Gulf Science and Technology Company

MEDICAL AND HEALTH RESOURCES DIVISION

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COPIES TO:

B. H. Gambrill, President
CHINA GULF PLASTICS CORPORATION
Post Office Box 22144
Taipei, Taiwan 105
Republic of China

Dear Bryan:

Enclosed are two copies of the report on the follow-up industrial hygiene survey of China Gulf Plastics Corporation's Toufen Plant and Taoyuan Plant conducted in November, 1981.

Occupational vinyl chloride exposure at CGPC has been reduced to around 2 ppm for reactor cleaners and other process area workers at Polymer Plant. Mercury exposure was in compliance with Chinese and the United States standards.

Future industrial hygiene emphasis should be placed in reducing employee exposures to solvent vapors and dusts, and in controlling fugitive VCM emissions.

Please let me know if there are any questions regarding this report.

Best Regards,

R. T Cheng

Robert T. Cheng

RTC/mim

Enclosures

cc: C. R. Grimes
J. R. Strausser
Runion/Davis
Microfilm (2)

FOLLOW-UP
INDUSTRIAL HYGIENE SURVEY
OF
CHINA GULF PLASTICS CORPORATION
NOVEMBER 1981

By

R. T. CHENG, Ph.D., P.E.
Regional Industrial Hygiene Director
Gulf Science & Technology Company

I. SUMMARY

A follow-up industrial hygiene survey of China Gulf Plastics Corporation's manufacturing facilities at the Toufen General Plant and Taoyuan Branch Plant was conducted in November, 1981. The purpose of the survey was to evaluate the progress of CGPC's Industrial Hygiene Program since the October 1979 audit. Primary attention was given to the review and evaluation of occupational exposures to vinyl chloride monomer (VCM), solvent vapors, and dusts of lead and chromium. Other occupational health hazards surveyed included workers' exposure to mercury vapor and noise. Following is a summary of the findings of this survey:

A. As indicated by the VCM exposure results, CGPC was already in compliance with the Chinese 10 ppm VCM exposure standard, and was very close in meeting the U.S. 1 ppm VCM exposure standard.

B. VCM odor was not detected in the normal work areas of the Polymer Plant and Monomer Plant during the entire duration of this survey. This indicates that acute exposures to high concentration (2000 ppm and above) have been virtually eliminated. This was an encouraging finding in view of a recent toxicological report that inhaling a single high dose of VCM (5000 ppm for 1 hr) may cause pulmonary tumors in laboratory mice.

C. Time-weighted average VCM exposure for Polymer Plant workers was between 200 ppm to 500 ppm before 1974. During this survey, Polymer Plant reactor cleaners and process area workers were exposed to an average of 1.5 ppm to 2 ppm of VCM during their 8-hour workshift. Workers in the Polymer Plant control room were exposed to less than 1 ppm of VCM as time-weighted average concentration.

D. In-plant VCM air pollution was caused by the dispersion and wind carry-over of stack effluents and other VCM emissions from the polymerization processes. VCM air pollution has been reduced since the last survey. Results of this survey indicate that office workers and engineers at the Engineering & Development Building, and "non-VCM" workers at the Fabrication Complex were exposed to less than 0.3 ppm of VCM due to in-plant VCM air pollution problem.

E. Occupational mercury vapor exposures have been brought under control by the various engineering and work-practice measures implemented. Chlor-Alkali Plant workers, including the flake caustic soda machine operators, showed mercury vapor exposures within the Chinese and the U.S. permissible limit.

F. Solvent vapor exposures for the #5 surface treating machine operators have been reduced after installation of the new local exhaust system. Toluene and MEK exposures for Toufen Printing Shop workers were excessive when the local exhaust systems for the printers were out of service. Solvent exposures for workers at the Engraving Room, the Catalyst Plant, and the Taoyuan Printing Shop were all well within the permissible limits.

G. Compounding ingredients mixing operators were overexposed to lead dust. Excessive exposures to PVC resin dust were indicated for several workers handling and transporting bags of PVC resin.

H. Dust and cyclohexanone exposures by flocking machine operators were determined to be excessive.

I. Occupational noise exposures exceeded permissible limit for all mixing roll operators and most of the winder operators of #1, #3, #5, #7, #8 and #15 calenders. The new #17 calender emitted much less noise than the older calenders.

J. CGPC's respiratory protection program was judged to be substandard.

Preliminary results of this survey have been reported to Mr. B. H. Gambrill, CGPC President, and Mr. S.K. Yeh, CGPC Vice President. A closing conference was held at the Toufen Plant with Mr. K. Yu, Vice President and General Plant Manager, with most of the plant management personnel also attending.

The author wishes to thank Messrs. B. H. Gambrill, S. K. Yeh, K. Yu, and other members of CGPC management for their courtesies during this visit. Gratitude to Mr. Ed Lu and his staff, and especially to Mr. J. Y. Huang, for their help in carrying out the survey work.

II. RECOMMENDATIONS

A. Conduct additional air sampling to confirm, but hopefully to refute, the findings of high vinyl chloride concentrations inside the Plating Shop Engraving Room.

B. Control fugitive VCM emissions by replacing some of the older and worn-out process equipment with double mechanical seal pumps, packless valves, or other proven no-leak or low-leak equipment.

C. A specially designed lid should be manufactured to fit the automatic water-jet cleaning machine and the reactor top manhole, thus reducing VCM emission during the time of water-jet cleaning.

D. Intensify the implementation of "search and secure" program. Encourage the reporting of VCM odor for speedy leak control.

E. Local exhaust ventilation system similar to that installed on the #5 surface treating machine should be installed on the #4 and #6 surface treating machines.

F. Local exhaust ventilation systems at the Toufen Printing Shop should be repaired and further improved to assure printer operators are exposed to acceptable levels of MEK and toluene.

G. Removable and cleanable ink catchers installed beneath the ink troughs can prevent the spilled ink from plugging the slots of the existing down-draft local exhaust system.

H. The flock addition chamber on top of the flocking machine should be enclosed. Improved local exhaust ventilation should be provided at the front end of the flocking machine to reduce flock dust and cyclohexanone exposures.

I. Ventilation on the third floor of the New Extrusion Plant should be improved by installing local exhaust hoods on the three supermixers and at the compounding ingredients preparation area.

J. Hygiene conditions at Taoyuan Plant's pigment packing room should be improved and a local exhaust hood installed for the weighing and handling of hazardous dusty materials.

K. Noise reduction by engineering control measures is preferred. When that is technically and economically infeasible, wearing of hearing protectors should be made mandatory by those operators whose time-weighted noise exposures approached or exceeded 100% of the permissible exposure limit.

L. Noise emission from #3108 PVC resin pelleting and vibrating machine can be significantly reduced by insulating the thin metal cabin shell with a layer of PVC leather, and operate this machine with cabin door closed.

M. CGPC should initiate an audiometric testing program for all new employees and for employees working in high noise areas.

N. CGPC should strengthen its respiratory protection program and initiate a respirator qualitative fit test program.

O. It would be most beneficial to CGPC if Mr. Ed Lu or Mr. J. Y. Huang could attend NIOSH Courses on "Industrial Hygiene Laboratory Quality Control" and/or "Industrial Hygiene Chemistry".

III. VINYL CHLORIDE EXPOSURE

A. Vinyl Chloride Health Effects

Early occupational health studies on vinyl chloride often reported acute toxic effects (dizziness, headaches, nausea, etc.). In January 1974, the B. F. Goodrich Chemical Company reported to the United States National Institute of Occupational Safety and Health (NIOSH) that several of its employees had died from angiosarcoma of the liver (a rare form of cancer) and that those deaths may have been related to occupational exposures to vinyl chloride. Experimental toxicological studies in later years confirmed that vinyl chloride is a carcinogen, mutagen and teratogen.

To date, more than 50 cases of liver angiosarcoma have been reported or confirmed worldwide among workers with a history of exposure to vinyl chloride. Most, but not all, of these cases have been among workers involved directly in PVC production. The latency period following the onset of occupational exposure is estimated to be about 13 to 30 years. While the focus of attention has been on liver cancer, it should be noted that a number of industrial studies suggest that the risk of developing other cancers, particularly lung and brain cancer, as well as liver dysfunction and other disorders, also has been related to vinyl chloride exposure.

B. Vinyl Chloride Exposure Standards

In the 1960's, the permissible exposure limit for vinyl chloride was 500 ppm in the United States and other countries. Available air monitoring data indicates that typical occupational exposures in PVC manufacturing plants were in the range of 100 to 400 ppm as 8-hour time-weighted average exposure.

In October 1974, after confirmation of carcinogenic effects, the U.S. Occupational Safety and Health Administration (OSHA) set the following permissible exposure limits for occupational vinyl chloride exposure:

1. No employee may be exposed to vinyl chloride at concentrations greater than 1 ppm averaged over any 8-hour period.
2. No employee may be exposed to vinyl chloride at concentrations greater than 5 ppm averaged over any period not exceeding 15 minutes.

3. No employee may be exposed to vinyl chloride by direct contact with liquid vinyl chloride.

In the Republic of China, the standard for vinyl chloride exposure remained at 500 ppm until 1981 when the Chinese Labor Department set a health standard limiting 8-hour time-weighted average vinyl chloride exposure at 10 ppm.

C. Historical Review of VCM Exposure and Control Actions at CGPC

1. Initial Industrial Hygiene Survey, February 1974

During this initial industrial hygiene survey, VCM concentrations above 10,000 ppm were sometimes encountered at Toufen's Polymerization Plant during reactor purging time. The odor of VCM (odor threshold ~2,000 ppm) could be detected very readily inside the Polymer Plant and sometimes at the Monomer Plant. It was established that the time-weighted average VCM exposure for Polymer Plant workers was in excess of 200 ppm, probably between 200 ppm and 500 ppm.

Control measures recommended and implemented included prolonged and improved vacuum-assisted recovery of unreacted monomer, and cover-up of the top manhole during reactor bleeding and air purging time, with the reactor exhausted through a vent pipeline leading to the outdoors.

2. Follow-up Industrial Hygiene Survey, August 1976

Odor of VCM was still detectable at the Polymer Plant and sometimes at the Monomer Plant. Long-term air sampling results suggest that the time-weighted average VCM exposure for Polymer Plant workers was in excess of 50 ppm.

A three-step VCM control program was recommended. Step one was to reduce workplace VCM concentration below odor threshold level. Step two was to achieve Canada's VCM exposure standard of 10 ppm. A "Search and Secure" team was formed to search for fugitive VCM leaks and secure the leaks through maintenance and repair measures. A Goodrich solvent spraying technique was adopted to reduce PVC scale formation, resulting in the reduction of reactor cleaning time.

3. Follow-up Industrial Hygiene Survey, November 1977

VCM odor was essentially eliminated from the Polymer Plant except during the short time (two to three minutes) of PVC scale flushing down from the dome of the reactor. It was estimated that a reactor cleaner's typical eight-hour time-weighted average VCM exposure was somewhere between 15 ppm to 50 ppm. Other workers at Polymer Plant were exposed to less than 10 ppm of average VCM concentration.

Reduction of VCM exposure was achieved through implementation of the "Search and Secure" program. Portable local exhaust hoods were used at the reactor bottom manholes to move VCM-contamined air to the outdoors during air purging time. Adoptation of one of the automatic reactor cleaning processes was recommended to eliminate routine reactor cleaning.

4. Follow-Up Industrial Hygiene Survey, October 1979

Odor of VCM was rarely detected in the Polymer Plant. Time-weighted average VCM exposure for reactor cleaners was 18 ppm. Other Polymer Plant workers were mostly exposed to 2 or 3 ppm of vinyl chloride.

Further reduction of VCM exposure was achieved through increase in VCM recovery from the reactor by prolonged vacuuming. Automatic water-jet cleaner was used to do the initial cleaning, thus reducing the manual cleaning time.

D. Results of November 1981 VCM Exposure Survey

Instruments employed during this survey included an H-NU Photoionization Analyzer for measurement of workplace airborne VCM concentrations, and 3M Brand Organic Vapor Monitors for long-term personnel air sampling. Grab air samples were collected with direct-reading VCM chemical detector tubes.

1. VCM Odor Survey

The odor of vinyl chloride was not detectable on each of the three floors of the Polymer Plant and at the Monomer Plant complex. Results of this odor survey suggest that acute exposures to 2000 ppm or more of vinyl chloride have been eliminated. This is very important because

laboratory studies have shown that inhaling a single high dose of VCM (5,000 ppm for one hour) caused pulmonary tumors in mice.

2. Workplace VCM Concentrations

The Model PI 101 Photoionization Analyzer by H-NU Systems, Inc. is capable of detecting VCM at roughly 0.2 ppm concentration. Survey with H-NU showed less than 0.5 ppm of VCM on the first floor, approximately 0.5 ppm on the second floor, and averaged 3 ppm on the third floor of the Polymer Plant. No VCM was detected inside the Control Room and Office Room on the third floor of this building.

During automatic water-jet cleaning of the reactors, VCM concentrations around the opened top manhole varied between 10 to 30 ppm. This could be the most significant source of VCM emission on the third floor. It is recommended that the top manhole should be covered as tight as possible to prevent vapor escape during the jet cleaning time. A specially designed lid should be manufactured to fit the automatic water-jet machine and the reactor top manhole.

VCM concentrations inside the reactor (measured at the bottom manhole) during the reactor manual cleaning time varied between 3 to 10 ppm, and averaged about 5 ppm. Two years ago, VCM concentration during reactor cleaning time was 20 to 30 ppm. This reduction of VCM concentration was achieved through increase of the vacuuming time before opening the reactor for cleaning; and through prolonging the duration of automatic water-jet cleaning before allowing personnel entry for manual cleaning.

Leaks of VCM were detected at several valves and flanges on the third floor of the Polymer Plant. Some of these process equipment were old and worn out. They should be replaced or repaired to reduce fugitive emission.

At the Monomer Plant, leaks were detected at level gauges and flanges of VCM tanks 337A, 337B and 338B. The tree transfer pumps near tank 336A and 336B leaked badly. Due to these fugitive VCM leaks, an average VCM concentration of 1 ppm was detected at the tank storage

building. VCM concentrations elsewhere at the Monomer Plant were either non-detectable or less than 0.2 ppm.

At the PVC Resin Drying Plant, airborne VCM concentrations ranged from non-detectable inside the Control Room to less than 0.5 ppm downstairs near the bagging process. At the Pilot Plant, the three large wall fans provided good general ventilation. No VCM was detected inside this building.

3. Time-Weighted Average VCM Exposure

Samples for assessing long-term time-weighted average VCM exposure were collected by attaching 3M Brand Organic Vapor Monitors on workers' lapels during their 8-hour workshift. Table I summarizes results of VCM exposures for workers at the Polymer Plant. Data in Table I were arranged in groups according to workers' job functions. For plant foreman, engineer, instrument operator and office worker who stayed mostly inside the control room and office area of the Polymer Plant, their VCM exposures ranged from 0.28 ppm to 0.87 ppm. Among workers in this group, the instrument operators (control board watcher) and the office worker showed the least exposures. The two plant foremen, who had to go out to the process area frequently, showed the highest exposures.

The job function of a reactor charger is to charge the reactor with vinyl chloride monomer, water and catalyst. Compared to plant foreman, the reactor chargers spend more time outside in the process area. Therefore, their VCM exposures were higher, ranging from 0.76 ppm to 1.5 ppm.

The job function of a reactor discharger is to drain the reactor of PVC resin after completion of the polymerization reaction, opening the top and bottom manholes, and setting up the automatic water-jet cleaning device. The three reactor dischargers monitored showed time-weighted average VCM exposures of 2.6 ppm, 3.4 ppm, and 24 ppm, respectively. The 24 ppm VCM concentration for Mr. O. K. Hsu was unusually high, and might be due to some untypical work pattern.

TABLE I

OCCUPATIONAL TIME-WEIGHTED AVERAGE VCM EXPOSURES
FOR WORKERS AT POLYMERIZATION PLANT
CGPC TOUFEN PLANT
NOVEMBER, 1981

EMPLOYEE IDENTIFICATION		JOB AT POLYMER PLANT	SAMPLING DURATION	VCM PPM
Peng, T.S.	55130	Foreman	420 min	0.87
Shieh, M.S.	56113	Instrument Oper.	418 min	0.28
Huang, H.L.	60388	Office Worker	364 min	0.31
Yeh, C.C.	69011	Engineer	363 min	0.41
Peng, S.S.	55131	Foreman	365 min	0.75
Huang, J.Y.	59110	Instrument Oper.	364 min	0.38
Fu, T.S.	56129	Reactor Charger	418 min	0.77
Huang, W.K.	67279	Reactor Charger	409 min	0.76
Chang, S.Y.	58116	Reactor Charger	363 min	1.5
Lin, H.S.	56110	Reactor Charger	355 min	1.1
Chen, C.Y.	59113	Reactor Discharger	411 min	2.6
Tsung, C.S.	58115	Reactor Discharger	356 min	3.4
Hsu, O.K.	54120	Reactor Discharger	357 min	24
Chio, Y.G.	67266	Reactor Cleaner	415 min	1.8
Lai, C.S.	64275	Reactor Cleaner	414 min	1.5
Li, J.H.	66123	Reactor Cleaner	414 min	2.7
Li, S.Y.	67277	Reactor Cleaner	413 min	1.5
Hsu, H.C.	65387	Reactor Cleaner	413 min	0.95
Chen, C.S.	64114	Reactor Cleaner	412 min	1.9
Koo, W.S.	69212	Reactor Cleaner	411 min	1.8
Chen, C.W.	64114	Reactor Cleaner	362 min	1.4
Chio, Y.G.	67266	Reactor Cleaner	361 min	1.3
Li, J.H.	66123	Reactor Cleaner	361 min	1.3
Tan, J.G.	66124	Reactor Cleaner	361 min	5.5
Li, S.Y.	67277	Reactor Cleaner	359 min	1.4
Koo, W.S.	69212	Reactor Cleaner	355 min	0.44

Reactor cleaners working during the dayshift usually clean six reactors manually. For the thirteen reactor cleaners monitored during this survey, their time-weighted VCM exposures ranged from 0.44 to 5.5 ppm, with an arithmetic mean exposure of 1.8 ppm for the group.

Overall, results in Table I indicate that control room workers at the Polymer Plant were exposed to less than 1 ppm of time-weighted average VCM concentration, while process area workers at the Polymer Plant were typically exposed to 1.5 to 2 ppm of VCM.

Table II summarizes occupational time-weighted average VCM exposures for workers at the Pilot Plant, Monomer Plant, and PVC Resin Drying Plant. Results indicate that all exposures were less than 1 ppm.

In conclusion, occupational vinyl chloride exposures at China Gulf Plastics Corporation were well within the Chinese 10 ppm standard, and very close indeed in meeting the U.S. OSHA 1 ppm standard.

CGPC workers and management should be congratulated in achieving this excellent record in VCM exposure reduction. CGPC has begun to replace the old and smaller reactors with new reactors of modern design. Occupational VCM exposure will be reduced further in the near future.

In view of the recent finding that a single high dose of VCM can produce cancer growth on laboratory animals, the significance of odor threshold of VCM (2,000 ppm) should be emphasized to all vinyl chloride workers. No one should be exposed to odor-detectable concentration of VCM for even a short duration. Workers should be encouraged to report vinyl chloride odor so that major leaks and emission sources can be secured. Workers should be able to refuse working in an area where VCM odor is detectable except during an emergency and when proper respiratory protection is provided.

4. Vinyl Chloride Air Pollution Problem

Due to wind carry-over, the air in areas downwind from the Polymer Plant could be contaminated by VCM vapors emitted from stacks and other sources at the Polymer Plant and the PVC Drying Plant. On November 11, 1981, the wind was blowing from the north and northeast

TABLE II

OCCUPATIONAL TIME-WEIGHTED AVERAGE VCM EXPOSURES FOR PILOT PLANT, MONOMER PLANT AND PVC DRYING PLANT WORKERS
CGPC TOUFEN PLANT
NOVEMBER, 1981

WORKER IDENTIFICATION		JOB	SAMPLE DURATION	VCM PPM
PILOT PLANT WORKERS				
Wu, K.L.	69020	Engineer	402 min	< 0.036
Lin, W.C.	59196	Operator	401 min	Lost
Chang, S.S.	66140	Operator	401 min	0.28
Shih, H.C.	65278	Operator	400 min	0.80
Lin, M.Y.	59198	Operator	402 min	0.35
Chen, S.Y.	67237	Operator	401 min	0.073
MONOMER PLANT WORKERS				
Wen, F.M.	60291	Instrument Oper.	343 min	0.086
Fan, W.C.	69109	VCM Unloading	336 min	0.81
Chen, C.W.	55120	Instrument Oper.	335 min	0.066
PVC DRYING PLANT				
Fong, Y.T.	65318	Instrument Oper.	347 min	< 0.041

TABLE III

AMBIENT VCM CONCENTRATIONS AT
VARIOUS LOCATIONS OF CGPC FACILITIES
NOVEMBER, 1981

SAMPLING LOCATION	SAMPLE DATE	NUMBER OF SAMPLES	RELATIVE TO POLYMER PLANT	RANGE OF VCM CONCENTRATION
Printing Shop	11/11/81	15	Downwind far	ND* - 0.081
Catalyst Plant	11/11/81	3	Downwind near	0.16 - 0.54
Leather Plant	11/17/81	14	Downwind	ND - 0.17
Plating Shop	11/18/81	3	Upwind	9.6 - 14 **
Printing Shop	11/20/81	12	Downwind far	ND
Leather Plant	11/24/81	12	Downwind	ND - 0.064
Plating Shop	11/25/81	3	Upwind	1.2 - 4.8 **
TAOYUAN Plant	11/13/81	4	None	ND

ND* - Not detected, detection limit approximately 0.03 ppm of VCM.

** - Further investigation should be conducted to confirm or reject these consistent high readings of VCM concentrations at the Printing Shop.

to south and southwest direction at moderately high wind speed (∿ 4 to 5 meter/second). Measurements with H-NU Photoionization Analyzer and with VCM direct-reading detector tubes showed the following ambient VCM concentrations:

MEASUREMENT LOCATION	RELATIVE TO POLYMER PLANT	VCM ppm
New Extrusion Plant	Upwind	Not detected
Raw Material Warehouse	Crosswind	0.1
LC #2 Station	Downwind	0.1 - 0.2
#17 and #19 Calender	Downwind	0.2 - 0.3
Engineering Building	Downwind	0.2 - 0.3
#7 and #8 Calender	Downwind	0.1 - 0.2

The above results indicate that employees working downwind from the Polymer Plant were exposed to very small amounts of VCM due to in-plant air pollution problems.

Further evidence of the minor in-plant VCM air pollution was obtained by analyzing VCM concentrations in organic vapor samples collected from workers at facilities other than the Polymer Plant and the PVC Drying Plant. As shown in Table III, long-term average VCM exposures for the three Catalyst Plant workers varied from 0.16 ppm to 0.54 ppm. The Catalyst Plant is located downwind near the Polymer Plant and PVC Resin Drying Plant. Further distances downwind from the sources of VCM emissions are the Leather Plant and the Printing Shop where workers were exposed to VCM concentrations ranging from non-detectable to 0.17 ppm. Four personal organic vapor air samples collected from Taoyuan's Printing Plant workers were analyzed for VCM contents. The results, all non-detectable, were listed at the bottom of Table III. Taoyuan Plant is simply a PVC fabrication facility.

For some unknown reasons, the samples collected from the three Plating Shop workers consistently showed high VCM concentrations. Plating Shop is located upwind from the Polymer Plant. Therefore, it was unlikely that VCM emissions from the Polymer Plant would affect workers at the Plating Shop. Unless there was an unexpected VCM emission source near or inside the Plating Shop, the detected VCM might be unrelated to airborne VCM concentrations, but due to chemical

interferences of the sampling media by the electroplating and engraving operations.

CGPC Industrial Hygiene Department should conduct surveys (with VCM detector tubes) either to locate the unexpected VCM emission sources, or to confirm the non-existence of VCM inside the Plating Shop.

E. Control of Fugitive VCM Emissions

Further reduction of VCM exposures at China Gulf Plastics Corporation can be achieved through control of fugitive emissions. Fugitive emissions include emissions that occur from valve stems, flanges, pressure relief valves, pumps, compressors, and agitator seals, from loading and unloading of monomer, and from sampling for laboratory analysis. These fugitive or unaccountable losses represent the most significant sources of emissions in PVC plants. Rapid detection of a leak so that it can be quickly repaired is an important facet of reducing fugitive losses. Large VCM leaks can be visually detected by the frosting which occurs at the discharge because of the cooling effect of gas expansion. Large leaks can also be detected by the odor of vinyl chloride.

Small leaks can be detected by several methods. A fixed multipoint gas chromatograph, analyzer and recorder system can be used to periodically sample the VCM content in the ambient plant air at as many as 100 points within a plant. The recorder can be fitted with an alarm to alert the operator of high VCM levels. When a high level is detected in a specific section of the plant, the exact location of the leak can be determined by the use of a portable hydrocarbon analyzer. Many of the U.S. PVC manufacturers have installed continuous monitoring instrument systems in recent years. Included in the Appendix of this report are two types of these monitoring systems used by U.S. PVC manufacturers.

CGPC's Industrial Hygiene and Safety Department has one set of Century Organic Vapor Analyzers. The Company has recently purchased a second set of Century Analyzers to be kept and used by Polymer Plant operators. Consequently, VCM leaks can be monitored on a more frequent basis, and repairs can be carried out soon after leak detection.

Detailed record of "search and secure" program should be maintained. The conditions surrounding each leak should be recorded. A periodic evaluation of these records serves to pinpoint recurring problem areas.

Single mechanical seals are presently used on most vinyl chloride pumps. The seal faces on single seal pumps are lubricated by a slight outward flow of VCM between the stationary and rotary faces. This flow can be eliminated by using a double mechanical seal pump in which a seal fluid such as glycerin and water, or ethylene dichloride is circulated and maintained, at a pressure greater than exists in the pump, between the two seals. When leakage occurs, a small amount of seal fluid can leak into the pump, but VCM cannot leak out of the pump. The initial capital cost of double mechanical seal pump is greater, however, the frequency of maintenance is much less.

Mr. C. S. Lee, Superintendent of the Polymer Plant requested information on valves, the types of valves that will leak the least. The U.S. Environmental Protection Agency have contracted studies undertaken to provide fugitive emission factors for various chemical process equipment. It is their recommendation that packless valves provide best control for vapor leaks. Packless valves are commercially available. There are two main types, differing chiefly in the means of isolating the valve stem from the process stream. In the diaphragm type, closure of a flexible diaphragm to vary flow rate is accomplished by means of a plunger attached to the stem. For high temperature and high pressure service, a sealed metal bellows type of packless valve is a more suitable choice.

A U.S. PVC manufacturer have replaced all ball valves with eccentric plug valves manufactured by FWI, Inc. (Tulsa, Oklahoma). Plant engineering and maintenance personnel believed that historical data indicates that FWI valves are the best for VCM service at that plant.

IV. MERCURY EXPOSURE

During the initial Industrial Hygiene Survey of February 1974, mercury vapor concentration at the central aisle of the Electrolysis Room was 0.25 mg/m^3. Since that time, many engineering control measures have been adopted to reduce the workplace mercury concentration. These include opening up all windows on both sides of the main floor to promote natural air circulation between indoor and outdoor air; removing most of the walls on all four sides of the basement to achieve the same general air circulation effect; installation of a local exhaustion ventilation system along the central aisle of the mercury cells; and, most importantly, enclosure of the head boxes and end boxes of the mercury cells to prevent mercury vapor evaporation.

Dramatic reduction of workplace mercury concentrations has been accomplished since 1974. Results of surveys indicated that the mercury vapor concentration along the central aisle of the cell room was reduced to 0.05 mg/m^3 during 1976 and 1977; and further reduced to about 0.02 mg/m^3 during 1979. This dramatic reduction was achieved despite the fact that many more new mercury cells were installed inside the cell room during the past years. The only remaining problem area was the flake caustic soda machine operation in the basement of the cell room, where, due to bad ventilation and mercury spill, the airborne vapor concentration remained above 0.15 mg/m^3.

Additional engineering controls have been installed since 1979. The flake caustic soda machine was moved out from the basement of the cell room to an open area along the Electrolysis Building. After the move, the mercury concentration at the new flake caustic soda machine was reduced to around 0.03 ppm. Other engineering and workpractice controls completed after 1979 included improvement of the brine purification system, total enclosure of the top box and end box of each mercury cell, and exhausting the top and end boxes to the brine tank to recover mercury. CGPC also employed a vacuum pump system to recover spilled mercury.

Various analytical instrumentation have been employed to conduct mercury vapor surveys at China Gulf Plastics Corporation. CGPC Industrial Hygiene Department have a set of JW Model MV-2 Mercury Sniffer and a Perkin-Elmer Model 50 Mercury Analyzer. A Jerome Gold-Film Mercury Vapor Analyzer and Personal Dosimeter System have been used to confirm the readings obtained by CGPC's instruments.

Bendix Brand mercury vapor detector tubes were used to collect grab air samples at point sources. During the 1981 Industrial Hygiene Survey, personal mercury vapor dosimeters by 3M Company were employed to measure long-term time-weighted average exposures to mercury vapor. Unfortunately, the 3M dosimeters showed corrosion due to chemical interference or other unknown reasons (e.g., storage in the refrigerator with other materials and samples, breakage of the sealing aluminum foil, etc.). Consequently, no valid results of the 3M Mercury Dosimetry Survey have been obtained.

Table IV presents results of three most recent surveys of mercury vapor concentrations in the Chlor-Alkali Plant. The mercury vapor monitoring positions are indicated on a map of the Electrolysis Room as shown in Figure 1. CGPC Industrial Hygiene Department conducts such mercury vapor surveys roughly once every two months. Review of the survey results indicate that China Gulf Plastics Corporation was meeting the occupational mercury vapor exposure standard of 0.05 mg/m^3.

For temporary, short-duration exposure to high mercury vapor concentrations such as during maintenance and clean-up of the mercury cells, proper type of respirator should be worn by the workers. Substantial protection can be provided by a disposable type of mask by 3M Company (3M Brand Mercury Vapor Respirator #8707). 3M has a sales office in Taipei.

TABLE IV

WORKPLACE MERCURY VAPOR CONCENTRATIONS
IN CHLOR-ALKALI PLANT, TOUFEN, CGPC

FIXED SAMPLING POINTS	LOCATION	MERCURY VAPOR CONCENTRATION (mg/m^3) Test 1	Test 2	Test 3
1	Office	0.03	0.015	0.025
2	NW of #35 Cell	0.005	0.015	0.02
3	S. of #35 Cell	0.005	0.005	0.03
4	S. of #29 & #31 Cells	0.01	0.025	0.01
5	S. of #23 & #25 Cells	0.015	0.03	0.01
6	S. of #17 Cell	0.02	0.045	0.05
7	S. of #11 & #13 Cells	0.02	0.04	0.045
8	S. of #5 Cell	0.03	0.045	0.055
9	E. end of South Cells	0.015	0.03	0.065
10	E. end, Center of Building	0.06	0.015	0.03
11	NE of #3 & #5 Cells	0.025	0.03	0.03
12	N. of #7 & #9 Cells	0.06	0.02	0.03
13	Center of #9 & #10 Cells	0.045	0.02	0.015
14	N. of #17 Cells	0.065	0.02	0.04
15	N. of #21 & #23 Cells	0.05	0.03	0.02
16	Center of #29 & #30 Cells	0.03	0.015	0.015
17	SW of #36 Cell	0.01	0.008	0.01
18	Booth	ND**	ND	ND
19	N. of #36 Cell	0.005	0.005	0.01
20	N. side of #30 & #32 Cells	0.02	0.013	0.01
21	N. side of #24 & #25 Cells	ND	0.01	ND
22	N. of #18 Cell	ND	0.005	0.005
23	N. of #12 & #14 Cell	ND	0.005	0.005
24	N. of #6 Cell	0.01	0.015	0.005
25	E. of North Cells	0.005	0.005	0.01
26	Caustic Soda Machine*	--	0.02	0.07
27	Laboratory	0.005	0.005	0.005
28	Rest Room	0.01	0.01	0.01

* Two additional measurements with MV-2 Mercury Sniffer showed mercury vapor concentrations of 0.015 and 0.025 mg/m^3 at the new flake soda machine operation.

** ND: Not detected, concentration less than 0.005 mg/m^3.

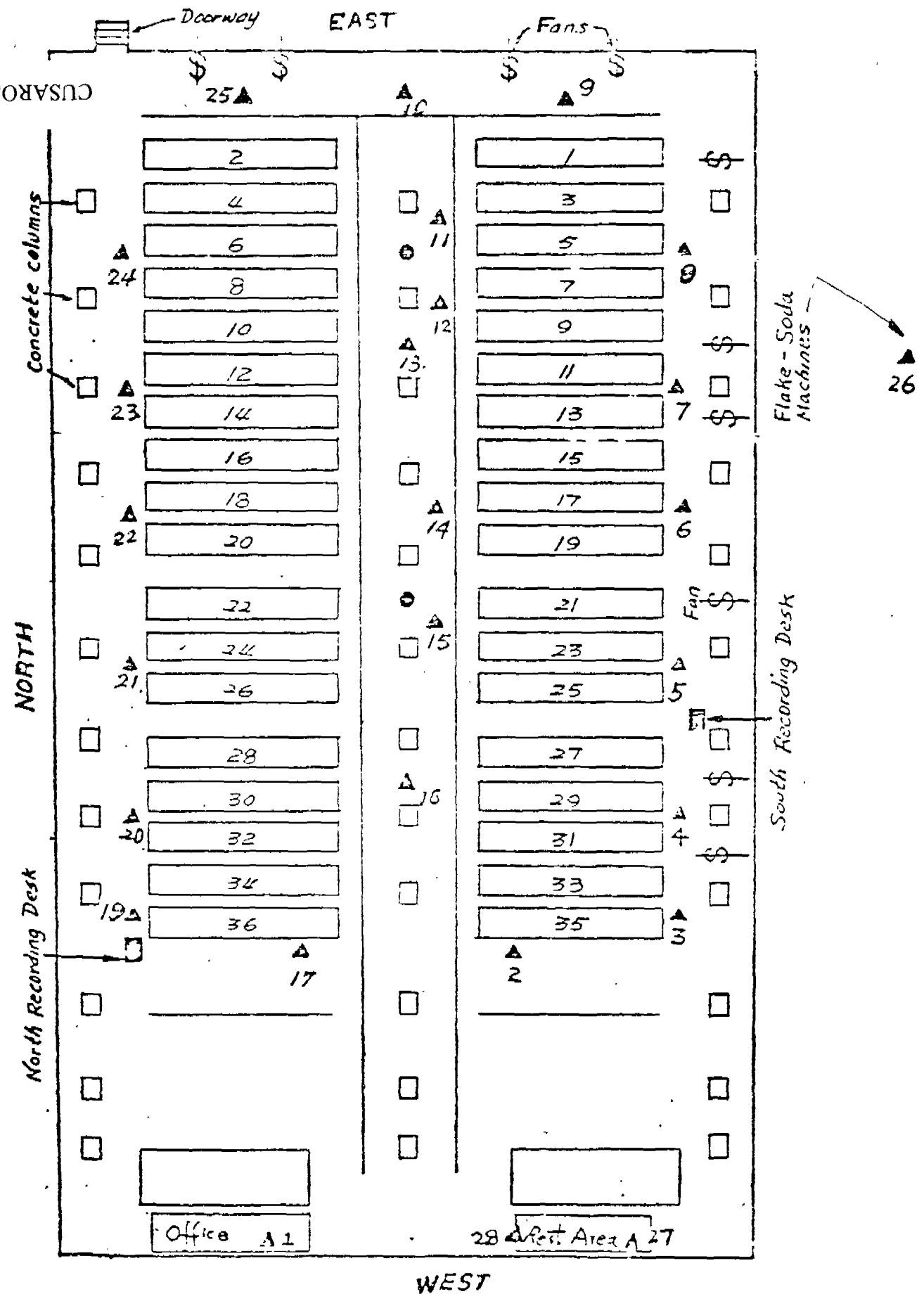

FIGURE 1 - Mercury Vapor Monitoring Points at Chlor-Alkali Plant

V. SOLVENT EXPOSURE

Bulk quantities of industrial solvents were consumed at the Flexible Products Fabrication Complex of Toufen Plant and at Taoyuan Plant's printing shop. The solvents were used mainly as surface treating agents and as an ink carrying vehicle in the manufacturing of PVC leathers, films and fabrics. The predominant solvents used by CGPC were methyl ethyl ketone (MEK) and toluene, each consumed at approximately 20 tons per month. Other solvents consumed in large quantities were methanol, methyl isobutyl ketone (MIBK), cyclohexanone, ethyl acetate, and dimethyl formamide. Benzene was not used by CGPC as a solvent in the fabrication processes. However, industrial grade toluene could contain benzene as impurity.

A. Surface Treating Machines

During the industrial hygiene survey of 1974, none of the surface treating machines in the Leather Plant was ventilated with local exhaust hood. The general ventilation condition inside the Leather Plant was grossly insufficient for diluting solvent vapors to an acceptable level. Total solvent vapor concentrations, as measured with a Century Organic Vapor Analyzer around the surface treating machines, varied between 200 to 1,000 ppm. The plant was operated at less than 50% capacity at that time, but workers complained about headache, nausea, and poor appetite due to solvent overexposures.

Working conditions at the surface treating machines have been greatly improved since the 1974 survey. Installation of local exhaust ventilation hoods at the surface treating machines was responsible for the decrease in occupational solvent vapor exposures. Total organic vapor concentrations at the surface treating machines have been reduced to mostly below 200 ppm. A high capacity side-draft exhaust hood with air curtain was newly installed at the #5 surface treating machine. Total organic vapor concentration was 300 ppm in front of the ink trough of the #5 machine before the new exhaust system was in operation, and reduced to 50 ppm at the same location after the new exhaust system was in operation.

Several long-term breathing zone air samples were collected from surface treating machine operators with 3M Brand organic vapor monitors. Table V summarizes the air sampling results. The current permissible exposure limits

TABLE V

TIME-WEIGHTED EXPOSURES TO MEK, TOLUENE, MIBK AND BENZENE BY CGPC SURFACE TREATING MACHINE

	EMPLOYEE I.D.		MEK ppm	TOLUENE ppm	MIBK ppm	BENZENE ppm
	#2 Surface Treating Machine Operators					
	Lin, Y.L.	61233	27	6.7	2.9	< 0.05
	Chen, M.L.	61239	5.7	1.8	0.77	< 0.05
	Hsu, Y.P.	67208	6.0	1.8	0.77	<0.05
	#3 Surface Treating Machine Operators					
	Shieh, Y.L.	61277	16	6.2	1.5	< 0.05
	Ko, A.W.	70145	16	4.9	1.5	< 0.05
	#4 Surface Treating Machine Operators					
	Tsai, C.S.	60222	8.4	3.2	0.85	0.1
	Wu, Y.S.	69117	0.83	0.54	0.15	< 0.05
	Huang, L.Y.	60177	4.1	1.8	0.52	< 0.05
*	Lin, R.H.	59179	240	43	20	0.06
*	Li, H.C.	61396	130	35	16	< 0.05
	Chen, T.F.	70127	6.7	2.4	0.85	< 0.05
	#5 Surface Treating Machine Operators					
	Liu, P.S.	67249	0.86	1.2	0.2	0.09
*	Peng, W.C.	60209	660	248	60	0.17
	Li, K.J.	58260	3.8	1.6	0.16	0.1
	Chang, J.G.	64126	0.98	1.1	0.18	0.1
	Wu, F.Y.	61211	58	13	< 0.05	< 0.05
	Peng, F.A.	64189	1.8	0.51	< 0.05	< 0.05
	Wu, Y.S.	59160	< 0.05	26	0.3	< 0.05
	#6 Surface Treating Machine Operators					
	Yeo, M.S.	61418	3.7	1.7	0.48	0.08
	Lin, J.S.	61302	20	81	2.6	< 0.05
	Pang, J.T.	64198	84	26	8.5	0.12
*	Tien, C.Y.	61328	150	45	10	< 0.05
*	Chieo, S.H.	60355	180	51	11	< 0.05
*	Huang, C.L.	61350	140	43	9.6	< 0.05
	Shop Foreman					
	Liu, S.L.	58213	5.3	2.1	0.6	< 0.05
*	Lo, F.S.	56153	96	56	10	< 0.05

* Employee was overexposed to total solvent vapors.

for individual solvent is 200 ppm for MEK, 100 ppm for toluene, 100 ppm for MIBK, and 10 ppm for benzene. Because the health effects of these solvents are additive, results in Table V indicate that a few operators had exceeded the combined permissible exposure limit for the group of solvents. It appears that the existing ventilation system is adequate for controlling solvent exposures at the #2 and #3 surface treating machines, while the #4 and #6 surface treating machines should be improved further to reduce employee solvent exposure.

Among the seven operators of the #5 surface treating machine, only one person, Mr. W. C. Peng, received unusually high exposure. Because his MEK, toluene and MIBK exposures were so out of line from others having the same job, it is likely that his high exposures were caused by an unusual occurence. For example, a drop of solvent might have been accidentally splashed onto the air sampling monitor.

The new local exhaust ventilation system for the #5 surface treating machine was determined to be effective. Similar ventilation systems should be installed at the #4 and #6 machines to reduce occupational solvent exposure at those two machines.

B. Toufen Printing Shop

There are three printers inside the Toufen printing shop. A 4-color printer, a 5-color printer, and a 6-color printer. Solvent vapors, mainly those of MEK and toluene, evaporate from the ink troughs and from the treavelling PVC fabrics. The printing shop was surveyed on November 11, 1981 and again on November 20, 1981. The results of the two surveys were drastically different. All three printers were in operation on November 11. The shop was very clean and the odor of solvent vapors was barely detectable. Measurements with an H-NU Model PI 101 photoionization analyzer showed that the total solvent vapor concentrations ranged from 20 ppm to 50 ppm. Measurements with MEK and toluene chemical detector tubes showed MEK and toluene concentrations in the 10 to 30 ppm area.

On November 20, 1981, only two printers (the 5-color and the 6-color) were in operation. The down-draft local exhaust systems under the two printers were disassembled for repair and cleaning. Solvent odors were readily

detectable. Measurement with H-NU analyzer showed total organic vapor concentrations ranged from 200 to 1,000 ppm. Measurement with MEK and toluene detector tubes confirmed the high vapor concentrations.

Long-term breathing zone air samples were collected from Toufen printing shop workers on November 11 and again on November 20 with 3M Brand Organic Vapor Monitors. Table VI presents results of this personal exposure survey. On November 11, printing shop workers had time-weighted average exposures to MEK, toluene, MIBK and benzene all well within the permissible limits of these solvents. On November 20, 1981, however, seven printing shop workers showed excessive toluene exposures and very high MEK exposures.

Results of these surveys proved the importance of the local exhaust systems for reducing solvent vapor concentrations at the printing shop. The air exhaust slots should be free of ink, grease and other contaminations to achieve top performance. Perhaps a removable and cleanable ink catcher installed just beneath the ink trough could prevent the spilled ink from plugging the exhaust slots of the down-draft ventilation system.

C. Taoyuan Printing Shop

Taoyuan Plant's printing shop has one 6-color printer located inside a rather spacious building. Housekeeping inside this shop was excellent. The floor around the printer was free of ink stains. Although the same type of down-draft local exhaust hood as those used at Toufen printing shop was used for this 6-color printer, workers at Taoyuan plant made an extra effort to prevent spilled ink from plugging the exhaust slots by placing layers of paper on top of the ventilation hood to catch the spilled ink. Measurements of ventilation adequacy with smoke tubes showed satisfactory air flow pattern for controlling solvent vapors under the travelling PVC fabric and from the ink troughs.

Table VII presents results of personal time-weighted average exposures to solvent vapors by Taoyuan printing shop workers. All four workers had exposures well within the permissible limits.

D. Engraving Room

MEK and toluene were used inside the engraving room of the Plating Shop

TABLE VI

TIME-WEIGHTED EXPOSURES TO MEK, TOLUENE, MIBK AND BENZENE BY CGPC TOUFEN PRINTING SHOP WORKERS

EMPLOYEE I.D.		MEK ppm	TOLUENE ppm	MIBK ppm	BENZENE ppm
SURVEY ON NOV. 11, 1981					
Chen, Y.L.	65348	16	14	0.24	<0.05
Chen, L.F.	56138	26	18	0.72	<0.05
Lin, J.C.*	60220	7.5	8.9	0.24	<0.05
Cheng, J.M.	68198	17	15	0.24	<0.05
Liu, M.Y.	70140	0.42	0.3	0.06	<0.05
Chen, T.C.	61380	34	28	0.40	<0.05
Tzeng, C.Y.	56014	15	12	0.70	<0.05
Koo, W.C.	65125	36	19	0.20	<0.05
Tang, S.L.	66157	37	20	0.27	<0.05
Tan, C.S.	67132	20	14	0.19	<0.05
Chio, W.G.	65359	21	14	0.73	<0.05
Chen, L.C.	70139	19	10	0.23	<0.05
Kao, M.S.	67136	41	23	4.7	<0.05
Peng, W.S.	56134	28	17	1.1	<0.05
Chio, C.S.	56238	42	26	6.3	<0.05
SURVEY ON NOV. 20, 1981					
† Ko, C.F.	67202	120	643	1.7	<0.05
Lin, W.T.	70124	4.9	5.4	0.3	0.09
† Hsu, V.T.	64125	230	464	1.9	1.2
† Liao, W.H.	57132	190	683	1.8	1.0
† Tsai, F.L.	65335	140	664	2.0	0.87
† Tong, S.L.	67278	120	641	1.4	0.77
Li, B.B.	65139	49	22	3.0	<0.05
Liu, S.Y.	67204	15	12	1.7	<0.05
Wu, J.Y.	67133	12	10	1.4	<0.05
Lin, J.C.*	60220	2.0	1.8	0.1	0.05
† Fu, J.B.	57131	130	663	2.0	0.84
† Chuang, M.L.	68112	120	660	1.6	0.76

NOTES: On November 11, 1981, all three printers were in full operation.

On November 20, 1981, only the 5 color and 6 color printers were in operation.

* Mr. J. C. Lin is ink preparation room worker.

Permissible Exposure Limits: MEK: 200 ppm, Toluene: 100 ppm, MIBK: 100 ppm and Benzene: 10 ppm

† Employee overexposed to solvent vapors.

TABLE VII

OCCUPATIONAL TIME-WEIGHTED AVERAGE MEK AND TOLUENE
EXPOSURES FOR TAOYUAN PRINTING SHOP WORKERS
CGPC TAOYUAN PLANT
November 13, 1981

WORKER IDENTIFICATION	JOB	MEK ppm	TOLUENE ppm	MIBK ppm	BENZENE ppm
Lo, C.C. 61908	Printer	0.10	2.6	< 0.03	< 0.05
Li, C.H. 65973	Foreman	0.71	4.4	< 0.03	< 0.05
Le, M.C. 66919	Foreman	1.2	7.9	< 0.03	< 0.05
Feng, D.M. 68840	Printer	0.93	8.3	< 0.03	< 0.05

to wash and degrease rollers of the printing machines. Workers of the engraving room mentioned solvent vapor inhalation due to working with solvents without adequate ventilation (wall fans cannot be used in order to preserve air cleanliness). Long-term personal samples were collected with 3M Organic Vapor Monitors to determine their solvent exposures. Table VIII presents results of samples collected on two working days. All three engraving room workers showed toluene and MEK exposures well within the permissible exposure limits.

E. Catalyst Plant

MEK and MIBK are used in the catalyst plant. Table IX presents results of long-term personal samples collected from catalyst plant workers for solvent vapor analysis. Results indicate occupational exposures to MEK and MIBK were at minimal or non-detectable levels.

F. Flocking Machine

A new flocking machine was installed inside the building where the old floor tile plant was located. Cyclohexanone was used as the solvent in the preparation of glue and surface treating solution. The air around and above the flocking machine was odorous and caused minor throat irritations. Cyclohexanone concentrations were 20 to 50 ppm at the front end of the machine and approximately 5 ppm at the tail end of the machine. The highest cyclohexanone concentration was at the fabric entrance to the baking oven where 100 to 150 ppm was detected. Inside the office area, cyclohexanone concentration was 15 to 20 ppm.

Cyclohexanone concentration at 25 ppm was not objectionable to most human subjects during a 5 minute exposure. Throat irritation was the most marked effect at 50 ppm. Cyclohexanone at 190 ppm caused liver and kidney injury to rabbits upon prolonged exposure. In 1978, NIOSH recommended a time-weighted exposure limit of 25 ppm. The new threshold limit value (TLV) recommended by the American Conference of Governmental Industrial Hygienist has been reduced from 50 ppm to 25 ppm for occupational cyclohexanone exposure.

Based on survey results, it is likely that workers operating the flocking machine could have cyclohexanone exposures exceeding the new TLV of 25 ppm,

TABLE VIII

OCCUPATIONAL TIME-WEIGHTED AVERAGE EXPOSURES TO
MEK AND TOLUENE BY ENGRAVING ROOM OPERATORS
CGPC TOUFEN OPPERATION
NOVEMBER 25, 1981

WORKER IDENTIFICATION		DATE	SAMPLE DURATION	MEK ppm	TOLUENE ppm
Cheng, Y.D.	66113	11/18/81	480 min	1.2	8.7
Huang, A.C.	64290	11/18/81	480 min	1.1	8.4
Liao, C.M.	66115	11/18/81	480 min	0.54	9.2
Cheng, Y.D.	66113	11/25/81	429 min	0.36	1.2
Huang, A.C.	64290	11/25/81	428 min	0.36	1.3
Liao, C.M.	66115	11/25/81	427 min	0.37	1.7

TABLE IX

OCCUPATIONAL TIME-WEIGHTED AVERAGE EXPOSURES TO
MEK AND MIBK BY CATALYST PLANT OPERATORS
CGPC TOUFEN OPERATION
NOVEMBER 11, 1981

WORKER IDENTIFICATION		SAMPLE DURATION	MEK ppm	MIBK ppm
Wang, M.S.	55134	366 min	< 0.05	< 0.05
Tsung, W.J.	55136	366 min	< 0.05	0.05
Woo, W.F.	69144	365 min	< 0.05	< 0.05

but still within the current Chinese standard of 100 ppm. It is recommended that the existing local exhaust ventilation system should be improved. Major emphasis should be placed on the picking up of cyclohexanone vapors escaped from the baking oven, and for controlling cyclohexanone and flock fiber emissions from the flock addition chamber. Ventilation at the front end of the machine can be improved by installing a side-draft local exhaust system similar to that newly installed for the #5 surface treating machine. No improvement is required at the tail end of the machine.

VI. DUST EXPOSURE

CGPC Toufen Plant now has two compounding ingredients mixing rooms, one for the Old Extrusion Plant and one for New Extrusion Plant. The compounding ingredients include plasticizers, stabilizers, lubricants, fillers, pigments, etc. The stabilizers are added to avoid the disintegration of the PVC resin and to prevent discoloration. At CGPC, powders of lead, cadmium and barium stearates are used as stabilizers.

Many types of dyes and pigments are mixed with PVC resins to impart color to products. It is not unusual to find very toxic compounds in dyes and pigments. Inorganic pigments include salts and oxides of lead (particularly lead chromate), molybdenum, chromium, antimony and titanium. CGPC reported the monthly consumption of two pigments, molybdate orange P-380 and chrome yellow GL at 5.1 ton and 6.1 ton, respectively.

In the United States, the current permissible occupational exposure limits are: 0.05 mg/m^3 for chromate compounds, 0.05 mg/m^3 for lead, 0.5 mg/m^3 for barium, and 0.05 mg/m^3 for cadmium. The U.S. National Institute for Occupational Safety and Health (NIOSH) has declared that certain forms of hexavalent chromium, including lead chromate, have been found to cause increased respiratory cancer mortality among workers. NIOSH recommends that exposure to those carcinogenic hexavalent chromium be not greater than one microgram per cubic meter of air (1 $\mu g/m^3$).

Long-term breathing zone air samples were collected from workers at dusty operations. These samples were analyzed for total particulate concentration, and for lead, barium, cadmium and chromium concentrations. Table X summarizes the results of occupational time-weighted average exposures.

Excessive exposures to cadmium and chromium occurred only to the compounding ingredients mixing operator of the Old Extrusion Plant. Excessive lead exposures occurred to all compounding ingredients mixing operators, and to a few operators of the blenders and mixers at Toufen. Quite a few samples showed massive exposure to total dust. One sample showed 210 mg/m^3 of total dust (mainly PVC resin dust).

Most of those huge dust exposures occurred not as a result of massive airborne dust concentration in the general workplace, but due to close contact of the workers to the dust sources. For example, many workers were involved in carrying

TABLE X

OCCUPATIONAL EXPOSURES TO AIRBORNE CONCENTRATIONS OF
BARIUM, CADMIUM, CHROMIUM, LEAD AND TOTAL DUST
CHINA GULF PLASTICS CORPORATION
NOVEMBER, 1981

EMPLOYEE NAME	JOB AND LOCATION	BARIUM mg/m^3	CADMIUM mg/m^3	CHROMIUM mg/m^3	LEAD mg/m^3	TOTAL DUST mg/m^3
COMPOUNDING INGREDIENTS MIXING						
Shu, L.C.	Old Compounding Plant-Nov. 11	.24	.16 *	.34 *	3.4 *	20 *
Shu, L.C.	Old Compounding Plant-Nov. 27	.0016	< .0028	< .0046	0.13*	1.4
Tsung, G.H.	New Compounding Plant-Nov. 11	.0015	< .0022	< .0037	0.48*	3.8
Tsung, G.H.	New Compounding Plant-Nov. 27	.0072	< .0028	< .0046	0.56*	3.9
BLENDER & MIXING OPERATORS						
Liao, R.S.	Old Extrusion Plant Blender	.0100	.0052	< .0044	0.17 *	2.0
Koo, L.C.	Old Extrusion Plant Blender	.0010	< .0026	< .0043	0.017	0.16
Chen, C.Y.	Old Extrusion Plant Mixer	.0011	< .0026	.012	0.030	0.30
Chang, S.C.	Old Extrusion Plant Blender	.0064	.021	.0044	0.24 *	210*
Huang, S.C.	Old Extrusion Plant Blender	.021	.0078	.0062	0.25 *	14 *
Yeh, Y.Y.	Old Extrusion Plant Blender	.0008	< .0023	< .0039	0.011	0.51
Tzeng, T.T.	Blender, #4 Calendar	.0041	< .0037	< .0062	0.025	97 *
Lu, C.C.	Blender, #2 Calendar	.0023	< .0026	< .0043	< .0043	0.59
Lin, S.M.	Blender, #8 Calendar	< .0004	< .0026	< .0043	< .0043	0.60
OTHER DUSTY OPERATIONS						
Chen, C.F.	Flocking Machine Operator	< .0004	< .0025	.018	.0066	61 *
Wu, C.P.	PVC Leather Buffing Machine	.0025	.0025	.0099	.025	30 *
TAOYUAN PLANT						
Ko, Y.G.	Pigment Packing Room	< .0004	< .0023	< .0038	< .0038	0.43
Chang, C.C.	Supermixer, #9 Operator	< .0004	< .0023	< .0038	< .0038	7.4
Wu, S.L.	Ribbon Mixer, #15 Calendar	< .0004	< .0024	< .0040	< .0040	0.14
Lu, T.S.	Bambury, #11 Calendar	< .0004	< .0004	< .0040	< .0040	50 *

* Indicates overexposure.

Permissible Exposure Limits: Barium: 0.5 mg/m^3, Cadmium: 0.05 mg/m^3, Chromium: 0.05 mg/m^3, Lead: 0.05 mg/m^3, Total Dust (nuisance): 10 mg/m^3