Vinyl Studies

Within the past several years, significant advancements have been made in the PVC industry to minimize employee exposure to vinyl chloride monomer (VCM). Improvements in PVC manufacturing processes to reduce residual vinyl chloride monomer (RVCM) content of finished resins have been a key factor in maintaining acceptable atmospheric vinyl chloride monomer levels (AVCM) in work areas during storage, shipment and thermal processing.

Our knowledge and understanding of the diffusion[1,2] of VCM out of finished PVC resins under storage conditions and during thermal processing are also much improved based on extensive experimental data, modeling studies and work place monitoring.

Based on these facts, it is concluded for PVC resins and compounds with 8.5 ppm RVCM or less, the AVCM will be less than 0.5 ppm over an 8-hour day. The storage, transportation and thermal processing of these products will result in worker exposure less than 0.5 ppm AVCM over an 8-hour day.

Diffusion of VCM

The diffusion of VCM out of PVC resin is dependent on several critical factors:

- Particle size
- Particle porosity
- Temperature

The concentration of AVCM that can accumulate in enclosed work areas is additionally affected by:

- Resin quantity/storage volume ratio
- Ventilation rate of work area
- Residence time
- RVCM content of the resin

Using the above variables and data obtained from diffusion experiments, models have been developed that allow determination of the maximum concentration of AVCM that can occur under a wide variety of conditions. Additionally, monitoring of work place atmospheres has been carried out for a number of years. The results of this "real world" monitoring have confirmed the validity of the developed models.

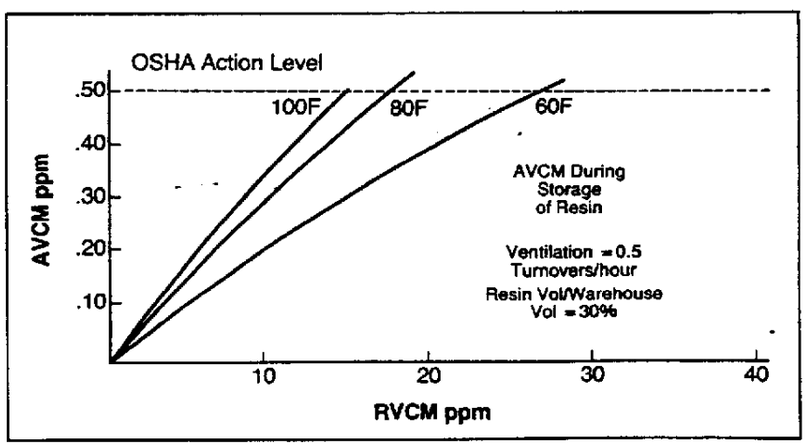
Storage and Warehousing of Resin

The development of a model that allows determination of AVCM in large storage areas presents a number of special problems. Many types of resins containing different quantities of RVCM are frequently moved in and out of the storage enclosures. Additionally, the diffusion rate of VCM out of resin at room temperature is very slow and does not follow the ideal behavior exhibited at higher temperatures (above the glass transition temperature). Consequently, it was necessary to study the behavior of stored resin in large-scale experiments designed to simulate warehouse storage conditions. The variables and ranges studied included:

- Temperature — 74 to 115°F
- Ventilation rate — 0.5–3.0 turnovers/hour
- Loading (PVC volume/storage volume) 11–34%
- Resin RVCM — 0.01–123 ppm
- Storage time — 1–170 hours

Using a Computer Optimized Experimental Design (COED), 24 large-scale experiments were selected to study the above listed variables to define their effects on atmospheric VCM in a storage compartment or warehouse. A multiple correlation analysis of these experimental results permitted the derivation of a model[3] which can be used to predict any combination of the variables studied. Thus, it is possible to predict the atmopsheric concentration of VCM in a storage area under the worst conditions of temperature, ventilation rate, loading and storage time. Based on these considerations, the AVCM is less than 0.5 ppm over an 8-hour day when the RVCM content of PVC resin is 8.5 ppm or less.

The validity of this model was confirmed by ambient air monitoring in BFGoodrich warehouse facilities in three locations over a one-month period. The measured atmospheric VCM level in these warehouse facilities was in excellent agreement with predicted results based on the developed model. Thus, "real world" monitoring was used to confirm the model based on experimental data. A more detailed description of this work is reported in the Journal of Vinyl



Technology (Vol. 1, No. 3, September, 1979).

Transportation of Resin

Since compartments used for transporting PVC resin (such as trucks and railway cars) are in effect a mobile warehouse, the previously described model for a warehouse can also be applied to shipping compartments. The variables included in the transportation model included:

- Temperature
- Ventilation rate
- Loading
- Resin RVCM content
- Residence time

Obviously, the range of some of the variables is somewhat different than in a warehouse (e.g., loading, ventilation and residence time). As in the warehouse study, the derived model was used to determine AVCM for worse-case situations, i.e., high loadings, high ambient temperatures, low ventilation rates and longest expected residence time.

Based on the above model, AVCM in a shipping compartment is less than 0.5 ppm over an 8-hour day provided the resin RVCM content is below 10 ppm. Again, as in the warehouse study, a significant amount of "real world" monitoring of atmospheric VCM in shipping compartments has been done to confirm the validity of the transportation modeling study.

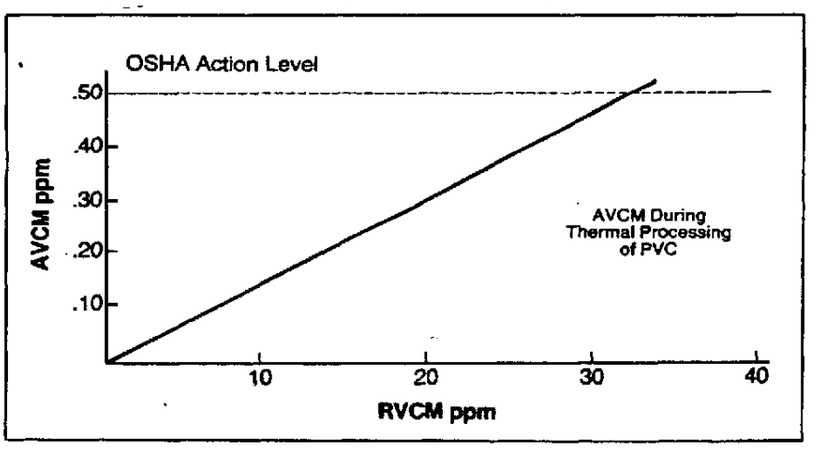
Thermal Processing of PVC

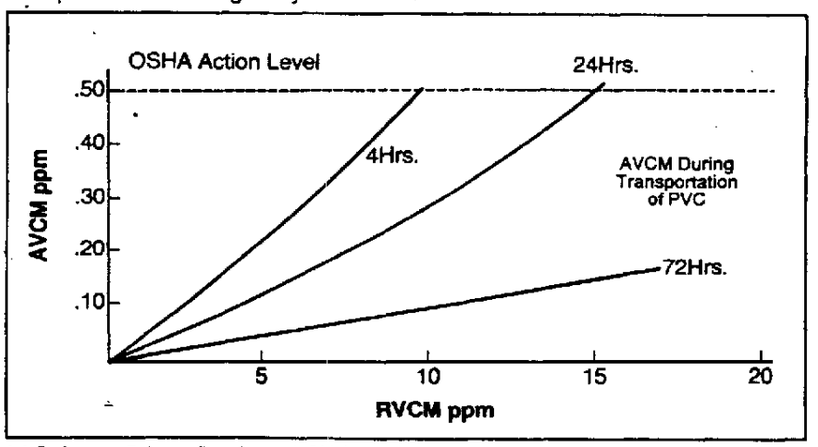
In the thermal processing of PVC, the variables affecting the relationship between RVCM and atmospheric VCM are, of course, somewhat different than those expressed for warehousing and transportation. A similar approach to modeling can be used, however, when these variables are considered:

- RVCM content of resin or compound
- Volume of processing building
- Processing rate, pounds/hour
- Ventilation rate, air turnovers/hour
- Building temperature
- Percent of VCM lost in thermal processing

This latter variable, percent of VCM lost in thermal processing, has been determined experimentally for a wide variety of resins and compounds.

Again, using a set of worse-case conditions, the developed model was used to determine the relationship between RVCM in resin or compound and atmospheric VCM in the work place. This model shows that the AVCM is less than 0.5 ppm over an 8-hour day when the RVCM level is below 32 ppm. A significant amount of personnel monitoring has also been done in PVC thermal processing areas to confirm the validity of the developed model.





Summary

The relationship between RVCM in PVC resin or compound and AVCM in work place areas, used for storage, transportation and thermal processing of PVC, has been subjected to intensive study. Models have been developed to determine AVCM level under the most adverse conditions. The validity of the models has been confirmed by "real world" monitoring. When the RVCM content is 8.5 ppm or less, the storage, transportation or thermal processing will result in worker exposure less than the action level of 0.5 ppm AVCM during an 8-hour day.

[1] A.R. Berens, Polymer Preprints, 15, 203 (1974)
[2] A.R. Berens, L.B. Crider, C.J. Tomanek & J.M. Whitney, Journal of Applied Polymer Science, 19, 3169 (1975)
[3] L.B. Crider, M.M. O'Mara, R.L. Bowles, Journal of Vinyl Technology, 1, 168 (1979)

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