U. S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTER FOR DISEASE CONTROL
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION REPORT
HE 79-96-729

PROTECTIVE COATINGS CORPORATION
FORT WAYNE, INDIANA

AUGUST 1980

I. SUMMARY

A Health Hazard Evaluation was conducted by the National Institute for Occupational Safety and Health (NIOSH) at the Protection Coatings Corporation plant (SIC 3060) in Fort Wayne, Indiana, on June 8, July 31, and August 1, 1979. The purpose of this evaluation was to study possible hazards to employees resulting from occupational exposure to various substances used in the relining of tanks. Environmental samples were taken for toluene, xylene, methyl ethyl ketone (MEK), methyl isobutyl ketone (MIBK), trichloroethylene, tetrachloroethylene, crystalline silica, and particulate. Medical interviews were conducted to relate worker exposure with health effects.

Results of this evaluation indicate that, on the days of sampling, several employees were overexposed to xylene, toluene, crystalline silica, and a mixture of organic compounds. Time weighted average concentrations ranged up to 480 parts per million (ppm) for xylene and 120 ppm for toluene. The recommended maximum level for both is 100 ppm. Additive exposure of these and other organic compounds reached 469% of the recommended maximum exposure. Breathing zone concentrations of respirable crystalline silica reached 0.5 milligrams per cubic meter of air (mg/M^3), a level ten times the NIOSH recommended maximum of 0.05 mg/M^3. The most common physical symptoms exhibited by employees included shortness of breath, cough, headache, mucous membrane, and eye irritation and light-headedness. These symptoms were consistent with overexposure to the organic compounds. Procedures for working in confined spaces and for use of respiratory protection were not adequate.

Based on the information collected during this evaluation, NIOSH found that a health hazard did exist at Protective Coatings Corporation due to overexposure to solvents and silica. Measured exposures to workers were several times above the recommended maximum levels. Recommendations to reduce personal exposures and improve operating conditions are included in Section VIII of this report.

II. INTRODUCTION

Under the Occupational Safety and Health Act of 1970*, NIOSH investigates the toxic effects of substances found in the workplace. A representative of the Allied Industrial Workers Union requested such an evaluation to determine the hazards presented by various substances at Protective Coatings Corporation. This request questioned the possible relationship between occupational exposures to various substances and symptoms such as headache, nausea, skin irritation, breathing problems, and nervousness, as well as a recent heart attack.

Subsequent to the on-site portion of this investigation, written reports were submitted to the company and union in July and November 1979, detailing progress at those times.

III. BACKGROUND

Protective Coatings, Incorporated has been in production since 1958 and at the time of this evaluation had approximately 65 hourly employees at two geographically separate facilities in Fort Wayne, Indiana. One building, the roundhouse, is used exclusively for the relining of railroad tank cars with rubber sheeting. The other area, the main plant, is involved in the relining of semi-trailer tanks and tanks of all sizes, the production of expansion joints and making of a variety of belts and special rubber products.

Tanks to be relined must have the old lining removed. This is sometimes done by heating the outside of the metal tank with a propane flame to burn away the old lining. Other times the old lining is cut away from the inside of the tank. In either case employees go into the tank to cut up and remove the old lining and then the interior of the tank is blasted with metal shot or silica sand to make a clean, smooth surface. When the tank is prepared for relining, a crew from one to several men, depending on the size of the enclosure, will then enter the tank and apply a new lining.

Many of the jobs in this plant include the use of a variety of organic solvents, glues, cements and curing agents. These substances contain xylene, toluene, MEK, MIBK, trichloroethylene, and tetrachloroethylene. In addition to these substances, employees also have exposure to metal and silica dusts from shot and sand blasting operations used to clean and prepare tanks for lining. There is also a potential exposure to rubber combustion products formed when old tank linings are burned to remove them prior to relining, as well as exposure to residual of unknown substances in tanks coming in for relining.

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* Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6), authorizes the Secretary of Health and Human Services, following a written request by any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

IV. EVALUATION DESIGN AND METHODS

An initial walk-through visit was conducted at both locations of this plant on June 8, 1979. During this visit bulk samples of several substances were obtained for qualitative analysis of suspected contaminants and information was obtained on processes and materials.

On July 31 and August 1, 1979, a joint environmental-medical evaluation was conducted. Personal breathing zone and general area air samples were collected using battery-powered sampling pumps to determine atmospheric concentrations of various substances to which employees were exposed. Activated charcoal sampling tubes were used to collect the organic compounds. Analysis was by gas chromatography. Filters were used to sample for metals, silica, and total particulate. Analysis for these substances was by atomic absorption spectroscopy, x-ray diffraction and reweighing of tared filter, respectively. Ventilation and work practices were evaluated. A medical team familiar with the plant processes and substances interviewed many employees to elicit symptoms and problems and to ascertain if these problems were related to a particular area or type of exposure.

V. EVALUATION CRITERIA

Airborne Contaminants

1. Toluene -- The primary acute exposure effect of toluene is narcosis. In concentrations of 300-600 ppm, fatigue, mental confusion, exhilaration (a "high" feeling), nausea, headache, and dizziness can result in as little as 2-3 hours.

   With chronic lower level exposure inconsistent changes in red and white blood cells have been reported with no definite consistent effects noted. Most industrial exposures result from breathing toluene vapor since it is absorbed slowly through the skin. Because of its irritant and defatting properties causing irritation, skin contact should be avoided. The current acceptable exposure limit is 100 ppm time weighted average over an 8-hour work shift, with a ceiling concentration of 200 ppm for a 10 minute sample.

2. Xylene -- The primary effects from acute exposure to xylene parallel toluene but certain isomers may have similar effects at a lower concentration. Narcosis, as well as various levels of fatigue, mental confusion, exhilaration (a "high" feeling), nausea, headache, and dizziness can occur within a few hours with exposures in the 200-600 ppm range. Chronic exposures have been reported to cause minor changes in white blood cells and platelets. Xylene is poorly absorbed through the skin but is a powerful irritant and skin contact should be avoided. The current acceptable exposure limit is 100 ppm for 8 hours on a time weighted average, with a ceiling concentration of 200 ppm for a 10 minute sample.

3. Methyl ethyl ketone -- A highly volatile flammable liquid with an odor like acetone, this compound carries a much lower degree of toxicity than toluene or xylene. It can cause narcosis at high concentrations, but its primary health effect is skin and mucous membrane (including eye) irritation. The current exposure limits for MEK is 200 ppm on an 8 hour time weighted average basis.

4. Methyl Isobutyl Ketone -- Exposure to MIBK can cause eye and nose irritation, headache, dizziness or nausea. It can also cause narcosis, gastrointestinal disorders, and peripheral neuropathy. Its action and effects are similar to MEK, and should be considered as additive. The recommended maximum concentration of MIBK is 50 ppm.

5. Trichloroethylene -- Trichloroethylene is absorbed rapidly by the lungs and affects the central nervous system, the cardiovascular system, the liver, and kidneys. It produces narcosis as well as eye and skin irritation. Trichloroethylene causes liver cancer in some rodents but is at most a weak human carcinogen. The NIOSH recommended maximum time weighted average environmental level is 25 ppm.

6. Tetrachloroethylene -- This compound, also known as perchloroethylene, has similar affects to trichloroethylene. It affects the liver, kidneys, and central nervous system. It produces narcosis, eye, skin and upper respiratory tract irritation. It has also been shown to cause liver cancer in mice. NIOSH recommends that tetrachloroethylene be handled as if it were a human carcinogen. The recommended time weighted average environmental level is 50 ppm, with a ceiling concentration of 100 ppm for a 15 minute sample.

7. Silica -- Exposure to sand or other substances containing a high concentration of free crystalline silica is capable of causing a lung condition known as silicosis. The term silicosis represents a variety of pathological and clinical disease states described in a single term. In simple silicosis, while pathologic evidence of exposure may be present, no clinical symptoms are apparent. Even in a more aggressive form of the disease; i.e., massive fibrosis, symptoms may not occur until late. The earliest symptom is shortness of breath which progressively gets worse. As massive fibrosis progresses, pulmonary hypertension develops eventually leading to cor pulmonale. Therefore, it can be said that the health effects of exposure to silica can be divided into several categories:

    a. No effect even on x-ray, no symptoms

    b. X-ray evidence of silicosis (simple), no symptoms

    c. Massive fibrosis with shortness of breath and eventually death

Silicosis can be present and produce an abnormal x-ray in as little as nine months with heavy exposure and the breathing problems can occur in as few as 17 months exposure although much longer exposures are usually necessary. The degree of silicosis produced is dependent on the concentration of free crystalline silica, the size of the particles, and the worker's individual response to the exposure. The recommended maximum exposure limit of free crystalline silica is 0.050 mg/M^3 on a time weighted average basis.

8. Nuisance Dust -- The evaluation criteria for airborne particulate or "nuisance dust" is based on its ability to reduce workshop visibility, create unpleasant deposits in the ears, eyes, and nasal passages, or cause injury to the skin or mucous membranes by chemical or mechanical action per se or by rigorous cleansing procedures necessary for its removal. The American Conference of Governmental Industrial Hygienists has recommended a concentration of 10 mg/M^3 as a maximum acceptable level for total particulate in air, or 5 mg/M^3 respirable dust.

Toluene, xylene, MEK, MIBK, tetrachloroethylene, and trichloroethylene can act additively to produce irritation, headache, nausea, fatigue, narcosis, and other symptoms listed above. When an employee is exposed to 2 or more of these compounds, as is usually the case in this plant, their combined effect rather than that of one individual component should be considered. If the sum of the following fraction exceeds unity,

$$\frac{C_1}{T_1}+\frac{C_2}{T_2} + \ldots\frac{C_n}{T_n}$$

then the maximum allowable exposure should be considered as being exceeded. C_1 indicates the measured atmospheric concentration of compounds 1, C_2 the concentration of compounds 2, and so forth. T_1 indicates the maximum allowable exposure of compounds 1, T_2 the exposure of compounds 2, and so forth.

Confined Spaces

Since much of the work in this plant is done inside railroad tank cars, truck tank trailers, portable tanks or in other "confined spaces" with restricted entry and exit and no natural ventilation, special precautions are necessary to insure a safe and healthy working environment. Appendix I, taken from the NIOSH Criteria Document on working in confined spaces, presents recommendations for entry, rescue, testing, training, work practices, and other aspects of working in confined spaces.

VI. RESULTS AND DISCUSSION

Environmental

The results of analysis of bulk samples collected on the June visit are as follows:

Substance	Analyte	Results
Steel Grit	Beryllium	<0.002%
"Black Beauty" shot	"	"
Mica	Asbestos	Negative
Talc	"	"
Xylene	Benzene	<0.04%
Silica Sand	Crystalline Silica Polymorphs	96% Quartz

Tables I through V show the results of environmental samples taken for various substances on July 31 and August 1, 1979. Tables II, III, & IV also show the "additive exposure," that is, a number calculated by the method shown in Section V to determine if a worker is overexposed to a combination of substances. All tables except IV indicate overexposure either to individual substances or combinations.

Eleven samples for xylene and toluene were taken on men lining or cementing in tanks in the roundhouse or the tank lining area of the main plant. Seven of these eleven were overexposed to one or a combination of these compounds. These overexposures represent both short term and time weighted average exposures. Exposure to MEK, MIBK, trichloroethylene and tetrachloroethylene was not a problem. Two samples were taken for silica inside the sandblasters' hood. Both indicated an overexposure.

Ventilation measurements taken in the roundhouse indicate an exhaust of 900 to 1,000 cubic feet of air per minute (CFM) into the ducts at tracks 2 and 3, and approximately 600 CFM at track 1. Depending on the size of the tank car being lined, this would correspond to an air change every three to six minutes. In addition to this low volume, the supply air ducts were not being used properly and sometimes they were not used at all. Instead of the supply air being released well inside the tank as was intended, the supply ducts were only pushed a short distance into the tank, and the air was being blown in and quickly drawn out of the tank. All this air movement took place near the opening, and there was essentially no ventilation at either end of the tank. Additionally, observations indicated that the ductwork was not in good repair.

Observation and inquiries regarding respiratory protection and work inside tanks indicated that the company did have a written standard operating procedure for the selection and use of respirators. The program, however, did not meet the minimum acceptable requirements as established by OSHA regulation 1910.134. Deficiencies include proper methods for selection, training, cleaning, storage, and inspection of respirators, as well as a determination of whether an employee is physically able to use such equipment.

In some instances when employees were working in confined spaces there was verbal and/or auditory contact with other employees outside that space. This was not always the case, and there was almost a total lack of compliance with safety procedures such as those outlined in Appendix I of this report. Most notable was the lack of medical surveillance, training and rescue procedures for working in atmospheres which cause such symptoms as narcosis, dizziness, mental confusion, and fatigue.

Other observations made during this evaluation indicate apparent safety problems, such as frayed wires on "explosion-proof" lights and extension cords running through puddles of water.

Medical

All workers evaluated, both at the roundhouse and the main plant, were from the first shift during which most of the hourly employees work. A total of thirty-five (35) workers were questioned. Those individuals questioned could be separated into the following job categories.

1.	Tank lining	16
2.	Expansion joint	1
3.	Belt fabrication	10
4.	Tube winder	3
5.	Maintenance	4
6.	Supervisory	1
	Total	35

In evaluating the workers on a job category basis, the men employed as tank liners had more subjective complaints than any other group. Fifteen of 16 (94%) had 3 or more problems they thought were related to work. Shortness of breath, cough, headache, mucous membrane and eye irritation, and light-headedness were the most common complaints. In the belt fabrication area 5 of 10 workers (50%) had 3 or more complaints, consisting of mucous membrane irritation, eye irritation, headache, and nausea as the most common problems reported. In the maintenance area none of the four workers had work related complaints. In tube winding, one of three individuals (33%) questioned had problems, and these were similar in nature to the belt fabricators. In the remaining groups, supervisory and expansion joints, one worker each, no significant problems were reported except for the high heat in the summer months.

There appear to be many existing acute health problems and the possibility exists of chronic problems occurring at Protective Coatings, Incorporated. Most of these problems are of a mild nature and consist of light-headedness, mucous membrane irritation, eye irritation,

headache, nausea, and other symptoms related to the various organic chemical exposures existing at the plant. These problems can be dealt with effectively by proper work practices, protective equipment, and improved ventilation, the latter of which is quite lacking in certain areas, especially the tank lining operation.

The area of the plant that poses the greatest chronic disease potential problems is the tank lining areas where high silica content sand is used to prepare tanks for lining. Although workers seldom stay in this area for prolonged periods of time or for long durations, they have the potential for substantial exposure to high free crystalline silica content materials.

Based on the limited information available there appeared to be no substantial relationship of the recent heart attack to the occupational exposures at Protective Coatings, Incorporated. While the occupational exposures cannot completely be ruled out as partial causative factors, the presence of known vascular risk factors, i.e., high blood pressure, high cholesterol, heavy cigarette smoking in several of these workers, makes the occupational exposure and its contribution to these diseases very difficult to evaluate.

NIOSH investigators were told of three employees who were absent from work due to illness resulting from exposure experienced on a "road job," that is, the relining of a tank at a location remote from either the main plant or the roundhouse. Several employees, when asked about road jobs indicated that there were fewer precautions and less ventilation when working at these remote sites than when working at the plant.

VII. CONCLUSIONS

No beryllium, asbestos or benzene was found in this plant. Several overexposures to solvents were measured, primarily in tank lining operations. Existing general ventilation in the expansion joint and belt fabrication areas appeared to be adequate on the days of this evaluation to keep solvent exposure within safe limits, although half the workers in the belt fabrication area stated they had occasional symptoms of work-related problems. Overexposure to free crystalline silica was measured inside the sandblasters' hood. Ventilation in tanks and procedures for respiratory protection and working in confined spaces were not adequate.

VIII. RECOMMENDATIONS

An alternative abrasive should be found, if possible, to replace the high crystalline silica sand presently being used in the roundhouse. Employees working with this sand for more than three months a year should be offered a medical monitoring program as outlined in the NIOSH silica standard. If it is not possible to replace the sand with a less toxic substance, a better air-supplied hood should be obtained to reduce personal exposure.

The ventilation system needs to be upgraded. Existing ventilation should be repaired and maintained. Additional ventilation should be installed. A system for adequately ventilating tanks lined on road jobs should be developed. Supply and exhaust systems should be balanced and make-up air tempering should also be considered.

Written standard operating procedures should be developed and implemented for working in confined spaces. This should be done in conjunction with an upgrading of the respiratory program. Guidelines to follow include the NIOSH recommended criteria for working in confined spaces and the OSHA standard for respiratory protection (1910.134).

An adequate number of employees at each location, including road jobs, should be trained in rescue and first aid techniques. This should include cardiopulmonary resuscitation and the use of self-contained breathing apparatus. Equipment should be readily available for such emergencies.

When procedures are developed for safeguarding the health and safety of workers, and workers have been informed and trained regarding these procedures, the workers then have a responsibility to conform to these procedures and continue to do their jobs in a safe and healthful manner.

Workers, especially those who are being hired into the tank lining department, should receive a preemployment history and physical examination along with a baseline chest x-ray as a minimum. The employer should make an effort to reveal to the workers the type of materials being used in the plant and their known hazards as well as getting as much information as possible on the contents of certain previously used tanks and their contents so that workers may be informed as to the potential hazards with which they work.

After corrective actions have been taken, environmental sampling should be repeated to assure the effectiveness of control measures. This repeated sampling can be done by NIOSH or by other groups experienced in this field.

IX. REFERENCES

1. Criteria for a Recommended Standard: Occupational Exposure to Trichloroethylene, HEW Publication No. HSM 73-11025, 1973.

2. Criteria for a Recommended Standard: Occupational Exposure to Toluene, HEW Publication No. (NIOSH) 73-110, 1973.

3. Criteria for a Recommended Standard: Occupational Exposure to Xylene, HEW Publication No. (NIOSH) 75-168, 1975.

4. Criteria for a Recommended Standard: Occupational Exposure to Ketones, HEW Publication No. (NIOSH) 78-173, 1978.

5. Criteria for a Recommended Standard: Occupational Exposure to Tetrachloroethylene, HEW Publication No. (NIOSH) 76-185, 1976.

6. Criteria for a Recommended Standard: Occupational Exposure to Crystalline Silica, HEW Publication No. (NIOSH) 75-120, 1974.

7. Criteria for a Recommended Standard: Working in Confined Spaces, HEW Publication No. (NIOSH) 80-106, 1979.

8. U.S. Department of Labor, Occupational Safety and Health Administration, OSHA Safety and Health Standards (29 CFR 1910) (Revised November 7, 1978).

9. Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1979, Published by the American Conference of Governmental Industrial Hygienists, P.O. Box 1937, Cincinnati, Ohio 45201.

10. Industrial Ventilation - A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists Committee on Industrial Ventilation, 15th edition, Lansing, Michigan, 1978.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

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XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this determination report are currently available upon request from NIOSH, Division of Technical Services, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After ninety (90) days the report will be available through the National Technical Information Service (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati, Ohio address.

Copies of this report have been sent to:

1. Protective Coatings, Incorporated
2. Allied Industrial Workers of America
3. U.S. Department of Labor, Region V
4. NIOSH, Region V

For the purpose of informing the approximately 60 "affected employees," the employer shall promptly "post" the determination report for a period of 30 days in a prominent place near where exposed employees work.

Table I

Xylene Concentrations

Protective Coatings, Inc.
Ft. Wayne, Indiana

HE 79-96

July 31 - August 1, 1979

Description/Department	Day	Duration	Concentration (ppm)
Helper/Expansion Joint	7/31	7:25 am - 3:20 pm*	2
Builder/Belt	7/31	7:55 am - 3:20 pm*	4
Builder/Belt	7/31	8:00 am - 3:20 pm*	4
Tube Winder/Belt	7/31	8:25 am - 3:30 pm	1
Tube Winder/Belt	7/31	8:20 am - 3:30 pm*	2
Press Operator/Belt	7/31	9:05 am - 3:30 pm*	7
Finisher/Tank Lining	7/31	8:30 am - 3:30 pm	3
Builder/Expansion Joint	7/31	7:20 am - 3:15 pm*	13
Fitter/Tank Lining[1]	7/31	7:30 am - 2:00 pm*	33
Stock Cutter/Roundhouse	7/31	9:10 am - 3:00 pm*	14
Tube Winder/Belt	8/1	7:40 am - 3:20 pm*	4
Builder/Belt	8/1	7:45 am -12:30 pm	2
Press Operator/Belt	8/1	7:40 am - 3:20 pm*	5
Builder/Belt	8/1	7:25 am - 3:20 pm	4
Press Operator/Belt	8/1	7:30 am - 3:20 pm*	3
Press Operator/Belt	8/1	7:45 am - 3:20 pm*	10
Tube Winder/Belt	8/1	7:35 am - 3:20 pm*	2
Liner/Tank Lining	8/1	7:20 am -11:30 am	5
Liner/Tank Lining	8/1	7:20 am -11:25 am	4
Press Operator/Belt	8/1	7:30 am - 3:20 pm*	4
Liner/Tank Lining	8/1	7:15 am - 3:15 pm*	8
Liner/Tank Lining	8/1	7:15 am - 3:15 pm*	9
Builder/Expansion Joint	8/1	7:10 am - 3:15 pm*	6
Helper/Expansion Joint	8/1	7:10 am - 1:25 pm*	4
Liner/Tank Lining[2]	8/1	2:25 pm - 2:34 pm	480

Recommended 8-hour maximum concentration	100
Recommended ceiling concentration	200

* These samplers were turned off for thirty minutes while employee was eating lunch

1 Employee was away from work station from 12:00-2:00 to accompany NIOSH investigat on tour of facility

2 Sample taken while worker cementing inside semi trailer tank, wearing air supplie respirator

Table II

Xylene, Toluene, MIBK and Tetrachloroethylene Concentrations

Protective Coatings, Inc.
Ft. Wayne, Indiana
HE 79-96
July 31 & August 1, 1979

Description/Department	Day	Duration	Concentration (ppm) Xylene	Toluene	MIBK	Tetrachloroethylene	Additive Exposure***
Liner/Tank Lining	7/31	7:35 am - 3:30 pm*	144	11	N.D.**	0.1	1.55
Liner/Tank Lining	7/31	7:40 am - 3:15 pm*	5	5	N.D.	N.D.	0.10
Finisher/Tank Lining	7/31	8:30 am - 3:30 pm	4	29	N.D.	N.D.	0.33
Builder/Expansion Joints	7/31	7:20 am - 3:15 pm*	8	1	N.D.	N.D	0.09
Tank Liner/Roundhouse	7/31	9:25 am - 3:00 pm	73	35	N.D.	1	1.08
Liner/Tank Lining	8/1	7:15 am - 3:15 pm*	9	1	N.D.	N.D.	0.10
Cementing/Tank Lining	8/1	10:12 am -11:20 pm	460	9	N.D.	4	4.69
Cementing/Tank Lining	8/1	2:25 pm - 2:34 pm	850	12	N.D.	3	4.31
Tank Liner/Roundhouse	8/1	8:55 am - 3:30 pm	80	120	N.D.	N.D.	2.00
Tank Liner/Roundhouse	8/1	9:00 am - 3:30 pm	N.D.	7	N.D.	N.D.	0.07
Stock Cutter/Roundhouse	8/1	8:25 am - 3:20 pm	14	N.D.	N.D.	N.D.	0.14
Recommended 8-hour average maximum concentration			100	100	50	50	
Recommended ceiling concentration			200	200	125	100	

* These samplers were turned off for thirty minutes while employee was eating lunch

** None Detected

*** Stated as fraction of maximum recommended exposure considering additive effects, e.g, anything greater than 1.00 is overexposure

Table III

Xylene, Toluene and Trichloroethylene Concentrations

Protective Coatings, Inc.
Ft. Wayne, Indiana
HE 79-96

July 31 - August 1, 1979

Description/Department	Day	Duration	Concentration (ppm) Xylene	Toluene	Trichloroethylene	Additive Exposure**
Stock Cutter/Roundhouse	7/31	9:05 am - 3:00 pm	18	70	N.D.*	0.88
Tank Liner/Roundhouse	8/1	8:55 am - 3:30 pm	60	104	N.D.	1.64
Stock Cutter/Roundhouse	8/1	8:25 am - 3:25 pm	14	19	N.D.	0.33
Recommended 8-hour average maximum concentration			100	100	25	
Recommended ceiling concentration			200	200		

* None Detected
** Stated as fraction of maximum recommended exposure considering additive effects, e.g., anything greater than 1.00 is overexposure.

Table IV

MEK, MIBK, and Trichloroethylene Concentrations

Protective Coatings, Inc.
Ft. Wayne, Indiana
HE 79-96

July 31 - August 1, 1979

Description/Department	Day	Duration	Concentration (ppm) MEK	MIBK	Trichloroethylene	Additive** Exposure
Liner/Tank Lining	8/1	7:20 am -11:30 am	N.D.*	4	1	0.09
Liner/Tank Lining	8/1	7:20 am -11:25 am	1	1	1	0.03
Fitter/Tank Lining	8/1	7:15 am - 3:15 pm	N.D.	1	N.D.	0.02
Liner/Tank Lining	8/1	7:15 am - 3:15 pm	N.D.	5	N.D.	0.10
Stock Cutter/Roundhouse	8/1	8:25 am - 3:25 pm	N.D.	28	N.D.	0.56
Recommended maximum concentration			200	50	25	

* None Detected
** Stated as fraction of maximum recommended exposure considering additive effects, e.g., anything greater than 1.00 is over exposure.

Table V

Respirable Particulate and Free Crystaline Silica Concentrations

Protective Coatings, Inc.
Ft. Wayne, Indiana

HE 79-96

July 31 - August 1, 1979

Description/Department	Day	Duration	Concentration (mg/M^3) Particulate	Silica	Comments
Tank Liner/Tank Lining Dept.	7/31	7:45 am - 3:15 pm	0.1	ND*	
Sand Blaster/Roundhouse	7/31	9:30 am - 2:50 pm	0.4	0.2	Sampler inside hood while blasti
Shot Blaster/Tank Lining Dept.	7/31	7:45 am -11:20 am	68.0	0.8	Sampler hanging on belt
Sand Blaster/Roundhouse	8/1	8:30 am - 9:00 am	0.8	ND	Cleaning area, not blasting
Sand Blaster/Roundhouse	8/1	9:00 am -11:20 am	1.4	0.5	Blasting in tank, sampler inside hood
Recommended maximum concentration			5.0	0.05	

* None detected

I. RECOMMENDATIONS FOR A STANDARD FOR WORKING IN CONFINED SPACES

NIOSH recommends the procedures set forth in the following sections as a means of protecting the health, and significantly reducing accidental injury and death associated with entering, working in, and exiting from confined spaces. The standard is designed not only to make the confined space safe for the worker, but also to make the worker cognizant of the hazards associated with this work area and the safe work practices necessary to deal with these hazards. The criteria and standard will be reviewed and revised as necessary.

Section 1 - Definitions - For Purposes of this Document

Atmosphere	Refers to the gases, vapors, mists, fumes, and dusts within a confined space.
Ceiling Level	The maximum airborne concentration of a toxic agent to which an employee may be exposed for a specified period of time.
Combustible Dust	A dust capable of undergoing combustion or of burning when subjected to a source of ignition.
Confined Space	Refers to a space which by design has limited openings for entry and exit; unfavorable natural ventilation which could contain or produce dangerous air contaminants, and which is not intended for continuous employee occupancy. Confined spaces include but are not limited to storage tanks, compartments of ships, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.
Confined Space, Class "A"	A confined space that presents a situation that is immediately dangerous to life or health (IDLH). These include but are not limited to oxygen deficiency, explosive or flammable atmospheres, and/or concentrations of toxic substances.
Confined Space, Class "B"	A confined space that has the potential for causing injury and illness, if preventive measures are not used, but not immediately dangerous to life and health.
Confined Space, Class "C"	A confined space in which the potential hazard would not require any special modification of the work procedure.

Hot Work	Any work involving burning, welding, riveting, or similar fire producing operations, as well as work which produces a source of ignition, such as drilling, abrasive blasting, and space heating.
Inerting	Displacement of the atmosphere by a non-reactive gas (such as nitrogen) to such an extent that the resulting atmosphere is noncombustible.
Isolation	A process whereby the confined space is removed from service and completely protected against the inadvertent release of material by the following: blanking off (skillet type metal blank between flanges), misaligning sections of all lines and pipes, a double block and bleed system, electrical lockout of all sources of power, and blocking or disconnecting all mechanical linkages.
Lower Flammable Limit (LFL)	The minimum concentration of a combustible gas or vapor in air (usually expressed in percent by volume at sea level), which will ignite if an ignition source (sufficient ignition energy) is present.
Oxygen Deficiency	Refers to an atmosphere with a partial pressure of oxygen (PO_2) less than 132 mm Hg. Normal air at sea level contains approximately 21% oxygen at a PO_2 of 160 mm Hg. At an altitude of 5,280 feet normal air contains approximately 21% O_2 at a PO_2 of 132 mm Hg.
Oxygen Enriched Atmosphere	Any oxygen concentration greater than 25% (PO_2 - 190 mm Hg) at normal atmospheric pressure.
Permissible Exposure Limit (PEL)	The maximum 8-hour time weighted average of any airborne contaminant to which an employee may be exposed. At no time shall the exposure level exceed the ceiling concentration for that contaminant as listed in 29 CFR Part 1910 Sub Part Z.
Purging	The method by which gases, vapors, or other airborne impurities are displaced from a confined space.
Qualified Person	A person designated by the employer, in writing, as capable (by education and/or specialized training) of anticipating, recognizing, and evaluating employee

	exposure to hazardous substances or other unsafe conditions in a confined space. This person shall be capable of specifying necessary control and/or protective action to insure worker safety.
Respirator (Approved)	A device which has met the requirements of 30 CFR Part 11 and is designed to protect the wearer from inhalation of harmful atmospheres and has been approved by the Bureau of Mines and the National Institute for Occupational Safety and Health, and Mine Safety and Health Administration (formerly, Mining Enforcement and Safety Administration).
Standby Person	A person trained in emergency rescue procedures and assigned to remain on the outside of the confined space and to be in communication with those working inside.

Section 2 - Entry and Rescue

The Confined Space Classification Table on page 4 is based on existing or potential hazards relative to the confined space. The classification is based upon the characteristics of the confined space, oxygen level, flammability and toxicity. If any of the hazards present a situation which is immediately dangerous to life or health (IDLH), the confined space shall be designated Class A. The classification shall be determined by the most hazardous condition of entering, working in, and exiting a confined space. Class B confined space has the potential for causing injury and illness but is not immediately dangerous to life and health. A Class C entry would be one in which the hazard potential would not require any special modification of the work procedure.

The Check List of Consideration on page 5 delineates the minimum preparation required for each class of confined space entry. In the recommended standard where specific procedures, activities or requirements are correlated with a classification: the procedure, activity or requirement is mandatory. As an example, Section 3 - Permit System (Class A, B and C) means that a permit is mandatory for Class A, B, and C confined space entry.

CONFINED SPACE CLASSIFICATION TABLE

Parameters	Class A	Class B	Class C
Characteristics	immediately dangerous to life - rescue procedures require the entry of more than one individual fully equipped with life support equipment - maintenance of communication requires an additional standby person stationed within the confined space	dangerous, but not immediately life threatening - rescue procedures require the entry of no more than one individual fully equipped with life support equipment - indirect visual or auditory communication with workers	potential hazard - requires no modification of work procedures - standard rescue procedures - direct communication with workers, from outside the confined space
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm Hg)	16.1% to 19.4% *(122 - 147 mm Hg) or 21.5% to 25% (163 - 190 mm Hg)	19.5% - 21.4% *(148 - 163 mm Hg)
Flammability Characteristics	20% or greater of LFL	10% - 19% LFL	10% LFL or less
Toxicity	**IDLH	greater than contamination level, referenced in 29 CFR Part 1910 Sub Part Z - less than **IDLH	less than contamination level referenced in 29 CFR Part 1910 Sub Part Z

*Based upon a total atmospheric pressure of 760 mm Hg (sea level)
**Immediately Dangerous to Life or Health - as referenced in NIOSH Registry of Toxic and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

CHECK LIST OF CONSIDERATIONS FOR ENTRY,
WORKING IN AND EXITING CONFINED SPACES

ITEM	CLASS A	CLASS B	CLASS C
1. Permit	X	X	X
2. Atmospheric Testing	X	X	X
3. Monitoring	X	O	O
4. Medical Surveillance	X	X	O
5. Training of Personnel	X	X	X
6. Labeling and Posting	X	X	X
7. Preparation			
Isolate/lockout/tag	X	X	O
Purge and ventilate	X	X	O
Cleaning Processes	O	O	O
Requirements for special equipment/tools	X	X	O
8. Procedures			
Initial plan	X	X	X
Standby	X	X	O
Communications/observation	X	X	X
Rescue	X	X	X
Work	X	X	X
9. Safety Equipment and Clothing			
Head protection	O	O	O
Hearing protection	O	O	O
Hand protection	O	O	O
Foot protection	O	O	O
Body protection	O	O	O
Respiratory protection	O	O	
Safety belts	X	X	X
Life lines, harness	X	O	
10. Rescue Equipment	X	X	X
11. Recordkeeping/Exposure	X	X	

X - indicates requirement
O - indicates determination by the qualified person

If the work practice involved in the confined space has the potential to increase existing hazards or generate additional ones, it shall be necessary to frequently evaluate the space to determine if a classification change is warranted.

Rescue procedures shall be specifically designed for each entry. If a confined space has an A or B Classification, there shall be a trained standby person assigned to that confined space with a fully charged, positive pressure, self-contained breathing apparatus (SCBA) at hand. Additional duties of the standby person are to maintain unobstructed life lines and communications to all workers within the confined space, and to summon rescue personnel if necessary. Under no circumstances will the standby person enter the confined space until he is relieved and is assured that adequate assistance is present. However, while awaiting rescue personnel the standby person will make rescue attempts utilizing the life lines from outside the confined space. Rescue teams entering a Class A or B confined space shall be equipped with all the aforementioned safety equipment of the standby person and required life lines.

In the event of a Class C confined space rescue, a supplied-air respirator or a self-contained breathing apparatus shall be used. A person summoned or one who recognizes the need for rescue shall summon assistance and await their arrival outside the confined space. Respirators and life lines shall be donned by rescue personnel with necessary equipment for removal of the victim(s).

Section 3 - Permit System (Class A, B, and C)

Entry into a confined space shall be by permit only. The permit is an authorization and approval in writing that specifies the location and type of work to be done, and certifies that all existing hazards have been evaluated by the qualified person, and necessary protective measures have been taken to insure the safety of each worker.

The supervisor or a qualified person shall be responsible for securing the permit and both shall sign off when the following areas and actions have been reviewed and confirmed:

(a) Location and description of the work to be done.
(Class A, B, and C)

(b) Hazards that may be encountered.
(Class A, B, and C)

(c) Complete isolation checklist.
(Class A, B, and C)

(1) Blanking and/or disconnecting.

(2) Electrical lockout.

(3) Mechanical lockout.

(d) Special clothing and equipment.
(Class A and B)

(1) Personal protective equipment and clothing

(2) Safety harness and/or lines.

(3) Tools approved for use in accordance with the Hazardous Location Classification (NEC-1978).

(4) Approved electrical equipment.

(e) Atmospheric test readings.
(Class A, B, and C)

(1) Oxygen level.

(2) Flammability and/or explosive levels.

(3) Toxic substance levels.

(f) Atmospheric monitoring while work is being performed.
(Class A on a continuous basis and Class B as determined by the Qualified Person)

(g) Personnel training and complete understanding of the hazards.
(Class A, B, and C)

(h) Standby person(s) as named on the permit.
(Class A and B)

(i) Emergency procedures and location of first aid equipment.
(Class A, B and C)

(j) Confined space classification A, B, and C.

This permit shall be dated and carry an expiration time that will be valid for one shift only. The permit shall be updated for each shift with the same requirements.

The permit for a Class A or B confined space shall be posted in a conspicuous place, close to the entrance, with a copy on file with the employer.

The sample permit in Appendix III should serve as a guide and not be limited to the areas mentioned. The training requirements of personnel entering and/or working in confined spaces shall be suitable for the nature of the hazard and the work to be performed and will therefore vary with the confined space classification. The permit will vary among different industrial activities. However, it should serve the same purpose for all industries, to insure the safety of the worker.

Section 4 - Medical (Class A, B)

(a) Workers who enter a Class A or B confined space shall have a pre-placement physical examination made available to them. The employer shall provide to the physician performing or responsible for the medical surveillance program information such as the type of confined space the employee may be required to enter, the type of substances the employee may encounter, and a description of any protective devices or equipment the employee may be required to use. The physical examination shall include:

(1) A demonstration of the worker's ability to use negative and positive pressure respirators as cited in 29 CFR 1910.134.

(2) A demonstration of the workers ability to see and hear warnings, such as flashing lights, buzzers or sirens.

(3) The examination should place emphasis on general evaluations of the employee's ability to carry out his assigned duties and the detection of any diseases or abnormalities which may make it difficult to work within confined spaces.

(b) Following completion of the examinations, the physician shall give to the employer a written statement specifying any condition or abnormality found which would increase risk to the employee's health by working in confined spaces.

(c) Periodic medical examinations shall be made available to employees required to work in Class A or B confined spaces.

(d) First Aid Provisions

(1) For Class A and B entry there shall always be someone readily available in the area of the confined space who is currently trained in cardio-pulmonary resuscitation (CPR) and basic first-aid procedures.

(2) Employees shall be aware of the location of the nearest first-aid equipment, and how to obtain emergency assistance and medical attention. An adequate supply of first-aid equipment shall be within easy access of the confined space.

(e) Records of exposure to known health hazards shall be included in that employee's medical record. These records shall be made available to the designated medical representatives of the Secretary of Health, Education and Welfare, of the Secretary of Labor, of the employer and of the employee or former employee.

Section 5 - Training (Class A, B, and C)

The employer shall be responsible for training personnel and for the safety of the entire operation. Personnel who work in the vicinity of confined spaces shall be made aware of the hazards associated with confined spaces during orientation. Personnel who are required to work in a confined space, or in support of those working in a confined space shall have additional training in the following areas:

(a) Emergency entry and exit procedures (Class A, B, and C);

(b) Use of applicable respirators (Class A, B, and C);

(c) First aid (Class A, B);

(d) Lockout procedures (Class A, B, and C);

(e) Safety equipment use (Class A, B, and C);

(f) Rescue and training drills designed to maintain proficiency shall be given initially to new employees, and thereafter, at least annually, or at lesser intervals as determined necessary by the judgment of the employer (Class A, B, and C);

(g) Permit system (Class A, B and C); and

(h) Work practices as recommended in Section 9 of this proposed standard. (Class A, B and C)

Training shall not be considered as complete until the supervisor or other employer-designated official, safety or training officer, judges that the employee has attained an acceptable degree of proficiency for entering and working in confined spaces. The trainee's judgment of the adequacy of his training should be properly considered.

Section 6 - Testing and Monitoring (Class A, B, and C)

Entry into a confined space is prohibited until initial testing of the atmosphere has been done from the outside. Appropriate tests shall be made to insure that the atmosphere is safe. The tests performed shall include those for oxygen content, flammability, and toxic materials. Any necessary additional tests will be selected and performed to the satisfaction of the qualified person. Monitoring of a Class A confined space shall be done on a continuous basis. Class B and C shall be monitored as determined by the qualified person.

Entry into a confined space for any type of hot work shall be prohibited when tests indicate the concentration of flammable gases in the atmosphere is greater than 10% of the lower flammability limit (LFL). It is necessary to determine the oxygen level (by appropriate testing) prior to measuring the range of flammability to make necessary corrections in the flammability measurement. Monitoring of the atmosphere shall be performed in accordance with the permit. Equipment for continuous monitoring of gases and vapors shall be explosion proof and equipped with an audible alarm or danger signaling device that will alert employees when a hazardous condition develops. Instruments used for testing the atmosphere in a confined space shall be selected for their functional ability to measure hazardous concentrations. Instruments shall be calibrated in accordance with the manufacturer's guidelines or manuals. Each calibration shall be recorded, filed by the employer, and available for inspection for 1 year after the last calibration date.

In any confined space classified as a Class II or Class III hazardous location according to the 1978 National Electrical Code, Article 500 Sections 5 and 6, a fire watch shall be established as part of the entry procedure. In such areas surface dust and fibers shall be removed and no hot work shall be initiated until the airborne particulate level is below 10% of the LFL for the material. When combustible dusts or ignitable fibers/flyings are present, all equipment and ventilation systems used in the confined space shall comply with Articles 502 and 503 of the National Electrical Code.

The percentage of oxygen for entry into a confined space shall be no less than 19.5% nor greater than 25% at 760 mm Hg. At sea level the normal atmospheric pressure for air (20.9% O_2 + 78.1% N_2 + 1% Ar + trace amounts of various inert gases) is 14.7 psi or 760 mm Hg absolute. The partial pressure of oxygen (PO_2) at sea level will be approximately 160 mm Hg. PO_2 can be reduced by reducing the O_2 level in air at a given elevation or through increasing altitude. If tests indicate the oxygen level to be greater than 25% hot work is prohibited until ventilating techniques have reduced the oxygen level to approximately 21%. If the percentage of oxygen falls below 19.5% approved respiratory equipment shall be used in accordance with Section 8 and Appendix II.

When the contaminants in the atmosphere cannot be kept within permissible exposure levels as set down in 29 CFR Part 1910 Sub Part Z, then the employee shall wear an approved respirator.

Section 7 - Labeling and Posting (Class A, B, and C)

(a) All warning signs shall be printed both in English and in the predominant language of non-English reading workers. Where established symbols exist, they shall also be used. Workers unable to read labels and posted signs shall receive information regarding hazardous areas and shall be informed of the instructions printed on the signs.

(b) All entrances to any confined space shall be posted. Signs shall include but not necessarily be limited to the following information:

DANGER

CONFINED SPACE

ENTRY BY PERMIT
ONLY

(c) When a specific work practice is performed or specific safety equipment is necessary, the following statement shall be added, in large letters, to the warning sign:

RESPIRATOR REQUIRED
FOR ENTRY

LIFELINE REQUIRED
FOR ENTRY

HOT WORK PERMITTED
OR
NO HOT WORK

(d) Emergency procedures, including phone numbers of fire departments and emergency medical services shall be posted conspicuously within the immediate area of the confined space, or at the telephone from which help would be summoned.

Section 8 - Safety Equipment and Clothing (Class A, B, and C)

The entry permit shall include a list of necessary protective equipment to be used in the confined space as determined by the qualified person. The employer shall be responsible for the proper use of the safety equipment, and the inspection and maintenance procedures performed on the safety equipment. The type of protective equipment required, will be determined by the qualified person.

Those items normally used to protect against traumatic injury include: safety glasses, hardhats, footwear and protective clothing.

(a) Eye and Face Protection - For persons who wear corrective spectacles, either prescription ground safety glasses or plano-goggles shall be provided. Additionally if eye-irritating chemicals, vapors, or dusts are present, safety goggles shall be required, and if both the face and eyes are exposed to a hazard, as during scrapping scale or cutting rivets, a full coverage face shield with goggles shall be used. During welding operations the special goggles or shields required shall be in accordance with 29 CFR 1910.252.

(b) Head Protection - Hard hats shall meet the requirements cited in 29 CFR 1910.135.

(c) Foot Protection - All foot protection shall meet or exceed the requirements cited in 29 CFR 1910.136 and shall provide, in addition to protection from falling objects, protection from any other hazard identified by the qualified person.

(d) Body Protection - All personnel entering a confined space shall wear full coverage work clothing as specified by the qualified person. Gloves and clothing made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. If the hazards of heat or cold stress exist in the confined space, clothing which has been tested to provide protection from over-exposure to these hazards shall be worn. Other body protection required in specific operations such as welding (flame proofed), riveting (heat resistant) and abrasive blasting (abrasion resistant) shall be provided to insure worker safety.

(e) Hearing Protection - Shall be required when engineering technology is insufficient to control the noise level, and the ambient exposure limit exceeds those allowed in Table G-16 of 29 CFR 1910.95. Emergency alarms shall be distinguishable when hearing protection is worn. The sound level meters used to measure noise levels shall be certified by NIOSH in accordance with 24 CFR 82. Where the potential for explosion exists, the sound level meters shall be of an explosion proof design.

(f) Respiratory Protection - Shall be determined by the qualified person based upon conditions and test results of the confined space, and the work activity to be performed. Halfmask respirators are not recommended for use in any atmosphere greater than 10 x PEL because of the probability of accidently breaking the facepiece to face seal due to the work condition in a confined space. Also, gas masks designed for the same respiratory protection may be substituted for chemical cartridge respirators in the table (see Appendix II), but they are more cumbersome and restrictive to movement. The minimum service time of self-contained breathing apparatus shall be calculated on the entry time, plus the maximum work period, plus twice the estimated escape time for safety margin.

The respirators used shall be NIOSH and MSHA approved devices and shall be fitted and maintained in accordance with 29 CFR 1910.134. However, supplied-air respirators purchased before 1975 and bearing Bureau of Mines approval may be used until March 31, 1980. Self-contained breathing apparatus, with audible alarms and all gas masks, approved by the Bureau of Mines may be used until further notice.

(g) Hand Protection - If hands are exposed to rough surfaces or sharp edges, the degree of protection can range from canvas to metal mesh gloves, depending on the material handled. Gloves made of impervious rubber or similar material are to be worn to protect against toxic or irritating materials. Heat protective gloves are required when employees handle objects with temperatures greater than 60 C (140 F). Where a current flow through the body of more than 5 milliamperes may result from contact with energized electrical equipment, employees shall wear insulating gloves that have been visually inspected before each use. Above 5,000 volts, rubber gloves in accordance with 29 CFR 1910.137 shall be worn.

Additional safety equipment that is necessary to protect the worker in the environment of a confined space: a safety belt with "D" rings for attaching a life line shall be worn at all times; the combination of a body harness and/or safety belt with life line shall be used when an employee is required to enter to complete the gas analysis; when an employee is working in an area where entry for purposes of rescue would be contraindicated (special limitations or fire hazard); when any failure of ventilation would allow the build-up of toxic or explosive gases within the time necessary to evacuate the area, or when the atmosphere is immediately dangerous to life and health. Safety belts may be used as the primary means of suspension for the life line only when rescue may be made by keeping the disabled body in a position that will maintain easy passage through exit openings. If the exit opening is less than 18 inches (45 cm) in diameter, then a wrist type harness shall be used. When it is determined by the qualified person that none of the special hazards associated with confined spaces pose an immediate threat to life, as in a Class C entry, then life lines shall be readily available but not used during entry and work procedures.

Other protective measures shall include: safety nets used to protect employees working 10 feet (3 m) above ground or grade level when other protective devices are impractical; life jackets worn if the workers are exposed to falls into liquid over 4 feet (1.2 m) in depth; and insulated floor mats when hot work requires use of electrical energy.

When employees enter a ~~confined space~~, a barricade shall be erected if inadvertent entry poses a problem. The barricade shall have a mechanism to prevent closure of the escapeway, signs warning of the danger present, a physical barrier (fence) to keep the area clear, and an adequate platform (3 feet x 3 feet as a minimum) for entry or exit. Such added features as a tripod with block and tackle for safety lines and communication equipment should be considered when the entry plan is formulated. The employer shall be responsible for maintenance of the barricade system.

Section 9 - Work Practices (Class A, B, and C)

~~Before entering a confined space,~~ employees shall review the specific guidelines appropriate for safe entry and emergency exit. These guidelines or standards shall be compiled by the qualified person and be definitive on all the possible hazards. Areas covered by such guidelines shall follow this recommended standard.

(a) Purging and Ventilating (Class A, B)

Environmental control within a confined space is accomplished by purging and ventilating. The method used will be determined by the potential hazards that arise due to the product stored or produced, suspected contaminants, the work to be performed, and the design of the confined space. When ventilating and/or purging operations are to be performed, the blower controls shall be at a safe distance from the confined space. In a Class A entry, an audible warning device shall be installed in all equipment to signal when there is a ventilation failure. When a ventilation system is operational, air flow measurements shall be made before each workshift to ensure that a safe environmental level is maintained. Initial testing of the atmosphere shall be performed from outside the confined space before ventilation begins to determine what precautions are necessary in purging and ventilating. Testing of more remote regions within the confined space may be performed once the immediate area within the confined space has been made safe. Exhaust systems shall be designed to protect workers in the surrounding area from contaminated air. If flammable concentrations are present all electrical equipment shall comply with the requirements of NEC (NFPA no. 70) hazardous locations, and the bonding requirements of Article 250 of NEC, 1978. Where continuous ventilation is not a part of the operating procedure, the atmosphere shall be tested until continuous acceptable levels of oxygen and contaminants are maintained for three tests at 5-minute intervals. Care shall be taken to prevent recirculation of contaminated air and interaction of airborne contaminants.

Continuous general ventilation shall be maintained where toxic atmospheres are produced as part of a work procedure, such as welding or painting, or where a toxic atmosphere may develop due to the nature of the confined space, as in the case of desorption from walls, or evaporation of residual chemicals. General ventilation is an effective procedure for distributing contaminants

from a local generation point throughout the work space to obtain maximum dilution. However, special precautions shall be taken if the ventilating system partially blocks the exit opening. These precautions include a method for providing respirable air to each worker for the time necessary for exit, and a method of maintaining communications.

Local exhaust ventilation shall be provided when general ventilation is not effective due to restrictions in the confined space or when high concentrations of contaminants occur in the breathing zone of the worker. Local high concentrations of contaminants may occur during work activities such as welding, painting, and chemical cleaning. The worker shall not be exposed to concentrations of contaminants in excess of those specified in 29 CFR Part 1910 Sub Part Z. Therefore, respiratory protection, as recommended in Section 8, may be needed in addition to engineering controls. The use of respiratory protection will be determined by the qualified person. However, when fumes may be generated that contain highly toxic or other airborne metal contaminants, the provisions of 29 CFR 1910.252 shall be observed. When freely moving exhaust hoods are used to provide control of fumes generated during welding, such hoods shall maintain a velocity of 100 feet per minute in the zone of the welding. The effective force of freely moving exhaust hoods is decreased by approximately 90% at a distance of one duct diameter from the plane of the exhaust opening. Therefore, to obtain maximum effectiveness the welder shall re-position the exhaust hood as he changes welding locations to keep the hood in close proximity to the fume source.

Special precautions shall be taken when outgassing or vaporization of toxic and/or flammable substances are likely. If the vapor-generating rate can be determined, the exhaust rate required can be calculated to dilute the atmosphere below the PEL and/or 10% of the LFL, whichever is the lower. This shall be the lowest acceptable ventilation rate. If the area of concern is relatively small, diffusion of the contaminants may be controlled by enclosure with a relatively low volume exhaust for control, or by exhaust hoods located as close as possible to the area of vaporization or outgassing. If the area to be ventilated is too extensive to be controlled by local exhaust, then general ventilation procedures shall be used to control the contaminant level. When the problem of outgassing is due to the application of protective coatings or paint, ventilation shall be continued until the build-up of a flammable and/or toxic atmosphere is no longer possible.

There are three components necessary for combustion: fuel, oxygen, and a source of ignition. If work with fire becomes necessary in a confined space and the source of fuel cannot be controlled, then the atmosphere shall be inerted. This is a highly hazardous work situation, and continuous monitoring of the inert make-up ventilation is mandatory. Monitoring shall include flow measurement as well as gas analysis. The inerting operation shall be continuously monitored and supervised by the qualified person. Since every confined space will have its own infiltration rate, inerting shall continue for the entire duration of the work at a rate that will prevent air from entering the confined space.

(b) Isolation/Lockout/Tagging (Class A, B)

The isolation procedures shall be specific for each type of confined space. Safety equipment required during this procedure shall be designated by the qualified person and be dependent upon the potential hazards involved. A

Class A or B confined space shall be completely isolated from all other systems by physical disconnection, double block and bleed, or blanking off all lines. In continuous systems, where complete isolation is not possible, such as sewers or utility tunnels, specific written safety procedures that are approved and enforced by the employer shall be used. Blanks used to seal off lines shall be capable of withstanding the maximum working pressure or load of the line (with a minimum safety factor of 4), be provided with a gasket on the pressure side to insure a leakproof seal, and be made of chemically non-reactive material. Shutoff valves serving the confined space, shall be locked in the closed position and tagged for identification. In addition to blanking, pumps and compressors serving these lines entering the confined space shall be locked out to prevent accidental activation.

All blanks for that specific confined space shall be recorded on the entry permit and recorded in the employer's file, which shall be available for inspection.

If a drain line is located within the confined space, provision shall be made when necessary to tag it and leave it open. This shall also be recorded on the entry permit.

Additional procedures, which are necessary when the confined space is of a double wall type construction, eg, water jacketed or similar type, shall be determined by the qualified person and noted on the entry permit.

Electrical isolation of the confined space to prevent accidental activation of moving parts that would be hazardous to the worker is achieved by locking circuit breakers and/or disconnects in the open (off) position with a key-type padlock. The only key is to remain with the person working inside the confined space. If more than one person is inside the confined space, each person shall place his own lock on the circuit breaker. In addition to the lockout system, there must be an accompanying tag that identifies the operation and prohibits use.

Mechanical isolation of moving parts can be achieved by disconnecting linkages, or removing drive belts or chains. Equipment with moving mechanical parts shall also be blocked in such a manner that there can be no accidental rotation.

(c) Cleaning (Class A, B, and C)

Procedures and processes used to clean the inside of a confined space shall be reviewed and authorized by the qualified person. The method to be prescribed shall be dependent upon the product in the space. If the confined space contains a flammable atmosphere above the upper flammable limit, it shall be purged with an inert gas to remove the flammable substance before ventilating with air. Initial cleaning shall be done from outside the tank if at all possible.

Special procedures should be adopted to handle the hazards created by the cleaning process itself. For example: if the tank is steamed, (1) it shall be allowed to cool prior to entry; (2) ventilation shall be maintained during neutralization procedures to prevent build-up of toxic materials; (3) steaming shall not be used as a cleaning method when the product stored was a liquid with an autoignition temperature 120% or less of the steam temperature, and

(4) the pipe or nozzle of the steam hose shall be bonded to the tank to decrease the generation of static electricity that could accumulate in tanks during steaming procedures. These and other hazards and controls shall be evaluated by the qualified person.

(d) Equipment and Tools (Class A, B, and C)

Equipment and tools to be used in a confined space shall be carefully inspected and shall meet the following requirements:

(1) Hand tools shall be kept clean and in good repair.

(2) Portable electric tools, equipment, and lighting shall be approved in accordance with 29 CFR Part 1910 Sub Part S and be equipped with a ground fault circuit interrupter that meets the requirements of 29 CFR 1910.309. All grounds shall be checked before electrical equipment is used in a confined space.

(3) All electrical cords, tools, and equipment shall be of heavy duty type with heavy duty insulation and inspected for visually detectable defects before use in a confined space.

(4) Air driven power tools shall be used when flammable liquids are present. The use of air driven power tools will reduce the risk of explosion, not eliminate it. Explosions can arise by tools overheating (drilling), sparks produced by striking (percussion), grinding or discharge of accumulated electrostatic charges developed from the flow of compressed air.

(5) Lighting used in Class A and B confined spaces shall be of explosion proof design and where necessary, equipped with guards. Only equipment listed by the Underwriters Laboratories for use in Division 1, atmospheres of the appropriate class and group, or approved by U.S. Bureau of Mines or Mining Enforcement and Safety Administration or Mine Safety and Health Administration, or the US Coast Guard shall be used. Lighting shall not be hung by electric cords, unless specifically designed for that purpose. The illumination of the work area shall be sufficient to provide for safe work conditions as referenced in the ANSI standard A11-1-1965, or the revision, 1970. Under no circumstances will matches or open flames be used in a confined space for illumination.

(6) Cylinders of compressed gases shall never be taken into a confined space, and shall be turned off at the cylinder valve when not in use. Exempt from this rule are cylinders that are part of self-contained breathing apparatus or resuscitation equipment.

(7) Ladders shall be adequately secured, or of a permanent type which provides the same degree of safety as cited in 29 CFR Part 1910 Sub Part D.

(8) Scaffolding and staging shall be properly designed to carry maximum expected load (safety factor of 4), be equipped with traction type planking, and meet the requirements of 29 CFR 1910.28.

(9) Electrical lines, junctions and appurtenances will be in accordance with National Electrical Code (NEC) and National Fire code (NFC) as cited in 29 CFR 1910.309.

(10) Only hose lines and components designed specially for the compressed gas and working pressure shall be used, and such systems shall have a pressure relief valve outside the confined space.

(11) All equipment that may be used in a flammable atmosphere shall be approved as explosion proof or intrinsically safe for the atmosphere involved by a recognized testing laboratory such as the US Bureau of Mines, MESA, or MSHA for methane and by the Underwriters Laboratories or by Factory Mutual for all cases.

(e) Recordkeeping (Class A, B)

The employer shall maintain a written record of training including safety drills, inspections, tests, and maintenance. The records shall be retained 1 year after the last date of training, inspection, test, or maintenance. In the event of separation of the employee, disposal of equipment or appliance, records may be disposed of after 1 year.

Where atmospheric testing indicates the presence of a toxic substance, records shall be maintained in accordance with the existing Federal regulation(s). These records shall include the dates and times of measurements, duties and location of the employees within the confined space, sampling and analytical methods used, number, duration, and results of the samples taken, PEL concentrations estimated from these samples, type of personal protective equipment used, if any, and employees' names. These records shall be made available to the designated representatives of the Secretary of Labor, of the Secretary of Health, Education, and Welfare, of the employer, and of the employee or former employee.