Injuries and Accident Causes in Fertilizer Manufacturing

A Detailed Analysis of Hazards and Injury-Frequency Rates in 1946 by Region, Plant-Size, and Department

Bulletin No. 949

UNITED STATES DEPARTMENT OF LABOR

BUREAU OF LABOR STATISTICS

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Maurice J. Tobin, *Secretary*

BUREAU OF LABOR STATISTICS

Ewan Clague, *Commissioner*

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Letter of Transmittal

UNITED STATES DEPARTMENT OF LABOR,
BUREAU OF LABOR STATISTICS,
Washington, D. C., February 15, 1949.

THE SECRETARY OF LABOR:

I have the honor to transmit herewith a report on the occurrence and causes of work injuries in the fertilizer manufacturing industry based upon injuries reported during the year 1946.

This report, a portion of which appeared in the December 1948 Monthly Labor Review, constitutes a part of the Bureau's regular program of compiling work-injury information for use in accident-prevention work. The statistical analysis and the preparation of the report were performed in the Bureau's Branch of Industrial Hazards by Frank S. McElroy and George R. McCormack. The specific accident-prevention suggestions were prepared by the engineering staff of the Safety Standards Division of the Bureau of Labor Standards.

EWAN CLAGUE, *Commissioner.*

Hon. MAURICE J. TOBIN,
Secretary of Labor.

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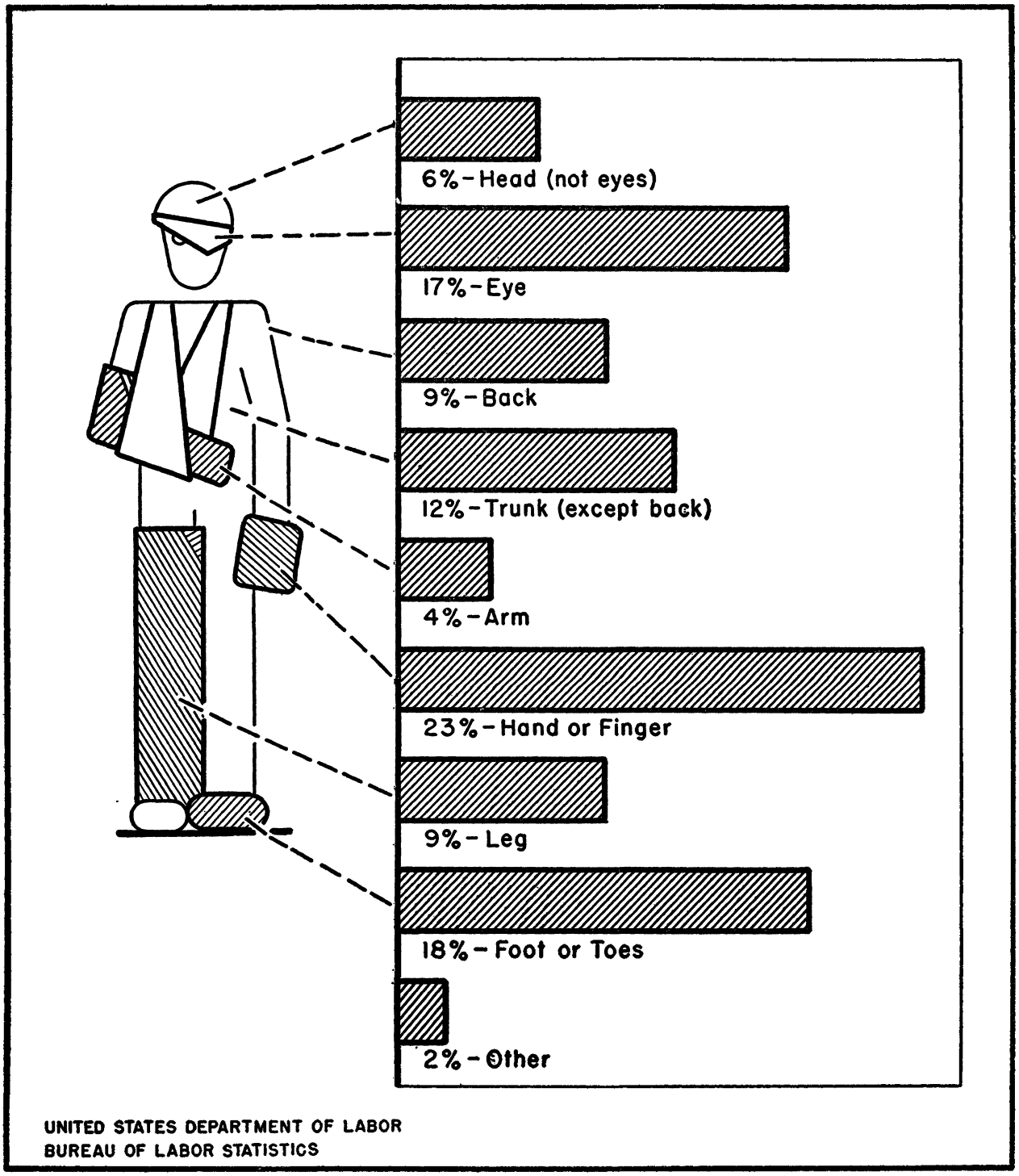

Injuries and Accident Causes in Fertilizer Manufacturing

The Injury Record[1]

A disabling work injury for every 14 employees, the highest injury-frequency rate in the chemical-manufacturing group of industries, and one of the highest injury-severity rates in the entire list of manufacturing industries—this was the work-injury record of the fertilizer manufacturing industry for the year 1946.[2]

Although the 1946 injury-frequency rate for fertilizer manufacturing—35.7—represented the peak of an upward trend which had its beginning in 1940, high injury rates are not unusual in this industry. In the prewar years 1938 and 1939, the frequency rate for fertilizer manufacturing was about 26; for all chemical manufacturing industries it was about 10, and for all manufacturing about 15. Wartime influences, which began to be effective in 1940, pushed the frequency rates for most industries to higher levels, reconversion problems helped to hold them at those high levels through 1946.

In 1946 the rate for the fertilizer industry, as above stated, was 35.7;[3] the average rate for the chemical group of manufacturing industries was 15.7 and the all-manufacturing rate was 19.9. A significant feature of these rates is that their relation to each other was nearly the same as in 1938 and 1939.

A high degree of hazard is admittedly present in fertilizer manufacturing. But this is also true in many other industries which have achieved far better injury records through strict attention to basic safety principles. In 1946 the explosives industry had an injury-frequency rate of 5.7; iron and steel a rate of 9.5; cement, 11.0; motor-vehicles, 10.8; and shipbuilding, 20.7. Even among the woodworking industries, which are generally listed at the top of all hazardous operations, planing mills had a slightly better rate (35.1) than fertilizer manufacturing in 1946. Only 14 of the 151 manufacturing industries for which 1946 rates were available had rates higher than the fertilizer rate.

The available information indicates that about 2,360 employees in fertilizer manufacturing were disabled by work injuries in 1946. About 20 died as a result of their injuries, and about 60 were left with some form of permanent physical impairment. The other 2,280 were more fortunate in that their disabilities were temporary in nature, leaving no adverse effects to restrict their working ability.

Immeasurable humanitarian and social implications are presented by these injuries. From the economic viewpoint alone, however, they represent a very large expense item which the industry must absorb. Actual time lost by fertilizer workers because of work injuries experienced in 1946 is estimated at about 48,000 man-days. On the basis of average weekly earnings of $32.92 for production workers in the industry during that year, this would represent a direct loss of $225,000 in wages alone.

Time lost within the year, however, does not adequately measure the real loss resulting from the injuries. Many of the seriously injured work-

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[1] This study was based upon summary reports from 521 fertilizer plants, which in 1946 employed 27,460 workers, representing approximately 83 percent of the estimated total employment in the industry. The reporting group included 336 dry-mixing plants, 78 integrated plants combining acid and superphosphate production with dry-mixing, 57 plants combining superphosphate production with dry-mixing, 18 plants producing only superphosphate, and 32 plants which did not indicate their specific operations.

[2] A disabling injury is one which results in death or permanent physical impairment, or renders the injured person unable to work at any regularly established job, which is open and available to him, throughout the hours corresponding to his regular shift on any day after the day of injury.

The injury-frequency rate is the average number of disabling work injuries for each million employee-hours worked.

The severity rate is the average number of days lost or charged for each 1,000 employee-hours worked. The standard time-loss ratings for fatalities and permanent disabilities are given in the American Standard Method of Compiling Industrial Injury Rates, approved by the American Standards Association, 1945.

[3] In 1947 these rates moved down to 31.6 for fertilizer manufacturing, 12.6 for the chemical group, and 18.8 for all manufacturing.

ers will find that their earning ability is reduced for the remainder of their lives. With regard to those who were killed, the loss is equivalent to their entire expected earnings during the years in which they would have continued to work if their careers had not been cut short. If additional allowance is made for the future effects of the deaths and permanent impairments included in the total, the economic time loss chargeable to the injuries experienced in 1946 would amount to about 234,000 man-days. Evaluated on the basis of 1946 earning levels, this would represent a loss of $1,100,000 in present and future earnings, all of which must be absorbed by the employers, the workers, their dependents, and the consumers.

Wage losses, however, represent only part of the total cost of accidents which produce work injuries. In addition there are payments for medical and hospital care and many indirect costs such as damage to materials or equipment, lost production, and supervisory time spent in caring for the injured or reorganizing operations after the accident. The indirect costs are seldom a matter of record, but this does not lessen their reality. Studies have indicated [4] that for manufacturing generally, indirect costs of injury-producing accidents average about four times the direct cost of compensation payments plus hospital and medical expense. Assuming that this ratio is approximately correct for the fertilizer industry, it may be estimated, conservatively, that the indirect costs associated with injuries in that industry during 1946 amounted to at least 3.3 million dollars and that the total cost probably was over 4.4 million dollars.

Injury Severity

In general, the injuries experienced by fertilizer workers tended to be more severe than those reported in most other manufacturing industries. The proportion of all disabling injuries resulting in death or permanent-total disability (0.9 percent) was three times as high as for all-manufacturing. Permanent-partial disabilities, on the other hand, constituted only 2.5 percent of the fertilizer industry cases as compared with 4.9 percent for all-manufacturing. The average time charge for each permanent-partial disability in the fertilizer industry, however, was 1,165 days in contrast to an average of 938 days for all-manufacturing. In respect to temporary-total disabilities, the comparison was more favorable. In the fertilizer industry these cases had an average time loss of 15 days, while the all-manufacturing average was 17 days.

Reflecting the high ratio of death and permanent-total disability cases and the high average time charge for permanent-partial disabilities, the average time charge for all disabling injuries in the fertilizer industry was 99 days per case. The corresponding average for all-manufacturing was 82 days per case. Similarly, the standard severity rate for fertilizer manufacturing (3.5) was substantially higher than the all-manufacturing rate (1.6).

Injury Rates by Type of Plant

The manufacture of commercial fertilizer consists of three distinct operations—the manufacture of sulphuric or phosphoric acid, the manufacture of superphosphate, the mixing of the fertilizer materials into the finished product. Although some of the larger plants perform all of these operations, most plants in the industry purchase the acid and superphosphate and perform only the mixing operations on their own premises. A few plants combine the manufacture of superphosphate with dry-mixing and a few others manufacture only superphosphate for sale to the exclusively dry-mixing plants. As the inherent hazards of these three operations differ substantially, the injury records for the different types of plants showed marked variations.

Injuries were most common in the integrated plants which perform all three operations. For this group the injury-frequency rate was 40.7. The plants manufacturing only superphosphate had a rate of 40, while those combining the manufacture of superphosphate with dry-mixing had a rate of 37.4. The lowest average, 31.9, was for the exclusively dry-mixing plants. On the basis of these rates it appears that the greatest injury probabilities lie in the manufacture of superphosphate.

In respect to the severity of the injuries, however, the record was different. Although superphosphate workers were injured more frequently, their injuries generally were less severe than those experienced by workers engaged in dry-mixing

[4] See Industrial Accident Prevention, by H. W. Heinrich, New York, McGraw-Hill Book Co., 1941.

operations. The plants manufacturing superphosphate alone had a very low ratio of serious disabilities which gave them a low average time charge per disabling injury (19 days) and a correspondingly low severity rate (0.7). The fully integrated plants, with a higher ratio of serious injuries, had an average time charge of 58 days and a severity rate of 2.4. The exclusively dry-mixing plants had an average time charge of 108 days and a severity rate of 3.4 while the combination superphosphate and dry-mixing plants had an average time charge of 121 days and a severity rate of 4.5.

Regional and State Injury-Frequency Rates

Many factors contribute to the wide differences in the injury-frequency rates prevailing in the various States and regions, and in particular instances it may be difficult to specify which is the controlling factor. Variations in the types of operations carried on by the reporting establishments may have a direct bearing upon the level of frequency rates when the number of reporting units is small. When the groups to be compared are reasonably large and the comparisons are limited to establishments engaged in similar activities, however, the differences in the average injury-frequency rates may be considered as reflecting primarily variations in safety activities rather than variations in inherent hazards. Differences in State safety requirements and in the degree to which the requirements are enforced exert a 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, local safety councils, or other organizations may have considerable effect upon the accident record of an area. The average size of the plants in different areas and the availability or the lack of experienced personnel are also factors which may influence the injury-frequency rate levels.

The plants participating in the survey were distributed among 37 States, but 288 of the 521 reporting plants were located in the South Atlantic region and 56 others were in the East South Central region. As a result the coverage in many States and in some regions was insufficient to permit the computation of representative averages for the various types of operations. For purposes of general comparison the reports were combined into regional groups corresponding to the nine regions used in the tabulations of the United States Bureau of the Census.[5] On this basis average frequency rates for exclusively dry-mixing plants were computed for four regions; averages for plants combining superphosphate production with dry-mixing were computed for three regions; and averages based upon the experience of completely integrated plants were computed for five regions.

In addition it was possible to compute separate State averages covering the operations of dry-mixing plants in seven States and for integrated plants in eight States. Only three State averages could be computed for plants combining superphosphate and dry-mixing operations.

DRY-MIXING PLANTS

The highest of the four regional frequency-rate averages for dry-mixing plants was 40.2 for the 29 plants reporting from the East South Central region. No State averages could be computed in this area.

The lowest of the regional averages was 26.7 for the 195 plants reporting from the South Atlantic region. With this volume of reports it was possible to compute separate averages for six of the eight States comprising the area. Georgia's average of 17.8, covering the experience of 48 plants, was the lowest in the region. The highest, 35.9, for 28 plants in Florida, was only slightly above the national average of 31.9 for all dry-mixing plants. In Maryland, 16 plants had an average of 27.5; in Virginia 21 plants had an average of 26.2; in South Carolina 36 plants had an average of 24.8; and in North Carolina 40 plants had an average rate of 22.2.

In the Pacific region the 22 reporting establishments had an average rate of 38.8. Seventeen of these plants, with an average rate of 36.2, were located in California.

Nineteen dry-mixing plants reported from the

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

East North Central region. These plants had an average frequency rate of 30.8. No State averages could be computed for this area.

COMBINATION SUPERPHOSPHATE AND DRY-MIXING PLANTS

In the East South Central region 12 plants, which combined production of superphosphate with dry mixing, had an average frequency rate of 43.4. In the East North Central region 12 plants had an average of 32.4 and in the South Atlantic region 23 plants had an average of 26.9. Each of these was well below the national average of 37.4. State averages could be computed only for Georgia, 33.1; for Ohio, 25.9; and for Tennessee, 49.8.

INTEGRATED PLANTS

The 5 regional average injury-frequency rates for fully integrated plants ranged from a high of 53.3 for 3 plants in the Middle Atlantic region to a low of 28.4 for 9 plants in the East South Central region. No State averages could be computed in either of these regions.

In the South Atlantic region the average rate for 46 integrated plants was 41.4—slightly above the national average of 40.7. Among the 6 State averages computed in this region the Florida rate of 51.5 based on the experience of 4 plants was high and the North Carolina rate of 29.2 based on 9 plants was low. Each of the other rates for States in this region was above the national average. The Georgia average for 14 plants was 41.9; the Maryland average for 4 plants was 42.1; the Virginia average for 7 plants was 42.5; and the South Carolina average for 8 plants was 44.0.

Four integrated plants in the West South Central region had an average frequency rate of 33.0. Three of these plants in Louisiana had an average rate of 39.2.

In the East North Central region the 12 reporting plants had an average rate of 34.3. The Ohio average based on the experience of 7 of these plants was 40.7.

Injury Rates and Size of Plant

Previous studies in other industries have indicated that there is generally a direct correlation between injury-frequency rates and the size of the plants as measured by employment. The most common findings have been that the small plants in which the owners are in close contact with actual operations and the large plants, which commonly have safety-engineers on their pay rolls, usually have the lowest average frequency rates. The medium-size plants, which are too large for intimate supervision by top management and too small to have regularly established safety departments commonly constitute the group which has the highest average frequency rate.

Small plants predominate in the fertilizer industry. Of the 521 reporting establishments, 226 employed fewer than 25 workers apiece. Only 67 plants reported as many as 100 employees and only 11 of these reported that they employed 250 or more workers. Nevertheless, the frequency rates in this industry closely followed the pattern observed in other industries.

The plants employing 25 to 49 workers had the lowest average frequency rate, (30.5), followed by the large plants each of which employed over 250 workers, with an average rate of 32.7. The very small plants, each employing fewer than 25 workers, had an average rate of 33.9. These were all lower than the over-all average of 35.7. The highest averages were for the two groups of medium-size plants, 37.0 for plants with 50 to 99 employees and 39.2 for plants with 100 to 249 employees.

In respect to the severity of the reported injuries, however, the picture was different. The large plants (250 employees and over) had the highest injury severity rate, 6.3, and the highest average time charge per disabling injury (193 days). The lowest severity rate, 2.0, and the lowest average time charge, 50 days, was for plants in the 100 to 249 employee group. The very small plants (under 25 employees) made a relatively good showing in this comparison with a severity rate of 2.4 and an average time charge of 70 days. Plants reporting 25 to 49 employees, however, had a high severity rate, 3.9, and a high average time charge, 128 days.

Plant Safety Activities

Relatively few plants in the fertilizer industry have developed formal safety programs. Only 14 of the 521 establishments reporting in the survey indicated that they employed full-time safety engineers and only 169 reported that they had

organized safety committees.

Although it is probably inaccurate to ascribe all of the difference to the fact that they employed a full-time safety engineer, the record does show that the plants which had safety engineers achieved a far better average injury record than that of the plants which had no safety expert on their pay rolls. The 14 plants with safety engineers had an average frequency rate of 17.4, while those which did not have safety engineers had an average rate of 36.0. The most pronounced difference was in the volume of temporary-total disabilities, but it was also apparent that the plants with safety engineers had a somewhat lower rate for fatalities and permanent-impairment cases.

The value of safety committees could not be clearly demonstrated from the available data, primarily because there was no information regarding the relative activity or inactivity of the respective committees. The data indicated, however, that among the plants which had safety committees better results were achieved when both supervisors and nonsupervisory employees participated than when committee membership was limited to supervisory personnel.

Twelve of the 14 plants having safety engineers also reported that they had safety committees. These 12 plants had an average frequency rate of 17.3, which did not differ significantly from the 17.4 average for all 14 plants with safety engineers. Among the 12, however, there were 8 plants which included only supervisors in their committees. These plants had an average rate of 27.7 in contrast to the average of 12.9 for the 4 plants which included both supervisors and nonsupervisors in their committees.

In the group of plants which did not employ safety engineers 157 reported that they did have safety committees. For some reason, however, the average frequency rate for these plants, 38.0, was considerably higher than the average for those which did not have committees (33.5). The plants having safety committees composed only of supervisors had an average rate of 40.0, while those which included both supervisory and nonsupervisory employees on their committees had an average of 35.9.

Many of the cooperating plants reported that they furnished or required the use of personal protective equipment, such as goggles, respirators, gloves, or safety shoes in certain hazardous operations. These requirements, however, were far from uniform, and the accident record indicated further that the rules were frequently disregarded with unfortunate results.

Slightly over half of the plants reported that they required the use of goggles in at least one operation or department. Most commonly this requirement applied to workers in the sulphuric-acid, dry-mixing, and maintenance departments. A few plants required face shields instead of goggles. Nearly half of the plants required workers in their sulphuric-acid and/or dry-mixing departments to use respirators, and a few required gas masks for some operations in their sulphuric-acid departments. About one-fifth of the plants required the use of gloves in certain operations. Only 14 plants reported any requirements regarding the use of safety shoes. Of the entire group of 521 plants, 330 reported that they had some requirements regarding the use of personal protective equipment and 191 reported that they had no rules whatever on this subject.

First-Aid Facilities

Although the provision of adequate first-aid facilities is not an accident-prevention measure, the presence of such facilities can do much to reduce the severity of the injuries which occur and may prevent many minor injuries from becoming disabling.

Of the 482 plants which reported upon their first-aid facilities, 259 indicated that they had established regular first-aid rooms. However, only 7 of these first-aid rooms were staffed with professional attendants. Of the 223 plants without first-aid rooms, 152 provided first-aid kits and 71 made no provision at all for first-aid treatment on the premises.

Because of the wide variations in other factors which have a more direct bearing on the occurrence of accidents, frequency-rate comparisons have little significance in indicating the value of first-aid programs. Generally, those plants with better than average first-aid facilities also had better than average safety programs. It is of interest, however, that the plants with first-aid rooms had an average frequency rate of 33.7 while those without first-aid rooms had an average of 34.4. The 7 plants which provided professional

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attendants in their first-aid rooms had an average frequency rate of 14.3. In a more restricted comparison limited to plants which employ safety engineers in addition to maintaining first-aid rooms, those which staffed their first-aid rooms with physicians or registered nurses had an average rate of 8.5, while those employing nonprofessional attendants in their first-aid rooms had an average of 38.4.

In conjunction with their first-aid programs, 23 plants reported that they required pre-employment physical examinations of all new employees to guide them in making work assignments. These plants, employing a total of 3,400 workers, had a combined injury frequency rate of 29.6, about 13 percent lower than the average rate for plants which did not require pre-employment physical examinations.

Departmental Injury Rates

Commercial fertilizer consists primarily of nitrogen, phosphate, and potassium mixed in varying quantities. Most plants purchase their potash and nitrogen requirements. Many also purchase the phosphate and confine their operations to mixing the ingredients according to their special formulas. Fully integrated plants, on the other hand, manufacture sulphuric acid and use it in the production of superphosphate, which they use in mixing the commercial fertilizer.

The extent to which details were available concerning the experience of workers engaged in particular operations varied greatly among the reporting plants. In many of the small plants, particularly those which specialize in one of the general types of operations, there was very little formal departmentalization. Most of the plants, however, were able to report their experience in broad categories of operations and many were able to furnish details for their service workers in three general divisions, administrative and clerical, maintenance, and watchmen.

SULPHURIC-ACID DEPARTMENT

The 44 sulphuric-acid departments for which separate reports were received had an average frequency rate of 38.4. In comparison with the records for most manufacturing activities this was a relatively high rate. It was, however, lower than the rates for the other major operating departments of the fertilizer industry. None of the injuries reported in the sulphuric-acid departments resulted in death or permanent disability. As a result, the record showed a lower average injury severity for these departments than for any of the other operating divisions. It should be noted, however, that this average is based upon only 42 injury cases and may not be truly representative.

In most of the sulphuric-acid departments, gases from the combustion of sulphur are mixed with steam, water, and other chemicals to form sulphuric acid. This is primarily a chemical reaction and relatively few employees are needed. Generally, the sulphur is shoveled into a hopper from which it is fed automatically into the sulphur burner. The burner is a long, cylindrical, metal shell which is mechanically rotated to speed the burning of the sulphur. From the combustion chamber the resulting gases are forced through a number of lead tanks where the water, steam, and other chemicals are introduced to combine with the gases and form sulphuric acid.

The principal hazard of the department is the possibility of coming into contact with the acid itself. Workers necessarily must come close to the tanks in which the reaction takes place to read the tank gages, to test the strength of the acid at various stages, and to control the process. In these tasks they are frequently exposed to acid splashing from the tanks or dripping from leaks in the tanks and feed pipes.

Access to the tanks is usually provided by erecting platforms near the bottom and at the top of each tank. Some of these platforms extend over the tanks. Falls from the platforms or from the ladders or steps leading to the platforms are common sources of injury. Hazards frequently encountered in the sulphur-burning operation include: exposure to fumes from the burners; unguarded gears by which the burner is rotated; overexertion in lifting or moving sulphur to the hopper; and the possibility of contact with the hot surfaces of the burner or with steam pipes.

SUPERPHOSPHATE DEPARTMENT

The average frequency rate for the superphosphate department (52.6), was higher than the rate for any other division of the industry. The injuries, however, tended to be less severe than

those experienced in most other departments. No deaths were included among the 144 disabling injuries reported and only 3 cases developed into permanent impairments. The severity rate (3.1) was high in comparison with the all-manufacturing average (1.6), but was below the fertilizer industry average (3.5). Similarly, the average time charge per disabling injury (60 days) was well below the industry average (99 days).

In this department sulphuric acid and finely ground phosphate rock are mixed together to form superphosphate, the bulk material of commercial fertilizer. Occasionally phosphoric acid is used in place of sulphuric acid and the resulting product is called concentrated superphosphate or triple phosphate.

The phosphate, which usually comes to the plant in rock form, is first put through a rock grinder. From the grinder the pulverized phosphate is fed mechanically into a mixer where it is combined with dilute sulphuric acid. During the mixing, a chemical reaction takes place between the acid and the particles of phosphate. When the reaction has proceeded to a predetermined point the operator drops the semiliquid mixture, now called superphosphate, into a bin beneath the mixer. In this bin, known as the den, the chemical reaction continues and the superphosphate hardens into a solid mass which must be broken up before it can be moved. Two methods of removing superphosphate from the den were observed in the course of the survey. In one of these methods a hydraulic ram and a set of revolving blades are mounted at opposite ends of the den. The ram forces the superphosphate against the blades which cut it into small pieces. The pieces fall onto a conveyor which carries them to storage bins for further aging. In the second method a scoop attached to cables and powered by an electric motor cuts into the pile and deposits the superphosphate on a conveyor or truck for transfer to the aging bin.

The atmosphere in this department is usually very dusty, particularly in the vicinity of the rock grinder. Respirators and goggles, therefore, generally are considered essential equipment. Fine particles of rock dust and superphosphate settle on the floors and stairways, creating slipping hazards. In the den the floor is usually rough and uneven because of adhering superphosphate. Another hazard encountered in the den is the possibility of being struck by lumps of superphosphate falling or sliding from the piles. Contact with the acid in the superphosphate is a common source of burns not only in the den but throughout the department. Unguarded gears and belts on den machines, rock grinders, and conveyors are hazards found in many plants. Some plants use overhead industrial railways to transport the superphosphate to the storage or aging bins. Cars falling from these trackways present a serious hazard to the operators and to any other nearby workers. Workers near the aging bins are exposed to lumps of superphosphate falling from the piles in the bins and to traffic hazards created by the trucking operations necessary to move the material from the bins to the dry-mixing department. The superphosphate-mixer operator stands on the enclosed tank, in which dangerous fumes are constantly being generated. These fumes are exhausted mechanically, but any break-down in this system presents a serious hazard to the operator.

DRY-MIXING DEPARTMENT

The dry-mixing department had an average injury-frequency rate of 40.0 and an average severity rate of 3.6. A relatively high proportion of the injuries in this department resulted in serious disabilities—6 of the 879 disabling injuries were fatilities, 1 resulted in permanent-total disability, and 23 resulted in permanent-partial disability. As a result, the average time charge per disabling injury, 91 days per case, was higher than in any of the other major operating departments.

In this department superphosphate and other dry ingredients are combined to make the complete fertilizer. The mixing machine is generally placed near the roof of the building so that it may be emptied by gravity.

Powered scoops, commonly called payloaders, deliver the materials to a point under the mixer. Here the ingredients are weighed and dumped into floor openings leading to a bucket conveyor which carries them up to the mixer. After the ingredients have been mixed sufficiently to assure homogeneity, the fertilizer is stored for further aging. When fully cured, the fertilizer is again conveyed to an elevated hopper which feeds through a screening mechanism to the bagging

machine. The operator of the bagging machine suspends an empty bag under the delivery nozzle of the machine, permits a sufficient quantity of the fertilizer to flow into the bag, closes the nozzle, and releases the filled bag from the machine. As it is released, the filled bag stands upright on a belt conveyor, which carries it to a sewing machine where it is closed and fastened. From the sewing machine the filled bags are taken to the warehouse for storage or are taken directly to railroad cars for shipping.

The air of the mixing room is generally heavily laden with dust, most of which originates at the point where the dry ingredients are dumped into the hopper of the bucket conveyor. Generally the conveyor itself is enclosed, partly to guard against contact with its moving parts and partly to minimize the release of dust. Nevertheless, thick clouds of dust rise from the hopper as the materials are dumped in. A wide variety of hazards are created by this dust. Dermatitis and irritations of the eyes and respiratory passages frequently result from working in the dusty atmosphere. As the dust settles on floors and stairways it creates a slipping hazard and when it accumulates in thick layers it frequently hardens to make the surfaces rough and uneven. These irregularities constitute tripping hazards and make it difficult to control the movements of the hand trucks and power trucks, which are extensively used in this department. Poor visibility because of the dust in the air creates another hazard which is particularly dangerous in the vicinity of the floor openings leading to the bucket conveyors, into which workers might fall or into which they might run their trucks.

Back strains and crushed fingers or toes resulting from the mishandling of heavy materials are common in the dry-mixing department. Many of these occur in handling bags of fertilizer, which generally weigh over 100 pounds, or in placing temporary gang-plates for hand trucking operations.

Other hazards frequently encountered in this department include: unguarded moving parts on conveyors or sewing machines, and the "overhang" on piles of superphosphate, which develops during the removal of the material from the aging bins. A less common, but nevertheless serious hazard, arises from the occasional use of dynamite to loosen superphosphate which has hardened in the aging bins.

MAINTENANCE DEPARTMENT

Maintenance department workers had an injury-frequency rate of 51.0, a severity rate of 3.0, and an average time charge of 58 days per disabling injury. On the basis of these averages, this department ranks among the most hazardous of the industry.

By the very nature of their work, maintenance workers meet, on occasion, every hazard faced by any fertilizer worker, and in addition must contend with many which are seldom present in normal operations. As a result, maintenance workers sustain all kinds of injuries. Eye injuries and injuries to the hands and feet, however, are particularly common in this department, indicating that greater attention should be given to the use of goggles, gloves, and safety shoes. These workers should also be thoroughly trained to recognize and cope with every plant hazard.

ADMINISTRATIVE AND WATCHMEN'S DEPARTMENTS

Administrative and clerical workers seldom encounter the many hazards of the operating departments. This was reflected in their relatively low injury-frequency rate, (2.8). It is noteworthy, however, that 3 of the 12 injuries reported for these workers resulted in permanent disabilities, a higher proportion than occurred in any other department.

Watchmen, who generally enter the plant only during shut-down periods, also escape most of the operating hazards. However, they do encounter many of the hazards associated with poor housekeeping. In comparison with the rates of the operating departments their injury-frequency rate (8.3) was low, but it was substantially higher than the rate for the administrative and clerical department.

Kinds of Injuries Experienced

Inasmuch as the basic purpose of an accident-prevention program is to avoid the occurrence of events which result in injuries, analysis of the injuries which have occurred can serve a definite purpose in setting the stage for the more pertinent analysis of accident causes. It also performs a direct "injury prevention" function by indicating the possibilities of utilizing personal protective

equipment to supplement more specific accident-prevention methods.

The most significant element in the general pattern of the reported injuries was the relatively high proportion of eye cases. Over 9 percent of all the disabling injuries and over 24 percent of the medical cases were eye injuries. About half of these were irritations, scratches, or bruises caused by dust or flying particles. The other half consisted primarily of chemical burns. Eye injuries were common in every operating department, but were of outstanding importance in the maintenance, sulphuric-acid, and superphosphate departments. As the general use of goggles undoubtedly would have prevented all of these injuries, the need for an expanded eye-protection program in the industry is evident.

About 18 percent of the disabling injuries and 26 percent of the medical cases were hand or finger injuries. The majority of these were cuts or bruises although there were a considerable number of sprains, fractures, and burns. Finger injuries were particularly common in the maintenance department and hand injuries were particularly important in the superphosphate department. Protective equipment which will prevent crushing injuries to hands and fingers is generally considered impracticable. Nevertheless, the use of proper gloves when handling chemicals or hot, rough, and sharp-edged materials, would probably have prevented most of the hand and finger burns and a large proportion of the cuts and lacerations.

More than 23 percent of the disabling injuries and 13 percent of the medical cases were foot and toe injuries. The great majority of these injuries were bruises, cuts, or fractures resulting primarily from dropping heavy objects or from setting them down improperly. Many of these injuries probably would have been avoided if the workers had been wearing safety shoes or metal foot guards. Foot and toe injuries were particularly numerous in the dry-mixing department.

Back injuries accounted for over 12 percent of the disabling cases and for over 6 percent of the medical cases. Most of these were strains or sprains resulting from lifting excessive weights or lifting improperly.

Eleven percent of the disabling injuries and 7 percent of the medical cases were leg injuries. About half of the leg injuries were bruises. The remainder included a considerable number of cuts, strains, chemical burns, and scalds.

Injuries to the head, other than eye cases, were relatively infrequent. Three of the 6 fatalities and 1 of the 2 permanent total disabilities reported in the survey, however, resulted from head injuries.

Trunk injuries other than back cases accounted for 14 percent of the disabling cases and 10 percent of the medical cases. These were predominately bruises, but the total included a substantial number of strains, sprains, and hernias.

The need for specialized safety programs for each of the major operating departments was strongly indicated by the differing patterns formed by the injuries in these departments. In the sulphuric-acid department 34 percent of all the reported injuries were chemical burns, 18 percent were strains or sprains, and 16 percent were bruises. The most urgent need in this department therefore, is to develop safer methods of handling the acid to reduce this high proportion of chemical burns.

In the superphosphate department 26 percent of the injuries were bruises or contusions, 23 percent were chemical burns, 20 percent were cuts, and 14 percent were strains or sprains. Here the emphasis apparently should be placed first upon improving the methods of handling heavy materials and secondly upon avoiding contacts with acid.

In the dry-mixing department 39 percent of the injuries were bruises or contusions, 20 percent were cuts, and 20 percent were strains or sprains. All of these types of injuries are associated with manual handling of heavy materials. Their prevention calls for close study of the material-handling methods now in use with the objective of revising those methods to reduce the hazards.

In the maintenance department 27 percent of the injuries were bruises, 20 percent were cuts, 16 percent were foreign bodies in the eyes, and 14 percent were strains or sprains. The particular need for greater utilization of goggles is apparent in this department.

Agencies Involved in Accidents

Determination of the physical items or objects which are most frequently involved in accidents constitutes one of the fundamental steps in accident-prevention work. When these objects are

known it becomes possible to take steps to overcome their accident-producing possibilities. To permit the precise determination of these items, which are commonly called "agencies," the American Recommended Practice for Compiling Industrial Accident Causes defines an agency as "the object or substance which is most closely associated with the injury, and which in general could have been properly guarded or corrected." Application of this definition indicates that the agencies most commonly involved in accidents in the fertilizer industry are vehicles, working surfaces, hand tools, chemicals, and machines.

Vehicles were involved in approximately 20 percent of the accidents. Hand trucks were designated as the agencies in about half of these cases and tractors or payloaders were involved in about one-third. Other vehicles involved in fewer, but nevertheless substantial numbers of accidents, included railroad cars, motor trucks, and wheelbarrows. Vehicles were particularly important agencies of accident in the dry-mixing department where they were involved in over 29 percent of the accidents. In the superphosphate department nearly 14 percent of the accidents involved vehicles.

Working surfaces were specified as the agencies in about 13 percent of the accidents. About half of these cases involved slippery, rough, or otherwise defective floors. Defective surfaces on scaffolds, platforms, and ramps, however, were common. Defective working surfaces constituted a prominent source of accidents in all departments, but were particularly important in the dry-mixing department, where they were associated with the occurrence of over 14 percent of the accidents.

Hand tools, constituting the third most prominent group of agencies, were involved in 10 percent of the accidents. The particular tools most commonly involved were bars, hammers, torches, and shovels. One in every five accidents in the maintenance department and one in every eight in the sulphuric-acid department was a hand-tool accident.

Although chemicals were designated as the agency in only 7 percent of the total volume of accidents in the industry, this group of agencies was of outstanding importance in the sulphuric-acid and superphosphate departments. Chemicals constituted the agency in 16 percent of the superphosphate-department accidents and in 14 percent of the accidents in the sulphuric-acid department.

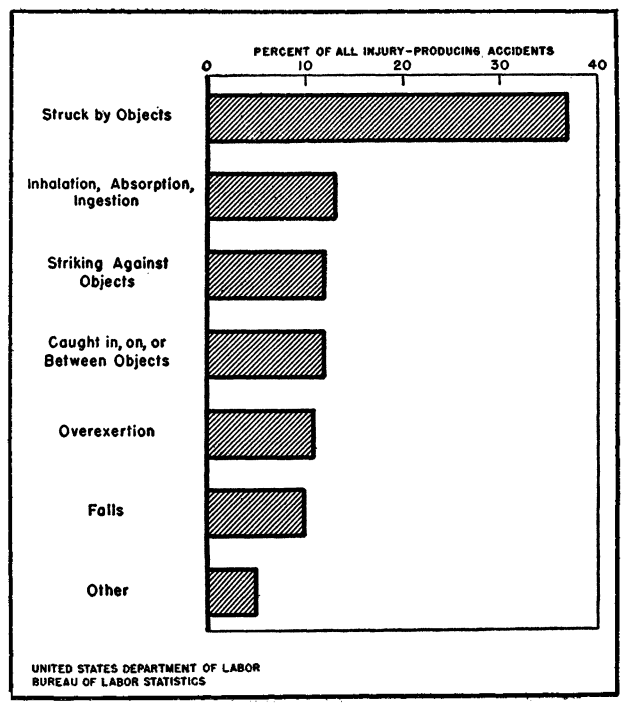
Machines were directly associated with the occurrence of about 7 percent of all accidents in the industry. Nine percent of the accidents in the superphosphate department and 8 percent of those in the maintenance department were machine accidents.

Other agencies of lesser prominence in the industry totals were nevertheless particularly important in the experience of individual departments. Defective boilers and tanks, for example, constituted the leading source of accidents in the sulphuric-acid department, where they were involved in over 14 percent of the accidents. Flying particles which entered workers eyes were also important as accident agencies in this department as well as in the maintenance department.

Types of Accidents

The most common type of accident was that in which an employee was struck by a moving or falling object. This type of accident was responsible for 37 percent of the injuries for which

Chart 2.—Major Types of Accidents in the Fertilizer Manufacturing Industry, 1946



details relating to the manner of their occurrence were available. The agencies most commonly involved in these accidents included vehicles, hand-tools, lumps of superphosphate or fertilizer, bags of materials, gang planks, lumber, and metal parts. The "struck by" type of accident was common in all departments but was of particular importance in the maintenance and dry-mixing departments. Accidents of this type produced 47 percent of the injuries in the maintenance department, 38 percent of those in the dry-mixing department, and over 20 percent in those experienced by workers in the sulphuric-acid and superphosphate departments.

The general group of accidents designated as inhalation, absorption, and ingestion accounted for 13 percent of the injuries. Most of these injuries were chemical burns resulting from the absorption of chemicals by the skin or eyes. In both the sulphuric-acid and superphosphate departments this was the most common type of accident. Nearly 40 percent of all injuries in the sulphuric-acid department and 30 percent of the injuries in the superphosphate department resulted from the absorption of chemicals.

Accidents in which the injured person bumped into or struck against objects or equipment produced 12 percent of the reported injuries. Most of these accidents involved contact with fixed objects, although accidents involving machines, conveyors, and other moving equipment were not uncommon. The "striking against" type of accident was relatively most important in the superphosphate, dry-mixing, and maintenance departments.

Accidents in which employees were caught in, on, or between objects or equipment also accounted for about 12 percent of the injuries. Moving equipment, such as conveyors and hand trucks, was involved in many of these accidents, but there were also many cases of mashed fingers, which were caught between hand trucks and fixed objects during hand-trucking operations, between bags of fertilizer or other materials during piling operations, or between gangplanks and floors as the gangplanks were being placed in position. Approximately 14 percent of all injuries in the dry-mixing department and 11 percent of those in the superphosphate department were attributed to this type of accident.

Overexertion, primarily in lifting bags of fertilizer or other heavy objects, was responsible for 11 percent of the injuries. Accidents of this type were particularly common in the dry-mixing and sulphuric-acid departments.

Falls accounted for about 10 percent of the injuries. For the industry as a whole, falls from one level to another were only slightly more numerous than falls on the same level. In the maintenance department, however, falls from elevations outnumbered falls on the level by 6 to 1, and in the sulphuric-acid department by 2 to 1.

Accident Causes

This analysis is based on the accident records of 185 of the fertilizer plants surveyed.[6] Although the combined injury-frequency rate of 41.6 for this group was higher than the industry average, there was no reason to believe that the pattern of accidents in these plants was essentially different from that of the entire industry.

In order to broaden the analysis and permit greater detail, this part of the survey was extended to include not only disabling injuries, but also all other injuries requiring treatment by physicians. These data, covering 2,532 injury cases, were then analyzed according to the American Recommended Practice for Compiling Industrial Accident Causes, as approved by the American Standards Association.

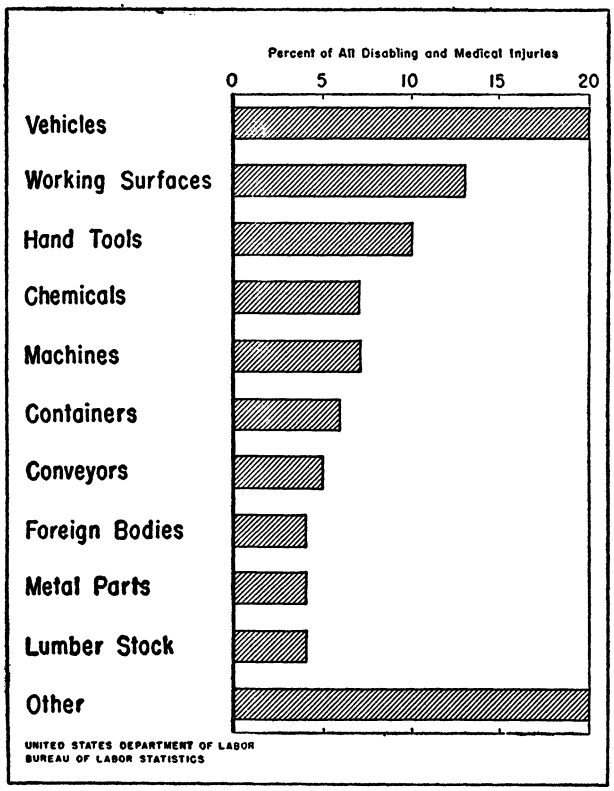
UNSAFE WORKING CONDITIONS

The most direct, and usually the most productive, accident-prevention measures are those which eliminate unsafe working conditions. Extensive engineering and the expenditure of large sums of money may sometimes be necessary to control particular hazards. Most unsafe conditions, however, can be controlled simply and easily through supervisory action. Unfortunately, the need for such action is frequently overlooked because the existing hazards have become so much a part of the work environment that neither workers nor supervisors recognize their influence in producing accidents. Hazards arising from poor housekeeping, from inadequate maintenance standards, or from operations which have grad-

[6] These plants employed nearly 15,000 workers during 1946. Bureau representatives transcribed from the original accident records of these plants a complete account of each work accident experienced by their employees during 1946.

ually expanded from their original scope without a definite plan often fall into this category.

Chart 3.—Major Agencies Involved in Accidents in the Fertilizer Manufacturing Industry, 1946



Basically, the existence of such hazards represents supervisory failure and carries a strong implication of inefficient operation. A very large proportion of the accidents in fertilizer manufacturing stem directly from such supervisory failures.

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 36 percent of the analyzed accidents were directly due to defective agencies.

Slippery floors and slippery surfaces on platforms, scaffolds, and gangplanks were particularly prominent sources of accidents. In many cases the slippery surface was due to accumulations of loose fertilizer or rockdust—an indication of poor housekeeping. This condition was very common in the superphosphate and dry-mixing departments. Metal gangplanks, used extensively in hand-trucking operations in the dry-mixing departments, were frequently slippery because of excessive wear—a sign of inadequate maintenance.

In addition to being slippery, floors and other working surfaces frequently were broken, cracked or irregular to such an extent as to present definite tripping hazards. These irregularities, moreover, frequently caused hand trucks to swerve and bump into nearby persons or objects, or to injure the operators. Hazards of this type are generally quite apparent, and their continued existence can be interpreted only as evidence of slack supervision and inadequate maintenance.

Defective vehicles also constituted a prominent source of accidents. Some of these were railroad cars with rough or slippery floors or splintered doors. The great majority, however, were plant vehicles such as payloaders with defective lifting mechanisms, or hand trucks with rough or splintered handles, loose wheels, or broken braces.

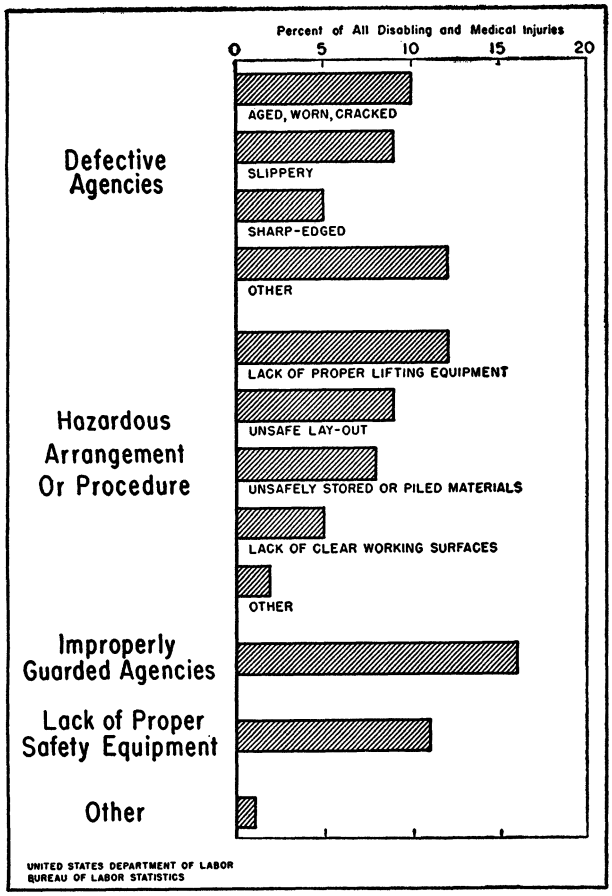
Other defective agencies, which caused fewer but nevertheless substantial numbers of accidents, included worn or cracked hand tools, worn or strained hoisting equipment, and sharp-edged or worn parts on conveyors, machines, boilers, and tanks. Most of these defects should have been apparent to the supervisors in the normal course of operations and specifically should not have been overlooked if regular safety inspections were made.

Hazardous arrangements or procedures. The hazards included in this general group usually result from a failure to plan operations so that they may be carried on safely, or from a failure to enforce operating rules relating to safety. Accounting for 36 percent of the analyzed accidents, this group of hazards ranked with defective agencies as an outstanding source of accidents in the industry.

Operations involving the handling of heavy or bulky materials always present serious injury possibilities and require thorough planning and supervision in order that accidents may be avoided. Careful consideration should be given to determination of the maximum weight any individual will be expected to lift, and mechanical equipment or sufficient additional help should be provided whenever the weight exceeds the determined limit. The many strains and sprains reported as resulting from lifting excessive weights,

particularly in the dry-mixing and maintenance departments, indicate that the industry generally has not given sufficient attention to this phase of safety.

Chart 4.—Major Types of Unsafe Working Conditions in the Fertilizer Manufacturing Industry, 1946



Safe operation of plant vehicles and safe handling of inherently hazardous materials such as acids also require careful planning by the supervisory staff and strict enforcement of the established rules of procedure. Vehicles, particularly hand trucks and pay loaders, were involved in a considerable number of collision accidents which probably could have been avoided if designated lanes for vehicular traffic had been provided and traffic rules had been enforced. Traffic accidents were common in nearly all departments. However, the greatest volume of accidents ascribed to other types of unsafe procedures were in the sulphuric-acid and superphosphate departments. Many of the latter mishaps involved a failure to provide the proper tools or equipment for the work at hand, which resulted in misuse of available equipment.

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 common among the poor housekeeping conditions which led to accidents. Loose superphosphate or fertilizer, lumber stock, and bags of fertilizer were the agencies most commonly involved in these accidents. Tripping accidents were very common.

Inadequately guarded agencies. Inadequately guarded agencies were responsible for approximately 16 percent of the analyzed accidents. Gears, belts, or other moving parts of machines and conveyors were the principal accident sources in this group. Over 60 percent of the accidents involving machines and conveyors resulted from inadequate guarding.

Scaffolds, platforms, and ramps without railings or toeboards, and unguarded openings in floors were relatively common causes of accidents. The record also indicated that many of the ladders used in fertilizer plants were not equipped with ladder safety-shoes, that hand tools such as knives frequently had no handle guards, and that electrical equipment was often ungrounded.

Lack of personal protective equipment. All plants reported that personal protective equipment was provided and that its use when necessary was required. The accident reports indicated, however, that observance of this requirement was inadequate. Nearly 11 percent of the accidents for which the cause was determined were found to have occurred because the prescribed safety equipment was not used.

Accidents in which workers experienced eye injuries because they were not wearing goggles or face shields while working with chemicals or in the very dusty areas of superphosphate or mixing departments were most common. In addition, a number of cases of respiratory irritations could have been prevented by the use of respirators, and many hand and toe injuries could have been avoided through the use of gloves or safety shoes. The sulphuric-acid and superphosphate depart-

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ments were most remiss in use of protective equipment, but the dry-mixing and maintenance departments also had very unfavorable records.

UNSAFE ACTS

For the purpose of accident analysis, an unsafe act is defined as "a violation of a commonly accepted safe procedure." [7] Literally, this means that no action may be designated as unsafe unless there is an alternative safe procedure, but it does not imply that the employee who committed the unsafe act must have known the alternative safe method. It is apparent from the analysis that many of the injured employees knew the safe methods but decided not to follow them. It is also evident that many other employees committed unsafe acts simply because they did not know the safe procedures. The elimination of unsafe acts, therefore, is a twofold problem: first, employees should be carefully instructed in the safe methods of performing their duties; and, second, an adequate number of well-trained, safety-minded supervisors should be provided to enforce safe practices.

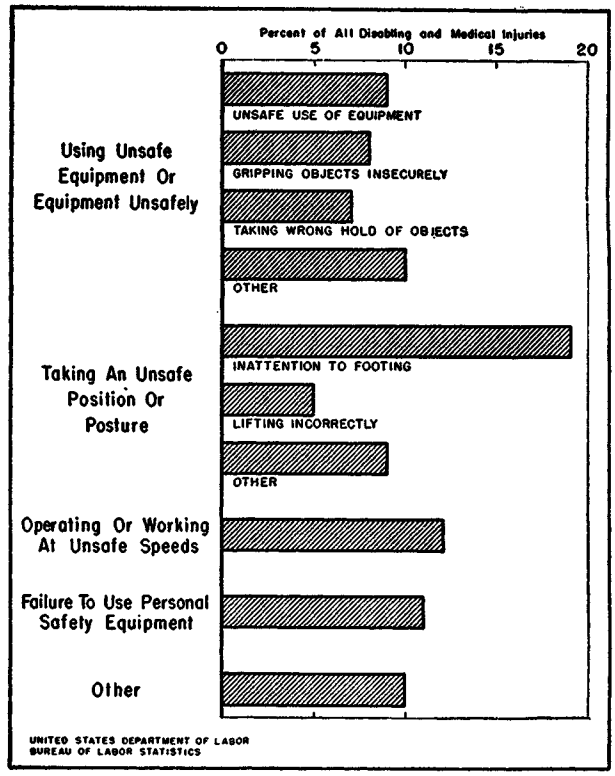
Four general groups of unsafe acts were outstanding—using unsafe equipment or using equipment unsafely; assuming unsafe positions or postures; operating or working at unsafe speeds; and failing to use personal safety equipment or to wear proper clothing.

Using Unsafe Equipment or Equipment Unsafely. Unsafe use of equipment, or its use for purposes for which it was not intended, accounted for about 9 percent of the analyzed accidents. Generally, these acts involved misuse of hand tools—for instance, using crowbars or pinch bars as hammers. This type of unsafe act was particularly frequent in the maintenance departments, but was also responsible for a high proportion of accidents in sulphuric-acid and superphosphate departments.

Gripping objects insecurely accounted for about 8 percent of the accidents. Many workmen, as a result of improper handling of lumber stock, hand tools, metal parts, bags of fertilizer, and similar articles, dropped these objects and in consequence suffered bruised or fractured feet, toes, hands, or fingers. Accidents caused by loose handling of materials or equipment were most common in the maintenance departments.

[7] In American Recommended Practice for Compiling Industrial Accident Causes, approved by the American Standards Association, 1941.

Chart 5.—Major Types of Unsafe Acts in the Fertilizer Manufacturing Industry, 1946



Taking the wrong hold of objects was the cause designated for accidents in which employees permitted their fingers to be caught between objects which they were piling, or between gangplanks and floors while they were placing the gangplanks in position, or between the handles of hand trucks and fixed objects. This type of unsafe handling accounted for 7 percent of the accidents.

Other specific unsafe acts in this group included pulling hand trucks instead of pushing them, using equipment known to be defective, and using hands instead of hand tools.

Assuming unsafe positions or postures. Failure to obey one of the basic safety rules, "Watch your step," was responsible for more accidents in the fertilizer industry than any other individual unsafe act. Over half of the accidents in the unsafe position or posture group, 19 percent of all accidents in the industry, and over 20 percent of all accidents attributed to unsafe acts in the superphosphate and dry-mixing departments were attributed to inattention to footing. Loose fertilizer or rock

dust, pieces of scrap lumber or metal, rough floors, and stairways were involved in many of these mishaps.

Incorrect lifting was responsible for approximately 5 percent of all accidents resulting from unsafe acts. Most of these accidents occurred when workmen attempted to lift objects while they were in awkward or stooped positions. Although it was sometimes very difficult to determine when objects were too heavy to be lifted by an individual employee, an attempt was made to exclude from the tabulation of unsafe acts all accidents which occurred because adequate assistance had not been provided—as it appeared that these actually resulted from unsafe working conditions rather than from unsafe acts.

Numerous accidents occurred because employees exposed themselves to pieces of superphosphate or other material falling or sliding from piles. Accidents of this type were most common in the superphosphate departments. Less common injury-producing unsafe acts in this group included walking or standing under suspended loads; entering enclosures which were unsafe because of high temperatures, gases, or other exposures; riding vehicles in unsafe positions; exposure on vehicular rights-of-way; running; and jumping from machines, railroad cars, ladders, or similar equipment.

Other Unsafe Acts. Operating or working at unsafe speeds caused about 12 percent of all accidents in the industry, and over 18 percent of all accidents in the dry-mixing departments. Vehicles, either hand or mechanically operated, were involved in a high proportion of these accidents.

Failure to wear personal safety equipment which had been provided, or failure to wear adequate clothing, was responsible for about 11 percent of the accidents. In the sulphuric-acid, the superphosphate, and the maintenance departments, failure to wear provided personal safety equipment was an especially noteworthy cause. Most of the instances resulted from the failure of employees to wear available goggles, respirators, and similar equipment.

Four percent of all accidents involving unsafe acts were the result of operating equipment without authority, starting or stopping equipment without giving warning signals, or failure to shut off or block equipment which was not being used.

Other unsafe acts which contributed to the occurrence of accidents were unsafe loading, placing, and mixing; working on moving or dangerous equipment; and fighting or quarreling.

Typical Accidents—Suggestions for Prevention

To illustrate the general types of accident problems encountered in the fertilizer-manufacturing industry, a number of accidents were selected for individual consideration. These cases were drawn from the experience of 11 typical plants. In selecting the cases, an effort was made to exclude accidents arising from conditions peculiar to a particular plant and to include only accidents which could be duplicated in many plants throughout the industry.

A number of the safety-engineering staff of the Bureau of Labor Standards of the United States Department of Labor investigated each of the selected accidents at the point of occurrence. On the basis of that investigation, recommendations were prepared to indicate specific procedures which might be employed to prevent the occurrence of similar accidents. The intention was not to make all-inclusive recommendations nor to attempt to propound authoritative safety rules for the industry. On the contrary, the purpose was merely to indicate that there is a simple approach to the prevention of practically every type of accident. Many safety engineers no doubt would attack the problems involved in these accidents from a different angle and would achieve equally good results. The method of prevention, however, is of secondary importance so long as it achieves its purpose. It is, nevertheless, significant that the recommendations repeatedly stress the necessity for greater attention to training the workers in safe procedures and for closer supervision to insure that the safe procedures are followed. It is recognized, however, that because much of the work in this industry is seasonal the problems of training and of providing adequate supervisions are more difficult than in industries where production is constant and employment is more regular.

The importance of proper attention to safety in the design and lay-out of plants and structures, and in the design and guarding of machinery and

equipment is indicated by the fact that many of the accidents described could have been eliminated or minimized in the design stage.

RECEIVING-DEPARTMENT ACCIDENTS

1. A laborer was working in a gondola car while it was being unloaded with a swinging grab bucket. When the bucket swung around, it crushed the worker between the bucket and the side of the car.

Workers should not be permitted in a gondola car which is being unloaded with a swinging grab bucket unless some provision has been made to control the bucket with a tagline.

2. A grab bucket was being used to remove material from the hold of a ship. One of the men working in the hold was injured when he was struck by the bucket as it was being lowered.

Close supervision and adequate job planning are necessary to prevent accidents of this type. Hatch tenders should never give signals to raise or lower buckets until all men are in the clear. Employees in the hold should remain out of the hatchway while buckets are being moved. Supervisors should be responsible for the strict enforcement of these rules.

3. A grab bucket was being used to unload a ship. An employee, working in the hold, was struck on the head by a piece of superphosphate which fell from the grab bucket.

(a) *Close supervision and adequate job planning are necessary to prevent accidents of this type. Hatch tenders should never give signals to move buckets until all men are in the clear. Employees in the hold should remain out of the hatchway while buckets are being moved. Supervisors should enforce these rules strictly.*

(b) *All employees working in the hold of a ship should be provided, and required to wear, safety hats.*

4. An employee was unloading limestone from a gondola car. A piece of limestone fell from the top of the pile and struck him on the foot.

(a) *Close supervision and adequate job training are necessary to prevent accidents of this type. The loading face of piles should be broken down to an angle of approximately 45°.*

(b) *Workers handling heavy materials should wear steel-toed safety shoes.*

5. While he was unloading a boxcar of superphosphate with a tractor, an employee was overcome by carbon-monoxide fumes. Investigation disclosed that only one door of the boxcar was open and the carburetor of the tractor was not adjusted properly.

(a) *Frequent inspections and proper maintenance of all equipment such as tractors are necessary to prevent accidents of this type.*

(b) *Adequate ventilation must be maintained in all areas where tractors are being operated. To secure cross-ventilation within the boxcar, both doors should have been opened.*

6. A laborer was moving a wheelbarrow load of phosphate rock from a boxcar to a platform. His wheelbarrow struck a broken board in the gangplank causing the handle of the wheelbarrow to strike him in the groin.

Regular and frequent inspections with proper maintenance are necessary to prevent accidents of this type. Defective equipment should be removed from service until the necessary repairs have been made.

7. An employee was using a wrench to open a valve on a tank car. As he was applying pressure to the wrench, the valve opened suddenly and he fell 8 feet to the ground, seriously injuring his back.

(a) *Close supervision and adequate job instruction are necessary to prevent accidents of this type. Only employees thoroughly trained in the hazards of this operation should be permitted to work on tank cars.*

(b) *A long-handled wrench should be used to provide greater leverage and, when necessary, two employees should be assigned to this work.*

(c) *A platform ladder should be provided for this work.*

8. Two men were unloading bags of scrap leather from a truck. One employee on the truck was throwing the bags of leather to the other on the platform. A third employee walked between the truck and the platform and was struck by one of the bags.

Close supervision and adequate job planning are necessary to prevent accidents of this type. Passageways and working areas in which materials are being thrown should be roped off.

9. A laborer was using a jackknife to open burlap bags containing scrap leather. The knife slipped and cut his left arm.

The use of jackknives should not be permitted in industrial operations. Safely designed industrial knives with suitable holders should be provided.

SUPERPHOSPHATE DEPARTMENT ACCIDENTS

10. An employee, operating a land plaster mill, felt an electric shock. He jumped from the mill and turned his ankle. The mill was not grounded and an inspection disclosed a loose connection on a 220-volt line.

(a) *All electrical equipment should be properly grounded.*

(b) *All equipment should be inspected frequently on a regular schedule. Defective equipment should be repaired immediately or removed from service until repairs have been made.*

11. A laborer experienced an injury to his left shoulder and ear when a bell weighing approximately 10 pounds fell on him. The bell was used as a signal to indicate the completion of a batch of superphosphate. Investigation disclosed that the metal supports to which the bell was fastened had corroded.

(a) *All equipment should be inspected frequently on a regular schedule. Defective equipment should be repaired immediately or removed from service until such repairs have been made.*

(b) *Overhead equipment in this department should be fastened to acid-resistant material.*

12. An employee was tending a wet-mix machine. While watching the mixing operation through a manhole, a particle of acid phosphate was blown from the machine and lodged in his eye. Investigation disclosed that there was no mechanical exhaust equipment on the mixer.

(a) *The wet-mix machine should be equipped with an exhaust fan and air duct to convey the fumes and gases to the outside of the plant. Frequent and regular inspections with proper maintenance are necessary to assure its effective operation.*

(b) *Workmen engaged in this work should be provided, and required to wear, goggles.*

13. While cleaning an elevator pit with a shovel, an employee struck his hands against a nail protruding from one of the bulkheads.

All protruding nails, spikes, and bolts should be removed.

14. A laborer was directed to unload an acid tank car. After connecting a hose to the valve, he applied the pressure necessary to force the acid from the car. When the acid did not flow, the employee opened the line to ascertain if there was pressure in the line. As he did so, acid sprayed over his face and neck, resulting in serious injuries. Investigation disclosed that the hose was clogged.

(a) *Definite safe procedures should be developed for this operation and the men should be trained in their application. In this case the employee should not have opened the line until the pressure had been cut off and the air bled from the tank.*

(b) *An inspection of the hose before it was used should have revealed the clogged condition.*

(c) *Face and eye protection should be worn while working with acids.*

15. The drag line of a Novell drag became tangled on the drum. An employee attempted to straighten the line while the drum was in motion. His finger was caught between the drum and the line and was amputated.

No powered equipment should be repaired or adjusted while it is in operation. Supervisors should enforce this rule strictly.

16. The operator of a double-drum drag line disengaged the clutch and attempted to pull back the line by hand before the drums had completely stopped. His hand was pulled into the pinch point and crushed between the cable and drum.

No adjustments or repairs should be made on any equipment while it is in motion.

17. An automatic switch on a rock-mill plow failed to operate, causing the machine to jerk. The sudden movement threw the operator against the plow. Investigation disclosed that the switch had been reported as defective and repairs had been requested, but that the repairs had not been made. The supervisor had authorized use of the machine despite its defective condition.

Defective equipment should be removed from service until repairs have been made.

18. A plank in the floor of a catwalk shifted under the weight of a buggy, causing the buggy to tilt and fall from the catwalk onto a pile of superphosphate 20 feet below. The operator fell with the buggy and suffered a broken back. Investigation disclosed that the maintenance crew had replaced a worn plank in the catwalk, but had not fastened the new plank in place.

(a) *All repair work should be supervised and inspected by competent personnel before the repaired equipment is returned to service.*

(b) *Catwalks should have standard railings.*

19. An overhead tractor operator stood up as his tractor passed under the hoppers from which material was to be loaded into the cars which he

was pulling. His head struck one of the hoppers and he was knocked from the tractor. The tractor continued to a curve, where it left the tracks and fell to the floor below.

(a) *Hoppers should be designed so that tractor drivers passing under them will have adequate head room.*

(b) *Where headroom is low "tell-tails" of short lengths of rope or light chains should be provided on both sides of the obstruction to give warning.*

(c) *Tractors should be equipped with "dead man" controls.*

(d) *Guard rails or barriers should be provided at all curves where the cars might jump the track at operating speed.*

20. An overhead tractor operator was fatally injured when he and his tractor fell 30 feet onto a pile of phosphate rock. The operator had dumped a load of phosphate rock and had backed his tractor about 10 feet when the tractor jumped the tracks. An investigation of the accident revealed two possible causes of accident: (1) two tractor wheels were very loose, and (2) the operator may have backed his tractor too fast for a curved portion of the track.

(a) *All equipment should be inspected frequently on a regular schedule. Defective equipment should be repaired immediately or removed from service until repairs have been made.*

(b) *Curved portions of trackways should be designed for speeds at which the tractors will be used.*

(c) *Speed governors should be installed on all tractors.*

(d) *Barrier guards should be erected along all overhead railways, especially at curves.*

DRY-MIXING AND SHIPPING DEPARTMENT ACCIDENTS

21. A payloader operator stepped from his vehicle to a trimming box which was used to hold excess materials at the weighing platform. When the box tipped, the operator fell and bruised his knee.

(a) *Floor spaces should be kept free of loose objects such as tools, trimming boxes, scale weights, etc.*

(b) *Trimming boxes should be anchored in position.*

22. A jitterbug operator crashed into a second jitterbug as he turned a "blind corner." Neither vehicle was traveling over 5 miles an hour but they were unable to stop because of the slippery condition of the floor due to dampness.

(a) *Where floors are likely to be wet, they should be designed for good drainage, and should be surfaced with a material having good antislip properties, even when wet.*

(b) *Mirrors should be placed at all "blind corners." In dusty places such as in dry-mixing departments, these mirrors must be cleaned frequently.*

23. A tractor operator was hauling fertilizer from a stock pile to an elevator. When he made a sharp turn, the tractor turned over and fell on him, fracturing both his legs.

(a) *Trafficways should be designed and plainly marked to eliminate sharp turns.*

(b) *All tractor operators should be fully trained in the hazards of their operations.*

24. As a tractor operator stepped down from his machine he slipped on some wet superphosphate and fell against the tractor fracturing a rib.

All working surfaces and passageways should frequently be cleaned of loose fertilizer, superphosphate, etc.

25. As a tractor operator uncoupled a fertilizer car from his tractor, the tractor rolled back and caught his thumb between the tractor and the car. A flat-head coupling pin was being used.

(a) *All workmen should be thoroughly trained in safe working procedures. Tractor operators should be instructed to lock the brakes on their machines when they are standing idle and supervisors should rigidly enforce that rule.*

(b) *A coupling-pin with a ring at the top for safe handling should be substituted for the straight flat-head pin.*

26. While pushing a fertilizer cart, a trucker pinched his hand between the handle of the cart and an upright beam.

Knuckle or finger guards should be installed on the handles of fertilizer carts and hand trucks.

27. An employee who was pulling a loaded Georgia buggy had his hand crushed between the handle and the wall when the buggy was deflected by striking a piece of hardened fertilizer lying in the passageway.

(a) *Employees should push Georgia buggies instead of pulling them.*

(b) *Knuckle or finger guards should be attached to the handles of all hand trucks.*

28. A buggy operator pushed his buggy up behind a standing tractor. The tractor operator

backed his machine without looking and crushed the buggy operator between the buggy and a wall.

(a) *Tractor operators should be trained never to back without first making sure that the path is clear.*

(b) *Hand truckers as well as tractor operators should maintain adequate clearance between trucks.*

29. An employee was adjusting the belt on a bagging machine while it was in operation. His hand was caught in the feeder belt lacing and was severely lacerated. The belt had been spliced with wire lacing.

(a) *No adjustments or repairs should be permitted on any machine until the power has been shut off and the machine stopped. Supervisors should be required to enforce this rule strictly.*

(b) *Leather lacing or spliced belting should be used instead of metal lacings.*

30. A foreman of the bagging crew noticed that a belt had slipped from a pulley. He attempted to replace the belt on the pulley while the machine was in motion. In doing so, his hand was caught in the pulley and severely crushed.

(a) *No adjustments or repairs should be permitted on any machines until the power has been shut off and the machine stopped.*

(b) *Regular and frequent inspection, with proper repair of all defective equipment, is essential for safety. In this instance the reason for the belt running off the pulley should have been determined and corrected.*

31. An employee was closing bags of fertilizer with a sewing machine which was suspended over a belt conveyor on which the bags were moving. To protect his clothing, the operator was using a burlap bag as an apron. The apron caught in the conveyor and the operator was thrown to the ground.

(a) *Workers should not be permitted to wear loose clothing around moving machinery. Supervisors should strictly enforce this rule.*

(b) *A barrier guard should be placed upon the conveyor to eliminate the possibility of contact with moving parts when the sewing machine operator reaches over the conveyor to operate the sewing machine.*

32. A worker was removing bags of fertilizer as they came off the end of a belt conveyor. As he reached for a bag, his hand was caught and crushed between the chain and sprocket at the end of the conveyor.

Chains and sprockets should be completely enclosed so that contact with them is impossible.

33. A dust particle entered the eye of an employee while he was working at the elevator hole. Goggles and dust masks had been provided for this operation, but the worker was not wearing either.

Generally this is one of the most dusty spots in a fertilizer plant. Goggles and respirators should be furnished and their use required in all work at this location. Supervisors should enforce this rule strictly.

34. An employee was shoveling fertilizer into an elevator hole when another employee drove a tractor in beside him and dropped the tractor dipper on his foot. Investigation indicated that the shovelers in this location work very close to the tractors and that the tractor operators generally depend upon the shovelers to move out of the way of the dipper.

Inasmuch as the motion of the dipper is controlled by the tractor operator, the responsibility for its safe operation should be placed upon him. Operators should be trained to give warning before moving the dipper and should not move it until everyone is in the clear. This rule should be enforced strictly.

35. A workman was directed to make an adjustment on an overhead conveyor. As no ladder was available, he asked a payloader operator to raise him to the conveyor in the payloader bucket. As he was being raised, he steadied himself by grasping the sides of the bucket. His fingers were crushed between the edge of the bucket and one of the bucket supports.

(a) *Proper ladders or platforms should be provided for all work which is beyond reach from the floor and the use of makeshift supports should be prohibited.*

(b) *Equipment should never be used for any purpose other than that for which it was intended. This rule should be enforced strictly.*

36. A laborer was digging into a pile of fertilizer. He undercut the pile and was struck by a piece of solidified material which fell from the overhang.

This is a very common accident in the fertilizer industry. Careful instruction in safe procedures and close supervision are essential if these accidents are to be avoided. Safe practice in breaking down piled fertilizer requires that the working surface of the pile be maintained at not over a 45° angle.

37. While sweeping around a milling machine, an employee experienced a serious foot injury when his foot was caught in an unguarded V belt.

All V belts should be completely enclosed.

38. A stock mill laborer was drilling a hole in a pile of superphosphate preparatory to placing a charge of dynamite. His supervisor had directed him to work on the side of the pile which was at an angle of approximately 45°. When his foot slipped, the electric drill penetrated his abdomen.

This accident was the direct result of poor supervision. A level working surface should have been provided before the workman began drilling.

39. A workman on the floor of the dry-mix department was struck on the head by a 3-inch grease cup which fell from the catwalk of an overhead conveyor. A repairman had left the cup lying on the catwalk and the vibration of the conveyor had caused it to roll off.

(a) *All elevated working surfaces should be equipped with toe boards to prevent materials from sliding or rolling over the edge.*

(b) *All equipment should be carefully inspected by competent personnel before being returned to operation after repair or adjustment. If such an inspection had been made, the discarded grease cup probably would have been seen and removed.*

40. A laborer was hand-trucking fertilizer on a loading platform. When one of the bags fell in front of his truck, the truck stopped suddenly and he walked into the handle.

Adequate job instruction and close supervision are necessary to prevent accidents of this type. Supervisors should make sure that all truck loads are uniform and properly stacked.

41. A hand trucker was wheeling bags of fertilizer into a boxcar. One of the wheels of his truck struck a small piece of wood on the floor, causing the truck to tilt. He strained his back attempting to right the truck.

Good housekeeping is imperative to safety. Floors and all working surfaces should be kept free from loose objects.

42. A laborer was trucking bags of fertilizer from a warehouse to the loading platform. When his foot slipped on some wet fertilizer he fell and the loaded hand truck fell on him.

All working surfaces and passageways should be kept free from loose fertilizer, etc.

43. Several laborers were loading a boxcar during a rainstorm. While pushing a hand truck into the boxcar, one of the laborers sprained his ankle when his foot slipped from the gangway. The gangway was extremely slippery due to wet fertilizer.

Gangways, with nonslip surfaces, should be provided. Peanut-hull meal or other similar substances are frequently used to reduce the slipperiness of gangways and floors.

44. A hand trucker was moving bags of fertilizer from the mill to a boxcar. As he was pushing a loaded truck into the car, he collided with an empty truck which was being returned from the car. As a result of the collision, the employee's hand was caught between the side of the boxcar and the handle of the truck.

(a) *Close supervision and adequate job planning are necessary to prevent accidents of this type. Trafficways should be designed for safety and plainly marked. Truckers should follow designated lines of travel to prevent collisions and should not attempt to pass each other unless there is adequate clearance.*

(b) *All truck handles should have knuckle guards.*

45. A buggy operator pushed his cart under a tractor bucket which was being used to fill buggies with fertilizer. When the tractor bucket swung down, it fell across the cart, striking the right hand of the operator.

Safe working procedures should be worked out for this operation and employees thoroughly trained to follow them. Supervisors should strictly enforce these procedures. Workmen should not be permitted to stand or work under suspended loads.

46. A laborer was pulling a Georgia buggy loaded with raw material. One of the cart legs struck his foot, injuring his heel.

Adequate job instruction and close supervision are necessary to prevent accidents of this type. Georgia buggies should be pushed, not pulled.

47. A laborer was taking 100-pound bags of fertilizer from a 10-foot pile. As he pulled one bag from the pile it dislodged a second bag which fell on him.

(a) *Piled bags should be interlocked by turning the alternate rows. When the pile is higher than shoulder height, each row should be stepped back and planks should be used to provide a stable working surface on the steps.*

(b) *Workers should not be required to move materials to or from surfaces above shoulder height.*

48. A worker was piling bags of fertilizer in a truck. As he placed the first bag for a new stack

he dislodged the adjacent stack which fell on him. This employee had not been given any instruction as to the proper method of piling bags and at the time of the accident was working without supervision.

(a) *Piles of bagged fertilizer should be interlocked by turning the alternate rows and each pile should be given a slight taper.*

(b) *Proper instructions should be given with each new assignment and the supervisor should train the worker for a long enough period to be sure that he is following the safe procedure.*

49. While attempting to open a boxcar door, a laborer was injured when his hand slipped from the handle of the door and struck the side of the car.

Generally, boxcar doors are too heavy for an individual to move. A group of men, thoroughly trained to work as a team, should be assigned to this job, or a mechanical door puller should be provided.

50. A fork truck operator was seriously injured when his truck suddenly rolled back, pinning him between the warehouse wall and the steering wheel. Investigation disclosed that the truck had faulty brakes.

(a) *Equipment should be inspected frequently on a regular schedule. Defective equipment should be repaired immediately or removed from service until repairs have been made.*

(b) *A metal frame should be welded to the fork truck behind the driver to protect him from being struck by other vehicles or moving equipment and from being caught between his truck and other objects while he is backing.*

MAINTENANCE DEPARTMENT ACCIDENTS

51. A mechanic was replacing a cagemill in a hopper. While "lining up" the mill by hand, his foot slipped from the frame of the hopper and he fell between the cage mill and the side of the hopper.

Proper staging should have been erected to assure firm footing for mechanics engaged in this work.

52. A maintenance man was called to repair loose boards on the loading platform. The boards were not marked and in trying to locate them by stamping on the platform he knocked one of them aside and suffered a fracture when his foot slipped into the opening.

Defective equipment should be marked and withdrawn from service pending repair. In the case of defective flooring, the defective area should be barricaded or covered with a warning standard.

53. A mechanic assisting in the installation of a new overhead mixer dropped a wrench on the head of a worker on the floor below.

The area directly below the mechanics should have been roped off.

54. An employee was using a sledge hammer to loosen a shaft from a bearing. While he was engaged in this work, a small piece of steel flew from the sledge and struck the workman's face, cutting his lip.

(a) *A shaft and bearing puller should be used to remove shafts from bearings. If the puller is not available, a soft-faced mallet should be used instead of a sledge hammer.*

(b) *All hand tools should be inspected frequently and regularly. Defective tools, such as hammers or sledges with mushroomed or hardened heads, should be removed from service.*

(c) *Goggles or face shields should be worn in work of this nature.*

55. A mechanic was using a wrench to tighten a coupling on a tank car. The wrench slipped and his fingers were crushed between the wrench handle and the car. Investigation disclosed that the jaws of the wrench had been sprung so that it did not fit firmly on the nut.

Tools should be inspected frequently and those found to be defective should be replaced immediately.

56. A maintenance man burned his hand when he touched a weld which he had just completed. Gloves were provided for this operation, but he was not wearing them. Investigation revealed that this man had been given some training in welding, but was rarely called upon to perform this kind of work.

Supervisors should be familiar with the hazards involved in the work performed by their employees and should see that all required precautions are taken. This is particularly important in respect to operations which are unusual and with which the worker may not be entirely familiar. In this instance the supervisor should have insisted upon the use of all the protective equipment provided for welding operations.

57. A painter, working on a sloping roof without support, fell to the ground and fractured his leg.

Work on sloping roofs should always be safeguarded by such means as crawling-board stagings, guard ropes, or life lines.

58. A repairman attempted to raise an electric motor with a chain hoist. As it left the floor it swung against him, injuring his knee.

Chain hoists should always be carefully spotted directly above the object to be lifted in order to minimize the possibility of the load swinging. In making a heavy lift, a second person should control the swing of the load by means of a tag line.

59. A repairman was working under a tractor which was supported on a hydraulic jack. The jack suddenly released and allowed the tractor to settle, pinning him to the ground and crushing his chest.

(a) *Employees should not be permitted to work under equipment while it is supported by a jack. Solid blocking should be placed to take the weight after the equipment has been raised with the jack.*

(b) *Regular equipment inspections probably would have revealed the defect in the hydraulic jack.*

60. While a laborer was trying to remove a broken stem from an acid line valve, some acid splashed into his eyes.

Employees working with or around acid should be furnished with and required to wear goggles.

61. A worker who was grinding a chisel had his hand pulled against the grinding wheel when the chisel caught on the wheel. Investigation disclosed that the distance between the tool-rest and the wheel was over one-half inch.

The distance between the tool rest and the wheel should not be greater than ⅛ inch, so that tools cannot jam between them. Employees who use grinders should be thoroughly instructed as to their proper use and their procedures should be checked frequently to make sure they follow instructions.

62. A worker's toe was fractured by an iron plate which fell from his workbench. The workbench was cluttered with tools and scrap metal. The plate had been resting on top of some of this material and slid off when he touched it.

(a) *Good housekeeping is essential to safety. Facilities for storing scrap material and for tools which are not in use should be provided and supervisors should insist that all workmen make use of such facilities.*

(b) *Workmen who handle heavy materials should wear steel-toed safety shoes.*

MISCELLANEOUS ACCIDENTS

63. A workman stood on a bagging machine to reach an overhead light. His foot slipped and he fell against the motor of the machine, bruising his hip.

(a) *All overhead lights should be controlled by switches placed in accessible locations.*

(b) *The practice of climbing on equipment, tables, boxes, shelves, or other makeshift supports should be prohibited. When it is necessary to work at a point not accessible from the floor a suitable ladder should be used.*

64. A laborer in the yard gang was pulling a wire cable from a boxcar winch in order to attach it to a nearby car. A broken wire in the cable lacerated his hand. He was not wearing gloves.

All workers should be required to wear heavy gloves while handling wire cable.

65. A night watchman attempted to switch on a light at one of his stations. In order to reach the pull-cord, he stood on a hand truck. When the truck moved, the watchman fell, fracturing his hip.

(a) *All electric switches should be accessible from the floor.*

(b) *Hand trucks should never be used as step-ladders.*

66. A yard laborer was moving a hydrogen cylinder. When he attempted to lift the cylinder, he sustained a hernia.

All such workmen should be given general training in safe lifting and should be specifically instructed in the safe handling of heavy and awkward objects such as gas cylinders.

Appendix: Statistical Tables

TABLE 1.—*Industrial injury rates for 521 fertilizer establishments, classified by kind of plant and by extent of disability, 1946*

Kind of plant [1]	Number of establishments	Number of employees	Employee-hours worked (in thousands)	Number of disabling injuries				Frequency rates of [2]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary-total disabilities	Average number of days lost or charged per injury		Severity rate [4]
					Death or permanent-total disability [3]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
Total	521	27,460	55,236	1,970	(3) 18	50	1,902	35.7	0.3	0.9	34.5	99	15	3.5
Superphosphate plants	18	1,015	2,101	84	--------	1	83	40.0	--------	.5	39.5	19	15	.7
Dry-mixing plants	336	9,709	17,762	566	(1) 5	19	542	31.9	.3	1.1	30.5	108	16	3.4
Superphosphate and dry-mixing plants	57	4,039	8,316	311	(1) 4	8	299	37.4	.5	1.0	35.9	121	15	4.5
Integrated acid, superphosphate, and dry-mixing plants	78	9,649	20,665	842	(1) 3	17	822	40.7	.1	.8	39.8	58	15	2.4

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

TABLE 2.—*Industrial injury rates for 521 fertilizer establishments, classified by geographic area, State, kind of plant, and extent of disability, 1946*

Kind of plant by geographic area and State [1]	Number of establishments	Number of employees	Employee-hours worked (in thousands)	Number of disabling injuries				Frequency rates of [2]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary-total disabilities	Average number of days lost or charged per injury		Severity rate [4]
					Death or permanent-total disability [3]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
United States: Total	521	27,460	55,236	1,970	(3) 18	50	1,902	35.7	0.3	0.9	34.5	99	15	3.5
New England: Total	23	758	1,422	111	--------	3	108	78.0	--------	2.1	75.9	48	19	3.7
Middle Atlantic: Total	47	1,896	3,939	207	7	2	198	52.5	1.8	.5	50.2	232	16	12.2
Integrated acid, superphosphate, and dry-mixing plants	3	748	1,482	79	1	--------	78	53.3	.7	--------	52.6	90	14	4.8
New Jersey: Total	15	967	1,977	104	1	2	101	52.6	.5	1.0	51.1	98	13	5.2
Pennsylvania: Total	19	567	1,220	60	6	--------	54	49.2	4.9	--------	44.3	619	21	30.4
East North Central: Total	49	3,520	7,624	260	--------	6	254	34.1	--------	.8	33.3	43	14	1.5
Dry-mixing plants	19	835	1,817	56	--------	1	55	30.8	--------	.6	30.2	20	15	.6
Superphosphate and dry-mixing plants	12	1,105	2,406	78	--------	3	75	32.4	--------	1.2	31.2	70	13	2.3
Integrated acid, superphosphate, and dry-mixing plants	12	1,324	2,800	96	--------	2	94	34.3	--------	.7	33.6	44	14	1.5
Illinois: Total	10	1,110	2,280	79	--------	1	78	34.6	--------	.4	34.2	44	13	1.5
Indiana: Total	8	438	957	32	--------	1	31	33.4	--------	1.0	32.4	88	14	3.0
Ohio: Total	24	1,687	3,744	119	--------	4	115	31.8	--------	1.1	30.7	37	13	1.2
Superphosphate and dry-mixing plants	6	514	1,158	30	--------	2	28	25.9	--------	1.7	24.2	85	16	2.2
Integrated acid, superphosphate, and dry-mixing plants	7	765	1,645	67	--------	1	66	40.7	--------	.6	40.1	19	12	.8

See footnotes at end of table.

TABLE 2.—*Industrial injury rates for 521 fertilizer establishments, classified by geographic area, State, kind of plant, and extent of disability, 1946*—Continued

Kind of plant by geographic area and State [1]	Number of establishments	Number of employees	Employee-hours worked (in thousands)	Number of disabling injuries				Frequency rates of [3]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary-total disabilities	Average number of days lost or charged per injury		Severity rate [4]
					Death or permanent-total disability [2]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
South Atlantic: Total	288	15,133	30,516	952	(3) 9	29	914	31.2	0.3	1.0	29.9	109	16	3.4
Dry-mixing plants	195	5,728	10,431	278	(1) 4	11	263	26.7	.4	1.1	25.2	155	15	4.1
Superphosphate and dry-mixing plants	23	1,280	2,639	71	(1) 3	2	66	26.9	1.1	.8	25.0	295	22	7.9
Integrated acid, superphosphate, and dry-mixing plants	46	5,427	11,787	488	(1) 1	12	475	41.4	.1	1.0	40.3	51	15	2.1
Florida: Total	38	2,270	4,716	186	2	2	182	39.4	.4	.4	38.6	87	11	3.4
Dry-mixing plants	28	1,173	2,369	85		1	84	35.9		.4	35.5	14	11	.5
Integrated acid, superphosphate, and dry-mixing plants	4	460	1,029	53		1	52	51.5		1.0	50.5	42	8	2.2
Georgia: Total	80	3,172	6,245	208	(1) 1	4	203	33.3	.2	.6	32.5	56	14	1.9
Dry-mixing plants	48	955	1,517	27		1	26	17.8		.7	17.1	23	12	.4
Superphosphate and dry-mixing plants	11	728	1,510	50	(1) 1	1	48	33.1	.7	.7	31.7	164	21	5.4
Integrated acid, superphosphate, and dry-mixing plants	14	1,223	2,671	112		2	110	41.9		.7	41.2	24	12	1.0
Maryland: Total	21	1,517	3,188	111	(1) 1	3	107	34.8	.3	.9	33.6	132	22	4.6
Dry-mixing plants	16	582	1,165	32		3	29	27.5		2.6	24.9	220	25	6.0
Integrated acid, superphosphate, and dry-mixing plants	4	841	1,804	76	(1) 1		75	42.1	.6		41.5	101	22	4.2
North Carolina: Total	55	2,438	4,608	116	1	8	107	25.2	.2	1.7	23.3	115	14	2.9
Dry-mixing plants	40	1,316	2,338	52	1	4	47	22.2	.4	1.7	20.1	204	15	4.5
Integrated acid, superphosphate, and dry-mixing plants	9	893	1,779	52		4	48	29.2		2.2	27.0	48	12	1.4
South Carolina: Total	50	2,088	4,037	152	1	2	149	37.6	.2	.5	36.9	63	17	2.4
Dry-mixing plants	36	802	1,209	30		1	29	24.8		.8	24.0	29	13	.7
Integrated acid, superphosphate, and dry-mixing plants	8	1,019	2,365	104		1	103	44.0		.4	43.6	22	16	1.0
Virginia: Total	37	3,536	7,515	170	(1) 3	10	157	22.6	.4	1.3	20.9	226	19	5.1
Dry-mixing plants	21	810	1,680	44	(1) 3	1	40	26.2	1.8	.6	23.8	517	19	13.5
Integrated acid, superphosphate, and dry-mixing plants	7	991	2,139	91		4	87	42.5		1.9	40.6	81	20	3.5
East South Central: Total	56	3,707	6,651	246	2	6	238	37.0	.3	.9	35.8	85	13	3.1
Dry-mixing plants	29	1,160	1,768	71		2	69	40.2		1.1	39.1	50	15	2.0
Superphosphate and dry-mixing plants	12	1,073	2,051	89	1	1	87	43.4	.5	.5	42.4	83	10	3.6
Integrated acid, superphosphate, and dry-mixing plants	9	1,022	2,046	58	1	1	56	28.4	.5	.5	27.4	150	16	4.2
Alabama: Total	35	1,483	2,502	80	1	2	77	32.0	.4	.8	30.8	117	16	3.7
Tennessee: Total	11	1,596	2,948	124	1	1	122	42.1	.3	.3	41.5	64	11	2.7
Superphosphate and dry mixing plants	4	639	1,245	62			62	49.8			49.8	9	9	.5
West South Central: Total	27	1,502	3,011	97		2	95	32.2		.7	31.5	37	15	1.2
Integrated acid, superphosphate, and dry-mixing plants	4	601	1,301	43		2	41	33.0		1.5	31.5	63	15	2.1
Louisiana: Total	9	741	1,540	50		2	48	32.5		1.3	31.2	56	15	1.8
Integrated acid, superphosphate, and dry-mixing plants	3	499	1,097	43		2	41	39.2		1.8	37.4	63	15	2.5
Pacific: Total	24	686	1,436	67		2	65	46.7		1.4	45.3	33	18	1.6
Dry-mixing plants	22	568	1,185	46		2	44	38.8		1.7	37.1	43	21	1.7
California: Total	19	641	1,357	61		2	59	45.0		1.5	43.5	35	18	1.6
Dry-mixing plants	17	523	1,106	40		2	38	36.2		1.8	34.4	46	21	1.7

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

TABLE 3.—*Industrial injury rates for 521 fertilizer establishments, classified by size of plant and by extent of disability, 1946*

Size of plant	Number of establishments	Number of employees	Employee-hours worked (thousands)	Number of disabling injuries				Frequency rates of[2]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary-total disabilities	Average number of days lost or charged per injury		Severity rate[3]
					Death or permanent-total disability[1]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
Total	521	27,460	55,236	1,970	(3) 18	50	1,902	35.7	0.3	0.9	34.5	99.	15	3.5
Less than 25 employees	226	3,006	4,922	167	1	2	164	33.9	.2	.4	33.3	70	15	2.4
25 to 49 employees	119	4,248	8,171	249	(1) 3	11	235	30.5	.4	1.3	28.8	128	16	3.9
50 to 99 employees	109	7,490	15,602	577	5	19	553	37.0	.3	1.2	35.5	99	16	3.7
100 to 249 employees	56	7,907	16,673	654	(1) 1	11	642	39.2	.1	.7	38.4	50	14	2.0
250 employees and over	11	4,809	9,868	323	(1) 8	7	308	32.7	.8	.7	31.2	193	17	6.3

[1] Figures in parentheses indicate the number of permanent-total disability cases included.
[2] The frequency rate is the average number of industrial injuries for each million employee-hours worked.
[3] The severity rate is the average number of days lost for each thousand employee-hours worked.

TABLE 4.—*Industrial injury rates for 521 fertilizer establishments, classified by type of safety program and by extent of disability, 1946*

Type of safety program[1]	Number of establishments	Number of employees	Employee-hours worked (thousands)	Number of disabling injuries				Frequency rates of[3]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary-total disabilities	Average number of days lost or charged per injury		Severity rate[4]
					Death or permanent-total disability[2]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
Total	521	27,460	55,236	1,970	(3) 18	50	1,902	35.7	0.3	0.9	34.5	99	15	3.5
With full-time safety engineer	14	2,306	5,070	88	1	4	83	17.4	.2	.8	16.4	168	17	2.9
With safety committee	12	2,127	4,624	80	1	4	75	17.3	.2	.9	16.2	182	15	3.1
Of supervisory employees	8	615	1,374	38	1	----	37	27.7	.7	----	27.0	171	14	4.7
Of supervisory and nonsupervisory employees	4	1,512	3,250	42	----	4	38	12.9	----	1.2	11.7	192	16	2.5
Without full-time safety engineer	472	21,907	43,796	1,576	(2) 12	44	1,520	36.0	.3	1.0	34.7	92	16	3.3
With safety committee	157	11,545	24,040	914	(2) 8	24	882	38.0	.3	1.0	36.7	94	16	3.6
Of supervisory employees	47	3,589	7,647	307	(2) 4	8	295	40.0	.5	1.0	38.5	127	18	5.1
Of supervisory and nonsupervisory employees	79	6,717	13,679	491	4	13	474	35.9	.3	1.0	34.6	90	15	3.2
Without safety committee	310	10,251	19,548	655	(1) 4	20	631	33.5	.2	1.0	32.3	91	17	3.0

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

TABLE 5—*Industrial injury rates for 521 fertilizer establishments, classified by department and by extent of disability, 1946*

Department [1]	Number of units reporting	Number of employees	Employee-hours worked (thousands)	Number of disabling injuries				Frequency rates of [3]—				Severity		
				Total	Resulting in—			All disabling injuries	Death and permanent-total disabilities	Permanent-partial disabilities	Temporary total disabilities	Average number of days lost or charged per injury		Severity rate [4]
					Death or permanent-total disability [2]	Permanent-partial disability	Temporary-total disability					All disabling injuries	Temporary-total disabilities	
Total	[5] 521	27,460	55,236	1,970	(3) 18	50	1,902	35.7	0.3	0.9	34.5	99	15	3.5
Sulphuric-acid department	44	456	1,093	42	--------	--------	42	38.4	--------	------	38.4	17	17	.7
Superphosphate department	79	1,224	2,739	144	--------	3	141	52.6	--------	1.1	51.5	60	15	3.1
Dry-mixing department	388	11,482	21,978	879	(1) 7	23	849	40.0	.3	1.0	38.7	91	16	3.6
Administrative and clerical	285	2,094	4,260	12	(1) 1	2	9	2.8	.2	.5	2.1	--------	--------	2.5
Maintenance department	147	1,108	2,469	126	--------	5	121	51.0	--------	2.0	49.0	58	19	3.0
Watchmen	128	319	721	6	--------	1	5	8.3	--------	1.4	6.9	--------	--------	.8
Other departments	83	952	1,931	67	1	--------	66	34.7	.5	--------	34.2	106	17	3.7

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

TABLE 6.—*Plant rules relating to the use of personal protective equipment in 521 fertilizer manufacturing plants, 1946*

Type of equipment	Plants requiring use in certain operations		Plants having no requirements		Type of equipment	Plants requiring use in certain operations		Plants having no requirements	
	Number	Percent of total	Number	Percent of total		Number	Percent of total	Number	Percent of total
Any type	330	63.3	191	36.7	Aprons	30	5.8	491	94.2
Goggles	273	52.4	248	47.6	Safety shoes	14	2.7	507	97.3
Respirators	250	48.0	271	52.0	Hoods	2	.4	519	99.6
Gloves	108	20.7	413	79.3	Rubber trousers	1	.2	520	99.8
Gas masks	37	7.1	484	92.9	Finger guards	1	.2	520	99.8
Face shields	34	6.5	487	93.5	Coveralls	1	.2	520	99.8

TABLE 7.—*Disabling and medical injuries in 185 fertilizer establishments, classified by part of body injured and by extent of disability, 1946*

Part of body injured	Total number of disabling and medical injuries[1]		Number of disabling injuries					Average number of days lost per temporary-total disability	Number of medical injuries		Average number of medical injuries per disabling injury
			Total		Resulting in—						
	Number	Percent[2]	Number	Percent[2]	Death or permanent-total disability[3]	Permanent-partial disability	Temporary-total disability		Number	Percent[2]	
Total	2,532	100.0	1,238	100.0	(2) 8	31	1,199	15	1,294	100.0	1.0
Head	585	23.2	172	14.1	(1) 4	2	166	8	413	32.1	2.4
Eye(s)	424	16.9	110	9.1		2	108	7	314	24.4	2.9
Brain or skull	48	1.9	20	1.6	(1) 3		17	12	28	2.2	1.4
Other	113	4.5	42	3.4	1		41	10	71	5.5	1.7
Trunk	538	21.4	326	26.6	3	3	320	16	212	16.5	.7
Chest (lungs), ribs, etc	98	3.9	50	4.1	3		47	10	48	3.7	1.0
Back	231	9.1	151	12.3		2	149	14	80	6.3	.5
Abdomen	67	2.7	48	3.9			48	30	19	1.5	.4
Hip(s) or pelvis	37	1.5	23	1.9		1	22	14	14	1.1	.6
Shoulder	58	2.3	28	2.3			28	16	30	2.3	1.1
Other	47	1.9	26	2.1			26	13	21	1.6	.8
Upper extremities	658	26.2	277	22.6		22	255	14	381	29.6	1.4
Arm(s)	103	4.1	58	4.7		1	57	16	45	3.5	.8
Hand(s) (including wrist)	186	7.4	81	6.6		3	78	14	105	8.2	1.3
Finger(s) and/or thumb(s)	369	14.7	138	11.3		18	120	14	231	17.9	1.7
Lower extremities	684	27.3	421	34.4	(1) 1	3	417	17	263	20.5	.6
Leg(s)	228	9.1	135	11.0	(1) 1		134	20	93	7.2	.7
Foot (including ankle) or feet	371	14.8	234	19.2		2	232	16	137	10.7	.6
Toe(s)	85	3.4	52	4.2		1	51	13	33	2.6	.6
Body—General	45	1.8	28	2.3		1	27	16	17	1.3	.6
Unclassified; insufficient data	22		14				14		8		

[1] A disabling injury is one which results in death or permanent impairment, or causes an inability to work extending beyond the day of injury. A medical injury is a nondisabling injury requiring treatment by a physician or surgeon.

[2] Percents are based on classified cases only.

[3] Figures in parentheses indicate the number of permanent-total disability cases included.

TABLE 8.— *Disabling and medical injuries in 185 fertilizer establishments, classified by nature of injury and by extent of disability, 1946*

Nature of injury	Total number of disabling and medical injuries[1]		Number of disabling injuries					Average number of days lost per temporary-total disability	Number of medical injuries		Average number of medical injuries per disabling injury
			Total		Resulting in—						
	Number	Percent[2]	Number	Percent[2]	Death or permanent-total disability[3]	Permanent-partial disability	Temporary-total disability		Number	Percent[2]	
Total	2,532	100.0	1,238	100.0	(2) 8	31	1,199	15	1,294	100.0	1.0
Amputations	18	.7	18	1.5	(1) 1	17					
Bruises, contusions	828	33.0	457	37.6	(1) 3	1	453	12	371	29.0	.8
Without infection	807	32.2	445	36.6	(1) 3		442	12	362	28.3	.8
With infection	21	.8	12	1.0		1	11	18	9	.7	.8
Burns, scalds (except chemical burns)	84	3.4	44	3.6			44	16	40	3.1	.9
Chemical burns	248	9.9	96	7.9		2	94	11	152	11.9	1.6
Without infection	238	9.5	93	7.7		2	91	11	145	11.4	1.6
With infection	10	.4	3	.2			3	8	7	.5	2.3
Cuts, lacerations, punctures	489	19.6	182	14.9	1	3	178	13	307	23.9	1.7
Without infection	454	18.2	160	13.1	1	3	156	13	294	22.9	1.8
With infection	35	1.4	22	1.8			22	13	13	1.0	.6
Foreign bodies in eyes, ears	191	7.6	27	2.2			27	6	164	12.8	6.1
Fractures	122	4.9	100	8.2	1	7	92	41	22	1.7	.2
Hernias	22	.9	22	1.8			22	50			
Industrial diseases	37	1.5	16	1.3			16	11	21	1.6	1.3
Strains, sprains	434	17.4	241	19.8			241	12	193	15.1	.8
Other	27	1.1	15	1.2	2	1	12	11	12	.9	.8
Unclassified; insufficient data	32		20				20		12		

[1] A disabling injury is one which results in death or permanent impairment, or causes an inability to work extending beyond the day of injury. A medical injury is a nondisabling injury requiring treatment by a physician or surgeon.

[2] Percents are based on classified cases only.

[3] Figures in parentheses indicate the number of permanent-total disability cases included.

TABLE 9.—*Disabling and medical injuries in 165 fertilizer establishments, classified by nature of injury and by department, 1946*

Nature of injury	Total number of disabling and medical injuries [1]		Department											
			Sulphuric acid department		Superphosphate department		Dry mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]
Total	2,395	100.0	134	100.0	251	100.0	1,104	100.0	498	100.0	169	100.0	239	100.0
Amputations	16	.7	1	.7	4	1.6	4	.4	5	1.0	1	.6	1	.4
Bruises, contusions	780	33.0	21	15.7	65	26.0	425	39.2	133	26.9	47	28.0	89	37.4
Burns, scalds (except chemical)	79	3.3	8	6.0	11	4.4	15	1.4	36	7.3	3	1.8	6	2.5
Chemical burns	242	10.2	45	33.7	57	22.8	81	7.5	32	6.5	14	8.3	13	5.5
Cuts, lacerations, punctures	464	19.6	11	8.2	51	20.4	218	20.2	97	19.6	34	20.2	53	22.4
Foreign bodies in eyes, ears	177	7.5	9	6.7	10	4.0	54	5.0	79	16.0	13	7.7	12	5.1
Fractures	112	4.7	9	6.7	5	2.0	44	4.1	33	6.7	8	4.8	13	5.5
Hernias	18	.8	1	.7	2	.8	5	.5	6	1.2	1	.6	3	1.3
Industrial diseases	35	1.5	3	2.2	8	3.2	13	1.2	2	.4	4	2.4	5	2.1
Strains, sprains	420	17.8	24	17.9	34	13.6	212	19.6	69	14.0	42	25.0	39	16.5
Other	21	.9	2	1.5	3	1.2	10	.9	2	.4	1	.6	3	1.3
Unclassified, insufficient data	31				1		23		4		1		2	

[1] A disabling injury is one which results in death or permanent impairment, or causes an inability to work extending beyond the day of injury. A medical injury is a nondisabling injury requiring treatment by a physician or surgeon.

[2] Percents are based on classified cases only.

TABLE 10.—*Disabling and medical injuries in 185 fertilizer establishments, classified by part of body injured and by nature of injury, 1946*

Part of body injured	Total number of disabling and medical injuries [1]	Nature of injury											
		Amputations	Bruises, contusions	Burns, scalds (except chemical)	Chemical burns	Cuts, lacerations, punctures	Foreign body in eyes, ears	Fractures	Hernias	Industrial diseases	Strains, sprains	Other	Unclassified; insufficient data
Total	2,532	18	828	84	248	489	191	122	22	37	434	27	32
Head	585		54	38	194	82	191	2		7	8	8	1
Eye(s)	424		15	28	178	8	191			1	1	1	1
Brain or skull	48		16			31		1					
Other	113		23	10	16	43		1		6	7	7	
Trunk	538		179	5	4	7		20	22	18	268	12	3
Chest (lungs), ribs, etc.	98		50			2		9		16	10	11	
Back	231		39	1		1		5		1	182	1	1
Abdomen	67		18	1	3				22		22		1
Hip(s) or pelvis	37		22			1		2			11		1
Shoulder	58		19	2		1		4			32		
Other	47		31	1	1	2				1	11		
Upper extremities	658	15	250	21	25	244		43		5	50		5
Arm(s)	103	1	34	8	11	21		8		4	15		1
Hand(s) (including wrist)	186		60	9	12	63		9		1	30		2
Finger(s) and/or thumb(s)	369	14	156	4	2	160		26			5		2
Lower extremities	684	3	322	14	22	151		56		1	106	2	7
Leg(s)	228	1	117	8	11	46		10		1	30	2	2
Foot (including ankle) or feet	371		156	6	11	94		23			76		5
Toe(s)	85	2	49			11		23					
Body—General	45		21	6	2	5		1		5		5	
Unclassified; insufficient data	22		2		1					1	2		16

[1] A disabling injury is one which results in death or permanent impairment, or causes an inability to work extending beyond the day of injury. A medical injury is a nondisabling injury requiring treatment by a physician or surgeon.

TABLE 11.—*Disabling and medical injuries in 165 fertilizer establishments, classified by part of body injured and by department, 1946*

Part of body injured	Total number of disabling and medical injuries [1]		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [2]	Number	Percent	Number	Percent	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]	Number	Percent [2]
Total	2,395	100.0	134	100.0	251	100.0	1,104	100.0	498	100.0	169	100.0	239	100.0
Head	554	23.3	44	32.9	70	27.9	199	18.3	160	32.3	40	23.8	41	17.3
Eye(s)	404	17.0	39	29.2	50	19.9	137	12.6	131	26.5	25	14.8	22	9.3
Brain or skull	45	1.9	1	.7	4	1.6	22	2.0	8	1.6	5	3.0	5	2.1
Other	105	4.4	4	3.0	16	6.4	40	3.7	21	4.2	10	6.0	14	5.9
Trunk	503	21.2	33	24.6	51	20.3	226	20.8	85	17.2	53	31.6	55	23.2
Chest (lungs), ribs, etc	88	3.7	10	7.5	11	4.4	31	2.8	13	2.6	11	6.5	12	5.1
Back	220	9.3	13	9.7	17	6.7	111	10.2	32	6.6	25	14.9	22	9.2
Abdomen	59	2.5	3	2.2	5	2.0	27	2.5	11	2.2	6	3.6	7	3.0
Hip(s) or pelvis	36	1.5	3	2.2	7	2.8	17	1.6	3	.6	3	1.8	3	1.3
Shoulder	55	2.3	2	1.5	7	2.8	23	2.1	10	2.0	4	2.4	9	3.8
Other	45	1.9	2	1.5	4	1.6	17	1.6	16	3.2	4	2.4	2	.8
Upper extremities	622	26.2	31	23.1	66	26.3	283	26.0	135	27.3	43	25.6	64	27.0
Arm(s)	99	4.2	11	8.2	10	4.0	40	3.7	17	3.4	12	7.1	9	3.8
Hand(s) (including wrist)	174	7.3	6	4.5	28	11.1	76	7.0	38	7.7	13	7.7	13	5.5
Finger(s) and/or thumb(s)	349	14.7	14	10.4	28	11.2	167	15.3	80	16.2	18	10.8	42	17.7
Lower extremities	650	27.4	23	17.2	56	22.3	362	33.2	104	21.0	32	19.0	73	30.8
Leg(s)	219	9.2	7	5.2	19	7.6	119	10.9	32	6.5	11	6.5	31	13.0
Foot (including ankle) or feet	353	14.9	14	10.5	29	11.5	206	18.9	58	11.7	16	9.5	30	12.7
Toe(s)	78	3.3	2	1.5	8	3.2	37	3.4	14	2.8	5	3.0	12	5.1
Body—General	45	1.9	3	2.2	8	3.2	19	1.7	11	2.2	------	------	4	1.7
Unclassified; insufficient data	21	------	------	------	------	------	15	------	3	------	1	------	2	------

[1] A disabling injury is one which results in death or permanent impairment, or causes an inability to work extending beyond the day of injury. A medical injury is a nondisabling injury requiring treatment by a physician or surgeon.

[2] Percents are based on classified cases only.

TABLE 12.—*Agencies involved in injury-producing accidents in 165 fertilizer plants, classified by operating department, 1946*

Agency	Total number of accidents		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2,395	100.0	134	100.0	251	100.0	1,104	100.0	498	100.0	169	100.0	239	100.0
Machines	157	6.7	7	5.3	23	9.3	67	6.2	41	8.3	11	6.6	8	3.4
Mixers	41	1.7	1	.8	15	6.1	21	1.9	2	.4	2	1.2	------	------
Other	116	5.0	6	4.5	8	3.2	46	4.3	39	7.9	9	5.4	8	3.4
Hoisting apparatus	43	1.8	3	2.3	6	2.4	14	1.3	18	3.7	1	.6	1	.4
Conveyors	113	4.8	1	.8	17	6.9	64	5.9	13	2.6	5	3.0	13	5.5
Belt type	49	2.1	1	.8	7	2.8	30	2.8	2	.4	2	1.2	7	3.0
Bucket type	49	2.1	------	------	8	3.3	24	2.2	10	2.0	2	1.2	5	2.1
Other	15	.6	------	------	2	.8	10	.9	1	.2	1	.6	1	.4
Boilers and tanks	66	2.8	19	14.4	10	4.0	11	1.0	14	2.8	4	2.4	8	3.4
Vehicles	481	20.4	5	3.8	34	13.8	316	29.1	30	6.1	28	16.9	68	28.5
Motor trucks	22	.9	------	------	------	------	14	1.3	3	.6	4	2.4	1	.4
Tractors, payloaders, etc	143	6.1	------	------	11	4.5	77	7.1	14	2.9	6	3.6	35	14.7
Hand trucks	217	9.2	2	1.4	16	6.5	163	15.0	7	1.4	9	5.5	20	8.4
Wheelbarrows	26	1.1	1	.8	3	1.2	20	1.8	1	.2	------	------	1	.4
Railroad cars	61	2.6	1	.8	3	1.2	38	3.5	5	1.0	7	4.2	7	2.9
Other	12	.5	1	.8	1	.4	4	.4	------	------	2	1.2	4	1.7
Electrical apparatus	28	1.2	1	.8	2	.8	6	.6	16	3.2	1	.6	2	.8
Hand tools	226	9.6	16	12.1	17	6.9	54	5.0	102	20.7	12	7.2	25	10.5
Bars (crowbars, punch bars, etc.)	36	1.5	4	3.0	2	.8	12	1.1	10	2.0	1	.6	7	2.9
Hammers	60	2.5	4	3.0	7	2.8	13	1.2	27	5.5	2	1.2	7	2.9
Torches (welding and burning)	23	1.0	1	.8	1	.4	------	------	18	3.7	2	1.2	1	.4
Other	107	4.6	7	5.3	7	2.9	29	2.7	47	9.5	7	4.2	10	4.3

[1] Percents are based on classified cases only.

TABLE 12.—*Agencies involved in injury-producing accidents in 165 fertilizer plants, classified by operating department, 1946*—Continued

Agency	Total number of accidents		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Chemicals	165	7.0	18	13.6	39	15.8	79	7.3	7	1.4	11	6.6	11	4.6
Acids	41	1.7	11	8.3	15	6.1	10	.9	3	.6	2	1.2		
Fertilizer	24	1.0			2	.8	19	1.8	1	.2			2	.8
Other	100	4.3	7	5.3	22	8.9	50	4.6	3	.6	9	5.4	9	3.8
Working surfaces	307	13.0	15	11.4	24	9.7	154	14.2	54	11.0	21	12.7	39	16.4
Floors	159	6.8	8	6.1	14	5.7	86	7.9	25	5.2	7	4.2	19	8.0
Platforms, scaffolds	46	1.9	4	3.0	4	1.6	14	1.3	16	3.2	3	1.8	5	2.1
Ramps (gangplanks)	54	2.3	1	.8	1	.4	39	3.6	1	.2	3	1.8	9	3.8
Other	48	2.0	2	1.5	5	2.0	15	1.4	12	2.4	8	4.9	6	2.5
Containers	151	6.4	3	2.3	8	3.2	100	9.2	5	1.0	26	15.7	9	3.8
Bags	123	5.2	1	.8	5	2.0	95	8.7	2	.4	13	7.8	7	3.0
Other	28	1.2	2	1.5	3	1.2	5	.5	3	.6	13	7.9	2	.8
Miscellaneous	623	26.3	44	33.2	67	27.2	219	20.2	193	39.2	46	27.7	54	22.7
Bins, pits	39	1.7	2	1.5	13	5.3	14	1.3	6	1.2	1	.6	3	1.3
Cables, ropes, wires, chains	27	1.1			2	.8	10	.9	8	1.6	1	.6	6	2.5
Foreign bodies (eye injuries)	101	4.3	8	6.1	7	2.8	27	2.5	44	9.0	8	4.8	7	2.9
Ladders	27	1.1	3	2.3			9	.8	10	2.0	2	1.2	3	1.3
Lumber stock	93	3.9	2	1.5	8	3.2	26	2.4	34	6.9	10	6.0	13	5.5
Metal parts	95	4.0	11	8.2	8	3.2	24	2.2	37	7.5	8	4.8	7	2.9
Piles of material	47	2.0	2	1.5	11	4.5	28	2.6			2	1.2	4	1.7
Stairs	23	1.0	1	.8	4	1.6	11	1.0	2	.4	3	1.8	2	.8
Other	171	7.2	15	11.3	14	5.8	70	6.5	52	10.6	11	6.7	9	3.8
Unclassified; insufficient data	35		2		4		20		5		3		1	

TABLE 13.—*Types of accidents resulting in injuries in 165 fertilizer plants, classified by operating department, 1946*

Accident type	Total number of accidents		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2,395	100.0	134	100.0	251	100.0	1,104	100.0	498	100.0	169	100.0	239	100.0
Striking against	289	12.2	8	6.0	39	15.8	141	12.9	52	10.5	18	10.8	31	13.1
Struck by	886	37.2	28	21.1	59	23.9	416	38.0	234	47.1	58	34.6	91	38.3
Caught in, on, or between	279	11.7	10	7.5	27	10.9	157	14.3	36	7.2	14	8.4	35	14.8
Falls—Total	232	9.8	12	9.0	19	7.7	105	9.6	51	10.3	20	12.0	25	10.5
On same level	109	4.6	4	3.0	9	3.6	68	6.2	8	1.6	10	6.0	10	4.2
To different level	123	5.2	8	6.0	10	4.1	37	3.4	43	8.7	10	6.0	15	6.3
Slips (not falls)	57	2.4	5	3.8	6	2.4	24	2.2	12	2.4	5	3.0	5	2.1
Contact with extreme temperatures	36	1.5	2	1.5	4	1.6	9	.8	16	3.2	1	.6	4	1.7
Inhalation, absorption, ingestion	308	13.0	53	39.8	74	30.0	106	9.7	32	6.4	22	13.2	21	8.9
Overexertion	252	10.6	15	11.3	17	6.9	129	11.8	42	8.5	28	16.8	21	8.9
Other	37	1.6			2	.8	8	.7	22	4.4	1	.6	4	1.7
Unclassified; insufficient data	19		1		4		9		1		2		2	

[1] Percents are based on classified cases only.

TABLE 14.—*Agencies and unsafe working conditions involved in injury-producing accidents in 153 fertilizer plants, 1946*

Agency	Total number of accidents	Unsafe working conditions																		
		Improperly guarded agencies	Defective agencies						Hazardous arrangements or procedures						Lack of personal safety equipment			Other unsafe conditions	Unclassified; insufficient data
			Total	Rough	Slippery	Sharp-edged	Aged, worn, cracked, etc.	Other	Total	Unsafely stored or piled	Lack of clear walkways or working surfaces	Unsafe planning or lay-out of traffic or process operations	Lack of proper lifting equipment	Other	Total	Goggles	Other		
Total	2,387	194	444	27	114	67	115	121	437	91	63	115	139	29	126	109	17	12	1,174
Machines	160	61	17	1	1		4	11	11	1		7	3		15	14	1		56
Mixers	42	11	6	1			3	2	5			5			6	6			14
Other	118	50	11		1		1	9	6	1		2	3		9	8	1		42
Hoisting apparatus	49	1	14			1	10	3	10			5	3	2					24
Conveyors	111	52	19			5	4	10	5	2			2	1	4	3	1		31
Belt type	47	28	6			1	1	4							2	2			11
Bucket type	48	19	9			4		5	2				1	1	2	1	1		16
Other	16	5	4				3	1	3	2			1						4
Boilers and tanks	63	3	22			1	10	11	12			6	3	3	8	8			18
Vehicles	466	9	62	4	7	11	8	32	63	5	2	43	7	6	4	2	2	3	325
Motor trucks	19		3		2	1			3	2		1							13
Tractors, payloaders, etc.	154	4	29	1		1	3	24	22			16	4	2	2	2		3	94
Hand trucks	200		11	1		3	2	5	26	3		19	1	3	1		1		162
Wheelbarrows	22		1					1	2			2							19
Railroad cars	58	3	17	2	5	6	3	1	8		2	5		1	1		1		29
Other	13	2	1					1	2				2						8
Electrical apparatus	27	7	8				1	7	4				4						8
Hand tools	218	7	26	1			20	5	23	4		19			13	13		1	148
Bars (crowbars, punch bars, etc.)	33								5	1		4			1	1			27
Hammers	57		10				9	1	6	1		5			2	2			39
Torches (welding and burning)	25	1	1					1	2			2			5	5		1	15
Other	103	6	15	1			11	3	10	2		8			5	5			67
Chemicals	162								9			9			62	51	11	5	86
Acid	39								4			4			9	8	1		26
Fertilizer	22								2			2			15	14	1		5
Other	101								3			3			38	29	9	5	55
Working surfaces	314	28	179	12	94	24	29	20	67	1	60	1	1	4					40
Floors	168	6	96	8	60	17	11		49		47			2					17
Platforms, scaffolds	44	11	26	1	5	2	11	7	2		2								5
Ramps (gangplanks)	51	4	36	1	17	2	3	13	4	1		1	1	1					7
Other	51	7	21	2	12	3	4		12		11			1					11
Containers	154		14	3		2	8	1	88	11			75	2	2	1	1		50
Bags	127		6			1	4	1	83	10			73		2	1	1		36
Other	27		8	3		1	4		5	1			2	2					14
Miscellaneous	632	24	83	6	12	23	21	21	144	66	1	25	41	11	18	17	1	3	360
Bins, pits	39	2	14		1	2	5	6	6			2	1	3	4	4		1	12
Cables, ropes, wires, chains	25		7			5	2		2			1		1					16
Foreign bodies (eye injuries)	106														7	7			99
Ladders	28	9	2					2	2	1		1							15
Lumber stock	91		13	2		8	1	2	27	16		1	9	1					51
Metal parts	97		6			3	2	1	31	10		1	20						60
Piles of material	51								39	34		5							12
Stairs	23		10		9			1	1		1								12
Other	172	13	31	4	2	5	9	11	36	5		14	11	6	7	6	1	2	83
Unclassified; insufficient data	31	2							1	1									28

TABLE 15.—*Unsafe working conditions involved in injury-producing accidents in 148 fertilizer plants, classified by operating department, 1946*

Unsafe working condition	Total number of accidents		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified: insufficient data	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2,254	100.0	132	100.0	244	100.0	1,021	100.0	474	100.0	153	100.0	230	100.0
Improperly guarded agencies	188	16.3	10	12.5	18	15.0	82	15.1	49	21.9	12	15.4	17	15.2
Defective agencies	417	36.0	28	34.9	43	35.8	193	35.6	77	34.3	28	35.9	48	42.8
Rough	26	2.2	1	1.3	3	2.5	15	2.8	2	.9	1	1.3	4	3.6
Slippery	106	9.2	6	7.4	6	5.0	67	12.3	8	3.6	7	9.0	12	10.7
Sharp-edged	63	5.4	3	3.8	9	7.5	31	5.7	7	3.1	5	6.4	8	7.1
Aged, worn, cracked, etc.	110	9.5	11	13.6	10	8.3	32	5.9	40	17.8	8	10.2	9	8.0
Other	112	9.7	7	8.8	15	12.5	48	8.9	20	8.9	7	9.0	15	13.4
Hazardous arrangements or procedures	416	36.0	27	33.8	41	34.2	199	36.8	73	32.6	33	42.3	43	38.4
Unsafely stored or piled materials, etc.	87	7.5	4	5.0	11	9.2	46	8.5	10	4.5	7	9.0	9	8.0
Lack of clear walkways or working surfaces	61	5.3	1	1.3	8	6.7	25	4.6	15	6.7	7	9.0	5	4.5
Unsafe planning or lay-out of traffic or process operations	106	9.2	12	14.9	14	11.6	42	7.7	18	8.0	4	5.1	16	14.3
Lack of proper lifting equipment	134	11.6	7	8.8	5	4.2	75	14.0	26	11.6	11	14.1	10	8.9
Other	28	2.4	3	3.8	3	2.5	11	2.0	4	1.8	4	5.1	3	2.7
Lack of personal safety equipment	126	10.9	15	18.8	17	14.2	63	11.6	23	10.3	4	5.1	4	3.6
Goggles	109	9.4	12	15.0	12	10.0	57	10.5	21	9.4	4	5.1	3	2.7
Other	17	1.5	3	3.8	5	4.2	6	1.1	2	.9	-------	-------	1	.9
Other unsafe conditions	9	.8	-------	-------	1	.8	5	.9	2	.9	1	1.3	-------	-------
Unclassified; insufficient data	1,098	-------	52	-------	124	-------	479	-------	250	-------	75	-------	118	-------

[1] Percents are based on classified cases only.

TABLE 16.—*Unsafe acts involved in injury-producing accidents in 160 fertilizer plants, classified by operating department*

Unsafe act	Total number of accidents		Department											
			Sulphuric acid department		Superphosphate department		Dry-mixing department		Maintenance department		Other departments		Unclassified; insufficient data	
	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]	Number	Percent [1]
Total	2,387	100.0	134	100.0	251	100.0	1,099	100.0	497	100.0	169	100.0	237	100.0
Operating without authority, failure to secure or warn	67	4.1	6	7.6	6	3.4	18	2.4	22	6.6	8	7.3	7	4.1
Operating or working at an unsafe speed	199	12.3	4	5.1	10	5.6	137	18.3	9	2.7	9	8.2	30	17.6
Driving or operating too rapidly, slowly, or carelessly	66	4.1	1	1.3	4	2.2	35	4.7	3	.9	4	3.7	19	11.1
Using hand trucks unsafely or carelessly	99	6.1	1	1.3	5	2.8	80	10.7	1	.3	4	3.6	8	4.7
Other	34	2.1	2	2.5	1	.6	22	2.9	5	1.5	1	.9	3	1.8
Using unsafe equipment or equipment unsafely	543	33.7	26	32.9	47	26.4	246	32.8	135	40.9	28	25.5	61	35.9
Unsafe use of equipment	150	9.4	10	12.6	19	10.6	38	5.1	65	19.8	8	7.2	10	5.9
Gripping objects insecurely	130	8.0	6	7.6	9	5.1	57	7.6	36	10.9	6	5.5	16	9.4
Taking wrong hold of objects	115	7.1	5	6.3	9	5.1	52	6.9	21	6.3	7	6.4	21	12.3
Pulling instead of pushing hand trucks	55	3.4	1	1.3	2	1.1	48	6.4	1	.3	-------	-------	3	1.8
Other	93	5.8	4	5.1	8	4.5	51	6.8	12	3.6	7	6.4	11	6.5
Unsafe loading, placing, mixing, etc.	59	3.6	5	6.3	6	3.4	21	2.8	15	4.5	5	4.5	7	4.1
Failure to use personal safety equipment	176	10.9	17	21.5	33	18.5	50	6.7	53	16.0	13	11.8	10	5.9
Goggles	142	8.8	13	16.4	27	15.1	37	5.0	50	15.1	11	10.0	4	2.4
Other	34	2.1	4	5.1	6	3.4	13	1.7	3	.9	2	1.8	6	3.5
Taking unsafe positions or postures	538	33.3	18	22.8	70	39.3	260	34.7	90	27.2	45	40.9	55	32.4
Exposure to falling or sliding objects	48	3.0	1	1.3	11	6.2	25	3.3	6	1.8	1	.9	4	2.4
Inattention to footing	306	19.0	9	11.3	36	20.2	159	21.3	47	14.3	26	23.7	29	17.1
Lifting incorrectly	80	4.9	4	5.1	8	4.5	30	4.0	17	5.1	13	11.8	8	4.7
Other	104	6.4	4	5.1	15	8.4	46	6.1	20	6.0	5	4.5	14	8.2
Working on moving or dangerous equipment	28	1.7	3	3.8	6	3.4	14	1.9	4	1.2	1	.9	-------	-------
Other	7	.4	-------	-------	-------	-------	3	.4	3	.9	1	.9	-------	-------
Unclassified; insufficient data	770	-------	55	-------	73	-------	350	-------	166	-------	59	-------	67	-------

[1] Percents are based on classified cases only.

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