UNITED STATES DEPARTMENT OF LABOR
Frances Perkins, *Secretary*

BUREAU OF LABOR STATISTICS
Isador Lubin, *Commissioner* (on leave)
A. F. Hinrichs, *Acting Commissioner*

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Injuries and Accident Causes in the Foundry Industry, 1942

Bulletin No. 805

[Reprinted from the Monthly Labor Review, December 1944, with additional data]

Letter of Transmittal

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington 25, D. C., December 11, 1944.

The SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the occurrence and causes of work injuries in the foundry industry during 1942. This report was prepared by Frank S. McElroy and George R. McCormack in the Industrial Hazards Division, under the direction of Max D. Kossoris, chief.

A. F. HINRICHS, *Acting Commissioner.*

Hon. FRANCES PERKINS,
Secretary of Labor.

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United States Bureau of Labor Statistics

[Reprinted from the MONTHLY LABOR REVIEW, December 1944, with additional data]

Injuries and Accident Causes in the Foundry Industry in 1942

The Industry Record

It has long been recognized that foundry work includes some of the most hazardous operations found in any manufacturing activity. Reflecting these occupational hazards, the frequency of disabling industrial injuries in independent[1] iron and steel foundries, for which the Bureau of Labor Statistics regularly compiles accident statistics, has consistently been more than double the national average for all manufacturing. A comparison of the records for this group and for all manufacturing, for the 5 years 1939 to 1943, follows:

	Injury-frequency rates[1]	
	Independent iron and steel foundries	*All manufacturing*
1939	35. 9	14. 9
1940	36. 1	15. 3
1941	47. 0	18. 1
1942	49. 7	19. 9
1943	43. 4	20. 0

[1] Average number of disabling injuries per million man-hours worked.

In 1942, the year selected for detailed study, nearly 50 workers in independent iron and steel foundries experienced disabling industrial injuries in the course of every million employee-hours worked. This rate, which represents about 1 disabling injury for every 9 full-year employees, was exceeded in only 4 of the 109 other manufacturing industries for which data were available.[2]

Coverage, in the present detailed study, was extended to include not only the independent iron and steel foundries, but also foundries using nonferrous metals and the foundry departments of establishments which are normally considered part of other industry groups. The participating foundries were classified into three major groups: Ferrous job foundries, nonferrous job foundries, and other than job (or non-job) foundries. For more specific comparisons the ferrous job foundries were further divided into gray-iron foundries, malleable-iron foundries, steel foundries, and cast-iron pipe foundries.

[1] Independent in the sense that they are exclusively foundry establishments. Both job and production foundries are included, but foundry departments which constitute a part of a larger manufacturing establishment are not included in this group.

[2] Manufacturing industries with 1942 frequency rates higher than that of iron and steel foundries were logging 89.6, sawmills 61.7, fiber boxes 55.3, and wooden containers 50.2. (See Bureau of Labor Statistics Bulletin No. 758: Industrial Injuries in the United States During 1942.)

The reporting units included 850 ferrous job foundries, 441 nonferrous job foundries, and 897 non-job foundries, most of which were departments of larger manufacturing plants. In the aggregate these 2,188 foundries had nearly 246,000 employees who worked more than 553 million employee-hours in the course of the year. The total volume of disabling injuries reported was 25,363, of which 92 resulted in death, 30 resulted in permanent total disabilities which will prevent the injured persons from ever again engaging in any normal occupation, 680 caused permanent physical impairments, and 24,561 resulted in temporary disabilities involving an average time loss of 15 days each. In the ferrous job foundries, approximately 1 in every 8 employees experienced a disabling injury during the year. In the nonferrous job foundries and also in the non-job foundries the ratio was about 1 disabling injury for every 12 employees. (See table 1.)

Reflecting the inclusion of additional types of operations, the average injury-frequency rate for the entire group of reporting foundries was 45.8, as compared with the previously mentioned frequency rate of 49.7 for independent iron and steel foundries. For purposes of analysis, however, the variations among the different types of foundry operations are much more enlightening than the general averages.

The nonferrous job foundries, with an average of 35.3 disabling injuries for each million employee-hours worked, had the best injury record among the several groups. It should be noted, however, that even though this was the lowest of the foundry averages it was still 75 percent higher than the average for all manufacturing.

The non-job foundries, consisting mostly of foundry departments of plants primarily devoted to other activities, had the next highest average frequency rate, 37.3. It was characteristic of the departmental foundries that those which were attached to industries which normally have low injury-frequency rates had better safety records than similar foundry departments of the industries with higher rates. As the operations performed were generally quite comparable, it seems reasonable to infer that these differences were the result of variations in the amount of attention devoted to safety rather than differences in the prevailing hazards.

The entire group of ferrous job foundries included in this study had an average frequency rate of 52.0. Within this group, however, the gray-iron foundries had an average of 55.8 disabling injuries per million employee-hours worked, the highest for any type of foundry operations; the steel foundries had an average of 50.8, the malleable-iron foundries 49.3, and the cast-iron pipe foundries 46.2.

In addition to reporting the lowest injury frequency, the nonferrous job foundries also reported a much lower proportion of fatal cases than either of the other foundry groups. In part, the lower frequency rate as well as the lower proportion of serious injuries in the nonferrous job foundries probably was due to the lighter type of work done there. The highest proportion of serious injuries, both fatalities and permanent impairments, occurred in the non-job foundries, but no specific reason for this tendency was noted. As between the ferrous job foundries and the non-job foundries, there was little difference in frequency rates for serious injuries. The ferrous job foundries, on the other hand, had a much higher frequency of temporary disabilities than the non-job foundries.

A possible explanation of the difference in the frequency of injuries causing temporary total disability is that many of the non-job foundries were departments of larger plants which have medical units that give treatment for injuries on the premises and on company time. In such plants many injured workers have their injuries treated and return to work without chargeable absence from the plant. Such injuries would not be reported as disabling under the standard definition of a disabling injury, as they involve no lost time beyond the day of injury. Among the ferrous job foundries, on the other hand, many are of insufficient size to maintain a medical office, and treatment for injuries must be obtained outside the plant. As a result, in numerous cases injuries which merely need redressing or observation on days following the day of injury may require the employee to remain away from work in order to obtain treatment. Consequently, certain injuries must be counted as disabling and therefore be included in the frequency rates of some plants, whereas identical cases in other plants are classed as nondisabling and are excluded from the frequency rates, depending entirely upon the availability of medical attention at the workplace. It is possible therefore that, as the frequency of fatalities and permanent impairments (which is not affected by the factor of lost time) was approximately the same for both the ferrous job foundries and the non-job foundries, the considerable difference in the frequencies of temporary total disabilities for the two groups may have been due at least in part to differences in plant medical facilities and not entirely to differences in the actual number of injuries.

Basically, however, the difference between the frequency rates of the ferrous job foundries and the non-job foundries lies in the fact that most of the latter group are production foundries. Non-job foundries usually produce hundreds of identical castings and are organized and equipped for standardized mass production. The work in these foundries is highly mechanized and each step is more easily engineered for efficiency and safety than in the job foundries. The procedures are subdivided and workers are trained in the performance of standardized operations, which leads to a high degree of understanding at each stage in the process. This mechanization, engineering, and high degree of familiarity with the individual operations can do much to overcome the inherent hazards of foundry work and is largely the reason that non-job foundries have better safety records than job foundries. In addition, the departmental foundry has the advantage of sharing in the benefits of over-all plant medical and safety programs, which are more difficult to maintain in an independent and smaller establishment.

In job foundries, on the other hand, the items produced are continually changing. Frequently only one casting will be made in a particular design. Standardization of the operations is, therefore, impossible and the workers must be trained as craftsmen capable of undertaking a wide variety of operations rather than as specialists. The possibilities of mechanization are limited and a very large part of the work must be performed manually by procedures worked out on the spot as the occasion arises. This condition necessitates the employment of skilled journeymen who have had training in all branches of foundry work and are capable of handling each job through every stage of production. In the smaller job foundries it is common procedure for a single journeyman to perform or direct all operations involved in making a particular casting or set of castings. In the larger job foundries some degree of specialization is possible, however, and the journeymen are assigned to particular phases of the work such as patternmaking, coremaking, molding, or crane operating. Competent journeymen generally have served a formal 4-year apprenticeship. Much of the work in job foundries, however, is performed by laborers or helpers, who have been given little training and who work under direct supervision of the journeymen.

TABLE 1.—*Injury Rates and Extent of Disability, Classified by Kind of Foundry, for 2,188 Foundries, 1942*

Kind of foundry [1]	Number of establishments	Number of employees	Employee-hours worked (in thousands) [2]	Number of disabling injuries				Total time lost (days)	Injury rates [4]		Average days lost per temporary total disability
				Total	Resulting in— Death and permanent total disability [3]	Permanent partial disability	Temporary total disability		Frequency	Severity	
Total	2,188	245,786	553,175	25,363	(30) 122	680	24,561	1,694,547	45.8	3.1	15
Ferrous job foundries	850	143,875	325,692	16,948	(13) 70	415	16,463	1,017,250	52.0	3.1	15
Gray-iron	652	52,830	119,705	6,675	(5) 31	153	6,491	403,925	55.8	3.4	14
Malleable-iron	53	20,672	44,233	2,180	(2) 5	57	2,118	112,596	49.3	2.5	16
Steel	105	57,660	132,707	6,744	(5) 30	157	6,557	390,781	50.8	2.9	15
Cast-iron pipe	37	12,482	28,533	1,319	(1) 4	45	1,270	107,302	46.2	3.8	16
Nonferrous job foundries	441	14,052	32,147	1,134	1	31	1,102	52,084	35.3	1.6	15
Other than job foundries	897	87,859	195,336	7,281	(17) 51	234	6,996	625,213	37.3	3.2	15

[1] Totals include figures for items not shown separately because of insufficient data.
[2] Totals based on unrounded data.
[3] Figures in parentheses indicate the number of permanent total disability cases included.
[4] The frequency rate is the average number of disabling injuries for each million employee-hours worked. The severity rate is the average number of days lost for each thousand employee-hours worked.

Although the group averages present a relatively unfavorable picture of safety achievement in the foundry industry, the individual plant records indicate that safety is not an impossible goal in any foundry. Over 24 percent of the ferrous job foundries, 63 percent of the nonferrous job foundries, and 29 percent of the non-job foundries had no disabling injuries in 1942. It is true that most of the plants which had zero frequency rates were small, but among them there were a number of plants which regularly employed over 250 workers each. An additional 10 percent of the ferrous job foundries, 6 percent of the nonferrous job foundries, and 14 percent of the non-job foundries had frequency rates which were lower than the 1942 national average of 19.9 for all manufacturing.

In sharp contrast, a considerable number of plants in each of the groups had frequency rates of over 100. Most of these plants were also small, but there were some plants which employed over 500 workers in this extremely high rate group. Generally speaking, however, the very small foundries with fewer than 24 employees and large foundries employing 500 or more employees had the lowest average frequency rates.

In all three classes of foundries the most hazardous departments were shake-out, melting, and cleaning, chipping, and finishing. The record of the molding departments was about average in each group. Pattern shops and core rooms had the lowest injury-frequency rates among the principal operating departments.

In addition to providing summary reports, which were included in the general study of injury-frequency rates, 66 of the ferrous job foundries also supplied details concerning each of their reported accidents.[3] The 4,600 cases reported were analyzed according to the "American Recommended Practice for Compiling Industrial Accident Causes" as approved by the American Standards Association. Strictly speaking, the conclusions drawn from this analysis apply only to gray-iron, malleable-iron, and steel job foundries, as no other types of foundries participated in this part of the study. In general, however, it appears safe to say that the experience of these three types of job foundries is fairly representative of all ferrous foundries and, to a somewhat less extent, may be considered as similar to that of the nonferrous foundries.

A Bureau agent visited each of these foundries, and, insofar as possible, transcribed from their records the following items regarding each injury: Age, race, and experience of each person injured; place where the accident occurred and time it occurred; nature and extent of the resulting injury; type of accident; unsafe condition and unsafe act which led to the accident; and the object or substance (agency) which caused the injury. A brief record was also made of the safety activities of the different plants and of the first-aid or medical facilities provided on the premises. In some instances, however, all of the desired details were not available. For this reason, the number of cases analyzed in respect to particular accident factors varies considerably. All parts of the analysis, however, are based upon the records of at least 58 foundries. Of the foundries visited, 31 were gray-iron or cast-iron pipe foundries; 24 were malleable-iron foundries; and 11 were steel foundries. The entire group employed approximately 40,000 workers, and their records included the details relating to over 4,600 disabling injuries. The plants were located in 22 States, providing a cross section representing all regions except the Mountain Region.

The detailed analysis indicated that 26 percent of the disabling foundry injuries were foot and toe cases, 23 percent were hand and finger injuries, 10 percent were eye injuries, 12 percent were back injuries, and 10 percent were other trunk injuries. The greater part of the injuries to toes, feet, hands, and fingers consisted of cuts, sprains, bruises, or fractures resulting from mishandling of heavy materials. Most of the eye injuries were cuts or lacerations inflicted by flying particles, and nearly all of the back injuries were strains or sprains resulting from lifting excessive weights or lifting improperly. Burns, however, were quite numerous and affected all parts of the body. Poor housekeeping and the lack of proper personal safety

[3] Tables 1 to 4 of this report are based upon the general reports furnished by 2,188 establishments; tables 5 to 14 are based upon the detailed analysis of the records of the 66 foundries visited by the Bureau's representatives.

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equipment for use in hazardous operations were the outstanding unsafe working conditions which led to the injuries. On the personnel side, the outstanding unsafe acts which contributed to the occurrence of injuries were (1) using unsafe equipment or using equipment improperly, (2) assuming an unsafe position or posture, (3) failing to wear safe clothing or provided safety equipment, and (4) unsafe lifting.

Departmental Differences

Although most of the hazards encountered in foundry work are directly connected with particular operations and, therefore, are of primary concern to the workers engaged in those specific operations, there are certain hazards which in some degree must be faced by all foundry workers regardless of their assignments. Practically all workers in foundries at times must move, or assist in moving, heavy materials and thereby are exposed to the possibilities of sprains, or crushed fingers or toes. Nearly all workers on the foundry floor at times must work in proximity to pouring operations and are thus exposed to injury from spilled or splashed molten metal. The movement of heavy materials is frequently accomplished by means of overhead cranes which may swing their loads over the heads of workers who are unaware of the imminent possibility of materials falling upon them. Improperly piled materials present dangers to any workers who approach them. Many parts of foundries are always quite warm while other sections may be cool or even cold, and these differences in temperature present the possibility of chills to all workers who must move around the plant. The hazard of contracting silicosis from the silica dust dispersed in molding and cleaning operations may also affect all workers on the foundry floor regardless of their occupations. It should be noted, however, that relatively few cases of this industrial disease were reported in the survey. As this low volume of silicosis cases is contrary to the viewpoint frequently expressed by commentators upon foundry hazards, particular care was taken to insure that no cases on record in the plants visited were omitted. It is possible, of course, that because of its gradual onset and the similarity of its symptoms to those of other nonindustrial diseases some cases of silicosis may go unrecognized. There was, however, no ground for doubting the completeness of the records of these cases, as silicosis is usually a compensable disease; and all cases which had been so diagnosed would of necessity be formally recorded and reported to the State workmen's compensation commissions.

Departmental organization in the foundries which participated in the survey varied widely—from none at all in the small plants to as many as 20 departments in the larger plants. For this reason there were many differences in the number of units and in the operations and occupations included in the various departmental groups. This was particularly true in respect to the operations performed by unskilled and semiskilled workers. Generally speaking, however, foundry operations naturally break down into five related but distinct procedures which form the basis for the departmentalization usually found. These most commonly reported departments were pattern shops; core rooms; molding departments; melting departments; and cleaning, chipping, and finishing departments. Other departments frequently reported separately included maintenance departments, shipping departments, storage departments, and shake-out departments.

In all three classes of foundries the most hazardous departments were shake-out; melting; and cleaning, chipping, and finishing. The record of the molding departments was about average in each group. Pattern shops and core rooms had the lowest injury-frequency rates among the principal operating departments.[4]

PATTERN SHOPS

The first step in making a casting is to prepare a full-scale model or pattern of the desired casting. These patterns are usually made from wood, although metal, plaster of paris, or rubber may be used in some instances. Pattern shops, therefore, are generally woodworking establishments.

Much of the work of making wood patterns requires very close fitting and finishing in which hand tools, such as chisels, gauges, knives, spokeshaves, saws, planes, drills, hammers, screw drivers, try squares, and measuring devices, are used. Many of these tools have sharp cutting edges and when mishandled can inflict severe wounds. The most serious hazards are encountered, however, in the operation of power-driven woodworking machines, such as saws, lathes, planers, boring machines, jointers, and sanders. Generally speaking, the greatest danger involved in the use of these machines is that the operator may bring his hand into contact with the cutting parts as he feeds the stock at the point of operation. There are, however, various types of guards for these machines which make it nearly impossible for such accidents to occur when guards are properly applied and used.[5]

When patterns are to be used repeatedly, however, they are often made from metal. Common practice in making metal patterns is to construct a wooden pattern first and from this cast the metal pattern. In many instances, however, the practice is to cut metal patterns from solid metal blocks. When this procedure is followed the pattern shop takes on all the characteristics of a machine shop, and most of the work is performed upon metalworking machines such as milling machines, shapers, planers, drill presses, engine lathes, grinders, and power-driven hacksaws. Each of these machines presents some "point of operation" hazard to the fingers and hands of the operators. The heavier materials used in metal-pattern shops also present a crushing hazard to fingers or toes, if they are mishandled or dropped.

In comparison with the experience of the other major operating departments, the frequency rates of the pattern shops were relatively low. In the ferrous job foundries the wood-pattern shops had an average frequency rate of 21.2 disabling injuries per million employee-hours worked, while the metal-pattern shops had an average rate of

[4] For a detailed description of foundry processes and procedures see Job Descriptions for Job Foundries, prepared by the Job Analysis and Information Section, Division of Standards and Research, United States Employment Service (U. S. Government Printing Office, Washington), 1938; and The Making, Shaping, and Treating of Steel, by J. M. Camp and C. B. Francis (Carnegie-Illinois Steel Corporation, Pittsburgh Pa.), 1940.

[5] For a more detailed discussion of the hazards of woodworking see Causes and Prevention of Injuries in the Manufacture of Lumber Products, 1941, in Monthly Labor Review, November 1942, p. 960 (or Bureau of Labor Statistics pamphlet, Serial No. R. 1491).

29.8. In the non-job foundries the rates were lower, but the relationship was reversed, the wood-pattern shop average being 15.0 compared with an average of 7.4 in the metal-pattern shops. In the nonferrous foundries the average frequency rate for all pattern shops was 20.9. It is pertinent to note that 1 in every 9 of the injuries reported in wood-pattern shops resulted in some form of permanent impairment. (See table 2, p. 17.)

Finger injuries were more numerous in the pattern shops than were injuries to any other part of the body, with foot and toe injuries constituting the second most important group. The frequency of finger injuries in these departments reflects the use of power tools, particularly powered woodworking tools, and points to a need for greater emphasis upon the proper guarding of such equipment. The relatively high proportion of foot and toe injuries is somewhat surprising, and indicates that the desirability of more general use of safety shoes should not be overlooked in this department. (See table 7, p. 31.)

CORE ROOMS

Cores are simply patterns which reproduce the openings or hollow spaces that are desired in the finished casting. When a mold of the solid pattern has been made the cores are fixed in place within the opening and the molten metal is poured in around them. Cores must possess three essential characteristics. They must be sufficiently cohesive to retain their shapes while being placed and while the metal is being poured; they must be highly refractory to stand up under the intense heat of the molten metal; and they must be capable of being easily broken up so that they can be removed from inside the finished casting. Various materials are used in making cores, but the dry-sand core is the most common type. In general the process of core-making consists of mixing sand with a binder material, such as flour, powdered resin, linseed oil, or a mixture of molasses and water, and of tamping this mixture into molds which give it the desired shape. The molded cores are then baked or dried to make them hard. Cores may be shaped by hand-ramming the sand into a core box; by the use of a conveyor-screw core-making machine, which is similar in appearance to a meat grinder and which is used to compact the sand into bar-like cores of uniform cross section; or by the use of a core-turnover-draw machine, which compacts the sand into the core boxes by jarring and jolting.

A variety of hand tools, such as mallets, trowels, shovels, pliers, core boxes, clamps, core plates, and compressed-air blowers for cleaning, are used in core rooms. Various machines, and other mechanical equipment, such as sand-mixers, conveyors, wheelbarrows, baking ovens, and molding machines, are also commonly used in this department. The hand tools used are not particularly hazardous, but the machines which may be used frequently present serious possibilities of injury to hands and arms from contact with moving parts. Burns from contact with hot ovens or oven trays are common.

Generally, core making is not considered very heavy work. The metal core boxes and core plates, however, are sometimes fairly heavy and present lifting hazards and the possibility of pinched or crushed fingers or toes, if they are mishandled or dropped.

The frequency of injuries reported for the core rooms was somewhat greater than that for the pattern shops, but was less than that for any of the other major departments. In the ferrous job foundries the core rooms had an average of 30.9 disabling injuries for each million employee-hours worked. In the nonferrous job foundries the average frequency rate for core-room work was 12.7, and in the non-job foundries it was 18.6. (See table 2, p. 17.)

Injuries to hands, fingers, feet, toes, and backs were outstanding among the reported injuries to core-room workers. Injuries in these categories are all closely related to the use of hazardous machines or to the handling of heavy, bulky, or awkward materials, and indicate a need for better machine guarding and for careful planning and training of the workers in the operations they must perform. The volume of foot and toe injuries also indicates that the use of safety shoes or foot guards might well be emphasized in the core rooms. (See table 7, p. 31.)

MOLDING DEPARTMENTS

Although permanent metal molds are sometimes used when many identical castings are to be made, the common practice is to prepare individual sand molds for each casting. Briefly, the process of making a sand mold consists of compacting sand around a pattern and then withdrawing the pattern so as to leave an opening in the sand which reproduces the outside contours of the pattern. Cores, which are solid reproductions of the hollow spaces desired within the finished casting, are then fixed in their proper places inside the opening in the sand and sufficient molten metal to fill the opening is poured in and allowed to harden.

The first step in making a mold is to prepare the sand by mixing it with binder materials such as clay and water. This is frequently done by hand-mixing with a shovel, but in the larger foundries sand-mixing machines or mullers are commonly used. In either case the work is comparatively heavy, because the sand usually must be moved several times in the course of the operation. Aside from the hazard of overlifting, the chief danger in mixing the molding sand is that of coming into contact with the moving parts of the mixing machines.

When the sand and binder have been mixed to the proper consistency the pattern is placed inside a frame, called a flask, and the sand is firmly rammed into place around the pattern. To facilitate the subsequent withdrawal of the pattern, both the pattern and the flask are generally divided into two sections. The bottom, or drag, section of the flask is usually rammed first in an inverted position. Then the drag is turned over and the upper, or cope, section placed on top and the packing of the sand is completed. The cope section is then removed from the drag, the pattern sections are withdrawn from the sand, and any necessary cores are placed in position within the opening left by the pattern. Then the cope is replaced upon the drag and the two sections are firmly clamped together ready for the pouring of the metal, which is introduced into the mold cavity through a channel or gate cut through the sand. In job foundries these operations are generally performed by hand. In production foundries, however, machines are commonly used to compact the sand, withdraw the patterns, and sometimes to turn over the flask sections. The principal hazards connected with hand molding are those arising from lifting and moving the flasks, which are frequently very heavy. The same hazards prevail in machine molding, with the added danger of contact with the moving parts of the machines.

When the mold has been completed and placed in position for pouring, the molten metal is drawn from the furnace and transported to the mold in a ladle. For small castings a ladle with a capacity of about 80 pounds is used. These small ladles have a single long handle and are carried by one man. For larger castings requiring up to 300 pounds of molten metal, bull ladles, which have double end shanks so that they may be carried by two men, are used. Ladles of this size are frequently supported by a hoist during pouring and are often moved by means of a monorail crane or on a wheeled carriage. Either of the latter methods relieves the workers of the necessity of lifting and holding the heavy ladle, but it still must be pushed into position. Large ladles, with a capacity up to about 50 tons, are transported by overhead cranes, and a geared mechanism is used to tilt them for pouring.

The greatest hazard connected with pouring operations is that of severe burns from contact with the molten metal which may splash or spill as it is being carried or poured, or may overflow if the mold is poured too full, or may even break out of the mold if the mold is not properly vented so as to permit the escape of gases formed by the contact of the molten metal with the sand. It is recognized as essential, therefore, that workers engaged in pouring operations should wear goggles and insulated clothing, particularly leggings, gloves, and molder's-type safety shoes, which can be pulled off instantly in case molten metal should get inside them. It is also important to maintain good housekeeping in the pouring area to avoid the possibility of bumping the ladle against improperly placed materials and to eliminate tripping hazards which might cause the ladle carriers to spill the metal. Only workers who are participating in the pouring should be permitted to be within the range of a possible spill, and all steps in the pouring should be under close supervision.

The removal of the casting from the mold after the metal has solidified and cooled sufficiently to be handled, generally termed shake-out work, is commonly a function of the molding department although it is not unusual for this work to be assigned to a general-labor department or even to be constituted as a separate department in large foundries. This operation consists of opening the flask and removing the sand, pulling the casting from the sand, shaking off any adhering sand, breaking out the cores, transporting the castings to the finishing department, and returning the flasks and sand to stock. Jolting machines are sometimes used to loosen the sand, but usually the only equipment used consists of sledges, mallets, bars, shovels, wedges, wheelbarrows or hand trucks, and, when the castings are large, hoists or cranes. The principal hazards are those involved in handling heavy, rough, and sharp-edged materials. Safety shoes and gloves are generally considered to be essential equipment in this operation.

In terms of total employment the molding departments constitute the largest of the foundry operating sections. The experience of the molding departments, therefore, has a great influence upon the overall average frequency rate for foundry operations. This is apparent from the fact that in all three of the foundry groups the average frequency rates for the molding departments closely approximated the average rates for all operations. Nevertheless, the average frequency rates for the molding departments are considerably higher than the averages prevailing in most other industries and approach the level which is generally considered very high. In the ferrous job foundry group the average for the molding departments was 59.7 disabling injuries per million employee-hours worked; in the nonferrous job foundries the molding department average was 34.2; and in the non-job group it was 43.0. In some of the ferrous job foundries and in some non-job foundries it was possible to report shake-out work separately. The resulting frequency rates for this particular operation strikingly emphasize its extreme hazards. In the ferrous job foundries shake-out work had an average of 110.3 disabling injuries per million employee-hours worked and in the non-job foundries it had a comparable average rate of 85.9. Each of these was the highest rate recorded for any operation in its group. (See table 2, p. 17.)

The high proportion of injuries to the lower extremities reported for the molding departments points to a need for greater emphasis upon the use of footguards, safety shoes, and leggings. Similarly the large volume of hand and finger injuries indicates need for more general use of gloves and for better training in the safe procedures in handling materials. Back injuries were very common in this department, a situation which points to a need for more instruction in the proper methods of lifting and closer supervision to see that the proper methods are used. Eye injuries were also quite numerous, indicating that more extensive use of goggles would be highly desirable. (See table 7, p. 31.)

MELTING DEPARTMENTS

Most common among the various types of melting furnaces used in foundries are the cupola, the crucible, the reverberatory, the electric, and the open-hearth furnaces. The cupola furnace is used exclusively for melting iron and is commonly found in gray-iron foundries. Crucible, reverberatory, and electric furnaces may be used in either ferrous or nonferrous foundries; these three types of furnaces permit a greater degree of control over the quality of the metal and are used in iron foundries whenever particular characteristics are essential in the finished castings. Open-hearth furnaces are essentially steel-making furnaces rather than melting furnaces and are generally used only in foundries connected with steel works or engaged in making very large quantities of steel castings.

In design and operation a cupola furnace is somewhat like a blast furnace. Essentially it is a steel cylinder lined with firebrick, open at the top and closed at the bottom with dual doors. The entire furnace is supported upon a framework, which leaves an open space several feet high beneath the bottom doors. The top of the furnace extends through the roof and may be as high as 40 feet. Alternate layers of coke and pig iron are charged into a door from a charging platform at a point near the middle of the shaft's height. Near the bottom of the furnace are blast openings (tuyères) through which air is blown to accelerate combustion. The central opening in the bottom, or bedplate, of the furnace is closed by hinged cast-iron doors which are dropped at the completion of the run to permit the unconsumed fuel and the residue of iron in the cupola to fall out. Molten iron is taken out through a taphole near the bottom, and slag is removed through a hole in the opposite side at a slightly higher level.

The procedure of "dropping bottom" to clear the furnace presents the most spectacular hazard of cupola operations. Cupola workers, however, are also exposed to a wide variety of other hazards, such as burns from spattering metal while tapping or from slag thrown from the slag hole; injury from falling objects, such as may occur when a scrap-iron pile collapses or when workmen on the charging floor drop tools or other objects into or outside the cupola; injury from explosion; injury from falls while cleaning or repairing the cupola, or from falling off the charging floor into the cupola or onto the ground; and eye injuries from flying particles or radiations from the hot metal. Charging operations generally involve the use of an elevator; in some cases they are otherwise mechanized. Considerable manual labor is involved, however, even in the highly mechanized plants; and the workers are constantly exposed to the hazards of crushed hands or feet while moving heavy pieces of scrap or pig iron, and of cuts from the sharp edges of scrap. The elevators are frequently hazardous, and there is danger of burns from sparks thrown through the open charging door. Insulated clothing, gloves, goggles, hard hats, and safety shoes can help to reduce the possibilities of injury to cupola workers. Good housekeeping practices around the furnace, particularly on the charging floor, and the provision of safety devices, such as shields for the slag hole and shields suspended over the workers while they are cleaning or repairing the inside of the cupola, can also do much to reduce the volume of accidents arising from cupola operations.

Crucible furnaces are used primarily for melting relatively small quantities of metal. This type of furnace consists of a cylindrical metal shell lined on the bottom and sides with firebrick and is usually placed in a pit so that the top is level with the floor. In some instances coke is used as fuel, but generally the heat is provided by burning oil or gas. Unlike the cupola process, the crucible method does not permit the metal to come into direct contact with the flame. The crucible, a cup-shaped container which holds the metal, is placed in the furnace and the flames play around its outside surface. Crucible-furnace operators do not have the great volume of heavy materials to handle that is common in cupola operations. They are, however, exposed to intense heat radiations when removing the crucible or whenever the cover is off while the furnace is lighted, and they are faced with the danger of burns from the molten metal and of eye injuries from light radiations or from spattering metal. Heavy clothing and goggles are essential equipment.

The reverberatory furnace is a horizontal furnace in which metal is melted in a basin (hearth) by heat from flames and from radiating furnace walls. The furnace is constructed of firebrick supported on a metal framework. Flames and hot gases from oil, gas, or coal fire are generated in the firebox at one end of the furnace, conducted over a firebrick wall (fire bridge), deflected down over the hearth chamber, and conducted out through a stack at the other end. Their passage heats the interior walls of the hearth chamber, and the heat radiated and deflected (reverberated) from these walls and from the flames melts the metal placed on the hearth. The molten metal collects in the basin of the hearth and is drawn off through a taphole. The top of the furnace is constructed in removable bungs which can be lifted off to provide access for charging or repairing the furnace. The metal to be charged may be placed upon the hearth manually, but is commonly handled mechanically, frequently in large charging buckets handled by a crane. Slagging is performed by hand and involves opening the slag door, stirring the molten metal with a puddling bar to make the slag rise to the surface, and then skimming the slag from the surface with a skimming bar. Samples of the molten metal for test purposes are also taken from the furnace through the slag door by means of a small hand ladle.

Reverberatory furnace workers are exposed to intense heat during slagging, sampling, and tapping operations, and they frequently experience burns and eye injuries from spattering metal. They are also exposed to all the hazards of crane operations while charging their furnaces. Safety shoes, goggles, and heavy clothing are generally considered essential for the protection of these workers.

The electric furnaces used in foundries may be either the electric arc type or the induction type. In the arc-type furnace, heat is generated by intense arcs formed between electrodes so placed that the arcs pass through the charge. In the induction furnace the heat is generated by the resistance of the charge to electric currents induced within its mass by passing heavy currents through a ring encircling the furnace. The arc type is the more common.

Arc furnaces vary widely in design. One type consists of a bowl-shaped metal shell lined with firebrick and fire sand, mounted on trunnions, supported by a heavy frame, and provided with a cover or roof. The arched roof is constructed of a refractory material and contains openings through which three triangularly arranged electrodes pass. These electrodes can be raised and lowered by small electric motors so as to place them close to the surface of the charge in order that the arcs will either lick the surface of the charge or pass through it. The intensity and length of the arc is adjusted by manipulating switches or turning wheels while observing meters in the arc circuits. These are all conveniently grouped upon a control board. In opposite sides of the furnace are two doors, one for charging and pouring, the other for slagging. Spouts for conducting the molten metal or slag from the furnace are attached to the respective door frames. The doors, electrodes, electrode clamps, and roof openings are water-jacketed and water-cooled. In some furnaces the roof is arranged so that it may be swung aside to permit access to the interior Generally these furnaces are charged by hand, and the molten metal is removed by tilting the entire furnace upon its trunnions. Slagging is done by hand with a skimming bar, and the charge frequently must be rearranged during the melting process by pushing and poking with a heavy metal bar. In many instances the charge is partially melted in other furnaces before being introduced into the electric furnace.

Electric-furnace operators are exposed to the hazards of handling heavy, rough, and sharp materials in charging; are faced with intense

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heat in slagging, rearranging or adding to the charge, and when taking samples of the melt in hand ladles; and are subject to injuries and burns from spilled or spattered metal in pouring. There is also some danger of shock or burns from contact with electric circuits. Gloves, goggles, safety shoes, and heavy clothing are essential equipment.

The injury-frequency rates for the melting departments were uniformly high, both actually and in comparison with the rates for other foundry departments. In the ferrous-job-foundry group the melting departments had an over-all average of 68 disabling injuries per million employee-hours worked, which was exceeded only by the averages for cleaning, chipping, and finishing; general labor; and shake-out work. In the nonferrous-job-foundry group the melting department's average frequency rate of 74.2 was the highest departmental rate recorded. Similarly the average rate of 53.1 for the melting departments of the non-job foundries was higher than that for any of the other departments except the shake-out departments. Among the melting departments of the ferrous job foundries, those which operated electric furnaces had the highest average frequency rates (77.9) and those which operated open-hearth furnaces had the lowest (51.8). Among the melting departments of the non-job foundries, on the other hand, those operating cupola furnaces had the highest average rate (61.7) and those operating crucible furnaces had the lowest (34.4). (See table 2, p. 17.)

Injuries to feet and toes, hands and fingers, eyes, and backs were most common among the melting department injuries reported in the survey. Protection from hot and heavy materials is recognized as essential in this department, but the injury distribution indicates that the proper protective equipment frequently is not used. It is evident that greater attention should be given to the use of protective equipment for the lower extremities, and that the use of gloves and goggles should be stressed. (See table 7, p. 31.)

CLEANING, CHIPPING, AND FINISHING

When castings are first removed from the mold they are generally somewhat rough and have arm-like spurs resulting from the molten metal which fills the gates and risers. These superfluous projections are removed with a sledge, a metal bandsaw, or a power-operated shear. The castings are then either tumbled or sandblasted to smooth the rough surfaces and to impart a dull finish to the metal. Tumbling consists simply of placing a group of castings inside a steel drum and allowing them to rub and bump together as the drum revolves. In sandblasting, a blast of air and sand or metallic grit is directed against the surface to be cleaned. Small castings may be sandblasted inside a closed machine, but large castings must be cleaned in the open or in a large enclosed blasting room. Great quantities of flying particles and dust accompany all sandblasting and present serious hazards to all workers in the vicinity unless proper precautions are taken. Gloves and goggles are essential equipment for the operator of a blasting machine, and blasting-room workers should wear fresh-air-supplied airline helmets or masks, gloves, and heavy clothing. The blasting room should have an efficient exhaust system discharging into a dust arrester, in order to provide visibility and to prevent the dust from escaping into the plant.

After the castings have been tumbled or sandblasted, any remaining undesirable projections are removed either by chipping or by burning with an oxyacetylene torch. Chipping is generally performed with a pneumatic chisel, although a hand hammer and chisel are used at times. The chisels shave off small pieces of metal which frequently fly considerable distances and strike with great force. Goggles, gloves, and heavy garments are essential for the protection of the chippers and for all others who come near the chippers.

In the burning process, the operator directs the flame from an oxyacetylene torch against a spot on the parting line and heats it to incandescence; then he releases a stream of oxygen against it by pressing a valve on the torch and guides the torch across the projection as the metal is burned and melted away. Filter-lens goggles must be worn as protection against the glare of the torch flame and the molten metal, while heavy gloves and heavy clothing are essential for protection against burns from the hot metal and sparks.

The final, or finishing, process in cleaning castings is to grind off the remaining rough spots and chisel marks, left by the chipper, by the use of an abrasive wheel. Abrasive wheels are also used to impart a polish to the entire surface of some castings. Stationary grinding wheels are used for small castings. These castings are hand-held on waist-high rests and are pressed against the grinding wheels. Larger castings are placed upon the floor, and grinding wheels, mounted on counterbalanced, swivel-supported beams, are swung against them. Portable grinders are used for grinding surfaces inaccessible to the larger wheels. Grinding produces large quantities of flying emery and metal particles, which constitute a very great eye hazard not only for the operator but also for everyone else in the vicinity of the operation. Goggles are essential equipment in this operation, even when there is an exhaust attached to the grinding wheel. Grinding wheels also present a number of other hazards. If they are improperly mounted, operated at excessive speed, struck a sharp blow while in motion, or used for a type of work other than that for which they were designed they may shatter and the pieces may fly in any direction. It is not unusual for workers to be killed when struck by parts of a broken grinding wheel. It is important, therefore, that grinding wheels be mounted properly and used only in accordance with the manufacturer's instructions, and that each wheel be covered with a guard which will effectively check any flying pieces if the wheel should break. Grinders are also exposed to the danger of severe cuts or abrasions if they come into contact with the moving wheel.

In all cleaning, chipping, and finishing operations the workers are constantly exposed to the possibility of injury arising from the necessary handling of the castings. The castings, which are frequently quite heavy, must be moved and turned so that all surfaces can be reached. This presents great possibilities of strained backs, and of bruised or mashed fingers and toes. Rough spots and sharp edges on the castings also present the possibility of severe cuts and scratches to the workers who handle them. The use of gloves and safety shoes by all workers in this department is generally recognized as desirable.

In the ferrous-job-foundry group the cleaning, chipping, and finishing departments had the highest average injury-frequency rate (73.1) among the major operating departments. In the nonferrous-job-foundry group and in the non-job foundries, however, the frequency rates of the cleaning, chipping, and finishing departments were somewhat lower than the corresponding rates of the melting departments. The cleaning, chipping, and finishing rates of 46.1 in the nonferrous group and 50.2 in the non-job foundries were, nevertheless, quite high. (See table 2, p. 17.)

Eye injuries were of outstanding importance in the cleaning, chipping, and finishing departments and by their numbers indicate strongly the great need for the universal use of goggles by workers in these departments. The high proportions of finger, hand, foot, toe, and back injuries, all of which are related to the handling of heavy, rough, and awkward-shaped materials, call for greater attention to the methods of handling such materials and call for the wider use of gloves, foot guards, and safety shoes. (See table 7, p. 31.)

MACHINE SHOPS

In the machine shops also, the frequency of eye injuries indicates a serious need for greater eye protection through the use of transparent shields on the machines or the use of face shields or goggles by the operators. The desirability of more widespread use of safety shoes by machinists is indicated by the high proportion of foot and toe injuries, and the need for better machine guards is stressed by the considerable number of finger and hand injuries.

MAINTENANCE

By the very nature of their work, maintenance workers meet on occasion every hazard faced by any foundry worker and in addition must contend with many which are seldom present in normal operations. As a result maintenance workers sustain all types of injuries; and the outstanding fact indicated by their experience is that these workers need to be furnished with every type of safety equipment and thoroughly trained to recognize and cope with every foundry hazard. The record indicates that as a very minimum every maintenance worker should have and use safety shoes, goggles, and gloves.

SHIPPING, STORAGE, AND TRANSPORTATION

In these departments most of the injuries are experienced in lifting or moving heavy objects. Foot, toe, hand, finger, back, and trunk injuries predominate. Most important from the accident-prevention standpoint would be greater attention to the training of employees in safe-handling methods coupled with closer supervision to insure that those methods are followed. The general use of safety shoes, however, would reduce the volume of foot and toe injuries and a greater use of gloves would avoid many of the hand and finger injuries.

TABLE 2.—*Injury Rates and Extent of Disability, Classified by Kind of Foundry and Department, for 2,188 Foundries, 1942*

Kind of foundry and department	Number of units reporting	Number of employees	Employee-hours worked (in thousands)	Number of disabling injuries: Total	Resulting in— Death and permanent total disability [2]	Resulting in— Permanent partial disability	Resulting in— Temporary total disability	Total number of days lost	Injury rates [1]: Frequency	Injury rates [1]: Severity	Average days lost per temporary total disability
Ferrous job foundries											
Total	[3] 850	143, 875	325, 692	16, 948	(13) 7	415	16, 463	1, 017, 250	52. 0	3. 1	15
Pattern shops	413	2, 673	6, 180	125	0	15	110	7, 537	20. 2	1. 2	14
Wood	309	1, 621	3, 772	80	0	11	69	5, 582	21. 2	1. 5	11
Metal	86	507	1, 141	34	0	3	31	1, 554	29. 8	1. 4	21
Not specified	18	545	1, 267	11	0	1	10	401	8. 7	. 3	10
Core room	645	13, 601	30, 897	954	(1) 2	18	934	30, 403	30. 9	1. 0	13
Molding, including shake-out	762	41, 548	93, 177	5, 565	(4) 23	131	5, 411	349, 013	59. 7	3. 7	16
Shake-out only	43	556	1, 125	124	0	2	122	2, 455	110. 3	2. 2	15
Melting	796	6, 105	14, 090	958	(1) 3	22	933	49, 831	68. 0	3. 5	15
Cupola	544	2, 829	6, 435	449	0	10	439	13, 270	69. 8	2. 1	15
Electric furnace	70	1, 099	2, 527	197	(1) 1	2	194	8, 783	77. 9	3. 5	11
Open-hearth furnace	27	763	1, 948	101	1	5	95	12, 616	51. 8	6. 5	22
Other	155	1, 414	3, 180	211	1	5	205	15, 162	66. 4	4. 8	16
Cleaning, chipping, and finishing	639	27, 540	62, 337	4, 557	(6) 17	100	4, 440	254, 397	73. 1	4. 1	13
Heat treating	146	1, 610	3, 620	173	1	0	172	8, 553	47. 8	2. 4	15
Service and maintenance	2, 738	28, 468	64, 913	2, 019	12	72	1, 935	167, 299	31. 1	2. 6	15
Administration	458	2, 860	6, 631	25	0	1	24	679	3. 8	. 1	16
Clerical	540	5, 473	12, 056	41	0	0	41	427	3. 4	(4)	10
General labor	81	1, 985	4, 375	400	2	12	386	27, 385	91. 4	6. 3	12
Machine shop	81	3, 706	8, 485	214	0	9	205	14, 042	25. 2	1. 7	20
Maintenance	432	7, 586	17, 777	713	7	28	678	80, 610	40. 1	4. 5	16
Metallurgical laboratory	119	560	1, 329	11	0	1	10	485	8. 3	. 4	19
Pattern storage	196	466	1, 101	16	0	0	16	251	14. 5	. 2	16
Power or heating plant	104	429	984	10	0	0	10	134	10. 2	. 1	13
Shipping	442	2, 408	5, 424	200	0	12	188	6, 383	36. 9	1. 2	11
Storage yard	200	2, 185	4, 972	296	2	8	286	29, 290	59. 5	5. 9	17
Yard transportation	85	810	1, 779	93	1	1	91	7, 613	52. 3	4. 3	14
Miscellaneous	343	22, 330	50, 478	2, 597	(1) 12	57	2, 528	150, 217	51. 4	3. 0	14
Nonferrous job foundries											
Total	[3] 441	14, 042	32, 147	1, 134	1	31	1, 102	52, 084	35. 3	1. 6	15
Pattern shops	78	212	477	10	0	0	10	64	20. 9	. 1	6
Core room	296	1, 608	3, 711	47	0	2	45	1, 808	12. 7	. 5	10
Molding, including shake-out	370	4, 092	9, 490	325	0	9	316	19, 469	34. 2	2. 1	18
Melting	316	935	2, 237	166	0	3	163	4, 945	74. 2	2. 2	14
Crucible	202	551	1, 307	75	0	1	74	1, 781	57. 4	1. 4	16
Other	114	384	930	91	0	2	89	3, 164	97. 8	3. 4	12
Cleaning, chipping, and finishing	263	2, 443	5, 677	262	0	8	254	9, 222	46. 1	1. 6	14
Administration	193	519	1, 206	7	0	1	6	370	5. 8	. 3	11
Clerical	221	603	1, 319	3	0	0	3	90	2. 3	. 1	30
Miscellaneous	455	3, 630	8, 030	314	1	8	305	16, 116	39. 1	2. 0	15
Other than job foundries											
Total	[3] 896	87, 859	195, 336	7, 281	(17) 51	234	6, 996	625, 213	37. 3	3. 2	15
Pattern shops	605	4, 124	9, 266	113	(1) 2	12	99	20, 918	12. 2	2. 3	18
Wood	410	2, 631	6, 120	92	0	9	83	7, 726	15. 0	1. 3	18
Metal	168	1, 061	2, 176	16	(1) 2	1	13	12, 560	7. 4	5. 8	20
Not specified	27	432	970	5	0	2	3	632	5. 2	. 7	11
Core room	668	12, 161	26, 202	488	(1) 1	14	473	28, 130	18. 6	1. 1	14
Molding, including shake-out	815	27, 424	61, 352	2, 640	(7) 15	67	2, 558	191, 407	43. 0	3. 1	16
Shake-out only	43	428	1, 024	88	0	2	86	2, 011	85. 9	2. 0	13

See footnotes at end of table.

Table 2.—*Injury Rates and Extent of Disability, Classified by Kind of Foundry and Department, for 2,188 Foundries, 1942*—Continued

Kind of foundry and department	Number of units reporting	Number of employees	Employee-hours worked (in thousands)	Number of disabling injuries: Total	Resulting in— Death and permanent total disability[2]	Resulting in— Permanent partial disability	Resulting in— Temporary total disability	Total number of days lost	Injury rates[1]: Frequency	Injury rates[1]: Severity	Average days lost per temporary total disability
Other than job foundries—Con.											
Melting	891	5,131	11,510	611	3	19	589	55,003	53.1	4.8	14
Crucible	168	714	1,481	51	1	0	50	6,667	34.4	4.5	13
Cupola	508	2,590	5,707	352	2	10	340	34,237	61.7	6.0	15
Electric furnace	68	650	1,733	80	0	3	77	3,649	46.2	2.1	12
Other and not specified	147	1,177	2,589	128	0	6	122	10,450	49.4	4.0	14
Cleaning, chipping, and finishing	614	16,302	36,222	1,818	(1) 11	54	1,753	137,327	50.2	3.8	13
Heat treating	87	579	1,180	36	0	2	34	1,181	30.5	1.0	17
General labor	84	2,653	5,403	251	1	8	242	17,357	46.5	3.2	12
Miscellaneous	433	19,485	44,201	1,324	(7) 18	58	1,248	173,890	30.0	3.9	19

[1] The frequency rate is the average number of disabling injuries for each million employee-hours worked. The severity rate is the average number of days lost for each thousand employee-hours worked.
[2] Figures in parentheses show the number of permanent total disabilities included.
[3] Number of foundries reporting.
[4] Less than 0.05.

Regional and State Differences

Basically, the wide variations in average injury-frequency rates for similar foundry operations in different areas reflect variations in safety activities rather than differences in actual hazards. Many factors contribute to these differences, and in particular instances it may be very difficult to specify which is the controlling factor. Differences in State safety requirements and in the degree to which the requirements are enforced have a very direct influence upon the frequency-rate levels in different States. Similarly, safety activities, or the lack of such activities, on the part of trade associations or other organizations can have considerable effect upon the general accident record of an area. The average size of the plants in different areas, and the availability or the lack of experienced foundry personnel, are also factors which may influence the injury-frequency rate levels.

The 2,188 foundries included in the survey were located in 46 States. However, the number of States from which the coverage was sufficient to permit computation of averages for the different types of foundry operations varied widely. For general comparison purposes the reports were combined into regional groups corresponding to the nine regions used in the tabulations of the United States Bureau of the Census.[6] (See table 3.)

[6] The regional groupings and the States included in each region are (1) New England—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; (2) Middle Atlantic—New Jersey, New York, and Pennsylvania; (3) East North Central—Illinois, Indiana, Michigan, Ohio, and Wisconsin; (4) West North Central—Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota; (5) South Atlantic—Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia; (6) East South Central—Alabama, Kentucky, Mississippi, and Tennessee; (7) West South Central—Arkansas, Louisiana, Oklahoma, and Texas; (8) Mountain—Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming; (9) Pacific—California, Oregon, and Washington.

GRAY-IRON JOB FOUNDRIES

The reporting gray-iron job foundries were highly concentrated in the Middle Atlantic and East North Central regions. Sufficient reports were received, however, to provide representative average frequency rates for each of the other areas except the West South Central and Mountain regions.

The regional average frequency rates for gray-iron job foundries all fell within a comparatively narrow range. The lowest was 52.1 for plants in the East North Central region and the highest was 68.4 for those in the Pacific region. (See table 3.) The reports included in the Pacific region's average were nearly all from plants in California. The regional average for the Pacific States, therefore, corresponds closely with the average rate of 67.3 for gray-iron job foundries in California.

The plants included in the average for the East North Central region, on the other hand, were well distributed among all of the States in that region. Individual State averages within the region ranged from 37.7 injuries per million employee-hours worked in Ohio, which was the lowest average for any State, to 91.1 in Wisconsin, which in turn was the highest average recorded for any State. Illinois and Michigan each had average frequency rates in the high 40's, somewhat below the national average of 55.8. Indiana's average rate (64.9), however, was higher than the national average.

MALLEABLE-IRON JOB FOUNDRIES

Malleable-iron job foundry reports were received in sufficient volume to permit the computation of representative State averages only from the five East North Central States, and from two of the Middle Atlantic States. It was possible, however, to compute a regional average for the New England area. The three regional average frequency rates for malleable-iron job foundries were 46.8 for the East North Central region, 49.2 for the Middle Atlantic region, and 69.3 for the New England region. The New England average, however, was based upon the experience of only four foundries located in four different States and may not be representative of any particular conditions.

Michigan had the lowest State average frequency rate for malleable-iron job foundry operations (30.7), and Indiana had the highest (89.5). The Ohio average (41.5) was comparatively low. All of the other State averages were grouped closely around the national average of 49.3.

STEEL JOB FOUNDRIES

Average injury frequency rates were computed for steel job foundries in 5 of the 9 geographic regions and for 11 individual States. The lowest regional average was 41.8 for the Middle Atlantic region. The highest was 63.8 for the West North Central region. The other regional averages were 52.6 for the East North Central region, 55.1 for the Pacific region, and 57.4 for the New England region.

The lowest State average frequency rate for steel job foundries was 39.9 in Indiana. The average rates for New York (41.1) and Pennsylvania (42.3) were also comparatively low in respect to the national average (50.8). The highest State average was 104.2 for Oregon; Connecticut (91.8) and Michigan (90.4), however, also had very high average rates.

CAST-IRON PIPE FOUNDRIES

Cast-iron pipe operations were reported in relatively few States. Only five had sufficient coverage to permit the computation of State averages. These averages showed extremely wide variations, ranging from an average of 28.7 disabling injuries for every million employee-hours worked in Alabama to 119.0 in Pennsylvania. The New Jersey average frequency rate was 34.0, Virginia's was 55.4, and California's was 90.6.

NONFERROUS JOB FOUNDRIES

More than 60 percent of the plants and about two-thirds of the nonferrous job foundry employment included in the survey was reported from the States comprising the Middle Atlantic and East North Central regions. However, regional average frequency rates were computed for three additional regions. The lowest regional average was 26.2 for the West North Central region. The highest was 41.3 for the adjacent East North Central region. The Pacific region had an average of 27.5, largely based upon the experience of plants in California. Better-than-average records in Pennsylvania and New Jersey over-balanced the above-average injury experience of the New York plants and held the Middle Atlantic region's average (32.2) slightly below the average for the country as a whole. The New England average of 33.7 represented primarily a combination of low-rate plants in Connecticut and fairly high-rate plants in Massachusetts.

Among the individual States the most favorable injury frequency rates for nonferrous job foundry operations were Connecticut, 19.3; California, 20.5; Missouri, 22.8; Pennsylvania, 25.6; and Illinois, 28.3. The least favorable State averages were: Michigan, 81.2; Massachusetts, 43.5; and New York, 41.5.

OTHER THAN JOB FOUNDRIES

The non-job foundries included in the survey were widely distributed and it was possible to compute average frequency rates for these operations for each of the nine regions and for 23 individual States.

The lowest regional frequency rate was 15.6 for the Mountain region. The highest was 51.0 for the West North Central region. The averages for the East South Central region (28.2), the East North Central region (34.0), and the Pacific region (36.2) were below the national average (37.3). The Middle Atlantic region's average (37.5) was very close to the national level; while those of the West South Central region (43.4), the New England region (46.8), and the South Atlantic region (47.7) were considerably higher than the national average.

Kentucky had the lowest State average frequency rate for non-job foundry operations (13.9). Other States with comparatively low averages were Virginia, 20.0; Indiana, 24.9; Ohio, 27.9; and Pennsylvania, 29.9. The highest State average was 87.0 for Rhode Island. Georgia (72.8) and Missouri (71.0), however, had rates of over 70, and Minnesota (62.6) and Wisconsin (60.6) had rates of over 60.

Table 3.—*Injury Rates, by State and Kind of Foundry,[1] for 2,188 Foundries, 1942*

Geographic area, State, and kind of foundry	Number of establishments	Number of employees	Employee-hours worked (in thousands)[2]	Disabling injuries		Injury rates[4]		Average days lost per temporary total disability
				Number	Days lost[3]	Frequency	Severity	
United States: Total	**2,188**	**245,786**	**553,175**	**25,363**	**1,694,547**	**45.8**	**3.1**	**15**
Ferrous job foundries	850	143,875	325,692	16,948	1,017,250	52.0	3.1	15
Gray-iron	652	52,830	119,705	6,675	403,925	55.8	3.4	14
Malleable-iron	53	20,672	44,233	2,180	112,596	49.3	2.5	16
Steel	105	57,660	132,707	6,744	390,781	50.8	2.9	15
Cast-iron pipe	37	12,482	28,533	1,319	107,302	46.2	3.8	16
Nonferrous job foundries	441	14,052	32,147	1,134	52,084	35.3	1.6	15
Other than job foundries	897	87,859	195,336	7,281	625,213	37.3	3.2	15
New England: Total	202	15,077	37,220	1,996	81,608	53.6	2.2	17
Ferrous job foundries	73	7,170	17,487	1,114	33,953	63.7	1.9	14
Gray-iron	62	4,321	10,630	696	21,894	65.5	2.1	15
Malleable-iron	4	1,030	2,480	172	6,903	69.3	2.8	18
Steel	5	1,763	4,235	243	2,756	57.4	.7	10
Nonferrous job foundries	54	1,334	3,178	107	3,232	33.7	1.0	18
Other than job foundries	75	6,573	16,555	775	44,421	46.8	2.7	20
Connecticut: Total	57	5,541	13,465	630	29,223	46.8	2.2	15
Ferrous job foundries	12	2,471	5,852	386	9,106	66.0	1.6	14
Gray-iron	8	798	1,853	126	2,363	68.0	1.3	19
Steel	3	1,063	2,517	231	2,333	91.8	.9	10
Nonferrous job foundries	18	534	1,293	25	576	19.3	.4	12
Other than job foundries	27	2,536	6,320	219	19,541	34.7	3.1	16
Maine: Total	12	561	1,236	54	1,131	43.7	.9	21
Other than job foundries	6	454	1,012	48	1,003	47.4	1.0	21
Massachusetts: Total	89	5,624	13,632	517	25,411	37.9	1.9	18
Ferrous job foundries	39	3,012	7,184	274	18,416	38.1	2.6	16
Gray-iron	35	2,197	5,213	251	15,404	48.1	3.0	16
Nonferrous job foundries	24	716	1,701	74	2,597	43.5	1.5	21
Other than job foundries	26	1,896	4,746	169	4,398	35.6	.9	21
New Hampshire: Total[5]	19	708	1,710	118	1,695	69.0	1.0	14
Rhode Island: Total	18	1,618	4,469	440	13,556	98.5	3.0	20
Ferrous job foundries	7	478	1,249	162	2,994	129.8	2.4	17
Other than job foundries	3	1,093	3,103	270	10,503	87.0	3.4	22
Vermont: Total[6]	7	1,025	2,709	237	10,590	87.5	3.9	12
Middle Atlantic: Total	558	68,229	155,942	6,682	533,277	42.8	3.4	16
Ferrous job foundries	192	34,188	78,396	3,818	310,633	48.7	4.0	17
Gray-iron	137	9,418	21,515	1,247	103,010	58.0	4.8	17
Malleable-iron	11	4,949	10,964	539	32,113	49.2	2.9	17
Steel	31	16,486	38,526	1,611	141,770	41.8	3.7	16
Cast-iron pipe	13	3,335	7,392	421	33,740	57.0	4.6	14
Nonferrous job foundries	122	3,760	8,675	279	14,349	32.2	1.7	15
Other than job foundries	244	30,281	68,871	2,585	208,295	37.5	3.0	16
New Jersey: Total	94	10,953	25,478	1,273	127,942	50.0	5.0	16
Ferrous job foundries	36	5,539	12,993	587	84,187	45.2	6.5	18
Gray-iron	28	2,370	5,653	330	43,342	58.4	7.7	19
Cast-iron pipe	6	2,267	5,318	181	26,783	34.0	5.0	17
Nonferrous job foundries	31	545	1,256	38	1,427	30.3	1.1	18
Other than job foundries	27	4,869	11,229	648	42,328	57.7	3.8	14
New York: Total	142	13,427	31,540	1,446	150,074	45.8	4.8	16
Ferrous job foundries	47	6,456	14,949	698	88,413	46.7	5.9	15
Gray-iron	37	2,650	6,210	318	12,522	51.2	2.0	15
Malleable-iron	3	1,055	2,313	117	12,325	50.6	5.3	13
Steel	6	2,720	6,352	261	59,562	41.1	9.4	16
Nonferrous job foundries	35	1,349	3,202	133	6,159	41.5	1.9	14
Other than job foundries	60	5,622	13,390	615	55,502	45.9	4.1	17
Pennsylvania: Total	322	43,849	98,924	3,963	255,261	40.1	2.6	16
Ferrous job foundries	109	22,193	50,454	2,533	138,033	50.2	2.7	17
Gray-iron	72	4,398	9,651	599	47,146	62.1	4.9	18
Malleable-iron	8	3,894	8,651	422	19,788	48.8	2.3	19

See footnotes at end of table.

TABLE 3.—*Injury Rates, by State and Kind of Foundry,*[1] *for 2,188 Foundries, 1942*—Continued

Geographic area, State, and kind of foundry	Number of establishments	Number of employees	Employee-hours worked (in thousands)[2]	Disabling injuries: Number	Disabling injuries: Days lost[3]	Injury rates[4]: Frequency	Injury rates[4]: Severity	Average days lost per temporary total disability
Pennsylvania—Continued.								
Ferrous job foundries—Continued.								
Steel	23	12,864	30,152	1,274	68,146	42.3	2.3	16
Cast-iron pipe	6	1,037	2,000	238	2,953	119.0	1.5	12
Nonferrous job foundries	56	1,866	4,217	108	6,763	25.6	1.6	15
Other than job foundries	157	19,790	44,252	1,322	110,465	29.9	2.5	16
East North Central: Total	**779**	**111,482**	**248,823**	**11,322**	**735,680**	**45.5**	**3.0**	**14**
Ferrous job foundries	303	69,589	158,879	8,168	451,258	51.4	2.8	14
Gray-iron	223	28,230	64,261	3,346	204,484	52.1	3.2	13
Malleable-iron	33	13,377	28,099	1,315	71,458	46.8	2.5	15
Steel	44	27,613	65,649	3,453	174,526	52.6	2.7	15
Nonferrous job foundries	154	5,591	12,605	521	16,572	41.3	1.3	14
Other than job foundries	322	36,302	77,339	2,633	267,850	34.0	3.5	14
Illinois: Total	181	29,104	64,304	2,621	152,258	40.8	2.4	12
Ferrous job foundries	64	17,237	39,689	1,841	74,192	46.4	1.9	12
Gray-iron	46	4,447	10,010	486	19,315	48.6	1.9	11
Malleable-iron	8	2,683	5,569	287	5,522	51.5	1.0	9
Steel	10	10,107	24,110	1,068	49,355	44.3	2.0	14
Nonferrous job foundries	38	1,470	2,965	84	1,290	28.3	.4	12
Other than job foundries	79	10,397	21,650	696	76,776	32.1	3.5	13
Indiana: Total	96	14,914	33,752	1,523	88,592	45.1	2.6	16
Ferrous job foundries	40	9,836	22,298	1,229	60,262	55.1	2.7	15
Gray-iron	33	3,790	8,244	535	28,712	64.9	3.5	13
Malleable-iron	3	1,272	2,693	241	11,170	89.5	4.1	13
Steel	4	4,774	11,361	453	20,380	39.9	1.8	18
Other than job foundries	43	4,750	10,739	267	27,457	24.9	2.6	20
Michigan: Total	151	26,100	54,753	2,729	127,369	49.8	2.3	13
Ferrous job foundries	64	17,492	38,893	2,116	108,315	54.4	2.8	13
Gray-iron	49	10,392	23,224	1,141	73,408	49.1	3.2	14
Malleable-iron	4	3,425	7,398	227	14,932	30.7	2.0	17
Steel	11	3,675	8,270	748	19,975	90.4	2.4	12
Nonferrous job foundries	27	894	2,032	165	2,611	81.2	1.3	9
Other than job foundries	60	7,714	13,827	448	16,443	32.4	1.2	13
Ohio: Total	245	28,456	65,475	2,541	243,787	38.8	3.7	18
Ferrous job foundries	96	18,148	41,653	1,854	134,178	44.5	3.2	18
Gray-iron	68	7,078	16,691	629	47,011	37.7	2.8	15
Malleable-iron	10	3,541	7,230	300	22,825	41.5	3.2	23
Steel	15	7,160	16,862	871	63,552	51.7	3.8	19
Nonferrous job foundries	54	1,524	3,485	119	4,409	34.1	1.3	25
Other than job foundries	95	8,784	20,337	568	105,200	27.9	5.2	16
Wisconsin: Total	106	12,908	30,539	1,908	123,674	62.5	4.0	11
Ferrous job foundries	39	6,876	16,345	1,128	74,311	69.0	4.5	12
Gray-iron	27	2,523	6,091	555	36,038	91.1	5.9	11
Malleable-iron	8	2,456	5,209	260	17,009	49.9	3.3	13
Steel	4	1,897	5,046	313	21,264	62.0	4.2	12
Nonferrous job foundries	22	1,375	3,408	126	7,389	37.0	2.2	15
Other than job foundries	45	4,657	10,785	654	41,974	60.6	3.9	10
West North Central: Total	**156**	**13,209**	**28,063**	**1,597**	**82,256**	**56.9**	**2.9**	**13**
Ferrous job foundries	74	8,662	17,671	1,121	46,244	63.4	2.6	13
Gray-iron	63	3,743	8,327	514	11,030	61.7	1.3	14
Steel	6	4,384	8,448	539	34,217	63.8	4.1	12
Nonferrous job foundries	22	976	2,174	57	6,105	26.2	2.8	16
Other than job foundries	60	3,571	8,222	419	29,907	51.0	3.6	12
Iowa: Total	35	3,334	6,553	397	14,304	60.6	2.2	11
Ferrous job foundries	15	1,608	2,818	242	3,045	85.9	1.1	11
Gray-iron	12	645	1,398	95	1,194	67.9	.9	10
Other than job foundries	17	1,668	3,602	155	11,259	43.0	3.1	11
Kansas: Total	20	1,031	2,536	99	6,798	39.0	2.7	15
Other than job foundries	9	530	1,448	54	6,201	37.3	4.3	17

See footnotes at end of table.

TABLE 3.—*Injury Rates, by State and Kind of Foundry,*[1] *for 2,188 Foundries, 1942*—Continued

Geographic area, State, and kind of foundry	Number of establishments	Number of employees	Employee-hours worked (in thousands)[2]	Disabling injuries		Injury rates[4]		Average days lost per temporary total disability
				Number	Days lost[3]	Frequency	Severity	
Minnesota: Total	45	2,014	4,539	272	12,376	59.9	2.7	11
Ferrous job foundries	23	1,353	2,871	176	2,645	61.3	.9	12
Gray-iron	19	743	1,707	108	2,171	63.3	1.3	15
Other than job foundries	14	497	1,309	82	8,860	62.6	6.8	11
Missouri: Total	46	6,560	13,880	800	46,565	57.6	3.4	14
Ferrous job foundries	23	5,288	11,081	669	40,098	60.4	3.6	14
Gray-iron	19	1,942	4,320	277	7,209	64.1	1.7	15
Steel	3	3,329	6,719	388	32,769	57.7	4.9	14
Nonferrous job foundries	8	616	1,405	32	5,093	22.8	3.6	20
Other than job foundries	15	656	1,395	99	1,374	71.0	1.0	14
South Atlantic: Total	130	7,734	17,698	908	69,790	51.3	3.9	13
Ferrous job foundries	60	5,143	11,815	640	57,649	54.2	4.9	13
Gray-iron	51	1,888	4,349	255	34,834	58.6	8.0	10
Cast-iron pipe	5	2,208	5,066	275	21,366	54.3	4.2	17
Other than job foundries	60	2,346	5,241	250	10,693	47.7	2.0	13
Delaware: Total[7]	6	744	1,771	61	1,068	34.4	.6	18
Georgia: Total	21	897	2,087	150	4,344	71.9	2.1	13
Other than job foundries	12	718	1,677	122	4,093	72.8	2.4	14
Maryland: Total[8]	18	846	1,767	60	7,146	34.0	4.0	9
North Carolina: Total	24	838	1,908	134	4,391	70.2	2.3	11
Ferrous job foundries	11	633	1,469	90	1,963	61.3	1.3	12
Virginia: Total	28	2,523	5,819	260	23,658	44.7	4.1	16
Ferrous job foundries	17	1,947	4,367	233	20,665	53.4	4.7	17
Cast-iron pipe	4	1,775	4,008	222	20,473	55.4	5.1	17
Other than job foundries	10	505	1,251	25	2,373	20.0	1.9	12
West Virginia: Total	18	1,620	3,758	203	28,578	54.0	7.6	13
Ferrous job foundries	6	1,305	3,063	190	27,556	62.0	9.0	11
Gray-iron	4	898	2,200	133	27,041	60.4	12.3	12
East South Central: Total	77	11,911	25,903	903	84,865	34.9	3.3	19
Ferrous job foundries	32	8,222	18,398	683	60,379	37.1	3.3	19
Gray-iron	24	2,364	4,828	262	15,594	54.3	3.2	17
Cast-iron pipe	7	5,693	13,231	395	40,999	29.9	3.1	21
Other than job foundries	39	3,565	7,225	204	24,406	28.2	3.4	19
Alabama: Total	32	7,812	17,558	584	47,869	33.3	2.7	19
Ferrous job foundries	19	6,653	14,991	489	44,305	32.6	3.0	20
Gray-iron	13	1,810	3,638	147	7,790	40.4	2.1	19
Cast-iron pipe	5	4,678	11,014	316	32,729	28.7	3.0	20
Other than job foundries	11	1,063	2,344	80	3,514	34.1	1.5	18
Kentucky: Total	17	1,157	2,233	98	26,201	43.9	11.7	18
Other than job foundries	9	949	1,803	25	19,014	13.9	10.5	24
Tennessee: Total	23	2,864	5,938	221	10,795	37.2	1.8	19
Ferrous job foundries[9]	7	1,342	2,922	122	8,917	41.7	3.1	19
Other than job foundries	15	1,510	2,992	99	1,878	33.1	.6	19
West South Central: Total	62	1,972	4,606	279	19,375	60.6	4.2	20
Ferrous job foundries	23	688	1,653	155	12,139	93.8	7.3	15
Other than job foundries	25	1,124	2,625	114	7,125	43.4	2.7	29
Texas: Total	39	1,532	3,700	248	17,619	67.0	4.8	16
Ferrous job foundries	14	616	1,517	149	12,105	98.2	8.0	15
Other than job foundries	15	814	1,981	90	5,407	45.4	2.7	17
Mountain: Total	42	1,943	4,593	158	2,699	34.4	.6	15
Ferrous job foundries	22	1,120	2,591	114	1,937	44.0	.7	14
Other than job foundries	14	657	1,662	26	662	15.6	.4	24

See footnote at end of table.

Table 3.—*Injury Rates, by State and Kind of Foundry,[1] for 2,188 Foundries, 1942*—Continued

Geographic area, State, and kind of foundry	Number of establishments	Number of employees	Employee-hours worked (in thousands)[2]	Disabling injuries: Number	Disabling injuries: Days lost[3]	Injury rates[4]: Frequency	Injury rates[4]: Severity	Average days lost per temporary total disability
Colorado: Total	21	863	1,890	74	1,129	39.1	.6	11
Ferrous job foundries	11	489	1,117	45	874	40.3	.8	13
Utah: Total	7	581	1,362	69	1,081	50.7	.8	16
Ferrous job foundries	6	564	1,329	68	1,039	51.2	.8	15
Pacific: Total	182	14,229	30,323	1,518	84,999	50.1	2.8	12
Ferrous job foundries	71	9,093	18,801	1,135	43,058	60.4	2.3	11
Gray-iron	55	2,230	4,398	301	12,151	68.4	2.8	9
Steel	11	6,196	13,067	720	29,592	55.1	2.3	12
Cast-iron pipe	3	513	1,049	95	1,002	90.6	1.0	11
Nonferrous job foundries	53	1,696	3,926	108	10,057	27.5	2.6	19
Other than job foundries	58	3,440	7,596	275	31,884	36.2	4.2	15
California: Total	137	12,551	26,431	1,237	75,317	46.8	2.8	12
Ferrous job foundries	52	8,218	16,722	936	39,125	56.0	2.3	11
Gray-iron	41	2,036	3,937	265	9,873	67.3	2.5	8
Steel	6	5,515	11,449	557	27,937	48.6	2.4	12
Cast-iron pipe	3	513	1,049	95	1,002	90.6	1.0	11
Nonferrous job foundries	44	1,341	3,080	63	7,176	20.5	2.3	14
Other than job foundries	41	2,992	6,629	238	29,016	35.9	4.4	13
Oregon: Total	18	866	2,057	169	1,908	82.2	.9	11
Ferrous job foundries	9	623	1,503	154	1,612	102.4	1.1	10
Steel	3	578	1,410	147	1,390	104.2	1.0	9
Washington: Total[10]	27	812	1,835	112	7,774	61.0	4.2	19

[1] Totals include figures for items not shown separately because of insufficient data.
[2] Totals based on unrounded data.
[3] Includes standard time charges for permanent impairments and fatalities, as provided in the American Standard Method of Computing Industrial Injury Rates.
[4] The frequency rate is the average number of disabling injuries for each million employee-hours worked. The severity rate is the average number of days lost for each thousand employee-hours worked.
[5] Ratio of employment coverage included is ferrous job foundries, 22; nonferrous job foundries, 1; other than job foundries, 19. Ratio of employment included in the United States coverage is ferrous job foundries, 10; nonferrous job foundries, 1; other than job foundries, 6.
[6] Ratio of employment coverage included is ferrous job foundries, 4; other than job foundries, 1; no nonferrous job foundries were covered. Ratio of employment included in the United States coverage is ferrous job foundries, 10; nonferrous job foundries, 1; other than job foundries, 6.
[7] Ratio of employment coverage included is ferrous job foundries, 30; nonferrous job foundries, 1; other than job foundries, 5. Ratio of employment included in the United States coverage is ferrous job foundries, 10; nonferrous job foundries, 1; other than job foundries, 6.
[8] Ratio of employment coverage included is ferrous job foundries, 4; nonferrous job foundries, 1; other than job foundries, 4. Ratio of employment included in the United States coverage is ferrous job foundries, 10; nonferrous job foundries, 1; other than job foundries, 6.
[9] Predominantly cast-iron pipe foundries.
[10] Ratio of employment coverage included is ferrous job foundries, 1; nonferrous job foundries, 2; other than job foundries, 1. Ratio of employment included in the United States coverage is ferrous job foundries 10; nonferrous job foundries, 1; other than job foundries, 6.

Size of Plant

Generally speaking, very small foundries (with less than 24 employees) and large foundries (with over 500 employees) had the lowest average injury-frequency rates. The distribution of frequency rates within the various size groups, however, conclusively indicated that size of plant need not be a controlling factor in safety. (See table 4.) In all size groups there were plants which reported excellent safety records, and in most size groups there were a few with exceptionally poor records. Plant size, in one way or another, may either facilitate or impede the functioning of a safety program, but it seems evident that regardless of size, those plants which take a genuine interest in safety do have lower injury-frequency rates than those which make only perfunctory efforts toward safety.

Plant size becomes a factor in the advancement of safety in many ways. In small shops the supervisor, who is frequently the owner with a personal financial interest in keeping the accident volume at a minimum, is generally able to keep all operations under observation. He can, therefore, see unsafe conditions and practices as they develop and can take immediate precautions to eliminate incipient hazards.

In very large shops the volume of production generally makes it possible to give special attention to safety. Plants with 500 or more employees can usually afford to employ a safety engineer to carry on a scientific accident-prevention program, and can generally afford to provide all guards and safety equipment known to be available. Large plants also can generally maintain some form of medical or trained first-aid service upon the premises. They also have the advantage of professionally engineered plant lay-out and work processes, and are generally in a position to utilize mechanical equipment more extensively than are the smaller plants. This is of particular importance in connection with material-handling operations, in which the provision of mechanical conveyors, hoists, cranes, and power trucks can do much to avoid many of the injuries associated with the manual performance of such operations.

In medium-size foundries the problem of safety is complicated by the fact that the responsible head of the plant seldom can devote much of his time to observing shop operations and, therefore, must delegate much of the responsibility for safety to others. Unfortunately, few such plants can afford to employ a safety specialist and as a result the responsibility for safety must be vested entirely in foremen or supervisors, who seldom have had safety training and who frequently feel that their production responsibilities are of much greater importance than attention to safety.

Because of the varying numbers of plants reporting in the different foundry categories, it was impossible to establish a uniform size break-down for each of the groups. It is interesting to note, however, that among the gray-iron, malleable-iron, and steel job foundries the highest average frequency rates were those of the plants which had between 150 and 249 employees. In the gray-iron foundry group the lowest average was that of the very small plants, which employed less than 10 workers. In the malleable-iron and steel job foundry groups, however, the lowest average frequency rates were those of the larger plants—the malleable-iron plants with over 500 employees and the steel foundries with over 1,000 employees.

In the nonferrous foundry group the plants with 75 to 99 employees had the highest average frequency rate, while those with 10 to 24 employees had the lowest average. Among the other than job foundries, the lowest average was that of the plants with 500 to 999 employees and the highest was that of the plants with 50 to 74 employees.

In most industries it is not at all unusual for individual plants to complete 1,000,000 or more employee-hours of operation without a single disabling injury, which is approximately equivalent to a year's operations in a plant having 500 full-time employees. It is pertinent to note, however, that not one of the 114 foundries which reported 500

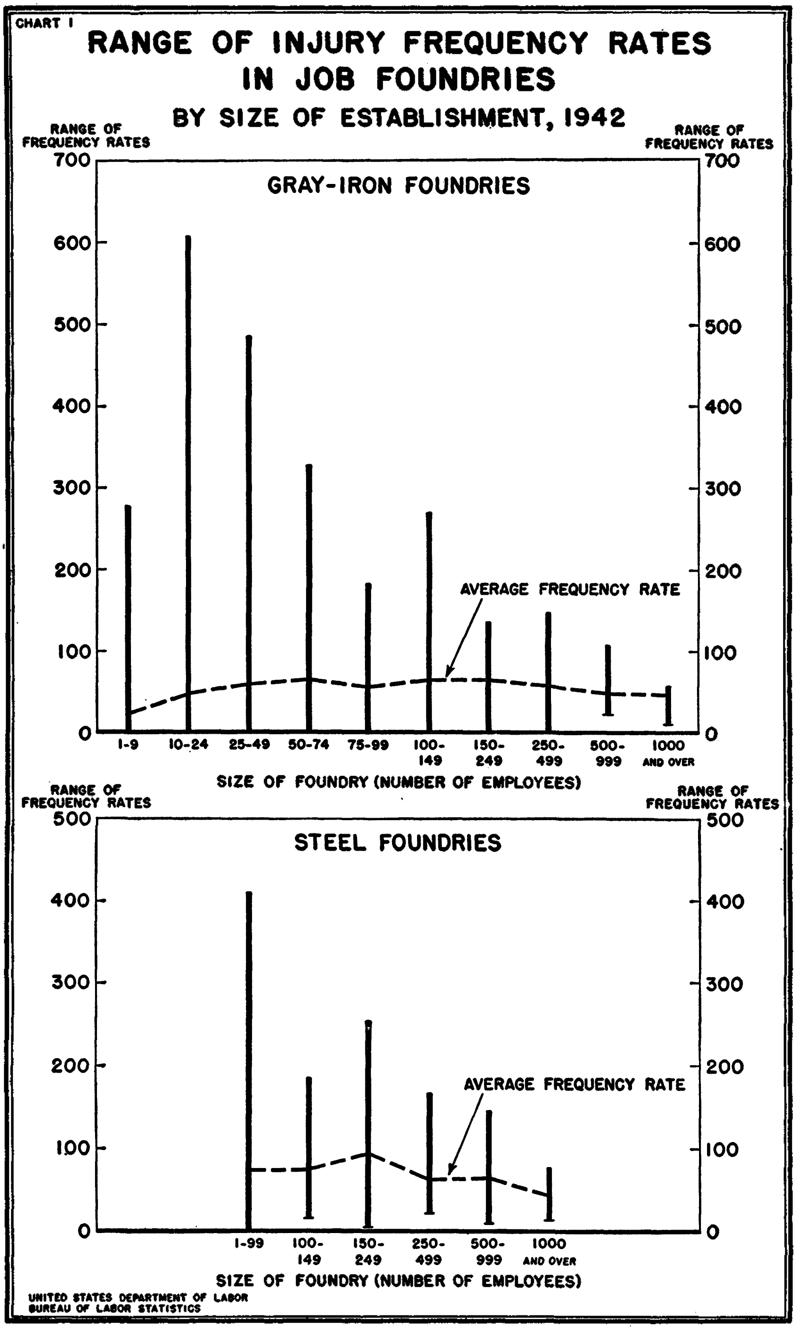
CHART 1
RANGE OF INJURY FREQUENCY RATES
IN JOB FOUNDRIES
BY SIZE OF ESTABLISHMENT, 1942
RANGE OF FREQUENCY RATES
GRAY-IRON FOUNDRIES
700
600
500
400
300
200
100
0
AVERAGE FREQUENCY RATE
1-9
10-24
25-49
50-74
75-99
100-149
150-249
250-499
500-999
1000 AND OVER
SIZE OF FOUNDRY (NUMBER OF EMPLOYEES)
RANGE OF FREQUENCY RATES
STEEL FOUNDRIES
500
400
300
200
100
0
AVERAGE FREQUENCY RATE
1-99
100-149
150-249
250-499
500-999
1000 AND OVER
SIZE OF FOUNDRY (NUMBER OF EMPLOYEES)
UNITED STATES DEPARTMENT OF LABOR
BUREAU OF LABOR STATISTICS

or more employees had an accident-free record in 1942. There was, however, one cast-iron pipe foundry which reported only one injury in 1,917,552 employee-hours worked, which gave it a frequency rate of 0.5 for the year, the lowest rate achieved by any of the plants with 500 or more employees. In direct contrast, one of the malleable-iron job foundries with 591 employees and 1,376,216 employee-hours worked during the year, reported 198 injuries, which gave it a frequency rate of 143.9.

Table 4.—*Distribution of Injury Rates in 2,182 Foundries, by Kind of Foundry and Size of Establishment, 1942*

Kind of foundry and number of foundry employees	Total number of establishments	Number of employees	Employee-hours worked (in thousands)	Total number of disabling injuries	Injury rates [1]		Average days lost per temporary total disability	Number of plants with low frequency rates	
					Frequency	Severity		Number with rate of 0	Number with rates of 10 or less
Ferrous job foundries:									
Gray-iron foundries	652	52, 830	119, 705	6, 675	55. 8	3. 4	14	197	22
1 to 9 employees	116	676	1, 344	27	20. 1	9. 3	18	97	0
10 to 24 employees	135	2, 291	4, 806	224	46. 6	3. 8	15	65	0
25 to 49 employees	123	4, 573	10, 074	581	57. 7	2. 7	13	23	7
50 to 74 employees	81	4, 858	10, 845	667	61. 5	3. 2	15	5	4
75 to 99 employees	58	4, 914	11, 235	607	54. 0	3. 1	15	3	3
100 to 149 employees	57	6, 844	15, 466	957	61. 9	2. 4	12	2	3
150 to 249 employees	44	8, 225	19, 392	1, 216	62. 7	3. 8	13	1	2
250 to 499 employees	27	9, 644	20, 786	1, 192	57. 3	3. 5	16	1	2
500 to 999 employees	8	5, 293	13, 130	633	48. 2	4. 0	12	0	0
1,000 employees and over	3	5, 512	12, 627	571	45. 2	3. 2	14	0	1
Malleable-iron foundries	53	20, 672	44, 233	2, 180	49. 3	2. 5	16	1	2
1 to 149 employees	13	1, 537	3, 281	245	74. 7	1. 7	16	1	0
150 to 249 employees	9	1, 920	4, 250	346	81. 4	4. 2	13	0	0
250 to 499 employees	14	4, 597	9, 586	461	48. 1	1. 9	15	0	0
500 employees and over	17	12, 618	27, 116	1, 128	41. 6	2. 6	17	0	2
Steel foundries	105	57, 660	132, 707	6, 744	50. 8	2. 9	15	4	3
1 to 99 employees	19	697	1, 604	116	72. 3	. 8	11	4	0
100 to 149 employees	7	880	2, 069	152	73. 5	1. 3	14	0	0
150 to 249 employees	21	4, 397	10, 076	931	92. 4	5. 5	12	0	1
250 to 499 employees	20	7, 146	17, 542	1, 050	59. 9	3. 1	12	0	0
500 to 999 employees	25	16, 381	37, 989	2, 340	61. 6	3. 2	13	0	2
1,000 employees and over	13	28, 159	63, 427	2, 155	34. 0	2. 5	18	0	0
Cast-iron-pipe foundries	37	12, 482	28, 533	1, 319	46. 2	3. 8	16	2	2
1 to 149 employees	14	913	2, 010	202	100. 5	7. 8	16	2	0
150 to 249 employees	5	1, 035	2, 034	188	92. 4	4. 1	16	0	0
250 to 499 employees	10	3, 518	7, 821	497	63. 5	1. 6	12	0	1
500 employees and over	8	7, 016	16, 668	432	25. 9	4. 3	22	0	1
Nonferrous job foundries	441	14, 052	32, 147	1, 134	35. 3	1. 6	15	281	6
1 to 9 employees	179	831	1, 665	40	24. 0	. 3	13	154	0
10 to 24 employees	124	1, 934	4, 208	79	18. 8	1. 4	14	85	0
25 to 49 employees	68	2, 255	5, 061	140	27. 7	. 6	12	25	3
50 to 74 employees	33	2, 016	4, 658	152	32. 6	2. 1	16	10	2
75 to 99 employees	12	1, 035	2, 167	147	67. 8	1. 2	18	2	0
100 to 149 employees	11	1, 311	2, 837	95	33. 5	1. 1	13	3	0
150 to 249 employees	5	930	2, 323	95	40. 9	1. 2	15	1	1
250 to 499 employees	6	1, 959	4, 899	273	55. 7	3. 3	14	1	0
500 to 999 employees	3	1, 781	4, 329	113	26. 1	1. 9	23	0	0
Other than job foundries	894	87, 859	195, 336	7, 281	37. 3	3. 2	15	259	53
1 to 9 employees	185	917	1, 875	73	38. 9	4. 9	16	143	0
10 to 24 employees	196	3, 141	6. 799	285	41. 9	3. 2	16	74	0
25 to 49 employees	151	5, 282	11, 731	643	54. 8	3. 6	14	26	3
50 to 74 employees	91	5, 667	12, 492	696	55. 7	2. 8	14	2	8
75 to 99 employees	58	4, 982	11, 697	609	52. 1	2. 8	15	2	2
100 to 149 employees	75	9, 218	21, 108	937	44. 4	4. 1	15	10	6
150 to 249 employees	56	10, 583	24, 330	882	36. 3	3. 2	15	1	17
250 to 499 employees	45	15, 150	35, 734	1, 154	32. 3	3. 1	17	1	6
500 to 999 employees	27	17, 967	40, 421	1, 096	27. 1	3. 9	20	0	7
1,000 employees and over	10	14, 952	29, 149	906	31. 1	1. 7	12	0	4

[1] The frequency rate is the average number of disabling injuries for each million employee-hours worked. The severity rate is the average number of days lost for each thousand employee-hours worked.

Safety Programs and First-Aid Facilities

Details relating to the safety programs and first-aid facilities maintained upon the premises were obtained from 58 of the foundries visited in the course of the survey. The variations from plant to plant were too numerous to permit detailed comparisons, but a few significant general comparisons were possible.

Three of the 58 plants had fewer than 100 employees each, 29 had from 100 to 500 employees, 18 had from 500 to 1,000 employees, 5 had from 1,000 to 2,000 employees, and 3 plants employed over 2,000 workers. The smallest plant had 55 employees and the largest had 3,900. The sample therefore omitted all very small plants, which generally rely upon first-aid kits for injury treatments and rarely employ safety engineers.

No plant with less than 250 employees reported the employment of a full-time safety engineer. However, among the foundries with 250 to 500 employees each there were 4 which had safety engineers on their pay rolls. In the range of 500 to 1,000 employees, 6 out of 18 foundries had safety engineers, as did 3 out of 5 having 1,000 to 2,000 employees, and the 3 plants having more than 2,000 employees.

Each of the 8 plants having 1,000 or more employees maintained first-aid rooms on the premises, and all but one of these had either a doctor or a trained nurse on full-time duty. In the 500-to-1,000-employee range, 16 out of 18 plants had specially equipped first-aid rooms. Ten of these were attended by full-time doctors or trained nurses, 3 were attended by workers who had received Red Cross training in first aid, and 3 were under the supervision of workers who had had no formal training in first aid.

Three of the 32 plants reporting less than 500 employees had first-aid rooms with full-time registered nurses in attendance; 8 had first-aid rooms with Red Cross trained attendants; and 12 had first-aid rooms with untrained attendants.

The striking differences in the injury-frequency rates of these plants, as shown in table 5, graphically portray the variations in the emphasis upon safety indicated by the type of safety leadership and first-aid facilities provided. The 16 foundries which employed full-time safety engineers had an average of 41.3 disabling injuries for every million employee-hours worked, compared with an average of 63.8 for the 42 plants which did not have full-time safety engineers.

Inasmuch as nearly all of the plants which employed a full-time safety engineer also employed a doctor or registered nurse to administer first aid, the variations in first-aid facilities in this group involve too few establishments to permit valid comparison on that basis. Among the 42 foundries which did not employ safety engineers, however, the 31 which had first-aid rooms had an average frequency rate of 60.5 compared with an average of 78.8 for the 11 without first-aid rooms. Similarly, within the group of plants with first-aid rooms the average frequency rates varied directly with the quality of the supervision provided for the first-aid rooms. The best average rate (45.3) was for the six plants which had doctors or trained nurses in attendance. The 10 foundries which had first-aid attendants who had been given Red Cross training had an average rate of 65.4, while the 15 plants which had untrained attendants in their first-aid rooms had a rate of 71.3.

The individual plant frequency rates varied widely from their group averages, and there was considerable overlapping between the groups. Each of the groups included at least one plant which had a rate higher than the highest group average, and nearly all of the groups included one or more plants with rates which were lower than the lowest group average. It is interesting, however, to note that the lowest individual plant rates in the different groups held the same relationship to each other as that existing among the group averages. The inference to be drawn from these individual plant variations is that many factors other than the employment of a safety engineer or the maintenance of first-aid facilities enter into the safety record of individual plants. The direct correlation between the employment of a safety engineer or the maintenance of first-aid facilities and the group averages, however, does show that these factors generally do indicate the level of safety existing in particular plants.

TABLE 5.—*Variations in Injury-Frequency Rates Compared With Differences in Plant Safety Programs and First-Aid Facilities, for 58 Foundries, 1942*

Item	Number of establishments	Number of employees	Average number of employees	Frequency rate [1]	Lowest individual plant frequency rate [1]	Highest individual plant frequency rate [1]
Total	58	36,461	629	52.0	9.9	148.1
Foundries with full-time safety engineers	16	19,010	1,188	41.3	9.9	103.2
With first-aid rooms	16	19,010	1,188	41.3	9.9	103.2
With doctor or trained nurse	14	18,455	1,318	40.0	9.9	103.2
With attendant trained in first-aid	2	555	278	85.7	84.3	87.0
Foundries without safety engineers	42	17,451	416	63.8	25.7	199.9
With first-aid rooms	31	14,392	464	60.5	25.7	199.9
With doctor or trained nurse	6	4,789	798	45.3	25.7	108.4
With attendant trained in first-aid	10	4,901	490	65.4	31.3	148.1
With untrained attendant	15	4,702	313	71.3	34.2	199.9
Without first-aid rooms	11	3,059	278	78.8	40.5	144.0

[1] The frequency rate is the average number of disabling injuries for each million employee-hours worked.

Injuries and the Age of Workers

None of the foundries visited were able to supply an age distribution covering all employees. No conclusion can be drawn, therefore, as to whether or not there was any relationship between the age of workers and the frequency of injuries. Sixty of the plants, however, were able to supply details regarding both the age and the disability experienced by those of their employees who were injured. The volume of fatal and permanent impairment cases was insufficient for an extended break-down, but from the data relating to temporary total disabilities it was possible to establish relationships between the age of the injured persons and the average time lost because of their injuries. (See table 6.) These data corroborate the findings of previous studies in other industries, that injuries to older persons are likely to result in more serious disabilities than those experienced by

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younger persons, the differences primarily being due to the greater recuperative ability of the younger persons.[7]

In all three types of job foundries the average time lost by workers who were less than 18 years old at the time of injury was quite low. To some extent this is undoubtedly due to efforts on the part of the foundries to keep young persons away from more dangerous operations, which present greater possibilities of severe injury. If this age group is excluded as being affected by particular circumstances, the most pronounced differences in recuperative ability appear to develop at about the age of 30, with a gradual increase in the required recovery time for each higher age group.

Table 6.—*Average Days Lost per Temporary Total Disability, by Kind of Foundry and Age of Injured, for 60 Foundries, 1942*

Age	Average days lost per temporary total disability in—			Age	Average days lost per temporary total disability in—		
	Gray-iron foundries	Malleable-iron foundries	Steel foundries		Gray-iron foundries	Malleable-iron foundries	Steel foundries
All ages	16	14	17	31-35 years	17	14	17
				36-40 years	19	13	16
Under 18 years	10	6	9	41-45 years	19	15	19
18-20 years	12	11	15	46-50 years	18	17	22
21-25 years	15	10	14	51 years and over	20	19	24
26-30 years	14	10	13				

Kinds of Injuries Experienced

THE ENTIRE GROUP

The use of personal protective equipment as a rule does not prevent accidents. It seems apparent, however, from the character of the injuries experienced by foundry workers that more extensive use of protective equipment could do much to prevent or minimize a great many foundry injuries. Conservatively, it is estimated that 40 percent of all foundry injuries could be avoided through the general use of proper goggles, gloves, leggings, spats, and safety shoes by workers engaged in operations which present eye, hand, foot, and leg hazards.

More than 26 percent of all the disabling injuries analyzed were foot and toe cases. Over nine-tenths of the toe injuries and more than three-fifths of the foot injuries were cuts, bruises, or fractures resulting primarily from dropping heavy objects or setting them down improperly. Most of these injuries probably would have been avoided if the workers had been wearing safety shoes or metal foot guards. Burns, primarily caused by hot metal spilled in pouring, were the source of about a third of the foot injuries. Most of these injuries might well have been prevented through the general use of proper spats and molder's-type shoes.

[7] See Relation of Age to Industrial Injuries, in Monthly Labor Review, October 1940 (p. 789).

Table 7.—*Disabling Injuries, Classified by Department and Location of Injury, for 64 Foundries, 1942*

Department	Total number of disabling injuries	Location of injury					
		Eye(s)	Head, other than eye(s)	Back	Chest	Abdomen	Other trunk injuries
All departments	4,646	490	199	545	117	127	213
Pattern shop	44	3	1	3	0	1	1
Core room	336	14	13	60	8	5	14
Molding, including shake-out	1,723	99	52	259	47	53	93
Shake-out only	75	7	2	16	0	1	4
Melting	239	24	8	23	6	4	20
Cleaning, chipping, and finishing	1,383	272	78	103	31	42	39
Machine shop	150	34	1	8	2	3	8
Annealing	83	1	2	9	2	3	5
General labor	94	3	6	14	0	1	4
Maintenance	221	26	14	13	5	7	10
Shipping	65	3	3	9	4	0	4
Storage yard	158	6	14	17	6	4	10
Yard transportation	17	0	1	2	1	0	3
Not elsewhere classified	35	4	4	3	2	2	0
Unknown	98	1	2	22	3	2	2

Department	Location of injury—Continued							
	Arm(s)	Hand(s)	Finger(s) or thumb(s)	Leg(s)	Foot or feet	Toe(s)	Multiple injuries	Unknown
All departments	175	318	737	397	835	394	76	23
Pattern shop	1	3	15	4	7	5	0	0
Core room	6	30	62	29	53	34	8	0
Molding, including shake-out	67	115	247	147	400	111	31	2
Shake-out only	2	8	7	4	18	5	1	0
Melting	11	7	36	19	43	26	10	2
Cleaning, chipping, and finishing	44	82	241	126	189	123	10	3
Machine shop	11	10	31	8	15	16	1	2
Annealing	2	5	14	9	15	16	0	0
General labor	4	9	11	8	21	12	0	1
Maintenance	10	22	37	18	34	21	4	0
Shipping	1	3	10	4	10	9	5	0
Storage yard	8	15	19	14	27	16	2	0
Yard transportation	2	1	1	2	3	0	1	0
Not elsewhere classified	3	5	2	3	5	1	1	0
Unknown	5	11	11	6	13	4	3	13

Hand and finger injuries accounted for 23 percent of the entire volume of disabilities. The majority of these were cuts, sprains, and bruises, although one out of every five hand injuries was a burn, and a similar proportion of the finger injuries were fractures. Protective equipment which will prevent crushing injuries to hands and fingers is generally considered impracticable. Nevertheless, merely the provision of gloves, and their use when handling hot, rough, or sharp-edged materials, would probably have prevented most of the hand and finger burns and a large proportion of the cuts and lacerations.

Eye injuries totaled about 10 percent of all the disabilities. The majority of these were cuts or lacerations caused by flying particles, although one in every six was a burn. The use of safety goggles by all workers exposed to flying particles undoubtedly would have prevented practically all of the eye injuries.

Back injuries accounted for nearly 12 percent of the disabilities. Practically all of these were strains or sprains resulting from lifting excessive weights or lifting improperly. It should be noted, however, that in a number of instances back disabilities, which became evident when the workers attempted to lift materials, might have resulted from sudden chilling after exposure to great heat rather than from lifting.

Injuries to other parts of the trunk constituted about 10 percent of the total number of disabilities. A large proportion of these were strains and sprains arising from lifting or overexertion. One in every eight of the injuries in this group was a hernia case.

Injuries to the head (other than eye cases) and injuries to arms were relatively infrequent. Leg injuries, however, totaled nearly 9 percent of all the cases analyzed. Three-fourths of the leg injuries were cuts, sprains, and bruises arising primarily from forcible contact with mishandled materials. (See table 7.[8])

INJURIES IN DIFFERENT TYPES OF FOUNDRIES

In general the injuries in each of the three types of foundries visited were of much the same pattern. There were, however, a few significant differences among the three groups.

Foot injuries were of outstanding importance in all three groups; relatively, however, they were considerably more important in the gray-iron plants than in either the malleable-iron or steel foundries. On the other hand, back and trunk injuries were of greater importance and eye injuries were of much less importance in the malleable-iron foundries than in either of the other groups. In the steel foundry

TABLE 8.—*Disabling Injuries, Classified by Kind of Foundry and Nature of Injury, for 65 Foundries, 1942*

Nature of injury	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability
	Number	Percent		Number	Percent		Number	Percent	
All injuries	1,500	100.0	16	1,059	100.0	14	2,075	100.0	16
Amputations and enucleations	35	2.3	------	17	1.6	------	45	2.2	------
Burns and scalds	231	15.4	22	192	18.1	17	212	10.2	15
Cuts and lacerations	441	29.4	10	281	26.5	10	682	32.9	12
Without infection	393	26.2	10	240	22.6	9	611	29.5	12
With infection	48	3.2	11	41	3.9	12	71	3.4	15
Strains, sprains, and bruises	590	39.4	13	440	41.5	11	753	36.2	12
Fractures	174	11.6	36	94	8.9	25	344	16.6	34
Hernia	16	1.1	40	23	2.2	44	20	1.0	46
Industrial disease	8	.5	10	7	.7	9	11	.5	16
Not elsewhere classified	5	.3	9	5	.5	6	8	.4	8

[8] Nature and location of injuries for 3 types of foundries are shown in tables 8 and 9, and for certain occupations, in table 10.

group, toe, leg, hand, finger, and head injuries were proportionately more important and back and trunk injuries proportionately less important than in either the gray-iron or malleable-iron foundries.

In all three types of foundries the most important injury categories were strains, sprains, or bruises, and cuts or lacerations. Burns were third among the injury categories, followed by fractures in the gray-iron and malleable-iron foundries. In the steel foundries, however, there were more fractures than burns. (See tables 8 and 9.)

Table 9.—*Disabling Injuries, Classified by Kind of Foundry and Location of Injury, for 65 Foundries, 1942*

Location of injury	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability
	Number	Percent		Number	Percent		Number	Percent	
Total	1,518	100.0	16	1,059	100.0	14	2,082	100.0	16
Eye(s)	172	11.3	6	79	7.5	5	239	11.5	6
Head, other than eye(s)	53	3.5	15	42	4.0	7	104	5.0	13
Back	187	12.3	14	159	15.0	10	209	10.0	14
Chest	37	2.4	20	35	3.3	15	46	2.2	21
Abdomen	37	2.4	30	45	4.2	27	46	2.2	22
Other trunk injuries	77	5.1	16	57	5.4	15	84	4.0	15
Arm(s)	58	3.8	14	38	3.6	15	79	3.8	17
Hand(s)	103	6.8	14	68	6.4	15	148	7.1	13
Finger(s) or thumb(s)	231	15.2	14	168	15.9	12	343	16.6	17
Leg(s)	116	7.6	21	84	7.9	18	199	9.6	22
Foot or feet	310	20.6	21	197	18.6	17	336	16.1	21
Toe(s)	107	7.0	19	75	7.1	13	215	10.3	19
Multiple injuries	30	2.0	22	12	1.1	18	34	1.6	13

OCCUPATIONAL EXPERIENCE

Chainmen

Chainmen, sometimes called hookmen or riggers, work on the foundry floor as assistants to the crane operators. Their duties are to prepare heavy materials to be lifted by the cranes by placing, or rigging, heavy chains around them and to attach the crane hook to the load. When the load has been moved into position they release the crane hook and remove the chains. Frequently they are also required to direct the movements of the cranes by means of hand signals, to guide or push the suspended loads into position, and to warn other workers on the floor of the approach of the suspended load.

Material falling from crane loads, and loads lowered upon the workers were the primary sources of injuries to chainmen. There were, however, numerous cases of crushed fingers resulting from the failure of chainmen to keep their hands off suspended loads and away from chains which were being placed under tension. The predominant types of injuries in this occupation were cuts, bruises, and fractures to the hands, fingers, feet, and toes.

Greater use of safety shoes by chainmen undoubtedly would have prevented many of the foot and toe injuries. The most essential measures for the prevention of injuries to these workers, however, are (1) better training in the proper rigging of crane loads, (2) arrangements for better teamwork between the chainmen and the crane operators, and (3) strict supervision to see that safe procedures are followed.

Chippers

Chippers cut undesirable projections from metal castings and smooth and shape the surface of the castings with air chipping hammers or with hand hammers and chisels. Flying chips caused more injuries to workers in this occupation than any other single agency. There were, however, a considerable number of chippers who experienced hand, foot, and trunk injuries in the course of lifting or moving the castings on which they were working.

Practically all of the injuries caused by flying chips were eye injuries which would not have resulted if the workers had been wearing proper impact goggles at the time of the accident. The absolute necessity for the use of goggles in all chipping operations is generally recognized. Nevertheless there were some injuries reported which resulted directly from performance of chipping operations without the use of goggles. It is important to note, however, that many chippers experienced eye injuries which were caused by chips coming from fellow-workers' hammers rather than from their own. Most of these cases occurred when the injured worker had stopped chipping and had removed his goggles.

On the basis of the record, the most effective accident-prevention measures in this occupation would be (1) to make it a hard and fast rule that all chippers must wear proper impact goggles not only while performing chipping operations themselves, but also whenever others are chipping in the same room, (2) to provide and use screens or booths to segregate individual chipping operations so as to prevent chips from striking other workers, and (3) to train chippers in the proper methods of lifting or moving heavy castings, and see that proper lifting equipment or sufficient help is available when weights which are too heavy for one man must be moved.

Coremakers

The coremaker compacts a cohesive mixture of sand and binder, either by hand or machine, into hollow forms or core boxes and carefully removes the forms so as to leave the cores intact and undamaged. After being baked, the cores are used in molds for hollow castings to prevent molten metal from completely filling the mold cavity, thus forming a hole or hollow of the desired shape in the casting.

Although coremaking is comparatively light work, back strains were reported in this occupation more frequently than any other type of injury. There were, also, a considerable number of coremakers who were disabled by cut or bruised hands and feet. Adequate instruction in proper lifting methods and an increased use of safety shoes undoubtedly would substantially reduce the number of injuries to coremakers.

Grinders

A grinder removes undesirable projections or surface imperfections on castings, using a power-driven grinding wheel. Stationary grinders are used for small castings and large swing or balanced grinders are used for heavy castings. Portable or hand-held grinders are used for interior surfaces and corners which cannot be reached on the stationary or swing grinders.

Eye injuries produced by foreign particles were more common than any other type of injury in this occupation. Working without goggles was usually the cause of these accidents. There were, however, a number of reports of eye injuries which stated that the workers had been wearing goggles and that the goggles were properly fitted and equipped with cups or side shields. As a possible explanation of this seemingly impossible occurrence, one safety engineer suggested that, in the course of grinding, many metal particles may adhere to the worker's forehead or eyebrow. When he removes his goggles and wipes his face, some of these particles may be brushed into his eye. The entrance of these particles into the eye could easily go unnoticed at the time, and later develop a noticeable irritation. This irritation might become apparent during later grinding operations when goggles are being worn and the case would be reported as a foreign particle entering the eye despite the use of proper goggles.

The reason generally given for the failure of grinders to wear goggles was that they are uncomfortable. The importance of arranging to have all goggles properly fitted to the individual wearers, therefore, cannot be overemphasized. In this connection it is pertinent to note that in several of the foundries visited the Bureau representative was told that in normal times those plants had imposed penalties for failure to wear goggles when doing grinding. At the time of the survey, however, most of these penalty rules were being ignored because of the fear that enforcement would result in the resignation of much-needed workers.

Finger and foot injuries were also comparatively common among the grinders. Finger injuries frequently occurred because of lack of proper care in holding castings against the grinding wheel, causing the casting to "catch" on the wheel and to pull the operator's hands against the wheel. Dropped castings produced most of the foot and toe injuries.

Laborers and Shake-out Men

In many foundries shake-out men were classed as laborers and were so reported. For this reason the injuries reported under both these occupational designations were considered together.

Foundry laborers perform many unskilled tasks, such as the moving of materials and the cleaning of workplaces, to facilitate the work of more skilled workers. They generally work under the supervision of a gang foreman or under the direct supervision of any skilled worker to whom they may be assigned as helpers. Shake-out work, which is only one of the many tasks which may be given to a laborer, consists of removing castings from the mold in which they were cast, shaking the adhering sand from the castings, and either stacking or transporting the castings to the appropriate department for further processing.

Nearly a third of the injuries in these occupations were foot and toe cases, 23 percent were injuries to the back or other parts of the trunk, and 21 percent were hand and finger injuries. A fairly high proportion of the injuries, particularly among those affecting arms, hands, and feet, were burns. The majority, however, were cuts, sprains, bruises, and fractures. Most of these injuries resulted directly from improper methods of handling, lifting, or moving heavy materials.

In view of the very large volume of foot and toe injuries, there can be little doubt that more general use of safety shoes and foot guards by laborers and shake-out men would do much to reduce the number of disabling injuries in these occupations. Better training in the safe ways of lifting and moving heavy materials, the provision of more mechanical equipment for the handling of heavy objects, and close supervision to insure that safe procedures are followed would probably eliminate most of the back and trunk injuries and also many of the hand and finger injuries.

Ladlemen or Pourers

Ladlemen transport molten metal from the melting furnace to the molds in a ladle and pour the molten metal into the molds. The ladles used may be carried by hand, by either one or two men; they may be mounted on wheels; they may be swung from the hoist of a monorail crane; or they may be supported and carried by an overhead crane.

Burns predominated among the injuries experienced by ladlemen. In most cases the burns resulted from the splashing or spilling of molten metal from the ladles, and generally the burns were on the legs and feet. Moisture in the ladles and lack of proper care in taking the hot metal from the furnaces were frequently given as the causes of these accidents. Careful training, strict supervision, and the use of proper protective clothing probably would have avoided many of the injuries experienced by ladlemen.

Machinists

Many castings require considerable processing beyond the cleaning and rough-finishing stage to fit them for their ultimate use, particularly to insure a close fit when they are to be fitted into an assembly. Some foundries perform this additional function and for this purpose maintain a machine shop in which all types of metalworking machine tools may be employed.

Hand and finger injuries, eye injuries, and foot and toe injuries were most common in this occupational classification. The eye injuries resulted primarily from chips or metal particles thrown off by machines. The finger injuries were generally the result of contact with moving parts at the point of operation, while the foot and toe injuries generally were caused by dropped materials. Greater attention to machine guarding, the use of impact goggles when using machines which may throw out chips or particles, and the use of safety shoes would have prevented a large proportion of the injuries experienced by machinists.

Molders and Molder's Helpers

Molders produce sand molds by ramming and compacting molding sand around a pattern and withdrawing the pattern so as to leave an impression or mold of the pattern into which molten metal is poured to make the casting. The work may be performed entirely by hand or may be performed in part with the assistance of various types of molding machines.

Because of the heavy work in these occupations, back strains and injuries to other parts of the trunk were particularly prominent among the injuries experienced by molders and their helpers. In proportion to the total number of injuries the number of hernias reported for molders was double that of any other occupation.

Foot injuries and hand or finger injuries were also quite numerous. Many molders and their helpers are required to pour their own molten metal, and as a result a high percentage of the foot injuries were burns. Slips in placing the cope upon the drag produced many of the finger injuries.

Molders generally have served long apprenticeships so that the excuse of inexperience and unfamiliarity with the hazards of the work cannot explain the failure to follow safe procedures or to use proper safety equipment, which was apparent in the descriptions of many of the molders' accidents. General safety instruction to stimulate interest in safe methods and strict supervision to stop slipshod procedures appear to be needed to reduce the accident record of this occupation.

Sandblasters

Sandblasters clean castings by means of a blast of abrasive-laden compressed air which removes adhering scale and imparts an even finish to the casting surfaces. Small castings are sandblasted in enclosed machines, but large castings must be cleaned by directing the blast against the surface by means of a hand-held nozzle. Finger injuries predominated in this occupation. Most of these occurred when the workers got their fingers caught in the sandblasting equipment.

Table 10.—*Disabling Injuries, Classified by Occupation and by Location and Nature of Injury, for 65 Foundries, 1942*

Occupation and location of injury	Total number of disabling injuries	Nature of injury								
		Amputations and enucleations	Burns and scalds	Cuts and lacerations	Strains, sprains, and bruises	Fractures	Hernia	Industrial disease	Not elsewhere classified	Unknown
All occupations	4,682	97	635	1,404	1,783	612	59	26	18	48
Eye(s)	490	2	79	396	9			2		2
Head, other than eye(s)	199		17	115	52	11		3		1
Back	555		12	2	531	7			1	2
Chest	118		3	2	70	36		6		1
Abdomen	128		4	4	61		59			
Other trunk injuries	218		5	6	201	4		1		1
Arm(s)	175		54	46	54	18		1		2
Hand(s)	319		68	130	90	28		2		1
Finger(s) or thumb(s)	742	87	23	385	94	149				4
Leg(s)	399	1	60	134	170	31		2	1	
Foot or feet	843		273	116	329	120		3		2
Toe(s)	397	7	9	61	112	207				1
Multiple injuries	76		27	7	10	1		6	16	9
Unknown	23		1							22

Table 10.—*Disabling Injuries, Classified by Occupation and by Location and Nature of Injury, for 65 Foundries, 1942*—Continued

Occupation and location of injury	Total number of disabling injuries	Nature of injury								
		Amputations and enucleations	Burns and scalds	Cuts and lacerations	Strains, sprains, and bruises	Fractures	Hernia	Industrial disease	Not elsewhere classified	Unknown
Chainmen	221	13	14	70	65	57	1	1		
Eye(s)	10		3	5	2					
Head, other than eye(s)	16			9	6	1				
Trunk	19				16	2	1			
Arm or hand	13			8	2	3				
Finger(s) or thumb(s)	57	11		26	1	19				
Leg(s)	26		2	8	11	4		1		
Foot or feet	49		8	7	22	12				
Toe(s)	29	2		6	5	16				
Multiple injuries	2		1	1						
Chippers	310		21	137	117	30	2	2	1	
Eye(s)	73		3	67	3					
Head, other than eye(s)	30		2	16	7	3		2		
Trunk	46			1	41	2	2			
Arm(s)	13		4	2	5	2				
Hand(s)	27		6	11	8	2				
Finger(s) or thumb(s)	43			24	11	8				
Leg(s)	29			14	14	1				
Foot or feet	34		6	1	20	7				
Toe(s)	14			1	8	5				
Multiple injuries	1								1	
Coremakers	145	3	11	42	70	15		2		2
Eye(s)	8		1	7						
Back	33				31	1				1
Trunk, other than back	11				10	1				
Hand(s)	17		2	8	6	1				
Finger(s) or thumb(s)	28	3	3	13	3	6				
Leg(s)	9		1	3	3	1		1		
Foot or feet	19		2	4	12	1				
Toe(s)	11		1	2	4	4				
Other	9		1	5	1			1		1
Grinders	296	3	10	183	67	28		1	2	2
Eye(s)	111		2	109						
Trunk	38			1	33	3		1		
Arm or hand	11		1	7	3					
Finger(s) or thumb(s)	61	3		42	4	11				1
Leg(s)	17		3	5	9					
Foot or feet	25		3	7	11	4				
Toe(s)	21			4	7	10				
Other	12		1	8					2	1
Laborers	1,333	19	177	351	583	165	12	5	5	16
Eye(s)	80		11	67	1					1
Back	182		6		175	1				
Trunk, other than back	131		2	3	102	9	12	2		1
Arm(s)	58		21	18	13	4				2
Hand(s)	94		21	37	25	10				1
Finger(s) or thumb(s)	188	18	11	92	32	33				2
Leg(s)	115		14	37	56	8				
Foot or feet	284		84	41	122	35		2		
Toe(s)	129	1	1	22	42	62				1
Other	72		6	34	15	3		1	5	8
Ladlemen or pourers	76	2	39	11	16	6		1		1
Eye(s)	12		8	4						
Back	5				5					
Finger(s) or thumb(s)	10	2		3	3	2				
Leg(s)	9		5	1	2	1				
Foot or feet	28		21	2	3	2				
Other	12		5	1	3	1		1		1

Table 10.—*Disabling Injuries, Classified by Occupation and by Location and Nature of Injury, for 65 Foundries, 1942*—Continued

Occupation and location of injury	Total number of disabling injuries	Nature of injury: Amputations and enucleations	Burns and scalds	Cuts and lacerations	Strains, sprains, and bruises	Fractures	Hernia	Industrial disease	Not elsewhere classified	Unknown
Machinists (machine operators)	132	10	6	57	34	23	1			1
Eye(s)	27	2	4	21						
Back	7				7					
Trunk, other than back	11			1	7	2	1			
Arm(s)	9			3	4	2				
Hand(s)	13		2	7	4					
Finger(s) or thumb(s)	32	8		16	1	7				
Leg(s)	7			4	2	1				
Foot or feet	11			2	6	3				
Toe(s)	13			2	3	8				
Other	2			1						1
Molders	508	6	142	77	234	33	14	1	1	
Eye(s)	24		11	12	1					
Back	112		4	1	106	1				
Trunk, other than back	84		5		60	4	14	1		
Arm or hand	49		13	11	22	3				
Finger(s) or thumb(s)	65	5	2	41	7	10				
Leg(s)	29	1	14	1	12	1				
Foot or feet	103		80	4	14	5				
Toe(s)	23		5	4	6	8				
Other	19		8	3	6	1			1	
Molder's helpers	158		19	50	59	27	1	1	1	
Eye(s)	8			8						
Head, other than eye(s)	7		1	3	3					
Back	12		1		11					
Trunk, other than back	18		1		13	2	1	1		
Arm or hand	17		1	9	5	2				
Finger(s) or thumb(s)	28			16	4	8				
Leg(s)	15		2	6	5	2				
Foot or feet	33		11	4	12	6				
Toe(s)	16			4	5	7				
Multiple injuries	4		2		1				1	
Sand blasters	61	1	3	24	19	13		1		
Eye(s)	7			7						
Back	5		1		4					
Finger(s) or thumb(s)	18	1		11	1	5				
Leg(s)	6			3	2	1				
Foot or feet	6			1	4	1				
Toe(s)	7			1	1	5				
Other	12		2	1	7	1		1		
Shakeout men	80	2	16	19	32	9	1			1
Eye(s)	7			7						
Back	14				14					
Trunk, other than back	6				5		1			
Hand(s)	9		3	2	4					
Finger(s) or thumb(s)	9	1		3	2	2				1
Foot or feet	21		12	4	3	2				
Toe(s)	6	1		1		4				
Other	8		1	2	4	1				
Occupation unknown	391	10	50	85	154	62	8			18
Other	971	28	127	298	333	144	19	9	6	7
Eye(s)	97		32	64				1		
Head, other than eye (s)	55		8	31	13	3				
Back	80			1	75	3			1	
Trunk, other than back	99		2	5	62	9	19	1		1
Arm(s)	42		16	9	12	4		1		
Hand(s)	76		19	30	17	8		2		
Finger(s) or thumb(s)	152	27	3	77	18	27				
Leg(s)	98		11	40	37	9			1	
Foot or feet	162		27	30	74	29		1		1
Toe(s)	85	1	1	10	22	51				
Other	25		8	1	3	1		3	4	5

Accident Types and Agencies Involved

THE AGENCIES

In the gray-iron foundries visited during the survey, the outstanding injury-producing agencies,[9] and the proportion of the total volume of injuries in which each was involved, were castings, 10.3 percent; molds, 9.4 percent; flasks, core plates, etc., 7.4 percent; hand ladles, 7.3 percent; and vehicles, 7.2 percent. (See table 11.)

In the malleable-iron foundries, considerably more injuries were associated with machines and proportionately fewer with flasks and core plates than in the gray-iron plants. Otherwise the agencies presenting the most common hazards were much the same in the two groups. For the malleable-iron group the outstanding injury-producing agencies and the proportion of all injuries in which each was involved were molds, 11.4 percent; castings, 9.0 percent; hand ladles, 8.7 percent; machines (other than grinders), 7.2 percent; and vehicles, 6.9 percent.

TABLE 11.—*Disabling Injuries, Classified by Kind of Foundry and Agency, for 65 Foundries, 1942*

Agency	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disbility
	Number	Percent [1]		Number	Percent [1]		Number	Percent [1]	
All agencies	1,523	100.0	16	1,062	100.0	14	2,097	100.0	16
Castings	149	10.3	17	91	9.0	12	308	16.0	17
Chipping hammer	11	.8	5	20	2.0	4	59	3.1	11
Dust particles	39	2.7	4	16	1.6	5	33	1.7	5
Electrical apparatus	6	.4	22	5	.5	11	11	.6	25
Flasks, core plates, etc	108	7.4	16	41	4.0	12	87	4.5	17
Furnaces	28	1.9	13	21	2.1	14	5	.3	24
Grinders	82	5.7	5	68	6.7	8	84	4.4	11
Hammer or sledge	34	2.3	12	17	1.7	17	47	2.4	16
Hoisting apparatus	99	6.8	20	41	4.0	15	229	11.9	24
Ladle—hand	106	7.3	22	88	8.7	16	33	1.7	14
Machinery—other than grinders	77	5.3	13	73	7.2	14	112	5.8	18
Metal stock	25	1.7	20	21	2.1	11	74	3.8	21
Molds	136	9.4	17	116	11.4	14	91	4.7	14
Nails, spikes, etc	12	.8	8	8	.8	4	12	.6	11
Patterns	9	.6	34	2	.2	30	15	.8	11
Piles of materials	26	1.8	20	12	1.2	9	15	.8	25
Radiations or radiating substances	3	.2	5	3	.3	8	41	2.1	7
Shovel	16	1.1	20	21	2.1	15	14	.7	18
Vehicles	105	7.2	22	70	6.9	20	104	5.4	18
Working surfaces	76	5.2	15	62	6.1	17	127	6.6	17
Not elsewhere classified	304	21.1	16	218	21.4	15	425	22.1	15
Unknown	72	------	16	48	------	11	171	------	13

[1] Percent of known cases.

[9] The agency is the object, substance, or exposure which is most closely associated with the injury and which could have been properly guarded or corrected.

In the steel foundries, however, the five most prominent injury-producing agencies formed a group very different from those of the gray-iron and malleable-iron plants. In the steel foundries, castings were involved in 16 percent of all the disabling injuries, a much higher proportion than in either of the other types of plants. Hoisting apparatus had a rather low percentage of the injuries in gray-iron and malleable-iron foundries, but in the steel foundries this equipment was involved in 11.9 percent of all the injuries. Defective working surfaces, accounting for 6.6 percent of the injuries, was the third most important injury-producing agency in the steel foundries, followed by machines (5.8 percent) and vehicles (5.4 percent).

Accident Types

"Struck by" Accidents

Nearly half of all the disabling injuries in the malleable-iron foundries and over half of the disabilities in gray-iron and steel foundries resulted from accidents in which workers were struck by moving, falling, or flying objects. (See table 12.)

Much of the work in foundries involves the handling of heavy materials. The castings, flasks, core plates, molds, and metal stock must frequently be shifted in the course of the work. They must be moved from one point of operations to another, and they must frequently be placed in piles or removed from piles. Hand trucks, power trucks, hoists, cranes, and conveyers are used for much of this work, but a great deal of the material moving must be done by hand. In many plants, space is at a premium and much of the moving of materials must be accomplished under the severe handicap of crowded work spaces. It is often necessary for the cranes to carry material over the heads of workmen and to set them down in spaces where there is little room for workers to stand clear. As a result of these circumstances many foundrymen are injured by being struck by materials and equipment.

Somewhat different from the ordinary danger of being struck by moving materials is the hazard of being struck by molten metal, which may splash or spill from the ladles or molds. The injuries resulting from contact with this material are generally very severe burns, rather than cuts, bruises, or crushing injuries such as result from being struck by other objects. All foundrymen who take molten metal from the furnaces, transport it to the molds, or pour it into the molds, and all others who work in the vicinity of such operations, face this hazard. A failure properly to control the flow of the metal either in filling the ladle or in pouring from the ladle may cause an overflow. Moisture in the ladle or in the mold, or pent-up gases in the mold, may cause the molten metal to spatter and fly about. Unsteady handling of the ladle may cause some of the molten metal to splash or spill. Uneven floors and material or equipment left in aisles or work spaces often present tripping and bumping bazards which can easily result in spilling the contents of the ladle. Over 6 percent of all the injuries in the gray-iron and malleable-iron foundries resulted from workers' being struck by molten metal. It is pertinent to note, however, that accidents of this type were much less common in the steel foundries, where hand ladles are not widely used.

In grinding castings, great quantities of metal particles from the material being ground and emery or carborundum particles from the grinding wheel are thrown off from the point of operation. The high speed of the wheel imparts a terrific velocity to these particles, and they frequently fly considerable distances from the point of operation endangering every one in the vicinity. Stationary grinders can generally be guarded by transparent shields and exhaust devices which intercept most of the particles before they travel far. Only comparatively small castings, however, can be ground on such equipment. For work on large castings, it is generally necessary to use portable or swinging grinders, which are much more difficult to guard. The chief danger from these particles is that they may strike and imbed themselves in the eyes of the operator or nearby workers. About 4 percent of all the foundry accidents were of this type.

Chipping operations similarly throw off bits of metal which constitute a very serious eye hazard. However, because the chips thrown off are larger and the resulting injuries are generally more severe, there is a tendency to be more careful in the use of goggles around chipping operations than in grinding. In the gray-iron foundries "struck by" accidents arising from chipping operations were few—less than 1 percent of the total volume of injuries. In the malleable-iron foundries, however, the proportion amounted to 1.9 percent, and in steel foundries it was 2.5 percent.

Slips (Not Falls) and Overexertion

Loose sand on working surfaces caused a majority of the reported slipping accidents. Many of these cases occurred when the workers were carrying materials or were attempting to push or pull heavy objects into position. The number of slips which resulted in disabilities was relatively small, however, in comparison with the number of injuries arising from overexertion in lifting or moving materials or in using tools and equipment. Overexertion was responsible for 18 percent of the disabilities in gray-iron foundries, nearly 25 percent of the disabilities in malleable-iron foundries, and about 13 percent of those which occurred in steel foundries. Generally, these injuries resulted from lifting excessive weights, lifting with the back instead of the legs, lifting in cramped or awkward positions, or failure of lifting teams to act in unison.

Caught In, On, or Between Objects

Accidents of the caught in, on, or between type accounted for about 7 percent of the disabling injuries in malleable-iron foundries, nearly 10 percent of the injuries in gray-iron foundries, and about 12 percent of those in steel foundries. The majority of these were crushing injuries—such as fingers and hands pinched between materials or caught in the chains used in rigging crane loads; persons crushed between crane loads and stationary objects or between vehicles and stationary objects; and hands and fingers caught in unguarded gears, pulleys, or other parts of moving machinery.

Striking Against

Accidents in which the injured person bumped into some stationary object—such as machines, castings, molds, etc.—accounted for nearly

10 percent of the disabilities in each of the three types of foundries. In many cases these accidents were the direct result of poor housekeeping, which in turn could be traced to a lack of sufficient space for the proper storage and placement of materials and equipment.

Falls

About 5 percent of all the disabilities were the results of falls. In the gray-iron and malleable-iron foundries the great majority of these cases were tripping accidents in which the injured person fell only to the surface on which he was working. In the steel foundries, however, falls from one elevation to another were nearly as numerous as falls on the same level.

TABLE 12.—*Disabling Injuries, Classified by Kind of Foundry and Accident Type, for 65 Foundries, 1942*

Accident type	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability
	Number	Percent [1]		Number	Percent [1]		Number	Percent [1]	
All types	1,523	100.0	16	1,062	100.0	14	2,097	100.0	16
Striking against	132	9.0	12	100	9.7	11	186	9.5	15
Grinders	14	1.0	13	23	2.2	11	21	1.1	17
Machinery, other than grinders	20	1.4	13	14	1.4	13	24	1.2	13
Other objects	97	6.6	12	63	6.1	10	139	7.2	15
Unknown objects	1	-------	5	0	-------	0	2	-------	9
Struck by	770	52.5	16	481	46.7	14	991	50.9	17
Grinders	68	4.6	3	39	3.8	7	62	3.2	9
Particles from point of operation	67	4.5	3	34	3.3	7	59	3.0	9
Other parts	1	.1	8	5	.5	6	3	.2	10
Hoisting apparatus	59	4.0	23	24	2.3	13	140	7.2	25
Hooks or slings	43	2.9	26	17	1.6	13	115	5.9	25
Other parts	16	1.1	16	7	.7	15	25	1.3	23
Vehicles	49	3.3	24	35	3.4	25	53	2.7	20
Hand tools	177	12.1	19	128	12.4	14	210	10.9	12
Chipping hammer	9	.6	5	20	1.9	4	49	2.5	11
Hammer or sledge	32	2.2	13	10	1.0	15	45	2.3	16
Ladle (including splashing particles)	96	6.6	23	70	6.8	18	28	1.4	14
Other	40	2.7	19	28	2.7	13	88	4.7	11
Flasks, core plates, etc	46	3.1	20	16	1.6	12	41	2.1	16
Castings	100	6.8	20	54	5.3	13	172	8.9	20
Dust particles	39	2.7	4	16	1.6	5	33	1.7	5
Metal stock	14	1.0	19	16	1.6	10	47	2.4	23
Molds	37	2.5	17	29	2.8	15	32	1.7	17
Other objects	180	12.4	13	122	11.9	16	195	10.1	15
Unknown objects	1	-------	0	2	-------	34	6	-------	33
Caught in, on, or between	142	9.7	17	75	7.3	13	240	12.3	19
Machinery	27	1.8	19	30	2.8	14	22	1.1	21
Hoisting apparatus	32	2.2	14	15	1.5	15	76	3.9	26
Hooks or slings	20	1.4	15	9	.9	21	46	2.4	21
Other parts	12	.8	12	6	.6	2	30	1.5	33
Vehicles	18	1.2	25	6	.6	18	21	1.1	18
Flasks, core plates, etc	18	1.2	16	5	.5	10	23	1.2	18
Castings	15	1.0	12	3	.3	16	45	2.3	14
Other objects	32	2.3	14	16	1.6	10	53	2.7	17

[1] Percent of known cases.

TABLE 12.—*Disabling Injuries, Classified by Kind of Foundry and Accident Type, for 65 Foundries, 1942*—Continued

Accident type	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability
	Number	Percent [1]		Number	Percent [1]		Number	Percent [1]	
Falls	83	5.7	22	49	4.8	26	124	6.4	20
On same level	60	4.1	18	36	3.5	23	69	3.6	14
From different level	23	1.6	34	13	1.3	36	55	2.8	29
Slips (not falls) and overexertion	281	19.2	15	274	26.7	13	291	14.9	14
Lifting	143	10.3	14	129	12.8	13	119	6.3	13
Vehicles	24	1.7	14	20	2.0	13	17	.9	14
Flasks, core plates, etc	26	1.9	13	15	1.5	9	11	.6	21
Castings	22	1.6	8	22	2.2	16	47	2.5	15
Molds	71	5.1	16	72	7.1	12	44	2.3	8
Using hand tools	29	2.1	13	50	5.0	14	37	2.0	16
Slips on working surfaces	16	1.2	8	21	2.1	9	37	2.0	19
Other	77	5.6	19	68	6.8	13	86	4.6	14
Circumstances unknown	16		12	6		5	12		9
Contact with temperature extremes	22	1.5	21	14	1.4	10	25	1.3	16
Inhalation, absorption, ingestion	11	.8	6	17	1.7	8	53	2.7	7
Contact with electric current	4	.3	27	2	.2	15	9	.5	27
Explosions	18	1.2	28	14	1.4	14	20	1.0	19
Other	2	.1	31	1	.1	27	9	.5	11
Unknown	58		18	35		11	149		12

[1] Percent of known cases.

Other Types of Accidents

Two types of contact with temperature extremes—consisting primarily of touching hot castings, and explosions in molds and pits when water and molten metal came into contact—each produced slightly over 1 percent of the reported injuries. Injuries resulting from the inhalation, absorption, or ingestion of dusts (including silica), gases, chemicals, and harmful light rays were very few in the gray-iron foundries. In the malleable-iron foundries, however, they constituted 1.7 percent of all the reported disabilities; and in the steel foundries, 2.7 percent.

Accident Causes

It is generally recognized that every accident may be traced to the existence of an unsafe working condition, to the commission of an unsafe act by some individual, or to a combination of these accident-producing factors. The correction of unsafe working conditions generally is entirely within the powers of management. The avoidance of unsafe acts, on the other hand, requires cooperation and understanding by both management and workers. Management must take the lead, however, by providing safety-minded supervision and by making sure that all workers are acquainted with the hazards of their operations and are familiar with the means of overcoming those hazards.

Over 90 percent of the foundry accidents which were analyzed in this study were found to involve both an unsafe working condition and an unsafe personal act. It is apparent, therefore, that any successful foundry safety program must include measures designed to eliminate both of these accident-producing factors.

UNSAFE WORKING CONDITIONS

Foundry operations undoubtedly present a wide variety of inherent hazards, and the problem of achieving safe working conditions in foundries may seem more difficult than in most other industries. There are, however, obvious and well-known methods of overcoming practically all foundry hazards, and the existence of unsafe working conditions generally may be taken as an indication of slack supervision.

The great majority of the unsafe conditions revealed by the accident analysis fell into five general categories. (See table 13.) Within individual plants the relative importance of these categories of unsafe conditions varied widely. It is apparent, however, that foundries generally should—

(1) Improve housekeeping conditions in and around all workplaces;

(2) Provide and require the use of adequate personal safety equipment in all operations presenting hazards which such equipment can overcome;

(3) Provide mechanical equipment or sufficient assistance when heavy or bulky materials are to be lifted or moved;

(4) Regularly inspect all tools, material, and equipment for defects, and immediately repair or replace all defective items; and

(5) Provide and require the use of proper guards for machinery and equipment.

Hazardous Arrangements or Procedures

The importance of good housekeeping and of the closely allied condition of safe plant lay-out as a means of avoiding accidents cannot be overemphasized in any foundry safety program. Thirty percent of all the foundry accidents for which full details were available were directly related to poor housekeeping conditions or unsafe work lay-out. In the gray-iron and steel foundries this group of unsafe conditions outranked all others, and in the malleable-iron foundries it was the third most important category of unsafe conditions.

Materials and equipment placed in irregular and unstable piles, stored materials which encroached upon aisles and workplaces, loose materials and equipment left in aisles and workplaces, and congestion of materials in small spaces were outstanding among the poor housekeeping conditions which led to accidents. Many workers were struck by materials which fell from improperly built piles; others bumped into the projecting corners of uneven or improperly placed piles of materials; and still others slipped on loose sand on the floor or tripped over tools, materials, vehicles, and debris lying in walkways or workplaces. A not unusual example of the accidents included in this group was described in a report covering an injury experienced by a worker in the course of taking a coreplate from a pile. The pile, which extended above his head, was composed of various sizes of plates and at the time of the accident a small plate was on top. This small plate, however, was pushed back and was not visible to him. As the worker pulled off what he thought was the top plate, the small plate slid from the pile and struck his head. In another instance three flasks, weighing approximately 10 tons, had been piled on rails, which were resting upon a large casting, bearing upon the cement core of the casting which had not been removed. Vibrations from an air drill caused the cement core to crumble and the flasks toppled on the worker who was using the drill.

Lack of adequate plant space, arising from expanded wartime activities, was the source of many of the poor housekeeping conditions. Similarly, lack of space was the underlying reason for many of the unsafe conditions which were classified as hazardous procedures or poor plant lay-out. The latter group primarily included such unsafe conditions as the placement of workers in close proximity to one another so that they interfered with each other's movements, or to the placement of operations so that the workers were exposed to the danger of being struck by cranes, crane loads, or passing vehicles.

Lack of Personal Safety Equipment

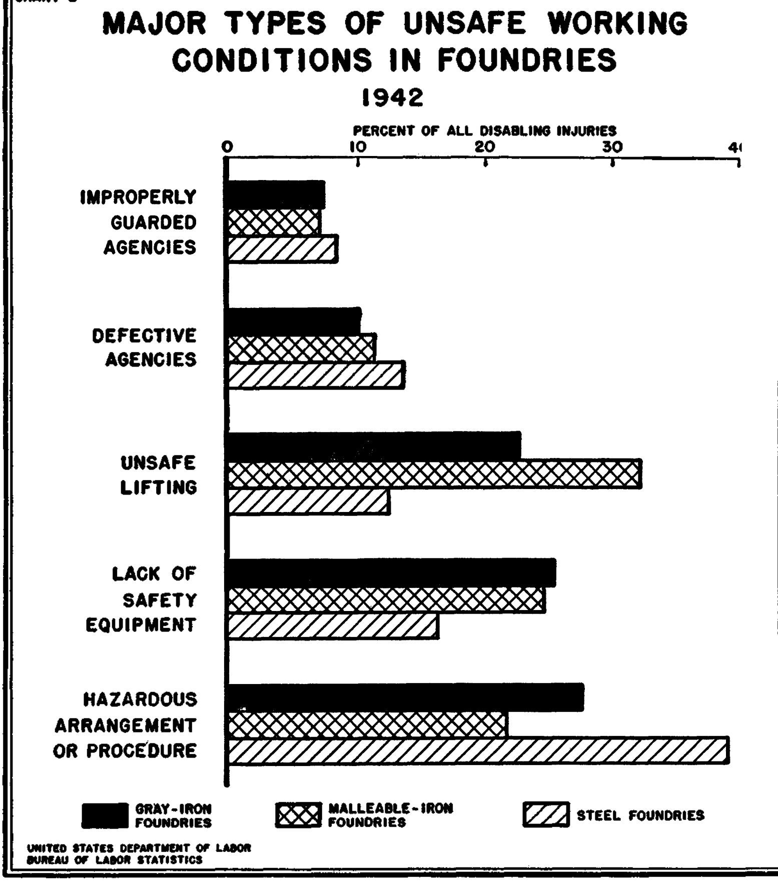
Many foundry operations involve inherent hazards which cannot be successfully eliminated or guarded at the point of operation, but which can be overcome through the use of proper personal safety equipment. In these circumstances the use of such equipment is recognized as an essential condition for the safe performance of the work, and its absence constitutes an unsafe working condition. About 1 in every 4 of the disabling injuries in the gray-iron and malleable-iron foundries, and 1 in every 6 in the steel foundries, resulted from unsafe working conditions of this type.

The most common unsafe condition in this group was the lack of goggles in the performance of work which presented obvious eye hazards, such as grinding, chipping, or handling molten metal. There were, however, many instances of unsafe conditions which involved a lack of other types of safety equipment, such as handling hot materials without gloves, handling molten metal without leggings or molder's shoes, handling acid or alkaline chemicals without gloves or other protective clothing, and other operations performed without specifically prescribed safety equipment.

Unsafe Lifting Conditions

In this category of unsafe working conditions are included accidents resulting from manual lifting of objects which should have been lifted mechanically, from individuals lifting objects which should have been lifted by a team, and from the lifting of objects in cramped or crowded quarters which should have been cleared before the operation started. In a few instances there was some question whether the injury might not have occurred because of (a) improper lifting procedure rather than because of (b) lifting excessive weight. When this question could not be specifically answered, the case was included as an unsafe lifting condition (b).

CHART 2



Unsafe lifting conditions constituted a much more prominent source of accidents in the malleable-iron foundries than in either the gray-iron or steel foundry groups. Comparatively, these unsafe conditions were involved in 1 out of every 3 of the malleable-iron foundry injuries for which details were available, slightly less than 1 in every 4 of the gray-iron foundry injuries, and 1 in every 8 of the steel foundry injuries.

Unsafe conditions of this type are due primarily to inadequate supervision. In all work that involves lifting, the immediate supervisor can be required to see that proper space is provided for the operation and that adequate teams or proper mechanical lifting equipment are available.

Defective Agencies

The general need for more adequate inspection and immediate repair or replacement of imperfect equipment, tools, and materials was strongly indicated by the fact that over 10 percent of the analyzed accidents in each of the three foundry groups involved defective material or equipment.

Defective hand tools, such as shovels with loose or split handles, hammers with loose heads, and chipping hammers with loose chisels were particularly common sources of injury which could have been eliminated very readily through regular tool inspection and repair.

Uneven or broken flooring resulted in many slips and falls and caused many wheelbarrows and hand trucks to tilt and spill their contents. These conditions are particularly dangerous in foundries, since the workers frequently carry heavy materials or molten metal which can inflict severe injuries if they are dropped or spilled as a result of a slip or fall. Such hazards generally are quite obvious and are seldom difficult to repair. Their continued existence is very definitely an indication of slack supervision.

Other defective agencies, which caused fewer but nevertheless substantial numbers of accidents, included defective molds which broke in pouring, defective chains, cables, and sheaves which caused crane loads to spill on workers, defective ladders and scaffolds which caused serious falls, and defective electrical equipment and wiring which caused electric shocks and burns. Nearly all of these unsafe conditions were such that they should have been noticed in the course of a normal inspection. The fact that they were permitted to exist until they caused accidents indicates that adequate inspections were not made.

Unguarded Agencies

About 7 percent of the injuries in the gray-iron and malleable-iron foundries and over 8 percent of those in the steel foundries were directly related to the absence of needed guards. Considerable numbers of these were due to the lack of guardrails around openings or at the edge of elevated walkways or working surfaces. The majority, however, were cases of unguarded machines or mechanical equipment.

Stationary grinders, power saws, jointers, punch presses, drill presses, and sanders were frequently listed as causing injuries because there were no guards at the point of operation. Open gears, open belts, and unfenced conveyers also were responsible for a number of injuries. Inadequate guards, which by their presence instilled a false sense of security, contributed to the occurrence of many injuries. In this connection it should be emphasized that machine guards are sometimes designed merely to meet minimum State requirements or for appearance to promote the sale of the machines, without regard for the extra protection which could be incorporated into the design at slight additional cost.

UNSAFE PERSONAL ACTS

For the purpose of accident analysis an unsafe act is defined as "a violation of a commonly accepted safe procedure."[10] Literally, this definition means that no personal action shall be designated as unsafe unless there was a reasonable and less-hazardous alternative method of procedure. There is, however, no implication that the alternative safe procedure must have been known to the person who acted in an

[10] American Recommended Practice for Compiling Industrial Accident Causes, approved by the American Standards Association, August 1, 1941.

Table 13.—*Disabling Injuries, Classified by Kind of Foundry and Unsafe Working Condition, for 59 Foundries, 1942*

Unsafe working condition	Gray-iron foundries: Number of disabling injuries: Number	Gray-iron foundries: Number of disabling injuries: Percent [1]	Gray-iron foundries: Average days lost per temporary total disability	Malleable-iron foundries: Number of disabling injuries: Number	Malleable-iron foundries: Number of disabling injuries: Percent [1]	Malleable-iron foundries: Average days lost per temporary total disability	Steel foundries: Number of disabling injuries: Number	Steel foundries: Number of disabling injuries: Percent [1]	Steel foundries: Average days lost per temporary total disability
Total	1,474	100.0	16	955	100.0	14	1,694	100.0	16
Improperly guarded	62	7.4	21	43	7.2	15	84	8.5	18
Grinders	13	1.5	13	11	1.8	11	12	1.2	19
Machinery, other than grinders	26	3.2	23	25	4.2	18	32	3.2	14
Other	23	2.7	24	7	1.2	13	40	4.1	21
Defective	85	10.1	18	68	11.4	12	136	13.7	20
Hand tools	16	1.9	20	17	2.8	10	17	1.7	18
Molds	11	1.3	27	10	1.7	19	7	.7	25
Working surfaces	12	1.4	10	8	1.3	12	18	1.8	27
Other	46	5.5	17	33	5.6	11	94	9.5	19
Hazardous arrangement or procedure	234	27.7	23	130	21.7	17	389	39.0	19
Unsafely stored or piled	101	12.0	20	76	12.6	17	188	18.9	16
Castings	15	1.8	20	11	1.8	7	53	5.3	17
Flasks, core plates, etc	12	1.4	13	6	1.0	20	15	1.5	20
Hand tools	13	1.5	27	2	.3	8	4	.4	6
Loose materials (sand, etc.)	12	1.4	23	8	1.3	10	6	.6	40
Vehicles	9	1.1	25	7	1.2	37	13	1.3	12
Other	40	4.8	18	42	7.0	18	97	9.8	14
Congestion of working surfaces	15	1.8	23	10	1.7	9	15	1.5	28
Exposure to hoisting apparatus	39	4.6	23	16	2.7	19	82	8.2	25
Exposure to vehicles	16	1.9	53	4	.7	18	22	2.2	22
Other	63	7.4	22	24	4.0	19	82	8.2	18
Lack of proper personal safety equipment	215	25.5	13	148	24.7	12	163	16.4	80
Lack of goggles	66	7.8	3	33	5.5	3	49	4.9	4
While using grinding wheels	64	7.6	3	21	3.5	4	35	3.5	4
While using chipping hammer	2	.2	2	12	2.0	3	14	1.4	3
Lack of proper personal safety equipment while pouring or carrying hot metal	73	8.7	23	53	8.8	17	16	1.6	14
Lack of proper personal safety equipment while working on mold to prevent—									
Burns	13	1.5	15	16	2.7	16	5	.5	10
Other injuries	5	.6	3	5	.8	12	2	.2	4
Other	58	6.9	11	41	6.9	11	91	9.2	9
Unsafe lifting	192	22.8	15	193	32.3	12	124	12.5	14
Castings	17	2.0	9	18	3.0	18	32	3.2	12
Flasks, core plates, etc	22	2.6	10	14	2.3	8	8	.8	10
Molds	59	7.0	15	65	10.9	11	22	2.2	11
Vehicles	16	1.9	11	16	2.7	11	4	.4	35
Other	78	9.3	19	80	13.4	12	58	5.9	15
Other	7	.8	7	1	.2	8	9	.9	8
No unsafe condition	48	5.7	19	15	2.5	10	89	9.0	17
Unknown	631	-------	15	357	-------	15	700	-------	15

[1] Percent of known cases.

unsafe manner, nor that his unsafe act was the result of a considered choice between the two possible procedures. In many instances, such as that of the grinder who elects to do a small grinding job without his goggles rather than take the time to go get them from his locker, it is apparent that the worker knew the safe procedure but consciously decided not to follow it. In a great many other instances, however, it is apparent from the circumstances that the person who acted unsafely did so not as a matter of choice, but simply because he did not know an alternative safe method. Strict safety-minded supervision is essential to eliminate this type of unsafe act. Thorough safety training for both workers and supervisors can do much to abolish unsafe acts which are committed unknowingly.

The great majority of the accidents analyzed in each of the three types of foundries involved one of four general groups of unsafe acts: (1) Using unsafe equipment or using equipment unsafely; (2) taking an unsafe position or posture; (3) failure to use safe attire or personal safety equipment; and (4) unsafe lifting. Together these four groups of unsafe acts contributed to 93 percent of the accidents for which details were available in the malleable-iron foundries, 87 percent of the gray-iron foundry accidents, and 83 percent of the steel foundry accidents. The fundamental approach to the elimination of unsafe personal acts in foundries, therefore, must stress measures to—

(1) Provide training in the safe methods of handling and using tools, materials, and equipment, and enforce the use of those methods through close supervision;

(2) Train both workers and supervisors to recognize and to avoid unsafe positions:

(3) Make sure that both workers and supervisors understand and can recognize the circumstances in which different kinds of safety equipment are necessary, and that the supervisors require the use of such equipment in those circumstances; and

(4) Provide thorough instruction in the proper methods of lifting heavy objects, particularly in the proper method of lifting with the legs instead of the back, and have the supervisors continue to emphasize such instructions during actual operations

Use of Unsafe Equipment or Unsafe Use of Equipment

The unsafe acts of this general group were factors in the occurrence of over 28 percent of the steel foundry injuries and of about 23 percent of the gray-iron and malleable-iron foundry accidents. The outstanding type of unsafe act in this group was the simple one of taking an incorrect hold or not maintaining a good grip upon objects being handled. Specifically, these included many cases in which materials or tools slipped from the worker's hands because there was oil or grease on the material or on his hands; or because the worker grasped the material at a sharp or rough spot which caused him to release his grip; or simply because the material or tool was not held firmly enough to control its movements. Particularly dangerous was the practice of using hands or feet to guide suspended crane loads into position or to adjust the chains holding the loads instead of using taglines or poles. Pinched and crushed fingers or feet were the most common injuries resulting from these practices.

Lack of skill and the lack of a full realization of the hazards involved in handling heavy materials undoubtedly had much to do with the occurrence of these accidents. Wider use of safety shoes would greatly reduce the resulting volume of foot and toe injuries. The elimination of the unsafe acts and the prevention of the actual accidents, however, can be achieved only by thorough training in safe procedures and close supervision of individual operations by safety-conscious supervisors.

Unsafe Position or Posture

In 23 percent of the steel foundry accidents, 13 percent of the gray-iron foundry accidents, and 10 percent of the malleable-iron foundry accidents, it was found that the injured person had unnecessarily placed himself in an unsafe position or posture. (See table 14.)

Most prominent of the specific unsafe acts in this general group was that of unnecessarily working or standing under or in the path of cranes, hoists, and suspended loads. Other unsafe acts in this group included working, standing, or walking in front of moving vehicles; unnecessarily working or walking too close to other workers who were performing hazardous operations such as carrying or pouring molten metal; walking, standing, or working on beams, girders, piled materials, or makeshift scaffolds, instead of using proper ladders or scaffolds; taking shortcuts instead of using the provided walkways; and working in cramped positions. Most of these practices can be overcome through intensified safety instruction and better supervision.

Failure to Wear Safe Attire or Personal Safety Equipment

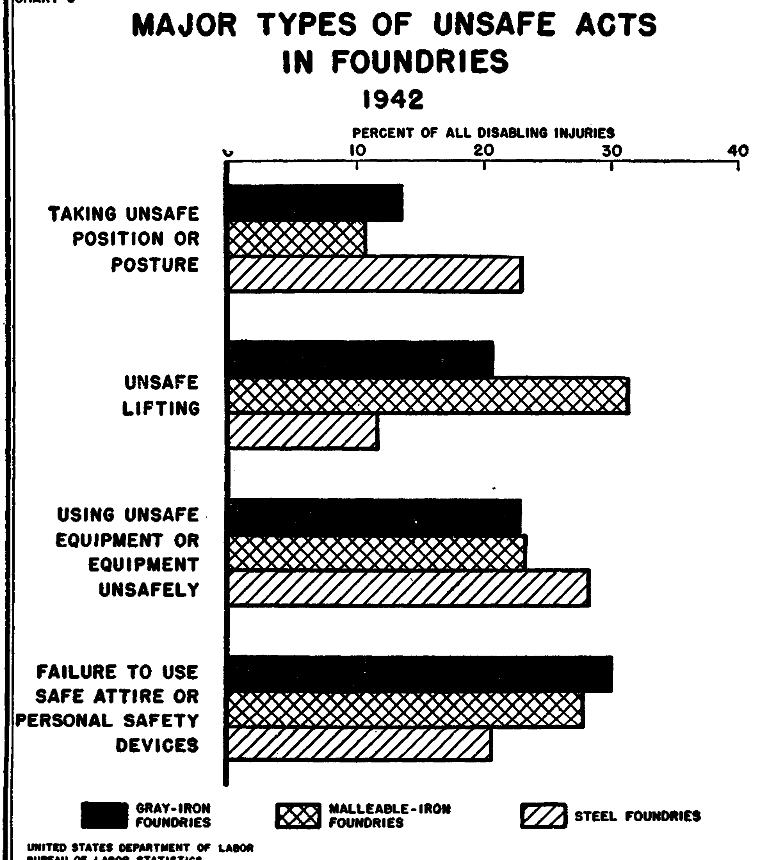
About 30 percent of the gray-iron foundry accidents, 28 percent of the malleable-iron foundry accidents, and 20 percent of the steel foundry accidents were directly associated with the failure to wear safe clothing or proper personal safety equipment.

The cases involving failure to wear safe clothing included workers who wore loose clothing which caught on projections or was caught in machines or in sling chains; workers who wore cuffed or frayed trousers, which tripped them; and workers who wore shoes with worn soles which permitted puncture wounds and burned feet. In the aggregate, however, the failure to wear safe clothing was of much less importance than was the failure to use proper personal safety equipment.

Primarily, the cases of failure to wear proper personal safety equipment consisted of the failure to use goggles while grinding, chipping, sandblasting, or handling chemicals or molten metal; to wear gloves, leggings, and molder's shoes while pouring molten metal; and to wear gloves while handling hot molds or castings. In all of the analyzed cases included in this category the necessary safety equipment was available on the premises, but for one reason or another was not being used.

It is obvious from these data that the plant which simply provides the various necessary items of personal safety equipment and invites the employees to use them has only partially solved the problem of overcoming the hazards which this equipment can guard against, nor does the issuance of shop rules requiring its use accomplish the purpose unless those rules are strictly enforced. The two most common excuses for not using the provided safety equipment were that it was uncomfortable and that it hampered the user's activities.

CHART 3



Particularly in respect to the use of goggles considerable objection was raised because of the tendency of goggles to "fog" when the wearers were working with hot metal. This condition, however, can generally be overcome easily through the application of "anti-fog" chemicals to the goggles. These chemicals are available commercially in a variety of forms. In other cases, the excuse was that the safety equipment was not conveniently at hand and the workers felt that it was not worth the time and effort to go get it. In still other instances it was apparent that the employee did not realize his need for the equipment. A common example of the latter group of cases was that of the laborers who move material into and out of grinding rooms or sandblast rooms without wearing goggles. Many of these workers failed to appreciate the fact that every one who approaches such operations is exposed to flying particles just as are the actual operators.

When both supervisors and workmen have been fully instructed in the need for safety equipment, and the equipment is available, there can be no question as to their joint responsibility for any injuries which occur because the equipment was not used. Management, however, can establish and maintain a definite program concerning the use of safety equipment. Such a program should include, as a minimum, the following measures:

(1) Maintenance at convenient locations of an adequate supply of safety equipment which has been selected with due consideration not only for its effectiveness but also for the ease and comfort of the worker who must wear it;

(2) Maintenance of every piece of safety equipment in good condition and making sure that it is properly fitted to the wearer;

(3) Making sure that all supervisors and workmen are fully acquainted with the hazards which require the use of safety equipment and that they are familiar with the type of equipment needed in each instance; and

(4) Establishment of rules requiring the use of safety equipment where it is necessary and requiring supervisors to prohibit the performance of hazardous operations unless the proper safety equipment is used.

Unsafe Lifting

Injuries resulting from manual lifting of heavy objects present a serious problem in foundries. In essence, every accident of this type is a case of lifting excessive weight—that is, excessive under the existing circumstances for the individual involved. Variations in the strength and skill of different individuals, however, make the determination of what is a safe maximum weight to be lifted by one person very difficult if not impossible. There can be no question, however, that a knowledge of and the strict application of proper lifting procedure—e. g., lifting with the legs instead of with the back—will render safe the handling of much greater weights than can be safely lifted by the hit-or-miss method of grabbing and jerking. In classifying the lifting accidents, an effort was made to exclude from this unsafe-act classification those cases in which individuals attempted to lift weights which obviously should have been handled mechanically or by a team. As far as possible, the cases included represent injuries which resulted from lifting weights generally handled by individual foundrymen and normally considered to be within the lifting ability of most workers. These cases represented 31 percent of the accidents analyzed in the malleable-iron foundries, 20 percent of those in the gray-iron foundries, and 11 percent of the steel-foundry accidents.

It is frequently impossible to specify exactly what was done incorrectly in certain lifting accidents. In most cases the injured person can report only that he was lifting and suddenly felt pain, and only rarely is there a witness who was observing the operation with sufficient care to identify accurately the specific faulty procedure. It is well known, however, that strains, sprains, and hernias frequently result from lifting with the back muscles instead of the leg muscles, from lifting in cramped or awkward positions, or from lifting while standing on irregular or insecure surfaces. Most of the accidents in this group undoubtedly resulted from one or the other of these unsafe procedures.

TABLE 14.—*Disabling Injuries, Classified by Kind of Foundry and Unsafe Act, for 59 Foundries, 1942*

Unsafe act	Gray-iron foundries			Malleable-iron foundries			Steel foundries		
	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability	Number of disabling injuries		Average days lost per temporary total disability
	Number	Percent [1]		Number	Percent [1]		Number	Percent [1]	
Total	1,474	100.0	16	955	100.0	14	1,694	100.0	16
Operating without authority; failure to secure or warn	14	1.5	40	1	.2	18	24	2.2	25
Running, jumping, or throwing	11	1.2	9	5	.8	6	27	2.5	21
Using unsafe equipment or equipment unsafely	217	22.9	15	148	23.4	16	307	28.4	16
Using defective equipment	10	1.1	8	5	.8	10	7	.6	13
Unsafe use of equipment	12	1.3	13	5	.8	20	5	.5	18
Using hands instead of hand tools	13	1.4	21	1	.2	2	11	1.0	17
Gripping objects insecurely or taking wrong hold of objects	172	18.0	15	133	21.0	16	268	24.8	16
Castings	51	5.2	19	23	3.6	11	66	6.1	19
Flasks, core plates, etc	18	1.9	18	14	2.2	13	26	2.4	12
Hand tools	27	2.9	16	28	4.4	13	58	5.4	14
Hoisting apparatus (including slings)	6	.6	3	9	1.4	16	31	2.9	16
Molds	10	1.1	8	5	.8	23	13	1.2	19
Vehicles	10	1.1	8	3	.5	18	5	.5	22
Other	50	5.2	12	51	8.1	19	69	6.3	14
Other	10	1.1	17	4	.6	24	16	1.5	15
Unsafe loading or placing	29	3.1	23	20	3.2	20	73	6.8	19
Castings	10	1.1	21	6	.9	21	32	3.0	19
Other	19	2.0	24	14	2.3	20	41	3.8	18
Taking unsafe position or posture	129	13.6	27	68	10.8	19	248	23.0	22
Exposure to hoisting apparatus	46	4.9	27	22	3.5	11	109	10.1	22
Sling or hook	36	3.8	30	17	2.7	12	94	8.7	22
Other parts	10	1.1	17	5	.8	8	15	1.4	19
Exposure to vehicles	10	1.1	66	2	.3	36	21	1.9	24
Other	73	7.6	21	44	7.0	23	118	11.0	22
Working on moving or dangerous equipment	11	1.2	32	2	.3	20	14	1.3	18
Failure to use safe attire or personal safety devices	285	30.1	16	177	28.0	12	224	20.7	10
Failure to use goggles	68	7.2	29	33	5.2	3	49	4.5	4
While grinding	65	6.9	29	21	3.3	4	35	3.2	4
While chipping	3	.3	3	12	1.9	3	14	1.3	3
Failure to use safe attire or personal safety devices while carrying or pouring molten metal	83	8.8	24	57	9.0	16	19	1.8	15
Failure to use safe attire or personal safety devices while handling molds to prevent—									
Burns	21	2.2	20	25	4.0	16	13	1.2	22
Other injuries	6	.6	11	5	.8	12	3	.3	4
Other	107	11.3	17	57	9.0	11	140	12.9	10
Lifting	197	20.8	16	199	31.4	12	126	11.7	14
Castings	17	1.8	9	18	2.8	18	31	2.9	11
Flasks, core plates, etc	22	2.3	10	14	2.2	8	8	.7	10
Hand tools	17	1.8	15	31	4.9	13	13	1.2	22
Molds	61	6.4	16	65	10.3	11	23	2.1	11
Vehicles	17	1.8	15	16	2.5	11	5	.5	29
Other	63	6.7	21	55	8.7	12	46	4.3	13
No unsafe act	31	3.3	17	8	1.3	4	29	2.7	12
Not elsewhere classified	22	2.3	19	4	.6	15	8	.7	23
Unknown	528	------	14	323	------	14	614	------	15

[1] Percent of known cases.

The complete elimination of manual lifting, which would avoid all accidents of this type, is an impossible goal. Many foundries, however, could do much to reduce the volume of lifting accidents by extending the use of mechanical handling equipment and by giving all employees thorough training in the safe methods of manual lifting.

Safety Codes and Safety Services

Foundry managements which desire to inaugurate safety activities or to improve those existing within their plants will find that there is available for this industry a very considerable volume of accident data and safety information. This helpful information is available from both private and governmental agencies.

PRIVATE ASSOCIATIONS

At least 10 trade associations and 1 professional association are active in the foundry industry, representing a combined membership of about 1,100 companies in the trade associations and about 3,500 individuals in the professional association. The trade associations from time to time distribute safety information to their members, but as a rule are not engaged in any continuing safety programs. The professional association, the American Foundrymen's Association, on the other hand has a permanent committee to consider safety and hygiene problems and has developed a comprehensive safety code for foundry operations entitled "Recommended Good Safety Practices for the Protection of Workers in Foundries." Other related publications of this association include the following: Code of Recommended Good Practices for Testing and Measuring Air Flow in Exhaust Systems; Code and Handbook on the Fundamentals of Design, Construction, Operations, and Maintenance of Exhaust Systems; Code of Recommended Practices for Grinding, Polishing, and Buffing Equipment Sanitation; and Code of Recommended Good Practices for Metal Cleaning Sanitation.

In the National Safety Council the study and dissemination of information concerning safety in foundries constitutes an important part of the work of the metals section. Many foundry safety problems and their solutions are covered in the publications of the council, particularly in its "Safe Practices" pamphlets.

Several safety codes which apply directly to foundry operations have been developed under the auspices of the American Standards Association and have been issued with the approval of the Association as "American Standards." The most pertinent of these codes is the Safety Code for Industrial Workers in Foundries, approved by the association in 1932. Some of the other codes approved by the association which are applicable to particular phases of foundry operations are Safety Code for Floor and Wall Openings, Railings, and Toe Boards; Safety Code for Elevators, Dumb-waiters, and Escalators; Safety Code for the Use, Care, and Protection of Abrasive Wheels; National Electrical Safety Code; Safety Code for Woodworking Plants; and Protection of Heads, Eyes, and Respiratory Organs.

GOVERNMENTAL ACTIVITIES

A number of the industrial States have established safety codes for foundries and have provided for plant inspections for the enforcement of the code requirements. The majority of these are special codes prepared by the individual States, so that there is considerable variation among them. Other States which do not have specific foundry codes frequently have incorporated references to foundries into their laws or regulations relating to industrial sanitation or to the employment of women and children. Because the State safety requirements are regulatory provisions, they should generally be considered as absolute minima rather than as constituting the basis of a fully satisfactory safety program. In most instances, however, the State inspection services are in a position to provide safety advice and assistance beyond the scope of the legal requirements.

In the Federal Government, statistical data concerning the occurrence of disabling injuries are regularly compiled and published by the Bureau of Labor Statistics. These data furnish a basis with which individual foundries may compare their own records to determine whether their accident rates are better or worse than the average for all foundries.

Also in the United States Department of Labor, the Division of Labor Standards cooperates with the States and with private associations in the development of new safety standards, and through the Committee for the Conservation of Manpower in War Industries offers free consultative service on safety matters to any plant which requests such service. Both the Division of Labor Standards and the Bureau of Labor Statistics regularly participate in the safety-code activities of the American Standards Association.[11]

In the United States Department of Commerce, the National Bureau of Standards conducts extensive research in the field of safety, and has played a leading part in the development of a number of recommended codes of safe practice which are directly applicable to foundry operations. Valuable information may also be secured from the United States Public Health Service, which conducts many studies in the field of industrial hygiene, particularly in respect to the methods of overcoming unsafe operating conditions that may produce dermatitis or other types of industrial disease.

Causes and Prevention of Typical Foundry Accidents

To illustrate the general types of accidents experienced in foundry work, brief accounts of a number of typical cases were secured and were given individual consideration. The descriptions of these

[11] A more detailed account of the safety activities of the Department of Labor will be given in Industrial Safety Services of the U. S. Department of Labor, a forthcoming bulletin of the U. S. Department of Labor.

accidents, accompanied by suggestions as to the preventative measures which might have avoided these accidents, are given below.

DESCRIPTION OF ACCIDENTS AND SUGGESTED METHODS OF PREVENTION [12]

Cleaning, Chipping, and Finishing Accidents

1. Worker was greasing the tumbling mill but had not shut off the machinery. His jumper caught on the jackshaft coupling, pulling him between the revolving jackshaft and the tumbling mill. Fatal.

(a) *All shafting and couplings within 7 feet of the floor should be enclosed.*

(b) *Tumbling mills should be fenced with gates so interlocked with the controls that access can be had only when power is off.*

(c) *Greasing should not be permitted while the machine is in operation.*

2. Laborer was moving castings away from a sprue-cutting machine. He stepped on a piece of sprue, turning his ankle, and dropped a heavy casting on his foot. Fractured three toes.

(a) *Good housekeeping around machines is essential to safety. Scrap should not be allowed to be on the floor.*

(b) *All workers who handle heavy materials should wear safety shoes.*

3. A chipper was working without goggles. A chip struck his eye. Lost sight of eye.

All chippers should be provided with and required to use proper impact goggles.

4. As a chipper turned a casting it struck a chisel, which whirled up and smashed his safety goggles, destroying his eye.

This accident almost certainly would have resulted in a fatality if the chipper had not been wearing goggles. Good tool housekeeping would have prevented the accident.

5. A new emery wheel (20 by 3 inches) fragmented, shearing five half-inch bolts which held the guard, and caused the guard to swing back and strike the operator's head. Fatal.

This appears to have been a case of inadequate flanges and too much space between the wheel and guard. Overspeed may have been a factor.

6. Operator was grinding a piece of gray iron, cylindrical in shape, 6 inches in diameter, and 14 inches long. He forced the piece into the 3-inch face of the emery wheel and jammed the wheel, which broke and kicked the piece back into his abdomen. Guards prevented broken pieces of the wheel from flying around. Fatal.

A properly mounted wheel of this type with a properly designed and correctly placed work rest will not break except from a blow, nor will it kick back.

7. Worker was grinding a casting when the emery wheel broke. No reason for the break is known. Fatal.

Wheel breakages can be almost wholly eliminated by careful selection of wheels, correct mounting, and correct use. Safety flanges and provision of the proper type of hoods will greatly reduce the chance of injury should the wheel break. See the American Standard Safety Code for the Use, Care, and Protection of Abrasive Wheels.

8. Operator of cutter was removing shavings from rear of cutter when his glove was caught by one of the blades and his finger was pulled between the blade and bearing. Thumb amputated.

(a) *Gloves should not be worn when there is any chance of getting them caught in moving machinery.*

(b) *The cutter should have been guarded.*

[12] In the analysis of these accidents, selected as typical of those reported, the authors had the assistance of R. P. Blake, senior safety engineer of the Division of Labor Standards, U. S. Department of Labor.

Conveyor Accidents

9. Employee was handling baked aviation cylinder head cores on a gravity conveyor. One fell off onto his foot. Broken toe; lost 29 days.

(a) *Safety shoes should be worn by all workers who handle heavy materials.*

(b) *In most cases the chance of articles falling from such conveyors can be lessened by the use of guard or guide rails, aprons, or barriers.*

10. A finisher was caught between squeeze head and flask on the flask-return conveyor. Fatal.

Safe clearance should be maintained between all moving parts of conveyors or conveyor loads and fixed objects. Where this is impractical, barriers should be provided to prevent entrance into the danger zone.

11. Worker was removing sand from conveyor belt at the pulley while it was in motion. His arm was caught between the belt and the pulley. Lost 2 weeks.

Belt-conveyor pulleys should be guarded to slightly more than arm's length from the nip point.

12. Employee climbed on guard rail to release material caught in belt conveyor. He overreached, lost his balance, and thrust his arm between the moving conveyor and the housing. Torn muscles resulted in the loss of use of his hand.

The rule that no adjustments or repairs to powered equipment shall be made without first cutting off the power should be universally understood and enforced.

Core-Room Accidents

13. A core maker stepped upon a core wire which punctured his shoe and entered his foot. Lost 3 days.

(a) *All foundrymen should wear substantial shoes and should be sure that the soles are in good condition.*

(b) *Loose materials and scrap should not be permitted to lie about the workplace.*

14. Core laborer was lighting core oven with kerosene. Fumes exploded, causing burns. Fatal.

A safe procedure for lighting should be worked out for each oven and followed without variation.

15. Employee was lighting gas core oven. Evidently the oven was filled with gas and exploded when he went to light it. Fatal.

All gas ovens should be thoroughly purged before being lighted. Small ovens not equipped for mechanical purging should be designed so that the doors must be open before the burners can be lighted. The doors should be open at least 5 minutes before the burners are lighted.

Crane, Elevator, and Hoist Accidents

16. Repairman working on crane rail repair was crushed against building column when crane was moved. Repairman depended on men stationed on floor to signal crane operator instead of using rail stops. Crane operator obeyed signal from an unauthorized man on floor. Fatal.

(a) *When runways are being repaired, rail stops and warning signs should be placed on both sides of the section being worked on.*

(b) *The operator should recognize signals only from the person who is supervising the lift, or an authorized signalman.*

An accident of this nature is indicative of poor training or poor supervision, or a combination of these faults.

17. While repairing a crane, a maintenance man caught his hand between trolley wheel and bumper. Middle finger amputated.

(a) *When repairs are being made to rail or bumper rail, stops and warning signs should be used to prevent the trolley from reaching the area of the work.*

(b) *When work is being done on the trolley, the controllers should be in the "off" position and the main and emergency switches should be opened. One of these should be locked open. Signs warning of men working should be placed on these switches, and removed only by the man placing them.*

Repair and maintenance work on this type of equipment is highly hazardous. Accidents can be prevented only by carefully planning and organizing the work *and by providing all practicable physical safeguards. Thorough training and close supervision of the workmen involved are essential for safety.*

18. Maintenance man was standing on a beam which supports the elevator track, while oiling a sheave bearing on a skip hoist. Another employee started the elevator and the maintenance man's hand was caught between the pulley and cable. The result was permanent impairment of all fingers on his left hand.

Elevator controls should have been locked or in charge of another person specifically assigned to protect the maintenance man and subject to no one else's order for the duration of the job.

19. Craneman was oiling the trolley. He slipped and fell 20 feet to the floor. Fatal.

Every crane should be equipped with railed runways, platforms, handholds, etc., to give safe access to all parts requiring oiling or other frequent attention.

20. A molder's finger was crushed between the ladle and rack when the craneman misunderstood the molder's signal and set the ladle down on his hand. Lost half of middle finger.

Standard signals should be used, and only those persons who have been thoroughly trained in giving signals should be permitted to direct the crane operation.

21. A workman was standing on a grab bucket holding the cable with his left hand while he placed the crane hook in the lifting hook of the bucket. The craneman lifted on a signal from another employee and the first worker's finger was crushed between the crane cable and the sheave wheel. Lost one finger.

(a) *A craneman should recognize signals only from the person who is supervising the lift or an authorized signalman.*

(b) *The signalman should see that everyone is in the clear before ordering any movement of the crane. Thorough training of the personnel involved is essential.*

22. Laborer was electrocuted when he attempted to replace a blown fuse on an overhead crane.

(a) *Electrical repair work should be done only by competent electricians.*

(b) *Only the safety type of switch should be used on cranes. This type of switch must be opened to give access to the fuse, thus killing that portion of the circuit.*

23. Chain on crane broke and dropped heavy mold on right hand. Right hand amputated.

Chain breakage is almost wholly preventable by systematic inspection, careful maintenance, and effective supervision as to the proper use of chains.

24. Injured was turning a magnet holding seven scrap freight-car wheels. Two wheels dropped, one striking his foot. Entire loss of great toe.

Since lifting by magnet always involves a considerable hazard of dropping part (or all) of the load, magnet-held loads should always be guided or turned by guide poles or lines, never by hand.

25. While a molder was bending and working over his mold, another mold was being raised by the crane. His fellow-workers called to him not to raise his head. Not understanding them, he raised his head, bumping it on the flask which was being carried by the crane. Died of blood clot under the skull.

Making lifts in such close quarters is highly hazardous. The crane operator should not have made the lift until everyone was in the clear. Safe procedures should be worked out, fully understood by all concerned, and strictly enforced.

26. Crane operator blocked main hoist, breaking cable and dropping casting tray which struck employee. Fatal.

Crane should have been equipped with an overhoist limit stop maintained in effective operating condition.

27. Man was attempting to pick up a casting. He used an "S" hook incorrectly, and this made it necessary for him to hold the hook as the crane block was raised. When the weight of the casting was put on the hook, it was pulled against the casting and caught man's finger, smashing it badly. Traumatic amputation of right little finger.

Under no condition should any person have his hand on load, hook, or block on a "lift." Cranemen should never make a lift in violation of this principle.

28. Molder had hooked onto a mold which was to be moved across the floor for inspection. As he was underneath, one of the four hooks came loose and the flask fell over. One leg badly crushed and later amputated.

Good safety practice includes a hard and fast rule prohibiting any person from working or being under a suspended load unless the load is securely blocked up.

29. Yardman had one foot on clamshell and the other on the ground when boom of rubber-tired crane touched high-tension wires. Fatal.

This type of accident is rather common, and is usually fatal. Whenever a crane must operate near a power line the responsible supervisor should survey the area with the crane crew and decide upon the proper precautions. Sometimes ground barriers can be provided to keep the crane away from the power line. In other cases the boom length can be limited or the power line rerun. These accidents are so expensive that great care and substantial expenditures are justified to eliminate or reduce the hazard.

30. A molder, who was using an electric hoist to lift a ladle, pulled the wrong control. The ladle tilted and spilled molten metal on a nearby worker. Fatal.

(a) *Each hoist-control grip should be distinctive, to lessen the chance of mistaken selection.*

(b) *Only well-trained and highly dependable persons should be allowed to perform such operations.*

(c) *All persons should be in the clear when such lifts are made.*

31. Cupola man was attempting to replace the control cable of the charging elevator on the lower pulley. In doing so he pulled the cable into the down position and was crushed when the elevator descended upon him. Fatal.

The power should have been cut off and the controls locked.

32. Cupola man was taking iron up to charge into cupola when the elevator cable broke and the elevator fell. Fractured hip, lost 6 months.

(a) *Systematic inspection should have resulted in discovery of the defect in the cable before it developed sufficiently to break.*

(b) *All nonhydraulic elevators should be equipped with safety stops operated by speed-governor control that will hold the elevator in case of cable failure.*

33. Cupola charger was hauling pig iron up to charging deck. Drum on the elevator broke causing the elevator to fall. Fractured foot; lost 8 weeks.

(a) *The drum was either too light for the loads handled or was defective. In either case systematic inspection should have revealed the condition before the accident.*

(b) *All nonhydraulic elevators should be equipped with safety stops operated by speed-governor control that will hold the elevator in case of cable or sheave failure.*

34. Worker was removing core from a large casting which was suspended by a chain hooked around a riser. The riser broke off, dropping the casting, and the workers' finger was crushed between the casting and the cleaning bar. Lost 3 days.

(a) *The strength of risers should never be depended upon.*

(b) *No work should be permitted on any suspended load unless the load is securely blocked up.*

35. A heavy plate was being carried by a crane over the head of a core maker. One of the chains broke and let the plate swing down to strike the core maker. Permanent partial loss of use of one leg.

(a) *Crane loads should not be carried over workmen.*

(b) *Proper chain inspection should have caught the defect and caused the chain to be removed from use before it broke.*

36. Employee lifted the safety gate of the elevator shaft at the first floor. The elevator at the time was at the second floor. He stepped into the open shaft and fell about 8 feet. Lacerations, fractured ribs, and fractured wrist; lost 6 weeks.

This is a continually recurring accident. All elevator gates should be so arranged that only the gate at the floor where the cage is can be opened from the outside without a key.

Furnace Accidents

37. A cupola liner was working from a scaffold. The scaffold collapsed, throwing him to the floor. Broken shoulder; lost 6 weeks.

Scaffolding for use in lining cupolas should be carefully designed for the purpose and substantially erected. The material used should be of first quality.

38. Cupola worker was caught in flames when the cupola bottom was dropped. Fatal.

Dropping bottom is one of the most hazardous of operations and can be conducted safely only when the procedure has been carefully planned, with suitable barriers provided and all persons assigned to safe positions.

39. Worker was cleaning out furnace pit when burning slag from the furnace broke out. Fatal.

No person should be allowed to enter a furnace pit while there is any practical possibility of a breakout from the furnace.

40. Worker was preparing a charge for the cupola when he dropped a piece of pig iron onto his foot. Fractured toe; lost 2 weeks.

Workers who handle heavy materials should wear safety shoes.

41. The operator of a furnace-car turntable attempted to put a dog in place while the turntable was in motion. Amputated finger.

No one should be permitted to adjust machinery while the equipment is in motion.

Pouring Accidents

42. A pourer, who was using a hand ladle, struck another worker, who was shifting molds, with the shank of the ladle. Molten iron splashed from the ladle and fell into the pourer's shoe. Lost 20 days.

(a) *All workers connected with pouring should wear foot and leg protection especially designed to protect against spilled or splashed molten metal.*

(b) *Supervisors should see that workers are placed so as not to interfere with each other's movements and that the pouring area is cleared of all persons who are not participating in the operation.*

43. Ladle broke in pouring and spilled molten metal on the molder's feet and legs. The molder was not wearing leggings or molder's shoes, despite a shop rule requiring their use in all pouring operations. Severe burns caused the loss of 45 days.

(a) *This occurrence should be used as an object lesson to secure better observance of the rule. However, if the rule cannot be enforced, it should be made advisory instead of mandatory.*

(b) *Apparently this ladle was defective, a fact which, if proper equipment inspections had been made, should have been discovered before the accident.*

44. A helper was pouring aluminum from a pot into a mold. The mold overflowed and the molten metal ran down onto the worker's foot. Lost 2 weeks.

Many persons do not consider foot and leg protection necessary in pouring aluminum. However, the record indicates otherwise. Foot and leg burns do occur frequently enough to justify the requirement that leggings and shoes which will turn molten metal, be worn when pouring aluminum.

45. A molder was standing beside a flask skimming the iron when an explosion in the mold caused molten iron to spurt out of the joint of the flask. The iron fell on the molder's foot and ran inside his shoe, which had no tongue and was unlaced. Lost 28 days.

(a) *Careful training and close supervision is necessary to avoid such accidents.*

(b) *The molder should have been wearing proper foot and leg protection.*

Sand-Mixing Accidents

46. Two workers were cleaning a sandmill. One placed his hand upon the gears just as the other started the mill to turn over the rollers. Right index finger amputated by gears.

(a) *All gears should be completely enclosed.*

(b) *When cleaning, repairing, or adjusting machines the controls should be locked to prevent unexpected operation.*

(c) *Men who are working together should be trained to warn each other before starting their machine.*

47. An overload had stalled the sand mixer. The operator shoveled some sand from the machine and then pushed the starter button. In starting this machine under full load, however, there is a delay of about 8 seconds after power is turned on because of the action of the relays. Apparently the delay caused the operator to think that the machine was still stalled and that the automatic cut-off had again operated. He jumped inside the machine with his shovel, evidently to remove more sand, just as it started. The mixer was examined immediately after the accident and was found to be mechanically and electrically perfect. Fatal.

Machines of this type should be protected by a barrier interlocked with the controls to prevent entrance unless the power is off.

48. Operator of sand mixer reached up to turn on the power and absent-mindedly placed his other hand on the edge of the mixer drum. The revolving blade amputated his index finger.

The design of machines of this type should include a covering for the blades to prevent unintentional contact with them.

49. The operator, who was cleaning the sand-mixing machine, put his finger into a small hole in the guard of the machine. Lost first phalange of index finger.

(a) *Openings in machine guards within finger length of moving parts should be too small to admit fingers.*

(b) *Machines should be shut down for cleaning or repairs.*

50. Worker was shoveling sand from under muller, which was operating. His glove caught in the gears and he lost 3 fingers.

(a) *All gears should be completely enclosed.*

(b) *Safe procedures should be worked out for such operations, and the employees concerned should be systematically trained to follow them.*

51. Core maker reached into the back of the sand-mixing machine while it was operating, to feel the texture of the mix. A blade caught and amputated his finger.

Sand-mixing-machine blades should be protected by screen barriers interlocked with the controls, and safe means of sampling should be provided.

Woodworking Accidents

52. A patternmaker was operating a jointer when the wood kicked back and his hand slipped into the blade. Ends of 3 fingers amputated.

Jointers should be protected by guards which ride over the stock in surfacing and thus keep the operator's hand away from the knife. Pieces shorter than about 14 to 16 inches should not be run unless a push stick or jig is used.

53. Worker was cutting a board on a miter saw. The board kicked and his hand went into the saw. Lost parts of 4 fingers.

Kick-backs on miter saws usually occur because the piece being cut is turned so that it pinches the saw, or because the saw is in bad condition. A hood guard, self-adjusting to the position of the saw, with antikick devices, should have been provided.

54. Workman was sawing ⅞-inch-square wooden flask bars, pushing the material across the table. One piece jammed, throwing his hand against the saw. Lost 3 fingers.

The saw should have been guarded. Guides should be used on this type of work.

55. Worker cleared off the table of a band-saw trimming machine with his gloved hand. The saw caught the glove and sawed off a finger.

Gloves should not be worn by band-saw operators. A brush should be used for cleaning. So far as possible, cleaning should be done when the saw is not in motion.

Maintenance Accidents

56. Maintenance man caught his finger in fan blade while working on hot-air blower. Permanent loss of use of one finger.

No repairs or adjustments should be made while machinery is in motion.

57. An oiler and maintenance man was attempting to tighten a bearing on the drive shaft of a bucket elevator. His sleeve caught in the gears and his right arm was crushed between the gear and pinion. Arm amputated.

(a) *All gears should be fully enclosed regardless of their position.*

(b) *No repairs or adjustments should be permitted while machinery is in motion.*

58. An electrician who was installing a new electric line fell over **a hot bus.** Electrocuted.

If it was necessary to do this work without killing the bus (or any other exposed conductors) hot-line protective equipment should have been used.

59. An extra employee, hired to clean up the shop in preparation for painting, disregarded warning signs and crawled into a restricted area underneath some transformer housings. He raised up and contacted an 11,500 volt wire. Electrocuted.

Warning signs are not sufficient guards for such conditions. The transformer area should have been fenced and locked. If it was necessary to clean under the transformers, the work should have been done by or under the direct supervision of an electrician.

60. A maintenance man who was filling a storage tank with fuel oil was burned when the oil overflowed and caught fire from an adjacent ladle. Fatal.

Oil storage tanks should be effectively isolated from all sources of heat, and safe drainage should be provided for any spillage. Refilling should be done on "down time" if at all possible.

61. (a) Maintenance man neglected to turn off the air while he was repairing an oil torch. Burned to death.

(b) Maintenance man was about to repair the motor of a dryer. He pulled the switch, climbed up onto the dryer, and before the motor stopped turning put his hand on the belt which pulled his hand into the motor. Lost little finger.

Both of these cases illustrate one primary safety rule—all maintenance men must be carefully trained to think and act safely and must be closely supervised to see that they follow safe procedure. Job safety analysis should be applied to all maintenance work.

62. Worker put gasoline into a blower to clean the fan chamber and started the motor. Sparks from the motor ignited the fumes and the fan blew out a torch-like flame against his arm. Lost 18 days.

Only noncombustible cleaning agents should be used.

Miscellaneous Accidents

63. Worker was drilling a pig for sampling. He attempted to brush off dirt and rust with one hand while holding the running drill with the other. His glove caught in the drill, and his left first finger was so torn that it had to be amputated.

Gloves should not be worn on work of this nature. Palm protection in the form of hand leathers which will pull off readily if caught or smooth close-fitting finger cots may be used.

64. Laborer was moving castings on a small truck. The side of the truck broke and spilled the castings out onto his foot. Three toes broken; lost 8 weeks.

(a) *Safety shoes should be worn by all workmen who handle castings.*

(b) *It is not clear whether or not this truck was designed for handling castings, if not, the supervisor should have prohibited its use for that purpose.*

(c) *If it was a proper type of truck, an adequate system of inspection should have revealed its defect and prevented the accident.*

65. An overhead exhaust pipe fell, striking a chipper. Fatal.

An adequate plant-inspection system would have included inspection of all exhaust lines and should have revealed the insecure suspension of this line.

66. Worker was heating a hollow brass casting in a forge preparatory to remelting. Moisture in the interior of the casting caused it to explode, throwing fragments all about. Fatal.

Explosions from this cause are not rare. All scrap metal should be carefully examined, and any which might have concealed spaces should be broken up or drilled with half-inch drill before remelting.

67. Worker slipped while taking a shower and caught his hand on a projecting nail on the shower platform. Lost 2 days.

Poor housekeeping. All projecting nails should be eliminated.

Recent Bureau of Labor Statistics Reports*

Accident-record manual for industrial plants. Bulletin No. 772. Price 10 cents.
This manual contains an outline of simple and useful methods of accident recording and of the use of such data for accident prevention; also explains how to compute and use injury-frequency and severity rates and how to determine the important causes of accidents.

Injuries and accident causes in the longshore industry, 1942. Bulletin No. 764. Price 10 cents.
Gives a detailed description of the hazards involved in loading and unloading ships.

Work injuries in the United States during 1943. Bulletin No. 802. Price 10 cents.
This bulletin summarizes the data collected in the Bureau's industrial injury survey for 1943. It presents average injury-frequency and severity rates computed on a national basis for each industry covered in the survey. Also shown are estimates of the total number of disabling injuries and of the total time lost in industry because of those injuries. The injury rates shown in this bulletin are used in evaluating the injury records of plants which are candidates for the Army-Navy "E" Award.

Effects of long working hours, Part I. Bulletin No. 791. Price 10 cents.
Contains a summary of six case studies designed to measure the effect of changes in working schedules (e. g., changes from 8 to 10 hours per day or from 40 to 48, 50, 54, or 60 hours per week) upon efficiency of production, accidents, and absenteeism.

Effect of long working hours, Part II. Bulletin No. 791–A. Price 10 cents.
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