tions with personnel thoroughly familiar with the usage and adaptability of the airfoams.

The term "equivalent isolation" best describes the use of airfoam in such studies. The automatic discharge of a sealing airfoam blanket over flammable liquids to isolate this hazard from affecting equipment and property has already been accepted in lieu of relocation of flammable storage.

For example, a paint manufacturer in New York state was faced with a relocation of his solvent storage to qualify for adequate insurance. Because of his peculiarly cramped position such relocation was estimated to cost in excess of $100,000. The installation of an airfoam system costing $25,000 achieved the desired recognition with a savings of $75,000.

A naval stores manufacturer, who had built his plant over a period of years, finally faced the fact that any fire in his plant could easily become a catastrophe. The only solution to this problem was the relocation and diking of flammable liquid storage and a re-design of building; the estimate for this work was well over $2,000,000. The board of directors of this firm appropriated $500,000 to cover the hazardous areas with airfoam. One of these systems laid a blanket of foam 40,000 sq. ft. in area and 6 in. deep in two minutes.

Conclusion

The application of airfoam as described herein gives promise of a sound improvement in fire safety where flammable liquids are used.

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Some Aspects of Laboratory Safety

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IT WAS DECIDED at the fall meeting of the American Oil Chemists' Society to increase the activities of the Technical Safety Committee by forming a general plant subcommittee and a laboratory subcommittee. The activity of these committees is getting under way, and this paper is presented as a general introduction to laboratory safety. It is hoped that, in the future, papers on laboratory safety will be given on specific problems in safety which face the industry and laboratory today.

The subject of laboratory safety is not new. However it is a subject which is overlooked by many chemists and laboratory workers. I would like to discuss briefly my convictions concerning the need for a laboratory safety program, some of the ideas which are generally acceptable in the organization of a safety program, and the part played by executive management, first-line supervision, laboratory personnel, and the safety representative in the functioning of such a program.

Owing to the very nature of the work the chemist or laboratory technician is exposed to the hazards of a wide variety of compounds which are toxic, flammable, and explosive and may cause severe burns or dermatitis if they come in contact with the skin. Howard Fawcett of the General Electric Research Laboratories stated that there are five specific hazards connected with most chemical laboratories: toxicity, chemical burns, fire, electric shock, and glass cuts (7).

Toxicity is the hazard which is least appreciated since it is not as apparent or easily recognized as a chemical burn or dermatitis. For many years the toxicity of common materials such as carbon tetrachloride, benzene, and hydrogen sulfide were not recognized and are still not fully appreciated.

Dr. Van Atta, who is staff representative of the Chemical Section of the National Safety Council, stressed the importance of training plant and laboratory people so they are well aware of the hazards connected with their work (13). He cited several case histories concerning poisoning from hydrogen sulfide. One concerned a freshman chemistry laboratory where, over a period of time, two students and a stockroom attendant were overcome by the fumes and had to be carried out.

Looking back on my freshman chemistry course in college, it is a miracle that some of us were not overcome by hydrogen sulfide poisoning. When one considers the stench which permeated the chemistry building, it is a wonder that any of us continued on in chemistry. In all probability some students may have deserted the field of chemistry for this very reason. This could easily have been remedied if adequate hood space had been provided and the students thoroughly briefed on the toxicity of hydrogen sulfide.

The interest in safety in university laboratories is increasing because of the efforts of the National Safety Council Chemical Section and Alpha Chi Sigma chemical fraternity. In some instances this interest has been catalyzed by a serious accident. In the March 25, 1957, issue of Chemical and Engineering News the safety programs at Ohio State University and Purdue were outlined.

Statistics on laboratory injuries, according to Dr. Van Atta, are rather hard to obtain. Based on a handful of laboratories, the latest frequency rate was two accidents per million man-hours, and the severity was 260 days charged per million man-hours. The chemical industry had a frequency of 3.9 and a severity of 640 compared to frequency of seven and a severity of 800 for all industries.

CHEMICAL AND ENGINEERING NEWS periodically publishes frequency rates for the chemical industry, which are compiled by the Bureau of Labor. This information was broken down for different chemical industries, and it was a surprise to me that the vegetable and animal oils and fats industry was consistently high, ranging in frequency rate from 19 to 23 injuries per million man-hours. According to these statistics, it appears that laboratories are relatively safe. However chemists should not be complacent because of the low frequency and severity rates. Since there is a difference in the frequency rates quoted by the National Safety Council and the figures from the Bureau of Labor Statistics, it is evident that this may not be a true picture and that there is room for improvement.

Chemists could contribute to plant safety by efficiently passing along all the information which is known regarding the hazards of the materials which manufacturing people are handling in volume. Many of the accidents which have occurred in plant operation could have been avoided had the operator been fully aware of the dangers.

Every day a wide variety of compounds is being used, and new ones are being prepared which have toxic properties that are unknown or not completely investigated or understood. It is essential that considerable care be exercised and precautions be taken, i.e., good ventilation through efficient fume hoods, protection of the skin with rubber gloves and face shields and protection of the eyes with goggles or glasses.

In setting up a safety program, one must remember that safety is an attitude or state of mind. Some persons naturally work and think safely while others throw caution to the wind and may be termed "accident-prone." A good safety program should aim at developing safety consciousness among all employees so that safety becomes a part of their lives at home as well as at work.

There is no sure-fire formula for a successful and effective safety program. Safety programs must be tailor-made for each individual laboratory. The larger laboratories, such as duPont, Eastman Kodak, General Electric Company, and National Institute of Health, have a full time staff whose prime responsibility is safety. Smaller laboratories, such as S. C. Johnson and Son Inc., may have one man or a committee assigned to setting up a safety program and keeping safety in front of the laboratory personnel. To do this there are many sources which the safety man can use.

For anyone assigned the task of setting up a safety program, a good place to start is with the National Safety Council booklet, "Service Guide 2.1." Phases of safety covered are Setting up a Safety Program; Five-Minute Safety Talks for Foremen; Films; Safety Graphs, which are complete talks with illustrations for training small groups; and Safety Posters (4).

To emphasize the importance of laboratory safety programs, the Manufacturing Chemists' Association have published a book, "Guide for Safety in the Chemical Laboratory" (2). Some of the subjects covered are Laboratory Design, Toxicity, Protective Equipment, Handling of Glassware, and a chapter on flammability. This chapter includes a table of approximately 600 chemicals, listing their flash points, explosive limits, vapor densities, boiling points, and fire-extinguishing agent which may be used on the particular chemical, plus 135 references at the end of the chapter. The Manufacturing Chemists' Association also publishes Safety Data Sheets on many of the chemicals which are used by industry. These sheets cover the hazards involved and the precautions which should be taken in handling these chemicals.

If one is interested in toxicity, see Pieters' book "Safety in the Chemical Laboratory" (11), which is particularly good for discussion on the toxicity of the more common chemicals and methods of detecting the presence of these materials. It also covers the physiological effects of the more hazardous chemicals and includes a good bibliography at the end of each chapter.

For the busy supervisor Joseph Guelich wrote the book, "Chemical Safety Supervision" (9). In a concise and readily usable manner it covers such subjects as Investigating a Chemical Accident; Handling, Storage, and Use of Chemicals; a check list for Laboratory Safety; and many others.

SMALL quantities of highly flammable solvents, such as ether, acetone, and heptane, are used extensively in the laboratories of the animal and vegetable oil industry. Therefore laboratory personnel have to be continually on the alert for conditions which may result in a fire or explosion when handling these solvents.

S. M. MacCutcheon of the Dow Chemical Company (10) published an article in Industrial and Engineering Chemistry on the handling of flammable liquids in the laboratory. The article listed four steps for controlling the hazards present in handling flammable liquids in laboratory quantities. These steps are to make certain that laboratory equipment and facilities are designed with safety in mind; develop handling standards through committee action—laboratory personnel should be heavily represented on the committee with engineering and safety personnel furnishing staff assistance; obtain management sanction of the completed standard so that all personnel recognize the standard as bearing the boss' stamp of approval; and incorporate the material contained in the standard into all job training to insure that laboratory personnel are familiar with the provisions outlined. This is followed by a discussion on the storage, handling, and disposal of flammable liquids.

One of the most frequently violated principles of safe practices is to run vacuum distillations without the use of a protective shield. Whenever there is a remote possibility of having an explosion or implosion, a protective shield should be a part of the set-up. In the S. C. Johnson laboratories are safety shields which fit on the front of hoods and will slide back and forth. With this set-up we have access to our equipment and still have the protection of the safety glass shield. In addition, special holders are provided for mounting safety shields in front of reactions being run on the open bench.

Toone, Ferber, and Flett discuss some of the common safe practices which should be observed in chemical laboratories and have several pictures illustrating right and wrong procedures (12).

Searching the literature, one may find many more articles of this type. Some of the articles published in the last 10 years are included in the bibliography of this paper.

NOW let us look at the role played by executive management, first-line supervision, and the safety representative. Salesmanship plays an important part in any safety program. In order for a company successfully to sell its products, they have to set up merchandising programs, advertise, and then get out and sell. So it is with a safety program. First of all, executive management must be sold on safety and back the program with action as well as words. Secondly, first-line supervision must be convinced of the

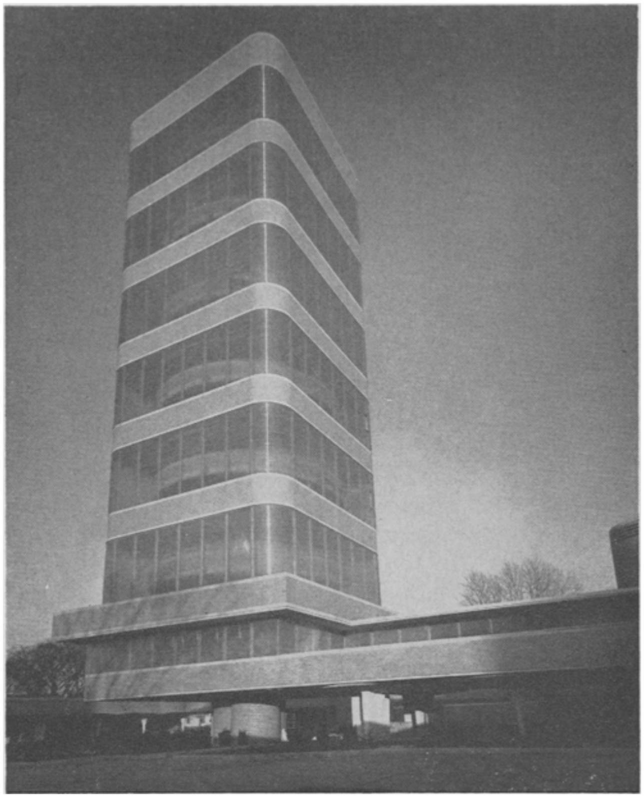

FIG. 1. Research and development laboratories of S. C. Johnson and Son Inc. are shown.

importance of safety and must have enough enthusiasm to carry the idea of safety to the people working for them. Supervisors have daily contact with their people and are the key men in carrying the gospel of safety. Safety should be put on a personal basis and, whenever the occasion arises, safe working practices should be discussed with the chemist or laboratory technician. When a new assignment is made, the supervisor should discuss with the individual concerned all the aspects of the problem including the hazardous properties of the compounds being handled and precautions to be taken. The day-to-day stressing of safety principles in carrying out the work assigned is more effective than an occasional large group meeting.

Usually the safety representative is under the personnel director or is assigned to a staff position responsible to a department or division head. The purpose of a safety man is not to discourage the use of dangerous or toxic chemicals, since that would hinder scientific advancement, but to recognize the inherent dangers and work with the chemist to provide adequate safeguards for his health and wellbeing. The functions of the safety representative are to locate, study, and make recommendations for the correction, removal, or, if either of these is impossible, the minimization of any hazard; provide and instruct personnel in the use of protective equipment and safe practices in the laboratory; and serve as an advisor and source of information about hazards connected with new chemicals, equipment, or laboratory procedures.

It is important to stress the individual responsibility of the chemist or laboratory technician because they are on the firing line. Their carelessness, lack of knowledge because of incomplete instructions from the supervisor, or disregard of safe practices may cause serious injury to themselves, their fellow workers, or possibly to the entire company if the result is a fire or explosion.

One of the services which I hope the laboratory subcommittee can render the industry is to serve as a clearing-house for information on safety problems which are prevalent in the industry. One of the problems which the subcommittee has been asked to investigate is the determination of residual solvent content in meal as it comes from the desolventizer. If a quick, accurate quantitative measurement of residual solvent can be found, it would benefit the entire industry.

Other information which could be shared would be case histories on any accidents occurring in a laboratory or plant which may benefit other laboratories and plants. In order to accomplish our objectives we need the cooperation of all members of the American Oil Chemists' Society.

IN CONCLUSION, I would like to point out some of the safety features in the S. C. Johnson laboratories and what has been done concerning the unique safety problems encountered in this type of structure (Figure 1).

Johnson laboratories were designed by Frank Lloyd Wright and were under construction for more than two years. The laboratory consists of a tower 153 ft. high with a concrete core going 54 ft. into the earth. There are 14 floors consisting of a library floor, six pairs of laboratory floors, and a machine room at the top of the tower. The tower is 40 ft. square, and the floors are cantilevered out from the center core which can be seen at the ground level. The building structure consists of heavily reinforced concrete completely supported by the center core. The main support core is 13 ft. across at the narrowest point and is divided into three individual fireproof sections. One section is for the elevator shaft, another for the stair-well; the third section is for ventilation ducts, fume ducts, and services which include hot and cold water, steam, vacuum lines, inert gas, illuminating gas, compressed air, electrical services, and dumb-waiter. The building and its furnishings are all of fire-proof construction.

Each pair of laboratory floors is composed of a main and mezzanine floor (Figure 2). The main floor is 40 ft. square, and the mezzanine floor 38 ft. in diameter. The safety equipment located on each floor consists

FIG. 2. This is a view of a mezzanine floor, showing fume hood and safety shower.

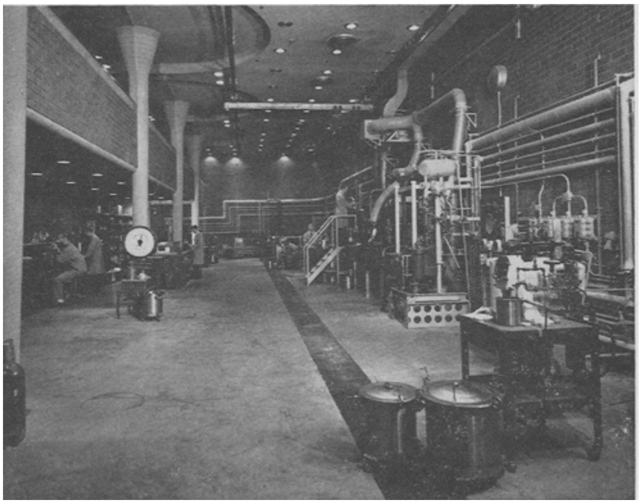

FIG. 3. Above is shown the experimental engineering laboratory at S. C. Johnson and Son Inc.

of an automatic sprinkler system, carbon dioxide fire extinguishers (in some areas these are backed up by powder fire extinguishers), a safety shower, fire blanket, gas mask, rubber and asbestos gloves, goggles, and face shields. The fume hoods have individual exhaust-fans expelling fumes into a center duct, where they are exhausted at the top of the tower by a large exhaust fan. If there is a flash fire or accident in the hood, main valves for turning off steam or gas and an electric switch are located in in front of the hood. As mentioned before, safety shields can be mounted in the front of the hoods. Each floor has a fire-alarm box. When an alarm is turned in, the call immediately goes to the City Fire Department and at the same time an auto-call signal tells everyone in the laboratory and plant the location of the fire.

In the event of a fire the evacuation of the tower could be a problem. Therefore we have a fire brigade, which is divided into two groups. One group, consisting of a man from each pair of floors, has the job of checking the floor to be sure everyone is out of the area. In evacuating the tower, everyone uses the stair-well as the elevator has a capacity of eight people and may not be a safe means of exit. The man on the top floor checks with the men from each pair of floors below, and, if there is no one in the stair-well to report a floor all clear, it is his job to check that floor and make sure it is clear. Upon reaching the ground level, he reports the extent of the fire, whether anyone is injured and how many men are at the scene fighting the fire or aiding any injured person. In surprise practice drills the tower has been evacuated in three to three and one-half minutes.

The second group reports to the scene of an accident or fire with additional fire extinguishers, gas masks, and self-contained, breathing apparatus to help extinguish a fire or render aid if it is needed. If there is any doubt as to their ability to control the fire, they are instructed to leave the building.

The pilot plant is located in the basement adjacent to the tower. It is laid out with a laboratory bench along one wall where new processes can be checked on a laboratory scale before running the larger-size batch. Along the other wall equipment and services are available for running larger-scale batches. In addition to the services, flexible fume ducts are available. The pilot plant is protected by a sprinkler system as well as an automatic carbon dioxide system (Figure 3).

The desk area of the engineers is located on the mezzanine overlooking the working area. Safety glass protects this area from accidents which may occur below.

The chemical and solvent storage-rooms and high-pressure laboratory are located in the basement surrounding the tower and are protected by sprinkler and automatic carbon dioxide systems.

In closing I would like to leave this thought with you. When it comes to safety, "Thou shalt be thy brother's keeper."

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Solvent-Extraction-Plant Operating Safety

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OPERATING an extraction plant safely is much the same experience as driving an automobile in heavy traffic. It is not a severely hazardous thing to handle as long as you are aware of the law, know its mechanical potentials, and are constantly alert in its operation. No one can afford to go to sleep at the wheel.

Like traffic laws, every safety-minded extraction plant has built up a series of rules and regulations according to good basic practice. There are many good printed references that can be used as a guide in establishing these for specific needs. We probably all have some kind of printed rules that are made known and posted to every person concerned or entering the plant areas. These rules usually specify no smoking; the use of non-sparking tools; proper shoes; and general safe-conduct.

Like automobiles, most extraction-plant engineering designs and its equipment are built with full mechanical safety potentials in mind. Various national, local,