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THE POTENTIAL PROBLEMS OF INDUSTRIAL HYGIENE IN A TYPICAL INDUSTRIAL AREA IN THE UNITED STATES

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THE POTENTIAL PROBLEMS OF INDUSTRIAL HYGIENE IN A TYPICAL INDUSTRIAL AREA IN THE UNITED STATES[1]

INTRODUCTION

Realizing the fact that the improvement of the general health status of the industrial worker is a public health problem and as such should be one of the functions of a department of public health, the health officials of one of the industrial areas in the United States decided to inaugurate a program of industrial hygiene. These health officials also realized that one of the first steps in such a program is to obtain a comprehensive conception of the extent of the problem as it exists today. Such a conception, in the absence of definite industrial morbidity and mortality statistics, may be approximated by means of a preliminary survey of the industrial establishments of the locality. This preliminary survey should be of a type which would reveal the number of persons employed in the various occupations, the materials, processes, and conditions associated with these occupations, and the welfare facilities afforded the workers in the industrial environment, thereby yielding a picture of the working conditions.

To accomplish such a study would have taken a considerable amount of time with the limited personnel at the disposal of the health department. Fortunately, an opportunity to conduct such an investigation in a comparatively brief period of time offered itself through the agency of the Civil Works Act, whereby it was possible to employ some 40 engineers for this problem. In order to conduct this survey in a standardized manner and under the guidance of experienced personnel, the aid of the Office of Industrial Hygiene and Sanitation of the United States Public Health Service was enlisted.

The present report deals with the results of this cooperative study and also contains definite recommendations for a program of industrial hygiene for the health department in the area surveyed. It was not possible to evaluate by exact quantitative methods the extent of exposure of workers to various materials and the effect of such exposure on the health of the workers, since to accomplish this would have required a great number of persons trained in industrial hygiene. For this reason, it must be kept in mind, that *the results presented in this report must not be interpreted as indicating in any manner whatsoever that an exposure to an industrial condition or material necessarily implies injury to a workman, but merely indicates the potentialities of the situation.*

[1] Submitted for publication June 29, 1934.

SCOPE AND PLAN OF SURVEY

It was realized at the beginning of this study, in January 1934, that not more than 2 or 3 months could be devoted to this work, since all C. W. A. activities were to be curtailed late in March of the same year. For this reason it was decided to include only the manufacturing and mechanical industries in the present inquiry.

Although graduate engineers were available for the conduct of the study, it was realized that one was dealing with men untrained in industrial hygiene methods. For this reason it was decided that the present inquiry would have to be of such a nature as to place very little stress on the judgment of the investigator and more on the proper filling out of a simple questionnaire. Accordingly, the first step in the study was to formulate a questionnaire which would fulfill the above requirements and still yield the necessary information. The forms used were so worded as to yield information concerning such items as products manufactured, sanitary facilities, raw materials employed, processes, occupations, etc. It is apparent, therefore, that the scope of the present survey was so planned as to be merely preliminary in nature, and *does not indicate the extent of any health hazards in the industries studied, but only shows the possibilities of the situation.* This point will be further clarified in the pages which follow.

METHODS USED IN STUDY

For the sake of those persons who may be interested in conducting a similar survey, the methods used in the present investigation are presented in detailed form.

The first step in the study was to make out an index card for each of the 700 industrial plants selected for study, listing on each card the name of the plant, the products manufactured, the address and telephone number. These cards were later sorted according to products manufactured and given a code number. During the actual survey it was very helpful to record on each card the names of the investigator, the date the survey commenced and any other pertinent data of use in keeping track of the work in progress. The next step in the study was to inform the plant officials of each of the establishments to be surveyed, of the nature of the inquiry. This was accomplished by sending a personal letter to each plant manager, explaining in some detail the purpose, scope, and plan of the study and enlisting the cooperation of the plant officials.

During the time that elapsed for the letters to be written and mailed, the prospective investigators were being given a general background of industrial hygiene. This consisted of lantern-slide lectures on the subject of industrial hygiene, as presented by one of the authors during a 2-day period. In addition, outside reading was available on numerous topics related to industrial hygiene. As a

result of these lectures, questions asked of the men, and essays which they wrote on the subject matter covered by this brief intensive course, it was possible to select 27 engineers who, it was felt, were qualified to carry on the study. These men were then given the survey forms designed for the study with a set of written instructions covering each item in the forms. A lecture was also given in the use of the forms which gave an opportunity to take up many points perhaps not fully clear in the instructions.

At the completion of the preliminary training course, which consumed 3 or 4 days, certain key men were taken out by one of the authors for practical instruction. Each man was taken individually to a plant and told to observe the proper methods in making a contact with the necessary plant official, how to make a workroom survey and the technic in obtaining answers to all the questions on the forms in as unobtrusive a manner as possible. After the demonstration, the prospective investigator was taken to another plant and told to go through the same procedure in the presence of the instructor. In this manner it was possible to point out to the investigator any mistakes he may have committed either in making his contact or in obtaining his information. Such a procedure made it possible to select about 5 men, who in turn could give individual training to the other men. At the end of 3 or 4 days each one of the 27 engineers had received individual instruction and was then given a definite assignment.

During the first week's work, the instructor (one of the authors) checked each individual's work and pointed out any errors or omissions. At the end of the first week's survey, it was patent that certain common misconceptions as to the information required were present. These were by no means of a serious nature and were soon ironed out at a meeting called for this purpose. It was decided, therefore, to institute a systematic procedure for checking the work of the men as soon as an investigator finished one plant. This work was checked by two of the key men who were familiar with many of the industrial processes the checking being done in the presence of each investigator, so that he could view errors, if any were made, and possibly return to the plant to obtain the information lacking. At the same time, two other individuals were employed in coding the results of the survey, that is, in recording some of the salient data on specially prepared forms which could later be used for the final analysis.[2] This coding served as an additional check on the investigator's work, since certain items which may have been overlooked by the checkers, were probably noted by the coders, because of the very nature of the forms used. It may be well to mention at this

[1] Only the survey forms are reproduced in this report at the appendix. The other forms used in the study may be had by communicating with any one of the authors.

time, that the investigators were assigned plants according to whether or not they were familiar with the processes in such plants. For example, chemical engineers were assigned chemical plants, electrical engineers were sent to electrical equipment manufacturing plants, men with foundry experience to foundries, and so on.

The following tabulation summarizes the time involved in the conduct of the study. As a rule, the men worked 6 hours a day, in a 5-day week.

Activity	Total number of hours	Remarks
Training period	360	Equivalent to 2 days for 30 men.
Field surveys	5,298	Represents about 7 weeks' work for 25 men.
Coding and checking	630	7 weeks' work for 3 persons.
Tabulating	216	2 weeks' work for 3 persons.

All told, about 630 plants were surveyed in the present study. Active work commenced on January 15, beginning with the training period, and terminated on April 2, when all tabulating was completed.

RESULTS OF SURVEY

The basis of the present survey was the filling out of the two forms reproduced in the appendix to this report. The shorter of the two forms dealt with data pertaining to the plant as a whole, and required such information as the kinds of products manufactured, number and types of buildings and a "yes" or "no" answer to certain questions relating to industrial welfare provisions and whether or not disability statistics were kept at each plant. The longer form dealt specifically with the individual workroom, there being one such form for each workroom in a plant. On this form the investigator had to record the type of work performed in the room, the lack or presence of certain kinds of sanitary facilities, the presence of potential exposure to accidents, fumes and gases, other poisons, dusty processes, and lastly, the various occupations and activities of each occupation. A close scrutiny of these forms will reveal the fact that the investigator had to use his own judgment but very little; most of the data being supplied by the plant management. As explained earlier, these forms were purposely framed in such a manner as to leave very little to the decision of each surveyor, since it was realized that even with the short instruction course given the men, they were still inexperienced in industrial hygiene methods. In view of the uniform manner in which the data were collected, it is felt that the information, as far as it went, represents the actual state of affairs existing in the various plants at the time this survey was conducted.

TYPE OF INDUSTRIES SURVEYED

TABLE 1.—*Number of workers and plants in manufacturing and mechanical industries surveyed*

Industry	Number of plants	Number of workers		
		Total	Male	Female
Metal products industries	252	13,955	12,805	1,150
Automobile plants	11	1,111	1,089	22
Electrical shops	15	2,320	1,978	342
Machine shops and foundries	226	10,524	9,738	786
Printing and allied industries	108	2,308	1,884	424
Photostating	4	23	23	0
Photo-engraving	21	240	223	17
Printing	76	1,947	1,544	403
Typesetting	7	98	94	4
Chemical industry	99	1,793	1,483	310
Artificial flowers	7	291	240	51
Fireworks	1	2	2	0
Films and plates	4	78	60	18
Oils and greases	4	24	22	2
Polishes	6	62	34	28
Soaps, glues, etc	16	386	282	104
Inks	10	72	66	6
Paints and varnishes	33	398	356	42
Other chemicals	18	480	421	59
Clay, glass, and stone:	53	1,372	1,370	2
Glass	14	94	94	0
Stone	39	1,278	1,276	2
Leather industry	46	8,031	4,469	3,562
Shoes	17	7,311	3,981	3,330
Leather goods	29	720	488	232
Dyeing and cleaning	29	925	310	615
Electroplating	18	89	88	1
Storage battery	5	16	16	0
Rubber goods	3	54	44	10
Fur preparation	2	143	141	2
Totals	615	28,686	22,610	6,076

Table 1 shows the number of male and female workers employed in the various plants at the time this study was made. For the sake of simplicity, the different plants are grouped into 10 main industries. Of 28,686 workers covered in this survey 22,610 (78.8 percent) were males. According to the United States census of 1930 (*1*),[3] there were at that time 44,449 employees working in the industries included in this survey, or about 15,000 more persons than found employed 4 years later. This figure may be considered as a very crude index of the inroads of the depression in the manufacturing plants in the area studied. The survey covered roughly about one-third of the persons working in all the manufacturing and mechanical industries in the locality which would indicate that the study included a good sample of the industrial population under consideration. The industries are

[3] Italic figures in parentheses denote reference cited.

arranged in the order of the number of plants found in each industrial group, which in all but one case (the leather industry) also meant in the order of the number of persons employed. By far the greatest number of plants and persons were found in the metal-products industry, which accounted for 41 percent of the plants and 48.7 percent of the workers.

SIZE OF PLANTS

TABLE 2.—*Percentage distribution of plants according to number of workers*

Industry	Number of plants	Percent of plants according to number of workers							
		Less than 10	10 to 19	20 to 29	30 to 39	40 to 49	50 to 74	75 to 99	100 or more
United States Census[1]	210,959	55.0	17.0	5.0	4.2	4.0	3.6	3.1	8.1
All industries studied	615	48.7	15.4	9.3	3.6	3.7	6.3	2.8	10.2
Metal products	252	41.7	13.5	11.1	4.7	4.4	7.9	3.6	13.1
Printing	108	37.8	30.6	13.0	2.8	5.6	6.5	0.0	3.7
Chemicals	99	67.8	15.2	4.0	2.0	3.0	3.0	2.0	3.0
Clay, glass and, stone	53	64.2	11.3	3.7	3.7	0.0	5.8	3.7	7.6
Leather products	46	32.6	4.3	8.7	2.2	0.0	8.7	8.7	34.8
Dyeing and cleaning	29	48.4	10.3	10.3	6.9	10.3	6.9	0.0	6.9
Electroplating	18	68.9	15.5	15.6	0.0	0.0	0.0	0.0	0.0
Storage battery	*5*	*100.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Rubber goods	*3*	*33.3*	*33.3*	*33.4*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Fur preparation	*2*	*50.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*50.0*

[1] 1929 census figures for all manufactures in the United States.

In table 2, an idea is obtained of the size of the plants from the viewpoint of the number of persons employed at the time this survey was conducted. The percentage distribution of the plants according to the number of employees shows that nearly half (48.7 percent) of the plants employed less than 10 workers, while 10.2 percent had 100 or more persons. The leather products industry, mostly shoe factories, contained the greatest number of plants with 100 or more workers (34.8 percent). In a few instances, the number of employees totaled close to 1,000; such large plants were more frequently found in the metal products industry. At first glance, one would be inclined to conclude that the plants surveyed in this study were of the small type, that is, employing but few workers. However, an examination of the data obtained by the United States census of manufactures,[4] shows that the so-called "small plant" predominates in our manufacturing industries in this country. In table 2, a percentage distribution for 210,959 manufacturing plants included in the 1929 census, shows an even larger percentage of plants with less than 10 workers than found in the present survey; in the United States, 55 percent as contrasted with 48.7 percent in the area surveyed. On the whole, the distribution for the plants studied compares very favorably with the manufacturing plants in the United States, indicating that the

[4] Personal communication.

establishments surveyed in the present study were quite representative from the standpoint of numerical size.

INDUSTRIAL WELFARE PROVISIONS

Many public health workers and industrialists will concede today that a program for the prevention of accidents and disease among the industrial population is a most rational plan. In fact, it is now well understood that the fostering of such programs for the minimization of the hazards incidental to employment is in reality a far-seeing economy. Such programs rightfully come under the heading of industrial welfare, an activity which contributes both to the social and industrial progress of any community. In view of the far-reaching and favorable influence which such activities have been known to exert in the industrial picture, it was deemed necessary to obtain some information of the extent of the industrial welfare provisions in the plants under consideration.[5] Tables 3, 4, 5, and 6 contain data on this subject.

Safety organization.—Table 3 indicates the extent of provisions regarding safety organizations in the 615 plants. It is quite evident that only 5 percent of the plants and about 20 percent of the workers were provided with the services of either a part-time or full-time safety director. The employees in the leather products and chemical plants had the benefit of this type of service to a greater extent than in any of the other establishments. Safety organization as exemplified by supervision from elected shop committees was more in evidence than the services of a safety director. Ten percent of the plants and one-third of the employees had this type of safety service. Under "other methods of organization" was included the safety work carried out by plant managers, foremen, poster service, etc. A large number of the plants resorted to this type of service in an effort to minimize the number of accidental injuries among their employees.

Since it was not possible to interpret the significance of these data in terms of the number of lost time accidents, no definite conclusions may be drawn from the extent of the safety service disclosed in this survey. Students of this problem realize full well that proper and adequate safety supervision during the past 20 years has more than paid for itself financially in lessened compensation costs, while the saving effected in life and limb from the humanitarian viewpoint is an item incapable of interpretation. In a later table (no. 10) an attempt is made to show the influence of safety supervision on the number of exposures to one of the common accident hazards.

[5] For detailed information on the extent and importance of medical supervision in industry, the reader is referred to the report published by the National Industrial Conference Board, Inc., New York, 1931, entitled "Medical Supervision and Service in Industry."

TABLE 3.—*Industrial welfare provisions (all plants)—Safety organization*

Industry	Number of plants	Number of employees	Percent of plants and persons to whom service is available							
			Safety director				Shop committees		Other methods of organization	
			Part time		Full time					
			Plants	Persons	Plants	Persons	Plants	Persons	Plants	Persons
			Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
All industries studied	615	28,686	4.9	21.0	4.9	23.8	10.2	33.6	80.2	72.9
Metal products	252	13,955	5.5	19.8	6.4	28.5	13.9	39.8	84.9	71.0
Printing and allied industries	108	2,308	0.9	4.4	1.9	4.5	3.7	7.5	88.0	92.6
Chemical	99	1,793	5.0	28.1	4.0	9.1	8.0	33.7	75.8	65.8
Clay, glass, and stone	53	1,372	9.4	14.6	3.8	24.6	15.1	43.8	83.0	90.3
Leather products	46	8,031	8.7	30.0	13.0	27.8	13.0	28.9	78.3	68.6
Dyeing and cleaning	29	925	3.4	4.4	0.0	0.0	3.4	27.2	82.8	88.4
Electroplating	18	89	0.0	0.0	0.0	0.0	0.0	0.0	50.0	70.8
Storage battery	5	16	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0
Rubber goods	3	54	0.0	0.0	0.0	0.0	0.0	0.0	66.7	85.2
Fur preparation	2	143	0.0	0.0	0.0	0.0	50.0	98.0	50.0	2.0

TABLE 4.—*Industrial welfare provisions (all plants)—Medical provisions*

Industry	Number of plants	Number of employees	Percent of plants and persons to whom service is available							
			First-aid room		Plant physician				Plant nurse	
					Part time		Full time		Part time	Full time
			Plants	Persons	Plants	Persons	Plants	Persons	Plants	Persons	Plants	Persons
			Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
All industries studied	615	28,686	9.8	48.5	3.1	17.3	1.3	15.3	0.7	2.7	3.4	34.1
Metal products	252	13,955	15.5	62.1	4.0	18.1	1.6	22.4	1.2	2.5	4.4	40.1
Printing and allied industries	108	2,308	0.9	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chemical	99	1,793	6.0	34.9	3.0	30.2	1.0	0.6	0.0	0.0	1.0	10.1
Clay, glass, and stone	53	1,372	11.3	42.2	3.8	11.2	0.0	0.0	0.0	0.0	1.9	18.8
Leather products	46	8,031	21.7	48.2	6.5	21.9	6.5	15.6	2.2	5.3	17.4	46.8
Dyeing and cleaning	29	925	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electroplating	18	89	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Storage battery	5	16	0.0	0.0	20.0	37.5	0.0	0.0	0.0	0.0	0.0	0.0
Rubber goods	3	54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fur preparation	2	143	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Medical supervision.—The extent of medical supervision in the industrial plants studied is presented in table 4. First-aid rooms were found in 9.8 percent of the plants serving 48.5 percent of the total working population. Metal products, leather products, chemical, and clay, glass and stone plants were fairly well provided from this standpoint. On the other hand, the other industries had no regular first-aid provisions to any great extent. Only 3 percent of the plants had a part time plant physician serving 17 percent of the workers and only 1.3 percent of the plants had a full time medical supervisor for

the 15.3 percent of the workers. The plant nursing service was in about the same status, there being practically no part time nursing service and only a few plant nurses on a full time basis, providing this type of service to 34.1 percent of the employees in all the plants. Table 4 shows the particular industries where medical provisions were the most prevalent. It is evident that the problem of medical supervision in the plants studied has been practically untouched.

Disability statistics.—Students of the industrial hygiene problem have recognized for some time the value of keeping accident and sickness records. Such records serve to indicate the extent of the problem and at times have been the means of initiating studies designed for the correction of those conditions revealed by an analysis of the records. An excellent example of such a case is the study of the pneumonia problem in the steel industry, undertaken by the Office of Industrial Hygiene and Sanitation of the United States Public Health Service as a result of the information disclosed by an analysis of records furnished by a group of steel companies (*2*). Certain industrial plants have sick benefit associations, maintained jointly by employers and employees, which are a means of correcting for some of the injuries incidental to industrial employment. As a rule, the sick benefit association is the agency authorized to keep disability statistics, and should be the body cooperating with the plant welfare department, in an attempt to correct certain hazardous conditions found to exist in the establishment. In view of the important part such records and associations play in any constructive industrial hygiene program, it was deemed of interest to obtain some information on this subject in the present survey.

TABLE 5.—*Industrial welfare provisions (all plants)—Disability statistics*

Industry	Number of plants	Number of employees	Percent of plants and persons with listed facility					
			Sick benefit association		Sick records		Accident records	
			Plants	Persons	Plants	Persons	Plants	Persons
			Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
All industries	615	28,686	6.8	29.4	16.8	40.0	83.0	98.1
Metal products	252	13,955	9.2	31.3	22.6	40.5	90.2	98.8
Printing and allied industries	108	2,308	5.6	18.3	13.0	29.5	88.0	94.8
Chemical	99	1,793	4.0	26.5	12.0	35.1	68.0	92.1
Clay, glass, and stone	53	1,372	3.8	1.3	11.3	32.3	85.0	97.4
Leather products	46	8,031	13.0	37.5	28.2	50.6	84.8	99.9
Dyeing and cleaning	29	925	0.0	0.0	3.4	9.7	79.3	95.0
Electroplating	18	89	0.0	0.0	5.6	10.1	27.8	58.4
Storage battery	5	16	0.0	0.0	0.0	0.0	60.0	75.0
Rubber goods	3	54	0.0	0.0	0.0	0.0	100.0	100.0
Fur preparation	2	143	50.0	97.9	0.0	0.0	100.0	100.0

Table 5 shows the percentage of plants in which sick benefit associations and disability records were found, and the percentage of per-

sons in these plants. Only 6.8 percent of the plants with 29.4 percent of the working population had sick benefit associations. The leather products, metal products, and chemical industries had the largest percentage of workers, among the chief industries, included in such associations. Sickness records were kept to the extent of 16.8 percent of all plants and for 40 percent of the total industrial population studied. Here it is evident that the industries having sick benefit associations were the ones more apt to keep sickness data. Accident records were existent in nearly all the plants (83 percent of the plants embracing 98.1 percent of the workers), since the local compensation law for accidental injuries required the keeping of such records. Considering the fact that the industrial area studied does not have a compulsory occupational disease law, it is quite encouraging to find that sickness records are kept to the extent disclosed in this study (40 percent of the persons included in such records). The question of sick benefit associations, however, is one still in need of further consideration.

Table 6 was prepared in an attempt to determine the influence of the small plant on the data relative to the industrial welfare provisions. This table shows the percentage of plants and employees having certain industrial welfare facilities in establishments employing 100 or more workers as contrasted with similar data for plants with less than 100 workers. (It should be recalled that 89.8 percent of the plants had less than 100 workers.)

TABLE 6.—*Industrial welfare service in plants with 100 or more employees as compared with plants having less than 100 persons*

Kind of service	Percent of plants with listed service		Percent of employees with listed service	
	100 or more	Less than 100	100 or more	Less than 100
Safety organization:				
Safety director:				
Part time	25.4	2.7	28.1	6.4
Full time	29.9	2.2	32.4	6.0
Shop committees	44.5	6.5	42.2	16.0
Other	73.0	81.6	66.4	86.4
Medical provisions:				
First-aid room	53.9	4.9	66.0	12.6
Plant physician:				
Part time	19.0	1.4	23.1	5.4
Full time	11.1	0.2	22.7	0.1
Plant nurse:				
Part time	3.2	0.4	5.3	2.0
Full time	31.7	0.2	50.5	0.3
Disability statistics:				
Sick benefit association	38.1	3.4	39.4	8.9
Sickness records	49.2	13.3	49.4	20.7
Accident records	100.0	78.6	100.0	93.9

It is apparent from the data in this table that for practically all the listed industrial welfare facilities previously discussed, the larger plants had a greater percentage of workers furnished with

such provisions; however, even some of these larger plants were somewhat lacking in medical and nursing service, safety directors, and disability records. It is rather superfluous to comment at length on the data disclosed in table 6, since it is felt that the information it contains speaks for itself. However, it is desired to point out one thing, and that is the fact that in this area as well as in the United States as a whole, about half of the plants employ less than 10 persons, and 90 percent less than 100 workers. It is the so-called small plant, therefore, that is predominant, and as this survey has revealed, it is this size plant which was found lacking in those welfare provisions which play a vital role in any constructive program of industrial hygiene. *For this reason, and others that will be developed in later portions of this report, a program of industrial hygiene, carried on by a department of health, one that will reach the small as well as the large plant, will be a means of furnishing the services now needed in industrial establishments.*

SANITARY PROVISIONS

Although insanitary conditions may not necessarily be associated with ill health, it has long been recognized that the elimination of sources of uncleanliness in factories is conducive to the general well-being and efficiency of the workers. For this reason, an attempt has been made to appraise the sanitary facilities of the industries studied by recording the various provisions of a sanitary nature. Table 7 presents the results of this part of the study, and indicates the percentage of workers in the various industries who were furnished with the listed sanitary facilities.

TABLE 7.—*Percentage of workers having certain sanitary facilities in the industries surveyed*

Industry	Number of employees	Percent of employees having facility specified									
						Toilets			Drinking water		
		Lunchroom	Cloakroom	Washing room	Common towel	In workroom	Separate room	Outdoors	Bubble fountain	Other	Common cup
All industries	28,686	19.1	67.8	98.0	13.0	41.9	57.8	2.0	72.9	33.2	19.5
Metal products	13,955	19.6	69.9	99.6	10.3	39.1	63.0	0.8	79.6	24.1	12.3
Printing and allied industries	2,308	19.3	55.3	100.0	26.5	45.8	54.3	0.4	33.8	70.1	45.7
Chemical	1,793	36.6	71.4	99.6	26.7	49.2	54.5	1.1	53.4	47.4	17.3
Clay, glass, and stone	1,372	0.0	41.3	63.8	5.4	14.4	54.7	30.8	36.1	63.4	43.7
Leather products	8,031	15.6	72.3	100.0	9.7	50.1	49.6	0.3	87.6	26.5	17.1
Dyeing and cleaning	925	27.2	75.0	99.8	31.9	23.3	76.3	0.0	39.8	60.0	53.0
Electroplating	89	0.0	40.4	97.8	32.6	68.8	31.2	0.0	12.4	87.6	50.6
Storage battery	16	37.5	37.5	100.0	87.5	25.0	75.0	0.0	75.0	25.0	12.5
Rubber goods	54	0.0	68.6	100.0	14.8	16.6	83.4	0.0	13.0	87.0	14.8
Fur preparation	143	97.9	2.1	100.0	2.1	78.6	21.4	0.0	97.9	2.1	0.

The results in this table need very little comment with the exception of two items. It is well to point out that in spite of the voluminous articles which have been written on the dangers of spreading disease by the use of the common drinking cup and the common towel, this survey disclosed that 19.5 percent of the workers were using the common drinking cup and 13.0 percent the common towel. In the printing, electroplating, clay, glass, and stone, and dyeing and cleaning establishments, about half of the workers were found using a common cup. It is of interest to note that in some of these same industries, the common towel was also tolerated.

POTENTIAL ACCIDENT HAZARDS

TABLE 8.—*Percentage of workers exposed to potential accident hazards*

Industry	Number of workers	Percent of workers exposed to each hazard										
		Unguarded machinery	Floor hazards	Fire hazards	Burns	Eye hazards	Cuts	Corrosive burns	Electric shock	Unprotected elevator shaft	Explosions	Unguarded stairs
All industries	28,686	41.9	13.2	8.8	8.4	7.5	6.5	5.0	2.3	2.1	2.0	0.4
Metal products	13,955	45.6	15.7	6.8	12.0	12.7	4.4	4.2	2.9	0.8	0.5	0.3
Printing, etc	2,308	62.3	11.3	23.3	11.2	7.1	13.8	10.7	6.6	0.7	0.0	0.7
Chemical	1,793	36.0	17.5	29.7	4.6	4.5	3.0	17.8	0.6	1.4	5.6	2.6
Clay, glass, and stone	1,372	24.9	12.7	0.5	1.6	3.7	7.1	3.6	0.7	1.1	25.6	0.1
Leather products	8,031	36.1	8.1	2.3	1.2	1.0	9.8	0.6	0.2	5.3	0.2	0.0
Dyeing and cleaning	925	24.5	9.9	31.7	28.9	0.5	0.0	9.3	0.2	0.0	2.4	0.0
Electroplating	89	88.8	59.6	0.0	3.4	2.2	0.0	66.3	73.0	0.0	0.0	0.0
Storage battery	16	43.8	50.0	37.5	18.8	0.0	0.0	93.8	43.8	0.0	0.0	0.0
Rubber goods	54	14.8	61.1	27.8	0.0	0.0	11.1	0.0	0.0	0.0	16.7	1.9
Fur preparation	143	2.1	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	2.1

In table 8 the percentage of workers who are potentially exposed to accident hazards is presented by cause. *It must be borne in mind that these figures do not imply the extent of accidental injuries but merely indicate the possibilities of the situation.* Unguarded moving machinery was found to be the main potential accident source, especially in those industries utilizing a preponderance of such devices, as in the printing and metal products industries. Forty-two percent of the workers were found to be exposed to unguarded moving machinery. Potential hazards arising from protruding nails in floors, objects over which one might stumble, and similar floor hazards, showed the next highest percentage of exposure, 13.2 percent of the workers in all the plants being subjected to this source of accidental injury. It is of interest to find that in spite of the wide-spread educational campaigns which have been carried on by various safety organizations on the protection of workers' eyes from flying chips, dusts, etc., by the wearing of goggles, the present survey disclosed that 7.5 percent of all the workers covered by this study were exposed

to the possibilities of eye injuries from such common sources as grinding wheels, lathes, and so on.

The nature of the present investigation did not allow for an analysis of accidents experienced by the various industries, so that it is not possible to draw any definite conclusions from the data shown in table 8, except to point out that additional precautions should be taken by the plant officials to eliminate some of the potential sources of accidents disclosed by this study. That such exposures may at times lead to actual accidental injuries is fairly well illustrated by the data contained in table 9. This table shows the percentage distribution of compensated cases by specific causes in certain industries in the State of New York for 1931 (*3*), as compared with corresponding percentages based on potential accident hazards revealed in the present survey. Only industries and causes common in both surveys were compared, so that it was necessary to omit some material from both studies. It is obvious that a striking relationship exists between the percentage distribution of potential accident hazards and compensated cases for nearly all the causes shown in the table.

TABLE 9.—*Percentage distribution of compensated cases by specific causes in certain industries in the State of New York for 1931, as compared with corresponding percentages based on potential accident hazards disclosed in survey of similar industries in present study*

Industry	Unguarded machinery		Floor hazards		Falls to different level		Electric shock, burns, explosions		Corrosive burns	
	Compensated	Potential	Compensated	Potential	Compensated	Potential	Compensated	Potential	Compensated	Potential
Totals	47.7	57.1	24.6	17.5	10.1	3.4	10.4	15.9	7.2	6.1
Metal products	50.7	55.6	22.2	19.2	9.0	1.4	12.8	18.7	5.3	5.1
Printing	55.2	60.2	27.1	10.9	10.0	1.4	4.4	17.2	3.3	10.3
Chemical products	19.6	41.8	24.7	20.3	18.6	4.6	15.5	12.6	21.6	20.7
Clay, glass, stone	36.9	35.5	35.4	18.1	13.3	1.7	6.7	39.8	7.7	4.9
Leather products	49.4	69.9	27.5	15.6	8.6	10.2	5.0	3.1	9.5	1.2

In concluding this portion of the report, one additional table is shown, which presents some information on the possible benefits which may be derived from a close supervision of safety work. Table 10 shows the number and percentage of workers exposed to unguarded moving machinery in plants having either a part time or full time safety director and compares these data with the findings for plants not having such safety supervision. It is apparent that in four of the largest industries under consideration (embracing 88 percent of the total population studied), the percentage of workers exposed to this particular type of potential hazard was in practically every instance much higher in the plants not having a safety director than in those plants provided with such personnel.

TABLE 10.—*Number and percentage of workers exposed to unguarded machinery in plants having safety directors as compared with plants not so provided* [1]

Industry	Number of workers		Percent exposed	
	With safety director	Without safety director	With safety director	Without safety director
Total	12,701	12,450	29.0	52.7
Metal products	6,744	7,211	36.3	54.2
Chemical	670	1,123	30.9	39.0
Clay, glass, and stone	537	835	26.4	23.9
Leather products	4,750	3,281	18.7	61.5

[1] Plants having part time or full time safety director are compared with those not having such personnel.

OCCUPATIONAL EXPOSURE TO SPECIFIED MATERIALS AND CONDITIONS

It is well known that numerous materials and conditions incidental to industrial processes are causative factors in the production of occupational diseases. Dublin and Vane (*4*) list some 94 groups of industrial poisons in the United States, associated with about 900 different occupations. In view of the influence these materials and conditions may have on the health of workers, one of the most important tasks undertaken in the present inquiry was the recording of raw materials, processes, and finished products associated with each occupation encountered in the 615 plants under consideration. All told, some 50 varieties of materials and conditions were encountered in this study, of which number 11 may be placed in the category of a minor exposure, that is, experience has shown that no cases of systemic poisoning have ever been associated with the handling of these 11 materials. *It should be pointed out again, that the data on occupational exposure to these materials and conditions must not be interpreted as signifying that the workers were being subjected to toxic amounts of hazardous materials, for, as mentioned earlier, no quantitative studies of the workroom environments were made in this investigation. The data contained in the following tables merely indicate the potentialities present in the plants studied.*

TABLE 11.—*Percent and number of workers exposed to specified materials and conditions in each industry* [1]

Materials and conditions	Percent of workers exposed							
	All industries	Metal	Printing	Chemical	Clay, etc.	Leather	Dyeing, etc.	Electroplating
Carbon monoxide	19.3	27.5	28.6	5.5	9.7	9.3	1.1	37.1
Emery dust	12.8	23.5	1.2	3.5	4.7	2.5	(2)	43.8
Lead compounds	10.2	11.1	37.7	20.9	1.2	1.0	(2)	2.2
Quartz dust	9.0	14.4	(3)	10.3	11.3	2.1	(2)	57.3
Benzol	5.4	(3)	9.6	3.9	(3)	13.1	6.4	(3)
Gasoline [3]	4.5	6.3	10.5	2.6	(3)	1.1	1.8	(3)
Amyl acetate [3]	4.1	3.2	1.3	7.1	(3)	6.5	(2)	32.6
Turpentine	3.9	5.3	4.6	14.0	1.4	(2)	(2)	(3)
Naphthas [3]	3.7	4.8	(3)	8.9	(3)	1.8	6.1	(3)
Benzine	3.5	1.6	11.5	10.4	(3)	3.1	6.7	(3)
Methanol	3.1	3.4	5.1	4.3	1.3	1.8	5.7	2.2
Aniline	3.0	(2)	15.5	14.4	(3)	1.6	2.5	(2)
Carborundum dust	2.8	5.0	(3)	2.8	2.0	(2)	(2)	4.5
Cyanides	2.0	2.7	2.1	4.3	(3)	(2)	(2)	48.3
Ammonia	1.7	(2)	1.3	5.4	2.0	1.4	9.7	4.5
Sulphur dioxide	1.4	2.9	(3)	(2)	(3)	(2)	(2)	(3)
Other silicate dusts	1.4	(2)	(2)	7.1	19.5	(2)	(3)	(3)
Acetone [3]	1.3	(3)	(3)	2.6	(3)	2.3	4.6	(3)
Chromium compounds [3]	1.3	1.1	3.7	5.4	(3)	(2)	(2)	19.1
Temperature variations	1.2	2.3	(2)	(2)	(2)	(2)	(2)	(2)
Cotton dust [3]	1.1	1.9	(3)	(2)	(2)	(2)	(2)	36.0
Asphalt [3]	1.0	1.8	(3)	1.0	(3)	(2)	(3)	(3)
Manganese compounds	(2)	(2)	(2)	11.3	(2)	(2)	2.8	(2)
Arsenicals	(2)	(2)	(2)	6.1	(2)	(2)	(2)	(2)
Talc dust	(2)	(2)	(2)	(2)	(3)	1.1	(2)	(2)
Oxalic acid	(2)	(2)	(2)	4.9	2.1	(2)	7.5	(2)
Asbestos dust	(2)	(2)	(2)	4.2	6.8	(2)	(2)	(2)
Antimony compounds [3]	(2)	(2)	7.9	(2)	(2)	(2)	(2)	(2)
Chloroform	(2)	(2)	(2)	(2)	(2)	(2)	10.7	(2)
Carbon tetrachloride	(2)	(2)	(2)	1.1	(2)	(2)	9.8	(2)
Nickel compounds [3]	(2)	(2)	(2)	(2)	(2)	(2)	(2)	21.3
Mercury and compounds	(2)	(2)	(2)	5.3	(2)	(2)	(2)	2.2
Kerosene [3]	(2)	(2)	2.4	(2)	(2)	(2)	(2)	(2)
Ether	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Cadmium compounds	(2)	(2)	(2)	(2)	(2)	(2)	(2)	18.0
Butanol	(2)	(2)	(2)	3.6	(2)	(2)	(2)	(2)
Butyl acetate	(2)	(2)	(2)	2.8	(2)	(2)	(2)	(2)
Toluol	(2)	(2)	(2)	2.3	(2)	(2)	(2)	(2)
Hydrogen fluoride	(2)	(2)	(2)	(2)	(2)	(2)	1.6	(2)
Chlorine	(2)	(2)	(2)	1.6	(2)	(2)	1.2	(2)
Phosphoric acid [3]	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Formaldehyde	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Toluidines	(2)	(2)	(2)	1.2	(2)	(2)	(2)	(2)
Carbon bisulphide	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Phenol	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Xylol	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Phosphorus and compounds	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Picric acid	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Hydrogen chloride	(2)	(2)	(2)	(2)	(2)	(2)	(2)	4.5
Ethylene dichloride	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] In the storage battery industry, 87.5 percent of the workers (14) were exposed to CO; 100 percent (16) to lead compounds; 37.5 percent (6) to turpentine. In the rubber goods industry 33.3 percent (18) were exposed to lead compounds; 51.8 percent (28) to benzol; 3.7 percent (2) to gasoline; 51.8 percent (28) to naphthas; 31.5 percent (17) to asphalt. In the fur preparation industry 4.9 percent (7) were exposed to quartz dust; 21.0 percent (30) to talc dust; 4.2 percent (6) to ammonia.

[2] Less than 1 percent.

[3] Minor hazards or exposures.

TABLE 11.—*Percent and number of workers exposed to specified materials and conditions in each industry* [1]—Continued

Materials and conditions	Number of workers exposed							
	All industries	Metal	Printing	Chemical	Clay, etc.	Leather	Dyeing, etc.	Electroplating
Carbon monoxide	5,538	3,842	660	99	133	747	10	33
Emery dust	3,678	3,282	28	63	64	202	0	39
Lead compounds	2,926	1,548	871	374	17	79	1	2
Quartz dust	2,585	2,014	7	184	155	167	0	51
Benzol	1,544	113	221	70	0	1,053	59	0
Gasoline [3]	1,283	879	242	47	5	91	17	0
Amyl acetate [3]	1,172	453	29	128	9	522	2	29
Turpentine	1,124	734	107	251	19	7	0	0
Naphthas [3]	1,065	672	6	160	0	143	56	0
Benzine	995	229	266	187	0	251	62	0
Methanol	881	471	118	77	18	142	53	2
Aniline	863	95	358	258	0	129	23	0
Carborundum dust	793	696	10	51	28	0	4	4
Cyanides	561	380	48	77	5	0	8	43
Ammonia	477	109	31	97	27	113	90	4
Sulphur dioxide	411	406	0	5	0	0	0	0
Other silicate dusts	403	1	0	127	268	0	7	0
Acetone [3]	386	115	0	47	0	181	43	0
Chromium compounds [3]	363	150	85	96	1	11	3	17
Temperature variations	330	320	0	0	4	0	6	0
Cotton dust [3]	305	266	0	0	0	7	0	32
Asphalt [3]	301	247	18	18	0	1	0	0
Manganese compounds	257	9	5	202	0	15	26	0
Arsenicals	222	96	15	110	0	0	1	0
Talc dust	204	66	6	11	0	91	0	0
Oxalic acid	203	0	0	88	29	17	69	0
Asbestos dust	199	29	0	76	93	1	0	0
Antimony compounds [3]	186	4	182	0	0	0	0	0
Chloroform	133	0	3	2	0	29	99	0
Carbon tetrachloride	123	0	3	20	0	9	91	0
Nickel compounds [3]	117	92	6	0	0	0	0	19
Mercury and compounds	113	1	15	95	0	0	0	0
Kerosene [3]	94	23	55	9	3	2	2	6
Ether	79	78	0	1	0	0	0	0
Cadmium compounds	70	40	0	14	0	0	0	12
Butanol	67	0	3	64	0	0	0	0
Butyl acetate	58	0	0	51	0	7	0	0
Toluol	48	0	0	41	0	7	0	0
Hydrogen fluoride	47	7	10	0	13	2	15	0
Chlorine	40	0	0	29	0	0	11	0
Phosphoric acid [3]	39	16	7	16	0	0	0	0
Formaldehyde	35	2	17	0	1	14	1	0
Toluidines	22	0	0	22	0	0	0	0
Carbon bisulphide	19	0	2	7	0	7	3	0
Phenol	16	0	9	6	0	0	1	0
Xylol	15	0	0	8	0	7	0	0
Phosphorus and compounds	13	13	0	0	0	0	0	0
Picric acid	13	0	10	0	0	0	3	0
Hydrogen chloride	4	0	0	0	0	0	0	4
Ethylene dichloride	1	0	0	1	0	0	0	0

See footnotes on p. 15.

Table 11 shows the number and percentage of workers handling specified materials in the 10 industries studied. It is evident that the highest exposure was to carbon monoxide (19.3 percent), this being present in greatest numbers among workers in the printing and metal products industries. Dusts are listed separately, but when they are combined the results indicate a greater percentage of exposure to dusts than to any other substance encountered. It is apparent that the percentage of exposure to the listed materials varies somewhat with the industry. For example, in the leather, and dyeing and cleaning plants, one finds a greater percentage of persons exposed to certain solvents, such as benzol, carbon tetrachloride, etc., than one

does in the other industries. This is as one might expect, and only serves to indicate to the public health worker the potential problems in each industry. This subject will be dealt with in more detail in a later portion of this report.

Table 11 presents a general picture of the materials and conditions existing in the 10 industries. The tables which follow reproduce some of this information in more detail, showing the percentage and number of workers exposed to only those materials present in each industry, and listing these exposures by specific occupations. Wherever there was an insufficient number of persons in any one occupation, and with an exposure to only one or two materials, the occupation was placed into a single group, entitled "Miscellaneous."

TABLE 12.—*Metal products industry: Occupational exposure to specified materials and conditions*

Material and conditions	Percent of workers exposed in each occupation											
	All occupations	Foundry workers	Electrical workers	Machinists	Light-metal workers	Heavy-metal workers	Miscellaneous	Grinders	Painters and woodworkers	Wire workers	Electroplaters	Welders
Carbon monoxide	27.5	7.3	4.6	5.6	5.5	2.8	(1)	(1)	(1)	(1)	(1)	(1)
Emery dust	23.5	1.8	5.0	10.2	2.3	1.2	(1)	2.9	(1)	(1)	(1)	(1)
Quartz dust	14.4	8.3	(1)	2.6	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Lead compounds	11.1	1.2	4.2	(1)	2.3	(1)	(1)	(1)	1.4	(1)	(1)	(1)
Turpentine	5.3	(1)	1.9	(1)	1.3	(1)	(1)	(1)	1.0	(1)	(1)	(1)
Carborundum dust	5.0	2.2	(1)	(1)	(1)	1.6	(1)	(1)	(1)	(1)	(1)	(1)
Methanol	3.4	(1)	1.7	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Sulphur dioxide	2.9	2.5	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cyanides	2.7	(1)	1.5	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Temperature variations	2.3	(1)	(1)	(1)	(1)	1.0	(1)	(1)	(1)	(1)	(1)	(1)
Benzine	1.6	(1)	1.2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Benzol	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ammonia	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Arsenicals	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Aniline compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ether	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Talc dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cadmium compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Asbestos dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Phosphorus compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Manganese compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Hydrogen fluoride	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Other silicate dusts	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Mercury and compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Formaldehyde	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

[1] Less than 1 percent.

TABLE 12.—*Metal products industry: Occupational exposure to specified materials and conditions*—Continued

Material and conditions	Number of workers exposed in each occupation											
	All occupations	Foundry workers	Electrical workers	Machinists	Light-metal workers	Heavy-metal workers	Miscellaneous	Grinders	Painters and woodworkers	Wire workers	Electroplaters	Welders
Carbon monoxide	3,842	1,018	637	780	762	395	111	1	21	63	1	53
Emery dust	3,282	245	696	1,427	325	163	4	410	0	11	1	0
Quartz dust	2,014	1,161	71	368	131	78	35	135	35	0	1	0
Lead compounds	1,548	169	581	133	315	0	50	2	199	62	0	37
Turpentine	734	38	264	33	183	51	18	0	147	0	0	0
Carborundum dust	696	301	11	0	102	222	5	55	0	0	0	0
Methanol	471	95	243	0	104	1	3	0	25	0	0	0
Sulphur dioxide	406	348	0	35	10	7	6	0	0	0	0	0
Cyanides	380	1	210	76	14	0	0	3	0	24	52	0
Temperature variations	320	115	59	0	0	146	0	0	0	0	0	0
Benzine	220	0	170	0	53	0	6	0	0	0	0	0
Benzol	113	0	0	0	10	0	0	0	102	1	0	0
Ammonia	109	0	0	0	88	0	14	0	0	0	7	0
Arsenicals	96	0	13	0	66	0	8	0	0	0	9	0
Aniline compounds	95	76	1	0	0	0	17	0	0	1	0	0
Ether	78	0	0	0	78	0	0	0	0	0	0	0
Talc dust	66	50	0	0	0	0	7	9	0	0	0	0
Cadmium compounds	40	0	0	3	0	0	0	0	0	0	37	0
Asbestos dust	29	0	0	0	22	0	7	0	0	0	0	0
Phosphorus compounds	13	0	3	0	10	0	0	0	0	0	0	0
Manganese compounds	9	0	0	6	0	0	0	0	3	0	0	0
Hydrogen fluoride	7	0	0	0	0	0	0	0	0	0	7	0
Other silicate dusts	1	0	0	0	0	0	0	0	1	0	0	0
Mercury and compounds	1	0	0	0	0	0	0	0	0	1	0	0
Formaldehyde	2	0	0	0	0	0	2	0	0	0	0	0

The occupational exposure of metal products workers is presented in table 12. As noted earlier the highest percentage of potential exposure in this industry is to carbon monoxide, followed by emery and quartz dust. Foundry workers (molders, core makers, etc.) show the highest percentage and number of exposures in this industry although there are more machinists exposed to the inhalation of emery dust than any other single occupation. It is apparent from the results shown in table 12 that the potential problems in the metal products industry are carbon monoxide, inorganic dusts, lead compounds, certain solvents, cyanides, and exposure to extreme temperature variations. The occupations presenting possibilities for studies are foundry workers, machinists, and electrical workers.

A consideration of the occupational exposure to certain materials in the printing plants shows a slightly different picture, as the results in table 13 indicate. In this industry the highest percentage exposure was to lead compounds, lead being an inherent material of this particular industry. Printers and linotypers show the highest exposure to lead, and these workers are also exposed in considerable numbers to carbon monoxide gas, aniline compounds, and certain solvents, such as benzol, benzine, and methanol. All told, some 24 materials were found in use in this industry, with those just mentioned leading the list in the number of exposures. From the data shown in table 13, the potential problems of the printing industry are quite obvious.

TABLE 13.—*Printing industry: Occupational exposure to specified materials*

Materials	Percent of workers exposed in each occupation							
	All occupations	Printers or linotypers	Lithographers	Etchers and engravers	Electrotypers	Photographers, etc.	Binders and paper cutters	Miscellaneous
Lead compounds	37.7	29.8	4.7	(1)	2.3	(1)	(1)	(1)
Carbon monoxide	28.6	19.4	(1)	2.7	2.5	(1)	2.3	(1)
Aniline compounds	15.5	14.7	(1)	(1)	(1)	(1)	(1)	(1)
Benzine	11.5	11.3	(1)	(1)	(1)	(1)	(1)	(1)
Benzol	9.6	3.2	5.1	(1)	(1)	(1)	(1)	(1)
Methanol	5.1	4.2	(1)	(1)	(1)	(1)	(1)	(1)
Turpentine	4.6	3.3	(1)	1.3	(1)	(1)	(1)	(1)
Cyanides	2.1	(1)	(1)	(1)	1.5	(1)	(1)	(1)
Ammonia	1.3	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Emery dust	1.2	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Formaldehyde	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Mercury and compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Carborundum dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Picric acid	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Phenol	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Quartz dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Hydrogen fluoride	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Talc dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Manganese compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Arsenicals	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Butanol	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Carbon tetrachloride	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Chloroform	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Carbon bisulphide	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

Materials	Number of workers exposed in each occupation							
	All occupations	Printers or linotypers	Lithographers	Etchers and engravers	Electrotypers	Photographers, etc.	Binders and paper cutters	Miscellaneous
Lead compounds	871	687	109	16	52	2	0	5
Carbon monoxide	660	448	18	63	58	18	54	1
Aniline compounds	358	340	0	0	0	2	16	0
Benzine	266	261	0	0	5	0	0	0
Benzol	221	73	118	0	0	19	9	2
Methanol	118	97	0	10	0	11	0	0
Turpentine	107	76	2	29	0	0	0	0
Cyanides	48	0	5	8	34	0	0	1
Ammonia	31	1	19	1	0	6	0	4
Emery dust	28	11	0	1	6	0	1	9
Formaldehyde	17	0	7	0	0	10	0	0
Mercury and compounds	15	0	5	3	0	7	0	0
Carborundum dust	10	6	0	2	0	0	0	2
Picric acid	10	0	0	0	0	0	10	0
Phenol	9	0	8	0	0	0	0	1
Quartz dust	7	6	0	0	0	0	0	1
Hydrogen fluoride	10	1	7	0	0	2	0	0
Talc dust	6	6	0	0	0	0	0	0
Manganese compounds	5	0	1	0	0	4	0	0
Arsenicals	15	13	0	0	0	2	0	0
Butanol	3	3	0	0	0	0	0	0
Carbon tetrachloride	3	3	0	0	0	0	0	0
Chloroform	3	1	0	2	0	0	0	0
Carbon bisulphide	2	2	0	0	0	0	0	0

[1] Less than 1 percent.

As might be predicted with some degree of certainty, the chemical industry handled the largest number of materials of any type of establishment studied, there being some 33 different substances in use in the 99 chemical plants investigated (table 14). Lead, aniline, turpentine, manganese, benzine, and arsenical compounds show the greatest percentage of exposures, with paint mixing the occupation experiencing the largest numbers among the various trades found in these plants. For all but 9 of the 33 materials the exposures exceeded 1 percent, with 20.9 percent of the workers handling lead compounds alone.

TABLE 14.—*Chemical industry: Occupational exposure to specified materials*

Materials	Percent of workers exposed in each occupation								
	All occupations	Paint mixers	Chemical workers	Ink mixers	Miscellaneous	Spray painters and woodworkers	Rubber cement workers	Flower makers	Film plate workers
Lead compounds	20.9	15.8	3.7	1.2	(1)	(1)	(1)	(1)	(1)
Aniline compounds	14.4	10.5	2.0	1.9	(1)	(1)	(1)	(1)	(1)
Turpentine	14.0	12.4	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Manganese compounds	11.3	6.1	4.4	(1)	(1)	(1)	(1)	(1)	(1)
Benzine	10.4	9.0	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Quartz dust	10.3	2.7	3.8	(1)	3.7	(1)	(1)	(1)	(1)
Other silicate dusts	7.1	6.6	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Arsenicals	6.1	(1)	6.0	(1)	(1)	(1)	(1)	(1)	(1)
Carbon monoxide	5.5	(1)	2.2	1.1	(1)	(1)	(1)	(1)	(1)
Ammonia	5.4	(1)	3.9	(1)	(1)	(1)	(1)	(1)	(1)
Mercury and compounds	5.3	1.2	3.6	(1)	(1)	(1)	(1)	(1)	(1)
Oxalic acid	4.9	(1)	4.9	(1)	(1)	(1)	(1)	(1)	(1)
Cyanides	4.3	(1)	3.3	(1)	(1)	(1)	(1)	(1)	(1)
Methanol	4.3	1.3	(1)	(1)	(1)	2.7	(1)	(1)	(1)
Asbestos dust	4.2	4.2	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Benzol	3.9	1.2	2.0	(1)	(1)	(1)	(1)	(1)	(1)
Butanol	3.6	3.6	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Emery dust	3.5	(1)	2.4	(1)	(1)	(1)	(1)	(1)	(1)
Carborundum dust	2.8	(1)	(1)	(1)	(1)	2.3	(1)	(1)	(1)
Butyl acetate	2.8	2.7	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Toluol	2.3	2.2	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Chlorine	1.6	(1)	1.6	(1)	(1)	(1)	(1)	(1)	(1)
Toluidines	1.2	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Carbon tetrachloride	1.1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cadmium compounds	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Talc dust	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Xylol	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Carbon bisulphide	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Phenol	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Sulphur dioxide	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Chloroform	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ethylene dichloride	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ether	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

[1] Less than 1 percent.

TABLE 14.—*Chemical industry: Occupational exposure to specified materials*—Continued

Materials	Number of workers exposed in each occupation								
	All occupations	Paint mixers	Chemical workers	Ink mixers	Miscellaneous	Spray painters and woodworkers	Rubber cement workers	Flower makers	Film plate workers
Lead compounds	374	284	67	21	1	1	0	0	0
Aniline compounds	258	188	35	34	1	0	0	0	0
Turpentine	251	222	10	4	0	11	4	0	0
Manganese compounds	202	110	78	14	0	0	0	0	0
Benzine	187	162	0	4	0	0	5	16	0
Quartz dust	184	48	68	0	66	0	0	2	0
Other silicate dusts	127	118	0	0	9	0	0	0	0
Arsenicals	110	2	108	0	0	0	0	0	0
Carbon monoxide	99	11	39	20	9	10	5	5	0
Ammonia	97	9	70	0	8	0	0	0	10
Mercury and compounds	95	21	64	8	0	0	0	0	2
Oxalic acid	88	0	87	1	0	0	0	0	0
Cyanides	77	0	60	0	0	15	0	0	2
Methanol	77	23	3	1	0	48	0	0	2
Asbestos dust	76	76	0	0	0	0	0	0	0
Benzol	70	21	36	10	1	0	0	0	2
Butanol	64	64	0	0	0	0	0	0	0
Emery dust	63	0	43	0	15	0	5	0	0
Carborundum dust	51	4	0	0	5	42	0	0	0
Butyl acetate	51	49	2	0	0	0	0	0	0
Toluol	41	40	0	0	1	0	0	0	0
Chlorine	29	0	29	0	0	0	0	0	0
Toluidines	22	8	0	14	0	0	0	0	0
Carbon tetrachloride	20	8	9	0	1	0	0	2	0
Cadmium compounds	14	10	0	4	0	0	0	0	0
Talc dust	11	7	4	0	0	0	0	0	0
Xylol	8	7	0	0	1	0	0	0	0
Carbon bisulphide	7	0	0	0	0	0	5	2	0
Phenol	6	0	0	6	0	0	0	0	0
Sulphur dioxide	5	0	0	0	0	0	5	0	0
Chloroform	2	0	2	0	0	0	0	0	0
Ethylene dichloride	1	0	0	0	1	0	0	0	0
Ether	1	0	0	1	0	0	0	0	0

The clay, glass, and stone industry showed the greatest number of workers exposed to the various types of dusts resulting from the working of the materials common to this industry (table 15). Glass workers, granite cutters, marble cutters, and concrete workers showed the highest percentage of exposures to quartz-containing dusts. On the other hand, brick and clay workers led the occupations in the number of exposures to silicate dusts other than those listed in table 15. Altogether, 15 materials and conditions were found present in this industrial classification, with dusts leading the list. It is apparent that the major potential problem in the clay, glass, and stone industry is that of dust, and that quartz and asbestos dusts are the two most important ones to be studied, since, with the exception of "other silicate dusts", the highest number of exposures was found to be to these two materials.

TABLE 15.—*Clay, glass, and stone industry: Occupational exposure to specified materials and conditions*

Materials and conditions	Percent of workers exposed in each occupation										
	All occupations	Glass workers	Brick workers	Clay workers	Granite cutters	Roofers	Kiln workers	Marble cutters	Miscellaneous	Concreters	Potters
Other silicate dusts	19.5	(1)	10.0	9.3	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Quartz dusts	11.3	3.0	(1)	(1)	4.3	(1)	(1)	2.0	(1)	1.7	(1)
Carbon monoxide	9.7	2.6	(1)	(1)	(1)	(1)	4.7	(1)	2.4	(1)	(1)
Asbestos dust	6.8	(1)	(1)	(1)	(1)	6.4	(1)	(1)	(1)	(1)	(1)
Emery dust	4.7	1.3	(1)	(1)	1.7	(1)	(1)	(1)	1.1	(1)	(1)
Oxalic acid	2.1	(1)	(1)	(1)	(1)	(1)	(1)	1.7	(1)	(1)	(1)
Carborundum dust	2.0	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Ammonia	2.0	2.0	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Turpentine	1.4	1.0	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Methanol	1.3	1.3	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Lead compounds	1.2	1.1	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Hydrogen fluoride	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Cyanides	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Temperature variations	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Formaldehyde	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)

Materials and conditions	Number of workers exposed in each occupation										
	All occupations	Glass workers	Brick workers	Clay workers	Granite cutters	Roofers	Kiln workers	Marble cutters	Miscellaneous	Concreters	Potters
Other silicate dusts	268	0	137	128	0	0	0	0	0	0	3
Quartz dusts	155	41	0	0	59	0	0	28	1	23	3
Carbon monoxide	133	35	0	0	0	0	65	0	33	0	0
Asbestos dust	93	0	0	0	0	88	0	0	5	0	0
Emery dust	64	18	0	0	23	0	0	4	15	0	4
Oxalic acid	29	0	0	0	5	0	0	24	0	0	0
Carborundum dust	28	5	3	0	5	0	0	11	0	4	0
Ammonia	27	27	0	0	0	0	0	0	0	0	0
Turpentine	19	14	0	0	0	0	0	0	0	5	0
Methanol	18	18	0	0	0	0	0	0	0	0	0
Lead compounds	17	15	0	0	0	0	0	0	1	0	1
Hydrogen fluoride	13	13	0	0	0	0	0	0	0	0	0
Cyanides	5	5	0	0	0	0	0	0	0	0	0
Temperature variations	4	0	0	0	0	0	4	0	0	0	0
Formaldehyde	1	1	0	0	0	0	0	0	0	0	0

[1] Less than 1 percent.

The leather products industry had the second largest number of workers employed in the plants studied (8,031 persons). Twenty-two different materials were being used in these plants at the time this survey was conducted. The largest number of workers were found to be handling compounds containing benzol, 13.1 percent for all the occupations, with shoe workers handling such compounds in the greatest numbers. Carbon monoxide, benzine, and emery and quartz dusts were the next important materials from the viewpoint of the number of exposures. Since the bulk of the plants studied in this industry were shoe factories, it is not surprising that most of the exposures were among shoe workers. The potential problem in this industry exists in this occupation and the materials to be investigated are such solvents as benzol, benzine and methanol and carbon monoxide gas.

TABLE 16.—*Leather products industry: Occupational exposure to specified materials*

Materials	Percent of workers exposed in each occupation						Number of workers exposed in each occupation					
	All occupations	Shoe workers	Miscellaneous	Cementers	Sanders	Leather workers	All occupations	Shoe workers	Miscellaneous	Cementers	Sanders	Leather workers
Benzol	13.1	12.0	(1)	(1)	(1)	(1)	1,053	969	0	84	0	0
Carbon monoxide	9.3	8.9	(1)	(1)	(1)	(1)	747	715	32	0	0	0
Benzine	3.1	1.3	(1)	1.9	(1)	(1)	251	102	0	149	0	0
Emery dust	2.5	1.6	(1)	(1)	(1)	(1)	202	126	76	0	0	0
Quartz dusts	2.1	(1)	(1)	(1)	(1)	(1)	167	63	32	0	63	9
Methanol	1.8	1.3	(1)	(1)	(1)	(1)	142	105	37	0	0	0
Aniline compounds	1.6	1.6	(1)	(1)	(1)	(1)	129	129	0	0	0	0
Ammonia	1.4	1.4	(1)	(1)	(1)	(1)	113	113	0	0	0	0
Talc dust	1.1	(1)	(1)	(1)	(1)	(1)	91	91	0	0	0	0
Lead compounds	1.0	(1)	(1)	(1)	(1)	(1)	79	28	51	0	0	0
Choloroform	(1)	(1)	(1)	(1)	(1)	(1)	29	29	0	0	0	0
Oxalic acid	(1)	(1)	(1)	(1)	(1)	(1)	17	2	15	0	0	0
Manganese compounds	(1)	(1)	(1)	(1)	(1)	(1)	15	0	15	0	0	0
Formaldehyde	(1)	(1)	(1)	(1)	(1)	(1)	14	14	0	0	0	0
Carbon tetrachloride	(1)	(1)	(1)	(1)	(1)	(1)	9	9	0	0	0	0
Turpentine	(1)	(1)	(1)	(1)	(1)	(1)	7	7	0	0	0	0
Butyl acetate	(1)	(1)	(1)	(1)	(1)	(1)	7	7	0	0	0	0
Toluol	(1)	(1)	(1)	(1)	(1)	(1)	7	7	0	0	0	0
Carbon bisulphide	(1)	(1)	(1)	(1)	(1)	(1)	7	7	0	0	0	0
Xylol	(1)	(1)	(1)	(1)	(1)	(1)	7	7	0	0	0	0
Hydrogen fluoride	(1)	(1)	(1)	(1)	(1)	(1)	2	2	0	0	0	0
Asbestos dust	(1)	(1)	(1)	(1)	(1)	(1)	1	0	0	0	0	1

[1] Less than 1 percent.

Among the 925 workers employed in the dyeing and cleaning industry the work was of such a nature as to call for but one occupation, that of dry cleaners (with the exception of four machinists). The exposure for the employees in these plants is shown in Table 17. Practically all the workers were found using materials of a solvent nature, the largest number of workers (10.7 percent) being exposed to chloroform, with carbon tetrachloride and ammonia showing 9.8 and 9.7 percent of the exposures, respectively. The potential problem in this industry arises from the use of such solvents as those just mentioned with the addition of benzine, benzol, and methanol.

TABLE 17.—*Dyeing and cleaning industry: Occupational exposure to specified materials and conditions*

Materials and conditions	Percent of dry cleaners	Number of dry cleaners	Materials and conditions	Percent of dry cleaners	Number of dry cleaners
Chloroform	10.7	99	Carbon monoxide	1.1	10
Carbon tetrachloride	9.8	91	Cyanides	(1)	8
Ammonia	9.7	90	Other silicate dusts	(1)	7
Oxalic acid	7.5	69	Temperature variations	(1)	6
Benzine	6.7	62	Carborundum dust	(1)	[2]4
Benzol	6.4	59	Carbon bisulphide	(1)	3
Methanol	5.7	53	Picric acid	(1)	3
Manganese compounds	2.8	26	Lead compounds	(1)	1
Aniline compounds	2.5	23	Arsenicals	(1)	1
Hydrogen fluoride	1.6	15	Formaldehyde	(1)	1
Chlorine	1.2	11	Phenol	(1)	1

[1] Less than 1 percent.

[2] Machinists.

There were only 89 persons employed in the electroplating plants covered in this survey. Table 18 shows the exposures of the various occupations to the 11 materials common to this type of plant. It is evident from the results shown in table 18 that electroplating is the most important occupation from the viewpoint of the number of persons exposed and the number of materials handled, with dusts and cyanides offering the largest percentage of exposures.

TABLE 18.—*Electroplating industry: Occupational exposure to specified materials*

Materials	Percent of workers exposed in each occupation				Number of workers exposed in each occupation			
	All occupations	Electroplaters	Grinders	Assayers	All occupations	Electroplaters	Grinders	Assayers
Quartz dust	57.3	57.3	(1)	(1)	51	51	0	0
Cyanides	48.3	48.3	(1)	(1)	43	43	0	0
Emery dust	43.8	6.7	37.1	(1)	39	6	33	0
Carbon monoxide	37.1	32.6	(1)	4.5	33	29	0	4
Cadmium compounds	18.0	15.7	(1)	2.2	16	14	0	2
Hydrogen chloride	4.5	(1)	(1)	4.5	4	0	0	4
Ammonia	4.5	4.5	(1)	(1)	4	4	0	0
Carborundum dust	4.5	4.5	(1)	(1)	4	4	0	0
Mercury and compounds	2.2	2.2	(1)	(1)	2	2	0	0
Methanol	2.2	2.2	(1)	(1)	2	2	0	0
Lead compounds	2.2	(1)	(1)	2.2	2	0	0	2

[1] Less than 1 percent.

Owing to the fact that but few persons were employed in the small number of storage battery, rubber goods, and fur preparation plants embraced in this investigation, the results for these 3 types of industries are grouped together into 1 table (table 19). Only seven materials were used in these plants, lead compounds being the substances to which the largest number of persons were found exposed. Talc dust and benzol were the next in importance from the standpoint of numbers. The potential problems in these industrial plants are made obvious by the results of this study.

TABLE 19.—*Storage battery, rubber goods, and fur preparation industries: Occupational exposure to specified materials*

Materials	Storage battery workers		Rubber goods workers		Fur preparation workers	
	Percent	Number	Percent	Number	Percent	Number
Lead compounds	100.0	16	33.3	18	0	0
Benzol	0	0	51.8	28	0	0
Talc dust	0	0	0	0	21.0	30
Carbon monoxide	87.5	14	0	0	0	0
Turpentine	37.5	6	0	0	0	0
Quartz dust	0	0	0	0	4.9	7
Ammonia	0	0	0	0	4.2	6

In many of the industries it was found that certain occupations had an exposure to more than one material or condition of work. Table

20 shows this finding by industry, indicating the ratios of the number of exposures to the number of workers. It is apparent that in some of the smaller industries, such as in the electroplating and storage battery plants, where fewer persons were employed and hence had diversified duties, the ratio of exposures to persons is higher than in some of the larger plants, 3.3 and 2.3, respectively, although even in some of these industries, such as the metal products, printing, and chemical plants, the ratio of exposures to employed persons were found to be 1.3, 1.5, and 1.8, respectively.

TABLE 20.—*Ratio of number of exposures to specified materials and conditions in the various industries to number of workers employed*

Industry	Ratio of exposures to number of workers employed			Number of exposures		
	Male	Female	Total	Male	Female	Total
Metal products	1.3	1.2	1.3	16,128	1,370	17,498
Printing, etc.	1.7	0.8	1.5	3,110	343	3,453
Chemical	1.8	1.8	1.8	2,734	555	3,289
Clay, glass, and stone	0.7	0.0	0.7	892	0	892
Leather products	0.5	0.5	0.5	2,228	1,826	4,054
Dyeing and cleaning	1.1	0.7	0.8	350	416	766
Electroplating	3.4	0.0	3.3	297	0	297
Storage battery	2.3	0.0	2.3	36	0	36
Rubber goods	1.9	1.0	1.7	83	10	93
Fur preparation	0.3	1.0	0.3	41	2	43

An idea of the extent of the problem in the plants covered in this survey is afforded by the results presented in table 21. This table shows the number and percentage of exposures (not workers, since as just shown a worker was exposed at times to more than one material), to some of the important materials found in this study. Inorganic, nonmetallic dusts, of which there were 6 varieties, had the largest number of exposures, 7,862 (27.4 percent). Carbon monoxide came next, with 19.3 percent of the workers exposed to this gas, while lead compounds accounted for 10.2 percent of the total exposures. The other materials and their corresponding figures are listed in this table. It is evident that from the viewpoint of the kind of materials offering possibilities for future study, inorganic, nonmetallic dusts of the type listed, carbon monoxide, and lead compounds are the ones associated with the greatest percentage of exposures (57 percent). The problem as to materials and number of exposures is certainly indicated quite clearly in the data shown in table 21.

TABLE 21.—*Number and percentage of exposures to some of the important materials disclosed in survey*

Materials	Number of exposures	Percent of exposures	Materials	Number of exposures	Percent of exposures
Inorganic nonmetallic dusts	7,862	27.4	Lead compounds	2,926	10.2
Emery dust	3,678	12.8	Benzol	1,544	5.4
Quartz dusts	2,585	9.0	Turpentine	1,124	3.9
Carborundum dust	793	2.8	Benzine	995	3.5
Other silicates	403	1.4	Methanol	881	3.1
Talc dust	204	0.7	Aniline compounds	863	3.0
Asbestos dust	199	0.7	Cyanides	561	2.0
Carbon monoxide	5,538	19.3	Ammonia	477	1.7

With reference to the occupations with which an industrial hygiene program would have to concern itself, the results in table 22 are of some aid on this point. This table shows the number of exposures by occupation in the various industries. It is apparent that foundry workers, electrical workers, machinists, and shoe workers lead the occupational list in the number of exposures. Any program of industrial hygiene will certainly need to deal with the problems incidental to these occupations, for they obviously out-number the ones listed in table 22.

TABLE 22.—*Number of exposures by occupation to materials and conditions*

Industry	Occupation	Number of exposures in each occupation
Metal products	Foundry workers	3,617
Do	Electrical workers	2,959
Do	Machinists	2,861
Leather products	Shoe workers	2,532
Metal products	Light metal workers	2,273
Printing, etc	Printers and linotypers	2,035
Chemicals	Paint mixers	1,492
Metal products	Heavy metal workers	1,063
Chemicals	Chemical workers	814
Miscellaneous	Miscellaneous [1]	751
Do	Painters and woodworkers [1]	723
Do	Grinders [1]	648
Dyeing and cleaning	Dry cleaners	643
Printing, etc	Lithographers	299
Electroplating	Electroplaters	269
Rubber and leather products	Rubber cement workers	262
Clay, glass, and stone	Glass workers	192
Metal products	Wire workers	163
Chemical	Ink mixers	142
Clay, glass, and stone	Brick makers	140
Printing, etc	Etchers and engravers	135
Do	Photographers and photostaters	135
Clay, glass, and stone	Clay workers	128
Printing, etc	Electrotypers	121
Clay, glass, and stone	Granite cutters	92
Metal products	Welders	90
Printing, etc	Binders and paper cutters	90
Clay, glass, and stone	Roofers	88
Do	Kiln workers	69
Do	Marble cutters	67
Rubber goods	Rubber workers	46
Fur preparation	Fur workers	43
Storage battery	Storage battery workers	36
Clay, glass, and stone	Concrete workers	32
Chemical	Flower makers	27
Electroplating	Assayers	12
Clay, glass, and stone	Pottery workers	11
Leather products	Leather workers	10

[1] These workers engaged in several of the industries under survey.

In order to form an idea of the entire problem concerning the handling of various materials in the plants covered by this survey, the data in table 23 were prepared in a manner to show the number and percent of contacts in the 5 major industries, using only those materials in which the exposures were 10 percent or more. It is quite clear that in the metal products industry dusts (of the types listed elsewhere), carbon monoxide and lead compounds constitute the major potential problems; in the printing industry lead compounds, carbon monoxide, aniline compounds, and benzine are of importance from the standpoint of the population covered; whereas in the chemical plants the list includes dusts, lead compounds, aniline compounds, turpentine, manganese compounds, and benzine. In the clay, glass, and stone industry only one substance stands out—dust, while in the leather products industry, materials containing benzol are apparently the only substances of importance from the viewpoint of the number of exposures. It is apparent that dust is still one of the most important materials of industrial hygienic significance, with carbon monoxide and lead compounds closely following.

TABLE 23.—*Materials in the five major industries in which there were 10 percent or more exposures*

Industry	Materials	Percent of exposures	Number of exposures
Metal products	Inorganic, nonmetallic dusts	43.6	6,088
	Carbon monoxide	27.5	3,842
	Lead compounds	11.1	1,548
Printing	Lead compounds	37.7	871
	Carbon monoxide	28.6	660
	Aniline compounds	15.5	358
	Benzine	11.5	266
Chemical products	Inorganic, nonmetallic dusts	34.1	612
	Lead compounds	20.9	374
	Aniline compounds	14.4	258
	Turpentine	14.0	251
	Manganese compounds	11.3	202
	Benzine	10.4	187
Clay, glass, and stone	Inorganic, nonmetallic dusts	44.3	608
Leather products	Benzol	13.1	1,053

SUMMARY

The present study was undertaken for the purpose of determining the necessity of an industrial hygiene program in an industrial community, and, if such a need was present, to learn just where and to what extent the problems existed. With the aid of funds supplied by the Civil Works Act, it was possible to hire some 30 or more engineers, who were first given a brief training period in industrial hygiene methods, in general, and the technic of making preliminary surveys of an industrial environment, in particular. With the aid of two simple survey forms, designed for the purpose of obtaining data on industrial welfare provisions, processes, materials, and conditions associated with the various occupations, 615 plants were surveyed by 25 men, during a period of approximately 7 weeks. (The remaining

men were engaged in coding and checking the daily results of the surveys.) The 615 plants were divided into 10 main industries; the metal products industry was found employing the greatest percentage of persons, 13,955 out of a total of 28,686, or 48.7 percent. The leather products industry, consisting mostly of shoe factories, accounted for 28 percent of the personnel. The percentage distribution of the plants according to the number of workers employed showed that 48.7 percent of the plants had less than 10 employees and only 10.2 percent had 100 or more persons. These data compare very well with industrial plants in the United States, as a whole, since the United States census data for 1929 show practically the same kind of a distribution.

The information on such industrial welfare provisions as safety supervision, medical and nursing facilities, sick benefit associations, and disability statistics, disclosed some very interesting findings. Only 5 percent of the plants and about 20 percent of the workers were provided with the services of either a part or full time safety director and, as one might expect, most of these supervisors were found in the plants with 100 or more employees. The medical and nursing care was found to be in about the same status as the safety work. Seventeen percent of the workers had a part time medical supervisor and only 15.3 percent had the services of a full time physician. Nursing service of a full time nature was found to be present for 34.1 percent of the employees with practically no part time nursing service available. The only type of disability statistics existing to a great degree in the plants under study, was that of accident records, the keeping of which is compulsory by the provisions of the State Compensation Act. Sickness records were kept, embracing 40 percent of the population studied, with most of such records existing in establishments having sick benefit associations. This study revealed the fact that the larger plants, those employing 100 or more workers, had the greatest percentage of workers furnished with the listed industrial facilities. The so-called "small plant" was found lacking in those welfare provisions which have been found to play an important role in any constructive program of industrial hygiene.

The study of sanitary provisions disclosed the fact that 19.5 percent of the workers were found using the common towel and 13 percent were exposed to the potential hazard of the common drinking cup.

An analysis of the data on potential accident hazards showed that unguarded moving machinery was the most common potential source of accidental injury, 41 percent of the workers being exposed to this type of risk. Floor hazards ranked next, with 13.2 percent exposures, while 7.5 percent of the workers were not protected against the possibility of eye injuries from flying particles. A comparison of the percentage distribution of the potential accident hazards in this study, with corresponding percentages for compensated cases for the same

types of causes in New York State for 1931, showed a striking correlation. The possible benefits which may be derived from a safety program were brought out in an analysis which showed that in those plants where either a part or full time safety director was furnished to the workers, the percentage of persons found exposed to unguarded moving machinery was in practically all cases less than in those plants not having such safety personnel.

With reference to the number of persons in each occupation exposed to various materials and conditions, data were presented for each of the 10 groups of industries studied. These data showed 50 materials and conditions existing in the 615 plants investigated, 39 of which may be considered of a potentially hazardous nature from the viewpoint of possible systemic poisoning. This study shows that inorganic dusts, carbon monoxide, and lead compounds are still the most important materials of hygienic viewpoint confronting the industrial hygienist.

RECOMMENDATIONS

The preliminary survey of the industrial establishments reported in the present paper indicates that a large part of the industrial population of the area studied is handling materials, and is associated with processes and conditions of manufacture, which, if not given proper consideration, may lead to possible injury and ill health of the workers. It is the feeling of public health workers that the improvement of the general health status of the industrial worker is as much of a public health problem as the control of communicable diseases, or any other phase of preventive medicine. As a result of the numerous studies conducted on the health of the industrial worker by the United States Public Health Service, as well as other agencies in this country, it is now established that morbidity and mortality rates are higher for the general industrial population, and that certain occupations are of first importance as factors in the causation of excessive sickness and mortality rates.

That the general health of the worker in industry is affected by the materials, processes, and conditions incidental to employment, aside from what we already know about the role played by specific occupational diseases, is interestingly presented by Dr. Louis I. Dublin in one of his recent papers (*5*). In this study, Dr. Dublin evaluated the effects of the industrial environment on the well-being of a large number of workers in a mortality study among 3¼ million white male wage earners insured in the industrial department of the Metropolitan Life Insurance Co. The study covered the 3-year period 1922 to 1924, inclusive, and is compared to a similar study made in the 3-year period 1911 to 1913. The group studied constituted a fairly representative social and economic class, and was considered as an urban wage-earning population.

Dublin's study definitely showed that the adult males of this class had a higher mortality and a diminished longevity than those in the other forms of work (clerical, professional, etc.). Age for age the mortality rates for the industrial workers were found to be from one and one-half times to more than double the rates for the nonindustrial workers. In terms of life expectancy, the picture is even more impressive. The industrial worker at the age of 20 has an expectation of life of 42 years as compared to 49 years for the 20-year-old nonindustrial worker. In other words, the industrial worker's life is shortened by about 7 years. Dublin concludes that while heredity and innate differences play some part, probably the most important factors are the conditions incidental to industrial employment, such as toxic gases, dusts, specific occupational poisons, extreme temperature variations, and numerous other industrial hazards. When one considers the size of the industrial population of the region covered in this study and the results of the present survey on a sample industrial population of that region, in which the potentialities of occupational hazards are clearly brought out, the possibilities of the situation are quite evident, and certainly merit the attention of the local health department.

We now know the effect on the human body of various communicable diseases such as typhoid, smallpox, diphtheria, etc., and take the necessary measures to control them. The effect on health of certain toxic materials used in industry is also known, and it would seem logical to take appropriate measures for the control of these occupational diseases. We now know about some of the toxic materials and processes which may affect one's health. For example, it is known that exposure to more than 20 million particles of granite dust (35 percent quartz) per cubic foot of air will in time cause silicosis of a disabling type, usually followed by tuberculosis (*6*); that the breathing of more than 1.5 milligrams of lead per 10 cubic meters of air, in the form found in lead storage battery plants, will in time lead to serious types of plumbism (*7*). In short, if these various materials and processes are not controlled they will affect the health of the individuals exposed to them, and in the case of a disease such as tuberculisis, others in the community may be affected.

The improvements in health and longevity which may be brought about by a preventive program are exemplified by the study of Dr. Dublin, just cited (*5*). It will be recalled that the mortality rates of industrial workers for the period of 1922–24 were compared with similar statistics for the period of 1911–13. The comparison with the earlier study shows that the industrial worker's general health status had greatly improved at the end of 1924. In terms of life expectancy, an average increase of 5 years may be noted for each industrial worker at age 20, occurring during the period of 1913–24.

According to Dr. Dublin, who is responsible for this analysis, the factors which aided in bringing about this improvement in the health and longevity of industrial workers are preventive industrial medicine, safety programs, education of employers and employees regarding the dangers inherent in certain occupations, decrease in hours of labor, and improved standards of living.

It may be said that occupational disease problems should and could be solved by industry itself. It is the feeling of students of this problem that such a procedure is no more feasible than the attempt of an individual to control communicable diseases in his own home, or industry, the pollution of streams. Industrial hygiene is now recognized as a major public health function, affecting directly the health of a large population and indirectly the well being and economic status of the entire community. The fact that industry will benefit by the control of occupational diseases should be considered as merely incidental. No industry is large enough to employ the personnel and facilities necessary for industrial hygiene work. And one must not lose sight of the fact that this study shows that in the present case, as well as in the country in general, the largest percentage of the industrial population is employed in small plants (nearly 50 percent of the plants in this survey employs less than 10 persons), and the greatest need is for these small plants which are incapable of dealing with their problems individually. A health department, with its public health commissioner, epidemiologist, public health nurse, sanitary engineer, bacteriologist, chemist, laboratory technicians, etc., all in one compact unit, is the only practical body equipped to conduct work of a preventive nature in industry.

The practice of industrial hygiene (control of occupational diseases) falls largely within the province of two types of workers, the physician and the engineer. It is within the sphere of the physician to diagnose occupational diseases and, primarily, to recognize the existence of those diseases due to the factory environment. Based on the findings of the physician, the engineer is in a position to learn where control measures are to be initiated. The engineer's work consists of studying the local plant conditions which have been shown to be detrimental to health and evaluating the various methods which may be designed for controlling the hazards. It is impossible to tell by a mere inspection of a workroom whether toxic materials in the air are present in such quantities as to constitute a hazard and whether the protection afforded is adequate. Precise quantitative measurements are needed. Once these measurements have been made, the engineer is able, with the aid of a knowledge of the toxicity of the materials studied, to determine definitely the extent of the hazard and the necessary remedial measures.

In order to inaugurate a constructive program of industrial hygiene it is felt that the following minimum personnel requirements are needed. As the program develops additional personnel may be required.

a. A physician thoroughly trained in public health procedure and one having a comprehensive knowledge of the effects upon health of the various materials and processes used in industry; in other words, one trained in industrial hygiene.

b. An engineer who is also trained in industrial hygiene and who is familiar with industrial processes. This person should know the following subjects from both a theoretical and practical viewpoint:

1. Microscopy.
2. Gas chemistry.
3. Mechanics of ventilation.
4. Physiology of ventilation.
5. Industrial sanitation.
6. Illumination.
7. Industrial hygiene survey methods.
8. Occupational disease literature.

c. A completely equipped laboratory for carrying on industrial hygiene studies in industry is essential in such a program.

With the personnel and facilities just cited, the following program could be inaugurated:

1. Reporting of all occupational diseases to the division carrying on industrial hygiene work. This will definitely establish where and to what extent certain occupational diseases are occurring, and to suggest corrective measures.

2. In order to acquaint industry, the medical profession, and others interested in such a program, it may be necessary that the personnel concerned with industrial hygiene carry on an educational campaign, designed to acquaint and interest the various groups involved as to the importance of the problem, in an effort to further the program. It has been the experience of other health departments that the best way to conduct work in industrial hygiene is to cooperate fully with industry, conducting studies in plants, as a rule, only upon request of industry. At the completion of such studies a confidential report on the results should be presented to the plant officials, this report also including recommendations for the improvement of conditions, if such information is necessary and available. All this should be made very clear to the individuals concerned in order to obtain the cooperation and aid necessary for such work.

3. Studies of the workroom environment and the health of workers by the industrial hygiene personnel as outlined in no. 2.

4. In order to carry on this work with the minimum amount of friction and in a spirit of cooperation, it may be necessary to provide a law or regulation which specifically states that the results of any investigation made by the health department can in no way be used in litigation, either by the employer or by the employee. The need for such a ruling is obvious if the interests of all concerned are to be served justly. Attention is called to the act under which the Bureau of Occupational Diseases of the Connecticut State Department of Health functions, as well as to the excellent work this Bureau is accomplishing in the control of occupational diseases in that State (*8*).

The additional cost for maintaining industrial hygiene personnel of the number and type given in this program would not exceed $10,000 a year, or slightly more than 1 cent per capita in the present case. When one realizes the fact that one case of silicosis often costs more than the $10,000 needed for a preventive program of the type outlined herein, the financial phase of the problem should certainly not preclude the establishment of such a vital adjunct of a health department in a large industrial center.

In closing, it is well to emphasize one important point; namely, that occupational diseases are in a large measure preventable and the degree of prevention exercised by a community will be reflected in the general health status of that community.

REFERENCES

1. 15th Census of the U. S. Census Bureau: Occupations by States, vol. 4, 1930.

2. Brundage, D. K., and Bloomfield, J. J.: The Pneumonia Problem in the Steel Industry. Jour. Ind. Hyg., vol. 14, no. 10, Dec., 1932.

3. Causes of Compensated Accidents, Two Years, 1930 and 1931. Special Bulletin, No. 182, Department of Labor of the State of New York, 1933.

4. Dublin, Louis I., and Vane, Robert J.: Occupational Hazards and Diagnostic Signs. U. S. Bureau of Labor Statistics Bulletin No. 582, 1933.

5. Dublin, Louis I.: The Mortality Trend in the Industrial Population. Am. Jour. Pub. Health, vol. 19, no. 5, May 1929.

6. Russell, A. E., Britten, R. H., Thompson, L. R., and Bloomfield, J. J.: The Health of Workers in Dusty Trades. II. Exposure to Siliceous Dust (Granite Industry). Pub. Health Bull. No. 187, 1929.

7. Russell, A. E., Jones, R. R., Bloomfield, J. J., Britten, R. H., and Thompson, L. R.: Lead Poisoning in a Storage Battery Plant. Pub. Health Bull. No. 205, 1933.

8. Necessity for Bureau of Occupational Diseases, Connecticut. Connecticut State Department of Health (Hartford), 1933, 20 pp. plus appendices.

No---------- Date----------

INDUSTRIAL HYGIENE AND SANITATION SURVEY—MANUFACTURING GROUP

PLANT SURVEY FORM

1. GENERAL:
   Name of plant---------- No. workrooms----
   Address----------
   Kinds of products manufactured----------

   Number and types of buildings----------
   ----

2. REMARKS:

	Yes	No
3. INDUSTRIAL WELFARE:		
Safety provisions:		
Director or safety engineer		
Part time		
Full time		
Shop committees		
Is safety work delegated to foremen and other persons?		
Medical provisions:		
First aid room		
Plant physician:		
Part time		
Full time		
Nursing service		
Part time		
Full time		
4. DISABILITY STATISTICS:		
Sick benefit association		
Records covering nature of disability and time lost:		
Sickness		
Accident		

No.---------- Date----------

INDUSTRIAL HYGIENE AND SANITATION SURVEY—MANUFACTURING GROUP

WORKROOM SURVEY FORM

1. GENERAL:
   Name of plant---------- Bldg. no.----------
   Work performed in this room----------
   ----

2. GENERAL SANITARY FACILITIES:

Personal service rooms:	Yes	No
Lunchroom		
Cloakroom		
Washing facilities:		
Common towel		
Toilets:		
In workroom		
Separate room		
Outdoors		
Drinking water:		
Bubbling fountain		
Other		
Common drinking cup		

3. ACCIDENT EXPOSURE:

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4. FUMES AND GASES:

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5. OTHER POISONS:

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6. DUSTY PROCESSES:

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7. JOB ANALYSIS:

Code no.	Name of occupation	Number of persons		Nature of job	Raw materials	End product
		M	F			