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ORIENTATION AND TRAINING OF THE MOD GENERATION

By RAYMOND E. BATTEN
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The "mod" generation is "making it" in industry with the help of programs designed to reach them

The Du Pont Chambers Works is situated in the heart of the Delaware Valley, approximately 30 miles south of Philadelphia. It is the largest Du Pont plant, in terms of people, and covers about 500 acres, providing employment for approximately 6,500 personnel in over 400 buildings. More than 2,500 items are produced at this site, and the problems are not unlike any other multi-product chemical plant, particularly with regard to safety.

Ultimately, the goal of all of us is an injury frequency rate of zero. Our company president has given us an initial goal of .25 frequency rate. We at Chambers Works have been able to steadily improve our performance, but we are still a little short of our goal. We are proud of our achievements to date, but they are not yet good enough. However, our works safety division provides leadership with intense, modern programs to effect continual improvement.

The words modern and intense also describe one of our major concerns at Chambers Works: The new, young employee. The "mod" generation. In an average year we hire into our labor pools over 300 of this generation, most of them just out of high school or the military. Some are the clean cut, old fashioned type, but the majority have the "long hair" look. Ninety-nine per cent live within 30 miles of the plant, and most come from the lower middle income bracket. In nearly all cases they have relatives or close friends working at the plant. They have heard something about our safety performance in their homes or communities through our off-job programs, which frequently include participation by civic groups and outsiders. Approximately one in three is married. Nearly all have held part time jobs, but employment at Chambers Works represents their first real exposure to industry and the "big" money.

We find that approximately five per cent of our new employees are unresponsive; i.e., we have been unable to find the answer or solution to their productivity problems. A majority of this group has terminated on their own, but a few have been discharged. The remaining 95 per cent are responsive. These are the average people—the kid next door type. The following comments apply to this group.

This group has two different attitudes toward wages. The married men are very conscious of their hourly rate, their shift differential, and their potential earning power. The single men are primarily concerned with their immediate needs. As long as they have enough money to make a car payment, put gas in the car, and take girls out, they are satisfied.

As a group, their attitude toward race is very good. We have had no major race problems. Approximately 15 per cent of our mod group are black.

The attitude of the group toward the union is generally one of little interest. The feeling prevails that they can make it on their own and don't need another group or individual to help them. There is very little resistance shown toward physical work. Seemingly, they would just as soon do hard

manual labor as work in an office or laboratory.

We find them to be very receptive to instruction. They quickly learn both job and safety requirements, and are generally retentive. Their attitude toward supervision is very good. They follow well. There is a tendency to want to remain in the group in which they started. Our experience has shown them to be very alert and willing to have a discussion at any time or any place about almost anything. They are eager to talk about themselves, their job assignment, their future, the company, or current events. Participation in our communication meetings is good.

Discipline is constructively accepted. Initially, they will "try you on for size" and see how far they can go. Once they learn the ground rules, they usually stick with them.

These people have high expectations. All of them expect recognition as an individual. They want to receive personal attention and feel an important part of something.

In general, we find the mod generation to be a good group. They are exuberant. They are also completely honest; giving false information doesn't appear to have any merit in their world. My personal contact with this group indicates, to me at least, that our society is in much better shape than thought by many.

A great majority of our mods have the potential to be good employees, provided they are guided in the right direction and handled properly. However, they are untrained. This brings us to our topic matter: the orientation and training of the mod generation.

Their first contact with on-plant safety is made with a large sign in our employment office:

> Notice to those seeking employment—unless you are willing to work safely to avoid an injury to yourself and fellow workers, do not ask for employment here. We no not want unsafe workers.

Next, as part of their employment procedure, they are given a programmed self-instruction course called "Nest" (new employee safety training). This course was originally developed specifically for use on Chambers Works. However, its success has caused it to be offered not only to the rest of Du Pont, but also to other companies in a modified version.

After completing this course they are sent to their assigned group. It is at this point that their formal orientation and training starts. First, they are given a tour of their assigned area and their responsibility is explained to them in general terms. The stress here is on the importance of their contribution and how a labor pool functions. All safety items, such as showers, rules, clothing, tools, special equipment, etc., are discussed in detail. After this initial indoctrination, which usually completes their first day, they are turned over to their assigned foreman, who then starts them on a very specific orientation program. This program is implemented by the use of four area guide orientation forms. In conjunction with the orientation guides, each man is given a performance review after 30 days, 90 days, and 150 days, using this form.

Within the first four weeks of employment, each new man is scheduled to attend a 2 ½ hour orientation program as part of a group of 30 to 40 personnel. The objective of this program is three-fold. First, it is informative about company history, size and scope of the company today, the products made at our site, and the contribution those products make in our everyday lives. Second, the program tries to get each person thinking about the opportunities available to him in different jobs, and his present versus potential contribution. Third, and most important, it's hoped that this program will help each person to feel more of an individual and an important part of a team doing an important job. The program begins with a modern movie production entiled "1+1+1," done up with flashing lights, modern music arrangements, and some cheesecake. It has been well received by the mod generation. Next, the group is addressed by the plant manager or his assistant with emphasis placed on personal safety. The remaining topics are presented in a manner which, hopefully, helps them to feel part of an important team and to start thinking about their individual futures.

A majority of our employee benefit plans become effective after one year's service.

Upon reaching this point, each man attends a meeting which has the objective of helping him to know background, policy, and important facts of the employee benefit plans. By this time, employees are sufficiently experienced to be able to relate to facts and figures about the plans.

These things represent the formal part of our program. Of more importance is the informal or daily training that each man receives. This entire effort is built around treating each man as an individual. Part of the jobs of our foremen, general foremen, and supervisors is to know each man personally and to talk with him frequently, not only about the job but also about the employee as a person, his family life, his hobbies, his interests, his aspirations, and his problems.

The training of a man is physically accomplished by assigning him to work with one of our better personnel. The old timer, or trainer, sometimes with only one-year's service, is actually given pretty much of a free hand in developing the new employee. This responsibility is not only welcomed but sought after by many of our people.

The routine learning of rules, regulations, and practices is supplemented and made more interesting by a variety of techniques, such as participation in safety programs, being part of a hazard hunting team, or participating in a monthy communication meeting which is oriented toward safety in their own department.

Monthly, large group safety meetings are held and are generally keyed toward our program for the year, or implemented by our plant safety task force committee's activities. Particularly successful are the daily tool box meetings that each foreman holds with his group at the beginning of his work day. These are a two-part meeting. Usually, the foreman talks safety about a current event happening or something with no direct connection with his group. Obviously, emphasis here is on off-job safety. He might discuss such things as an airplane crash, movement of poison gas across the country, any local calamity or disaster, hazards of the season, safety performance of other plants and industries, etc. Several groups also have a "word of the day" program which is talked about at this time. The word of the day might be spectacles, hands, tripping, horseplay, fumes, or any single word that merits discussion and pertains to on the job safety. This "word" program provides an easy opener for subsequent safety discussions throughout the day. In the second part of the tool box meeting, suggestions and safety problems of the group are solicited and discussed.

The picture I've painted here may seem like a Utopian situation, with Du Pont Chambers Works having all the answers. This is not true. We do have our problems. Picture, if you will, a young chap just out of high school whose only concern about safety has been the use of a football helmet, or a soldier just back from Vietnam who has perhaps been dodging bullets, running wildly through the dark, or being exposed to bombing and shelling. These are the people we get and deal with. It is physically impossible to have them immediately accept and fit into a 40-hour week world of rules, regulations, thou shalls and thou shall nots: you may smoke here at this time and not here at this time; you must do this this way and you must not do this that way. Our methods and mode of operation do not automatically appeal or justify themselves to these people. We do not offer any obvious outlet for excessive, young energy, which is our major problem. This energy manifests itself frequently in the form of horseplay. Not too long ago one of our new employees, a well built stalwart chap, said he injured his hand when he slipped going up a well lighted, clear stairway. This gentleman had been very enthused in the previous month or two about his karate lessons and the power he was developing in his right hand. By coincidence, this was the hand he injured in falling up the steps. Another night one of our foremen, upon entering a large office building, found two of our better young men racing each other down a long hallway by belly-flopping on dollies used to move trash barrels.

The presence of many mini-skirted young ladies, also of the mod generation, seems to foster a "show off the muscle" or "hang around and talk" type of problem. However, it is frankly a continuing source of surprise that somehow we have been able to turn

these people around to our way of thinking and doing business so quickly. Undoubtedly, much goes on that we don't know about, particularly on shifts. But we must be doing something right because our record is good, our achievements satisfactory. Like many good quarterbacks, we will continue using the same game plan as long as it works.

One other major point I would like to make is about the contribution that the mod generation has unknowingly and uncaringly made, not to us as Du Pont supervision, but to the establishment that we represent. All of us who are charged with the responsibility of training these people have learned a lot from them. Not about making products or writing safety rules, but about life itself, the importance of enthusiasm, the merits of honesty, and how great it is to be alive.

If I were asked to make one comment about the mod generation, if would be this: they are certainly no worse, and in many ways better, than their counterparts of ten, fifteen, and, from what I hear, twenty or twenty-five years ago.

EFFECTIVE INSTRUCTORS FOR EFFECTIVE TRAINING

By A. EUGENE BLOOMWELL
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My purpose is to describe for you a seminar program we have developed for our first line production supervisors and our mechanical department foremen. The seminar was developed primarily to meet a need for safety training and development, but set within the context of the supervisors' whole working environment.

We at Merck & Co., Inc. have a good safety record. However, there has been a growing feeling among some hourly people and first-line supervisors that the interest of upper management in most of the safety programs was declining. Probably the dropping of the safety awards program contributed to this feeling, and probably the program of Safety Talks had become rather perfunctory. In any case, it seemed to many that production was being emphasized above safety.

In an effort to do something about these problems and attitudes, our Rahway Plant Manager came to our relatively new Corporate Training Department to see where we could be of help. One of the several approaches he wanted to pursue was to upgrade the "5-minute safety talks" that supervisors were required to give to their men. He recognized several problem areas here.

1. Safety talks are very important, but they were being given rather mechanically, a *5-minute* safety talk was really not doing a job. You can not give any kind of effective presentation in 5 minutes.
2. The supervisors have had no training on how to develop and present a worthwhile talk, or even how to conduct a good discussion session.
3. The background material for these talks was not always in a useful format. The supervisors may, at best, read the safety literature passed along to them.
4. As part of the increasing awareness and emphasis on safety, our plant manager wanted something now that could be offered to these supervisors and foremen that would demonstrate that management is interested and concerned with safety.

We in the Training Department recognized this as a real problem. We also saw here an opportunity to develop and present to this

group of supervisors some other kinds of help directly related to their role, not only as safety trainers, but also as supervisors and on-the-job trainers. They are required to teach and motivate their men in *all* aspects of their jobs. However, with probably less than adequate training themselves on how to best approach their responsibilities as trainers, it is no wonder that results were poor and motivation and morale low.

We took what we call a *systems approach* to the problem. The overall objective of any training in Merck & Co., Inc. is to help us be more profitable and more efficient. Whatever else we accomplish we want to learn how to work *smarter*. The best way to do this is to take a look at how training fits into the big picture. We want to try to coordinate all aspects of the problem of training needs toward the specific objective of greater production efficiency. By taking a systematic look at our training needs, we want to help line management (from the Plant Manager down through the First Line Supervisor) to be able to plan, organize, lead and control the resources available to him to achieve his production objectives.

The Systems Approach is an attempt to take "training" out of the classroom and think about it in terms of manpower utilization. We want to do more than set up and run training programs. Our goal is not to have X number of men attend Y hours of training classes. Our primary goal is to set up a work situation where our employees will do correctly those things that they know how to do. The second goal is to train men in those areas where they lack knowledge, so that they can perform their jobs properly.

Management shouts, "Train these men!" So the Training Department goes through certain ritual and motions, confers the degree of "Trained" on the men and hopes for the best. Likely as not the trainer hears little more—good, bad or indifferent—about the results of the course. Why? Well, it is assumed that any kind of training must be beneficial. The results of training are always kind of nebulous—how can you tell whether or not you have accomplished anything specific? Besides, the Management has more important problems to worry about than training. "We trained these men, didn't we?!"

Training, per se, may not be necessary *or* beneficial.

Training results can be measured.

Let me make this latter point unmistakably clear:

If you can't measure it, don't train for it!

We can improve our training by looking at the bigger picture. We must have feedback information from the production department to the training department. Someone needs to tell the trainers whether or not the training is relevant, important, useful, and up-to-date. The best way to do this is to have first line supervisors involved in training to the greatest extent possible.

Let me illustrate one of the biggest pitfalls a trainer can get into: The Training Supervisor receives a frantic call from the Production Manager early one morning—before that all important second cup of coffee. "Look, we just had one of the costliest goofs of the year out in Factory 85. An operator sewered a whole batch of Vitamin Q. We must have some training to stop some of these operating mistakes. This goof alone cost us $10,000!"

The Training Supervisor surveys the situation, talks to the Factory Head and the First Line Supervisor to see what happened. Essentially, the chemical operator failed to close a valve as he was pumping the batch into the reactor.

"Ah, so! The problem seems to be that the operators don't know how or when to close valves." So the Training Supervisor immediately sets up a course on valves, how to close them, how to tell when they are closed, the importance of closing valves, the parts of a valve, pressure drop across valves, fluid flow theory, flow characteristics and Reynolds numbers.

After 3 months of concentrated effort, training every operator in the plant in proper valve procedure, the Production Manager and the Training Supervisor could not understand the latest operating error. An operator left a caustic valve open, and added caustic to a batch by mistake while adjusting the pH of material in another reactor. The batch was ruined.

Successful training involves two phases:

(1) Learning some new skill
(2) Performing the correct skill on the job

The training that was given to all of these men failed on both of these counts. They learned no skills that they did not already know. They did not perform the correct skills *on the job.*

First of all then, we have to ask a few very important questions: Does the employee know how or what to do? Did he know how or when to shut valves? Could he perform the job if his life depended on it? If the answer to these questions is "yes," then obviously he didn't need to be trained in a new skill. For some other reason the operators in our 2 examples didn't close valves. They forgot? They were too lazy? They weren't motivated (whatever *motivation* means)? They didn't care? They knew it wouldn't make any difference to themselves, whether they did a good job or a poor one? Something was radically wrong, but what?

Performing on the job must be the problem then—keeping the operators working up to standard. This can be done by providing the proper work environment: by giving the operator information, feedback on the quality of his work, by providing positive as well as negative consequences for his efforts. The emphasis should be on the positive. Structure the job environment to provide positive consequences through supervision, recognition, discipline, social contacts, or whatever way possible.

With this back ground in mind we set forth our objective for the Effective Instructor Seminar—to increase the training skills of first-line supervisors and foremen, so that they will be more effective in presenting safety talks to their men, and be more effective with on-the-job training.

This statement of our objective was good, but it was quite general and non-specific. We want to look at training in a very special, very specific way: *performance change.* As you look at your particular training problem, you must decide if there is some knowledge or skill lacking—if there is some information a person needs to do his job more efficiently. We need to specify just what the skill is, and how we are going to *measure* whether or not he acquires the skill as a result of our training. You can't develop and design a good, effective training course unless you know what the desired performance changes are to be. Training, in the sense we are talking about, should change job performance. Therefore, we must decide what needs to be changed.

Some statements need to be formulated that will describe specifically what training is needed—Terminal Performance Statements. These statements will describe specifically what performance we want our trainees to demonstrate after the completion or termination of their training.

Statements of Terminal Performance are a description of observable, measurable behavior which learners will be required to demonstrate *on the job* following a course of instructions.

Writing Terminal Performance Statements is a relatively easy way to answer questions such as these:

1. What is the problem?
2. How do I know what training is needed?
3. How do I know what training will *solve* the problem?
4. *If* training, *what* training?
5. If training is appropriate, how will I know if I have been successful? How can I evaluate this success at the end of the course *and* on the job?

Terminal Performance Statements can serve all of these functions. However, the major function is to *evaluate.*

The Terminal Performance Statement for this seminar program was written as follows:

> The supervisor completing this course will *develop* and *present* an effective safety talk for the men working for him.

With this overall objective and this Terminal Performance Statement clearly in mind, we set out to develop that material which would accomplish this. The material

was arranged into three sections, each requiring two to three hours of presentation time.

I General Training Background
II Communications and the Instructor
III Workshop

I would like to describe briefly some of the content of these sections, and the reaction of the men to them. For the General Training Background we discussed a variety of topics specifically related to teaching hourly people in job situations. We touched on the *purpose* and *importance* of any training, and specifically how we use the Systems Approach to give purpose and guidance to the training effort. Next, for the planning phase of any program, objectives and Terminal Performance Statements must be developed, even for a very simple Safety Talk. Normally there is an abundance of materials available from the Safety Department, but breaking this down into meaningful, purposeful presentations is the problem.

The facilities for giving safety talks led to discussions of a major problem for these men: the locker room, smoke area or shop are not places that are very conducive for an effective talk. In addition there are usually no chalk boards, flip charts or any other visual aids facilities available. Take away all visual aids gear, and you leave a trainer stark naked! Even the most ingenious supervisor will have difficulty in presenting safety talks to his men if he isn't provided with some kind of minimum facilities—an unused office or conference room near the work area, with a chalk board or flip chart. He also needs at least occasional use of a place to show one of the many excellent films or slides sets that are available. Without this kind of support—the physical facilities required—no training on giving effective safety talks will be worth the time.

Next we discussed some things about learning. It can be defined as "the process of acquiring skills, knowledge and attitude." There are attitudes to consider in the people being trained which may block or enhance learning. Adults have to be motivated to learn, and the way in which adults learn and the way adults are motivated are much different from the way children learn. You can teach an old dog new tricks, if the trainer uses a few tricks of his own.

Positive motivation was discussed at some length—getting a person to do a job because he wants to do a good job. Don't you enjoy working in the kind of atmosphere where you get the feeling that what you do is important and appreciated? Don't you tend to want to do a more conscientious job under circumstances where you felt management genuinely does care about what you do and how you do it?

Problems that first appear to be training problems can often be solved by ignoring training and structuring the job environment, through first and second line supervision, to maintain performance. Through positive motivation, the pat on the back when appropriate, instead of the constant kick in the pants, can be very effective. However, this concept was nearly impossible to sell to experienced supervisors. They reject this concept as much too much of the permissive management they see all the time! Perhaps some of it is.

This constitutes the major thrust of the Seminar. The second portion is more straightforward, covering the classical topics of "Communications" and "The Instructor." Within the context of these topics we spent a fair amount of time discussing On-the-Job training. We augmented our discussion with an excellent filmstrip series, to give these supervisors a firm grasp of the essentials involved.

On the surface, On-the-Job training would appear to be very simple and easy—a concept that any good first-line supervisor should be very capable of doing. There are ways, and there are ways of doing On-the-Job training, however. Done incorrectly, the results may not come out as expected.

The final session of the seminar is the critical test to determine if the course objectives have been met. For this session we divide the group in pairs. Their assignment is to choose a safety topic—or perhaps an on-the-job training topic—and develop a talk or training demonstration, using the techniques presented in the first two Seminar sessions. Sufficient time must be allowed, of course, to gather and develop a presentation. The trainees are to develop and present this talk

as if they were talking with the men working for them. The fellow supervisors and the training supervisor will give each presentation a critique, on how well they thought the talk would come across to hourly personnel. The idea is not to judge their oratory but to judge whether or not their terminal performance statement objectives have been met, and how the presentation could be made more interesting and more instructive to the men.

For the critique session we have also used video tape, to allow the speaker to actually see himself as others see him. Care must be taken here, however, because some men are very sensitive about this sort of thing—it can be very ego-deflating. To overcome this, we introduced the idea of video taping the talks early. We also gave the team an option of being video taped or not; we gave them a choice of one or both of the team pair presenting the talk, while the second member operates the video camera. This takes some of the "black magic" out of the video equipment. For this kind of presentation only room lights are needed. It is obviously not easy to act "natural" in front of a video camera, even under these conditions.

Our experience has been that the workshop session has been the most valuable portion of the seminar, and the men enjoy the video taping. Most of the supervisors have a bit of "ham" in them. They sat in rapt attention as they watched themselves give their presentations via video tape.

Overall, we feel that the seminar has been most successful. We have given it to a pilot group in our Rahway plant, to all of the mechanical foremen at our Pennsylvania plant to help them prepare for a new apprentice program being initiated, and to the supervisors at our brand new Puerto Rico plant. We plan to give this to all our first line supervisors at Rahway, as soon as time, schedules, and priorities permit.

Let me read to you the comments from one of the Rahway seminar participants:

> "I found the course very interesting. I thought at first it was going to be another safety program—'the same old hat,' but it turned out that after the meeting was over and I started walking away, I found myself thinking that maybe Merck was really trying to get their safety program across, and that we were not really just going through the motions of giving a safety talk to say that we did. I got the feeling that Merck realized that the present safety talks of five minutes were wholly inadequate and that very little was being accomplished by them, which brought up the question of what to do about it. The present sessions of trying to get the supervisors to be effective instructors, in my opinion, is a definite step in the right direction."

There are two key features to this seminar program which make it very valuable: its flexibility and its comprehensiveness. The seminar encompasses both the "academic" and "practical" aspects of training that first-line supervisors have to do with in context of their specific job assignments. Here, too, there is flexibility: the time allowed and the material to be covered can be tailored to meet the specific needs of the trainees, and the demands of management. The overall emphasis can be directed toward safety training or on-the-job training, depending on the need. For brand new supervisors, some of the material can be expanded in greater depth. For experienced supervisors, the Positive Motivation concept is most important.

A very valuable by-product of the seminar will be a library of Safety Talks, developed by supervisors themselves. Each time a seminar participant develops a talk, he is asked to write it up in a format that includes the talk objectives, supporting materials, the training text or lesson, etc. By requiring each pair of supervisors to prepare different topics, a library of talks can be accumulated. These then can be exchanged among supervisors in that plant or in other plants.

In the last analysis, the overall objective of the seminar must be kept in mind all of the time: to increase the training skills of supervisors so they will be more effective in presenting safety talks and doing on-the-job training. We all must learn to *work smarter.*

EFFECTIVE TESTING OF THE IN-PLANT ENVIRONMENT

By JEROME T. SIEDLECKI
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The preventive aspects of an occupational health program include the examination of the overall environment of the work site and production processes. To recognize the hazards of the environment, there must be familiarity with the various exposures and stresses on health and well-being of the worker. The potential hazards can be classified as follows: (1) chemical—solids, liquids, dust, fumes, mists, vapors, or gases; (2) biological—insects, mites and other arthropods, molds, yeast and fungi, bacteria, and viruses; (3) physical—electromagnetic and ionizing radiation, illumination, noise, and extremes of temperature, humidity, and pressure.[1]

The evaluation of environmental exposures requires a teamwork of professional disciplines. The physician, nurse, industrial hygienist, and safety engineer are complementary members of the team to control occupational disability. There is overlapping of areas of activity in conducting evaluation studies and, besides the disciplines named, there may be need of other specialists in the field.

The regulations promulgated under the Occupational Safety and Health Act of 1970 specify that exposure by inhalation, ingestion, skin absorption, or contact of any material or substance must not be above those specified in the Threshold Limit Values of Airborne Contaminants of 1970 of the ACGIH, except those listed by the American National Standards Institute.[2]

Under the same regulations, employers can also be requested to maintain accurate records of exposures to potentially toxic materials or harmful physical agents which are required to be monitored or measured and to promptly advise any employee of any excessive exposure and of the corrective action being undertaken. The Secretary of Labor, in cooperation with the Secretary of Health, Education, and Welfare, is authorized by the law to issue regulations in this area which shall provide employees or their representatives with an opportunity to observe such monitoring or measuring and to have access to the records thereof and to such records as will indicate their own exposure to toxic materials or harmful physical agents.[3]

For recordkeeping purposes, the Secretary's regulations may also require employers to conduct their own periodic inspections.

The Secretary is directed to issue regulations requiring employers to keep their employees informed of their protections and obligations under the law through posting of notices or other appropriate means. The information which employers may be required to give their employees may also include provisions of applicable standards.

Compliance officers of the Department of Labor may sample the work environment to determine whether there is compliance with the standards. The National Institute for Occupational Safety and Health will provide the necessary laboratory support which will include analytical chemistry, instrument calibration, and instrument maintenance and repair services.

Industry now has a moral and legal obligation to maintain a healthful environment. Effective testing of the environment is now a requirement. An occupational hygiene survey is essentially a planned sampling and analytical program, combined with engineering, scientific, and medical procedures designed to evaluate the work situation.

Survey of Work Processes

A detailed survey of the work processes requires skilled personnel to perform periodic inspections of the premises, including all facilities used by employees, and to evaluate the work environment in order to detect and appraise health hazards, mental as well as physical.

Blueprints for new processes and opera-

tions should be reviewed and the responsible organizations advised of any health hazards arising from new installations or chemicals, and ways to minimize the potential problem. When new chemicals are introduced, the medical, industrial hygiene, and safety sectors of the organization should be advised as to the nature and location of the potential hazard, the proposed consumption figures, the operators, and the area where the material will be processed, and they should be supplied with any health and safety instructions.

A mechanism should be established within the purchasing organization that will advise the industrial hygienist whenever potentially hazardous materials are going to be purchased for use within a department.

If a new chemical has a proprietary name, the supplier should be contacted to establish the chemical names of the proprietary material and its constituents and the approximate percentages present in the material. Any available toxicity data and safety instructions should also be obtained. There should be cooperation with functional organizations in establishing practices, procedures, and facilities for the safe storage, use, handling, and disposal of any new chemicals.

A periodic air sampling program will insure the adequacy of the exhaust and insure that the employees are making full use of the exhaust facilities.

Purpose of Sampling

The environmental investigation must define the exposure to a toxic substance. The concentration and the movement of the worker within a time space are not constant, but are highly variable. The five questions—what?–who?–where?–when?–how?–must be answered before any sampling can be initiated. More specifically, these five basic questions are: What is the potentially hazardous material? Who is the worker being exposed? Where is he exposed? When is he exposed—cycle of the operation—over what period of time, day, night, summer or winter? In what manner and how long must the worker be sampled in order to obtain a representative evaluation of his exposure?

In general, the purpose of the sampling is to determine the pattern of occupational exposure so that the average time-weighted exposure can be calculated. It is necessary to sample at the breathing zone of the worker, as well as to obtain samples in the general area adjacent to the operation or general room air. A worker near the point of contaminant generation will frequently have exposures which may be considerably greater than the area sample.

Continuous sampling of atmospheric concentrations is very desirable, particularly when materials are handled in large quantities and there is a potential for over-exposure. Sampling locations should be where the worker is more frequently located and in areas where there is a possibility of leakage. Whenever possible, the sampler should be attached to the worker to check his movement within a time-space. Biochemical sampling, sometimes called bioassay, of the urine or blood may give valuable evidence of internal contamination and will shed some light on the magnitude of the exposure. In this connection, whole body counters for measurement of gamma ray emitting isotopes will give an immediate measurement of a radioactive burden within the body.

Sampling should determine the duration of exposure, usually a complete cycle of operation. This may require a series of samples; that is, sampling for a period of time every hour. There must be a sound statistical approach in sampling design for the judgment of the overall exposure. The preferred method is usually the use of a personal sampler in which the sampling head is as close as conveniently possible to the employee's breathing zone.

The volume of sample or duration of sampling depends upon the sensitivity of the analytical procedure, the TLV, and an estimate of the air concentration. It must be adequate to permit a determination of known and reasonable accuracy. The volume of the sample may vary from a few liters when it is estimated that the concentration is high to several cubic meters where low concentrations may be anticipated.

The period of time the samples should be collected is determined by the information desired. If the operation continues for more than one shift, samples should be collected during each shift. When there are temperature variations during the seasons of the year, different sampling procedures must be planned. Generally, conditions vary in the summer, when there is sufficient ventilation to dilute the sample to give lower concentrations of the contaminant. During the winter months, when the plant ventilation may be poor, greater concentrations of air contaminants can be anticipated.

Since the Department of Labor has accepted the concept of time-weighted average work day concentration of the American Conference of Governmental Industrial Hygienists and American National Standards Institute, excursions of concentration are permitted above the listed value provided they are compensated by equivalent excursions below the listed value. Some substances are listed as having a ceiling value. These values cannot be exceeded even briefly, for this practice will constitute a violation.

A method is provided by the ACGIH for establishing excursion limits by applying factors based on the following:[4]

Range in Which	*Excursion Factor*
0 to 1 either ppm or mg/m^3	3
1 — 10	2
10 — 100	1.5
100 — 1000	1.25

A single sample taken continuously over a full shift will not furnish information concerning excursions. The preferred type of sampling would be a series of samples taken sequentially for the full work shift to provide information on excursions as well as the time-weighted average exposure.

In sampling, any variations from normal operation must be observed, such as change or breakdown of process or need of maintenance. One should also have information on such unusual and sometimes severe exposures as filter bag cleaning. Whenever a sample is collected, it should be noted whether personal protective equipment is utilized.

The method of sampling and analysis should be thoroughly investigated by the individual who will use it. The method must have the desired limits of sensitivity. The size of sample must be such that a definite result can be reported. Too large a sample can pose a problem if the sample must be shipped. Too much deposit on a filter may fall off in transit. There also is a limit of absorptive capacity if charcoal tubes are used for the sampling of gases or vapors. The apparatus selected must be frequently checked for calibration to be certain that the results are valid. It is necessary that the individual be competent in the field, have experience of sampling and analysis, and a thorough knowledge of information of the particular substance, energies, or other circumstances involving the exposure.

Many direct and recording instruments for air sampling and analysis have been developed in recent years, and it is likely that the trend will be accelerated. The accuracy of such instruments, if they are properly calibrated, can be determined in the same manner as with the traditional methods of sampling and analysis, and there is the added advantage of instantaneous results. Such instruments should be hand-held while the employee is followed without interfering with his work.

The accuracy of such devices as combustible vapor instruments, and colorimetric and stain indicating tests are usually adequate for preliminary samples. The principle of operation is simple and they can be used by untrained persons. However, the interpretation of the data must be made by a trained person so that complete confidence can be placed in the results. More complex instruments and analysis are necessary to evaluate the worker's exposures with complete certainty.

Calibration of Air Sampling Equipment

There are many methods for calibrating air sampling equipment by use of static or dynamic systems. One static system involving the use of plastic bags offers potential advantages over glass or steel containers.[5] Plastic bags are light, non-breakable, inexpensive, and not complicated to use. As with any calibrating source, they must be used with caution and knowledge to avoid serious errors in evaluation and studies of environmental problems. The bag material selected must be able to contain the substance for an extended period of time. It should not react with, absorb, or be permeable to the substance being

calibrated. A measured amount of gas or liquid is introduced into the bag. Since plastic bags have no volume, it is necessary to meter into the bag a known volume of air.

When a sample of air is being withdrawn from a plastic bag, dilution air does not enter the bag. This is a significant advantage, since the residual concentration does not have to be calculated. It then can be used to recheck the calibration.

Plastic bags must be preconditioned to the chemical vapor in the same concentration as the vapor to be tested. The rate of loss of gases or vapors from plastic bags is a function of the type of plastic used, adsorption and diffusion characteristics for the specific type and concentration of gas present, temperature, pressure, and interaction of mixture of gases and moisture and other factors. These must be evaluated when selecting a plastic bag either to collect samples or prepare known concentrations of the vapor in air.

Choice of Instruments

The selection of the air sampling method depends upon the physical and chemical characteristics of the air contaminant. The collection method selected will depend upon whether the air contaminant under investigation is in the form of a gas, liquid, or solid. Other factors which should be considered are molecular or particulate sizes involved, density, solubility, vapor pressures, dew or sublimation point, freezing point, chemical reactivity, radiant energy absorption, thermal conductivity, and ionization potential in solution. Other considerations are whether the presence of other substances interfere either with the collection of the contaminant under investigation or with the reliability of the analytical method. It may be necessary to collect simultaneous parallel or series samplings by different methods to determine the concentration of the contaminant.

The National Institute for Occupational Safety and Health is planning to develop a prescribed procedure for sampling to be used by compliance officers of the Department of Labor.

Solvent Vapors. Many of the solvent vapors in the atmosphere can be collected efficiently by adsorption or activated charcoal and then desorbed with a suitable solvent such as carbon disulfide prior to separation and analysis by means of a gas chromatograph with a flame ionization detector.

Sampling is done by means of a personal sampling pump plus the charcoal tube. In any such sampling, one charcoal tube must be a blank. It should be handled in the same manner except for taking the air sample.

Direct Reading Colorimetric Indicators. Glass indicating tubes containing solid chemicals which react with the contaminant sampled to give a stain or color are convenient and compact reading devices. The earliest indicator tube was the carbon monoxide tester, developed by the National Bureau of Standards. When manufactured in accordance with the Bureau's rigid specifications, concentrations of carbon monoxide can be detected in the range of 0.001 to 0.10 per cent by volume (10 to 1,000 parts per million). In the presence of carbon monoxide, the color intensity indicates the concentration of the gas immediately. A revolving color scale brings the various shades of color into position for direct comparison.

Another type of carbon monoxide detector gives a length of stain rather than a matching color. Confirmation of carbon monoxide poisoning is made by measuring the carboxyhemoglobin in the blood.

There has been a great expansion in the devlopment and use of direct colorimetric indicators. Tube sampling kits are commercially available for measuring more than 100 different chemical atmospheric contaminants. Generally, the supporting material is silica gel, alumina, ground glass, pumice, or resin. This is impregnated with a chemical indicator. There are many problems in the manufacture of these tubes. Very close controls must be kept on the purity of the supporting material and the chemical indicator.

Electrostatic Precipitator. For sampling particulates and certain aerosols, an electronic precipitator can realize better than 99.9 per cent efficiency. This model samples at a rate of three cfm and is maintained constant by means of a voltage stabilizer. It can be used for general room sampling or breathing zone sampling. The samples must be sent back to the laboratory for analysis.

Midget Impinger. The midget impinger is a portable, hand-operated instrument for dust sampling in any location. It can be operated by a hand-cranked pump or adapted to be used with compressed air or electric current. The operating principle is that air is impinged at high velocity against a glass plate. The particulate matter, momentarily arrested by the impinging process, is wetted by the water or absorption liquid and thus is trapped. The midget impinger in conjunction with a fritted tube can be used to collect samples of such substances as acid gases or mists in an appropriate medium.

Personal Samplers. There are many varieties of automatic personal samplers on the market for the measurement of toxic dusts, gases, and vapors. They can be used in conjunction with available accessories, reagent kits, and filter papers.

Air is drawn through the selected sample collector by a battery diaphragm pump or positive displacement vane rotary pump, with a built-in sample flow indicator controlled by sample and by-pass valves. The battery can be recharged from a 110 volt A.C. line.

Direct Reading Trace Gas Analyzer. Detection of minute concentrations of gases or vapors in air can be by instruments specifically calibrated for a particular contaminant. Principles of operation vary, but generally they operate using some modification of the Wheatstone Bridge circuit principle and measuring the flow of ion current. The effect of the contaminant on the conductivity of the ion chamber is a measure of the concentration of the gas or vapor of interest.

The Sequential Sampler. The sequential sampler can be used to collect consecutive air samples with midget impingers, bubblers, or filter sampling equipment. The operating principle in this sampler is that solenoid valves programmed by a built-in timer connect to a common header and vacuum pump. The unit can be operated to collect consecutive samples for sampling periods varying from two minutes to three hours.

Carbon Monoxide Alarm Detector. A color change is detected by a photo-optical system which automatically operates a relay and sounds an alarm. It will detect concentrations as low as 50 ppm.

Sound Level Meter. There are many manufacturers of sound level meters. Also available are personal noise exposure meters which can be a tached to the worker to measure, monitor, and record duration of exposure time to levels above a pre-set intensity (dbA level). This type of instrument provides a means for conducting personal surveys.

The sampling equipment and associated items which will be supplied to compliance officers of the Department of Labor include: light meter, indicator tubes, portable sampling pump, electric sampling pump, mercury vapor detector, sound level meter and field calibrator, air pressure vacuum gauge, calibrator rotameter, and Cahn electrobalance.

Conclusion

The effective testing of the in-plant environment requires a well-designed plan of approach. No single outline of sampling procedure and analysis is available or universally acceptable. The procedure followed depends on the nature of the substance or physical conditions involved, the intensity of exposure, the duration of exposure, and the susceptibility of the person exposed. The latter has not been discussed but should be given consideration in conjunction with the medical department.

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SAFE HANDLING OF SOLVENTS IN CENTRIFUGE OPERATIONS

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A nitrogen purge-oxygen analyzer system is designed to protect against fire and explosion hazards while extracting products from their flammable solvents in the centrifuge.

In the manufacture of various pharmaceuticals and fine industrial chemicals at Geigy's multipurpose Cranston, R. I., plant, stainless steel centrifuges are used to extract products out of such organic solvents as toluene, acetone, methanol, isopropyl alcohol, monochlorobenzene, and Amsco spirits. As with any operation employing highly volatile and flammable solvents, provisions must be made to avoid the basic danger of these materials being ignited and possibly exploding. Therefore, to remove any remote chance of fire within the centrifuging equipment, a system was designed for reducing the concentration of oxygen inside the units to a point well below the ignition requirements of the solvents present. Special precautions were also taken to reduce the possible causes of sparking, principally static electricity.

Geigy's basic centrifuging systems consist of vertical basket-type centrifuges ranging in diameter from 30 to 48 in., with portable bins for collecting the solid products and horizontal stainless steel receiver tanks located on the floors below the centrifuges for collecting the solvent mother liquors and/or wash liquids. The systems are fed by hoses from the bottom drain connections of any of several different reactors supported through the ceilings above the centrifuges.

To purge the centrifuging system effectively and economically, it must be essentially airtight with a vent on the downstream side only and be capable of withstanding a slight positive pressure. Because of the nature of the centrifuges installed at the Geigy plant, the sealing problem required a major concentration of effort to obtain an adequate solution. The units in question are of the bottom-discharge type with plowing attachments such as are represented by the Sharples 30-in. diameter Tornado. The air-driven plow must be adequately sealed for the internal pressures to be encountered. In most instances a portable bin is used to collect the plowed-off wet cake. It, too, must be completely sealed with the centrifuge bottom discharge. This closure is accomplished by the use of a flexible sleeve that connects the bottom discharge of the centrifuge to a bin cover. The bin cover is raised and lowered by the use of four pneumatic cylinders operated in unison and contains a Teflon-covered foam rubber gasket for sealing against the open top flanges of the portable bins.

The centrifuge and associated equipment are purged using nitrogen from the plant utility system. Nitrogen from the supply header passes through a solenoid valve and flow switch after which it is divided, half going through a flow indicator and flexible tubing to the top of the centrifuge curb and the other half similarly passing through a second flow indicator and flexible tubing to the portable bin cover. A bypass around the flow switch and rotameter to the bin cover connection is provided in larger size tubing. This bypass line contains a solenoid valve and manually operated spring-loaded ball valve piped in parallel. It is used to shorten the time period required for the initial purge of the equipment and to provide a means of giving the system a large shot of inert gas if a leak develops during a run or some other emergency. Gases are purged out of the centrifuge and product bin through the centrifuge vent line to the receiver and from the receiver to the atmosphere. The centrifuge vent line contains a three-way valve which is used to bypass the receiver when water-washing the product cake or centrifuging out of an aqueous slurry. The receiver vent line also contains a three-way valve which is used both to purge the receiver and to blow the solvent collected in the receiver to another location. Downstream of the three-way valve in the receiver vent line is a flow indicator and pressure-regulating relief valve piped in parallel. This relief valve is used to prevent the entire system from becoming over-pressurized and to provide protection for the various flexible connections.

An oxygen analyzer monitors the atmosphere within the centrifuge. A continuous sample of the gases present is drawn from the centrifuge vent line or top of the centrifuge curb through a filter and into a pump. From this pump it is driven through a moisture trap to eliminate any liquids that may have condensed, passed through the oxygen analyzer cell, and exhausted to the atmosphere. The oxygen analyzer instruments themselves operate completely automatically and require no more attention than a weekly calibration check. They are composed of two separate components. The analyzer unit consists of a microfuel measuring cell with its temperature control and compensation components, a flow manifold, and electric transmission elements all housed in an explosion-proof enclosure on top of which is an explosion proof gauge. This equipment is located in a suitable position in the vicinity of the centrifuge. The control unit, which consists of the electronics of the system, including the main meter, is located away from the centrifuge in a motor control room to avoid the cost of explosion proofing. The measuring cell itself is a solid-state structure with a usable life of about six months. Its operation is similar to that of a dry cell battery consuming oxygen from the gas around it and generating a proportionate microampere current that is amplified and converted to use by the rest of the instrument. The oxygen analyzer has an accuracy of two per cent and is capable of providing a reading of 90 per cent of the oxygen content of the sample gas within 10 seconds where the carbon dioxide content is between 0 and 0.1 per cent and the flow rate past the cell is at least 140 cc/min.

The following general procedure is followed in the operation of the centrifuge systems:

1. An empty portable bin is properly positioned under the centrifuge and sealed to the bottom discharge connection using the bin cover mechanism.

2. The three-way centrifuge vent valve is positioned to direct the vent gases from the centrifuge into the receiver. The three-way receiver vent valve is positioned to direct the vent gases from the receiver through the flow indicator to the atmosphere.

3. The liquid effluent valves are opened and the drains closed to permit the flow of mother liquors from the centrifuge to the receiver.

4. The manually operated feed and wash control valves are closed.

5. The centrifuge internals and plow operation are checked and the centrifuge cover is securely closed.

6. Since the centrifuge unit has been completely opened prior to the start of this operation, it should be full of air and the oxygen analyzer gauge should read about 21 per cent.

7. The centrifuge switch is now placed in the on position. This will turn on the oxygen analyzer sample pump, start a time delay relay, and energize the main nitrogen solenoid valve, opening it so that nitrogen will begin flowing through the flow switch and the rotameters into the centrifuge.

The nitrogen bypass solenoid valve now also will be energized and opened, thus al-

lowing nitrogen also to bypass the flow switch and rotameters and flow directly into the bottom of the centrifuge through a one-half inch line. This will provide a fast purge of the centrifuge system and minimize the time delay required before the unit is ready to operate.

8. The centrifuge pressure gauge located on the centrifuge vent line will indicate a pressure in the system of about 7 in. of water, which is the set pressure of the relief valve in the receiver vent line. The nitrogen pressure gauge will now indicate a positive pressure of about 5 psig, which indicates that nitrogen pressure is available for the purging of the system. The purge rotameters will indicate a full flow of nitrogen through these instruments to the centrifuge. During this initial purge period, most of the nitrogen is, of course, bypassing the nitrogen flow switch and rotameters and freely flowing directly into the centrifuge from the 22 psig plant supply header. However, if for any reason the flow of nitrogen through the flow switch is interrupted for more than one second an alarm horn will sound, a red blinking light will come on, and the system time-delay relay will stop, automatically stopping the start-up of the equipment. During this period of the cycle, the only thing that can cause an alarm and emergency shutdown is a nitrogen failure. The nitrogen flow switches have a one second delay incorporated into their electrical controls and, therefore, any momentary loss of the purge gas or oscillation of the supply will not cause an unnecessary shutdown of the centrifuge.

9. Automatic time delays have been built into each of the centrifuge systems to permit the inert gas purging of the equipment prior to the starting of the centrifuges. Locally mounted yellow indicator lights are lighted for the duration of this purge cycle, during which time the oxygen content of the gases inside the systems is reduced to a safe limit. The operator can observe the local oxygen gauge slowly going from an initial reading of 21 per cent to below five per cent during this period. For the solvents being used at the Geigy plant, a lower explosive limit of eight per cent oxygen was found to be safe. Therefore, the oxygen analyzer controls have been set to shut the centrifuge systems down if the oxygen content of the atmosphere within the centrifuge rises above six per cent; the operators have been instructed to maintain the running units at levels below five per cent oxygen. This criterion provides an adequate safety margin and allows for the small possible variations in the oxygen content of the gases at the various locations inside the equipment in relation to the analysis at the sampling point. The initial purge time delay starts the instant the centrifuge switch is turned to the on position. Its duration depends upon the size and configuration of the particular equipment involved and runs from about 10 minutes for the largest unit to about four minutes for the smallest unit. At the conclusion of the time delay, a locally mounted green indicator light will come on, indicating that the motor for the centrifuge hydraulic drive has been started, the automatic pneumatically operated valves in the feed and solvent wash lines to the centrifuge have opened, the nitrogen bypass solenoid valve has closed cutting off the flow through the one-half inch purge line so that all of the inert gas going to the centrifuge must flow through the nitrogen flow switch and rotameters, and the oxygen analyzer is now electrically interlocked with the equipment.

10. The oxygen content within the centrifuge system will gradually fall during the initial nitrogen purge cycle. At the end of this cycle and by the time the centrifuge hydraulic motor has started, the oxygen content of the gases inside the centrifuge will be down to approximately two to five per cent. A flow of about 1 to 1 ½ cfm nitrogen is normally required to maintain a safe oxygen concentration. If at any time while the equipment switch is in the on position and after the initial purge cycle the oxygen content of the gases inside the centrifuge rises above the set point or if there is an interruption in the flow of nitrogen into the equipment, the following will occur: the locally mounted alarm and red indicator warning light will come on, the automatic air operated valves in the feed and wash lines will close, the centrifuge speed controls will automatically be pushed to the stop position and, after a delay of about 1½ minutes to allow the centrifuge basket to stop

or at least slow down below a critical speed, the hydraulic drive electric motor will also stop. In this state, and as long as the system switch remains in the on position, the controls are so designed as to permit the continued flow of nitrogen into the centrifuge.

11. The centrifuge is now operated in its normal manner. However, when being fed from a reactor or other vessel, this feed tank must also contain an inert gas blanket to prevent the entrance of oxygen into the system from this source, especially when emptying the feed vessel.

In addition to the above noted safety precautions, all of the centrifuge systems and their associated piping have been suitably bonded and grounded to reduce the possibility of sparking caused by static electricity.

Ten centrifuging units utilizing the above noted safety modifications were placed in operation by Geigy during the period December 1967 to May 1968 and an eleventh unit in January 1969. Three more systems are presently under construction in a new pilot plant facility. Although some minor problems were encountered initially, especially with the older centrifuges, on the whole the systems have given Geigy very satisfactory safe operation since their installation.

Geigy is of the opinion that the nitrogen purge-oxygen analyzer system as now installed on the centrifuging systems provides all the necessary safeguards to protect the operating personnel and process equipment from the hazards of explosion and fire in the handling of highly flammable and volatile solvents. Although the operation of this system is more time consuming from a production point of view and much more expensive to operate because of the inert gas and maintenance costs involved, the money and time are considered well spent for the resulting safeguards achieved.

PRACTICAL SOURCES OF INFORMATION ON CHEMICAL SAFETY

Compiled by H. H. FAWCETT
National Research Council, Washington, D. C.

In order to keep abreast of current developments in chemical safety, many sources of information must be consulted. Books and printed matter quickly become outdated. Therefore, several practical sources of information are recommended to encourage wider use of a broad base approach. It is recognized that the following is incomplete, but may serve as a guide to other sources.

Emergency response systems are indicated by an asterisk. All other listings are non-emergency.

ASSOCIATION OF AMERICAN RAILROADS

Director & Chief Inspector
Bureau of Explosives—Room 620
Association of American Railroads
American Railroads Building
Washington, D. C. 20036
Area Code 202/293-4048*

AMERICAN CHEMICAL SOCIETY

The 174 local sections of the American Chemical Section are interested in assisting in chemical safety wherever practical and should be considered as a source of scientific expertise. The Committee on Chemical Safety of the A.C.S. will also assist whenever possible. The address and telephone number is the same as listed. For the names and addresses of the officers of the local sections, write to

American Chemical Society
Local Sections Operations

1155 Sixteenth Street, N.W
Washington, D. C. 20036
Area Code 202/RE7-3337—Ext. 465

DEPARTMENT OF COMMERCE—BUREAU OF STANDARDS

National Bureau of Standards
Washington, D. C. 20234
(Fire Research And Safety Information Collection)

Office of Flammable Fabrics
Area Code 301/921-3116

Office of Fire Research and Safety
Area Code 301/921-3175

Chief, Fire Research Section
Building Research Division
Area Code 301/921-3461

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE

Food and Drug Administration and Public Health Service
Bureau of Radiological Health
5600 Fishers Lane
Rockville, Maryland 20852
Area Code 301/443-4690

Office of Information
Area Code 301/443-3434

Division of Electronic Products
Area Code 301/443-4016

Division of Hazardous Substances
& Poison Control
Bureau of Product Safety
5600 Fishers Lane
Rockville, Maryland 20852
Area Code 202/496-7606

Poison Control Center
Area Code 202/496-7616

Toxicology Information Program
National Library of Medicine
8600 Rockville Pike
Bethesda, Maryland 20014
Area Code 301/496-1131

DEPARTMENT OF THE INTERIOR—BUREAU OF MINES

Coordinator of Explosives Research
Interior Building Room 4559
18th and C Sts., N.W.
Washington, D. C.
Area Code 202/343-3500

Director, Safety Research Center
(Combines Explosives, Explosions, Health and Safety Research)
4800 Forbes Avenue
Pittsburgh, Pennsylvania 15213
Area Code 412/621-4500 Ext. 260

DEPARTMENT OF LABOR

Information Services
Occupational Safety & Health Administration
1726 M Street, N.W.
Washington, D. C.
Area Code 202/961-3914

FEDERAL FIRE COUNCIL

The Federal Fire Council coordinates fire prevention efforts for the Federal government, but will also service non-governmental requests whenever possible. The Fire Council Library (now at the Bureau of Standards FRASIC collection), is an excellent source of reports and other publications.

Staff Director, Federal Fire Council
7th and D Streets, S.W.
Washington, D. C. 20407
Area Code 202/962-6228

MANUFACTURING CHEMISTS ASSOCIATION

M.C.A. CHEMTREC (Chemical Transportation Emergency Center) is designed to provide immediate emergency-type information regarding hazardous chemicals in transportation, on a 24-hour basis.

Manufacturing Chemists Association
1825 Connecticut Ave., N.W.
Washington, D. C. 20009
Toll free number
Area Code 800/424-9300*

The Safety and Fire Protection Committee of the M.C.A. develops useful information on the safety and fire aspects of chemicals. Approximately 100 data sheets, plus chemical information cards and water transport information cards are available.

Manufacturing Chemists Association
1825 Connecticut Ave. N.W.
Washington, D. C. 20009
Area Code 202/HU3-6126 Ext. 242

NATIONAL AGRICULTURAL CHEMICALS ASSOCIATION

National Agricultural Chemicals Association
1155 Fifteenth St., N.W.
Washington, D. C. 20005
Class B agricultural poisons
Area Code 202/296-1585
Emergency Calls (24-hour response)
Area Code 513/961-4300*

NATIONAL ACADEMY OF SCIENCES—NATIONAL RESEARCH COUNCIL

NAS-NRC-NAE
2101 Constitution Avenue, N.W.
Washington, D. C. 20418

Committee on Fire Research
Area Code 202/961-1486

Committee on Hazardous Materials
Area Code 202/961-1579

NATIONAL FIRE PROTECTION ASSOCIATION

The numerous publications of the N.F.P.A. include a *Fire Protection Guide on Hazardous Materials,* 3rd Ed., 1969, which includes 325A, 325M, 49, 491M and 704M. For availability of this book, plus other services and advice, contact

The National Fire Protection Association
60 Batterymarch Street
Boston, Mass. 02110
Area Code 617/482-8755

NATIONAL SAFETY COUNCIL

The Industrial Department of the N.S.C. includes: (a) Chemical Section, (b) Research and Development Section, (c) Public Employees Section, Fire Division, (d) Occupational Health Nursing, (e) Industrial Hygiene. Each has a staff representative. In addition, the NSC Library has extensive collections of literature on chemicals and other materials, and will assist in locating desired data.

The National Safety Council
425 N. Michigan Avenue
Chicago, Illinois 60611
Area Code 312/527-4800
(ask for services desired)

NEW YORK STATE

Information on fire aspects of chemicals in emergencies is available on a 24-hour basis.

Division of Fire Safety
155 Washington Avenue
Albany, N. Y. 12210
Area Code 518/474-6746
Note: Radio contact by KDX 409 on 45.88 mHz or KLG 647 on 45.56 mHz.

OFFICE OF CONSUMER AFFAIRS

Office of Consumer Affairs
Executive Office of the President
New Executive Office Building
Washington, D. C. 20506
Area Code 202/395-3682

Director for Industry Relations:
Area Code 202/295-3320

UNDERWRITERS' LABORATORY, INC.

Underwriters' Laboratory has extensive "chemical" files, acquired during evaluation and labeling. Ask for specific services desired.

Underwriters' Laboratory, Inc.
207 E. Ohio Street
Chicago, Illinois 60611
Area Code 312/642-6969

CANADIAN CHEMICAL PRODUCERS' ASSOCIATION

The Transportation Emergency Assistance Plan (TEAP) is an industrywide program of the Canadian Chemical Producers' Association (CCPA). It enlists the cooperation of its members and co-ordinates their

efforts to provide technical advice and assistance to police, fire and civil protection authorities in the event of highway, rail, and marine accidents involving chemical products. Further information may be obtained by writing to

The Canadian Chemical Producers' Association
Suite 2121 Tower "A"
Place de Ville
Ottawa, Canada

INDUSTRIAL HEALTH FOUNDATION

This group, whose membership includes over 400 companies and other groups, abstracts, researches and coordinates knowledge on industrial health and safety problems. For information on services (including excellent monthly abstracts and other services), contact

Industrial Health Foundation
5231 Centre Avenue
Pittsburgh, Pa. 15232
Area Code 412/687-2100

INTERNATIONAL LABOUR ORGANIZATION, GENEVA, SWITZERLAND

This group, founded under the League of Nations in 1920, is part of the United Nations, and has 121 national members. The Health and Safety Center abstracts and redistributes 30,000 documents per year of world literature and prepares 2,500 cards under the CIS system. For service details contact the

International Labour Office
666-11th Street, N.W.
Washington, D. C. 20001
Area Code 202/638-5656

or write directly to
International Occupational Safety
& Health Information Centre
International Labour Office
1211 Geneva 22,
Switzerland

AMERICAN MEDICAL ASSOCIATION

American Medical Association
Office of Occupational and
Environmental Health
535 Dearborn
Chicago, Illinois 60610
Area Code 312/527-1500 Ext. 481

NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

National Institute for Occupational
Safety & Health
1014 Broadway
Cincinnati, Ohio
Area Code 513/684-2693

OAK RIDGE NATIONAL LABORATORY

Nuclear Safety Information
Oak Ridge National Laboratory
P.O. Box Y

Oak Ridge, Tennessee 37830
Area Code 615/483-8611
Ext. 3-5453

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UNISIST

The United Nations Educational, Scientific and Cultural Organization and the International Council of Scientific Unions have recently completed a feasibility study on a World Science Information System (UNISIST). The results of this study are published in two forms: a full report and the abridged version, or synopsis.

Both the report and the synopsis are available in English, French, Russian and Spanish. The report was used as a reference document at the Intergovernmental Conference for the Establishment of a World Science Information System (UNISIST), which was held from 4th to 9th October, 1971 at Unesco House, Paris. The Synopsis was used as a working document for the Conference.

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EVALUATION OF CHEMICAL STABILITY

By DR. ROBERT D. COFFEE
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Predicting the explosive potential of a substance before producing it in quantity is made possible through a series of tests developed in Eastman-Kodak laboratories.

In 1969 a tank car of anhydrous ammonia splits open in a derailment in Crete, Nebraska. Nine persons are killed; 40 more are injured from the effects of the fumes.

In 1969 a freight train derails in Laurel, Mississippi, and 13 cars filled with propane gas blow up in the ensuing fire killing two, injuring 33.

In 1969 a gasoline truck crashes in Warsaw, New York, and sends rivers of flaming fuel through the town's sewer system. Four homes are incinerated and one man is killed.

The consequences of these accidents were not unexpected. The properties of the commodities involved were well known prior to the incidents mentioned. But let's take a look at a few other examples:

In 1958, there were two separate detonations of tank cars of nitromethane. In both incidents there were many injuries and over $1,000,000 in property loss.

In 1964, propargyl bromide was involved in a probable detonation which destroyed a plant, killed three people, and injured five others. In 1966, propargyl bromide was involved in another detonation which killed three people and caused over $1,000,000 in damages.

In 1960, a plant making aniline detonated after many months of successful operation.

Why? In each case the results were quite unexpected from the knowledge available at the time. However, full explanations were obtained from laboratory investigations made soon afterwards.

It is probably quite true that exhaustive testing of any one chemical will never disclose all the potential hazards. The combina-

tions and permutations involving binary mixtures alone are legion without even considering the ever widening gamut of environmental conditions. Even so, one does not throw up one's hands in hopeless despair. Something can be done. The most probable hazards can be discovered, permitting measures to be taken to prevent or minimize an incident. However, because of the rapidly growing list of new chemicals, a systematic approach to hazard evaluation must be developed. Fortunately, a number of conscientious professionals have been working towards this end for a number of years. As a result there is fairly general agreement that no one test will ever be sufficient for an assessment of potential hazard. The members of ASTM Committee E-27 have concluded that, exclusive of toxicity determinations, at least three tests are required to establish even a crude ordering or grouping of hazardous chemicals. They consider that, for a basic evaluation of potential hazards, computation, thermal analysis, and impact sensitivity will often suffice. Accordingly, they have established as their first order of business the development of standard equipment and test methods in these three areas.

Basic System

Since tens of thousands of new compounds are synthesized in our laboratories each year, some sort of a screening system becomes essential. The integrity of our plants and the health of our people are dependent upon the early recognition of the potential hazards of these compounds. Furthermore, the government, at both the Federal and state levels, and the courts are making it more and more clear that they expect the manufacturer to know the hazards to be encountered from the use of their chemicals and to be legally and financially liable for any damages resulting therefrom.

The system must conserve both time and material and be simple to follow. Most authorities now would agree that it is important to first characterize the thermal stability and impact sensitivity of a new chemical. In recent years, the Technical Safety Laboratory (Eastman Kodak Company) has also found that computational methods are of considerable value in predicting potential explosion hazards. Thus, with a few simple laboratory tests requiring less than a gram of material, plus some computer analyses, the laboratory feels that it can now characterize the explosion potential of a new chemical with some degree of confidence.

Similarly, the Laboratory of Industrial Medicine can often predict the potential health hazards by analogy or from a few basic screening tests.

Keeping in mind that supplemental tests may often be necessary to define particular hazards, let's see what we can learn from computation, thermal analysis, and impact sensitivity.

Computation

Many organic compounds or mixtures of compounds contain sufficient energy so that if they were to decompose or react in the right manner a dangerously high concentration of energy might be released. Whether or not this could happen depends on environmental conditions and chemical kinetics. Thus, it is desirable to know when such an energy release is thermodynamically possible so that this information may be used to appraise the hazard potential of the compound or reaction mixture even before the first gram of material is synthesized.

Personnel at our Tennessee Eastman Research Laboratories have devised mathematical methods for both locating the exact reaction by which a compound or mixture would have to react in order to generate the maximum energy release possible and for calculating the actual value of this maximum heat-of-reaction($_{\Delta}H_r$). These methods have recently been translated to a computer program which will be the basis of a forthcoming ASTM Standard: The CHETAH Program.

In order to locate the most energetic possible decomposition or reaction, the logic of the program considers every stoichiometrically possible reaction that can occur without violating the rules of chemical bonding. Linear programming techniques are employed to select from among all of the reactions which have negative free energies of reaction the one that has the most negative (exothermic) heat of reaction.* By correlating the computations for approximately 130 compounds and mixtures which included known explosives and mixtures reported to have caused explosions as well as compounds considered to be non-hazardous, it was found that a reaction with a ΔH_r greater than 0.7 K cal/g could be potentially explosive. The computer program, however does not guaranted a material to be either safe or hazardous since a few known mixtures and compounds, such as azides, do not now fall in with this general correlation. Nevertheless, the computations do indicate in a general way when the first few experimental grams of material may be synthesized in the laboratory in relative safety and when special precautions should be followed. If ΔH_r is greater than 0.7 K cal/g, then it is strongly recommended that not more than one gram of material be prepared and further evaluated before making larger quantities.

The computation does not state that a compound or mixture will or will not explode. Since it ignores kinetics it merely shows the presence or lack of a potential energy release. It is designed primarily to disclose those systems theoretically capable of explosive decomposition or reaction.

The potential hazard of a system may be rated "High," "Medium," or "Low," depending upon the calculated heat of decomposition (ΔH_d).

High	$\Delta H_d > 0.7$ *cal/gm*
Medium	$\Delta H_d > 0.7 < 0.4$
Low	$\Delta H_d < 0.4$

Recent work† by D. R. Stull seems to show that the probability of this energy release may be indicated by correlating the difference between the heat of combustion and the heat of decomposition ($\Delta H_o - \Delta H_d$) with the heat of decomposition (ΔH_d).

*The methods of Van Krevelen and Chermin1 and of Verma and Doraiswamy[2] are used to evaluate the free energies of formation and the heats of formation of the compounds at the specified temperatures.

†D. R. Stull; "Identification of Potential Chemical Reaction Hazards," *Loss Prevention*, Vol. IV (1970).

A cursory examination of the data being generated for two hundred plus bulk chemicals of interest to the U. S. Coast Guard shows that almost all of the compounds and their binary mixtures may be considered "low order." Individual compounds and binary mixtures may produce heats of reaction and generate pressures capable of rupturing containers through the development of vapor pressure and/or gas generation, but they do not seem to indicate a potential for explosive decomposition. The CHETAH program is not capable of further ordering the spectrum of hazard at this energy level. However, there are indications that other computational approaches may be successful. The approach may involve the application of the electron donating and accepting properties of Lewis acids and bases which are determinable through IR Analysis* (The ASTM Task Group on Computational Approaches to Hazard Evaluation proposes to explore this equally important area once their more generalized basic program has been completed.)

Impact Sensitivity

Because chemicals must often be pulverized, blended, pumped, and otherwise roughly treated for processing and transport, their reactions to these mechanical stimuli must be known early in the chemical's history. Thus, the second basic test in this system of evaluation is the determination of impact sensitivity.

For the testing of solid materials, the Technical Safety Laboratory utilizes the drop-weight tester** of Guillet and Meyers.3 For liquids, the Olin drop-weight tester*** is used.

Since the solids tester requires 40 mg. of sample per drop and the liquid tester 0.030 ml. of sample, 120 mg. or 0.100 ml. will

*Bull. Chem. Soc. of Japan, 41, pp. 767-773.

**A modification of the U.S. Bureau of Mines impact tester which permits an estimation of the amount of gas evolved on decomposition.

***This tester was originally developed by the Joint Army-Navy-Air Force Panel on Liquid Propellant Test Methods as Test No. 4. More recently, it has appeared as ASTM D2540-66T: "Tentative Method of Test for Drop-Weight Sensitivity of Liquid Monopropellants."

usually suffice for a go/no-go criteria, whereas about one gram or one ml. will be required for the determination of the 50 per cent level by the Bruceton up-down technique.[4]

It is generally conceded that impact levels of 550 in/lbs (solids) or 100 kg/cm (liquids) are greater than those normally encountered in practice.

Thermal Analysis

The third basic test comprises the determination of thermal stability and in reality consists of two tests: (1) Differential Thermal Analysis, DTA; and (2) Constant Temperature Stability, CTS. For hazard evaluations, the Du Pont Model 900 is used with a sample weight of five mg. and a temperature scanning rate of 30°C/minute. Accuracy is not critical since exothermic responses are rate dependent. The objective of the test is to quickly determine whether a sample will produce an exotherm and to approximate the temperature at initiation. The magnitude and sharpness of the exothermic response may be given some significance, but only qualitatively.

Because of the rate dependency, CTS studies are required for those materials exhibiting exotherms. Here, a small sample is held at some constant temperature below the temperature of initiation as approximated by the DTA curve. If an exotherm is found, the test is repeated at a lower constant temperature until a temperature level is found which will not produce an exotherm in a two-hour test period.[5]

Recently, there have been indications that the DTA approach may have to be further expanded, since examples have been found where the use of a capillary sample tube produces an exotherm which is not noted by the use of a flat pan, and vice-versa. Thus, it may be necessary to run tests with capillaries, flat open pans, and flat sealed pans as well as simultaneous DTA and TGA (Thermo-gravimetric analysis) measurements.

Interpretations

Knowledge of the behavior of similar chemicals plus the information gained from these three basic tests—computation, impact sensitivity, and thermal analysis—may be used to order the chemicals according to their degree of potential hazard. Table I shows that eight combinations of results are possible, with the potential explosion hazard increasing in a general way, with the combination number. Within each combination there are varying degrees of hazard depending upon the magnitude of the test results, and thus there is bound to be some overlapping. Some day it may be possible to apply suitable weighting factors which will enable the derivation of a "hazard number," but this aspect of the system has not been extensively explored.

The current studies for the Coast Guard indicate that the compounds and mixtures being considered seem to fall in groups 1 and 2.

When a chemical is about to graduate from the laboratory to pilot plant production, additional tests are usually required to define specific hazards related to conditions of manufacture, storage, and transport. Such tests should include the determination of flash points, explosive limits, autoignition temperature, dust explosibility index, etc. At the same time, a more comprehensive evaluation of the toxicity and health hazards should be initiated.

TABLE I

Comb. No.	Thermal Stability	Impact Sensitivity	Heat of Reaction
1	–	–	–
2	+	–	–
3	–	+	–
4	–	–	+
5	+	–	+
6	–	+	+
7	+	+	–
8	+	+	+

Code

Thermal Stability
- – no exotherm
- + exotherm by DTA

Impact Sensitivity
- – above 550 in/lb (solids) or 100 kg/cm (liquids)
- + less than 550 in/lbs or 100 kg/cm*

Heat of Reaction
- – below 0.7 K cal/g
- + above 0.7 K cal/g

Maximum values of impact for test equipment.

How the data from the three basic tests may be used and interpreted is best illustrated by presenting and discussing several typical examples.

Combination No. 1 (– – –)

Materials such as acetone, alcohol, benzene, dimethyl terephthalate, etc., show no exothermic activity, are not impact sensitive, and give values of ΔH_r less than 0.7 K cal/g. Fortunately, a large proportion of our common chemicals fall within this group. Being organic materials, however, they are not without hazard. They will burn and are capable of potentially severe explosions when their vapors or dusts are admixed with air in suitable proportions. This classification system only indicates that they will not decompose suddenly or violently and that therefore they may be prepared and handled in small quantities in the laboratory with the observance of general laboratory precautions. Additional classification systems or factors (including human response) must be considered when the chemical is to be produced or used in the plant.

Combination No. 2 (+ – –)

Theoretically, this combination of factors is not possible, except for very low order exotherms, and usually results either from inadequacies within the present computer program or from sample imputities. However, the combination is observed with sufficient frequency to warrant attention and in most cases serves as a warning flag for what may be an unsuspected hazard. Dihydrofuran falls in this group. The DTA curve for one sample clearly indicates a strong exotherm immediately after the boiling endotherm at 72°C. Since the dihydrofuran has boiled away at 72°C, the exotherm must be due to the decomposition of a residue. In this case, a peroxide was suspected and later confirmed. Thus, although such materials may be prepared and used in relative safety, special precautions are indicated during distillation or purification. The laboratory has found that most materials exhibiting this combination of factors have subsequently been found to be potential peroxide formers. So far, other unstable byproducts have been indicated only on rare occasions.

Combination No. 3 (– + –)

This combination of factors is relatively innocuous. The most common interpretation given is that the material may decompose under impact but that the decomposition is endothermic and therefore will not propagate. A typical example would be sodium bicarbonate, which can be made to decompose under test conditions with the evolution of carbon dioxide. However, this does not present a significant laboratory hazard.

Combination No. 4 (– – +)

When this combination is observed, it must be considered real until proven otherwise. Fortunately, it does not occur very often. The classification system, however, does indicate that the material may be made in small quantities with a reasonable assurance of no incidents. On a large scale, the story may be quite different. One example is 6-chloro-2, 4-dinitroaniline, which exhibits no exothermic instability by DTA, is not impact sensitive at 550 in/lbs, but does give a ΔH_r of at least 0.7 K cal/g. Subsequent testing showed that the material can be made to detonate using a tetryl booster with a yield equivalent to fifty per cent that of an equal weight of trinitrotoluene (TNT).

Thus, this combination warns that further and extensive testing is required before engaging in large scale production.

Combination No. 5 (+ – +)

This combination is most often associated with solid materials which may be classed as "high explosives." These materials are thermally unstable, but often at a relatively high temperature, and are capa-

ble of releasing large amounts of energy instantaneously under the proper conditions. Fortunately, these conditions are not normally encountered in laboratory preparations and small amounts may be prepared using suitable precautions such as providing barricades, limiting sources of heat, and utilizing no conditions of heavy confinement.

These materials are impact sensitive but not under the conditions of the laboratory test. Thus, they require an impetus greater than that to be expected from normal handling or processing conditions.

Combination No. 6 (− + +)

Usually it will be found that the sample is a liquid when this combination is encountered. It does not mean that exothermic decomposition is not possible but only that it is not noticeable at atmospheric pressure. The exotherm occurs at temperatures above the atmospheric boiling point. Again, further testing is indicated. Propargyl bromide is a typical example. When heated under confinement at about 150 psia and a temperature of 180°C, the liquid decomposes violently and may detonate.6

Combination No. 7 (+ + −)
Combination No. 8 (+ + +)

In reality, Combinations 7 and 8 differ only in degree. The ΔH value may be real, in which case 7 should indicate a lesser hazard than 8, or it may be due solely to a fault of the computer program. However, when a material is found to be both thermally unstable and shock sensitive, it should be treated with utmost caution until larger scale tests have more clearly defined the degree of potential hazard. It will be found that azides, diazos, peroxides, perchlorates, nitro compounds, and the like fall into this group.

General Discussion

Since most organic chemicals are primarily constructed from atoms of carbon and hydrogen, the authorities and the general public expect them to be flammable or combustible and usually treat them accordingly. However, there are few signposts warning them which chemicals are capable of sudden energy release. Thus, the system depicted here, although developed primarily for the preliminary classification of new chemicals, may be used to provide one factor of a classification system for chemicals in transport or storage. In general, chemicals in groups 1, 2, and 3 do not release energy suddenly; chemicals in groups 4 and 5 are capable of high energy release but are difficult to initiate, while groups 6, 7, and 8 represent chemicals capable of high energy release and ready initiation.

A careful study of the system will disclose many reasons why a single test is considered inadequate for establishing a general classification. A single test method is only suitable for establishing the relative sensitivity of a material to a particular stimulus. Similarly, this classification is only suitable for establishing the relative potential of a chemical or a reaction mixture to release energy suddenly and to indicate to some extent the relative amount of energy released. It does not consider other potential hazards such as flammability, reactivity, toxicity, etc. For these hazards other criteria are needed.

Summary

A system has been developed for establishing the relative potential of a chemical to release energy suddenly and to indicate the relative magnitude of that energy release. The system is based upon three simple tests requiring a minimum of sample (1 gram or 1 ml.): (1) computation; (2) impact sensitivity; and (3) thermal stability. Sufficient examples have been provided to illustrate the development and use of the system. Although developed primarily for the preliminary classification of new chemicals, the system is suitable for reaction mixtures as well. The system may also find application in providing one factor of a general classification system for chemicals in transit or storage.

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Fertilizer Sessions

ENVIRONMENTAL QUALITY—A POSITIVE APPROACH TO NEGATIVE SITUATIONS

By DONALD N. COLLINS
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A rebuttal of some current misconceptions regarding the use of fertilizer and its relation to environmental quality.

The clouds of controversy over contributions of American agriculture to the problems of water pollution continue to swirl and build higher and higher. At least three observations in regard to this controversy have become quite evident:

1. Public concern over the environment is not going to "just go away" or wear off.

2. Many sincere individuals are justly concerned about our quality of life and surroundings.

3. Agriculture and agri-industry is going to fall under more and more regulation.

Those of us devoted to American agriculture's greatness must be watchful and active in the effort to maintain a viable agriculture and protect it against unjust regulation.

Let me discuss those three observations a little more:

1. What many of us in agriculture thought was a passing craze—a "whistle-in-the-wind" type of concern based on radical charges—has grown into a nation-wide campaign, reaching through many levels of governmental and community activity. The 1970's surely will become the Great Environmental Decade. Like it or not, we all will feel increasing effects of the national effort to improve our surroundings. It will affect the way we live and the way we work for a very long time.

2. Many spokesmen for environmental activities are truly concerned and sincere in their efforts to promote healthier, more enjoyable surroundings for man. They are open-minded in their search for the best solution to proven problems and refuse to be prodded into hasty legislative or regulatory actions without sound facts on which to base their opinions. We in the fertilizer industry also endeavor to meet criticisms of our manufacturing processes and of our product use in a positive manner. Admittedly, it is difficult not to react in a defensive and negative way when faced with unfounded charges and emotional criticism. But we think it essential that each charge be checked out as thoroughly as current research will allow. Fortunately for all concerned, much of the emotionalism evidenced in early environmental movements is fading.

3. It is incumbent on those of us connected with agriculture to protect this vital arm of our economy from unjust and restrictive legislation. It is obvious, of course, that this serves the best interests of those in agri-business, but more importantly, it serves the best interests of our nation. Any hope of national prosperity and improved level of living rests on an economically strong agriculture. We must be more vocal about the important contributions agriculture has made and is making—and avoid the easy way out of controversy with "No comment" when asked for answers.

It is difficult for any industry, or individual for that matter, to react quickly to unsuspected attack. The last few years have made up a period of confusion for those connected with agriculture, as the production tools of farming have come under increasing attack.

The tremendous concentration of effort upon improving the productivity of the American farmer is now pointed to by some as something akin to inhumane activity. Scientific truth has been completely obscured in many cases by the attempt to gain headlines. What one eminent scientist vigorously asserts, another scientist, equally as eminent, vigorously refutes. The gray area thus formed by misinformation, conclusion-jumping, and "one-up-manship" grows deeper, wider, and more murky.

The wider this span, the more myths or misconceptions spring up, as well as debatable points. And only by discussing all sides of a question, by discarding that material lacking in fact, can an individual scientist or the public at large arrive at what is true.

The need for protecting our agricultural environment and improving soil fertility became evident in the U.S. soon after the early pioneers opened the West.

In Eastern and Southern States, vast native forests already had been stripped away for crop cultivation. On many acres soil had been ravaged by harsh water erosion. Hillsides were scarred with gullies. Free-flowing streams were choked with fertile silt washed from the land. The soils of the Great Plains were laid open by the plow. With vegetative cover gone, soil was blown away by the fast-moving prairie winds.

Devastating Dust Bowl conditions of the 1930's awakened America to the fact that soil and its fertility must be protected. In the 40 years that followed, fertile lands have been rebuilt and protected by farmers through soil conservation, wise land use, and fertilization to sustain crop productivity. Contour farming on hillsides, strip-cropping, correct crop fertilization, and improved pasture and range-land—these practices and more saved the soil and its life-giving nutrients. Farmers found that with intelligent soil management practices, the land could be conserved and still yield food and fiber in unequaled abundance—a direct contribution to America's greatness.

This continuing effort in agriculture has done far more than any other endeavor to improve man's quality of living and was begun long before environment became a popular word.

But even though agricultural production has kept pace with the nation's population growth, this burst of population has had its affect on the nation's environment. The rapid growth in population has meant more mouths to feed and at the same time, less acreage on which to grow that food. The demand for living space, more recreational facilities, more highways, has meant much less land for cultivation and crop growth. Another threat to agriculture's continued abundant production—city-bred air pollution, smog, smaze, or whatever you call it—spells disaster for many truck garden crops grown near by. Estimates by U.S. Department of Agriculture place such agricultural damage as high as $500,000,000 each year.

Farmers have made great strides in their use of proven crop production methods, such as fertilizer use, to promote rapid growth of soil-holding crop cover and plant residues. But farmers have no control over plant nutrients that abound in city sewage and industrial wastes or that wash off with soil eroded from the few poorly-managed farms and from many urban construction sites—sites that could be protected with quick-growing grass cover or other soil protection methods. More and more communities are requiring builders to furnish protection of soil at building sites. These urban wastes and silt pollute the waters, accelerate water plant growth, and help destroy lakes and streams. It's estimated that four billion tons of silt and sediment enter U.S. streams and lakes each year. Fully half or more comes from non-agricultural sources. No wonder sediment is ranked the number one pollutant from agriculture.

Work is continuing on solving pollution problems connected with agriculture. Problems do exist; solutions are on the way: new methods of handling the vast amounts of livestock wastes to keep them out of streams, rivers, and underground water supplies, development of smog-resistant crop varieties; guides to optimum fertilization; soil filtration of sewage and wastes; research on multiple-use of water.

In these studies to meet environmental problems, the emphasis is on scientific fact and reason, and adoption of recommended practices by farmers rather than emotional

alarm and hasty legislation or, as some have said, the "Chicken Little syndrome."

The years of care and effort of those in agriculture to conserve the nation's largest single resource—soil— has given America a better environment and a decided advantage in the fight against remaining pollution.

Let me list as briefly as possible some of the current misconceptions regarding use of fertilizer and environmental quality, and attempt to answer or at least debate these points:

Myth No. 1. Modern agricultural methods are unnatural. Man must re-establish the balance of nature to relieve environmental pressures.

Fact. Man's advances are made in spite of nature. Nature has never been in balance. At any point of time, one or more inhabitants have been in danger of extinction. If we were to "return to nature," we would give up nearly all of the progress won in areas of health, safety, nutrition, not to mention our affluence, culture, and many freedoms.

Man's progress in developing ways to feed and clothe himself more efficiently and abundantly has freed his time and energies for tremendous advances in numerous fields, discoveries undreamed of a few short years ago, plus giving him a great deal of time to ponder upon the quality of his environment, enjoyably so in most cases.

Most of these advances have been made in spite of nature, not in cooperation with her! I believe few people seriously wish to go back to nature.

Myth No. 2. With problems relating to livestock waste disposal, farmers could profitably use such organic wastes as fertilizers rather than commercially-produced inorganics.

Fact. Spreading manure is no novel idea to farmers, and if such a practice had continued to be profitable, it would still be in vogue. However, the pressure of waste disposal problems brought on by today's immense feed lots and concentrated metropolitan areas will encourage increasing fertilizer use of these materials on the land. After all, one steer produces as much waste as 16 humans; a hog or sheep, as much as two; seven chickens as much as one person. The computers at USDA have figured up that all U.S. livestock contribute two billion tons of waste per year.

No wonder, then, that disposal methods will receive increased attention. However, such disposa. vill g: in support not because of the economics involved in fertilization, but because of need to get rid of the material somewhere other than our streams and rivers. And, believe me, the disposal methods will not be inexpensive.

As you know, several metropolitan areas are studying this disposal problem as it applies to city sewage with farm lands in mind as disposal areas. Chicago has started a pilot program of piping sewage sludge to farm land for disposal.

Myth No. 3. Organic farming—using organic forms of nitrogen—produce more nutritious foods and reduce pollution as well.

Fact. Plants can only use nitrogen in inorganic form, and they do not distinguish between sources. In other words, to a plant, nitrogen is nitrogen. Nitrogen from organic sources, such as manures, plant and animal remains, must be converted to inorganic nitrogen by soil bacteria before the plant can take up the nutrient. Actually, the only difference between foods organically grown and those fertilized with inorganic commercial fertilizers is in cost of production, and low cost is on the side of commercial, inorganic forms. Naturally occurring organic materials, such as plant residues and sewage sludge, because of low percentage of plant nutrient content, require greater volume of application to supply crop needs, which means more handling, more labor, and greater cost of production.

Myth No. 4. Organic materials are more beneficial to the soil, whereas inorganics deplete the soil humus.

Fact. Organic materials *do* aid in humus build-up in the soil, and so do inorganics. However, because of the slow release of nitrogen from organic sources in the soil, use of organics fail to produce as efficient crop yields unless used in concentrated forms (such as urea) or used in tremendous volumes over long periods.

University of Minnesota soil scientist, Curtis Overdahl, among many other scientists, points out that:

"Farmers today have unknowingly become organic farmers. On any high producing farm, chemical fertilizers, even though inorganic, produce large quantities of organic residues that are incorporated into the soil. It isn't the nutrients from organic matter that is so important, but organic matter improves the soils physically so that they hold more moisture.

"Today's farming probably puts back twice as much organic residue into the soil compared to 30 to 40 years ago," Overdahl continues. "Proponents of certain organic ways fail to recognize that our least expensive source of organic matter is that obtained indirectly through inorganic materials. Usually, residues will return two to four tons of organic matter per acre each year and are byproducts of crop production that cost practically nothing."

Myth No. 5. Nitrogen and phosphate fertilizers end up in water runoff and/or leach into ground water to become major causes of eutrophication and health hazards.

Fact. No evidence yet exists that fertilizers properly used contribute significantly to water pollution. Eutrophication is a process as old as time. We know that excessive plant nutrients in water cause acceleration of this process, leading to algae-choked lakes. But occurrence of plant nutrients in water should not be equated with farm fertilizer use. Plant nutrients come from many sources into waters.

When algae die in water, oxygen-consuming bacteria decompose the algae and thereby deplete the oxygen supply, making such waters uninhabitable by many water plants and fish.

Phosphorus in fertilizers called phosphate can end up in lakes and streams, if heavy soil erosion occurs. Phosphate binds to soil particles and moves when soil moves or when removed from soil by plants.

Nitrogen leaches easily in porous soils, but incorporates into most unfrozen soils quickly upon application, thus it rarely escapes in surface runoff. This nutrient can percolate down to ground water levels eventually, if not intercepted first by plant roots.

However, it has not been proven, nor is it likely, that farmers will ever apply more nitrogen fertilizers to crops than their crops can use efficiently in one season. In this way, growing crops keep nitrates from leaching. In fact, 30 years of fertilization and irrigation records kept by USDA's Agricultural Research Service in the Rio Grande Valley show that nitrate concentration in the river did not increase over that period. Nitrogen fertilization, however, on irrigated lands draining into the river increased from 35 to 100 times the amount used at the beginning of the 30-year period.

Myth No. 6. Use of fertilizer nitrogen upsets the natural nitrogen cycle.

Fact. Rainfall averages about .70 parts per million of nitrogen. Only about .30 parts per million of nitrogen is necessary for accelerated eutrophication. There are some 40 specie of algae able to fix their own nitrogen. In this regard, there is more than enough nitrogen supplied by natural sources to accelerate eutrophication. In fact, according to an authority in environmental work, Dr. G. W. Cornwell, School of Forestry, University of Florida, who traced nitrogen sources entering Lake Okeechobee, fully 25 per cent come from the air. This means, of course, that the remainder was transported in sewage and organic matter entering the lake, from organisms already in the lake, and so on.

If anything, use of nitrogen fertilizers helps fulfill the nitrogen cycle by contributing to increased organic matter from crop residues such as expanded root growth, which is always left in the soil (except for root crops) even though other plant parts may be harvested, and through accelerated soil bacterial action.

Myth No. 7. Fertilizers destroy physical qualities of the soil.

Fact. Century-old experimental plots in England and the U.S. have proven that plots receiving no or very poor fertilizer treatments for more than 50 years responded immediately to good fertilizer and lime treatment applied according to soil tests. Even unfertilized plots left to erode away at the mercy of nature were restored to normal-yielding ability the very first year of adequate fertilization. On other plots in these experiments, comparison was made between chemical fertilizers and manure. No difference in yield or crop quality has ever been perceptible in

hundreds of comparisons involving equivalent amounts of nutrients, whether from manure or fertilizer.

I might add also that nutritionists continue to find no nutritional difference in crop quality between food and feed crops grown organically and those grown under commercial fertilization.

Myth No. 8. Naturally-occurring wilderness waters are somehow always pure, and we should attempt to keep waters always in their natural state.

Fact. Outside of laboratories there is very little "pure water." Streams and lakes abound with micro organisms, bacteria, dead and dying plants and animals, other organic matter such as wild fowl and animal wastes, and so on.

If this were not the case, the vast deposits of peat moss oil, coal, and muck would not be available for modern man's uses as energy sources. Nourishment for production of these energy sources came chiefly from algae activity in primeval lakes and waters.

However, this process of eutrophication has been accelerated by man, and the threat of early-aging of our lakes is very real. The problem, however, primarily stems from increased loads of organic-rich silts and sewage entering the nation's lakes and streams.

What *would* happen if inorganic, commercial fertilizers were banned completely or their use restricted?

A study completed by two economists with Iowa State University earlier this year sought to answer that question. The two, Leo Mayer and Stanley Hargrove, both on the staff of ISU's Center for Agricultural and Economic Development came to these conclusions:

If all commercial fertilizer use was halted, all "set-aside" acres would come back into production; corn yields would nose dive from 1969 average of 84 bushels per acre to approximately 48 bushels per acre the first year.

Much of the extra acres placed in production would be in rotation crops such as legumes. Therefore, total corn crop would be down drastically, grain prices up, with corn price doubled by 1980. Crop production and harvesting costs would rise, forcing higher marketing and consumer prices. The two ISU economists estimate that the retail price of beef, for instance, would increase 28 cents per pound by 1980, given no other inflationary or cost effects.

If fertilizer use were banned, they add, total food costs would rise 11 per cent the first year, 27 per cent by 1975, and nearly 40 per cent by 1980.

It is unlikely that total use of commercial fertilizers would be banned, but any significant restriction on fertilizer use would result in higher crop production costs and, eventually, higher food costs.

Our nation's concern with our environment is not going to subside, nor should it. There are many problems with pollution that must be solved. It has become clear that these solutions will be expensive and that the final expense will be borne by the consumer either in higher product costs or increased taxes. With this realization, the frenzy and emotionalism is being replaced, in many cases, with sincere, conscientious effort to find causes of pollution and initiate action for solution of problems—action based on fact, not supposition.

This does not mean that agriculture and those of us dependent on agriculture can relax. In fact, it is even more important that we maintain and strengthen our vigil in protecting our nation's farming productivity. It is our obligation to seek facts, provide information, and assume necessary responsibility in working with those governmental agencies and departments charged with setting and enforcing environmental regulations. It is essential that we explain to concerned citizen and community groups the facts about our industry and its products in today's modern agricultural environment. The story is a positive one: it is one to be proud of, and it's yours to tell.

THE COMPLIANCE SYSTEM

By M. L. GREINER
Safety Coordinator, Minerals & Chemical Div., J. R. Simplot Co.

There was a time, possibly as recently as April 27, 1971, when plant inspection often lacked purpose and direction, at least in the thinking of many management and even safety personnel.

The real intent behind many of these repititious routines may have been an effort to comply with union contractual requirement that safety inspections be held every so often. Or perhaps we were trying to salve our conscience by going through this "grand-daddy" of safety "sacraments." Perhaps also we secretly held the view that this was one routine we could really get along without—if we could only think of a suitable substitute. And certainly many considered this routine as quite distinct and separate from the normal work activity. It was instead an activity which took members of the inspecting group (supervisors, union representatives, etc.) away from their work. It was not often considered a part of work.

But now the Act! With the emphasis on voluntary compliance, self inspection and correction is the most important self-initiated evidence of an attempt to identify deficiencies in safety and health standards and fulfill employer responsibilities under the Williams-Steiger Occupational Safety and Health Act which went into effect April 28, 1971.

The Act then becomes the starting point for voluntary compliance and I will here attempt to develop the necessary ingredients of a "compliance system," focusing mainly on internal plant inspections.

As occupational safety and health standards are communicated to the employer, these are studied in relation to his own type of operation. After selecting those standards which are applicable, the responsible employer conducts his own preliminary safety audit. The basic guiding principles to keep in mind during such an audit are: identify hazards and deficiencies, record, and establish priorities.

During the audit a hazard rating can be used for each item inspected. One example of such a rating system is that developed by Kaiser Aluminum & Chemical Corporation. Injury severity potential is rated low, moderate, or high, with one point being scored for low hazard, four points moderate hazard, or six points for high severity potential. Frequency of employee exposure may score one point for low, two points for moderate, or three points for high employee exposure. Probability of accident exposure may score one point for low, two points for moderate, or three points for high probability. Violation of safety codes, standards, rules, etc. may score zero for no violation or one point for each violation.

On the basis of such a rating the task of establishing priorities for corrective action is made much easier. Again referring to Kaiser's rating system, if an item scores from ten to thirteen points, it is an emergency. If it scores from eight to ten points it should be corrected today. Six to eight points is allowed one week for correction; four to six points is allowed one month.

In any case, whether you rate the condition as a high or low hazard, whether by the Kaiser rating method or whatever, corrective procedures *must* follow the preliminary safety audit, with priority being given to the more serious situations. If a permanent correction is not immediatedly possible, then some type of temporary measure must be taken.

However, identifying, recording, and correcting hazards and violations does not complete the so-called "compliance system." I would like to rephrase the dictionary meaning of the word "compliance" as I think it should apply to employers under the OSHA Act. It goes something like this: "A permanent and continuing adjustment of conditions, equipment, and procedures in accordance with occupational safety and

health standards."

The "permanent and continuing adjustment" can only be accomplished through a regular internal inspection program which will also ensure follow-up of corrective procedures.

There are many varieties of ways to maintain a surveillance of in-plant conditions. One tried and proven method is the joint labor-management approach where a committee composed of representatives of both management and labor regularly conduct inspections of all facilities, detecting and recording unsafe conditions and practices. Another approach is to have the supervisor of each work area or operation do his own inspection on a routine basis. Another less satisfactory method is to have the safety department do the survey. The disadvantage in this is that it fails to sharpen management's and labor's responsibility for safety and health. In any event, a checklist should be developed and used to assist in the detection of hazards.

In addition to using one or more of the above methods, there should be a preventive maintenance program, which should include not only the normal operating equipment and tools but also life-support systems and equipment such as respiratory equipment, emergency lighting systems, fire detection and protection systems, ladders, ropes, barricades, scaffolds, etc.

For regular in-plant inspections such as I have been referring to, I like to use the National Safety Council's S-A-R-C code rating: *S* meaning satisfactory, *A* meaning a safer arrangement is necessary, *R* meaning an item has to be repaired or replaced, and *C* meaning cleanup required. Coding of this sort suggests action and provides direction for those responsible for follow-up.

To sum up then, the compliance system begins naturally with the OSHA standards and concludes with compliance. However, before an employer has reached that state of "permanent and continuing" adjustment to the standards he must first become acquainted with the standards, selecting those applicable to his particular operation. He must then perform a preliminary internal safety audit, make the necessary corrective procedures, temporary and permanent and, finally, set up a regular internal inspection program which will ensure permanent and continuing adjustment or compliance with the Occupational Safety and Health Act.

THE PSYCHOLOGY OF FIRE

By MIKE ELLISON
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Since the dawn of history no other threat has sent terror to the hearts of all living creatures like the threat of fire. If you have ever fought a forest fire and noticed the frantic running of the animals and terrified screams of the birds ahead of the flames and smoke that are destroying their homes, you know what I mean.

Or if you have gone with the city firemen to the scene of a major fire in a residential section and seen the forlorn and helpless looks on the faces of the families as the angry flames leap skyward from the falling roof of their home, there will never be a doubt in your mind about fire being one of man's worst enemies.

The shout of "Fire" in crowded halls and buildings has taken the lives of hundreds of people as they pushed and fought each other trying to get outside through the nearest door or window. Realization of this frailty of the human race has caused laws to be passed saying that outside doors of public buildings shall open outward. There are many cases on record of dead bodies piled on top of each other, sometimes 15 bodies high, just inside doors that only opened inward. The fear-crazed mob would not move back far enough to open the doors and give themselves freedom.

It is hard to believe that the shout of "Fire" in a crowded opera house or ballroom can turn highly educated, cultured people into a mass of screaming, fighting animals running over the fallen bodies of children and weak old folks in a desperate effort to flee from their age old enemy, fire.

That is why it is necessary to have a constant training program in all fire departments and in all progressive industrial plants. We must be so thoroughly familiar with our fire fighting equipment that we will react automatically if a fire starts and do the right thing without hesitation. Knowing what we can do with a fire extinguisher gives us confidence in ourselves and lets us use our equipment to the very best advantage.

It is said that untrained personnel only get 40 per cent efficiency out of their equipment.

Once I saw a small oil spill on a concrete floor burst into flames under a $300,000 turbine. The supervisor picked up a 20 pound dry chemical extinguisher, ran 30 feet to a light, and began to read the instructions, while a worker put out the fire with a 10 pound unit.

We had a fire start in a waste paper can at an office desk. A Ph. D. ran down the corridor, grabbed a soda-acid extinguisher, turned it upside down, and ran back up the hallway spraying water all over the floor and expensive walls. Meantime, back in his office a high school graduate had covered the trash with two heavy books and smothered the fire out.

Just recently an assistant area superintendent tried to put out a fire in heavy grass a foot thick in a five mile wind with a CO^1 extinguisher, and wondered why it did not extinguish the flame.

Some of the costly fires in insurance history have been caused by men doing the wrong thing under the pressure of fear and excitement.

Fire is not only man's worst enemy, but it is also his best friend. In ancient times man knew only four elements—earth, air, water, and fire. And for countless ages man has never ceased to wonder about fire; their fear and fascination was so great in many cases that some tribes worshipped fire and made sacrifices to it as their God.

One of the great truths about fire is that once it has started it will continue to burn until either the fuel, the heat, or the oxygen is removed from the scene. There is no exception to this rule. Regardless of whether it is warming the baby's formula, heating grandmother's tea, or consuming the unfortunate passengers of a fallen jet plane, this

ruthless monster called fire has no friends, no pity, and no mercy.

It is said that man has been on this planet for over seven million years, and for nearly one million years he has used fire in some way to cook his food, to keep him warm and, more recently, to turn raw materials into useful products.

Controlled fire is responsible for all the things by which we measure our progress today. Had it not been for man's ability to control fire, there would be no iron, brass, copper, aluminum, or other priceless metals as we know them today. There would be no plastics, rubber, synthetic clothing, processed foods, jet planes, space craft or atomic energy, concrete highways, skyscrapers, nor electricity; in fact, not a single modern industry would exist today if man did not possess the miracle of fire and the knowledge of how to control it.

But fire will work against us just as quickly and as vigorously as it works for us, and once it gets out of control it can be man's worst enemy, because uncontrolled fire is one of the most ruthless destroyers ever faced by man.

Of all the major disasters recorded in history those caused by fire are among the most tragic. Witness for example, the Great Chicago Fire October 3, 187'—250 lives lost, $196,000,000 damage. Peshtigo, Wisconsin, 1871—1,152 lives were lost. San Francisco Fire, 1906—452 people died.

Another reason for us to fear and dread fire is that it changes the molecular structure of everything it touches; things that are fire proof at 500 degrees may become fuel at 1, 000 degrees and help heat other items which will burn at 10,000 degrees. It is said that any material on earth will burn if it gets hot enough.

Thus it is no wonder that man stands in awe of this bright yellow flame that has the power to destroy cities, planes, factories, boats and cars, and leave us only a mass of twisted steel, poison fumes, and ashes.

If we are to survive in the great cities that we must build in the world of tomorrow, or ride from planet to planet in the space craft that is just a little way ahead of us in the point of time, we must learn how to control fire with a firm steady hand and make it work for us in the beautiful world that is just ahead of us in the march of civilization.

While you were reading this, 31 homes burned somewhere in the United States and four people died as a result of those fires. The cost was over $250,000.

The best way to fight fire is to never let it start.

GENERAL LIABILITY INSURANCE

By J. A. HOUGHTON
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and

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Whether you have responsibility for general liability accident loss assigned to you or not, we feel those people responsible for workman's compensation loss prevention (usually the safety manager) must be aware of and participate in the control of General Liability accident loss. Why?

The average total cost per accident involving loss is increasing almost two and a half times faster for general liability claims than for workman's compensation. Court interpretations have been changing constantly. The law often may not be what the court said last time, but what it says this time. Damage awards have been greatly liberalized. There are already companies where cost of their liability claims exceeds the cost of their workman's compensation claims. This is a trend which it appears, will continue and expand.

Broad coverage is given under a general liability policy. There are many causes for the high losses but we will only have time to touch on a few. Most will have direct application to the fertilizer industry.

Injury to Visitors

First, let's look at injury to "visitors" to your plant, dealing only with "working visitors." Large contractors will have workman's compensation coverage, and if one of their employees is injured while doing contract work at your plant he will be covered automatically by the workman's compensation law. But, if there is a question of negligence on your part, then he can sue to recover damages which are invariably greater than he would receive under compensation. It is very easy to allege negligence on the part of the plant.

Many small contractors who have just a truck, tools, and one helper are not required by law to carry workman's compensation coverage. A requirement could be written into all your contracts to be certain that he has this coverage, but this may not always be practical.

Hold harmless clauses can be written into contracts or included as part of a purchase order, but these may or may not hold up under an actual suit. They will not hold up if there is negligence, and failure to warn about a potential hazard could be construed as negligence. You have an obligation to provide a reasonably safe working place for visitors as well as your own employees, but visitors may not be aware of potential hazards which seem apparent to your employees.

There is a perennial question as to whether contractors should have permission to use plant equipment such as tools or ladders, or should be provided with safety equipment. We suggest permission be kept to a minimum, but it would be difficult to make a hard and fast rule prohibiting such use. A small contractor may not have the needed equipment and work could be delayed. Just be certain any equipment you loan him is in good condition.

Temporary help presents special problems, particularly when obtained from organizations who specialize in providing temporary help. They will have their own workman's compensation coverage, but when this help is used alongside of your own employees or put under the supervision of

one of your employees, then you assume a responsibility for him. The use of such temporary help is common practice in many parts of the country and, when used, it must be realized that the temporary help may need special attention to warn of hazards. Safety supervisors can help considerably by indoctrinating the temporary help and making certain they are aware of the safety rules of your plant and the need to follow these rules.

Injury to Railroad Employees

If railroad employees spot equipment on your spur track, then you have a spur track agreement with the railroad. This will be a carefully written document which was drawn up by experienced lawyers of the railroad. Safety supervisors should be well acquainted with the requirements and specifications of the agreement.

The spur track agreement will specify certain distances from the track for overhead lines and for buildings and other construction. Changes in construction will occur in any plant, and your new construction may encroach on the distances from the track. Variances can be obtained in some cases, but where variances occur, the area must be posted to warn about the distances. Weathered and illegible signs are not satisfactory.

Spillage of material alongside of a spur track can be a source of trouble if a brakeman steps off a car onto the spilled material. An accident to a brakeman will be covered by liability insurance, but it is invariably a costly claim which will be reflected in the loss experience of your plant. If you have the responsibility in your plant for safety, be certain that you have a copy of your spur track agreement and know the requirements. If there is any doubt about compliance with the specified distances, be certain by taking actual measurements.

Injury or Damage from the Use of Rental Equipment

Rental of specialized farm equipment has become common practice in many parts of the country, particularly rental of spreaders for the application of liquefied ammonia and pesticide sprayers. To have such equipment available is an advantage to the farmer and helps the distributor sell products. Farmers are jacks-of-all-trades who are familiar with many types of farm machinery and too frequently it is assumed that he can operate the specialized equipment satisfactorily with little or no guidance. In most cases this is true, but the farmer may not appreciate the severe consequences from a spill of liquid ammonia, or the distance a pesticide spray can travel, or he may not recognize difficulties when the equipment is not functioning properly. Temporary summer help hired by the farmer can also add to the chances of accident from the mishandling of the specialized equipment.

The most frequent type of accident reported to us is from the use of liquefied ammonia spreaders. Breaks in hose lines or connections have sprayed ammonia on individuals and serious burns have resulted. Transfer of liquefied ammonia from nurse tanks is relatively simple if connections are in good condition, but inexperienced men have been injured when poor connections were made and ammonia escaped. Worn connections are another source of trouble. The service organization supplying equipment is responsible for the condition of the equipment and must not only supply equipment that is in good repair but must give proper instructions for operating the equipment.

Poorly maintained equipment can also cause crop damage. In one case, a liquid ammonia-base solution was applied to three rows at a time through a perforated pipe. But the holes were partially clogged which resulted in uneven application of the fertilizer solution. One row showed excessive growth, the middle row was in good condition and the third was stunted, and this pattern was repeated through the entire field. We paid for the crop loss. In another case, a large sprayer was rented out and used to spread a herbicide but was not cleaned out. The next renter used it to spread an insecticide on a growing crop. We paid for this crop also.

Advice on what to apply and the rate of application is frequently part of the service given when renting equipment. In the press of business during the growing season, advice is sometimes hurried. Excessive application of ammonia resulted in abnormal growth in a cotton field, which ruined the harvest because the automatic pickers could not be used. Pesticides have been recommended for certain crops without consideration of the type of plant in an adjacent field and carry-over of spray has damaged the second crop.

Injury From The Use Of Products

Our experience in covering products manufactured and distributed by the fertilizer industry has been good, and claims for damage from the products have been relatively few in comparison with many other industries. The exception to this comes from the sale and distribution of new and untried pesticide products. Pesticide labels require approval before use to warn about health hazards. In general the warnings are good, but could be improved in some respects. Many warnings are simple negative statements, and the requirements of the Environmental Protection Agency are minimum requirements. (The new EPA has taken over label approval from the Department of Agriculture). These minimum EPA requirements are seldom enough to defend against a suit which alleges that the warnings are inadequate. The warnings will be inadequate for defense purposes if they include just the bare minimum requirements of the law.

For example, if the product is dusty, the bare warning "avoid breathing the dust" is not sufficient. Nor will the added warning "use with adequate ventilation" be sufficient. The label should state the product will dust if handled roughly and that it must be handled with care and dumped slowly. If a respirator is required, the warning should stress the use of an approved respirator. Where possible, the reason for the warning should be given. That is, the label should state "Do not . . . because . . . " and give the reason for the warning. It is true that, in general, people seldom read a label in its entirety, and farmers are no exception. But the label should give the warnings and attention should be called to the warnings when the product is sold.

When a new product comes on the market it is an unknown product in many respects, even though it may have been tested by the manufacturer under many conditions. It would be impractical to run every conceivable test before the product is marketed, and it must be realized that the final experience will only be obtained when it is used by many farmers under many conditions. We have had a number of claims where advice had been given to use a new product and crops were damaged because it was not suitable for a particular type of crop under the conditions. A new variety of crop can be damaged where the product would not damage older varieties of the same crop. Moisture conditions or soil conditions may differ, and other factors can affect the chances of damage. The farmer needs advice on the use of a new product, but the advice must be given with caution if liability is to be avoided—and repeat sales obtained.

Storage of products for agriculture in public warehouses is common practice in order to have the products available in the area when they are needed. But there are cases where a poor selection of warehouse facilities was made because no consideration was made of the other types of materials stored in the same warehouse. While it is true that the operator of the warehouse assumes responsibility for the products he stores, if he has not been warned of potential hazards, he can then start a third party action against the manufacturer or distributor. Ammonium nitrate and other fertilizer dusts have corroded metal equipment and television sets stored in the same warehouse. Leaking containers of pesticides have damaged adjacent stock.

Fires in warehouses, both public and private, have been a source of public liability loss. The storage of ammonium nitrate has been troublesome because of the spectacular incidents which have occurred from ammonium nitrate explosions. In each of the cases where ammonium nitrate has detonated, the nitrate has either been contaminated or has been under close confinement under fire conditions. The nitrate on the ships at Texas City were confined and heated by the fire. A railway explosion occurred when the nitrate was contaminated by oil spilled from a tank car. In another, an oil base product caught fire and the hot product ran through the floor onto ammonium nitrate stored below. An explosion occurred.

There have been many other instances where stored ammonium nitrate was involved in a fire and did not detonate. The fumes from burning ammonium nitrate are toxic and caution must be used in fighting the fire, but there should be no chance of detonation if proper precautions are followed. These precautions are spelled out in the standard of the National Fire Prevention Association No. 490 on Storage of Ammonium Nitrate. These are minimum standards, and no deviations or short cuts can be permitted from the requirements of this standard.

The involvement of pesticide products in a fire offers several potential exposures. In a hot and raging fire, the pesticides are destroyed effectively and the firemen are not endangered seriously, but they must still use precautions in fighting the fire. In cases where fire in adjacent materials can heat the pesticides, the pesticide containers can rupture and the pesticides volatilize. These vapors can be hazardous. The products of combustion of pesticides are frequently corrosive and can damage or corrode equipment. Fly ash from any fire deposited on automobiles in a parking lot can cause corrosion and paint damage, but this damage has been more severe when pesticides were involved.

Run-off water from water used to control the fire can be highly contaminated and present a liability exposure. A lot will depend on where the run-off flows. If it flows into a creek or stream, there can be a fish kill or death to cattle or other animals drinking from the stream. If it collects in pools, it can be an attractive nuisance to children. In one case, run-off water was toxic enough to kill fish in 30 seconds. Clean up and decontamination and disposal of such run-off water can be troublesome and expensive, as can be the clean up of residues in the rubble from the fire.

Proper selection of warehouse facilities and planning for emergencies of this nature can reduce chances of potential damage.

Pollution

Several of the items just mentioned bring us directly into the area of pollution. Pollution is any undesirable or unwanted material that spreads into an area, whether it causes actual damage or is only objectionable from an aesthetic standpoint. It often comes from the discharge of a valuable product or by-product. Pollution problems have made frequent headlines in the past few years and much of the emphasis has been on waste materials. However, less than 20 per cent of our losses from pollution damage have come from the deliberate discharge of wastes into the atmosphere or waterways. Most of our losses have come from the accidental release of material from process or storage or from failure of waste control systems.

Compliance with the strong Federal legislation now on the books will be a problem for the fertilizer industry, but even compliance will not guarantee control of all potential pollution losses. General liability insurance will protect against high losses when accidental pollution occurs, but it should be clearly understood that insurance covers only actual damages caused by *accidental* discharge and does not cover deliberate acts nor punitive damages imposed by legislation. For example, The Refuse Act of 1899, which was reactivated recently, sets a fine not exceeding $2,500 nor less than $500 for an unauthorized discharge and specifies that, at the discretion of the court, one-half of the fine may be paid to the person or persons giving information which leads to conviction. This fine would not be covered by insurance, but if the pollutant accidentally discharged into the waterway and damaged boats or other objects in the waterway, then the insurance would cover that damage.

Wastes. The discharge of fluoride wastes, either into the atmosphere or in liquid effluents has been the source of loss from damage to cattle and to plant life. Discharge of the liquid wastes into a stream or creek from scrubbing towers in the manufacture of phosphate fertilizers will require a permit from the Corps of Engineers. (The Refuse Act specifies "navigable water" or "tributary," and if it will float a log it is a "navigable water"). Some states have permitted the discharge of the liquid fluoride effluent into streams, but this is no guarantee that a federal permit can be obtained.

Lagooning of the fluoride effluent may be an answer in some areas but will introduce additional problems in other areas. This waste is acidic, and the lagoon will continue to give off fluoride gases which can damage vegetation in the vicinity. Also, lagoons are attractive nuisances and will be investigated by children. Fencing in a large lagoon and liming the effluent will reduce potential hazards, but finding methods of reclaim of fluoride will be needed.

Escape From Process. With proper operation of a contact sulfuric acid plant, the effluent should disperse from the stack without trouble. But this type of plant can be a source of difficulty when starting up after any shutdown, or when pushing the capacity of the plant. Under these conditions, excess amounts of sulfur dioxide and sulfur trioxide have escaped and damaged autos and neighboring plants.

Escape From Storage. Leaks from ammonia storage tanks and breaks in transfer lines or couplings during the transfer of ammonia have damaged automobiles in parking lots and homes in the vicinity of plants. A cloud of ammonia passing through a residential area can be quite annoying. Serious breaks have occurred from inattention to the operation, such as the use of worn hoses and couplings, or starting pumps to transfer a load and then going for a "coke," so the receiving tank has a chance to overflow. Using a jury-rigged pipe and hose across a spur track which was broken by a moving freight car has also occurred.

Failure of Waste Collectors. Dust collectors and scrubbing towers seldom receive the attention given to other equipment in the plant, and the lack of maintenance has caused the system to fail and spew the waste over the area. We have paid for the repainting of quite a few automobiles when dust collectors and scrubbing towers failed to function.

Summary

The area of general liability is rapidly becoming a major factor in accident dollar losses. If not already involved, safety managers should be getting involved in determing potential liability exposures in their plants and should bring these exposures to their management's attention. The areas we have only briefly touched on are: injury to "working visitors," such as contractors and their employees; injury to railroad employees on spur tracks; injury or damage from use of rental equipment; injury or damage from use or storage of products; and pollution damage.

Research and Development Sessions

ESTIMATION OF FLASH POINT

By RICHARD W. PRUGH
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A simple technique for determining the approximate flash point of a compound, knowing only its atomic composition and boiling point, has been developed from experimental data and some theoretical considerations.

It is generally agreed that before a chemical is first used or produced, appropriate precautions should be taken against its known or suspected explosive, combustible, flammable, toxic, or radioactive nature. A problem which frequently arises in R & D laboratories is how to estimate the degree of combustibility or flammability.

For some non-toxic, non-explosive, and non-radioactive materials, a simple test can be conducted to determine if a match flame or spark will cause ignition of vapors from the material at room temperature. If ignition is obtained the material is flammable, and there would be a fire or explosion hazard unless adequate precautions are taken. If there is no ignition, the test must be considered *inconclusive*, since the material might evolve vapors at some higher temperature which might be easily ignited. Thus, there would be a fire or explosion hazard during handling or use of the material at or above the higher temperature.

The distinction between combustible and flammable is intended to differentiate between degrees of hazard. For example, Webster's dictionary defines combustible as "capable of burning," whereas flammable is "capable of being easily ignited." Generally, the term "flammable" is assigned to materials whose vapors can be ignited by a spark or flame at temperatures which might normally be encountered during storage or handling. Accidental ignition of such vapors could result in a flash fire or explosion, depending upon the degree of confinement.

The upper limit to "normal" temperatures which should be anticipated differs with regulatory or advisory authorities. The National Fire Protection Association suggests a temperature of 140°F [1], with a separate distinction for liquids having flash points* below 100°F regarding precautions against ignition by static electricity. Factory Mutual makes a distinction between liquids having flash points above or below 110°F[2] regarding flame arresters in vessel vents, and a flash point of 80°F[3] regarding storage in basements. The Department of Transportation uses a flash point temperature of 80°F[4] to determine whether or not a container of flammable liquid must bear a red warning label.

Thus, to determine the precautions which should be taken to assure safe handling or use of a chemical, a vapor ignition test should be conducted at 140°F (using the most conservative guidelines). It is often not convenient or economically practical to conduct such a test prior to preliminary experimental work, because of the toxicity, radioactivity, or other hazardous property. Therefore a method of estimating a material's flash point would be useful.

Several methods for estimating flash point have been proposed. For hydrocarbons, it has been observed that there is a close relationship between flash point (FP, in °F) and boiling point (BP, in °F). This relationship[5,6] can be described by the equation

$$FP = 0.683\,BP - 119$$

and is applicable to hydrocarbons having initial boiling points between 200°F and 700°F.

Another method of estimating flash point, using molecular structure, has been proposed.[7] An intermediate calculation to determine autoignition temperature† is required and is based on the total number of carbon atoms in the molecule and the number of carbon atoms in branches. The flash point is then calculated from an equation involving the autoignition temperature and the number of hydrogen atoms in radicals.

During the 1967 National Safety Congress, the relationships between lower explosive of flammable limit, vapor pressure, and flash point were explained and demonstrated. [8] The statement was made that the vapor concentration in air above a liquid at its flash point should be equivalent to the lower flammable limit. In general, the vapor concentration corresponding to the lower flammable limit occurs at a temperature slightly below the flash point, when calculated from a vapor pressure curve. This discrepancy may result from experimental difficulties in attaining equilibrium in the testing apparatus and the fact that the flash point test is essentially a downward-propagation test, whereas lower flammable limits conservatively state upward-propagation vapor or gas concentrations. The theoretical and demonstrated close relationships between lower flammable limit, vapor pressure, and flash point would allow calculation of one characteristic (such as flash point) if the other two were known. However, for many novel chemicals, these data are not available.

The observation that vapor pressure curves of many hydrocarbons converge to a point was demonstrated by Cox.[9] Thus the locus of this point and the normal boiling point would be sufficient to describe the vapor pressure characteristics of any particular hydrocarbon. If there were only one convergence point for all organic and inorganic materials, the vapor pressure at any given temperature (e.g., the flash point) could be easily determined from the boiling point. Unfortunately, there is no single convergence point, but there are two areas of convergence (one for alcohols, and another for many other materials) near the infinite-temperature ordinate. For the purpose of the present flash-point estimation method, two points of convergence on the infinite-temperature ordinate are assumed. This assumption results in some loss of accuracy in estimated flash point.

The concentration of vapor in air at the flash point (i.e., the approximate lower flammable limit, *LFL*, in volume-per cent can be estimated from the vapor pressure (*VP*, in mmHg) at the flash-point temperature, using Dalton's and Amagat's laws:

$$LFL = (VP / 760)\,(100)$$

A relationship between lower flammable limit (*LFL*, in volume-per cent) and stoichiometric concentration (*CST*, in volume-per cent) for paraffin hydrocarbons was documented by Jones and Lloyd[10] and can be described by the equation:

$$LFL = 0.55\,CST$$

Other organic and inorganic materials behave similarly, and use of the 0.55 coefficient generally does not result in a relative error greater than 20 per cent in the lower flammable limit, as compared with an experimentally determined lower limit.

Calculation of the stoichiometric concentration of a vapor in air is relatively straightforward, if it can be presumed that: (a) all carbon (C) is oxidized to CO_2; (b) all sulfur (S) is oxidized to SO_2; (c) all halogens (X) react with hydrogen to form hydrogen halides; (d) any remaining hydrogen (H) is oxidized to water; and (e) all oxygen (O) in the molecule is available for oxidation of other constituents. An equation relating the stoichiometric concentration (*CST*, in volume-per cent) to number of atoms per molecule (in parentheses) is:

$$CST = 83.8 / [4(C) + 4(S) + (H) - (X) - 2(O) + 0.84]$$

*Flash point is the temperature at which a material gives off vapor sufficient to form an ignitable mixture with the air near its surface.

†Autoignition temperature is the minimum temperature required to cause self-sustained combustion of a material, independent of any other source of ignition.

Estimation of flash point from molecular composition would proceed as follows:

1. Calculate stoichiometric concentration.
2. Calculate lower flammable limit, using the Jones-Lloyd equation.
3. Calculate vapor pressure, using the Dalton-Amagat law.
4. Construct a vapor pressure curve (a straight line on inverse-temperature/logarithmic-pressure graph paper), using the boiling point and the "universal" Cox-chart locus.
5. Determine the temperature (flash point) corresponding to the lower flammable limit.

These steps have been combined on a nomograph to aid in estimation of flash point. The points shown on the graph represent flash point, boiling point, and stoichiometric concentration values for 200 chemicals for which these values are reported in a National Fire Protection Association publication.[11] The data cover a flash point range of −200°F to +400°F and a range of lower flammable limits from 0.4 per cent to 30 per cent. Sixteen chemicals have been deleted from the graph because there appeared to be serious errors in the reported flash points or boiling points, or the values in this publication disagreed with other literature data which corresponded very closely with the postulated relationships. The chemicals in the former category were anthracene, hexadiene, isobutyl acetate, isobutyraldehyde, isobutyl biphenyl, methyl cyclopentadiene, methyl ethyl ether, methyl phenyl ethylene, orthophenylene diamine, and propanal. In seven of the ten cases, the concentrations of vapor in air at the stated flash point would be 80 per cent to 500 per cent of the calculated stoichiometric concentration, and in two others, the concentration at the flash point would be less than 20 per cent of the stated lower flammable limit. For the tenth chemical, the flash point and lower flammable limit were consistent, but the boiling point appeared to be incorrect.

Since alcohols and other organic materials have distinctly different Cox-chart convergence "points", two lines are shown on the main graph. The procedure for use of the nomograph is as follows:

1. Calculate the stoichiometric concentration.
2. Find the intersection of the stoichiometric-concentration ordinate with the "alcohols" or "most organic materials" line.
3. Mark the boiling-point/flash-point ordinate corresponding to the above intersection.
4. Mark the boiling-point scale at the appropriate boiling point.
5. Connect the boiling point with the mark on the boiling-point/flash-point ordinate.
6. Read the approximate flash point where the connecting line intersects the flash-point line.

Use of this nomograph will yield flash points within approximately 20°F. This accuracy should be sufficient to provide a warning of potential fire or explosion hazard at room temperatures, or show that many of the precautions recommended for flammable materials may not be necessary.

The nomograph may be used in reverse, to obtain lower flammable limit if the flash point and boiling point are known. Also, this technique can be used to check the consistency of literature data, or to determine which of two differing data is more nearly correct.

Any comments or suggestions concerning this method of flash-point estimation will be appreciated.

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THE STATE OF THE ART IN FIRE PROTECTION

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A comparison of various fire detection and extinguishing systems currently in use in computer rooms.

In attempting to assess the state of the art in fire protection for research computers, the one word that comes immediately to mind is "fluid." The art has not been refined to the state where all can agree on precisely what the fire protection should be for every installation. If two teams of fire protection engineers surveyed a computer facility, it is not unlikely that there would be variations in recommendations for the detection system in type, spacing, and location of detector heads. The necessity for and selection of an extinguishing system might be viewed differently with the possibility of recommending no system, an automatic wet sprinkler system, a preaction sprinkler system, or a gaseous system.

A number of publications are in print that provide guidance in the form of documents such as a recommended practice, a technical bulletin, or a national standard and, of course, they don't all agree on the protection recommended. One type of protection on which they agree is the sprinkler system, although they vary in the conditions under which it is specified as a requirement. To focus on the state of the art as expressed in these references, some of the detection and extinguishing system features in each will be compared briefly.

Detection

It is generally agreed that products-of-combustion detection is the system of choice for computer facilities. There is no specific agreement, however, on the spacing for the detectors in a computer room, and there have been suggestions on arrangements of 3,600 ft²/unit to as close as 100 ft²/unit.

No specific spacings are allocated by Underwriters Laboratories to detectors in their January 1971 Fire Protection Equipment List. For test purposes, a 30 foot spacing is cited with the notation that in open area protection, three specified test fires using paper, plastic packing, or gasoline yielded a two minute maximum response time and a specified wood fire resulted in a four minute maximum response time. The 30 foot spacing is recommended only as a guide or starting point for establishing a revised spacing pattern based upon an engineering judgment that takes ceiling obstructions and air movement into consideration.

Factory Mutual has also indicated the necessity for engineering judgment with a unit spacing of not more than 500 ft²/detector

An interim guide proposed by P. E. Phil-

lips, Fire Protection Engineer, USAEC, Nevada Operations Office, suggests the use of a test employing materials common to the room or space. Where no specific test fire is chosen, the recommended material is one ounce of paper (about five sheets of 8 ½"x15" computer paper). The acceptance specification in this guide is that the "detectors shall detect the incipient fire within one minute after the combustible material is consumed at any location in the space." Where new construction is involved, one head per 400 ft² is specified with the requirement for a performance fire test within six months of completion.

One computer facility at a major university has a products-of-combustion system with an obviously insufficient number of detection heads. In an attempt to make this point, it was suggested to the laboratory director that a paper test of the type mentioned above be performed. He was appalled at the thought and refused to consider it. One of his subordinates, however, proposed to light a small piece of paper in an ash tray under a detection head. Convinced that this was the only test they would perform, it was reluctantly accepted. The paper was ignited. The detector identification light blinked, but the signal stopped there. The bells did not sound in the laboratory, nor did the alarm sound at the campus police headquarters. The point that a system needs a periodic test was made and there was a willingness to concede that there may be an insufficient number of heads. Unfortunately, the budget problem has not been resolved and the inadequate spacing still exists. This is a case in point to demonstrate the necessity for specifying adequate fire protection requirements as part of the computer installation.

At a number of computer facilities where detectors are located below the floor there may be a problem in locating the sub-surface detector heads. Several methods are used to simplify this process. In one facility they have placed markers on the floor plate below which a detector is located. Another procedure is to install the below-floor heads directly under those suspended from the ceiling.

Halon 1301 Systems

Halon 1301 (Bromotrifluoromethane) is a colorless, odorless, electrically nonconductive gas used as the extinguishing medium. The fire suppressing mechanism involves inhibition of the chemical reaction between fuel and oxygen, terminating the combustion chain.

A design concentration of five to six per cent can be used and Halon 1301 is listed in Group 6, the least toxic category, by Underwriters Laboratories. The liquid vaporizes into a gas and leaves no residue, making it particularly applicable for the delicate components of computer systems.

Two types of systems are in use. The total flooding system is designed to discharge the supply into an enclosed space containing the computer equipment. This enclosed space would generally be the computer room itself. A local application system is one designed for the supply to discharge directly on the burning material. Systems where the Halon 1301 is discharged directly into the computer frame would be considered local application.

These systems can be operated manually or automatically and where automatic activation is specified it is usually augmented by a manual pull station. Products-of-combustion detectors can be used to initiate the discharge, and in some systems they are backed up by a thermal detector.

The sensitivity of products-of-combustion detectors and the cost of Halon 1301 make it necessary to consider and to design for the possibility of an inadvertent or unnecessary discharge. Several devices have been used to cope with this potential. A two zone system or cross zoning operates on the principle that alternate detection heads are connected to different zones. Any one activated head will give an alarm, but activation of a second head in a different zone is necessary for discharge of the system. The initial alarm from a head in one zone can provide the opportunity to use a portable extinguisher on a small fire before another head in the second zone detects the fire or products of combustion. The alarm can also provide the time to abort the discharge, if it is unnecessary, by means of a hold down button, latching mechanism,

or similar device. In some systems the products-of-combustion detectors provide only an alarm, and thermal detectors initiate the discharge.

Distribution of the Halon 1301 is accomplished in several ways. A series of cylinders or a larger container in a central location can store the extinguishing medium for distribution through a piping system and nozzles. Another arrangement consists of smaller cylinders or spheres with up to about 100 pounds of Halon 1301, each with its own nozzle, distributed around the room. To effect a simultaneous rapid discharge, this system electrically fires initiators, with the explosive power of about a one-inch fire cracker, on each unit.

Depending upon the specific requirements of the installation, the detection system can be arranged to close doors held open by magnetic holders and shut down the power and air conditioning. Shutting down the power and ventilation is a matter to consider in view of the potential for a fire involving polyvinyl chloride covered cables in the underfloorspace and the resultant release of corrosive HCl fumes. High property damage has been reported from this source and an interesting protection design has been proposed to cope with this fire potential. The underfloor space is provided with a products-of-combustion detection system which, when activated, starts an exhaust fan to prevent HCl from rising into the computer room. If the condition proceeds to the point where a fire occurs, a thermal detector triggers discharge of the system, which would be interlocked to shut down the exhaust fan. There is at least one such installation using CO_2 rather than Halon 1301 as the extinguishing medium.

Halon 1301 Tests in a Simulated Computer Room

In April 1971 a series of Halon 1301 tests was conducted at the Fenwal Incorporated Reaction Test Facility in Holliston, Massachusetts. The description of the tests and the results discussed here are taken from the Fenwal Incorporated July 7, 1971 Report. PSR 414.

The tests were performed in a room 12x8x8 feet high constructed on a platform 13x9x1 feet high serving as a subfloor space. Ventilation was provided by a fan recirculating 200 cfm from the top of the main room, returning it to the subfloor to change the air 16 times per hour.

Products-of-combustion detectors and 140°F thermal detectors were used, and the Halon 1301 was stored in two containers. One sphere containing 18 or 19.2 lbs. of Halon 1301 was discharged into the main room through a six-inch length of one-inch pipe, a 45° elbow, and a conical spray nozzle. A cylinder containing 2.9 lbs. was discharged into the subfloor space through an eight-inch length of one-inch pipe, a 90° elbow, and a conical spary nozzle. An electro-explosive initiator was used in both units. Manual firing was achieved by use of a pull box.

Gas samples were taken from the subfloor and at two and six feet above the main room floor to detect HF and HBr. Concentration measurements of Halon 1301 were also taken.

The following fire conditions were tested:

1. Subfloor fire involving polyvinyl chloride jacketed copper wire on a metal frame.
2. Fire in a ventilated unit with alcohol ignition source under printed circuit boards and PVC coated wire.
3. Fire in open-top 30-gallon waste paper container.
4. Similar to 3, "Flame tamer" cover on container.
5. Fire in glowing charcoal as a deep seated Class A fire.
6. Repeat of Test 2 without ventilation in the unit.

The major results of these tests were:

1. All test fires were extinguished within 10 seconds or less after Halon 1301 discharge.
2. Maximum concentrations were limited to 6.7 ppm for HF and 1.7 for HBr. by the rapid extinguishment.
3. An IBM Model 2495 Tape Reader exposed to the conditions of the tests was found to be visually and functionally un-

affected at the end of the test series.

4. Continued soaking of glowing charcoal in the Halon 1301 did not generate significant quantities of pyrolysis products.

To summarize:

1. The fire protection system with the widest approval today, in spite of some opposition, is the automatic sprinkler system. It is employed most effectively in combination with a products-of-combustion detection system which will give an alarm before the sprinkler heads fuse.

2. The Halon 1301 extinguishing system is an innovation that is slowly gaining acceptance, although it, too, has its opponents.

3. Placement of products-of-combustion detector heads should be based upon engineering judgment and tests, with initial installation prior to test at no more than 400-500 ft^2/detector.

4. Recommendations for underfloor protection includes products-of-combustion detection, smoke exhaust capability, and a gaseous fire suppression system.*

* The most prominent of these are:
1. *Fire Protection for Essential Electronic Equipment.* Federal Fire Council, RPI – March 1962, Revised 1969
2. *Protection of Electronic Computer/Data Processing Equipment.* NFPA 75, 1968
3. *Fire Protection of AEC Electronic Data Processing Systems.* U.S. Atomic Energy Commission, Safety and Fire Protection Bulletin 12, 1968

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