.

Background, area, and personnel air samples were collected with the use of battery-operated pumps, duPont P4LCs*, to pull air through 0.8 μ mixed-cellulose, ester membrane filters. The background air samples were collected where air either entered into or exited from the filter press room. Two area samples were located at the ends of the filtration collection trough and one by a control panel. The personnel sample collection cassettes were attached to each operator's shirt collar.

Wipe samples were collected on two flat horizontal areas of the filter press, one at each end of the filter press.

In conjunction with measuring the volumes of sludge feed and filtrate, as well as weighing a chamber of the filter cake, bulk samples were taken of the sludge feed, filtrate, and filter cake. The sludge feed samples were grabbed from the storage tank immediately before the start of the sludge filtering stage. The filtrate samples were collected at the outlet of the collection trough discharge pipe. Small fragments of filter cake were selected from the chamber that was weighed.

Copper analyses of the sludge, filter cake, wipe, and filtrate samples were done by direct aspiration flame atomic absorption spectrophotometry, employing Method 220.1 of Methods for Chemical Analyses of Water and Wastes (EPA 600/4-79/020). Method 160.3 of the same reference was used to analyze total residue. NIOSH Method 7029 was used to analyze the air samples for copper, except that graphite furnace atomic absorption spectrophotometry was used for greater sensitivity.

A Kurz 441 M Air Velocity Meter measured air velocities. Smoke tubes indicated gross air movement within the filter press room.

Results

Worker inhalation exposure measurements for airborne copper were performed for four filtration operation cycles using three operators, A-1, B-1, and C-1 [the first operator (A-1) was monitored twice]. The geometric mean exposure, the average duration of the stage, and the average duration of operator's involvement during each st as well as the entire unit operation summarized in Table 1 (the minimu and maximums are also presented). total copper concentrations in the slu feed and the filter cake w approximately 0.1% and 1.0% by wei respectively. Total copper was in a hi insoluble form with a low vapor pressu

The head, neck, and lower arm a comprised the exposed skin surfaces all of the operators. Since the sec operator (B-1) did not wear any gl (and operators A-1 and C-1 did), hands were also potential sites for de exposure. The routes by which co was deposited on the skin were airb aerosols and contact with surfaces (w had visible deposits of green dust) in filter press room.

The air and wipe sampling res indicate the airborne copper con trations made aerosol deposition exposed skin surfaces a neglig consideration. Deliberate contact surfaces occurred when the opera opened and closed valves, turned on off pumps, grabbed the outer edge some of the plates and slid them sli forward to ensure they were corr aligned with the filter cloths, occasionally held onto the side of press for support while peering into press to inspect the filter cloths for residue. Incidental contact occurred v the operators hit their lower arms hands for operator B-1) on var surfaces.

No direct contact with the slu filtrate, or filter cake was observed.

The ventilation measurements sh that air movement through the filter p room was relatively constant at a g location throughout the study, but th velocities varied from location to loca Smoke tube studies showed most o air that entered the room via the doorway flowed directly towards the doorway. (These doorways were lo towards the front of the room on the wall. There were no other entrance the air, except through leaks in the w the lower level, and only one other the south wall exhaust fan.) As th moved from east to west, very litt from the work area by the filter pr became entrained into this mai current. The operators, however, most of their time in the other porti the room where the filter press located and in which ventil stagnation occurred.

An overall mass balance approach appropriate samples taken for

*Use of trade names or commercial products does not constitute endorsement or recommendation for use

Table 1. *Operators' Geometric Mean Inhalation Exposure to Airborne Copper Duration of the Stages and Operators' Involvement*

Stage	Geometric Mean Exposure, μg/m³	Minimum Exposure, μg/m³	Maximum Exposure, μg/m³	Average Stage Operation Duration, min	Minimum Duration, min	Maximum Duration, min	Average Duration of Operator Involvement, min	Minimum Duration, min	Maximum Duration, min
Sludge Filtering	4.1	3.8	4.8	39	26	57	11	9	13
Cake Drying	1.6	0.8	2.6	57	49	64	3	3	3
Cake Removal	30	11	130	17	15	20	17	15	20
Entire Operation (TWA)	6.4	3.1	25	113	98	141	31	27	33

Table 2. *Mass Balance Results*

Sample Site	Mass Total, Kg			Mass of Total Copper, Kg		
Influent	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Sludge feed	2150	1570	1660	2.9	2.0	1.9
Effluent						
Filtrate	1720	1210	1120	0.001	0.001	0.0009
Filter cake	338	335	339	5.3	3.0	2.1
Total Effluent	2058	1545	1459	5.3	3.0	2.1

copper, was used to quantitate chemical releases. Table 2 summarizes the results (for the three filtration operational cycles).

Although the average percent difference between the overall effluent and influent masses was -6.3% (range of -1 6% to 13% with a sample standard deviation of 5.9%), the average percent difference between the total copper masses in the effluent and influent was +36% (range of 10% to 59% with a sample standard deviation of 24%).

In addition to the overall mass balance approach, spills and leaks were observed and documented. These leaks and spills represent releases that would not have been included in the other mass measurements. The five releases observed were: (1) the air valve to the press leaked 1 drop of sludge onto the floor (of the lower level) every 10 sec during the sludge filtering stage, (2) the recessed chamber plates dripped liquid into the cake hopper; six leaks flowed at a rate of 1 drop every 2 sec, (3) the valve to the sludge feed pump leaked sludge onto the floor at a rate of 1 drop every minute, (4) the fine mist generated during the cake drying stage from the filtrate spigots fell onto the floor (of the lower level), which dampened an area of approximately 1.5 m², and (5) the small fragments of filter cake that missed the hopper fell onto the floor (of the lower level) as the recessed chambers were emptied during the cake removal stage; the fragments of cake averaged 5 cm³ in volume. It should be noted that the sludge dripping from the leaks in ımbers 1 through 3 was somewhat clearer in appearance compared with the murky, green color of the sludge. Therefore, the residue and copper concentrations in these leaks may have been lower than those in the original sludge. During each filtration cycle, these spills and leaks released approximately 1.1 g of total copper. The total copper released in the filtrate waste stream averaged 1 g per filtration cycle. An estimated 23 mg of copper was present in the air exhausted from the filter press room during each filtration cycle. Consequently, the total chemical releases from each filtration operation was approximately 2.1 g of copper, or slightly less than 0.1% of the total copper processed through the filter press.

The sealing point evaluation was performed to measure the aerosol concentration generated by the operation. No aerosol was detected above the total background levels (0.05 mg/m³) at any of the pumps, valves, or connections. Aerosol was detected at the 23 open-ended spigot lines and the filtrate collection trough. The aerosol concentration detected was 0.4 mg/m³. An aerosol concentration of 1.0 mg/m³ was also recorded for the open-ended line discharging filtrate into the sump. It must be noted that the measurements were for the total aerosol concentration; identification of a particular species (e.g., copper aerosol) was not possible.

Discussion

The total average duration of the filtration cycle was 113 min. Of this time, the operator was actively involved in the operation for 31 min on average (or 27%). If an operator were to be responsible for multiple filter presses, the "free times" within the various stages could permit the operator to stagger the stages of the individual presses and operate them simultaneously. With presses similar to ones in this study, an operator could perform the various tasks on three presses and finish in a 147-min period. During this span of time, the operator would accrue a total exposure duration of 93 min (three presses at 31 min each), which is equivalent to 63% of the total time. Therefore, to determine the worker exposure during the total filtration cycle, the number of filter presses operated by the worker must be known.

Based on a geometric mean inhalation exposure, 72% of an operator's exposure to copper occurred during the cake removal stage of the filtration operation. Fifteen percent of an operator's time was spent during this stage. An operator's time weighted average (TWA) exposure, based on the geometric mean, was 6.4 μg/m³.

To determine an operator's exposure, the following formula could be used (assuming the worker only operated one press).

$$\frac{\mu g\ Tc}{day} = \frac{\mu g\ Tc\ (TWA)}{m^3} \times \frac{1.25\ m^3}{hr} \times \frac{hr\ of\ operation}{cycle} \times \frac{\#\ cycles}{day}$$

where Tc = target chemical.

For this study, the operator's exposure would be (assuming an 8 hr shift per day),

$$\frac{\mu g\ copper}{day} = \frac{6.4\ \mu g\ copper}{m^3} \times \frac{1.25\ m^3}{hr}$$

$$\times \frac{(113/60)\ hr}{cycle} \times \frac{4\ cycles}{day} = \frac{61\ \mu g\ copper}{day}$$

Observations of the workers indicated any dermal exposure incurred during the sludge filter and filter cake drying stages was the result of casual or incidental contact of the hands with contaminated surfaces, which resulted in very minimal exposure. The filter cake removal stage did provide a greater opportunity for dermal exposure since the workers were in contact with the filter press and were in proximity to the filter cake. No direct contact with the filter cake was observed, however.

The protective equipment each operator wore included chemical safety goggles at all times in the filter press room and hearing protection devices during the cake drying stage. Operators A-1 and C-1 also wore cotton gloves. In addition, operator C-1 wore a disposable, half-face dust respirator.

Total copper was a very small portion of the material being processed. As such, the methods used to accomplish a mass balance were too insensitive to accurately or precisely quantitate the mass of total copper.

Conclusions

The workers' TWA exposures to total copper over the 113-min average duration of the unit operation ranged from 3.1 to 25 $\mu g/m^3$. The ACGIH's 1987-88 TLV for 8-hr exposures to copper dust and mist is 1 mg/m^3.

The total copper concentrations in the sludge feed and the filter cake were approximately 0.1% and 1.0% by weight, respectively. Therefore, it is uncertain whether the low worker exposures measured were solely attributed to the operational characteristics of the filter press or were a reflection of the low total copper concentrations.

The area of the room most frequently occupied by the workers was also the area that received the least air circulation. The air flow rate and distribution pattern inside the filter press room remained relatively constant throughout the study.

Data from this research also indicate that a worker's technique in removing the filter cake may be an important factor in determining a worker's exposure to within one order of magnitude. The range of inhalation exposures during the cake removal stage was 11 $\mu g/m^3$ to 130 $\mu g/m^3$. A noticeable difference in worker techniques was recorded for the high and low exposure readings.

The sludge filtering stage showed great variability among the work paths taken by the filter press operators but little difference among their resultant exposures (geometric mean exposure for the four sludge filtering stages was 4.1 $\mu g/m^3$). The sludge filtering stage comprised roughly one-third of the 113 min needed to complete an average filtration cycle.

The filter cake drying stage, which comprised slightly more than 50% of the time for the filtration cycle, was largely unattended by the operators and, therefore, contributed very little to their exposures. The working time was 3 min, and the geometric mean of the inhalation exposures to airborne copper was 1.6 $\mu g/m^3$.

Although manual removal of filter cake from the chambers of the filter press comprised only 15% of the time in an average filtration cycle, it produced 72% of the workers' exposures to copper during the filtration operation.

Dermal exposures to total copper were not quantitated. Observations of the operators' work practices indicated that their dermal exposures were probably very low and effectively eliminated through their use of work gloves when removing the filter cake.

Total chemical releases from the filter press were estimated to be 2.1 g of copper or 0.1% of the total copper mass that was processed through the u operation. Although the mass of chemi in the filtrate could be measured, t mass of chemical released in spills leaks of the feed material and filter ca could not be quantified. The study's d indicate that leaks or spills of fe material or filter cake can be a grea potential source of chemical releas than from the total filtrate effluent insoluble filter cake products.

Using a mass balance to calculate to copper processed through the filter pr was not an effective method measuring the individual chemi releases. The sampling and analyti errors associated with the mass balar measurements did not permit accur calculations of the relatively sm masses represented by the individ chemical releases.

Recommendations

The in-plant assessment study o filter press unit operation yielded d that provided insight into worl exposures and chemical releases. Pi scale experiments should be conduc using different worker scenarios a target chemicals to quantify ranges exposures and chemical releases t can occur by varying these two variabl

For a future in-plant assessment st of a filter press, any one or more of following criteria should be considere the selection process·

- A liquid, high-molecular-weight, orga chemical should be studied.
- An operation with a more concentra chemical (cake product) in the f stream should be used.
- A larger filter press (one requiring operators to remove the filter ca should be used.

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The complete report, entitled "Assessing Chemical Releases and Worker Exposures from a Filter Press," (Order No. PB 90-119 587/AS; Cost: $23.00, subject to change) will be available only from:
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