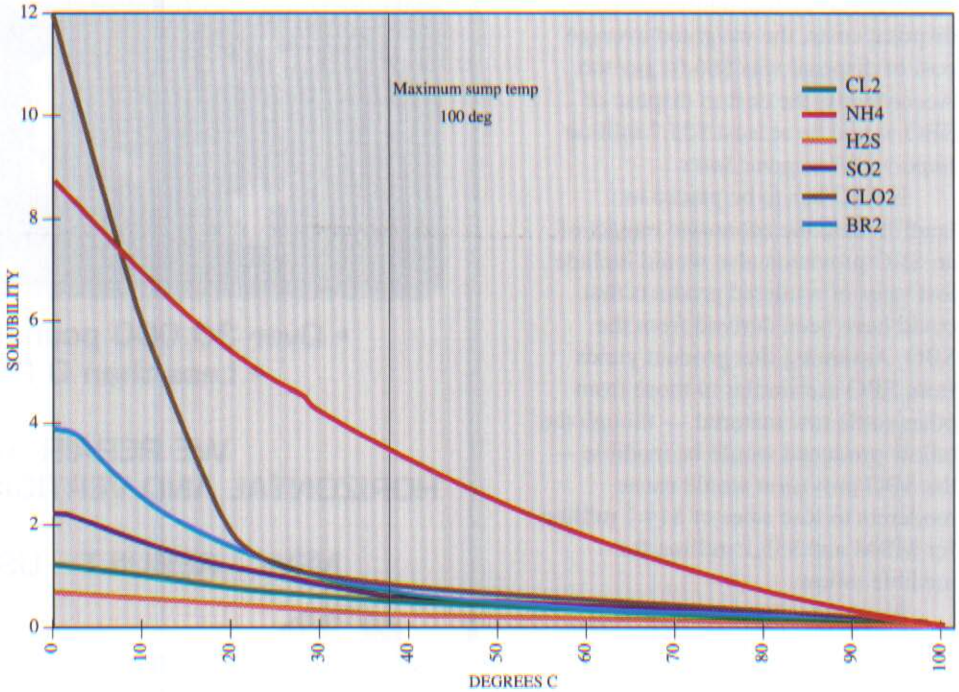
Wet Scrubber Removal of Odors and VOCs

by Charley J. Davis
Hydro Solutions, Inc.

All operating rendering plants produce volatile organic compounds (VOCs) due to the breakdown of the materials which are being processed. Please bear in mind that these emissions are insignificant compared to the amount of VOCs which would be emitted to the environment if the material were left to decay naturally. All odorous compounds are considered airborne contaminants, but not all odorous compounds are VOCs. All rendering plants in "non-attainment" areas will eventually be required, if not already, to meet point of discharge VOC limitations in their permits as established in the Clean Air Act of 1990 as amended (the "Act"). The new levels proposed by the Environmental Protection Agency (EPA) in 1996 will cause more cities to become "non-attainment" areas,

Chart 1. Solubility vs Temperature



placing a larger percentage of the rendering industry under the lower limits.

To understand the scientific basis of the Act, please refer to the article in the October 1996 edition of the *Journal of the Air and Waste Management Association* (JAWMA) entitled "Scientific Basis for the VOC Reactivity Issues Raised by Section 183(e) of the Clean Air Act Amendments of 1990" by Dr. Basil Dimitriades, Atmospheric Processes Research Division of the National Exposure Research Laboratory, EPA. In the introduction of this technical article, Dr. Dimitriades explains the reasoning and chemistry behind the VOC portion of the Act.

Oxidizing air treatment programs, especially ozone and chlorine dioxide programs, when fed in excess, remove nitric oxide from the atmosphere. This contributes to the excess accumulation of ozone in the atmosphere, the primary reason for the VOC limitations on stack emission permits (JAWMA Oct. 96). Most oxidizers and oxidizing chemical programs fall under the section of the Act (per EPA) entitled "Hazardous Air Pollutants."

In order to be effective in removing VOCs from the air stream, all air treatment programs whether oxidizing or non-oxidizing, must **react** with odor or VOC compounds. The resulting reaction products need to have flashpoints higher than the bulk water temperature of the scrubber sump. Oxidizing programs do not "burn up" organics coming from the rendering plant so they are no longer present but rather form oxidized by-products which collect in the sump water or continue out in the air stream. Not all oxidizing programs remove or react with all rendering odor/VOC compounds. For example, a very good oxidizing agent, chlorine dioxide, will not readily react with organic acids, primary amines and ammonia. Primary amines are highly reactive, odorous, volatile organic compounds.

All odor/VOC reactants, oxidizing or non-oxidizing, will be unable to remove odors if the conditions are not maintained to promote the reactions. The reaction by-products have solubility restraints, as do the air treatment programs or products being used to control rendering odor/VOCs. In other words, the sump water will only hold so much before it becomes necessary to replace that water with "unused" water. Operational temperatures determine the types of materials which can be captured. Each type of material (odor or VOC) has a temperature above which it is considered volatile. These compounds do not become volatile until a minimum temperature is reached and remain essentially nonvolatile below that temperature. A rule of thumb is that the inverse of a compound's flashpoint correlates with its volatility (the higher the flashpoint the less volatile the material). All air scrubber treatment programs are adversely affected by elevated temperatures. Chart 1 sets forth the solubility curves for some compounds commonly found in wet scrubber systems. You will note that the higher the temperature the less soluble these materials become and that more of the material could leave the stack as odors or VOCs. **All** chemical program by-products are effected in the same way. Normal sump temperatures should be between 40 to 95 degrees Fahrenheit. Table 1 (see page 52) sets forth compounds (with their flashpoints and solubilities) commonly found in rendering plant emissions (scrubber

Continued on page 54

Table 1. Compounds Commonly Found in Rendering Plant Emissions

Rendering Odor Compounds	Melting Pt. (C/F)	Boiling Pt. (C/F)	Flash Pt. (C/F)	Solubility
Acrolein (2-Propenal)	-87.0/-124	52.7/127	-18/-4	20.8
Allyl Amine	-88.2/-126	53.3/127	-28/-18.4	20.8
Allyl Mercaplan (2-Propene-1-Thiol)	67/152	21/69.8	—	
Amyl Mercaptan	-59/-75.7	52.2/126.64	18.3/65	Insoluble
Butylamine	-50.5/-58	77.9/172.4	-1/30	Miscible
Dimethyl Amine	-92.2/-133	6.9/44.6	—	Very soluble
Dibutylamine	-62/-79.6	159.6/318	33/91.4	.47
Diisopropylamine	-96.3/-140	83.5/183	-6/21.2	11
Dimethylsulfide	-98.3/-137	37.3/100	-36/-32.8	2
Methyl Amine	-93.5/-137	-6.3/21.2	0/32	950ML/MLaq
Methyl Mercaptan (Methanethiol)	-123/-187	6.0/42.8	<0/32	2.3
Ethylamine	-81.0/-113	16.6/62	-17/3.2	Miscible
Ethyl Mercaptan (Ethanethiol)	-147.9/-238	35.0/95	-17/3.2	.68
Trimethyl Amine	-117.1/-180	2.9/37	3/37	41
Ammonia	See Solubility Curves (Page 46)			
Butyric Acid	-5.3/23	163.3/325	77/170	Miscible
Dibutyl Sulfide	-75.0/-103	188.9/372	76/168	Insoluble
Dimethylacetamide	-20/-4	165.5/329	70/158	Miscible
Dimethylformamide	-60.4/-76	153.0/307	57/134.6	Miscible
Ethyl Mercaptan (Ethanethiol)	-147.9/-234	35.0/95	17/62.6	.68
Hydrogen Sulfide	See Solubility Curves (Page 46)			
Oxidized Oils	—	33-44/91.4-111.21	—	Insoluble
Pyridine	89/156	273/525	—	.5
Skatole (3-Methyl-1H-Indole)	95/203	266/510	—	S
Triethyl Amine	-114.7/-173	89.6/194	-6/21.2	5.5
Sulfur Dioxide	See Solubility Curves (Page 46)			
Putrescine (1,4-Butanediamine)	28/82.4	159/318	51/123.8	S
Cadaverine (1,5-Pentanediamine)	-129.7/-202	179/354	62/143.6	S
Diethylamine	-50/-58	55.5/132.8	-28/-18	Miscible
1,2 Ethanediamine	8.5/48	117.3/242	33/91.4	Miscible
1,1 Butane diammonium chloride				Miscible
Ammonium chloride	520/968	339/642		37
1,5 Pentane diammonium chloride				Miscible
Triethyl ammonium chloride				Miscible
Diethyl ammonium chloride				Miscible
Sodium Ethyl mercaptan				
Sodium propyl mercaptan				
Sodium Methyl mercaptan				
Dimethyl Disulfide	-84.7/-120	109.7/228	24/75	Insoluble
Dipropyl Disulfide		193.5/379		
Diethyl Disulfide	-101.5/-150	153.9/307	—	SLS
Dibutyl Disulfide	-71/-95	231.4/447	93/199	Insoluble
Ethyl Ammonium Chloride				Miscible
Dichloropropanal	39/102	73-79/163-174	—	
Propanoic acid chloride		144/291		Miscible
3 chloro propyl ammine HCL	150/302			Miscible
Dimethylsulfoxide	109/228	238/460	143/289	Insoluble
Dimethylsulfate	-31.8/-25.6	188/370	83/181	Very soluble
Diethylsulfone	74/165	248/478		15
Diethylsulfate	-25/-13	209/408	78/172	Insoluble
2-chloropropionic acid		186/366	107/224	Miscible
3-chloropropionic acid	41/106	205/401	>112/>233	Very soluble
Acetic acid	16.6/63	117.9/244	40/104	Miscible
Dimethylamine HCL	171/339	—	—	369

Study *Continued from page 51*
million for veal hides.

Total lost sales for rendering firms, therefore, would amount to $644.9 million. Of this total, Livestock Packer/Renderers would lose sales of $202.4 million, while General Independent Renderers sales would be reduced by $442.5 million.

It is assumed that unless prices in the fats and oils complex are depressed, it would still make economic sense for Livestock Packer/Renderers to render ruminant raw materials to recover and sell tallow, though the resultant MBM would have to be discarded; this would be preferable to disposing of all ruminant raw materials coming from the captive slaughter operations.

Lost Employment and Compensation

Assuming that the number of lost jobs is proportional to the amount of sales — and thus production — that are foregone, it is estimated that 2,656 employees would lose their jobs. This is a very conservative estimate of job loss. The SCI survey of renderers indicated that average annual compensation across all employees (i.e., from the owner or manager to the machinery operator) who are dedicated specifically to livestock rendering operations was $42,632 in 1995, ***including benefits***. Accordingly, total loss compensation for the 2,656 employees affected would be $113.2 million annually.

Costs of Disposal

Given that 6.5 billion pounds (3.25 million tons) of material would have to be placed in landfill annually, the total cost of disposal to packers and grocery stores would be $220.0 million per year.

Livestock producers also would incur costs associated with properly disposing of ruminant dead stock, which no longer would be collected for rendering. The cost of disposal paid by producers would be $44.6 million.

Considering the foregone sales, the lost jobs and compensation, and the disposal costs, the total economic impact if no ruminant materials were rendered would be just over $1.0 billion.

Conclusions

If the FDA puts in place a narrow ruminant-to-ruminant feeding ban as proposed, the economic impact is estimated to be $160 million per year. Other alternative measures that the FDA is considering could place an additional $100 million burden on the marketing chain. If customer perceptions of meat and bone meal after the imposition of the FDA regulation are strongly adverse, then the economic impact of the rule could be even larger.

Wet *Continued from page 47*
stack or steam).

Loading or the amount of airborne contaminants per hour being captured determines air treatment program limitations. Inherent contaminants in the water may require adjustments to the program in order to control scale. Total air treatment program considerations should include a determination of both the type of contaminants and the solubility limitations of both the reaction products as well as inherent limitations existing for the chemical treatment programs.

Air treatment chemical program requirements for odor/VOC removal:

a) Treatment chemicals must contain components that are miscible in water;

b) Treatment chemicals and reaction products must have high flashpoints (flashpoints higher than sump bulk water temperatures);

c) Reaction products must either be insoluble (drop out as solids) or miscible in water; and

d) Treatment chemicals must react with odor/VOC compounds emitted by plant or contained in the air stream.

Masking agents do not remove VOCs or odors but are matched to provide a pleasant covering smell. Since they do not react they tend to separate in the air stream. Normally both the odor and mask can be monitored with a gas chromatograph, odor meter, or VOC meter. These products are not effective as wet scrubber programs. Rendering plants could have a "covering agent" available for those "unusual" times during breakdowns and uncooked product back-ups, when the odorous material is outside of contained areas.

Hopefully this article has provided some insight into using wet scrubbers for the removal of VOCs and odors. Questions pertaining to individual systems should be directed toward your chemical suppliers or wet scrubber manufacturers. A balance of the proper equipment, equipment control and chemicals will allow you to meet the requirements of odor removal and the VOC limitations of the Clean Air Act of 1990, as amended.