



SKID-MOUNTED monomer recovery unit is headed for installation at Tenneco vinyl plant.

Putting VCM emissions on skids

New methods of controlling VCM emissions are being developed, but allowable level in air still has not been set by OSHA

With the final standard for workers' exposure to vinyl chloride monomer scheduled for promulgation next month by the Labor Dept.'s Occupational Safety and Health Administration, engineering firms and vinyl producers are hard at work exploring alternative methods of reducing plant emissions.

Because no one knows how low the standard will be, the best that plant management can do right now is to improve housekeeping procedures (e.g., tightening leaks). But they have a good idea of what they must shoot for in developing new techniques. OSHA's proposed standard is "no detectable level," which translates to 1 ppm, because of present limitations of measuring equipment.

The industry says it would be forced to shut down if such a standard were enforced, contending that a 1-ppm. limit is technically impossible to meet. It's claimed that 1.7-2.2 million jobs would be eliminated, as would production valued at \$65-90 billion/year. Through the Manufacturing Chemists Assn., the industry has recommended a maximum emission limit of 25 ppm, which would be reduced to 10 ppm. in three years.

Ready for Trial: Among the techniques now under trial is activated carbon adsorption. Calgon, for example, has reported successful studies of monomer ad-

sorption from vent gases. The monomer is regenerated with steam. But vinyl producers say they can't determine how well the system will work commercially until it is proved in major demonstration units.

One such unit, designed, fabricated and skid-mounted by Chemical Design (Lockport, N.Y.), is currently being installed at the new polyvinyl chloride plant Tenneco Chemicals is building at Pasadena, Tex. (*also see p. 80*). Tenneco's laboratory work indicates that almost all the vinyl chloride monomer can be removed from purge gas streams—with a level of 5 ppm. "possibly" attainable. Whether the same result can be achieved on a commercial scale remains to be seen. Tenneco must obtain an operating permit from Texas Air Pollution Control Board; no problems are expected.

Another method of controlling VCM emissions is offered in the new PVC manufacturing process developed by Robin-tech (Ft. Worth). The technique, called Rocor IKC (in-kettle compound), combines the two commonly used steps—resin making and incorporation of additives.

The company is close-mouthed about details, but claims that PVC made by the process virtually eliminates worker exposure to VCM at the fabrication point. Robin-tech uses the method in its Painesville, O., plant, says it has received word

from the U.S. Patent Office that approval of the patent application on the process will be granted.

Drive for Completion: Stauffer Chemical is looking into new methods of cleaning up monomer from vent gas streams, but also is trying to get down to fundamentals. Executive Vice-President Harold S. Mickley says the company has had a research and development task force at work for months trying to find answers to basic questions such as: "Can you drive the polymerization reaction to completion?"

If it is possible to achieve complete polymerization, the problems of downstream cleanup can be eliminated.

Walter Schlegel, assistant process engineer at Crawford & Russell (Stamford, Conn.), explains that major trouble spots are at four primary points in the manufacturing process: (1) slurry holding tanks, (2) dryer, (3) reactor (during routine cleaning between batches), (4) recovery system for process vent gases.

"Theoretically, you could blow a hurricane of air through the plant and eliminate the worker exposure problem, but that would only transfer the problem somewhere else," says Stauffer's Mickley. In fact, the cleanup problem is complicated, since vinyl makers will have to meet Environmental Protection Agency regulations on air quality outside the plant, as well as OSHA's standard for worker exposure. EPA's standard, which was to have been issued on Aug. 15, still was not ready at CW's press time.

The agency has monitored plants in many locations, has indicated that air quality seems satisfactory, so the cleanup approach is centered on bottling up the VCM as completely as possible within the process.

In the Plant: PVC resin is produced by four polymerization processes: suspension (which is used in more than 75% of the tonnage now made), emulsion, solution and bulk. Polymerization takes place in a reactor (usual capacity: 2,000-5,000 gal., although newer units hold as much as 35,000 gal.). Reaction temperatures are 120-150F; operating pressures, 110-160 psig. The reaction proceeds to about 85-90% VCM conversion, at which time unreacted monomer is removed from the unit. (All plants have VCM recovery systems composed of a series of compressors and condensers.)

The polymerized slurry is removed from the reactor, dewatered in a centrifuge and then dried with a stream of hot air.

All reactors must be cleaned, which is

one point of possible worker exposure. Cleaning frequency ranges from every five batches to 50. Older reactors often are scraped manually. But C&R's Schlegel says that this cleaning method is giving way to high-pressure water and water-detergent systems. Some plants use solvents, such as tetrahydrofuran, dimethyl formamide, or ethylene dichloride, to remove baked-on polymer and absorb unreacted monomer. But this substitutes one problem for another: the solvent must be recovered.

The new, large (e.g., 35,000 gal.) reactors are more easily cleaned than small ones because water jets can be positioned more effectively. Also, larger quantities of resin can be produced before cleaning is necessary.

Perhaps the biggest source of headaches, however, is the cleaning of the huge quantity of air that has been used in drying the resin. For example, a plant may use 40,000 cu.ft./minute of air. The air may be contaminated with only 10-15 lbs./hour of monomer that must be removed after it leaves the rotary dryer. To overcome this problem, vinyl producers are working on methods of removing monomer before the resin reaches the dryer.

Chemical Design suggests another approach: dehydrate air from the rotary dryers to ambient air moisture level and recycle it to the dryers. A bleed of 2,000-2,500 cu.ft./minute could be removed from the recycle stream for cleanup in an activated carbon adsorption system. The company says that without dehydration, an adsorption system to clean up 70,000-80,000 cu.ft./minute of air contaminated with 250-300 ppm. of VCM would require a capital investment of almost \$3 million.

On the other hand, an adsorption system for 2,000-2,500 cu.ft./minute of bleed air contaminated with 665 lbs./hour of VCM would cost \$600,000-700,000. Dehydration equipment would add \$300,000-500,000 to the cost.

The final vent gas streams from vinyl plants can be refrigerated to remove most remaining VCM, but other methods are being investigated.

Remote Operation: Some of the new processing methods that undoubtedly will be developed during coming months may involve remote operation of plants. According to Robert A. Allen, vice-president of World-Wide Construction Services (Wichita, Kan.), technology has been developed to operate new, large reactors from remote, isolated control rooms. The control areas could be 300 ft.

or more from the reaction area.

However, Allen told a group of engineers at an American Institute of Chemical Engineers conference on hazardous materials last month that remote operation could create new problems. Reason: operators would no longer be close to potential trouble spots. He said these problems might be offset by use of closed-circuit television, highly sensitive vapor detectors and microphones that could provide audiomonitoring in the control room.

Vinyl producers already are spending heavily for new monitoring devices, in addition to following general house-keeping procedures recommended by the Dept. of Health, Education and Welfare's National Institute for Occupational Safety and Health. NIOSH developed these recommendations for B.F. Goodrich's Louisville, Ky., plant, where the VCM-cancer link was first discovered in workers.

Of the 24 cases of angiosarcoma, a rare liver cancer, that have been reported, only one involved a worker at a monomer plant (in Sweden). Of the other cases, 20 have been in PVC plants, two in compounding and fabricating operations and one (in West Germany) in an aerosol pesticide container-filling operation that used VCM as a propellant.

No one seems to be certain of the maximum dosage of VCM that produces cancer. Joseph Wagoner, chairman of NIOSH's occupational carcinogen committee, says, "I'm sure 25 ppm. will show cancer." And he warns that there is no way to demonstrate the safe level of a carcinogen (*CW*, July 31, p. 19).

But whether OSHA decides to set the standard at the level recommended by industry, or adopt one that is considerably lower, vinyl producers will have to develop production methods and VCM recovery systems that will fill the bill. Plant shutdowns would seem to be the only other alternative.

Producers and representatives of labor agree that self-contained air-supply packs, similar to those used by astronauts, could not be used in vinyl plants because the workers couldn't function.

And there is no substitute material available to take PVC's place for many applications. As Arthur D. Little (Cambridge, Mass.) puts it: "It would not be possible to duplicate the exact properties of vinyl plastic products by using substitute raw materials."

Whether PVC users will be forced to face up to making do with substitute materials remains to be seen.

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September 18, 1974 CHEMICAL WEEK 71

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Showdown on vinyl plant rule presages shutdowns

Newly issued advisory reports hint at compromise in fight to curb vinyl chloride fumes, but battle may continue in court. Industry insists OSHA's proposal would be ruinous

The bitter controversy over worker exposure to vinyl chloride gas may climax on Oct. 5 when the U.S. Dept. of Labor is expected to set permanent standards for the 17 U.S. plants that produce the monomer, the 37 that polymerize it to make polyvinyl chloride resins, and the thousands of plants that mold, extrude and otherwise shape those PVC resins into plastic pipe, vinyl flooring, house siding and phonograph records.

The controversy has raged since last January, when medical data apparently established a link between workers' exposure to vinyl chloride monomer (VCM) and angiosarcoma, a rare liver cancer.

And last week the scores of chemical and plastic companies that have a stake in this \$3-billion/year business were given some inkling of whether the government will stay with the 50-ppm. emergency standard, adopt the proposed "no detectable level" limit or move to some compromise position. Whatever standards are set could determine the profitability of producing and processing vinyl compounds in the U.S. for many years and are likely to be attacked in the federal courts, either by the companies or the labor unions involved.

Conflict: As to exactly what standards will be promulgated next week, various indications—sometimes contradictory—can be found in three newly issued reports:

■ Foster D. Snell's final report to the Occupational Safety and Health Administration on the economic impact of the agency's proposed VCM exposure standards. A principal conclusion: "achieving no detectable levels . . . is judged not feasible, both in PVC and VCM sectors."

■ The Occupational Health and Safety Administration's final environmental impact statement on the physiological ef-

fects of the proposed standard. This report does not discount the possibility of a level higher than the 1 ppm. implicit in "no detectable level." But it concludes that anything higher is a risk to workers. "Despite significant cost increases that may occur, the high demand for PVC resins is likely to continue," the report states.

■ The Environmental Protection Agency's notification that within nine months it will set VCM plant emission standards that could add 4% to the cost of PVC. This would seem to preclude the engineering possibility of venting all the in-plant VCM leaks to the atmosphere.

Double Negative: OSHA's proposed goal of operating monomer and polymer plants at no detectable level of vinyl chloride exposure is "not feasible," according to Snell. Moreover, the firm's analysis indicates that the U.S. industry would com-

els; and there are no technology transfer opportunities to permit development of design for no detectable levels in new plants. Moreover, Snell says that because PVC manufacture is a batch operation, emissions couldn't be completely eliminated.

Something to Live With: Those conclusions would seem to support a compromise regulation that the vinyl makers could live with—perhaps not too happily. But probably because of the imminence of the Labor Dept.'s new regulations, industry representatives were reluctant to discuss Snell's final report, noting that they haven't had time to examine it.

Nor did they have much time to react to Snell's preliminary report, which contained pretty much the same data used in the final report but did not contain any conclusions. OSHA issued the preliminary report Aug. 28, called for response by Sept. 6. Nevertheless, industry leaders submitted comments, and these were generally negative and caustic.

One point of contention in the preliminary report was the use of Firestone data for bringing a PVC plant into compliance with a no-detectable-level standard. Firestone, Snell reported, was the only company that said it could meet such a standard. Firestone replied that studies of its polymerization plants in Pottstown, Pa., and Perryville, Md., actually indicated a contrary judgment.

Declares a Firestone executive: "Independent of economic considerations and despite enormous equipment, engineering and process changes at both facilities, costing in excess of \$50 million, it is not possible to achieve the drastic exposure levels required by the proposed standard, based on engineering controls and technology that now exist."

Firestone, No. 5 in PVC output, has

OSHA's vinyl standards impact: higher costs, fewer plants

Proposed VCM exposure standard* (ppm.)		Increase in average unit costs (cents/lb.)			Time needed to comply (months)	Proportion of industry endangered ²
Maximum	Time-weighted average	Direct	Loss of productivity	Total ¹		
Monomer plants						
50	15	0.04	0.03	0.07 ± 10%	0	0%
25	15	0.09	0.03	0.12 ± 40%	24	0%
10	2-5	0.17	0.15	0.32 ± 40%	36	0%
"No detectable amount"		—	—		Not feasible	100%
Polymer plants						
50	=	0.19	0.35	0.54 ± 20%	0-6	Negligible
25-40	15-25	0.36	0.49	0.85 ± 35%	30	4%
15-25	10-15	0.90	0.70	1.60 ± 50%	30	26%
"No detectable amount"		4.01 ³	3.07 ³	7.08 ± 75% ³	30-48 ³	100%

* Vinyl chloride monomer (VCM) content, expressed as parts per million, in the air to which employees are exposed. ¹ With estimated range of variance for individual plants, based on partial statistical analysis of data. ² Percentage of capacity that management would seriously consider shutting down. ³ Based on Firestone's estimates; actual compliance is not considered feasible. Source: Foster D. Snell, Inc.

pletely collapse under that restrictive standard, with all producers indicating they would have to close their plants.

The study offers several reasons for reaching these conclusions: technology to eliminate VCM leaks and fugitive losses is not available; existing plants have not been designed for total VCM containment; there has been no operating experience in maintaining very low VCM lev-

September 25, 1974 CHEMICAL WEEK 15

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some differences with the rest of industry on the exposure level standards that would be manageable. Industry generally supports the Society of the Plastics Industry's proposal: that the present temporary emergency standard of 50 ppm. be lowered in several stages to 25 ppm. for PVC plants by Oct. 5, 1975, with further imposition of a time-weighted average limit of 10 ppm. Standards for VCM production, says SPI, could be more restrictive—10 ppm. by October 1975, and a time-weighted average (twa.) of 5 ppm.

T.C. Walker, president of Firestone Plastics, says that a "safe and medically sound—as well as technologically and economically feasible—standard" is 40 ppm. maximum exposure and 25-ppm. twa.

Snell's analysis offers data on several alternatives, maintaining the SPI distinction between VCM and PVC plants (table, p. 15). Cost data indicate that VCM makers can manage with a 10-ppm. limit and a 2-5-ppm. twa. without closing any plants. Meeting such a standard would increase their average unit manufacturing cost by an estimated 0.32¢/lb., which is about 4-5% of the present range (7-10¢/lb.) of list prices for various grades of VCM.

For polymer producers, however, some plant closings may be necessary when the present emergency standard is tightened. According to the Snell study, at an exposure limit of 25-40 ppm. and a 15-25 twa., 4% of the existing PVC plants may have to be shut down. This might not be too disastrous, considering that 58% of the industry's plants are more than 10 years old, and only 8% are less than five years old.

But for an exposure limit of 15-25 ppm. and a twa. of 10-15 ppm., 26% of the PVC plants could face the axe. Snell's survey indicates that with this standard, unit costs of PVC would increase 1.6¢/lb., or about 4-8%, at those plants that can take the needed engineering changes. At some older, smaller batch operations, the companies say it would be impossible to reach such a low exposure level without building a new plant. At certain plants, Snell believes, the additional cost might be 50% more or less than the 1.6¢/lb. average.

Schedule Makers: Snell estimates it will take VCM plants up to three years to achieve what it considers the lowest achievable level. For PVC plants, the estimate is two and a half years.

This is based on engineering estimates of installation time for various kinds of apparatus to reduce exposure levels at

PVC plants. Examples: major ventilation system improvement, 18 months; replacement or reconditioning of reactors, 18-24 months.

Overly Optimistic? Some companies contend that these estimates are overly optimistic in light of today's materials shortages and delivery delays. Observes a Firestone executive: "Individual company confidence in being able to attain compliance with even the SPI recommendations has been eroding as lead times for obtaining equipment expand, as capital costs rise rapidly, and as the prospect for financing these projects becomes dimmer."



VINYL SIDING costs will rise as makers meet new in-plant and emission standards.

Industry criticism has also centered on Snell's projection of cost data to meet projected standards. The figures are said to be heavily weighted in favor of newer plants and suspension homopolymerization units in warmer climates. Such plants could probably be most readily adapted to meet a more stringent exposure standard.

Separate Standards: The proposed no-detectable-level standards would be applicable to VCM and PVC plants as well as fabricators. But the Snell study follows the SPI proposal of separate standards for VCM and PVC plants.

Reasoning is based on relative ease of controlling emissions at VCM plants, which are generally closed systems, operating in the open air. Leaks may occur around pump packings, during samplings or maintenance operation, or at tank-car

loadings. The batch operation of PVC plants involves continuous emptying and recharging of autoclaves and frequent inspections and cleaning out of these reactors. Chance of VCM exposure in these plants is high even in the packing areas.

While separate standards would seem reasonable to manufacturers, the practicality of this approach is limited. It's unlikely that labor groups, strongly in favor of the no-detectable level and opposed to the concept of a threshold level for any carcinogen, could accept different exposures for workers in various plants.

Outside Plant: If the vinyl producers solve their in-plant exposure problems, they will still have to deal with monomer gas escaping from the plant. EPA Administrator Russell Train said last week that his agency will set standards for vinyl chloride plant emissions by next June. And without firm data on health effects of VCM at various levels in the atmosphere, Train is proposing that the standards be based on "best available technology."

EPA's survey of air and water around 10 PVC plants indicated VCM air levels of 1 to 2 ppm. Through those emissions, the agency estimates, PVC plants are losing monomer at the rate of 200 million lbs./year.

With controls, EPA says emissions from PVC and VCM plants could be cut 75% and 90%, respectively. Capital outlays for these controls are put at \$80 million for the industry as a whole, with operating expenses estimated at some \$40 million/year.

John Nelson, vice-president for manufacturing at B.F. Goodrich Chemical, approves of Train's analysis, especially the statement that there is "no imminent hazard" from VCM exposure in the atmosphere.

But if OSHA's no-detectable-level proposal becomes the law, the vinyl chloride industry might have to re-evaluate its domestic production. Although industry spokesmen have warned of extensive shutdowns if such a standard is adopted, OSHA's environmental impact statement merely suggests that the costs will be high but will be passed on to the consumer, and that the time needed to reach the standards would be long.

But this report also suggests that "in the long run U.S. companies might find it profitable to build plants abroad." Clearly, this will depend not only on traditional market and raw-material logistics but also on whatever in-plant and emission standards are put in force in the U.S. and other nations.

New suit for dye makers

Calina Industries, a New York-based warp-knit fabrics manufacturer, filed suit this month against eight of nine big dye makers indicted for price fixing by a federal grand jury in July (*CW Business Newsletter*, July 24). The Calina suit is a class action brought on behalf of "all purchasers of dyes from one or more of the defendants or their coconspirators" since early 1970.

Defendants include Du Pont, Baychem (now Mobay Chemical), Allied Chemical, American Cyanamid, BASF Wyandotte, Ciba-Geigy, Crompton & Knowles and GAF. American Color & Chemical (jointly owned by North American Phillips and Koppers) was the only company not named in the civil action.

Like the federal complaint, Calina's suit charges that Du Pont officials began sounding out other dye makers on the possibility of an across-the-board price boost in 1970 and that the defendants, along with some other firms, conspired to push through price increases shortly thereafter.

Calina says that as a result of the alleged conspiracy, it and others in the class action have been, and continue to be, overcharged for the dyes they purchase. The suit seeks treble damages and urges the court to enjoin the dye makers from future conspiracy on pricing.

A spokesman for Du Pont says his company has not had time to thoroughly study the Calina complaint. The primary area of concentration is still the federal complaint, he adds.

Lawyers for Calina declined to give further details.

Bitter news for Abbott

Last November, Abbott Laboratories called a press conference to report that the company was formally petitioning the Food and Drug Administration to reverse its 1969 ban on marketing of cyclamates (*CW*, Nov. 21, 1973, p. 15). Spokesmen presented 16 volumes of test reports—stacked impressively on a table—which they said would convince FDA that cyclamates were safe.

Last week, however, Abbott's high hopes were jolted. FDA informed the company that it considered the test reports inconclusive and recommended that Abbott withdraw its petition. FDA said it wanted more convincing data, such as lifetime animal feeding studies, which could require several years to conduct.

"We have concluded that questions

about the cancer-causing potential of cyclamates still are unresolved," FDA Commissioner Alexander Schmidt said.

Abbott Executive Vice-President Charles S. Brown responded that the additional research requested by FDA is "neither reasonable nor required by scientific judgment." He requested a meeting with FDA officials as soon as possible.

Partly in anticipation of a favorable decision by FDA, Abbott restarted cyclamates production at its North Chicago, Ill., plant in January. Most of the output so far has gone to customers in several European countries where no bans exist. These customers had been supplied from pre-ban stockpiles.

FDA's thumbs-down may short-circuit Abbott's plans to send similar petitions to governments of other nations that have banned cyclamates. The company had been holding off until it got a reply from FDA.

Potential cyclamate sales—which the company had expected to reach \$16 million/year, the pre-ban level—have not been included in sales estimates for 1974 or 1975, Abbott said.

No letup in price hikes

The wholesale price index for chemicals and allied products climbed to a seasonally unadjusted 158.5 in August from 148.4 in July (1967=100), the Dept. of Labor's Bureau of Labor Statistics reported last week. The corresponding August 1973 figure was 111.

Leading the parade in price hikes for specific chemical commodities were inedible fats and oils, which moved from an index of 347.4 in July to 380.2 in August, and plastic resins and materials, which rose from 147.5 to 160.7.

Other big gainers were agricultural chemicals and products, which jumped from 131 in July to 142 in August; and industrial chemicals, from 155.5 to 167.8.

Some CPI segments registered more modest price gains. Examples: drugs and pharmaceuticals edged up to 115.3 in August from 112.7 in July; and prepared paint to 152.3 from 149.7. One commodity that scarcely changed was paint materials: to 155.9 from 155.4.

Among other related products, pulp, paper and allied products rose from 153.3 in July to 162.9 in August; nonferrous metals, from 198.4 to 200.4; refined petroleum products, from 239.4 to 243.9.

For all commodities, the wholesale price index moved up to 167.4 in August, 17.8% above the August 1973 level.

Compliance complaint

On Oct. 5, the Occupational Safety and Health Administration is slated to issue a standard for worker exposure to vinyl chloride (*also see p. 66*). As that date approaches, controversy is erupting over an OSHA-sponsored economic impact report, issued in preliminary form late last month by Foster D. Snell, Inc.

Snell polled 23 polyvinyl chloride producers on the costs of complying with various hypothetical exposure standards and indicated that imposition of the "no detectable level" standard, proposed by OSHA in May, might well close down the entire industry. The final Snell report is scheduled to reach OSHA this week.

Firestone Plastics has asked OSHA for a chance to cross-examine the Snell researchers, charging the report misrepresents the firm's assessment of compliance costs. Firestone's protests won't delay issuance of the standard but could raise the level of controversy.

"Our biggest criticism of the report," says Firestone Plastics President Todd Walker, "is that it said Firestone was the only company with the ability to meet the no-detectable-level standard. The fact is that our whole testimony at the [OSHA] vinyl chloride hearings was directed at saying it couldn't be done." Walker also criticized Snell for coming up with "no hard data."

Snell Vice-President Joseph Nemec, however, says his firm will have no response until after its completed report is in OSHA's hands.

According to the preliminary report, all 23 PVC companies polled said they could reach a 50-parts-per-million standard immediately; five said they could manage 25 ppm. by the end of 1976, seven by the end of 1977 and four by the end of 1978.

Meanwhile, Ralph Nader's Health Research Group has criticized the report as appearing to accept industry's blanket assertion that the no-detectable limit is not feasible and that it focused too much on the direct impact on the PVC makers, not on the over-all economy. "This myopic concentration on compliance costs disregards entirely the personal, social and even industrial costs of continued disease," the group maintained.

Odds seem high that OSHA eventually will issue a 5-ppm. standard. Neither industry nor labor is expected to be satisfied with such a decision.

"There's a lot of pressure on OSHA from the top to ease off the no-detectable-level standard," says one AFL-CIO health official.