

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
CENTER FOR DISEASE CONTROL  
NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH  
CINCINNATI, OHIO 45226

HEALTH HAZARD EVALUATION DETERMINATION  
REPORT HE 77-127-516

GOODYEAR AEROSPACE CORPORATION  
AKRON, OHIO

AUGUST 1978

I. TOXICITY DETERMINATION

The production spray painters in Department 661 are exposed to toxic concentrations of carcinogenic chromium (VI) as zinc chromate. This determination is based on the environmental sampling data obtained on March 28 and 29, 1978 while the workers were spraying aircraft wheels with yellow lacquer primers (Specification Nos. 501-1035 and 501-1124). No evidence presented to the NIOSH epidemiologist indicated that unusual mortality patterns exist at the subject plant, and on that basis, a retrospective mortality study was not conducted.

The aforementioned production spray painters are not exposed to toxic concentrations of n-butanol, isobutanol, ethanol, toluene, methyl isobutyl ketone, methyl ethyl ketone, methyl cellosolve acetate, and 2,4-toluene diisocyanate as used or found. This determination is based on the (a) health questionnaire response and (b) environmental sampling data obtained on March 28 and 29, 1978.

The surface finish technicians in Department 541 are not exposed to toxic concentrations of m-xylene and toluene as used or found. This determination is based on the (a) health questionnaire response, and (b) environmental sampling data obtained on March 28 and 29, 1978.

II. 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 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 NIOSH, Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Goodyear Aerospace Corporation, 1210 Massillon Road, Akron Ohio 44315
2. International Headquarters of the United Automobile, Aerospace, and Agricultural Implement Workers of America, 8000 E. Jefferson Avenue, Detroit, Michigan 48214
3. Authorized Representative of United Automobile, Aerospace, and Agricultural Implement Workers of America, Local No. 856, 1131 Massillon Road, Akron, Ohio 44306
4. U.S. Department of Labor - OSHA - Region V
5. Regional Program Consultant, NIOSH, Region V

For the purpose of informing approximately "twenty-two affected employees" the employer shall promptly "post" for a period of 30 calendar days the Determination Report in a prominent place(s) near where exposed employees work.

### III. INTRODUCTION

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, Education, and Welfare, following a written request by an 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.

The National Institute for Occupational Safety and Health (NIOSH) received such a request from an authorized representative of Local No. 856, United Automobile, Aerospace, and Agricultural Implement Workers of America concerning exposure to various paints and solvents by spray painters in Departments 661 and 541. No symptoms of exposure were listed on the official request form. However, a copy of an accompanying letter from the union workers' compensation claim representative to Goodyear Aerospace Corporation listed seven persons (who had worked as spray painters in these departments) for whom claims are pending before the Industrial Commission of Ohio. Three of these persons are deceased.

### IV. HEALTH HAZARD EVALUATION

#### A. Process Description - Conditions of Use

Goodyear Aerospace Corporation is a manufacturer of large-scale weapon, electronic, and aero-mechanical systems. The Health Hazard Evaluation was limited to painting operations in Departments 661 and 541.

Department 661 employs 16 persons categorized as production spray painters. This department is a production shop involved with painting of aircraft wheels and brakes, and miscellaneous associated components using conventional compressed air spraying techniques. The department consists of 1 oil-wash and 5 water-wash paint spray booths and several low temperature drying ovens. Aircraft wheels suspended from an overhead automatic conveyor system are manually painted as they pass through the respective spray booths. Spray booth 1 is reserved for smaller parts such as brake housings which are positioned on a table and sprayed accordingly.

Department 541 employs 7 persons categorized as surface finish technicians. In contrast to Department 661, this department is a job shop involved with spray finishing of various aero-devices such as missile capsules also using standard compressed air spraying techniques; the painted parts air dry. Due to size and geometric configurations of the aero-devices, much of the work is done in a "high bay spray room". The smaller parts are sprayed in any of several water-wash or dry spray booths.

Because of the many different paint formulations that are used in both departments, the workers are potentially exposed to a myriad of different chemical compounds. In Department 661, the frequency of use on a comparative percentage basis is estimated (by Goodyear Aerospace) to be 45 percent zinc chromate wash primer (Specification No. 501-1124), 25 percent aluminum lacquer (Specification No. 501-1098), 25 percent zinc chromate primer (Specification No. 501-1035), and 5 percent all other specifications. Included in the 5 percent are acrylic, epoxy, and polyurethane base paint mixtures. In Department 541, the frequency of use on a comparative percentage basis with other paint mixtures is estimated (by Goodyear Aerospace) to be 50 percent enamels, 30 percent primers, and 14 percent lacquers.

## B. Evaluation Design and Methods

### 1. Preliminary Survey

A preliminary survey was conducted by a NIOSH team consisting of an industrial hygienist, epidemiologist, and physician assistant on October 21, 1977. An entrance meeting was conducted with labor and management representatives to fully discuss the nature of the request, and obtain background information concerning employee profile, medical and personnel records, materials, and operations. Since the health hazard evaluation request stated that work related mortality was suspected, the epidemiologist was necessary to determine whether a retrospective mortality study was feasible and warranted.

Based on review of the existing personnel records it would be feasible to conduct a retrospective mortality study. However, the size of the cohort (about 750) would be very small. Consequently, a population of this size and age would probably not be adequate to determine unusual mortality patterns unless they were of great significance. No evidence presented indicated that unusual mortality patterns exist at the subject company. However, this is not to say that no problem of excess mortality could exist. Rather, that there is no evidence that a problem does exist, and on that basis, a retrospective mortality study was not conducted.

Review of medical records and conduct of informal interviews with randomly selected painters indicated that medical follow-up was not warranted, other than completing health questionnaires on the workers.

## 2. Follow-up Survey

A follow-up survey designed to characterize and evaluate the chemical exposures experienced by the painters in Departments 661 and 541 was conducted on March 28 and 29, 1978. The production spray painters' personal breathing zone exposures to carcinogenic chromium (VI) as zinc chromate and multiple vaporous organic contaminants were evaluated during spraying of aircraft components with various paint formulations. The organic contaminants included n-butanol, isobutanol, toluene, methyl isobutyl ketone, methyl ethyl ketone, methyl cellosolve acetate, and 2,4-toluene diisocyanate.

The chromium (VI) samples were collected on 5.0 um (pore size) polyvinyl chloride filters and analyzed using a method based on NIOSH P&CA Method No. 169.<sup>2</sup> The organic vapor samples were collected on activated charcoal and analyzed according to NIOSH P&CA Method No. 127,<sup>2</sup> excluding those for 2,4-toluene diisocyanate. These samples were collected in an absorbing solution contained in a midget impinger and analyzed according to NIOSH P&CA Method No. 141.<sup>3</sup> The sampling parameters are contained in the respective tables of results.

A confidential non-directed health questionnaire was completed on 8 of the 16 production spray painters and on 3 of the 7 spray finishing technicians. The employees were interviewed concerning past occupational histories and present or recent medical symptoms.

## C. Evaluation Criteria

The environmental criteria used to assess the workroom concentrations of the contaminants evaluated are contained in the respective table of results (Tables 1 through 6). The criteria are based on the current state of knowledge concerning the toxicity of the substances for an 8-hour workday, 40-hour workweek over a normal lifetime. The criteria are time-weighted averages (TWA) for an 8-hour exposure, except that for chromium (VI) which is a ceiling concentration. NIOSH recommends 2 standards for chromium (VI).<sup>4</sup> One addresses the noncarcinogenic forms, the other the carcinogenic forms associated with an increased incidence

of lung cancer. NIOSH defines "noncarcinogenic chromium (VI)" as chromium (VI) in monochromates and bichromates (dichromates) of hydrogen, lithium, sodium, potassium, rubidium, cesium, and ammonium, and chromium (VI) oxide (chromic acid anhydride). NIOSH defines "carcinogenic chromium (VI)" as any and all chromium (VI) materials not included in the group above, such as zinc, lead, and calcium chromates. Therefore, the chromium (VI) as zinc chromate evaluated at Goodyear Aerospace Corporation under this hazard evaluation is considered to be carcinogenic chromium (VI). Other effects such as skin ulcers, irritation and ulceration of the nasal mucosa, kidney damage, liver damage, and erosion and discoloration of the teeth, have been reported and have resulted from contact with many different chromium (VI) materials.<sup>5</sup>

Exposure to organic solvent vapor can cause varying degrees of anesthesia, with minimal levels causing headache, and greater exposures causing lightheadedness, "drunkenness" and even unconsciousness. Additionally, they may have a somewhat disagreeable odor and be irritating to eyes, nose and throat. Skin contact with the solvents, particularly on a prolonged or repeated basis may remove the natural oil from the skin causing dryness and cracking.

TDI vapor is highly irritating to eyes, nose, and throat, and produces conjunctivitis. Pulmonary irritation, and in some cases pulmonary sensitization, may cause nonproductive cough, wheezing, shortness of breath, and tightness of chest. Sensitization requires removal from TDI exposure to prevent serious pulmonary problems.

## V. RESULTS AND DISCUSSION

### 1. Department 661

The airborne concentrations of chromium (VI) generated during spraying of yellow lacquer primers 501-1035 and 501-1124 containing approximately 30 and 11 percent by weight of zinc chromate, respectively, are shown in Table 1. One hundred percent (12/12) and 75 percent (9/12) of the samples showed airborne chromium (VI) concentrations in excess of the 1 ug chromium (VI)/cu m NIOSH recommended criteria and the 100 ug chromium (VI)/cu m OSHA standard, respectively. This representative sample data show that the production spray painters are exposed to toxic concentrations of carcinogenic chromium (VI).

Concomitant personal breathing zone exposure concentrations of n-butanol, isobutanol, toluene, methyl isobutyl ketone, methyl ethyl ketone, and methyl cellosolve acetate generated during the spraying of yellow lacquer

primer 1124 at booths 4 and 5, and 6 are presented in Tables 2 and 3, respectively. None of the measured concentrations exceeded the respective individual criteria for the substances evaluated. Because two or more chemical compounds are present that have similar toxicologic effects, their combined effects, rather than that of either individually, must be considered. That is, if the sum of the following fractions,

$$C_1/T_1 + C_2/T_2 + C_3/T_3 \dots C_n/T_n$$

exceeds 1, then the "standard of the mixture should be considered as being exceeded.

$C_1$  indicates the measured air level, and  $T_1$  the corresponding environmental criteria. None of the calculated mixtures exceeded the standard of the mixture.

The personal breathing zone concentrations of ethanol generated during the spraying of 3342 wash primer at station 2 are shown in Table 4. The 8-hour time-weighted average (TWA) concentrations were less than 10 percent of the environmental criteria.

2,4-toluene diisocyanate (TDI) exposure levels at booth 1 during spraying of anti-skid control boxes with a polyurethane based paint were measured. No TDI was detected in either of 2 samples collected at a flow rate of 1 liter per minute with total air volumes of 20 and 47 liters. The limit of detection was 1 ug/ml.

A non-directed health questionnaire was completed on 8 production spray painters. This constituted 50 percent of the total workers (16 males) exposed. The average age is 47 years (range 32-59; median 50.5) and the average length of working time in their present capacity is 9 years (range 2-24; median 7.5). One worker stated he had bronchitis and emphysema resulting from his past exposures to paint spray. One worker reported having occasional lightheadedness during paint spraying. One worker reported occasional chest pains, but did not associate the occurrence with any particular time or activity. Four workers associated symptoms of eye and mucous membrane irritation with spraying of urethane based paints. According to the workers, the symptoms were most prevalent while spraying large aircraft wheels on the production line. During the spraying of urethane based paints on the production line (includes spray booths 2-6), the workers are required to wear air-line supplied respirators. The worker who was monitored for TDI exposure while spraying anti-skid control boxes with a urethane based paint at booth 1 did not report any symptoms of eye or mucous membrane irritation; the worker wore a half-face chemical cartridge respirator. However, the expected exposure concentration generated while spraying the control boxes would be far less than that during spraying of wheels because of volume of paint used and duration of exposure.

## 2. Department 541

The painters' personal breathing zone exposures to m-xylene and toluene generated during spraying of Zincilate<sup>®</sup> primer and white enamel, respectively, were evaluated. The 8-hour TWA exposure levels of m-xylene (Table 5) and toluene (Table 6) were less than 10 percent and 5 percent of the respective environmental criteria.

A non-directed health questionnaire was completed on 3 surface finish technicians. This constituted 43 percent of the total workers (7 males). The average age is 51 years (range 45 - 54; median 51) and the average length of working time in their present capacity is 21 years (range 19 - 25; median 22). Each person stated he did not have any health problems at work or any that might be related to work.

## VI. RECOMMENDATIONS

1. The production spray painters in Department 661 are exposed to toxic concentrations of carcinogenic chromium (VI) as zinc chromate. It is recommended that Goodyear Aerospace Corporation's existing environmental and medical surveillance programs be thoroughly reviewed and amended according to Part 1, Sections 1 through 8, of the NIOSH Criteria Document on hexavalent chromium (See Appendix I).

2. Until engineering controls are instituted or existing ones modified to reduce the levels of chromium (VI) below the prescribed limits, the company should provide and maintain a respiratory protection program in accordance with the minimal OSHA requirements as outlined in 29 CFR 1910.134. A NIOSH document titled, "A Guide to Industrial Respiratory Protection"<sup>6</sup>, will serve as a reference source with information for establishing and maintaining a respiratory protection program that complies with 29 CFR 1910.134.

3. Because of infrequent spraying of urethane based paints (use determined by contract specifications), NIOSH was not able to evaluate TDI levels generated during production line painting of aircraft wheels. Although the workers are required to use air-line supplied respirators when spraying urethanes, the health questionnaire respondents indicate that eye and mucous membrane irritation suggestive of acute toxicity may be occurring. Therefore, it is recommended that existing work practices and procedures be reviewed, and environmental sampling be conducted to determine if such acute toxicity is occurring.

## VII. REFERENCES

1. P&CA Method No. 169. NIOSH Manual Analytical Methods. 2 Ed., Part 1, DHEW (NIOSH) Publication No. 77-157-A (1977).

2. Ibid., P&CA Method No. 127 (1977).
3. Ibid., P&CA Method No. 141 (1977).
4. Criteria for a Recommended Standard ... Occupational Exposure to Chromium (VI), USDHEW Publication No. (NIOSH) 76-129, (1975).
5. Ibid., pages 23-73, (1975).
6. A Guide to Industrial Respiratory Protection. USDHEW Publication No. (NIOSH) 76-1189, (1976).

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Table 1  
 Personal Breathing Zone Concentrations of Hexavalent Chromium Generated During Spraying of Yellow Lacquer Primers in Dept. 661

Goodyear Aerospace Corporation  
 Akron, Ohio  
 March 28 and 29, 1978

Sample Date	Sample No.	Sample Description <sup>1</sup>	Sampling Period	Sample Volume liters	Airborne Concentration <sup>2</sup> ug chromium (VI)/cu m
3-28	P-01	Painter 1: Spraying keyway liners with No. 1035 primer in front of booths 2 - 3	1743 - 1825	84	100.0
"	P-02	" " " " " " " " " "	1749 - 1804	30	1133.3
"	P-06	" " " " " " " " " "	1817 - 1825	16	875.0
3-28	P-03	Painter 1: Spraying inside & outside of DC-10 wheels with No. 1124 primer in booth 6	1744 - 1920		
"	P-04	Painter 1: Spraying outside of DC-10 wheels with No. 1124 primer in booth 6	2029 - 2040	214	266.4
"	P-07	Painter 1: Spraying inside of DC-10 wheels with No. 1124 primer in booth 6	1755 - 1810	30	400.0
"	P-08	Painter 2: Spraying outside of DC-10 wheels with No. 1124 primer in booth 6	1903 - 1918	30	933.3
"	P-05	Painter 2: Spraying inside & outside of DC-10 wheels with No. 1124 primer in booth 6	1905 - 1920	30	400.0
"	P-09	Painter 1: Spraying brake housings with No. 1124 primer in front of booth 2	1813 - 1920	158	88.6
3-28	P-10	" " " " " " " " " "	2029 - 2041	30	13.3
"	P-14	Painter 1: Spraying inboard half of wheel sub-assembly with No. 1124 primer in booths 4-5	2035 - 2050	30	113.3
3-29	P-15	" " " " " " " " " "	2122 - 2137	348	57.5
"	P-15	" " " " " " " " " "	1140 - 1434	30	2900.0
			1225 - 1240		

Environmental Criteria: Ceiling concentration

1.0<sup>3</sup>

1. Denotes that No. 1035 and No. 1124 primers contain approximately 30 and 11% by weight zinc chromate, respectively.
2. Denotes micrograms of hexavalent chromium per cubic meter of air sampled.
3. Denotes NIOSH recommended criteria (1975). Current (1976) OSHA Standard is 100 ug/m<sup>3</sup>, ceiling concentration.

Table 2

Personal Breathing Zone Concentrations of Organic Vapors Generated During Spraying of No. 1124 Yellow Lacquer Primer in Booths 4 and 5 in Dept. 661

Goodyear Aerospace Corporation

Akron, Ohio

March 29, 1978

Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppm <sup>1</sup>						Combined, Exposure
				n-Butanol	Isobutanol	Toluene	Methyl Isobutyl Ketone	Methyl Ethyl Ketone	Methyl Cellosolve Acetate	
CT-07	Painter 1: Spraying inboard half of wheel sub-assembly	1140-1434	6.6	7.3	3.1	1.8	3.0	7.6	2.5	0.39
CT-08	Painter 2: Spraying inboard half of wheel sub-assembly	1137-1435	7.8	4.9	1.7	1.2	1.8	4.7	1.7	0.25
Environmental Criteria: 8-hr. time-weighted average				50 <sup>3</sup>	50 <sup>3</sup>	200 <sup>4</sup>	100 <sup>3</sup>	200 <sup>3</sup>	25 <sup>3</sup>	1

1. Denotes parts of contaminant per million parts of contaminated air sampled by volume.

2. Denotes the workers combined daily exposure to multiple contaminants with similar toxicologic effects calculated as  $C_1/T_1 + C_2/T_2 + C_3/T_3 + \dots + C_n/T_n$

3. Denotes American Conference of Governmental Industrial Hygienists threshold limit values (1977). Current (1976) 8-hr. time-weighted average OSHA Standards are: 100 ppm n-butanol; 100 ppm isobutanol; 200 ppm toluene; 100 ppm methyl isobutyl ketone; 200 ppm methyl ethyl ketone; and 25 ppm methyl cellosolve acetate.

4. Denotes NIOSH recommended criteria (1973).

Table 3

Personal Breathing Zone Concentrations of Organic Vapors Generated During Spraying of No. 1124 Yellow Lacquer Primer in Booth 6 in Dept. 661

Goodyear Aerospace Corporation  
Akron, Ohio  
March 29, 1978

Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppm <sup>1</sup>						Methyl Cellulosolve Acetate	Combined <sub>2</sub> Exposure <sup>2</sup>
				n-Butanol	Methyl Isobutanol	Toluene	Methyl Isobutyl Ketone	Methyl Ethyl Ketone			
CT-01	Painter 1: Spraying DC-10 wheels	0735-1058	9.8	5.7	4.3	4.5	2.2	8.7	0.31	0.59	
CT-05	" " " " "	1142-1457	7.4	6.1	2.1	4.4	3.4	9.6	0.45		
CT-02	Painter 2: Spraying DC-10 wheels	0730-1059	13.8	5.2	0.64	0.67	0.55	2.9	0.11	0.39	
CT-06	" " " " "	1142-1459	9.7	7.0	1.18	3.3	1.5	6.1	0.39		
Environmental Criteria: 8-hr. time-weighted average				50 <sup>3</sup>	50 <sup>3</sup>	200 <sup>4</sup>	100 <sup>3</sup>	200 <sup>3</sup>	25 <sup>3</sup>	1	

1. Denotes concentration of contaminant per million parts of contaminated air sampled by volume.
2. Denotes the workers combined daily exposure to multiple contaminants with similar toxicologic effects calculated as  $C_1/T_1 + C_2/T_2 + C_3/T_3 + \dots + C_n/T_n$ .
3. Denotes American Conference of Governmental Industrial Hygienists threshold limit values (1977). Current (1976) 8-hr. time-weighted average OSHA Standards are: 100 ppm n-butanol; 100 ppm isobutanol; 200 ppm toluene; 100 ppm methyl isobutyl ketone; 200 ppm methyl ethyl ketone; and 25 ppm methyl cellosolve acetate.
4. Denotes NIOSH recommended criteria (1973).

Table 4

Personal Breathing Zone Concentrations of Ethanol Generated During Spraying of No. 3342 Wash Primer in Dept. 661

Goodyear Aerospace Corporation  
Akron, Ohio

March 29, 1978

<u>Sample No.</u>	<u>Sample Description</u>	<u>Sampling Period</u>	<u>Sample Volume</u> <u>liters</u>	<u>Airborne Concentration - ppm</u> <sup>1</sup> <u>Ethanol</u>
CT-03	Painter 1: Spraying aircraft wheels at station 2	0736 - 1058	9.8	164.4
CT-04	Painter 2: Spraying aircraft wheels at station 2	0740 - 1055	9.1	85.6
Environmental Criteria: 8-hr. time-weighted average				1000 <sup>2</sup>

1. Denotes parts of contaminant per million parts of contaminated air sampled by volume.
2. Denotes American Conference of Governmental Industrial Hygienists threshold limit value (1977). Current (1976) OSHA Standard is 1000 ppm, 8-hr. time-weighted average.

Table 5

Personal Breathing Zone Concentrations of m-Xylene Generated During Spraying of Zincilate<sup>®</sup> Primer in Dept. 541

Goodyear Aerospace Corporation  
Akron, Ohio  
March 29, 1978

Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppm <sup>1</sup> m-xylene
CT-13	Painter 1: Spraying capsules in booths 1-2	0731 - 0937	23.3	8.4
CT-14	Painter 2: Spraying capsules in booths 5-12	0735 - 1407	19.1	1.6
CT-15	Painter 2: Spraying capsules in booths 5-12	0836 - 0910	6.8	14.9
Environmental Criteria: 8-hr. time-weighted average				100 <sup>2</sup>

1. Denotes parts of contaminant per million parts of contaminated air sampled by volume.

2. Denotes NIOSH recommended criteria (1975). Current (1976) OSHA Standard is 100 ppm 8-hr. time-weighted average.

Table 6

Personal Breathing Zone Concentrations of Toluene Generated During Spraying of White Enamel in Dept. 541

Goodyear Aerospace Corporation  
Akron, Ohio  
March 29, 1978

Sample No.	Sample Description	Sampling Period	Sample Volume liters	Airborne Concentration - ppm <sup>1</sup> Toluene
CT-19	Painter 1: Spraying capsules in booths 1-2	0950 - 1225	30.5	15.3
CT-20	Painter 1: Spraying capsules in booths 1-2	1239 - 1403	13.9	11.4
Environmental Criteria: 8-hr. time-weighted average				200 <sup>2</sup>

1. Denotes parts of contaminant per million parts of contaminated air sampled by volume.

2. Denotes NIOSH recommended criteria (1973). Current (1976) OSHA Standard is 100 ppm, 8-hr. time-weighted average.

APPENDIX I  
to Health Hazard Evaluation Determination  
Report No. 77-127

criteria for a recommended standard . . . .

OCCUPATIONAL EXPOSURE  
TO  
CHROMIUM (VI)



U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE  
Public Health Service  
Center for Disease Control  
National Institute for Occupational Safety and Health  
1975

APPENDIX I  
(Continued)

I. RECOMMENDATIONS FOR A CHROMIUM(VI) STANDARD

The National Institute for Occupational Safety and Health (NIOSH) recommends that worker exposure to chromium(VI), ie, hexavalent chromium or Cr(VI), in the workplace be controlled by adherence to the following sections. The standard is designed to protect the health and safety of workers for up to a 10-hour workday, 40-hour workweek over a working lifetime. Compliance with all sections of the standard should prevent all noncarcinogenic adverse effects of exposure to chromium(VI) in the workplace air and through skin exposure and should reduce materially the risk of lung cancer from occupational exposure to carcinogenic chromium(VI). The standard is measurable by techniques that are valid, reproducible, and available. Sufficient technology exists to permit compliance with the recommended standard. The standard will be subject to review and revision as necessary.

For the purpose of this standard, "chromium(VI)" is defined as the chromium in all materials in the +6 (hexavalent) state.

There are 2 recommended standards for chromium(VI). One addresses occupational exposure to a group of noncarcinogenic, but otherwise hazardous, materials, while the other pertains to occupations and workplaces where there is exposure to other chromium(VI) materials associated with an increased incidence of lung cancer.

On the basis of the chemical analysis of airborne chromium(VI) materials, there is no practical means of distinguishing between these 2 groups of chromium(VI) materials. Until the airborne chromium(VI) in a particular workplace is demonstrated by the employer to be of the type

APPENDIX I  
(Continued)

considered to be noncarcinogenic, all airborne chromium(VI) shall be considered to comprise carcinogenic materials.

Based on current evidence, "noncarcinogenic chromium(VI)" is the chromium(VI) in monochromates and bichromates (dichromates) of hydrogen, lithium, sodium, potassium, rubidium, cesium, and ammonium, and chromium(VI) oxide (chromic acid anhydride). "Carcinogenic chromium(VI)" comprises any and all chromium(VI) materials not included in the noncarcinogenic group above. "Occupational exposure to carcinogenic chromium(VI)" is defined as exposure to airborne chromium(VI) at concentrations greater than one-half of the workplace environmental limit for carcinogenic chromium(VI). "Occupational exposure to noncarcinogenic chromium(VI)" is defined as exposure to airborne chromium(VI) at concentrations greater than one-half of the workplace environmental limit for noncarcinogenic chromium(VI). Exposure to chromium(VI) at concentrations less than one-half of the workplace environmental limit will not require adherence to the following sections, except for 3(a,b,c,d), 4a, 5, 6(b,c,e,f), and 7.

Section 1 - Environmental (Workplace Air)

(a) Concentration of Carcinogenic Chromium(VI)

Carcinogenic chromium(VI) shall be controlled in the workplace so that the airborne workplace concentration of chromium(VI), sampled and analyzed according to the procedures in Appendices I and II, is not greater than 1  $\mu\text{g Cr(VI)/cu m}$  of breathing zone air.

APPENDIX I  
(Continued)

(b) Concentration of Noncarcinogenic Chromium(VI)

Noncarcinogenic chromium(VI) shall be controlled in the workplace so that the airborne workplace concentration is not greater than 25 µg Cr(VI)/cu m of breathing zone air determined as a time-weighted average (TWA) exposure for up to a 10-hour workday, 40-hour workweek, and is not greater than 50 µg Cr(VI)/cu m of breathing zone air as determined by any 15-minute sample.

Procedures for sampling and analysis of chromium(VI) in air shall be as provided in Appendices I and II, or by any method shown to be equivalent in precision, accuracy, and sensitivity to the methods specified.

Section 2 - Medical

Medical surveillance shall be made available as outlined below for all workers with occupational exposure to carcinogenic or noncarcinogenic chromium(VI), including maintenance personnel periodically exposed during routine maintenance or emergency repair operations.

(a) Preplacement and annual medical examinations shall include:

(1) A comprehensive or interim work history.

(2) A detailed medical history including information on conditions indicating the inadvisability of further exposure to chromium(VI), eg, potential skin or pulmonary sensitization, a skin or mucous membrane condition that may be exacerbated by chromium(VI), smoking habits, and history of liver or kidney disease.

(3) Examination of the skin for evidence of dermatitis or chrome ulcers, and of the membranes of the upper respiratory tract for

APPENDIX I  
(Continued)

irritation, bleeding, ulcerations, or perforations.

(4) An evaluation of the worker's ability to use negative or positive pressure respirators.

(5) Urinalysis.

(b) For workers with occupational exposure to carcinogenic chromium(VI), preplacement and annual medical examinations shall include 14" X 17" chest X-rays. Other tests, including sputum cytology and liver function studies, shall be considered by the responsible physician.

(c) For workers with occupational exposure to noncarcinogenic chromium(VI) and not to carcinogenic chromium(VI), preplacement medical examinations shall include 14" x 17" chest X-rays. Thereafter, X-ray examinations shall be offered at 5-year intervals and annually after age 40. Other tests, such as liver function studies, may be considered by the responsible physician.

(d) Medical examinations shall be made available to all workers with signs or symptoms of skin or upper respiratory tract irritation likely to have been the result of exposure to chromium(VI).

(e) If clinical evidence of adverse effects due to chromium(VI) is developed from these medical examinations, the worker shall be kept under a physician's care until the worker has completely recovered or maximal improvement has occurred.

(f) Initial annual examinations for presently employed workers shall be offered within 6 months of the promulgation of a standard incorporating these recommendations.

(g) The medical representatives of the Secretary of Health, Education, and Welfare, of the Secretary of Labor, and of the employer

APPENDIX I  
(Continued)

shall have access to all medical records. Physicians designated and authorized by any employee or former employee shall have access to that worker's medical records.

(h) Medical records shall be maintained for all employees with occupational exposure to carcinogenic or noncarcinogenic chromium(VI) and for maintenance personnel with periodic exposure. Preplacement X-rays and X-rays for the 5 years preceding termination of employment and all medical records with pertinent supporting documents shall be retained at least 30 years after the individual's employment is terminated.

Section 3 - Labeling (Posting)

(a) Except for shipping and storage containers for lithium chromate, lithium bichromate, sodium chromate, sodium bichromate, potassium chromate, potassium bichromate, rubidium chromate, rubidium bichromate, cesium chromate, cesium bichromate, ammonium chromate, ammonium bichromate, and chromium(VI) oxide (chromic acid anhydride), as dry solids or concentrated solutions, all shipping and storage containers for chromium(VI) shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances:

APPENDIX I  
(Continued)

(Chemical name)  
(Synonyms)

DANGER! EXTREME HEALTH HAZARD  
MAY CAUSE IRRITATION, RASH, OR EXTERNAL ULCERS  
INHALATION MAY CAUSE CANCER

Keep container closed.  
Avoid contact with skin and eyes.  
Avoid breathing dust or solution spray.  
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. Flush skin with water.  
Wash clothing before reuse.

(b) All shipping and storage containers for lithium chromate, lithium bichromate, sodium chromate, sodium bichromate, potassium chromate, potassium bichromate, rubidium chromate, rubidium bichromate, cesium chromate, cesium bichromate, and ammonium chromate, the hydrates of these compounds, high purity aqueous solutions of these compounds, and dry mixtures containing only these materials shall bear the same label except that "Inhalation may cause cancer" shall be deleted and "Extreme Health Hazard" shall be replaced by "Moderate Health Hazard".

(c) Because of the flammable characteristics of ammonium bichromate (dichromate), shipping and storage containers for dry forms of this compound shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances:

AMMONIUM BICHROMATE  
DANGER! HIGHLY FLAMMABLE  
MODERATE HEALTH HAZARD  
MAY CAUSE IRRITATION, RASH, OR EXTERNAL ULCERS.

Keep away from heat, sparks, and open flame.  
Keep container closed.  
Avoid contact with skin and eyes.  
Avoid breathing dust or solution spray.  
In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician. Flush skin with water.  
Wash clothing before reuse.

APPENDIX I  
(Continued)

(d) All storage containers of chromic acid, or chromium(VI) oxide (chromic acid anhydride) shall bear the following label in addition to, or in combination with, labels required by other statutes, regulations, or ordinances.

CHROMIUM TRIOXIDE  
(CHROMIC ACID)  
DANGER! POWERFUL OXIDIZER  
CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE  
MAY CAUSE DELAYED BURNS OR EXTERNAL ULCERS

Keep container closed.  
Do not get in eyes, on skin, on clothing.  
Do not breathe dust or mist from solutions.  
In case of contact, immediately flush skin or eyes  
with plenty of water for at least 15 minutes.  
For eyes, get medical attention immediately.  
Wash clothing before reuse.  
Use fresh clothing daily. Take showers  
after work, using plenty of soap.

(e) In areas where there is occupational exposure to carcinogenic chromium(VI), the following warning sign shall be posted in readily visible locations, particularly at the entrances to the area.

WARNING  
CANCER-SUSPECT AGENT  
USED IN THIS AREA  
UNAUTHORIZED PERSONS KEEP OUT

The sign shall be printed both in English and in the predominant language of non-English-speaking workers, if any, unless they are otherwise trained and informed of the hazardous areas. All illiterate workers shall receive such training.

(f) In areas where airborne chromium(VI) comprises only lithium chromate, lithium bichromate, sodium chromate, sodium bichromate, potassium chromate, potassium bichromate, rubidium chromate, rubidium bichromate,

APPENDIX I  
(Continued)

cesium chromate, cesium bichromate, ammonium chromate, or chromium(VI) oxide (chromic acid anhydride), their hydrates, or mixtures containing only these chromium(VI) materials, the warning sign shall read as follows:

WARNING  
CHROMATES, BICHROMATES OR CHROMIC ACID ANHYDRIDE  
USED IN THIS AREA  
UNAUTHORIZED PERSONS KEEP OUT

The sign shall be posted in readily visible locations, particularly at the entrances to the area. The sign shall be printed both in English and in the predominant language of non-English-speaking workers, if any, unless they are otherwise trained and informed of the hazardous areas. All illiterate workers shall receive such training.

(g) In areas where airborne chromium(VI) contains ammonium bichromate, or where ammonium bichromate is stored, manufactured, or used, the following shall be added to the warning sign in (e) or (f) above:

FLAMMABLE SUBSTANCE

Section 4 - Personal Protective Equipment and Protective Clothing

(a) Protective Clothing

(1) Coveralls or other full-body protective clothing shall be worn in areas where there is occupational exposure to chromium(VI). Protective clothing shall be changed at least daily at the end of the shift and more frequently if it should become grossly contaminated.

(2) Impervious gloves, aprons, and footwear shall be worn at operations where solutions of chromium(VI) may contact the skin. Protective gloves shall be worn at operations where dry compounds of

APPENDIX I  
(Continued)

chromium(VI) are handled and may contact the skin.

(3) Eye protection shall be provided by the employer and used by the employees where eye contact with chromium(VI) is likely. Selection, use, and maintenance of eye protective equipment shall be in accordance with the provisions of the American National Standard Practice for Occupational and Educational Eye and Face Protection, ANSI Z87.1-1968. Unless eye protection is afforded by a respirator hood or facepiece, protective goggles or a face shield shall be worn at operations where there is danger of contact of the eye with dry or wet compounds of chromium(VI) because of spills, splashes, or excessive dust or mists in the air.

(4) The employer shall ensure that all personal protective devices are inspected regularly and maintained in clean and satisfactory working condition.

(5) Work clothing shall not be taken home by employees. The employer shall provide for maintenance and laundering of protective clothing.

(6) The employer shall ensure that precautions necessary to protect laundry personnel are taken when soiled protective clothing is laundered.

(b) Respiratory Protection from Carcinogenic Chromium(VI)

Engineering controls shall be used wherever feasible to maintain airborne carcinogenic and noncarcinogenic chromium(VI) concentrations below those recommended in Section 1 above. Compliance with the permissible exposure limits by the use of respirators is only allowed when airborne chromium(VI) concentrations are in excess of the workplace environmental limit because required engineering controls are being installed or tested,

APPENDIX I  
(Continued)

when nonroutine maintenance or repair is being accomplished, or during emergencies. When a respirator is thus permitted, it shall be selected and used in accordance with the following requirements:

(1) For the purpose of determining the type of respirator to be used, the employer shall measure the airborne concentration of chromium(VI) in the workplace initially and thereafter whenever process, worksite, climate, or control changes occur which are likely to increase the airborne concentration of chromium(VI); this requirement does not apply when carcinogenic chromium(VI) is present.

(2) The employer shall ensure that no worker is overexposed to chromium(VI) because of improper respirator selection, fit, use, or maintenance.

(3) A respiratory protection program meeting the requirements of 29 CFR 1910.134 and 30 CFR 11 which incorporates the American National Standard Practices for Respiratory Protection Z88.2-1969 shall be established and enforced by the employer.

(4) The employer shall provide respirators in accordance with Table I-1, or Table I-2 when appropriate, and shall ensure that the employee uses the respirator provided.

(5) Respirators described in Tables I-1 and I-2 shall be those approved under the provisions of 29 CFR 1910.134 and 30 CFR 11.

(6) The employer shall ensure that respirators are adequately cleaned, and that employees are instructed on the use of respirators assigned to them and on how to test for leakage.

(7) Respirators specified for use in higher concentrations of airborne chromium(VI) may be used in workplaces with lower

APPENDIX I  
(Continued)

concentrations of airborne chromium(VI).

(8) Where an emergency may develop which could result in employee injury from chromium(VI), the employer shall provide an escape device as listed in Table I-1, or in Table I-2 where appropriate.

TABLE I-1

RESPIRATOR SELECTION GUIDE FOR PROTECTION AGAINST  
CARCINOGENIC CHROMIUM(VI)

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Self-contained breathing apparatus with positive pressure in full facepiece

Combination supplied air respirator, pressure-demand type, with auxiliary self-contained air supply.

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Section 5 - Informing Employees of Hazards from Chromium(VI)

At the beginning of employment or assignment for work in a chromium(VI) area, employees with occupational exposure to chromium(VI) shall be informed of the hazards, relevant signs and symptoms of overexposure, appropriate emergency procedures, and proper conditions and precautions for the safe use of chromium(VI).

Instruction shall include, as a minimum, all information in Appendix III which is applicable to the specific chromium(VI) product or material to which there is exposure. This information shall be posted in the work area and kept on file, readily accessible to the worker at all places of employment where chromium(VI) is involved in unit processes and operations.

APPENDIX I  
(Continued)

TABLE I-2

RESPIRATOR SELECTION GUIDE FOR PROTECTION AGAINST  
NONCARCINOGENIC CHROMIUM(VI)

Multiples of TWA Limit	Respirator Type
Less than or equal to 10X	Half-mask respirator with replaceable high efficiency filter(s) or Type C supplied-air respirator, demand type (negative pressure), with half-mask facepiece
Less than or equal to 100X	Full facepiece respirator with replaceable high efficiency filter(s) or Type C supplied-air respirator, demand type (negative pressure), with full facepiece or Self-contained breathing apparatus in demand mode (negative pressure), with full facepiece
Less than or equal to 200X	Powered air-purifying (positive pressure) respirator with high efficiency filter(s)
Greater than 200X	Self-contained breathing apparatus with positive pressure in full facepiece or Combination supplied-air respirator, pressure-demand type, with auxiliary self-contained air supply
Emergency (no con- centration limit)	Self-contained breathing apparatus with positive pressure in full facepiece or Combination supplied-air respirator, pressure-demand type, with auxiliary self-contained air supply
Evacuation or Escape (no concen- tration limit)	Self-contained breathing apparatus in demand or pressure-demand mode (negative or positive pressure) or Gas mask, Type N, with high efficiency filter, and mouthpiece respirator with high efficiency filter(s)

Note: A high efficiency filter is defined as a filter having an efficiency of at least 99.97% against 0.3  $\mu$ m DOP(Dioctyl Phthalate)

APPENDIX I  
(Continued)

A continuing educational program shall be instituted to ensure that all workers have current knowledge of job hazards, proper maintenance procedures, and cleanup methods, and that they know how to use respiratory protective equipment and protective clothing correctly.

Information as specified in Appendix III shall be recorded on US Department of Labor Form OSHA-20 "Material Safety Data Sheet" or a similar form approved by the Occupational Safety and Health Administration, US Department of Labor.

Section 6 - Work Practices

(a) Control of Airborne Contamination

Emission of airborne particulates (dust, mist, spray, etc) of chromium(VI) shall be controlled at the sources of dispersion by means of effective and properly maintained methods such as fully enclosed operations and local exhaust ventilation. Other methods may be used if they are shown to effectively control airborne concentrations of chromium(VI) within the limits of the recommended standard.

(b) Control of Contact with Skin and Eyes

(1) Employees working in areas of possible contact of skin or eyes with chromium(VI), dry or wet, shall wear full-body protective clothing, including neck and head coverings, and gloves, in accord with Section 4(a).

(2) Clean protective clothing shall be put on before each work shift.

(3) If, during the shift, the clothing becomes wetted with a solution, slurry, or paste of a chromium(VI) material, or grossly

APPENDIX I  
(Continued)

contaminated with a dry form of such material, it shall be removed promptly and placed in a special container for garments for decontamination or disposal. The employee shall wash the contaminated skin area thoroughly with soap and a copious amount of water. A complete shower is preferred after anything but limited, minor contact. Then, clean protective clothing shall be put on before resuming work. When working directly with chromium(VI) oxide, with unsealed containers of chromium(VI) oxide, or with chromium(VI) oxide in other than fully enclosed operations, protective devices and clothing shall be removed and the arms, hands, and face thoroughly washed after working with chromium(VI) oxide, and at 30-minute intervals when working with chromium(VI) oxide for extended periods of time.

(4) Minor areas of skin (principally the hands) contaminated by contact with chromium(VI) shall be washed immediately and thoroughly with an abundance of water. Water shall be easily accessible in the work areas from low-pressure, free-running hose lines or showers.

(5) If chromium(VI) comes into contact with the eyes, the eyes should be flushed with a large volume of low-pressure flowing water for at least 15 minutes. Medical attention shall be obtained without delay but not at the expense of thoroughly flushing the eyes.

(c) Procedures for emergencies, including firefighting, shall be established to meet foreseeable events. Necessary emergency equipment, including appropriate respiratory protective devices, shall be kept in readily accessible locations. Only self-contained breathing apparatus with positive pressure in the facepiece shall be used in firefighting. Appropriate respirators shall be available for use during evacuation.

APPENDIX I  
(Continued)

(d) Special supervision and care shall be exercised to ensure that the exposures of repair and maintenance personnel to chromium(VI) shall be within the limits prescribed by this standard.

(e) Prompt cleaning of spills of chromium(VI)

(1) No dry sweeping shall be performed. Wet methods or dry vacuuming shall be used as appropriate.

(2) Wet spills and flushing of wet or dry spills shall be channeled for appropriate treatment or collection for disposal. They shall not be channeled directly into the sanitary sewer system.

(f) General requirements

(1) Good practices of housekeeping shall be observed to prevent or minimize contamination of areas and equipment and to prevent build-up of such contamination.

(2) Good personal hygiene practices shall be encouraged.

(3) Equipment shall be kept in good repair and free of leaks.

(4) Containers of dry chromium(VI) shall be kept covered insofar as is practical.

Section 7 - Sanitation

(a) Washing Facilities

Emergency showers and eye-flushing fountains with adequate pressure of cool water shall be provided and be quickly accessible in areas where there is potential of skin or eye contact with chromium(VI). This equipment shall be frequently inspected and maintained in good working condition.

APPENDIX I  
(Continued)

Showers and washbasins shall be provided in the employees' locker areas. Employees exposed to chromium(VI) shall wash before eating or smoking during the work shift.

(b) Food Facilities

Food storage, preparation, and eating shall be prohibited in areas where chromium(VI) is handled, processed, or stored.

Eating facilities provided for employees shall be located in nonexposure areas. Washing facilities should be accessible nearby.

(c) Employees shall not smoke in areas where chromium(VI) is handled, processed, or stored.

(d) Clothing and Locker Room Facilities

Locker room facilities shall be provided in a nonexposure area for employees required to change clothing before and after work. The facilities shall provide for the separate storage of street clothing and clean work clothing from soiled work clothing. Showers and wash basins should be located in the locker area to encourage good personal hygiene.

Covered containers should be provided for work clothing discarded at the end of the shift or after a contamination incident. The clothing will be held in these containers until removed for decontamination or disposal.

Section 8 - Monitoring and Recordkeeping Requirements

Workers are not considered to have occupational exposure to chromium(VI) if, on the basis of a professional industrial hygiene survey, (a) the airborne concentration of carcinogenic chromium(VI) is sufficiently low that a sampling volume greater than 1.0 cu m is necessary in order to collect 0.5 µg of carcinogenic chromium(VI) and (b) the airborne

APPENDIX I  
(Continued)

concentration of noncarcinogenic chromium(VI) is not greater than half the recommended limit of 25  $\mu\text{g Cr(VI)/cu m}$ . All samples of airborne chromium(VI) shall be analyzed by the chemical analytical method in Appendix II; if samples can be demonstrated to contain only noncarcinogenic chromium(VI), other methods of chemical analysis equivalent to the method in Appendix II may be used. Records of these surveys, including the basis for concluding that there is no occupational exposure to chromium(VI) shall be maintained until a new survey is conducted.

In workplaces where chromium(VI) is handled or processed, surveys shall be repeated annually and when any process change indicates a need for reevaluation. Requirements set forth below apply to areas in which there is occupational exposure to chromium(VI).

Employers shall maintain records of workplace environmental exposures to chromium(VI) based upon the following sampling, analytical, and recording schedules:

(a) In all monitoring, samples representative of the exposure in the breathing zone of employees shall be collected by personal samplers.

(b) An adequate number of samples shall be taken in order to permit construction of TWA exposures for every operation or process. Except as otherwise determined by a professional industrial hygienist, the minimum number of representative TWA determinations for an operation or process shall be based on the number of workers exposed as provided in Table I-3.

(c) The first determination of the workers' exposures to airborne chromium(VI) shall be completed within 6 months after the promulgation of a standard incorporating these recommendations.

APPENDIX I  
(Continued)

(d) A reevaluation of the exposures of workers to airborne chromium(VI) shall be made within 30 days after installation of a new process or process changes.

(e) Samples of airborne chromium(VI) shall be collected and analyzed at least every 2 months for those work areas with occupational exposure to carcinogenic chromium(VI) and at least every 3 months if the airborne chromium(VI) is noncarcinogenic.

(f) A reevaluation of the worker's exposures to airborne chromium(VI) shall be repeated at 1-week intervals when the airborne concentration has been found to exceed the recommended workplace environmental limit. In such cases, suitable controls shall be instituted and monitoring shall continue at 1-week intervals until 3 consecutive surveys indicate the adequacy of controls.

(g) Records of all sampling and analysis of airborne chromium(VI) and of medical examinations shall be maintained for at least 30 years after the individual's employment is terminated. Records shall indicate the details of (1) type of personal protective devices, if any, in use at the time of sampling, and (2) methods of sampling and analysis used. Each employee shall be able to obtain information on his own exposure. In the event that the employer who has or has had employees with occupational exposure to carcinogenic chromium(VI) ceases business without a successor, he shall forward their records by registered mail to the Director, National Institute for Occupational Safety and Health.

APPENDIX I  
(Continued)

TABLE I-3  
SAMPLING SCHEDULE

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Number of Employees Exposed	Minimum Number of Employees Whose Individual Exposures Shall Be Determined
1-20	50% of the total number of exposed employees
21-100	10 plus 25% of the excess over 20 exposed employees
over 100	30 plus 5% of the excess over 100 exposed employees

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(h) A regulated area shall be established and maintained where:

(1) Carcinogenic chromium(VI) is manufactured, reacted, repackaged, stored, handled, or used; and

(2) Airborne concentrations of carcinogenic chromium(VI) are in excess of the permissible exposure limit in Section 1.

(i) Access to the regulated areas designated by Section 8h shall be limited to authorized persons. A daily roster shall be made of authorized persons who enter; these rosters shall be maintained for 30 years.