Considerations For
Total Pollution Control:

ENERGY CONSERVATION & PROCESS CONTROL

UTILIZING COVERED TANKS

By

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ABSTRACT:

The objective of this paper is to provide an overview of costs benefits from properly designed and functioning process covers. The supply and exhaust of air in a process environment represents both a capital cost for equipment and an ongoing operating cost which is often sizable. Experienced designers, recognizing these costs and energy conservation needs, can demonstrate process covers to be a wise choice when selecting a plating equipment manufacturer.

There are several methods by which the cost of heating and cooling of large volumes of outside air can be reduced. (1) Reduction in the total flow of air handled. (2) Delivery of untempered outdoor air to the process area.(3) Recovery of energy from the exhaust air. (4) Recovery of warm, uncontaminated air from the process. The successful application of these engineering methods, without reduction in health hazard control and without impairing the inplant environmental concerns requires careful design consideration.

Recipients of this paper will receive valuable information in regard to the reduction of pollution control cost. This paper will explore the many ways covered processes reduce exhaust volumes and pollution. Designers must recognize that a significant amount of global pollution is generated from energy sources used in the operation of pollution abatement systems.

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Introduction

This paper/presentation is principally focused on controlling the amount of air volume used in industrial ventilation. To set the stage for this, it is helpful to recap some of the fundamentals of industrial ventilation.

First and foremost, it is essential to remember that the primary reason for having a ventilation system is to control worker exposure. Whether this exposure is to excessive heat and humidity or to toxic chemicals, determines what type of ventilation system will be used. An additional benefit to a ventilation system is the improved life of building and equipment due to control of corrosive chemicals.

The Occupational Safety & Health Administration (OSHA) has mandated a set of requirements regarding the acceptable worker exposure levels for a wide variety of substances. These requirements are referred to as Permissible Exposure Limits (PEL'S). PEL'S are generally defined as the amount of a contaminant that a worker can be exposed to for eight hours per day for an indefinite number of days with no ill effects.

Low toxic contaminants such as cutting oil mists and water vapor can be addressed with a scheme known as general ventilation. General ventilation is accomplished when large fans are used to completely evacuate the entire room a certain number of times per hour, expressed as air changes per hour. The primary advantage of general ventilation is that the cost of capital equipment is low. However, its effectiveness at controlling the worker exposure level is very limited.

Moderate to highly toxic airstreams must be addressed with local exhaust. Local exhaust occurs when a hood is mounted as close to the source of contaminant generation as possible. The hood and its associated duct and fan, are used to capture the contaminant before it can mix with the room ambient air. One of the key parameters in the design of a local exhaust system is the capture velocity. To illustrate this, look at the example of open surface plating tanks. As a mist or fume is emitted form the top of an open surface tank, they have a natural tendency to migrate randomly in all directions. The capture velocity is the velocity of air moving across the surface of the tank required to ensure that sufficient or required amount of the contaminant is drawn into the hood to comply with the regulatory guidelines.

The major drawback of local exhaust system is high initial capital costs, due to the hoods, ducts and high pressure fans required and the customized features of the system. The payback is that these systems have a much better capture efficiency, which means that less ventilation is required overall. It is important to note, ventilation works best if it is applied by an experienced engineer with an integrated approach. The process being vented, the ventilation system and the makeup air should be considered as one large system, not three individual ones. Remember, air is not free, particularly if it is tempered.

The implementation of the makeup air system is one of the simplest and most frequently overlooked aspects of a ventilation system. Frequently, no makeup air system is installed until after the exhaust system has been found to be operating improperly. The primary purpose of a makeup air system is to balance the pressure in the enclosure so that it is not to highly negative, which adversely affects the performance of the exhaust system. This can be achieved by a simple set of relief dampers. However, in most parts of the United States some tempering of the air is required. This tempering can be achieved by a dedicated air makeup unit with heating and cooling coils. More frequently the frigid or hot infiltration air is allowed to mix with the ambient air in the enclosure. This places an increased demand on the buildings HVAC system, which may not have been originally designed for it. One last aspect of a makeup air system which is very important is the distribution of the incoming air. Too frequently, the makeup air is dumped back into the area right around the capture hood. This can possibly set up cross drafts and turbulent airflow near the hood, which greatly decreases the effectiveness of the exhaust system. It is essential to consider the total air balance when designing a system.The energy usage associated with the operation of an exhaust system is often a significant source of cost for the facility. Methods used to reduce these costs fall into three main categories. The first is the reduction of the ventilation rate. This method is the primary focus of this paper and will be examined later. The second method is the use of untempered air. This simply means that unconditioned outside air is used for makeup air. This is frequently accomplished by leaving doors and windows open. This method is only practical in areas where the climate is acceptable for worker comfort. Also, it cannot be used for industries such as aerospace or semiconductor where daily variation in temperature could cause workpieces to deviate from required tollerances, lose specification and be rejected when they have reached a significant value-added state in the overall process.

The final method for reducing energy cost is to reclaim the heat leaving the building. A large source of heat is the warm air being exhausted. It is possible to install a Heat Exchanger which will transfer the energy from the warm exhaust air to the cold intake air. Air to air heat exchangers are usually 65-70% efficient, but tend to be quite large and expensive. Most facilities have a difficult time justifying the cost unless they are in bitterly cold climates. Another way to reclaim waste heat is to locate waste heat producing equipment in such a way that the heat can be dumped into the building in the winter. Items such as air compressors or air cooled refrigeration units are good examples for this sort of heat reclaim.

Concept Of Covered Tanks - An Important System Addition

The focus of this paper defines how Automatic Tank Covers incorporated into a well designed ventilation system can be used to reduce the amount of ventilation and still comply with the PEL requirements. An obvious benefit of this design is reduced operating costs and a net energy pollution savings. First the design methodology will be explained, then an actual case study will be used to illustrate the magnitude of potential savings realized.

Traditional wet processing systems, whether manually or automatically operated, accomplish chemical processing of parts by dipping them into open top tanks bearing a variety of different process and preparation chemutuer. Standard design of exhaust systems has been described by the American Conference of Governmental Industrial Hygienists in their publication entitled Industrial Ventilation, A Manual of Recommended Practice. Twenty three editions of the publication have been issued dating back to 1951. The publication has been accepted by industry to be the authoritative design standard for exhaust systems. In addition, many local air quality control boards across the USA have adopted or incorporated the manual into their regulatory criteria for exhaust system design. The primary goal of the usage of the manual is to determine the total air flow across the surface of chemical tanks to properly capture fumes evolving as a mist or fume from the open surface of the solution in the tank. The determination of the total system exhaust volume is a summation of the individual tank requirements. Segregation of the fumes is also determined by chemical make up of each exhausted tank, according to guidelines contained in the manual, as well as mandated by the Clean Air Act of 1990, as may have been modified from time to time.

Depending upon the toxicity or irritability of the chemistries contained in process tanks as well as its temperature, recommended air flow rates will vary from a minimum of 50 cubic feet per minute per square foot (CFM/FT2) to 250 CFM/FT2 for open top tanks. As an example, for a three (3) foot wide by six (6) foot long tank, typical exhaust flow rates would therefore range between 900 to 4500 CFM with an average at 2700 CFM. Assuming that a typical tankline may have ten exhausted tanks, the total exhaust system volume required is 27,000 CFM. As part of our example, we will also assume that the tankline has a single hoisting device for transporting work between process tanks. The hoist in our example may be manually or automatically operated .

In our example we have described a typical open top tank that contains chemistry and has exhaust hoods at the lip of the tank removing fumes fumes. The hoods may be of the lateral type design with fumes being captured at the lip of the tank with capture being accomplished simply by creating a flow of air over the surface of the tank a such a velocity so as to not allow contaminants to escape into the atmosphere. In some cases, push air systems are utilized in lieu of lateral exhaust, with the push air pipe located on the side of the tank opposite the hood. A small reduction of the exhausted air is allowed by the Industrial Ventilation Manual in the cases where push air is used. However, it is not clear if it is advisable to reduce exhaust volumes by more than 15% when using the push air approach. The point of the above discussion is to point out that exhausted open top tanks will draw large amounts of air from the room in which it is located.

To cut down on the total volume of air that is exhausted from a tankline, lateral hoods and tankcovers have been employed that have automatic dampers electronically interlocked to the covers that cut down the exhaust flow rate when the covers are closed and increase the exhaust flow rate when the covers are open. Tremendous savings of exhaust and subsequent make up air are realized through the use of automated tank covers with automatic dampers built into the outlet of the hood. Exhaust systems can be designed to run at approximately one third of the open top exhaust flow rate by utilizing the lateral exhaust hoods, tank covers, and automatic hood dampers. The importance of these three aspects of the overall system, operating in tandem, cannot be underestimated.

Design Assumptions

The basic design assumptions are as follows:

1. All covered tanks are normally closed except when work is being lowered into or being lifted from the tank. The exhaust of the covered tank will therefore need only be enough to prevent fumes from escaping around the perimeter of the tank. In practice,10- 25% of the full Industrial Ventilation works very well.

2. When the tank covers open, the exhaust volume is increased to full Industrial Ventilation flow rate, by the automatic opening of the exhaust damper(s) located on the outlet of the exhaust hood(s).

3. The velocity of the air traveling through the fume control device (horizontal or vertical scrubber or compoute mesh pad mist eliminator) must remain constant in order to ensure proper operation and control. Therefore a secondary device, an automatic relief damper, is needed to maintain a constant flow rate through the control device. The relief damper is installed upstream of the control device and downstream of the tankline exhaust manifold.

4. The total exhaust system sizing is based upon the assumption that all covers are in the closed position except for one tank, the worst case tank. The reasoning for this assumption is that, since the covers are automatically interlocked to the hood damper(s), and since our example system has one hoist, only one cover will be open at any one time. If the tankline is serviced by two hoists, then two covers could be open at one time, and the system would be sized accordingly. Therefore, the system sizing is dependent upon the number of hoists on the tankline, assuming that the worst case tanks could be open simultaneously, with work being

lifted or lowered into the tanks.

Therefore the system in our example is sized at approximately 25% of the full open top flow rate with the addition of the worst case exhaust volume of one tank. Therefore, the exhaust for nine of the ten tanks are sized at 25% of the average tank exhaust rate of 2700 CFM which is equal to 675 CFM. The worst case tank requires 4500 CFM. The system total becomes 6075 CFM + 4500CFM= 10,575 CFM. Compared against the open top exhaust flow rate of 27,000 CFM, a net savings of 16,425 CFM is realized, which represents approximately 60%, a dramatic achievement when translated into energy savings.

Case Study

A prominent aerospace company has installed a chemical processing line. The engineers decided to examine the concept of covered tanks as a way to reduce the amount of air being exhausted and lower costs.

The design methodology employed was to use 25% of the ACGIH recommended ventilation rate on all tanks except the worst case tank. The results can be seen in the table below:

Table 1

Station	**Process**	**Minimum Total CFM**	**Maximum Total CFM**
8	Alkaline Clean	1,500	5,850
7	Immersion Rinse (Back Up)	1,500	4,050
5	Sodium Dichromate	11,250	11,250
4	Immersion Rinse (Back Up)	1,500	4.050
11	Alkaline Clean	1,500	7,875
12	Immersion Rinse (Back Up)	1,500	5,850
14	Pasa Jel (T M)	1,500	11,250
15	Immersion Rinse (Back Up)	1,500	4,050
18	Paint Strip	1,500	5,850
19	Immersion Rinse (Back Up)	1,500	4,050
	TOTAL	**24,750**	**64,125**

Minimum Operational Requirements (Worst case cover open, all others closed): 24,750

Maximum Operational Requirements (All covers open): 64,125

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This represents a reduction in air volume of 39,375 CFM.

The flow of energy and pollution can be visualized as follows:

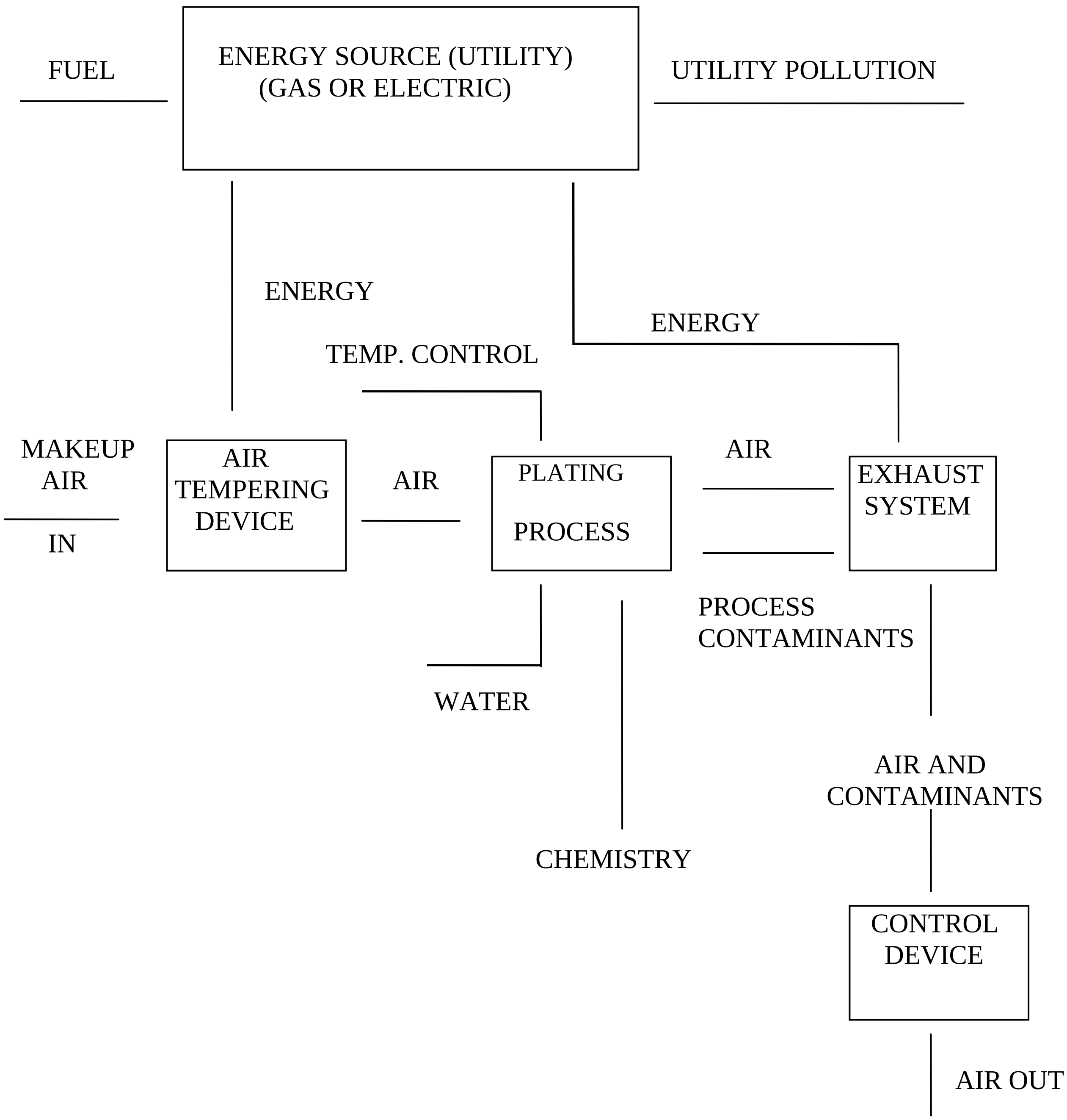
**See figure #1.

In some cases…….

Utility Pollution may be equal or greater than Plating Pollution

But with covered tanks the amount of utility pollution is decreased without decreasing the amount of contaminants captured in the exhaust system.

Figure #1



CONCEPT: If the energy consumption can be reduced in the pollution control on the process, the net pollution generated, including that from energy sources is significantly reduced.

Economics - Potential Savings

The savings realized by the plating line operator have three (3) sources

- Reduced fan horsepower
- Reduced heating in winter
- Reduced scrubber size

1) Horsepower (HP) cost savings.

If the system static pressure was estimated to be approximately 5.5” wg, we can use AMCA certified data tables to estimate the brake horsepower required for both operating conditions.

64,124 CFM = 84.36 HP
24,750 CFM = 30.11 HP

This is a reduction of 54.25 HP.

To calculate the amount of money saved it is necessary to estimate two important parameters, (1) the amount of time the fan runs, and (2) the cost of the energy. Because of the problems associated with heating large tanks, this facility is maintained at operating temperature on a continuous basis. If the tanks are hot, then they must be vented to prevent toxic buildup in the room. This means that the exhaust system must run three hundred sixty five (365) days per year. Also, the energy cost was assumed to be \$0.06/KWH (based on national averages). The amount of energy savings ES can be determined.

E.S. = 54.25HP x 0.746 KW/HP x 24 hours/day x 365 days/year x \$0.06/KWHR

E.S. = 354,521 KWH/YR x \$0.06/KWH

E.S. = \$7484.70

2) Heating Cost Savings.

This facility is climate controlled to maintain uniform process conditions. This requires that any air drawn out of the enclosure in the winter months must be replaced by heated air.

One way to estimate annual cost is given in the Industrial Ventilation Manual and is based on the degree day method. This formula is stated as follows:

$$\text{Annual Cost} = \frac{(0.154 \times \text{Airflow (CFM)} \times \text{degree days} \times \text{hours/week} \times \text{unit fuel cost}) \div (\text{BTU per unit of fuel})}{\text{Effienceny}}$$

After we input the appropriate numbers:

$$\text{Annual Cost} = \frac{(0.154 \times 39375\ \text{CFM} \times 6023 \times 168 \times \$5.00) \div 1{,}000{,}000}{0.75}$$

Annual Cost = $40,904.00

3) Reduction in scrubber size.

As the scrubber decreases in size, the amount of water recirculated over the packed bed decreases as well. A 70,000 CFM scrubber would typically require two (2) 7.5 HP pumps, but a 25,000 CFM unit will only require a 5 HP unit. This is a net horsepower reduction of 10 HP. The savings for this are calculated exactly like the fan energy.

E.S. = 10 HP x 0.746 HW/HP x 24 x 365 day/yr x $0.06/KWH

E.S. = 65349 KWH/Yr x $ 0.06/KWH

E.S. = $3,921.00

4)Potential effects on global pollution.

The biggest benefit to the global environment would be the reduction in combustion emissions associated with the reduction in energy. The reduction in pollution associated with the heating is calculated as follows.

Natural gas has an average heating value of 1,000 BTU/FT□, so to produce the 8180 million BTU's required, we must burn 8.180 million cubic feet of natural gas. Because of the nature of combustion of natural gas, we know that this translates into 1,389,588 pounds of CO_2 produced.

The reduction in pollutants associated with the reduction in electrical use is calculated differently. The primary fuel for electrical power generation is coal, and it is important to take into account the efficiency of the power plant.
The reduction in fan and pump motor HP yields a total estimated electrical reduction of 419,870 KWH/Yr or 1433 million BTU/Yr. However, when we account for the fact that the typical rankine cycle, coal fired utility plants in the US is 35-40% efficient, we find that the actual amount of energy required is 3583 million BTU/Yr. With coal having an average heating value of 11,000 BTU/Lb, this requires 325,685 pounds of coal (162.8 tons). This will result in 852,644 pounds of CO_2 emitted as well as 1075 pounds of particulate matter and 1969 pounds of SO_2 (based on EPA regulations).

Total Impact

Total impact of using covered tanks at this facility:

- Electrical Energy Saved 419,870 KWH
- Natural Gas Energy Saved 8,810 Million BTU
- Total Energy Cost Avoided $66,096
- Total Weight of CO_2 Avoided 2,242,232 Lb CO_2 (1121 Tons)

We recognize that these analysis are very simplistic, however we believe that the conservative assumptions for degree days and heating values allow us to use these numbers with a good level of confidence. We believe they illustrate how the use of covered tanks can have a large positive impact on operation and pollution prevention.

Summary

This paper/presentation has attempted to explain the role of ventilation in protection of the worker from toxic chemical exposure. It is important that the relationship between air flow and PEL requirements be understood. Once this understanding is achieved, it is easy to comprehend how the airflow can safely be reduced with the use of well designed mechanical covers. Once the how is understood, the why becomes evident through a study of the energy saved and pollution avoided. This also helps to overcome the resistance that some facilities may have towards as innovative approach to ventilation. As with any other novel design concept, it is recommended that vendor selection be carefully considered assuring sufficient experience has been gained in providing a well designed system.

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Personnel Bio's

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- 25 years experience as a business owner & entrepreneur in the design, fabrication and development of control devices & ventilation equipment for chrome & many other processes.
- Served on several panels, boards & association venues in support of the finishing industry needs for pollution control.
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