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MEDICAL AND HEALTH RESOURCES DIVISION

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February 8, 1980
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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 October, 1979.

Major areas of concern are VCM overexposures by reactor cleaners, in-plant VCM air pollution and dust overexposures. I have proposed a CGPC industrial hygiene personnel training program with emphasis on industrial hygiene laboratory quality control and ventilation engineering. Your early reply on this matter will be appreciated.

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

Thanks again for your help while I was in Taiwan.

Warm Regards,

R. T. Cheng

R. T. Cheng

RTC:vic

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A DIVISION OF GULF OIL CORPORATION

FOLLOW-UP
INDUSTRIAL HYGIENE SURVEY
Of
CHINA GULF PLASTICS CORPORATION

October 1979

By

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

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TABLE OF CONTENTS

		Page No.
I.	SUMMARY	1 - 3
II.	RECOMMENDATIONS	4 - 5
III.	VINYL CHLORIDE EXPOSURES	6 - 18
IV.	MERCURY EXPOSURES	19 - 23
V.	SOLVENT EXPOSURES	24 - 30
VI.	DUST EXPOSURES	31 - 35
VII.	PLATING ROOM	36
VIII.	OCCUPATIONAL NOISE EXPOSURES	37 - 44
IX.	CGPC'S INDUSTRIAL HYGIENE PROGRAM	45 - 51

I. SUMMARY

A follow-up industrial hygiene survey was conducted at China Gulf Plastics Corporation's Toufen and Taoyuan plants during the period of October 11th through 19th, 1979. The purpose of this survey was to evaluate the progress of CGPC's Industrial Hygiene Program. Extensive attention was given to the evaluation of the workplace concentrations of vinyl chloride monomer (VCM) and workmen's occupational VCM exposures. Other industrial hygiene problems surveyed or reviewed included mercury exposures, solvent vapor exposures, dust exposures, Plating Room conditions, and occupational noise exposures.

Following is a summary of the important findings during this survey:

A. Odor of VCM was rarely detectable in work areas of the Polymer Plant and the Monomer Plant, indicating that gross exposures to VCM (2,000 ppm and above) have been virtually eliminated. This was an encouraging finding in view of a recent toxicological report that inhaling a single (one hour) high dose of VCM (5,000 ppm) may cause pulmonary tumors in laboratory mice.

B. Time-weighted average VCM exposure for Polymer Plant workers was between 200 ppm to 500 ppm before 1974. During this survey, reactor cleaners were exposed to an average of 18 ppm of VCM during their 8-hour work shift. Other Polymer Plant workers' VCM exposures ranged from 1 ppm up to 33 ppm.

C. In-plant VCM air pollution was a severe health hazard caused by the dispersion and wind carry-over of stack effluents and other VCM emissions from the polymerization processes. Office workers and engineers at the Administration Building and Engineering & Development Building, and "non-VCM" workers at the Fabrication Complex could be exposed to a few ppm of VCM due to in-plant VCM air pollution.

D. Mercury vapor concentrations in the Chlor-Alkali Plant have been reduced approximately ten times from the pre-1974 levels. Mercury vapor exposures

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for the flake caustic-soda machine operator and the mercury spill recovery man were still in excess of the permissible limit. All other Chlor-Alkali Plant workers showed acceptable mercury exposure levels.

E. Impressive progress has been made in solvent vapor control since 1974; this was especially true at Toufen Printing Plant where the problem was completely under control. At the Leather Plant, a few operators of surface treating machines had exceeded the acceptable exposure concentrations for MEK and toluene. Exposures at Taoyuan Printing Plant were mostly light.

F. Dusts of lead, barium, cadmium and chromium compounds remained a serious threat to workers' health. In the United States, very recent toxicologic and epidemiologic findings suggest that PVC resin dust might be related to excessive pneumoconiosis among workers at polymerization plant and PVC fabricating operation. Many workers at CGPC's Extrusion Plant and PVC Drying Plant were overexposed to PVC dust.

G. Hygiene conditions were improved at the Plating Room. The odor and irritation of chromic acid mists were only slightly detectable.

H. Noise dosimetry results indicate occupational noise overexposure for #1, #3 and #5 calender operators, and a few blender and mixer operators at the Floor Tile Plant and the Extrusion Plant. At Taoyuan Plant, the only overexposed job was the operators of the #15 calender.

I. CGPC's Industrial Hygiene Program needed improvement in quality assurance, and lacked laboratory analytical capability in dust and noise monitoring.

Preliminary results of this survey have been reported to Mr. B. H. Gambrill, CGPC President. A closing conference was held with Mr. S. K. Yeh and Mr. K. Yü, CGPC Vice Presidents, and nearly all plant management personnel at Toufen Plant. Important findings were reported, obvious health hazards were pointed out, and some corrective measures were recommended and discussed at this conference.

The author wishes to thank Messrs. B. H. Gambrill, L. S. Ting, S. K. Yeh,

CUSAROSS 00920

K. Yü, and other members of CGPC management team for their many courtesies and assistance during this visit. Gratitude is expressed to Messrs. Ed Lu, C. Y. Huang, and K. C. Chen for their warm friendship and their help and cooperation in carrying out the survey work.

CUSAROSS 00921

II. RECOMMENDATIONS

A. The current practice of daily manual cleaning of reactors after each reaction batch should be reduced to a less frequent cleaning cycle; say, once every three to five batches.

B. Move toward the direction of adopting one of the automatic reactor cleaning processes. This might require the replacement of the existing old reactors with smoothly-lined reactors.

C. Implement vigorously the previously recommended "Search and Secure" program.

D. Strongly emphasize the significance of VCM odor threshold to all vinyl chloride workers. Encourage the reporting of VCM odor for speedy leak and emission control. No one should be exposed to odor-detectable VCM concentrations for even a short duration unless during an emergency and with proper respiratory protection.

E. In-plant VCM air pollution problem should be more or less under control after implementation of the above four recommendations. Additional VCM emission reduction can be achieved through enhanced recovery of unreacted VCM from reactor vessels.

F. Flake caustic soda manufacturing operation should be moved out of the basement of the Brine Electrolysis Building, or fresh air be supplied to the caustic soda machine operator.

G. Solvent vapor concentrations at #5 surface treating machine should be reduced by additional local exhaust capacity, or by opening a window on the nearby wall. Further reduction in solvent vapor exposures can be achieved at the Leather Plant by observing good housekeeping practices.

H. In view of the new toxicologic status of PVC dust, engineering dust control will be a major task for CGPC. The plant management should endeavor to control dust exposure through total or partial enclosure,

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application of local exhaust systems, and other engineering and administrative methods, instead of relying on the use of respirator.

I. Noise emitting from #1, #3 and #5 calenders can be reduced by maintenance service of the idlers, bearings and other rotating parts, or by returning the machines to a slower operating speed. Noise from mixers, crushers and blenders can be reduced with full enclosure or partial baffle.

J. Where engineering noise controls are either infeasible or not yet in effect, hearing protectors should be provided to, and used by, operators of overexposed jobs. CGPC should start an audiometric testing program.

K. CGPC should acquire dust monitoring air sampling pumps and dust sample weighing and analyzing instruments. Also needed are noise dosimeters and, maybe, audiometric testing equipment.

L. One or two members of CGPC's industrial hygiene personnel are invited to visit the United States to attend industrial hygiene training courses under the auspices of GS & T's Medical and Health Resources Division. Emphasis will be put on industrial hygiene laboratory quality control and ventilation engineering.

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III. VINYL CHLORIDE EXPOSURES

A. Recent Toxicologic and Epidemiologic Developments On Vinyl Chloride

The causal relationship between occupational exposure to vinyl chloride monomer (VCM) and the development of liver angiosarcoma is now well established. Furthermore, pathophysiological effects do not appear to be limited to the liver. For example, experimental animal research, as well as clinical and epidemiological studies of workers exposed to VCM and PVC dust, indicate a toxic effect on the respiratory system. Some of these same studies have also found increased risk of central nervous system tumors. Microbial test system studies and cytogenetic studies of VCM-exposed workers indicate possible genetic effects.

In April, 1979, a study conducted at the Chemical Systems Laboratory has indicated that inhaling a single high dose of vinyl chloride monomer may cause cancer in animals. Following a single (one hour) exposure at high dose levels (5,000 ppm and 50,000 ppm), the lab mice were allowed to live their normal life span and then were sacrificed and autopsied. Autopsy results indicate an excess of pulmonary tumors. The study's findings support the thesis that a single exposure to a high dose of VCM, or perhaps other similarly acting carcinogens, could post a risk of cancer to humans.

B. Historical Review Of VCM Exposures And Control Actions At CGPC

1. Industrial Hygiene Survey of February, 1974: During this initial industrial hygiene survey, VCM concentrations above 10,000 ppm were frequently encountered at Toufen's Polymerization Plant; mostly during reactor purging time. The odor of VCM (odor threshold = 2,000 ppm) can be detected very readily inside the Polymer Plant and sometimes at the Monomer Plant. It was estimated 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

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improved vacuum-assisted recovery of un-reacted VCM 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 Survey of 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. Step three was to comply with United States standard of 1 ppm. A "Search and Secure" team was formed to search for fugitive VCM leaks and secure the leaks through maintenance and repair measures. B. F. Goodrich solvent spraying technique was adopted to reduce PVC scale formation; thus, resulting in the reduction of reactor cleaning time.

3. Follow-up Survey of November, 1977: VCM odor was essentially eliminated from the Polymer Plant except during the 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.

   Further 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-contaminated air to the outdoors during air purging time. Adoptation of one of the automatic reactor cleaning processes was recommended to eliminate routine reactor cleaning, and to meet 1 ppm exposure standard.

C. <u>Results Of October, 1979, VCM Exposure Survey</u>

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A VCM odor survey plus four kinds of VCM air sampling techniques were employed during the 1979 industrial hygiene survey. The air sampling techniques included direct reading of airborne total organic vapors with a Century Organic Vapor Analyzer, grab air samples with VCM chemical detector tubes, long-term personnel and area air sampling with 3M Brand Organic Vapor Monitoring Badges, and long-term personnel air sampling with charcoal adsorption tubes.

1. VCM Odor Survey

   During the few times of walking through the three floors of the Polymer Plant and the Monomer Plant, this author only once sensed a faint odor of vinyl chloride monomer. This occurred on the third floor of the Polymer Plant when a reactor's upper manhole was opened for water flushing down.

   Results of this "nose survey" suggest that the grossly overexposed situations (2,000 ppm and above) have been essentially eliminated.

2. Survey With Organic Vapor Analyzer

   Survey with direct-reading organic vapor analyzer showed total organic vapor concentrations ranged from 0.5 to 1 ppm inside the Polymer Plant's control room, a couple of ppm on the reactor floors; up to 10 or 20 ppm near reactor manholes during cleaning time. Because vinyl chloride monomer was the only combustible gas present in significant quantities in the air inside the Polymer Plant, readings obtained with the Century Organic Vapor Analyzer, after adjustment for the instrument's sensitivity factor for vinyl chloride, should give a fair indication of workplace vinyl chloride concentrations. When the OVA instrument was calibrated with methane, its response to vinyl chloride will be only 35%. For example, a 3.5 ppm total organic vapor reading with the OVA instrument would indicate actual workplace VCM concentration at 10 ppm. CGPC's Industrial Hygiene Department should pay attention to this "low response" factor and correct their previous VCM survey results accordingly.

3. Survey With Detector Tubes

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Acceptable vinyl chloride chemical detector tubes were developed only two years ago. They can give a fast but rough estimation of airborne VCM concentration with ±50% accuracy. Table I summarizes VCM air sampling results obtained with Bendix brand vinyl chloride detector tubes. Especially noteworthy was the fact that repeated measurements showed 3 to 5 ppm of vinyl chloride inside the control room and the office of the Polymer Plant. The 0.3 to 1.0 ppm of VCM found inside the Administration Building and the Engineering and Development Building was due to wind carry-over from the Polymer Plant. Measurements taken on the north side of the Chlor-Alkali Plant, which were upwind from the Polymer Plant, showed 0 ppm of VCM.

4. Reactor Cleaner's Vinyl Chloride Exposure

The most hazardous job in terms of high workplace VC concentrations and lengthy exposure durations was the manual cleaning of the reactor vessel. After PVC resins and the un-reacted monomer were recovered and the reactor vessel air purged, three reactor cleaners were sent into the vessel through the bottom manhole to scrape PVC scales off the reactor walls with hand tools consisting of hammer, knife and chisel. Although air purging was continued during the reactor cleaning time, permeation of monomer from PVC scales on the reactor walls created approximately 50 ppm of VCM concentration within the reactor. With the adoptation of the solvent spraying technique, the problem of scale formation became less severe. The cleaning time has been reduced to approximately 20 minutes per reactor. Normally, a crew of reactor cleaners cleans six reactors per shift.

Air sampling devices (charcoal tubes or 3M badges) were attached to the reactor cleaners for the collection of long-term personal air samples during reactor cleaning time. Table II summarizes the reactor cleaners' time-weighted average VCM exposures. Results indicate that the cleaners were exposed to an average of 15 to 20 ppm of VCM during their 8-hour work shift.

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TABLE I

RESULTS OF VINYL CHLORIDE MEASUREMENTS WITH BENDIX BRAND VCM CHEMICAL DETECTOR TUBES AT CGPC TOUFEN PLANT

October 16-19, 1979

SAMPLING LOCATION	VINYL CHLORIDE CONCENTRATION, PPM		
	Test 1	Test 2	Test 3
Control Room, Polymer Plant	3	3	5
Office, Polymer Plant	3	3	5
Between Reactors A & D	4	12	-
Between Reactors B & E	4	12	36
Between Reactors I & J	4	-	-
Between Reactors G & H	4	-	-
Between Reactors K & L	7	-	-
During Air Purging, Reactor I			
Upper Manhole	20	-	-
Bottom Manhole	15	-	-
During Reactor Cleaning			
Upper Manhole	25	30	-
Drying Plant, General Area	1	2	-
Monomer Plant, Control Room	2	-	-
Monomer Plant, Electrical Control Room	2	-	-
Chemical Plant Office	1	1.5	-
Monomer Receiving Tank, Transfer Pumps	20	30	-
Main Office, Administration Bldg.	0.3	0.5	-
Laboratory, Engineering & Development Building	0.7	-	-
Office, Engineering & Development Building	0.5	1.0	-
Control Sample, North Side of Chlor-Alkali Plant, Upwind From Polymer Plant	0	0	0

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TABLE II

REACTOR CLEANERS' VINYL CHLORIDE EXPOSURE

CHINA GULF PLASTICS CORPORATION

REACTOR CLEANER	EMPLOYEE NUMBER	SAMPLE DATE	SAMPLE DURATION (MINUTES)	AVERAGE VCM EXPOSURE PPM	REMARKS
Chen, C. S.	64114	10-16-79	423	12	Cleaned 6 Reactors
Chuang, C. C.	60117	10-16-79	415	16	Cleaned 6 Reactors
Tan, C. K.	66124	10-16-79	405	23	Cleaned 6 Reactors
Chuang, C. C.	60117	10-17-79	442	20	Cleaned 6 Reactors
Tan, C. K.	66124	10-17-79	442	23	Cleaned 6 Reactors
Lai, T. Z.	67217	10-17-79	442	18	Cleaned 6 Reactors
Chen, C. S.	6414	10-18-79	46	16	Cleaned 1 Reactor
Lai, T. Z.	67217	10-18-79	44	22	Cleaned 1 Reactor
Chuang, C. C.	60117	10-18-79	43	17	Cleaned 1 Reactor
Chuang, C. C.	60117	10-18-79	45	18	Cleaned 1 Reactor
Lai, T. Z.	67217	10-18-79	45	17	Cleaned 1 Reactor
Chen, C. S.	64114	10-18-79	45	18	Cleaned 1 Reactor

Sample Matrix = Charcoal Tube and 3M Brand Organic Vapor Monitoring Badge.

Analytical Method = GC & FID

5. VCM Exposure of Other Polymer Plant Workers

Most other Polymer Plant workers were exposed to considerably less vinyl chloride concentrations than those experienced by the reactor cleaners. However, high exposures could occur to the discharge operator and the automatic cleaning machine operator because they have to stay near the upper manhole where VCM concentrations could be a few hundred ppm for the short time when the manhole cover was opened.

Several long-term personal air samples were collected from various Polymer Plant workers. Table III shows the VCM exposure results. A discharge operator and an automatic cleaning machine operator had time-weighted average exposures in excess of CGPC's 10 ppm vinyl chloride exposure standard. Every one of the Polymer Plant workers exceeded the United States' 1 ppm vinyl chloride standard.

6. Environmental Vinyl Chloride Pollution

Process areas around the Polymer Plant and non-process areas downwind from the Polymer Plant were affected by VCM due to wind carry-over and general air dispersion of VCM emissions from polymerization operations. Long-term environmental air samples were collected on October 19, 1979, from various locations of CGPC Toufen Plant. Air sampling results, as shown in Table IV, indicate severe in-plant air pollution problems.

On October 19, 1979, the wind was blowing from northeast to southwest direction at moderate wind speed (say - 5 miles per hour). This put the Engineering and Development Building directly downwind from the Polymer Plant, while the Administration Building and the Hydrochloric Acid Plant were on the two flanks of the Polymer Plant. Results show that the average VCM concentration was 2.6 ppm at Engineering and Development Building, but 0.44 ppm and 0.41 ppm at the Administration Building and the Hydrochloric Acid Plant, respectively.

The 15 ppm long-term average VCM concentration at the Second Power

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TABLE III

VINYL CHLORIDE EXPOSURES OF OTHER POLYMERIZATION PLANT WORKERS

CHINA GULF PLASTICS CORPORATION

WORKER	EMPLOYEE NUMBER	JOB	SAMPLE DATE	SAMPLE DURATION (MINUTES)	AVERAGE VCM EXPOSURE PPM
Peng, S. S.	55131	Foreman	10-16-79	416	1.5
Tzung, T. S.	58115	Discharger	10-16-79	408	1.5
Huang, J. Y.	59110	Instrument Operator	10-16-79	411	1.2
Chang, S. Y.	58116	Charger	10-16-79	404	2.4
Huang, H. L.	60388	Office Worker	10-16-79	459	1.0
Chiu, H. Y.	55133	Instrument Operator	10-16-79	378	2.0
Lai, T. Z.	67217	A.C.M. Operator*	10-16-79	398	20
Chen, C. S.	64114	A.C.M. Operator	10-17-79	376	2.4
Peng, S. S.	55131	Foreman	10-17-79	374	2.1
Tzung, T. S.	58115	Discharger	10-17-79	374	2.5
Huang, J. Y.	59110	Instrument Operator	10-17-79	374	4.2
Lin, H. S.	56110	Charger	10-17-79	374	3.7
Huang, H. L.	60388	Office Worker	10-17-79	370	1.4
Chang, S. Y.	58116	Charger	10-18-79	409	3.1
Tzung, T. S.	58115	Discharger	10-18-79	410	33
Huang, J. Y.	59110	Instrument Operator	10-18-79	406	2.3
Lin, J. T.	55047	Officer Worker	10-18-79	401	7.8

* A.C.M. Operator = Automatic Cleaning Machine Operator.

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TABLE IV

ENVIRONMENTAL AND WORKPLACE VINYL CHLORIDE CONCENTRATIONS AT TOUFEN PLANT

CHINA GULF PLASTICS CORPORATION

October 19, 1979

SAMPLE NUMBER	SAMPLE LOCATION	SAMPLE DURATION (MINUTES)	AVERAGE VCM CONCENTRATION PPM
AG7492	Office, Engineering and Development Building	457	2.6
AG7072	South of Administration Building	436	0.44
AG7289	South of HCL Plant	448	0.41
AG9331	South of Maintenance Shop	423	0.94
AH5605	West of Printing Plant	420	0.53
AH5149	2nd Power Station	417	15
AG7313	Office Room, Chemical Plant	412	2.1
AH5128	Booth at Monomer Plant	408	2.2
AG7370	Office Room, Polymer Plant	402	2.7
AG7055	PVC Package, Drying Plant	394	0.87
AG7112	Control Room, Drying Plant	392	1.4
AG7407	Polymerization Pilot Plant	397	5.0

Sample Matrix = 3M Brand Organic Vapor Monitoring Badges.

Analytical Method = GC & FID.

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Station was higher than expected. VCM concentrations at Monomer Plant, Drying Plant, and Pilot Plant may be partly caused by internal emission sources and partly due to air pollution (wind carry-over).

Further evidence of in-plant VCM air pollution was obtained by analyzing several organic vapor samples collected from workers at the Fabrication Complex. The Fabrication Complex, which included Leather Plant, Film Plant, Printing Plant , etc., is located 700 to 1,000 feet to the west and southwest side of the Polymer Plant. When the wind was blowing from the northeast direction, as it was blowing on October 16, 18 and 19, 1979, the Fabrication Complex was roughly downwind from the Polymer Plant. Table V shows VCM exposures by workers at the Fabrication Complex. On October 16, 1979, five workers at Leather Plant, Film Plant and Printing Plant were exposed to an average of 0.5 ppm of VCM over 6 to 7 hours of air sampling duration. On October 18, 1979, the average VCM exposure for 11 Printing Plant workers was about 0.15 ppm. On October 17, 1979, the wind was blowing mainly from the northern direction and most of the Leather Plant workers showed non-detectable vinyl chloride exposure.

Four personal organic vapor air samples collected from Taoyuan's Printing Plant workers were also analyzed for VCM contents. The results, all non-detectable, were listed on the bottom of Table V. Taoyuan Plant is simply a PVC fabrication facility with no monomer plant nor polymerization plant. This further proves that the VCM exposure of Toufen's Fabrication Complex workers was due to in-plant air pollution (wind carry-over), <u>not</u> due to residual VCM in the PVC resin.

D. <u>Conclusions And Recommendations</u>

Great advances have been made by CGPC in reducing occupational vinyl chloride exposures ever since the first industrial hygiene survey of February, 1974. Over the six-year period, the 8-hour, time-weighted

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TABLE V

VINYL CHLORIDE EXPOSURES OF FABRICATION COMPLEX WORKERS
DUE TO INPLANT VCM AIR POLLUTION

CHINA GULF PLASTICS CORPORATION

SAMPLE DATE	WORKER	JOB LOCATION	AVERAGE VCM EXPOSURE PPM
10-16-79	Liu, S. L.	Leather Plant - Toufen	0.54
10-16-79	Chen, Y. K.	Leather Plant - Toufen	0.49
10-16-79	Chai, C. S.	Leather Plant - Toufen	0.49
10-16-79	Chen, J. S.	Film Plant - Toufen	0.53
10-16-79	Lin, Z. S.	Printing Plant - Toufen	0.54
10-16-79	Chang, S. S.	Printing Plant - Toufen	
10-17-79	Chen, Y. K.	Leather Plant - Toufen	ND
10-17-79	Peng, W. C.	Leather Plant - Toufen	ND
10-17-79	Chai, C. S.	Leather Plant - Toufen	ND
10-17-79	Huang, W. H.	Leather Plant - Toufen	ND
10-17-79	Wu, C. Y.	Leather Plant - Toufen	ND
10-17-79	Liu, S. L.	Leather Plant - Toufen	0.03
10-17-79	Lee, K. J.	Leather Plant - Toufen	0.20
10-18-79	Chuang, M. L.	Printing Plant - Toufen	0.12
10-18-79	Chang, Y. H.	Printing Plant - Toufen	0.12
10-18-79	Chang, S. S.	Printing Plant - Toufen	0.15
10-18-79	Lien, Y. C.	Printing Plant - Toufen	0.15
10-18-79	Liao, W. H.	Printing Plant - Toufen	0.12
10-18-79	Tong, S. L.	Printing Plant - Toufen	0.15
10-18-79	Ko, C. F.	Printing Plant - Toufen	0.18
10-18-79	Chai, F. L.	Printing Plant - Toufen	0.15
10-18-79	Lin, Z. S.	Printing Plant - Toufen	0.15
10-18-79	Chen, J. S.	Printing Plant - Toufen	0.18
10-18-79	Hsu, Y. K.	Printing Plant - Toufen	0.12
10-11-79	Lee	Printing Plant - Taoyuan	ND
10-11-79	Tzung	Printing Plant - Taoyuan	ND
10-11-79	Feng	Printing Plant - Taoyuan	ND
10-11-79	Liu	Printing Plant - Taoyuan	ND

Sample Matrix = 3M Brand Organic Vapor Monitoring Badge.

Analytical Method = GC & FID.

ND = Not Detected; Less Than 0.01 ppm.

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average VCM exposures for the various Polymer Plant workers have been reduced from 200-500 ppm level down to approximately 2-20 ppm level. This was, indeed, an excellent achievement considering that the government of the Republic of China is still abiding by the old and obsolete 500 ppm permissible VCM exposure limit; while most of CGPC's local competitors have done less in controlling VCM exposures in their factories.

However, VCM exposures at CGPC were still excessive. In comparison with CGPC's own standard of 10 ppm time-weighted average exposure limit, all reactor cleaners and a few other Polymer Plant workers were overexposed. When compared with United States OSHA's 1 ppm VCM standard, then all workers at the Polymer Plant, and most workers at the Monomer Plant and Drying Plant exceeded the limit.

In addition, in-plant VCM air pollution was a severe health hazard caused by dispersion and wind carry-over of the stack effluents and other VCM emissions from the polymerization processes. Engineers, office workers and other "non-VCM" workers at the Fabrication Complex might be exposed to up to a few parts per million of VCM, depending on wind speed, wind direction, distance from the sources, and magnitude of the emissions.

If routine reactor cleaning cannot be eliminated, it is unlikely that the 10 ppm CGPC self-imposed VCM exposure standard can ever be achieved for reactor cleaners. On the other hand, if routine reactor cleaning is eliminated by adopting one of the several automatic reactor cleaning processes currently used by PVC manufacturers in the United States, Japan, and European countries, CGPC should be able to meet the U. S. OSHA 1 ppm VCM standard. CGPC is currently considering the replacement of the existing 12 small reactors with a few large size reactors from a Japanese manufacturer. The manufacturer can guarantee the compliance of the Japanese 2 ppm VCM standard with the new, large reactors and their automatic cleaning system.

Before the eventual adoptation of the modern reactor system, CGPC should implement vigorously the "Search and Secure" program. It should be recog-

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nized that successful implementation of a "Search and Secure" program will not only result in great reduction of occupational and environmental vinyl chloride hazards, but produce savings through feedstock and energy conservation. Therefore, it is recommended that this program be implemented with strong support from CGPC management.

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 re-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.

When a non-routine operation necessitates opening equipment which may release vinyl chloride to the atmosphere, e.g., the maintenance or repair of equipment, and where it would be impracticable to remove vapor by local exhaust ventilation, then respiratory protective equipment must be worn. Precautions must be taken to ensure that other personnel in the vicinity of the operation are not exposed to excessive levels of vinyl chloride.

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IV. MERCURY EXPOSURES

In the Chlor-Alkali Plant, chlorine is manufactured by the electrolysis of brine in the mercury cells. Sodium hydroxide and hydrogen gas are produced as by-products. Since the first industrial hygiene survey of 1974, several engineering control measures have been adopted to reduce the workplace mercury vapor concentrations in the Brine Electrolysis Building. 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.

The Chlor-Alkali Plant was surveyed for mercury vapors on October 16, 1979, with a Jerome Gold-Film Mercury Vapor Analyzer. Figure 1 shows the arrangement of the 36 mercury cells and the locations of the 30 mercury vapor sampling points. Table VI summarizes the air sampling results. Essentially, all samples collected on the main floor of the cell room showed mercury vapor concentrations well below the threshold limit value (TLV) of 0.05 $^{mg}/_{m^3}$. The highest mercury vapor concentrations were encountered downstairs in the basement of the cell room near the flake caustic soda machine (sampling point 27). Mercury concentrations there were consistently higher than the TLV value.

When mercury vapor data of previous industrial hygiene surveys are reviewed and compared with results of this 1979 survey, it is most satisfying to notice that the average mercury vapor concentration along the central aisle of cell room was 0.25 $^{mg}/_{m^3}$ during the 1974 survey, reduced to about 0.05 $^{mg}/_{m^3}$ during the 1976 survey, and further reduced to about 0.02 $^{mg}/_{m^3}$ during this 1979 survey. This dramatic reduction was achieved despite the fact that many more new mercury cells were installed inside the cell room during

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

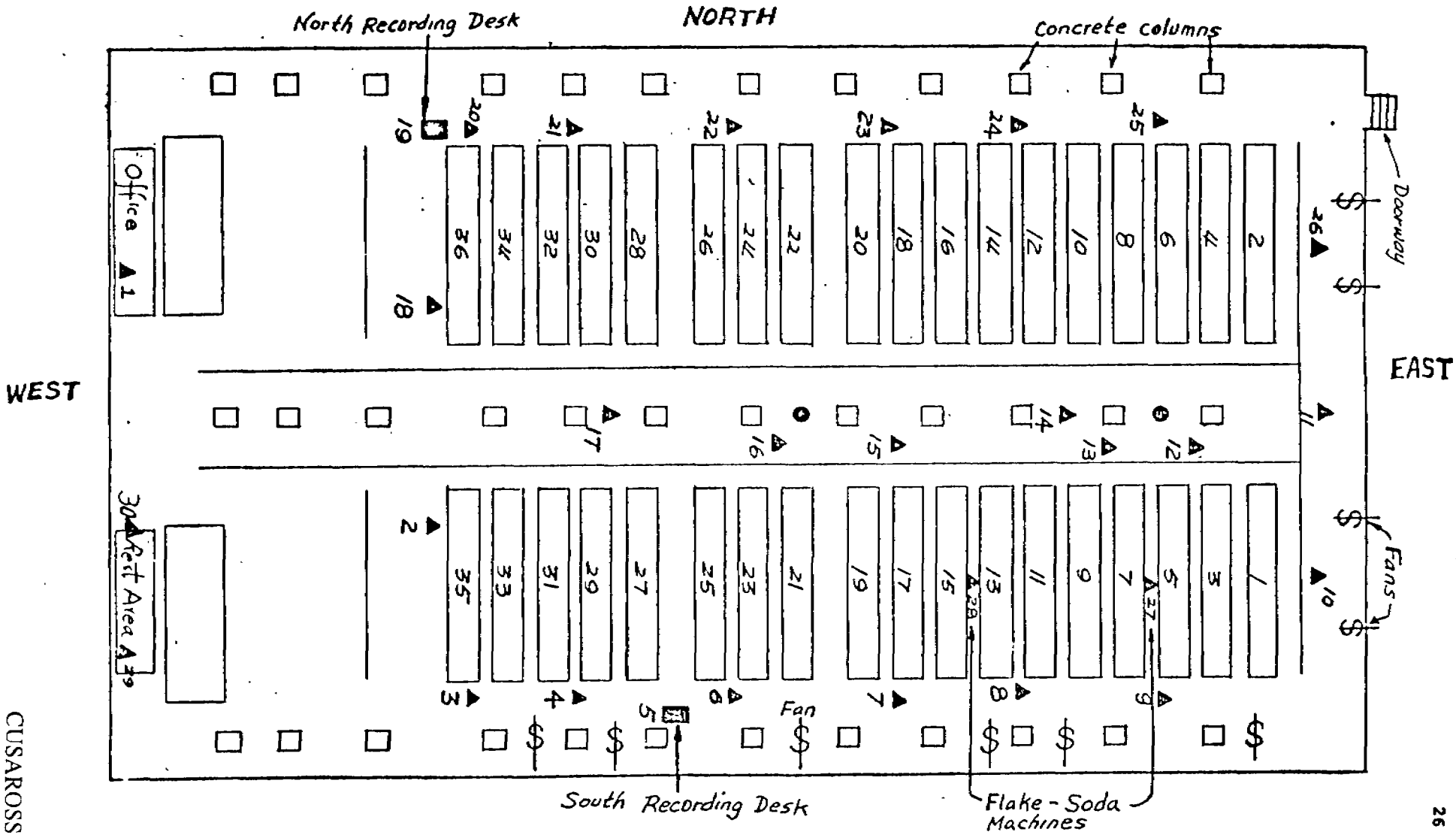

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TABLE VI

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

FIXED SAMPLING POINTS	MERCURY VAPOR CONCENTRATION (mg/m^3) Test 1	Test 2	Test 3
1	0.015	0.013	
2	0.014	0.009	
3	0.011	0.01	
4	0.019	0.015	
5	0.014	0.009	
6	0.025	0.07	0.05
7	0.029	0.034	
8	0.032	0.028	
9	0.068	0.049	
10	0.015	0.028	
11	0.046	0.064	
12	0.044	0.039	
13	0.045	0.02	
14	0.01	0.013	
15	0.01	0.011	
16	0.009	0.032	0.013
17	0.007	0.008	
18	0.007	0.004	
19	0.014	0.017	
20	0.011	0.008	
21	0.006	0.004	
22	0.008	0.012	
23	0.013	0.007	
24	0.005	0.003	
25	0.003	0.003	
26	0.005	0.005	
27	0.08	0.067	0.13
28	------	------	
29	0.009	0.01	
30	0.01	0.01	

CUSAROSS 00939

the past few years.

Several long-term personal air samples were collected from Chlor-Alkali Plant workers on October 17th and 18th, 1979, with Jerome Gold-Film Mercury Vapor dosimeters. The dosimeters were attached to the shirt collar of the workers so that the air samples represented breathing zone time-weighted average exposures. Table VII summarizes the survey results. Two workers were found to be overexposed to mercury vapor. One was the flake caustic soda machine operator, and the other was the mercury spills recovery man. Both of them spent lengthy working hours in the basement of the cell room where mercury vapor concentrations exceeded the TLV. Analyst Mr. Y. S. Chang's exposure of 0.047 $^{mg}/m^3$ was somewhat higher than expected. He might have worked very closely at the opened end-boxes of the mercury cells, or he might have spent some time in the basement.

Further reduction of workplace mercury vapor concentrations can be achieved by utilizing the wall-mount exhaust fans. Move the fans to the southeast corner of the east wall would be most beneficial since air circulation there was inadequate.

The working conditions in the basement have not been improved appreciably since 1974. The excessive mercury concentrations were due to leaks and spills of mercury from the cell room above. The air in the basement was hot and humid due to poor air circulation. It is recommended again that the caustic soda manufacturing operation be moved out of the basement.

For temporary, short-duration exposures to high mercury vapor concentrations such as during mercury recovery, cell maintenance, or for caustic soda machine operator, it is suggested that mercury vapor respirators be worn by the workers. Substantial protection can be provided by disposable 3M Brand Mercury Vapor Respirator #8707.

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TABLE VII

OCCUPATIONAL TIME-WEIGHTED AVERAGE MERCURY VAPOR EXPOSURES
FOR CGPC CHLOR-ALKALI PLANT WORKERS

October 17 - 18, 1979

EMPLOYEE I.D.	JOB AND LOCATION	AVERAGE MERCURY VAPOR EXPOSURE mg/m^3
Hu, C. S. 61409	Operator Electrolysis Room	0.03
Chen, S. F. 60290	Operator Electrolysis Room	0.013
Yang, T. K. 67197	Voltage Adjuster Electrolysis Room	0.013
Chang, Y. S. 61105	Analyst Electrolysis Room	0.047
Chiu, W. K. 58103	Operator Flake Soda Machine	0.13*
Chang, C. K. 67230	Operator Electrolysis Room	0.04
Shu, W. S. 65248	Voltage Adjuster Electrolysis Room	0.01
Woo, W. J. 56106	Operator Mercury Recovery	0.10*
Chang, Y. S. 61105	Analyst Electrolysis Room	0.017

Sample Matrix = Jerome Gold-Film Mercury Vapor Dosimeter.

Analytical Method = Jerome Mercury Vapor Analyzer.

Mercury Exposure Standard, TLV = 0.05 mg/m^3.

*Overexposed.

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V. SOLVENT EXPOSURES

At the Toufen's Flexible Products Fabrication Complex and at Taoyuan's Printing Shop, large quantities of industrial solvents were consumed in the surface treating and color printing of the leather and film products. The predominant solvents were methyl ethyl ketone (MEK) and toluene. Other solvents also consumed in bulk quantities were methanol, butyl acetate, methyl isobutyl ketone (MIBK), cyclohexanone, ethyl acetate, trichloroethylene, dimethylformamide and tetrahydrofuran. Although benzene was not used by CGPC as a solvent in the fabrication processes, industrial grade toluene could contain significant amount of benzene as impurity or through contamination.

A. Surface Treating Machines

During the industrial hygiene survey of 1974, none of the surface treating machines in the Leather Plant were ventilated with local exhaust hoods. 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 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. The present local exhaust system for the surface-treating machines consisted of an overhead canopy hood to control solvent evaporation from the coated fabric; and a down-draft, slotted hood under the ink trough to control vapor release right at the source. Results of flow tests with a velometer and control range tests with smoke tubes indicate that the present local

CUSAROSS 00942

exhaust ventilators were mostly adequate in total exhaustion capacity, and showed good vapor control characteristics at the ink troughs where the operators spend most of the working hours.

Several long-term breathing zone air samples were collected from surface treating machine operators with 3M Brand organic vapor monitoring badges. Table VIII summarizes the air sampling results. A few operators had exceeded the acceptable exposure concentrations of MEK and toluene. The 1979 threshold limit values (permissible long-term exposure limits) are 200 ppm for MEK, 100 ppm for toluene, and 10 ppm for benzene. Currently, the U. S. OSHA is pushing to have a 1 ppm benzene exposure standard approved by the United States Supreme Court.

Results in Table VIII indicate that operators at #5 surface treating machine had more severe exposures. This was partly due to the fact that the #5 machine was located close to a wall. Opening up a window on this wall may help to reduce local solvent vapor concentrations by dilution ventilation.

Mr. W. C. Peng's high MEK exposure (300 ppm), but relatively low toluene exposure (8.6 ppm) was unexpected. Was he responsible for transferring and mixing MEK from the storage container to the ink trough?

Further reduction in solvent exposures can be made at Leather Plant with good housekeeping practices. The floor around the surface treating machines was messy and sticky with spilled glues, inks and solvents. Many open containers of solvents and inks were scattered in the workplace, creating additional sources of solvent evaporation.

B. TOUFEN PRINTING PLANTS

During the 1974 industrial hygiene survey there were only two printers inside the Toufen Printing Plant. Neither of the two printers were ventilated. Concentrations of solvent vapors ranged from 100 ppm to 1500 ppm at various locations under and around the four-color printer. The six-color printer was not used at that time, but solvent vapor concentrations were still 100 ppm under and around that machine. Essentially,

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TABLE VIII

OCCUPATIONAL TIME-WEIGHTED AVERAGE EXPOSURES TO
BENZENE, TOLUENE, AND MEK BY SURFACE TREATING MACHINE WORKERS
AT TOUFEN, CHINA GULF PLASTICS CORPORATION

October 16 - 17, 1979

EMPLOYEE I.D.	JOB AND LOCATION	SAMPLE DURATION (MINUTES)	BENZENE PPM	TOLUENE PPM	MEK PPM
Liu, S. L. 58213	Operator, #5 Surface Treating Machine	375	1.3	130	200
Chen, Y. K. 61270	Operator, #3 Surface Treating Machine	370	0.21	7.2	17
Chai, C. S. 60222	Operator, #4 Surface Treating Machine	372	0.23	12	24
Chen, Y. K. 61270	Operator, #3 Surface Treating Machine	412	0.33	21	56
Peng, W. C.	Assistant, #3 Surface Treating Machine	408	0.68	8.6	300
Chai, C. S.	Operator, #4 Surface Treating Machine	407	0.75	60	180
Haung, W. H.	Assistant, #4 Surface Treating Machine	405	0.12	7.6	6.5
Wu, C. Y.	Foreman, Surface Treating Machines	404	0.36	25	58
Liu, S. L.	Operator, #5 Surface Treating Machine	386	0.87	100	130
Lee, K. J.	Assistant, #5 Surface Treating Machine	383	0.65	71	93

Sample Matrix = 3M Brand Organic Vapor Monitoring Badges.

Analytical Method = GC - FID.

CUSAROSS 00944

no solvent was used next door at the laminating shop; however, solvent vapors from the four-color printer entered the laminating shop through the connecting open doorways and affecting laminating machine workers.

Six wall fans and a local exhaustion system were installed in 1976. During the 1976 survey, with both the four-color and the six-color printer in operation, solvent vapor concentration was 150 ppm between the two machines, 300 to 500 ppm under the six-color printer, and about 150 ppm under the four-color printer. Next door at the laminating shop, no odors of solvent vapors were detected.

A third printer, a five-color printing machine, was added to the Printing Plant in 1977. During the 1977 survey, concentrations of organic vapor remained at 100 ppm to 500 ppm levels inside the Printing Plant because of inadequate air-moving capacity of the slotted hoods and bad housekeeping practices.

Significant improvements were made after the 1977 survey. The ventilation capacities of the down-draft slotted hoods have been greatly increased. The shop was orderly and in good housekeeping. Solvent vapor concentrations were mostly below 50 ppm when two out of the three printers were in operation.

Long-term personal breathing zone air samples were collected from Toufen Printing Plant workers on October 16 to 18, 1979. Table IX presents results of this solvent vapor exposure study. All Printing Plant workers had time-weighted average exposures to benzene, toluene and MEK well within the permissible limits of these air contaminants. In fact, one can conclude that solvent exposure hazard at Toufen Printing Plant was under control. CGPC only needs to maintain hygiene conditions at Toufen Printing Plant at the excellent levels as observed during this survey.

C. TAOYUAN PRINTING SHOP

A new printing shop was added to the Taoyuan Plant since the 1977 survey. Taoyuan Printing Shop is quite spaceous and there is only one printer, a six-color printer, in this shop.

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TABLE IX

OCCUPATIONAL TIME-WEIGHTED AVERAGE EXPOSURES TO BENZENE, TOLUENE AND MEK BY PRINTING PLANT WORKERS

TOUFEN, CHINA GULF PLASTICS CORPORATION

October 16 to 18, 1979

EMPLOYEE I.D.	JOB AND LOCATION	SAMPLE DURATION (MINUTES)	BENZENE PPM	TOLUENE PPM	MEK PPM
Chen, J. S.	Operator, 4 Color Printer	360	0.29	33	9.9
Chang, S. S.	Operator, 4 Color Printer	353	0.33	35	10
Hsu, Y. K.	Operator, 4 Color Printer	322	0.11	21	4.6
Chang, S. S.	Operator, 4 Color Printer	359	0.05	8.8	3.8
Ko, C. F.	Operator, 4 Color Printer	357	0.05	8.6	4.4
Chen, J. S.	Operator, 4 Color Printer	355	0.05	6.9	8.9
Tong, S. L.	Operator, 5 Color Printer	353	0.02	5.5	0.16
Chuang, M. L.	Operator, 5 Color Printer	363	0.16	15	13
Hsu, Y. K.	Operator, 5 Color Printer	368	0.16	17	15
Tong, S. L.	Operator, 5 Color Printer	361	0.16	15	12
Chai, F. L.	Operator, 6 Color Printer	354	0.16	13	11
Lin, Z. S.	Operator, 6 Color Printer	356	0.16	15	19
Lin, Z. S.	Operator, 6 Color Printer	358	0.29	26	7.2
Lien, Y. C.	Operator, 6 Color Printer	355	0.15	23	25
Lien, Y. C.	Operator, 6 Color Printer	353	0.16	16	12
Chang, Y. H.	Ink Prepare, Printing Plant	358	0.21	19	22
Liao, W. H.	Foreman, Printing Plant	362	0.16	16	9.4
Chang, Y. H.	Ink Prepare, Printing Plant	316	ND	ND	ND

CUSAROSS 00946

Occupational solvent exposures at the Printing Shop were mostly light. A few long-term personal organic vapor samples were collected. Table X summarizes air sampling results of time-weighted average exposures to solvent vapors by the four shop workers. None of the four workers were overexposed, although further improvements can be made in ventilation and in work practices to reduce exposures.

CUSAROSS 00947

TABLE X

OCCUPATIONAL TIME-WEIGHTED AVERAGE EXPOSURES TO BENZENE, TOLUENE AND MEK BY PRINTING SHOP WORKERS AT TAOYUAN PLANT, CGPC

October 11, 1979

SAMPLE NUMBER	EMPLOYEE I.D.	SAMPLE DURATION (MINUTES)	BENZENE PPM	TOLUENE PPM	MEK PPM
AG7067	Blank Control	---	ND	ND	ND
AG7128	Mr. Lee, 65973	270	0.75	60	100
AG6766	Mr. Tzung, 68845	268	0.39	31	56
AG7367	Mr. Feng, 68840	267	0.39	27	46
AG7094	Mr. Liu, 68830	266	0.4	26	44

Sample Matrix = 3M Brand Organic Vapor Monitoring Badge.

Analytical Method = GC - FID.

CUSAROSS 00948

VI. DUST EXPOSURES

A. New Toxicologic Status Of PVC Dust

Previously, PVC resin dust was treated as an inert, non-toxic, nuisance dust like dusts of gypsum, calcium carbonate and starch. But recent findings showed continuing evidence of excessive pneumoconiosis (dust-caused lung disease) among workers at vinyl chloride polymerization plants and PVC fabricating operations. The United States Occupational Safety and Health Administration is soliciting information on exposure levels, processes, available engineering controls and health studies concerning PVC dust. In a Federal Register notice (December 18, 1979) OSHA noted its particular concern with PVC dust, which is not covered by its carcinogen-based standard for vinyl chloride.

Although the new exposure standard for PVC dust has not been issued, one can expect that the future standard will be much more stringent than the 10 $mg/_m3$ time-weighted exposure standard for nuisance dusts. A likely PVC dust standard might be 2 $^{mg}/m^3$. Most workers at CGPC's Extrusion Plant and PVC Drying Plant, and many blender and mixer operators would exceed this projected PVC dust standard.

B. Toxic Dusts

The PVC compounding processes start in the Compounding Ingredients Mixing Room. 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 are salts and oxides of lead (particularly lead chromate), cadmium, selenium, chromium, antimony and titanium. The weighing and mixing of dyes and pigments is conducted

CUSAROSS 00949

at Master Batch Plant.

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 $\mu g/_m 3$).

C. Results Of Dust Exposure Survey

Several long-term breathing zone air samples were collected from workers at dusty operations. These samples were analyzed for total particulate concentration, but were not for lead, barium and cadmium concentrations because of laboratory equipment failure. Table XI summarizes the results of time-weighted average exposures to total particulates. A few samples showed massive dust exposures.

Results of previous dust surveys indicate that roughly 99% of the compounding room airborne dust was composed of fine powder of PVC resin. The remaining 1% was stabilizer dusts and dusts of dyes and pigments. Among the minor components, lead was by far the major ingredient and constituted more than half of the total weight. Based on the above rough estimation, it is reasonable to conclude that whenever the total particulate concentration exceeded 10 $mg/_m 3$, the lead component in the dust sample also exceeded the 0.05 $mg/_m 3$ lead exposure standard.

Results in Table XI indicate employees Lin, Tzen, Feng, Cheng and Ye exceeded the nuisance dust standard of 10 $^{mg}/m^3$, and, most likely, also exceeded the lead dust standard of 0.05 $^{mg}/m^3$.

In the Compounding Ingredients Mixing Room, three area samples were collected with the sampling devices placed 10 to 15 feet away from the ingredients weighing work counter. The measured values (2.2 to 4.0 $^{mg}/m^3$) indicate general dust concentrations inside the Compounding

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TABLE XI

OCCUPATIONAL TIME-WEIGHTED AVERAGE DUST EXPOSURES
FOR CGPC WORKERS

EMPLOYEE I.D.	JOB AND LOCATION	SAMPLE VOLUME (Liter)	DUST CONCENTRATION mg/m^3
Lin, W. S. 57117	Super Mixer Operator Extrusion Plant	540	0.21
Lin, P. S. 58178	Super Mixer Operator Extrusion Plant	532	510
Tan, J. K. 65186	Reborn Room Operator Extrusion Plant	520	1.9
Area Sample	Compounding Ingredients Mixing Room Extrusion Plant	546	2.5
Area Sample	Compounding Ingredients Mixing Room Extrusion Plant	514	2.2
Area Sample	Compounding Ingredients Mixing Room Extrusion Plant	644	4.0
Area Sample	2nd Floor Blender Extrusion Plant	644	0.14
Chen, O. Z. 67240	Super Mixer Operator Floor Tile	568	1.2
Yeo, P. C. 64283	Blender Operator Master Batch	560	0.18
Tzen, T. T. 68132	Blender Operator #4 Calender	562	48
Chen, C. M. 65349	Blender Operator #2 Calender	560	1.0
Feng, C. S. 64143	Blender Operator #7 Calender	498	130
Cheng, S. L. 60308	Blender Operator #1 Calender	694	120
Ye, Y. S. 60312	Blender Operator #3 Calender	734	130
Lin, C. C.	Blender Operator	690	1.5
Hsiao 66947	Mixer Operator Taoyuan Plant	650	1.4
Peng 67951	Mixer Operator Taoyuan Plant	650	2.2
Wu 65955	Stabilizer Operator Taoyuan Plant	640	1.3
Liu 66949	Mixer Operator Taoyuan Plant	640	1.1

CUSAROSS 00951

Ingredients Mixing Room, not the operator's breathing zone concentration. The operator, who refused to wear dust monitoring device, worked within a cloud of dust generated by himself during weighing and handling of the powdery compounding ingredients.

It should be mentioned, however, that all workers at dusty operations are required to wear dust masks. Observations during this hygiene survey confirm the fact that most workers do obey the dust mask regulation. Therefore, workers' actual dust inhalation were far less than those values listed in Table XI.

D. Dust Control Measures

The surest and most positive method of dust control is total enclosure of the dust-producing process, with exhaust of the enclosure to maintain a negative pressure within the enclosure. This is frequently impractical, but certain pieces of equipment can be enclosed and, in other instances, partial enclosure of the feed or hopper opening can be used with sufficient exhaust capacity to reduce dust emission.

Many side-draft, slotted local exhaust hoods have been installed on top of the compounding ingredients mixers and blenders. These hoods have reduced the workplace dust concentrations. Other engineering and work practice controls should be used to bring airborne dust levels within acceptable limits. Ventilation systems should be evaluated at least once every three months. Measurements shall include air flow measurements in and in front of hoods or openings, duct velocities and/or static pressure, as appropriate.

Floors, counters, walls and other surfaces in the Extrusion Plant, Master Batch Plant and especially inside the Compounding Ingredients Mixing Room were covered with a coat of powdery material. No doubt, most of the powders were dusts of PVC resin. But there could be significant amounts of stabilizer and pigment dusts mixed with the PVC resin dusts. Re-entrainment of the settled dusts by foot traffic and air currents could have created high airborne toxic metal concentrations. Therefore, these

CUSAROSS 00952

areas should be routinely vacuum cleaned.

It is recommended that all pigments and dyestuffs be handled with care. Effective local exhaust ventilation should be provided whenever powdery dyestuffs are poured, weighed and mixed. Any dyestuff that causes skin irritation, sensitization, or other hazards should be investigated. Replacement of unsafe dyestuffs with a safer product should be considered.

Dust respirators have a definite application at China Gulf Plastics Corporation. It is not unreasonable to insist on their use when protection is required for temporary high exposures. But the plant management should endeavor to control dust exposures through engineering methods, rather than rely solely on the use of respirators.

Protective work clothing and equipment should be provided. A shower facility should be provided and assurance made by the plant management of its usage by personnel working in dusty environments. Certain employees, e.g. compound ingredient mixing workers and powder handler, should not be allowed to leave the facility prior to removal of all contaminated clothing and take a shower.

CGPC's industrial hygiene laboratory should have field and laboratory equipment for measuring airborne particulates concentrations of lead, cadmium, barium and chromium. High flow rate personal air sampling pumps and filters should be acquired for capturing the suspended particulates, and proper analytical instrument (e.g., atomic absorption) for determining trace metal concentrations.

CUSAROSS 00953

VII. PLATING ROOM

Metal cleaning and plating processes are conducted in open-surface tanks in the Plating Room. Great improvements have been made since 1974 on Plating Room ventilation. The chrome plating tank, the cyanide bath and the dipping tank have all been equipped with side-draft local exhaust hoods. The Plating Room was like a steam bath with a roomful of pungent acid mists during the 1974 survey. During this survey, the air was clear and the odor and irritation of chromic acid mists were only slightly detectable. The malfunctioning ventilation fan on chromic acid tank should be repaired or replaced as soon as possible.

Next door in the art design and engraving room, the solvent dip tank (for washing the rollers) has been equipped with a slotted local exhauster along the entire length of the tank. Solvent emissions at this room was now under control.

Some workers wore slippers in the office area and changed into rubber boots when working inside the Plating Room. Due to possible contamination of the office floor by chromates, it is recommended that the company begin a "no bare feet, no slipper" rule for Plating Room workers.

A new emergency shower and eyewash fountain have been installed at the entrance of the Plating Room. This unit worked properly upon testing.

CUSAROSS 00954

VIII. OCCUPATIONAL NOISE EXPOSURES

Plant noise level surveys have been conducted a few times a year by CGPC industrial hygiene personnel with a General Radio Model 1565C Sound Level Meter. Major noise emitting sources and high noise work sites in each of the operating units were identified. Following is a summary of plant noise survey results:

A. Refrigeration Plant:

About 86 dBA in work areas and 77 dBA in control room.

B. Polymerization Plant:

Varied between 90 to 98 dBA at all four floors of the reactor building. Noise level inside the control room was around 75 dBA.

C. PVC Drying Plant:

Varied between 85 to 92 dBA at PVC resin packaging room, 94 to 97 dBA at vibrating screens operating positions, and about 85 dBA inside control room.

D. Boiler House:

90 to 104 dBA in working areas, but 80 to 85 dBA inside the noise isolating booth.

E. Chlorine Drying Plant:

90 to 94 dBA in working areas, but 71 to 72 dBA inside the noise isolating booth.

F. Chlor-Alkali Plant:

Mostly in the 70s and low 80s inside the Electrolysis Room. Noise levels may increase to the upper 80s or even lower 90s at a few locations if the ventilation wall fans were turned on. However, the overall noise exposure problem was minimal for Chlor-Alkali Plant workers.

CUSAROSS 00955

G. Extrusion Plant:

96 to 106 dBA at #3131A crusher in the Reborn Room, 85 to 95 dBA at #3102A-E blenders, and 85 to 93 dBA at #3102A-E mixers. Noise levels inside air compressors room varied between 86 to 95 dBA.

H. Printing and Laminating Plant:

85 to 91 dBA.

I. Film Plant:

#1, #3 and #5 calenders, mixing rolls, and winders were especially noisy, causing working area noise levels at 92 to 96 dBA. All workers on the first floor of film plant are likely to be overexposed.

J. Leather Plant:

Varied between 82 to 88 dBA. #2, #4 and #6 calenders, mixing rolls and winders were comparatively less noisy than the #1, #3 and #5 machines.

K. Floor Tile Plant:

The mixing roll and super mixer at the floor tile plant were very noisy, causing 94 to 97 dBA levels in the work areas.

L. Master Batch Plant:

The mixing roll, blender and trimming crusher caused noise level in excess of 90 dBA.

M. Boiler House of Fabrication Plant:

Noise level varied between 90 to 105 dBA at various locations inside the boiler house. Noise level within the isolation booth varied between 78 dBA to 90 dBA, depending on how many of the three boilers were operating at the same time.

N. Taoyuan Plant:

Some of the major noise sources were #9, #11 and #15 calenders, and the boiler. #15 calender was especially noisy, causing 90 to 95 dBA in its vicinity.

The fact that high noise levels do exist in plants of China Gulf Plastics Corporation does not automatically mean that the summation of exposure (dosage) of employees will be adverse or unlawful. The best present method for

CUSAROSS 00956

establishing the significance of noise environments, in relation to employee work patterns, is through use of a noise dosimetry. A noise dosimeter worn by the employee automatically integrates the intensity of measured sound with the duration of exposure.

CUSAROSS 00957

Noise dosimeters by Metrosonics (Model dB-301 Metrologger) were employed in the noise dosimetry survey at Toufen and Taoyuan plants. The db-301 Metrologger is a small battery-operated device which is carried on the worker's belt; attached is a microphone which is clipped to the worker's collar as close as possible to his ear. The maximum allowable exposure per 8-hour workday is 100%, and readings above 100% indicate exposure problems.

All plant operator jobs judged to be heavily exposed to the various high noise sources were selected in the dosimetry survey. Dosimetry data were gathered for 31 man-days at Toufen Main Plant and for 12 man-days at Taoyuan Branch Plant. Results of the dosimetry study are summarized in Table XII for Toufen Plant and in Table XIII for Taoyuan Plant. Several jobs showed noise exposures in excess of the 100% of the permissible level.

The jobs which showed noise overexposure at Toufen Plant were the mixing roll operators and winder operators of #1 calender, #3 calender and #5 calender. Also overexposed was a PVC compounding operator at the Floor Tile Plant, and the #3131A crusher operator at the Extrusion Plant. In addition, the jobs of instrument control operator at PVC Drying Plant, #3107 PVC Compounding Machine Operator at Extrusion Plant and the boiler house operators also showed a tendency of potential overexposure. At Taoyuan Plant, the only overexposed job was the operators for #15 calender.

Noise emitting from #1, #3 and #5 calenders can be reduced significantly by returning the speed of operation to their early, slower rate. Noise measurements made in 1977 showed sound levels were approximately 2 to 3 dB lower than those measured in 1979 when the machines were speeded up. A major noise source for the calenders was from the fast-turning idlers. They might require new bearings or lubrication and balancing. Diligent maintenance and service for other rotating machines and parts in also recommended for plant noise reduction.

At Extrusion Plant and Floor Tile Plant, the scraps were reprocessed by grinding, melting and mixing with new resin pellets. The grinding operation produced the highest noise levels. One may be able to enclose the #3131A

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TABLE XII

NOISE DOSIMETRY AT TOUFEN PLANT

CHINA GULF PLASTICS CORPORATION

October 1979

EMPLOYEE I.D.	JOB LOCATION	L OSHA (90)* EQUIVALENT	% PERMISSIBLE EXPOSURE
Chang, S. Y. 58116	Charger Polymer Plant	89	87
Chang, S. Y. 58116	Charger Polymer Plant	87	66
Chung, J. S. 58115	Discharger Polymer Plant	88	76
Chung, J. S. 58115	Discharger Polymer Plant	87	66
Lin, C. H. 54148	Operator Boiler House, Cl_2 Plant	89	87
Lin, C. H. 54148	Operator Boiler House Cl_2 Plant	84	44
Chiu, H. Y. 55133	Instrument Control, PVC Drying Plant	90	100
Chuang, H.H. 61183	Operator Cl2 Drying Plant	80	25
Lo, F. S. 55025	Operator Boiler, Film Plant	85	50
Lo, F. S. 55025	Operator Boiler House, Film Plant	89	87
Lin, Y. S. 68161	Operator, Trimming Crusher Master Batch Plant	84	44
Lo, L. C. 68115	Operator, Trimming Crusher Master Batch Plant	79	22
Wu, J. H. 64117	Operator, Mixing Roll Master Batch Plant	82	33
Huang, F. C. 65102	Operator, Mixing Roll Master Batch Plant	74	11
Lo, S. C. 64331	Operator, Mixing Roll #1 Calender	96	230**

CUSAROSS 00959

TABLE XII
Page Two

EMPLOYEE I.D.	JOB LOCATION	L OSHA (90)* EQUIVALENT	% PERMISSIBLE EXPOSURE
Lin, C. S. 59127	Operator, Winder #1 Calender	95	200**
Lo, S. Y. 65114	Operator, Mixing Roll #3 Calender	95	200**
Chang, C. F. 60148	Operator, Bombury #3 Calender	84	44
Lee, J. C. 60161	Operator, Winder #3 Calender	93	152**
Chen, F. Y. 67192	Operator, Mixing Roll #5 Calender	93	152**
Chuang, W.S. 60143	Operator, Bambury #5 Calender	80	25
Huang, S. K. 68131	Operator, Mixing Roll #8 Calender	87	66
Lin, S. M. 60387	Operator, Super Mixer #8 Calender	73	10
Huang, S. K. 58131	Operator, Mixing Roll #8 Calender	87	66
Chen, M. L. 61145	Operator PVC Compounding Floor Tile Plant	89	87
Chung, C. L. 67170	Operator PVC Compounding Floor Tile Plant	95	200**
Tan, J. K. 65186	Operator 3131A Crusher Extrusion Plant	93	152**
Lee, P. T. 64161	Operator #3106 PVC Compounding Machine Extrusion Plant	75	13
Shen, F. L. 56121	Operator #3105 PVC Compounding Machine Extrusion Plant	83	38
Chen, L. C. 57116	Operator #3107 PVC Compounding Machine Extrusion Plant	90	100
Liao, C. W. 60126	Operator #3102 Super Mixer Extrusion Plant	81	29

(See next page for footnotes).

CUSAROSS 00960

TABLE XII
Page Three

Footnotes from previous two pages.

* L OSHA (90) Equivalent is defined as the constant sound level, in a given situation and time period, that conveys the same OSHA equivalent average as does an actual time-varying sound during the same time period. The Chinese Government uses the same noise exposure standard as that used by the United States Occupational Safety & Health Administration (OSHA).

** Overexposed.

CUSAROSS 00961

TABLE XIII

OCCUPATIONAL NOISE EXPOSURES AT CGPC TAOYUAN PLANT

October 11 - 12, 1979

EMPLOYEE I.D.	JOB & LOCATION	L OSHA (90)* EQUIVALENT	% PERMISSIBLE EXPOSURE
Hsiao, W. S. 66947	#9 Mixer Operator	78	19
Huang, C. C. 68838	#11 Mixer Operator	83	38
Lin, C. S. 66984	#11 Mixing Roll	86	57
Ko, J. L.	#15 Mixing Roll	90	100
Peng, W. H. 67951	#15 Mixer Operator	82	33
Chiang, C. W. 68831	#9 Calender Operator	88	76
Tzeng, C. H. 68813	#11 Calender Operator	85	50
Ko, W. J. 65922	#11 Calender Operator	79	22
Chai, C. J. 68837	#15 Calender Operator	92	132**
Chiu, W. K. 65982	#15 Calender Operator	77	17
Chiang, J. L. 68833	#11 and #15 Wan-Ma-Li Machine	79	22
Chen, P. C. 61919	Boiler Operator	80	25

** Overexposed.

CUSAROSS 00962

crusher and some mixers. Even partial enclosure or with baffles installed on the operator's side can reduce noise exposures significantly.

When noise exposures regularly exceed the permissible level, feasible engineering or administrative controls should be implemented to reduce the exposure to acceptable levels. Where engineering noise controls are either not feasible or not yet in effect, hearing protectors (ear muffs or ear plugs) shall be provided to, and used by, operators of overexposed jobs. Although some jobs showed low to moderate exposures, dosimetry data are quite limited at this time and more data should be obtained in the future. Five samples per job is sometimes adequate, but eight to ten samples are preferred before making definite conclusions of underexposure or overexposure.

CGPC should start an audiometric testing program. New employees should receive baseline audiograms during pre-employment physicals or as soon thereafter as practical. It should set a policy to do annual audiograms on all employees who routinely work in plant areas having noise levels of 90 dBA or greater, and on those employees whose noise dosimetry results show 50% or more of the permissible exposure.

CUSAROSS 00963

IX. CGPC'S INDUSTRIAL HYGIENE PROGRAM

CGPC's industrial hygiene program is still the best in Taiwan. The personnel involved in managing and implementing this program are enthusiastic and capable individuals. CGPC also has a well equipped industrial hygiene laboratory with some field and laboratory instruments not readily available elsewhere in Taiwan. However, the social, political and economic climate in Taiwan have changed significantly in the past few years. There have been many more concerns about public health, environmental conservation, consumer safety, and occupational safety and health. Medium to large industries in Taiwan are required by law to have safety and hygiene professionals on the staff. Several large companies, including CGPC's competitors, have made significant improvement in their occupational health and hygiene functions. Therefore, it is urged that CGPC also strengthen its industrial hygiene program to stay ahead of its peers.

CGPC has four or five low-flow, personal air sampling pumps which were purchased in 1975. All of them were out of service and two of them could not draw air. But the CGPC's Industrial Hygiene Department have been using these pumps to collect air samples without knowing that they were malfunctioning. A set of sampling pump calibrating equipment should be purchased to assure proper operation of the air pumps.

CGPC's Century Organic Vapor Analyzers were also out of calibration. Although vinyl chloride calibrating gas is difficult to obtain, CGPC could calibrate the instrument with methane, n-hexane, or methyl isobutyl ketone. But please bear in mind that when the instrument is calibrated with methane or n-hexane, measurements of vinyl chloride would show a lower relative response of approximately 35% (100 ppm of vinyl chloride would show on the instrument's readout as 35 ppm).

CGPC Industrial Hygiene Department does not have the capability to conduct dust monitoring. In view of the large consumption of powdery lead, barium,

CUSAROSS 00964

cadmium and chromium compounds, and the new evidences that exposure to PVC dust could cause pneumoconiosis and other respiratory tract illness, it is recommended that CGPC purchase three to five high-flow air sampling pumps, and dust sample weighing and analyzing instruments. A sensitive electronic balance is essential; and an absorption flame photometer (atomic absorption) is preferred for metal analysis.

Occupational noise exposure monitoring should be conducted periodically at CGPC because noise dosimetry survey has shown overexposures for a group of workers. Three to five noise dosimeters should be acquired. Please also consider the acquisition of a set of audiometric testing equipment.

The United States National Institute for Occupational Safety and Health (NIOSH) is offering training courses to chemists faced with the responsibility of setting up and operating an industrial hygiene laboratory. NIOSH Course #586, "Setting Up An Industrial Hygiene Laboratory", Course #587, "Industrial Hygiene Laboratory Quality Control", and/or Course #590, "Industrial Hygiene Chemistry", would be most beneficial to CGPC if Mr. Ed Lu or one of his staff could visit the United States to attend one or more of these courses.

Gulf Science and Technology Company's Medical and Health Resources Division will sponsor an Industrial Hygiene Key Person Training Program in the Fall of 1980 for a group of engineers, chemists, and safety professionals from Gulf's international facilities. It is recommended that Ed Lu or one of his staff should participate in this training program. The trainee will spend one week in Gulf's Industrial Hygiene Laboratory to learn laboratory procedures, instrument operations, analytical techniques, equipment calibrations, and other industrial hygiene specialties, such as toxicology, heat and noise control engineering. He will also spend time with Gulf senior industrial hygieneists in on-the-hob training at Gulf's United States refineries and chemical plants.

Please advise Dr. Robert T. Cheng, Regional Industrial Hygiene Director, Gulf Science and Technology Company, P. O. Box 81608, San Diego, California 92138, as soon as possible if the managements of China Gulf Plastics Corpo-

CUSAROSS 00965

ration agree with the above-proposed training program. The detailed training and travelling agenda for the trainee will be submitted at a later time. Tentatively, the training program can begin in August, 1980.

Attached to this report are more detailed descriptions of the NIOSH courses. NIOSH Course #588, "Industrial Ventilation", is also included because CGPC will need expertise in ventilation engineering for dust control.

NIOSH COURSE 586

SETTING UP AN INDUSTRIAL HYGIENE LABORATORY (586)

This course will provide guidance to the chemist faced with the responsibility of setting up an industrial hygiene laboratory. Requirements for facilities, equipment, and supplies will be developed for typical situations. Selection of specific sampling and analytical procedures to meet the needs and resources of the participants will be guided by the NIOSH staff. Principles of and the steps to initiate an effective intralaboratory quality control program will be developed. Calibration and maintenance of equipment will be covered.

PREREQUISITES: Knowledge of analytical chemistry desirable.

OBJECTIVES: Each participant will be able to:

- Identify resources needed to set up a general purpose industrial hygiene lab.
- Determine analytical procedures and equipment appropriate to needs.
- Set up and operate a simple, effective laboratory quality control program.

COURSE TOPICS INCLUDE:

Laboratory Requirements
Laboratory Equipment
Analytical Separations
Spectroscopy
Gas Chromatography
X-ray Procedures
Workload Planning
Quality Control Principles
Applications of Quality Control
Instrumental Quality Control

WHO SHOULD ATTEND: Chemists and other professionals with the assignment of setting up a laboratory. Non-Chemists who must evaluate laboratory operations, either as a supervisor or contractually, will also benefit.

COURSE DURATION: Two (2) Days

CONTINUING EDUCATION CREDIT: 1.5 C.E.U.'s

CUSAROSS 00967

NIOSH COURSE 582

INDUSTRIAL HYGIENE LABORATORY QUALITY CONTROL (587)

This course presents a review of laboratory accreditation, a survey of the current program, and an in-depth analysis of the operational attributes and programs considered important for accreditation.

PREREQUISITES: A good knowledge of industrial hygiene laboratory operations.

OBJECTIVES: Each participant will be able to:

- Provide an integrated approach to a laboratory quality control system.
- Perform a self-evaluation of one's own laboratory quality control system.
- Respond to the rationale and procedures of the Industrial Hygiene Laboratory Accreditation program.

COURSE TOPICS INCLUDE:

Laboratory Accreditation History
Laboratory Accreditation Guidelines
Federal Clinical Lab Licensing Requirements
Accreditation Program Areas
Standard Reference Materials
Proficiency Analytical Testing
Evaluation of Quality Control Programs
Lab Quality Program Requirements
Legal Aspects of Recordkeeping
Corrective Action and Feedback
Calibration Systems
Simple Statistical Techniques for Lab Quality Control

WHO SHOULD ATTEND: Industrial Hygiene Chemists, Laboratory Supervisors, and those responsible for the evaluation of laboratory operations.

COURSE DURATION: 5 (5) Days

CONTINUING EDUCATION CREDIT: 4 C.E.U.'s

CUSAROSS 00968

NIOSH # 588

INDUSTRIAL VENTILATION (588)

This course covers the fundamentals of industrial exhaust ventilation including the air flow design of industrial exhaust systems. Designs will include exhaust and air supply ventilation systems, selection of exhaust hoods, principles and selection of fans, determination of air volumes and minimum duct velocities, sizing and selection of ducts, calculation of system pressure losses, and the selection of air cleaning devices. Computer design and cost analysis of ventilation systems will be discussed. Lectures will be augmented by laboratories and a field trip in order to acquaint the trainee with various instruments.

PREREQUISITES: Familiarity with engineering design calculations is required.

OBJECTIVES: Each participant will be able to:

- Select and identify appropriate exhaust ventilation systems for industrial processes.
- Measure the performance of exhaust systems using air flow, velocity and pressure measuring instruments.
- Design industrial exhaust systems.

COURSE TOPICS INCLUDE:

Air Flow Principles
Local Exhaust Ventilation
Hood Design
Entry Loss Calculations
General Ventilation
Duct Design Calculations
Computer Design of Industrial Ventilation Systems
Fans and Blowers
Measuring Instruments
System Performance Evaluation
Cost Analysis of Ventilation Systems
Collection Systems

WHO SHOULD ATTEND: Industrial Hygienists, Plant Engineers and Mechanical Engineers who design industrial systems.

COURSE DURATION: Five (5) Days

CONTINUING EDUCATION CREDIT: 4 C.E.U.'s

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, NIOSH COURSE 5, 0

INDUSTRIAL HYGIENE CHEMISTRY (590)

This course is designed for personnel in the field of occupational health who require specialized training in monitoring and evaluating the work environment. The topics listed below are covered through lectures, demonstrations and laboratory exercises.

PREREQUISITES: The participants should have education and training in chemistry and experience in laboratory instrumental analysis.

OBJECTIVES: The trainee will be able to:

- Select an appropriate sampling strategy using available sampling techniques and select a corresponding appropriate analytical method for quantitative characterization of the sample by using knowledge gained from the course and technical information references in the course, given a particular chemical health hazard commonly found in the occupational environment.
- Apply his knowledge of wet chemical and/or instrumental analysis in employment of current methodologies for evaluating the typical work environment.
- Perform and evaluate quantitative analytical determinations for four classes (types) of hazardous substances using a correspondingly different method for each class or type.
- Define the data in terms of actual environmental concentration levels and interpret the results in light of existing exposure standards given the analytical results obtained through proper measurement procedures.

COURSE TOPICS INCLUDE:
Gas Chromatography
Atomic Absorption Spectroscopy
Ion Selective Electrodes
X-ray Diffraction
Mass Spectrometry
Instrument Calibration
Direct Reading Instruments
Data Handling and Statistics
Sample Preparation and Handling
Current Topics

WHO SHOULD ATTEND: Chemists, Industrial Hygienists and other professional health personnel.

COURSE DURATION: Five (5) Days

CONTINUING EDUCATION CREDIT: 4 C.E.U.'s