IX. APPENDIX III

BIOLOGIC METHOD FOR SAMPLING AND ANALYSIS OF BENZENE

The recommended biologic method for urinalysis is derived from Sherwood and Carter. [102] It has been designed to determine the concentration of phenol and its conjugates, sulfate and glucuronide, in urine. It also determines orthocresol and meta- and paracresols. Urine is hydrolyzed with perchloric acid at 95 C, and the phenols and cresols are extracted with isopropyl ether and determined by gas chromatography.

Collection of Urine Samples

"Spot" urine specimens of about 100 ml are collected as close to the end of the working day as possible. If any worker's urine phenol level exceeds 75 mg/liter, procedures are instituted immediately to determine the cause of the elevated urine phenol levels and to reduce benzene exposure to the worker. Weekly specimens are collected as described above until 3 consecutive weekly determinations indicate that urinary phenol levels are below 75 mg/liter.

After thoroughly washing their hands with soap and water, workers shall collect urine samples from single voidings in clean, dry specimen containers having tight closures and at least a 120-ml capacity. Collection containers may be glass, waxcoated paper, or other disposable types if desired. Following collection of urine specimens, 1 ml of a 10% copper sulfate solution is added to each sample as a preservative, and samples are immediately stored under refrigeration, preferably at 0-4 C.

Refrigerated specimens will remain stable for approximately 90 days. If shipment of samples is necessary to perform analyses, the most rapid method available shall be employed utilizing acceptable packing procedures as specified by the carrier. Proper identification of each specimen shall include as a minimum, the worker's name, date, and time of collection.

<u>Analytical</u>

(a) Principle of the Method

Urine samples are treated with perchloric acid at 95 C to hydrolyze the phenol conjugates, phenyl sulfate, and phenyl glucuronide, formed as detoxification products following benzene absorption. The total phenol is extracted with diisopropyl ether and the phenol concentration is determined by gas chromatography analysis of the diisopropyl ether extract.

(b) Apparatus

(1) Gas chromatograph with a flame ionization detector and equipped with a 5-foot x 3/16-inch column packed with 2 w/w polyethylene glycol adipate on universal 'B' support. Operating conditions are as follows:

Column temperature	150 C
Detector temperature	200 C
Injection port temperature	200 C
Carrier gas	Nitrogen
Carrier gas flowrate	60 ml/min

(2) Water bath

(3) Glass-stoppered, 10-ml volumetric flasks

(4) 1-ml, 2-ml, and 5-ml volumetric pipets

(5) 5-μl syringe

(c) Reagents

(1) Phenol

(2) Perchloric acid

(3) Diisopropyl ether

(4) Distilled water

(d) Procedure

(1) Hydrolysis of Phenol Conjugates

Pipet 5 ml of urine into a 10-ml, glass-stoppered, volumetric flask. Add perchloric acid, mix by swirling, and transfer the lightly stoppered flask to a water bath at 95 C. After 2 hours, remove the flask from the water bath and allow to cool at room temperature.

(2) Diisopropyl ether extraction of phenol and cresols.

Pipet 1 ml of diisopropyl ether into the flask and adjust the volume to 10 ml with distilled water. Shake vigorously for 1 minute to extract the phenol and cresols. Allow the aqueous and ether layers to separate.

(3) Gas chromatographic analysis for phenol

Inject 5 μl of the diisopropyl ether layer into the gas chromatograph and record the attenuation and area of the phenol peak. Under the conditions described, phenol is eluted in 100 seconds, o-cresol in 130 seconds, and m- and p- cresols in 320 seconds.

(e) Standards Preparation

A 50 mg/liter standard aqueous solution of phenol is prepared. A 5-ml aliquot of the standard solution is then subjected to the hydrolysis, extraction, and gas chromatographic analysis procedures described under Procedure above.

(f) Calculations

Determine the phenol concentration in the urine by comparing the gas chromatographic peak area of the sample with that of the 50 mg/liter standard and adjust the value to a specific gravity of 1.024.

(g) Specific Gravity Correction

Due to the magnitude of correction which is required, samples having uncorrected specific gravities less than 1.010 shall be rejected and another sample shall be obtained.

Based on a survey of a large population in the United States in connection with urinary lead excretion, Levine and Fahy [139] found the mean specific gravity to be 1.024. Many investigators throughout the world now use this figure. Buchwald [130] in 1964 determined the mean specific gravity for residents in the United Kingdom to be 1.016, a value now frequently used for Northern Europeans. The importance of specific gravity adjustments can be seen in that a specific gravity of 1.016 will give results having two-thirds the value of those corrected to 1.024. It is important, therefore, that a value be chosen for standardization; since greater acceptance seems to be for 1.024, this value has been selected for adjustment of urinary concentrations of benzene recommended for biological monitoring.

$$\text{corrected concentration} = \frac{\text{observed concentration} \times 24}{\text{last 2 digits of sp gr (eg, 1.0\underline{21})}}$$

X. APPENDIX IV

SPECIAL MEDICAL CONSIDERATIONS

The literature on the subject of benzene intoxication, both acute and chronic, has been reviewed elsewhere in this document. Levels of exposure permitted in the standards set by this document have been shown to reduce the danger of acute intoxications to a minimum. [1,24,23] Barring accidental exposure, the need for constant monitoring for signs and symptoms of acute intoxication is unnecessary. The toxic effects of chronic low level exposures are not as well documented and, as has been discussed, exposures to 40 ppm have caused hematologic changes in animals. [66] The need for constant and complete monitoring of the organ systems known to be affected by chronic benzene exposure is, therefore, prudent and necessary.

The hematologic system is especially singled out by benzene's toxic effects. There is no agreement in the literature as to which parameter of hematologic function is the first indicator of early benzene intoxication. Monitoring a number of components, therefore, becomes necessary.

The life span of the erythrocyte has been calculated by various methods to be approximately 120 days. [140] This means that if erythrocyte production were to stop suddenly, as in the development of aplastic anemia, 0.83% of the red cell mass would be lost daily. In the asymptomatic individual exposed to very low concentrations of benzene, measurements of the red cell mass could safely be done every 3 months. In workers exposed to higher concentrations, the risk of developing aplastic anemia increases, and more frequent determinations become necessary. In the event of red cell agenesis, 2 weeks would be a sufficient time to reduce the red cell mass by 12%. A longer delay in discovering this condition would be deleterious to the prognosis; thus, monitoring the red cell mass in individuals with higher levels of exposure to benzene should be done at intervals not exceeding 2 weeks. Macrocytosis has also been stated to be the second most frequent toxic effect of benzene on the bone marrow [140]; therefore, bone marrow monitoring for macrocytosis by the measurement of appropriate corpuscular indices at the most frequent practical period is indicated.

No such simple means for estimating the decay of the white blood cell mass in the case of WBC agenesis is available because, to date, the life span of neutrophils has not been measured successfully, despite estimates of less than 12 days. [140] It is difficult to rationally set a maximum period beyond which it would be dangerous to delay measurement. Quarterly intervals in exposed individuals are felt to be maximum intervals prudent in this situation, reflecting the expense and difficulty of the differential WBC count, but measurement at shorter intervals is desirable where practical.

The life span of platelets has been variously estimated as from 9-12 days. These data are imprecise because of the difficulty inherent in the measurements. For those individuals exposed to greater than the maximum suggested TWA, a bimonthly measurement would seem sufficient to find a marked platelet reduction by estimation of platelets from a smear of peripheral blood. This finding might precede symptoms. However, by the time the abnormality is sufficiently advanced, the worker may already be complaining of symptoms caused by a decreased clotting function; therefore, no test more frequently than quarterly is recommended for a platelet determination.

Increased turnover of erythrocytes, probably through hemolysis, has been reported. [140,141] Counts of reticulocytes (immature, still nucleate red blood cells) give a rough estimate of the rapidity of erythrocyte turnover. Obtaining this value on a quarterly basis is suggested in workers having exposures from 1-10 ppm of benzene and annually in others. Hemolysis is discovered early by laboratory estimation of the breakdown products of hemoglobin, of which bilirubin is the easiest to measure. Again, the frequency of the determination is predicated upon the level of individual exposure.

Normal Hematologic Values

The generally accepted ranges of normal for the hematologic tests discussed in the body of this document are presented in Table XII-14 and are derived from values reported by Conn. [142] It should be noted that these values do not represent a definition of normal, but are only a rough guideline. Interpretation of laboratory results should be made on the basis of that laboratory's established normal range for the procedure as performed there. The values listed in Table XII-14 are applicable only to adults.

XI. APPENDIX V.

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material containing benzene shall be provided in the appropriate section of the Material Safety Data Sheet or approved form. If a specific item of information is inapplicable, the initials "n.a." (not applicable) should be inserted.

(a) Section I. Source and Nomenclature.

(1) The name, address, and telephone number of the manufacturer or supplier of the product.

(2) The trade name and synonyms for a mixture of chemicals, a basic structural material, or for a process material; and the trade name and synonyms, chemical name and synonyms, chemical family, and formula for a single chemical.

(b) Section II. Hazardous Ingredients.

(1) Chemical or widely recognized common name of all hazardous ingredients.

(2) The approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, ie, 10-20 by volume; 10% maximum by weight.

(3) Basis for toxicity for each hazardous material such as an established standard in appropriate units.

(c) Section III. Physical Data.

Physical properties of the total product including boiling point and melting point in degrees Fahrenheit; vapor pressure in millimeters of mercury; vapor density of gas or vapor (air=1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water=1); volatility, indicate if by weight or volume, at 70 degrees Fahrenheit; evaporation rate for liquids (indicate whether butyl acetate or ether=1); and appearance and odor.

(d) Section IV. Fire and Explosion Hazard Data.

Fire and explosion hazard data about a single chemical or a mixture of chemicals, including flash point, in degrees Fahrenheit; flammable limits in percent by volume in air; suitable extinguishing media or agents; special fire fighting procedures; and unusual fire and explosion hazard information.

(e) Section V. Health Hazard Data.

Toxic level for total compound or mixture, effects of exposure, and emergency and first-aid procedures.

(f) Section VI. Reactivity Data.

Chemical stability, incompatibility, hazardous decomposition products, and hazardous polymerization.

(g) Section VII. Spill or Leak Procedures.

Detailed procedures to be followed with emphasis on precautions to be taken in cleaning up and safe disposal of materials leaked or spilled. This includes proper labeling and disposal of containers holding residues, contaminated absorbents, etc.

(h) Section VIII. Special Protection Information.

Requirements for personal protective equipment, such as respirators, eye protection, clothing, and ventilation, such as local exhaust (at site of product use or application), general, or other special types.

(i) Section IX. Special Precautions.

Any other general precautionary information.

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

Form Approved
OMB No. 44-R1387

MATERIAL SAFETY DATA SHEET

Required under USDL Safety and Health Regulations for Ship Repairing, Shipbuilding, and Shipbreaking (29 CFR 1915, 1916, 1917)

SECTION I

MANUFACTURER'S NAME	EMERGENCY TELEPHONE NO.
ADDRESS *(Number, Street, City, State, and ZIP Code)*	
CHEMICAL NAME AND SYNONYMS	TRADE NAME AND SYNONYMS
CHEMICAL FAMILY	FORMULA

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)

SECTION III - PHYSICAL DATA

BOILING POINT (°F.)		SPECIFIC GRAVITY (H_2O=1)	
VAPOR PRESSURE (mm Hg.)		PERCENT, VOLATILE BY VOLUME (%)	
VAPOR DENSITY (AIR=1)		EVAPORATION RATE (________ =1)	
SOLUBILITY IN WATER			
APPEARANCE AND ODOR			

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)	FLAMMABLE LIMITS	Lel	Uel
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARDS			

(Continued on reverse side)

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SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE	
EFFECTS OF OVEREXPOSURE	
EMERGENCY AND FIRST AID PROCEDURES	

SECTION VI - REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE		
INCOMPATABILITY *(Materials to avoid)*			
HAZARDOUS DECOMPOSITION PRODUCTS			
HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR		

SECTION VII - SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED	
WASTE DISPOSAL METHOD	

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION *(Specify type)*		
VENTILATION	LOCAL EXHAUST	SPECIAL
	MECHANICAL *(General)*	OTHER
PROTECTIVE GLOVES	EYE PROTECTION	
OTHER PROTECTIVE EQUIPMENT		

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING	
OTHER PRECAUTIONS	

TABLE XII-1

SIGNIFICANT PHYSICAL PROPERTIES OF BENZENE

Formula	$C6H6$
Formula Weight	78.1
Boiling Point	80.1 C (176 F) at 760 mm Hg
Melting Point	5.5 C (42 F)
Specific Gravity	0.8790 g/ml at $\frac{20\ C\ (68\ F)}{4\ C\ (39.2\ F)}$
Solubility	0.06% in water, mixes freely with alcohol, ether and most organic solvents.
Explosive Range for Vapor	1.4 - 7.1% by volume in air
Flash Point	-12 to -10 C (10.4-14 F)
Ignition Temperature	490 C (914 F)
Vapor Density	2.7 (Air = 1.0)

Derived from references 7 and 8

TABLE XII-2

BENZENE REACTIONS OF COMMERCIAL IMPORTANCE

1. Halogenation and subsequent hydrolysis to produce phenol:

$$C_6H_6 + Cl_2 \xrightarrow{\text{(Metallic Iron Catalyst)}} \underset{\text{chlorobenzene}}{C_6H_5Cl} + HCl$$

$$C_6H_5Cl + NaOH \text{ (6-8\% aqueous solution) } \xrightarrow[\text{4500 lb/sq in}]{\text{360 C}}$$

$$C_6H_5ONa + HCl \longrightarrow \underset{\text{phenol}}{C_6H_5OH} + NaCl$$

2. Hydrogenation of benzene to produce cyclohexane:

$$C_6H_6 + 3H_2 \xrightarrow[\text{150-200 C, 25 atm}]{\text{(Metallic Nickel Catalyst)}} \underset{\text{cyclohexane}}{C_6H_{12}}$$

3. Friedel-Crafts reaction of benzene and ethylene to produce ethyl benzene which is then dehydrogenated to yield styrene:

$$C_6H_6 + C_2H_4 \xrightarrow{\text{(Phosphoric Acid Catalyst)}} \underset{\text{ethyl benzene}}{C_6H_5C_2H_5}$$

$$C_6H_5C_2H_5 \xrightarrow[\text{600 C}]{(Cr_2O_3 \cdot Al_2O_3 \text{ Catalyst})} \underset{\text{styrene}}{C_6H_5CH{=}CH_2} + H_2$$

From Chemical Economics Handbook [3]

TABLE XII-3

SUMMARY OF BLOOD FINDINGS
ON EXAMINATION OF WORKERS
EXPOSED TO BENZENE

Group	Room	Local ventilation	Average benzene in air, ppm		Blood findings	
			Summer	Winter	Number of persons examined	Number positive
I-A						
Small amount of benzene;	150B	-	100		9	2
no local ventilation;	60	-	150		1	0
low benzene content in air.	27A	-	110		2	1
I-B						
Small amount of benzene;	27B	-	700		2	0
no local ventilation; high	59	-	150	210	9	1
benzene content in air.	61A	-	130	210	12	6
	61B	-	1,360	580	1	1
II-A						
Large amount of benzene;	78A	+	70	90	0	
local ventilation; low	150A	+	90		1	1
benzene content in air.	75B	+	100		3	1
II-B						
Large amount of benzene;	91	+	180	400	5	*0
local ventilation; high	50B	+		430	3	1
benzene content in air.	50A	+		500	4	1
	75A	+	130	330	10	1
III						
Large amount of benzene; no	78B	-	340		1	0
local ventilation;high	23	-			6	2
benzene content in air.	83	-	620		9	6
	95	-	1,800		3	2
Total					81	26

*3 clinical cases, 1 fatal, since tests were made.
From Greenburg [19]

TABLE XII-4

DETAILED BLOOD COUNTS ON 13 WORKERS
EXHIBITING THE PICTURE OF EARLY BENZOL POISONING

Plant Code No.	Hb	RBC	WBC	Poly %	Lym-phocytes %	Large Mono-nuclears %	Eosin %	Trans %
23	65	4,376,000	5,300	58	36	3.5	1.5	0.5
23	75	4,400,000	5,200	55	39	3.5	2.0	0.5
23			4,100					
23			4,800					
27	55	4,304,000	4,667	55	36	5.0	1.0	2.0
59	70	5,424,000	6,140	47	47	3.5	0.5	1.0
61	85		4,450					
61	50		4,000					
	40	1,736,000	3,000					
61	75		2,850					
	80	1,736,000	4,200					
61	23	800,000	3,000					
83	27	1,055,000	1,450	58	36	5.0	1.0	0.0
	41							
	30	2,100,000	2,100					
	29	1,365,000	2,200	44	49	6.0	1.0	0.0
95	55	3,193,000	3,100	50	39	1.5	7.0	1.5
95	70	4,968,000	3,600	47	41	0.5	8.0	3.0
Normal male	90-110	5,000,000 5,500,000	7,500	65-70	30	1-2	1-2	2-4
Normal female	50-100	4,500,000 5,000,000	7,500	65-70	30	1-2	1-2	2-4

From Greenburg [19]

TABLE XII-5

INCIDENCE OF SIGNIFICANT ABNORMALITIES
IN CASES COMPLETELY STUDIED, BY DIAGNOSIS

Test	Criteria of Abnormality	Severe Cases No.	Severe Cases %	Early Cases No.	Early Cases %	Negative Cases No.	Negative Cases %
RBC	Less than 4.5 million	15	68.2	31	72.1		
Mean corp volume	More than 94 cu µm	14	63.6	25	58.1	9	24.3
Platelets	Less than 100,000	18	81.3	14	32.6		
Hemoglobin	Less than 13.0 gm/100 cc	8	36.4	11	25.6		
WBC	Less than 5,000	19	86.5	13	30.2		
Number of cases examined		22		43		37	

From Greenburg et al [17]

TABLE XII-6

COMBINATIONS OF TESTS WHICH WOULD REVEAL A HIGH PROPORTION OF INDIVIDUALS SHOWING THE BENZENE EFFECT, ACCORDING TO POSITIVE CASES WITH COMPLETE BLOOD STUDIES*

Combined Tests	Cases of Poisoning Revealed by Given Test Combinations No.	%
MCV + RBC	61	82.4
MCV + WBC	59	79.7
MCV + Hb	59	79.7
MCV + Platelets	57	77.0
RBC + Platelets	56	75.7
RBC + WBC	54	73.0
RBC + Hb	51	68.9
MCV + RBC + WBC + Platelets	72	97.3
MCV + RBC + WBC	69	93.2
MCV + RBC + Platelets	66	89.2
MCV + RBC + Hb	65	87.8
Single Tests		
MCV	48	64.9
RBC	47	63.5
Platelets	31	41.9
WBC	30	40.5
Hb	30	40.5
Total positive cases having complete blood studies	74	100.0

*Includes 9 cases with macrocytosis as the only blood abnormality.
From Greenburg et al [17]

TABLE XII-7

PRESUMPTIVE DURATION OF CONTACT AND INTERVAL BETWEEN LAST CONTACT AND DEATH OR BIOPSY IN CHRONIC BENZENE POISONING

Case	Sex	Age	Industry	Duration of Contact	Interval Since Last Contact
1	M	22	Rubber factory	6 months	9 months (N)
2	M	54	Artificial leather	7 years	1 month (N)
3	F	20	Rubber cement	8 months	1 month (N)
4	M	25	Artificial leather	3 years	1 month (N)
5	M	46	Cobbler*	years	1 month (N)
6	F	44	Rubber factory	4 years	6 months (N)
7	M	48	Artificial leather	12 years	5 months (B)
8	M	45	Artificial leather	1 1/2 years	4 months (N)
9	M	45	Artificial leather	3 years	1 1/2 years (N)
10	M	43	Artificial leather	years	? (N)
11	F	18	Rubber factory	7 months	1 month (N)
12	M	54	Artificial leather	3 years	3 months (N)
13	M	51	Cobbler*	2 years	? (N)
14	F	63	Telephone operator**	5 years	3 months (N)
15	M	28	Artificial leather	4 years	6 years (N)
16	M	57	Artificial leather	1 year	2 years (A) (B)
17	M	57	Artificial leather	5 years	5 months (A) (B)
18	M	41	Furniture finisher***	years	2 1/2 months (N)
19	M	12	Schoolboy***	?	2 months (A) (B)

(N) Necropsy, (B) Biopsy, (A) Alive.
*Used benzene as solvent for rubber cement.
**Used solvent containing 50% benzene for eradicating names on switchboard.
***Used paint remover containing benzene.
From Mallory et al [22]

TABLE XII-8

AIR ANALYSES AT A BENZENE COATING PLANT

Location	Benzene Vapor ppm December 1938	July 1946**	August 1946	Average
Coating Room-Machine No. 1	60*	70*	50*	60*
Coating Room-Average	45	40	40	40
Coating Room-Maximum	60	70	55	60
Mixing Room-Average	80	80		80

*Exposure of deceased worker or successor.
**Analysis by an insurance company.
Derived from Hardy and Elkins [57]

TABLE XII-9

SUMMARY OF ENVIRONMENTAL BENZENE LEVELS AND URINARY PHENOL EXCRETIONS FOR WORKERS IN A RUBBER COATING PLANT USING NAPHTHA SOLVENTS (3-7.5% by Volume)

Wkr	Job	Date Empl Began	Age When Hired	5/25/60 Urine Phenol mg/l	5/25/60 Equiv Air Level ppm	5/25/60 Actl Air Anal ppm	7/14/60 Urine Phenol mg/l	7/14/60 Equiv Air Level ppm	7/14/60 Actl Air Anal ppm	1/13/61 Urine Phenol mg/l	1/13/61 Equiv Air Level ppm	1/13/61 Actl Air Anal ppm	9/6/61 Urine Phenol mg/l	9/6/61 Equiv Air Level ppm	9/6/61 Actl Air Anal ppm
A	Spreader	7/55	55	106	10	5,11,	158	19	7,25	250	29	20,25	-	-	19,36,
B		9/44	17	114	13	12,27	75	10	(16.0)	160	19	(22.5)	130	13	25
C		6/57	24	68	10	(13.8)*	-	-		250	29		162	19	(26.3)
D		8/51	47	111	13		-	-		330	38		200	25	
E		12/55	34	270	31		-	-		-	-		200	25	
F		2/46	34	-	-		-	-		350	41		260	31	
G		7/60	33	-	-		-	-		-	-		255	31	
H	Saturator	8/57	20	570	74	68	-	-	57	700	95**	90	295	35	22,23
I	Churner	9/47	38	-	-		190	22	12,17	360	44		152	19	14,16,
J		9/53	22	-	-		-	-	(14.5)	270	31		106	10	44
K		2/59	18	-	-		-	-		300	35		-	-	(24.7)
L		10/58	21	-	-		-	-		480	62		390	47	

* Mean
** Extrapolated
From Pagnotto (written communication, 1972)

TABLE XII-9

SUMMARY OF ENVIRONMENTAL BENZENE LEVELS AND
URINARY PHENOL EXCRETIONS FOR WORKERS IN A RUBBER
COATING PLANT USING NAPHTHA SOLVENTS (3-7.5% by Volume)
(Continued)

		8/16/62			4/10/63			12/12/63			
Worker	Job	Urine Phenol mg/l	Equiv Air Level ppm	Actual Air Analysis ppm	Urine Phenol mg/l	Equiv Air Level ppm	Actual Air Analysis ppm	Urine Phenol mg/l	Equiv Air Level ppm	Actual Air Analysis ppm	Years Expos
A	Spreader	-	-	12,20,	195	25	35,10,	133	16	17,23,	8
B		96	10	18,3,4	230	27	10,21,	193	25	17,30,	19
C		68	10	(11.4)*	145	16	14,17,	132	16	35,20	6
D		87	10		350	41	38,39,	232	29	(25.3)	12
E		85	10		280	33	25,29	152	19		8
F		268	31		370	44	(21.5)	119	13		17
G		130	13		435	56		165	19		3
H	Saturator	280	33	10,14 (12)	440	56	43,43, 33 (39.7)	260	31	38,82, 140 (86.7)	6
I	Churner	-	-		160	19	6	-	-		16
J		-	-		150	16		-	-		10
K		-	-		-	-		-	-		?
L		206	25		300	35		325	38		5

*Mean
From Pagnotto (written communication, 1972)

TABLE XII-10

URINARY PHENOL LEVELS WITH CORRESPONDING EQUIVALENT ENVIRONMENTAL BENZENE EXPOSURE LEVELS

Urine Phenol (mg/liter)	Approx. Av. Equiv. Benzene Air Level (ppm)
100	10
120	13
140	16
160	19
180	22
200	25
220	27
240	29
260	31
280	33
300	35
320	38
340	41
360	44
380	47
400	50
420	53
440	56
460	59
480	62
500	65
520	68
540	71
560	74
580	77
600	80

From Pagnotto (written communication, 1972)

TABLE XII-11

SUMMARY OF HEMOGLOBIN LEVELS FOR WORKERS IN A RUBBER COATING PLANT USING NAPHTHA SOLVENTS (3-7% by Volume)

Worker	3/10/61	3/30/61	9/20/63	10/31/63
B		12.5		12.6
H		13.0	13.8	
J	13.4	12.8		
L	12.2	11.3	11.2	11.5
M	14.6			
N		12.7		
O		12.2		

From Pagnotto (written communication, 1972)

TABLE XII-12

COMPARISON OF BENZENE AIR LEVELS
FROM URINE PHENOL AND AIR SAMPLE DATA

Occupation	Urine Phenol* mg/liter	Benzene in Air ppm	
		Estimated from Urine Phenols	Air Sampling Data (TWA)
Agitator operator	105	10	1.3
Agitator operator	107	10	10.7
Benzol loader	<65	<5	1.7
Benzol still operator	<65	<5	6.7
Benzol oil still operator	<65	<5	0.8
Naphthalene operator	115	12	8.5
Analyst	105	10	2.4
Chemical observer	68	5	12.0
Foreman	<65	<5	none
Repairman	<65	<5	2.6
Chemical observer	65	5	17.1
Chemical observer	112	11	12.2
Chemical observer	66	5	6.5
Control tester	66	5	14.6
Stillman	212	24	39.2
Chemist	157	17	8.8
Pumpman helper	302	36	55
Pumpman helper	84	7	9.5

From Bethlehem Steel data (written communication, 1972)

*Values less than 65 mg/liter were not considered to differ significantly from that of an unexposed normal adult.

TABLE XII-13

BENZENE PLANT AIR LEVELS
ppm

Occupation	Benzene in Air 8-Hour TWA	Range
Agitator Operator	6.0	0.5 - 20
Benzol Loader & Loader Helper	4.0	0.5 - 15
Benzol Still Operator	4.0	1 - 15
Light Oil Still Operator	2.5	1 - 15
Naphthalene Operator	10	2 - 30
Analyst	10	2 - 30
Chemical Observer	10	4 - 50
Foreman	1.5	1 - 10

From Bethlehem Steel data (written communication, 1972)

TABLE XII-14

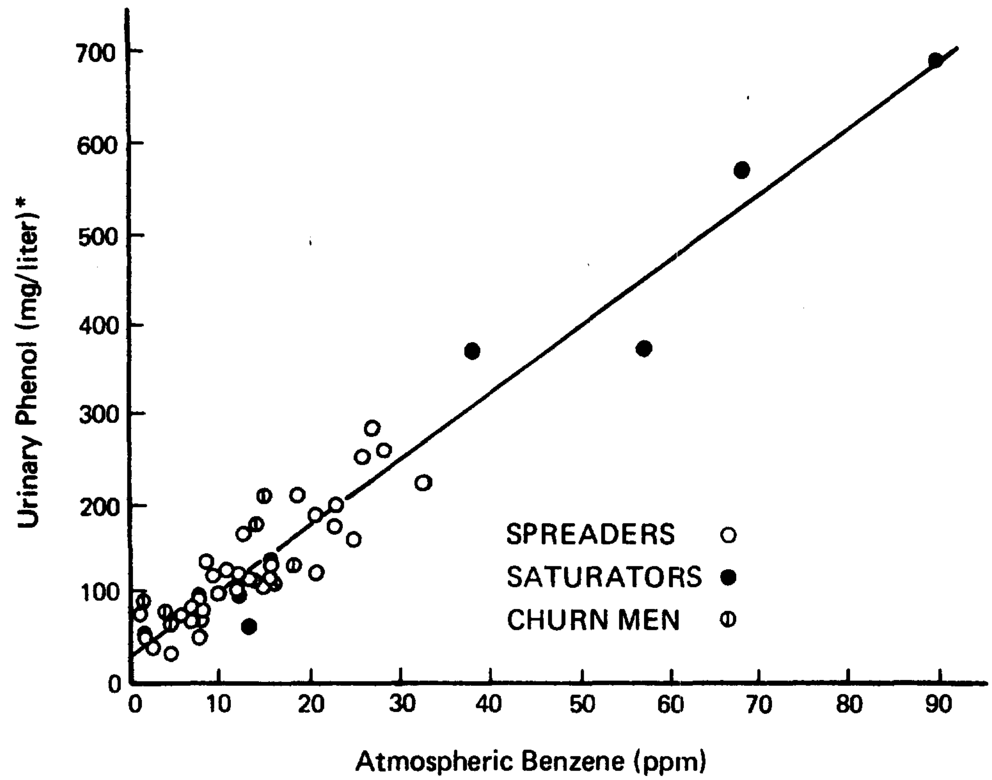
NORMAL HEMATOLOGIC VALUES

Cell Counts			
Erythrocytes	Male		4.6-6.2 million/cu mm
	Female		4.2-5.4 million/cu mm
Leukocytes	Total		5,000-10,000/cu mm
	Differential		
		Myelocytes	0%
		Immature polymorpho-nuclears	3-5%
		Segmented neutrophils	54-62%
		Lymphocytes	25-33%
		Monocytes	3-7%
		Eosinophils	1-3%
		Basophils	0-0.75%
Platelets			150,000-350,000/cu mm
Reticulocytes			0.5-1.5% of erythrocytes
Corpuscular Values for Erythrocytes			
Mean Corpuscular Hemoglobin			27-31 picograms
Mean Corpuscular Volume			82-92 cu micra
Mean Corpuscular Hemo-globin Concentration			32-36%
Hematocrit	Male		40-54%
	Female		37-47%
Hemoglobin	Male		14.0-18.0 g%
	Female		12.0-16.0 g%
Serum Bilirubin Concentration			
	Total		0.3-1.1 mg%
	Direct		0.1-0.4 mg%
	Indirect		0.2-0.7 mg%

From Conn [142]

FIGURE XII-1

COMPARISON OF PHENOL IN URINE WITH BENZENE IN AIR

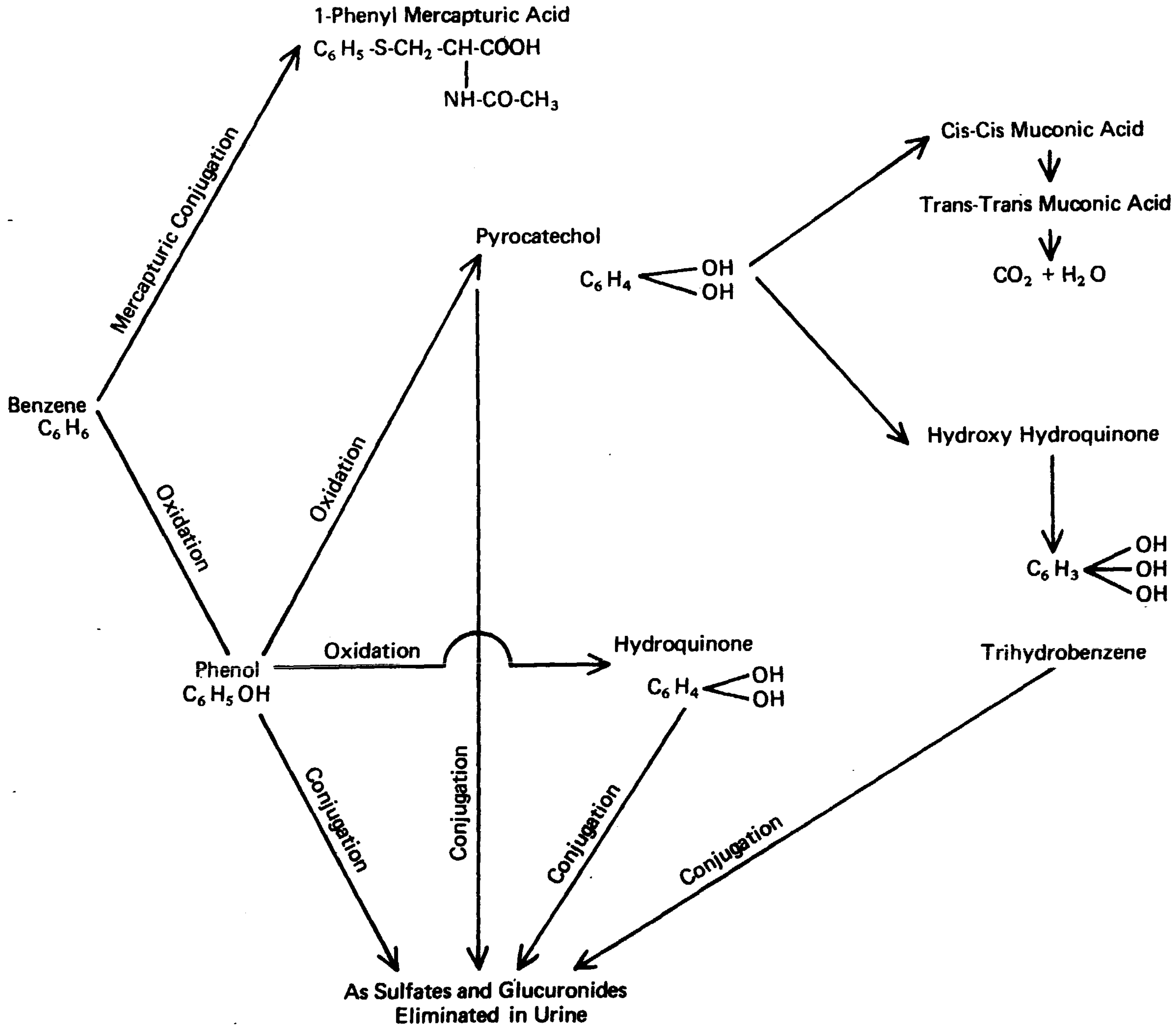


*Represents both phenol and paracresol. Phenol alone would result in values lower than indicated.

Derived from Pagnotto [12]

FIGURE XII-2

SUGGESTED METABOLIC TRANSFORMATION OF BENZENE IN MAN



From Truhaut [126]

*U.S.Government Printing Office: 1974 — 758-520/2150

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