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Safety in the Chemical Industry

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THERE exists no more fertile field for safety work than the chemical industry. While its accident record, so far as known, has not been conspicuously bad, there have occurred from time to time in various industries catastrophes of chemical origin, involving in the aggregate much loss of life and property damage. Many of these accidents were unquestionably due to the natural properties of the materials being handled or to hazards inherent in certain chemical processes—in other words, to conditions essentially peculiar to chemical work and likely to be met with in the chemical industry itself.

INHERENT ACCIDENT HAZARDS

It seems hardly necessary to point out that in the wide diversity of chemical processes there are encountered, in addition to the common industrial accident hazards, many dangerous materials such as acids, alkalies and other corrosive substances, as well as those which are by nature irritating, intoxicating, irrespirable or directly toxic. Hazardous conditions affecting the safety or health of employees may be due to the presence of vapors, gases or dusts or to the substance itself in solid, liquid or molten state. An acute fire hazard may be present or there may be danger from an explosion of dust clouds or of vapor or gases in admixture with air, or of the material itself either as a true explosive or when subject to rapid decomposition under confinement. Many of the newer chemical processes, moreover, necessitate the use of high electrical voltages or heavy currents, high temperatures or high pressures,

sometimes even exceeding 1000 pounds per square inch, and all these possess potential destructive power.

Contributing in no small way to the inherent hazards of the industry are other factors less obvious but equally difficult to control. The chemical industry is the youngest child of applied science and has not yet advanced beyond the stage of development to the point where standardization of method and process is entirely practicable. In fact, in many of its branches—for example, the dye industry—it is still in the experimental stages in which manufacture is peculiarly subject to sudden failures and to unexpected happenings. Indeed, the chemical engineer in designing new equipment or planning new processes is often seriously handicapped by absence of available information on the behavior of ingredients, products or even common structural materials under given process conditions and must depend to an unusual degree on his imagination and upon general deductions. The operating officials share to a great extent this same handicap. Under such conditions it is by no means surprising that serious injuries and even catastrophes take place. There is, besides, a natural dearth of men, both of the salaried and payroll class, experienced in chemical work. Of the latter class, it is often necessary to employ foreigners and a high rate of labor turnover caused by conditions not always within the employer's control militates against the creation of a safe establishment. All these factors add to the seriousness of the industry's accident prevention problem, although

it can be conjectured that some at least will be offset by the natural development which only time and experience can effect.

We have said that the chemical industry offers a fertile field for accident prevention work. This is not because its accident record has been conspicuously unsatisfactory but rather because conditions which are capable of causing accidents—using the term in its broadest sense—are particularly undesirable in a chemical plant. In such an establishment there are three factors of great economic importance, adverse variations in which are capable of seriously affecting not only the plant's operating efficiency but even the continuance of its existence as a successful commercial enterprise. Each of these factors is in turn adversely affected by accident occurrence. They are, briefly stated:

- (1) Conservation of materials.
- (2) Accuracy of chemical control.
- (3) Maintenance of equipment.

While many of the commoner chemical ingredients cost but a few cents per pound, others, as well as some of the chemical products manufactured from relatively cheap ingredients by a proc-

ess that is expensive to operate, have values reaching from a few dollars to \$50 per pound. Losses of such materials or products through explosion, fire, decomposition, leakage or escape of dust are not only commercially intolerable but are sometimes the direct cause of bodily injury or occupational disease and, through their influence on plant housekeeping and maintenance, are the indirect cause of accidents of other sorts. Conservation of materials is therefore of importance both from the commercial and from the humane standpoint.

Accuracy of chemical control demands knowledge, experience, intelligent supervision, high grade personnel, a trained and stable organization, good working conditions, suitable and reliable equipment, pure ingredients and many other requirements found only in an efficiently conducted establishment. Absence of accurate chemical control inevitably results in poor yields and occasionally in serious accidents which interrupt the routine of manufacture, curtail production, increase operating costs, and disturb the peace of mind of all employed. Even minor accidents may result in depreciation or damaging of plant equipment, in loss of materials

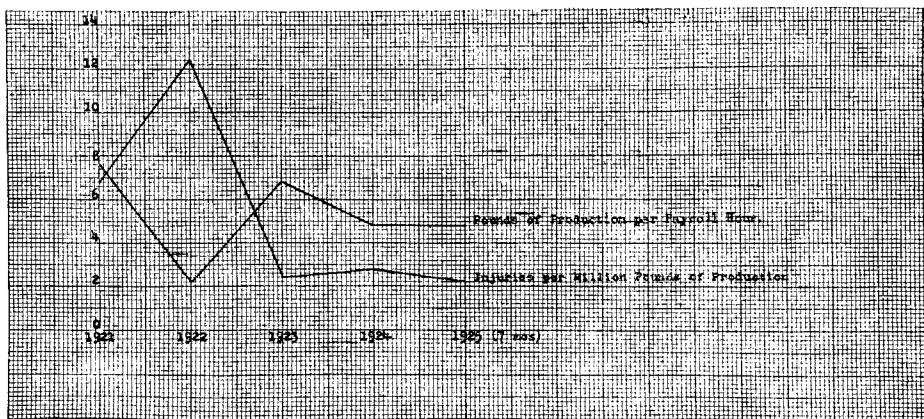


CHART I

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or product, or in physical injury and, sometimes, death. In the chemical industry accurate control is indispensable.

Maintenance of equipment is important from the commercial viewpoint because of the high first cost of chemical equipment, its rapid depreciation under even normal conditions of use and the bearing that its condition has on chemical control and the prevention of avoidable process losses. Single pieces of equipment, such as autoclaves, may cost \$10,000 or more and the structure, foundation, piping and auxiliary appliances necessary for their operation, as much more. A single accident arising from faulty maintenance may not only wipe out the entire investment but entail physical injury and additional structural damage costing in excess of \$50,000. Aside from the high rate of obsolescence due to rapid developments in the art, there frequently exists an abnormally high rate of depreciation from natural wear, often accentuated by the action of the ingredients on the equipment or by the nature of the process itself. Depreciation of fifteen per cent per year in the value of chemical equipment is not unusual and individual autoclaves, retorts or other process containers may last but a year, even when given the best of care. Almost invariably the rate of depreciation is increased by

abnormalities in the process, in other words, by accidents. In some processes the rate of depreciation and the actual condition of the equipment is difficult to determine. If its deterioration progresses faster than expected or is increased by misuse or abuse, sudden and unexpected failure may result with consequent structural damage and loss of life. Careful inspection of equipment and adequate maintenance are therefore essential to satisfactory operation and both depend to a great extent upon the existence of an enlightened administrative policy and the presence of a capable and efficient executive and production organization.

ECONOMIC ADVANTAGES

The joint effect on production efficiency and accident occurrence of such important factors as cost of materials, chemical control and maintenance, and of the manufacturing conditions upon which they depend, will be readily understood by those familiar with plant operation. It is the *raison d'être* of the familiar statement, "a safe plant is an efficient plant." In Chart I have been reproduced curves showing the five-year record of a chemical plant with somewhat over 1500 payroll employees. It will be noted that the relation between production efficiency (expressed as pounds of production per

GROUP	NO. OF PLANTS	TOTAL NO. EMPLOYEES	NO. OF DEATHS	NO. OF ALL INJURIES	FREQUENCY RATE	SEVERITY RATE
Acid.....	2	241	0	54	76.2	9.03
Explosives.....	3	1804	2	22	5.1	2.81
Paint and Varnish	1	2561	3	39	6.3	3.18
Smelters and Copper Refiners.....	3	2744	3	232	27.2	2.90
Dyes.....	3	4064	4	194	24.9	4.74
By-Product Coke and Coal Tar.....	4	1625	0	161	36.4	1.00
Miscellaneous.....	14	6219	4	564	34.1	2.65
Total.....	30	19,258	16	1266	26.1	3.07

payroll-hour) and injury occurrence (expressed as number of injuries per 1,000,000 pounds of production) is reciprocal; in other words, as safety increases efficiency increases, and vice versa. This is precisely what we should expect to find since, in the last analysis, accident prevention is but one form of waste prevention and waste is the enemy of efficiency.

SAFETY PROGRESS

By carrying somewhat further the thought expressed in the preceding paragraph, we reach the conclusion that the most conspicuous accident reductions should be looked for in the records of the more efficient chemical plants and that the more progressive (and probably the larger) chemical manufacturing corporations should exhibit signs of real progress in effective safety work that might be lacking in the case of the less progressive (and generally smaller) concerns. This, the author believes, does express the condition of affairs at the present time and also sufficiently explains why the chemical industry as a whole, at least so far as available statistical information permits any conclusion, has as yet shown no conspicuous reduction in the frequency or severity of industrial injuries. That progress is being made in accident prevention within the chemical industry is assured, but that the rate of progress is sufficiently rapid to overtake the expansion of the industry itself is open to question. Safety as a principle has been accepted by the present-day executive and engineer, but safety as a practice is quite another matter and many able executives and engineers do not yet see it as a subject of primary importance, inextricably interwoven with production efficiency. Until they do so and make of it an executive function its advance will be faltering and slow.

The injury records furnished the National Safety Council by the individual members of its Chemical Section show improvement in injury severity at least for, while the frequency rate (number of injuries per million man-hours worked) increased from 24.6¹ in 1923 to 26.1² in 1924, the severity rate (number of days lost per thousand man-hours worked, weighted for permanent disability and death) decreased from 4.78¹ to 3.07,² the latter figures representing a 36 per cent reduction. This is an excellent record, but one must remember that the membership of these companies in the National Safety Council suggests that they are representative of the more advanced class rather than the average of the industry. The 1924 rates for the entire section are given on page 128.

These groups are in themselves too small to permit comparison for relative hazard; the total figures, however, are significant. Comparison with those of other industries will probably convince the reader that, in spite of inherent hazards, work on a chemical plant can be made comparatively safe. In explanation of this, Dr. C. L. Reese, former Chemical Director of the duPont Company, President of the American Institute of Chemical Engineers and for years a close student of the chemical industry, is authority for the statement that where hazards are recognized extra precautions are taken to provide for the safety of the plant and its operatives. He states:

This is notably true in the explosives industry, the accident record of which compared with the records of many of the purely mechanical industries shows much lower loss of life, in spite of the spectacular character of the accident losses

¹ Mean rate for thirteen companies employing 7181 average employees.

² Mean rate for thirty companies employing 19,258 average employees.

—all of which goes to show that recognition of danger, once established, is met by the exercise of extraordinary precautions. This doubtless applies also to other branches of the chemical industry.

OUTSIDE AID

Through its Chemical Section the National Safety Council has made many valuable contributions to the accident prevention movement in the chemical field, which will be found in its published Proceedings, Safe Practice Pamphlets, Safety Bulletins, and Chemical Data Sheets. The recent report of its Benzol Poisoning Committee is an especially noteworthy contribution. The National Fire Protection Association in its own field has added much authoritative information to what was previously a scanty fund of knowledge. Among state agencies

contributing work of constructive value on the prevention of chemical injuries and occupational disease the departments of labor of New York, Ohio, Massachusetts, Wisconsin, and especially Pennsylvania and New Jersey should be mentioned. The U. S. Public Health Service, Bureau of Mines and Department of Labor have also done much to help the chemical manufacturer, as have also many national associations, too numerous to be here mentioned. Research, investigation and the collection, correlation and publication of actual experience in chemical safety and health is constantly going on and in time there will be built up a body of authoritative information of immense value to those chemical manufacturers who are earnest in their desire to maintain safe and healthful industrial establishments.