PLAINTIFF'S EXHIBIT

NSC-343

1978 National Safety Congress Transactions

VOLUME 12

Industrial
Subject
Sessions



National Safety Council

66th NATIONAL SAFETY CONGRESS

Papers Delivered in the INDUSTRIAL SUBJECT SESSIONS

Exposure Reduction ..... *Hugh F. Keepers* 3

Destructive Testing of Crane Booms ..... C. A. Brolin 7

Consumer Factors in Product Safety ..... *Camille Haney* 13

Product Safety/Liability Prevention Methods ..... *Richard M. Jacobs* 17

How To Sell Management on an Off-the-Job Program ..... *Jerry Hebb* 22

Slips and Falls: High Risk Populations ..... *Stella Gore Lansing* 27

Pregnant Women in the Workplace and Toxic Exposures ..... *Richard L. O'Connell* 35

Non-medical Issues Presented by the Pregnant Worker ... *Leon J. Warshaw* 40

Pregnant Women in the Workplace— A Company Program To Control Toxic Exposures .... *Leonard A. Krause* 46

An Environment, Safety, and Health Assurance Program ..... *M. S. Tierney and A. C. Ellingson* 50

The Department of Energy Environment, Safety, and Health Program ..... *H. Hollister* 54

Incorporating Proven Principles into Health Programs ... *William D. Burnett* 57

Department of Energy Implementation Efforts ..... *H. Hollister* 74

Machine and Equipment Safeguarding Technology ..... *John Proctor* 77

Safeguarding of Machines and Equipment ..... *W. Atkinson* 80

The Human Element in Safety Man-Machine Systems .. *Julien M. Christensen* 81

The "Statistics" of Safeguarding System Reliability Evaluation ..... *James H. Capps* 88

Supervising Handicapped Workers for Safety ..... *Wayne T. Brooks* 95

Physical Fitness in the Workplace ..... *Robert E. Dedmon* 98

Self-Evaluation for OSHA Compliance ..... *Frank W. Godbey* 100

A Self-Evaluation Program for Electric Utilities ..... *P. G. Rentos* 102

Testing of the Self-Evaluation Instrument ..... *William E. Brammer* 106

Self-Evaluation Questionnaire for OSHA Compliance, Electric Utility Industry ..... *Loren L. Hatch* 108

A Working Experience ..... *Gary McCormick* 111

The Risk Aversive Society ..... *William D. Rowe* 113

Regulation as a Means of Controlling Occupational Health and Safety ..... *Leonard A. Sagan* 121

EXPOSURE REDUCTION

By HUGH F. KEEPERS, P.E., C.S.P.
Safety Engineer, Texas Railroad Commission,
Liquefied Petroleum Gas Div., Austin, TX

In the early '30s and '40s liquefied petroleum gas, commonly referred to as butane, was just being introduced into the rural countryside. Butane replaced coal and coaloil as a more efficient, cleanburning fuel whose sole purpose was preparing food and heating homes. Butane was referred to as "the gas system beyond our natural gas mains."

There was very little known about the characteristics of butane in the early days, except that it would burn and could explode if not handled properly. So by trial and error the LP gas industry got its start. Many times by error, which was chalked up as learning the hard way.

As people in industry became more and more familiar with the product, more and more uses were discovered. When the petro-chemical industry, with its vast knowledge and research capabilities, came into focus on this product they saw its potential and butane developed into one of the most versatile fuels known to man. Today in Houston, Texas, alone, there are over (6,500) different uses for liquefied petroleum gases, from domestic use to carburetion, steel manufacturing, glass processing, aerosol propellant, propane air-gas mix systems, for large industrial plants, LP-gas standby systems to support peak shave operations at such installations as hospitals. Also for standby to large manufacturing plants where it is used to supplement depleted natural gas supplies during winter periods so production will not have to shut down due to the domestic demands.

What Are Your Exposures?

The LP gas industry did not always have the wide acceptance it now enjoys, because of the fear that the earlier users had of the product. However, the LP gas industry, realized that in order to sell the product to industry they would have to remove this fear and have it replaced with respect. This was done by selling safety along with the product. City and state governing bodies across the nation adopted national safety standards for the safe construction of LP gas vessels and wrote rules and regulations setting forth minimum requirements.

These rules and regulations were designed for a safe installation under normal operations, these being that LP gas would be safely transported and dispensed without danger to personnel, property, the adjoining neighbor, or the adjoining neighbor's property.

Today, however, it is not enough to be content with these earlier rules and regulations. These lead to a false sense of security. A plant engineer, safety engineer, or safety director must be looking at exposure potentials now and 10 years ahead. He must exceed the minimum standards.

For instance, a plant built with LP gas storage five years ago, in the middle of nowhere, now finds itself surrounded by sub-divisions, shopping malls, churches, schools, and hospitals. These are known as exposures or loss potentials.

These Exposures Can Be Your Liability

A fire in an industrial plant with involvement of an LP gas bulk storage could result in the container rupturing, especially if the vapor space of the container is exposed to prolonged heat and flame. I have personally measured the distance that some of these vessels have traveled following such a container rupture and found that they can travel from ¼ to ½ mile.

You must also consider the concussion factor which always follows such

incident. These concussion forces can and do destroy buildings in the immediate and surrounding areas. A shock wave produces forces which move in an outward direction, building up as it moves outward due to heated expanded gases being expelled from such container rupture.

What Can We Do To Reduce the Exposure?

Prior to selecting a new plant site, the plant engineer, or safety engineer, or safety director, whatever the title, along with the architect and company management should meet with state and local officials for joint consultation to consider exposures, future developments in the area, and always for future expansion of the plant facilities itself.

One mistake, made regularly, is the architect custom-designing the plant to meet the demands of plant management for production without consideration of exposure liability. Safety must be placed in our designs for the installation of an LP gas standby unit, and the design should allow for additional storage to be added at the necessary future date.

The following five items should be placed high on the priority list in making an LP gas installation at an industrial plant:

1. Never install LP gas containers end-to-end. In the event of a fire, if one container should fail, it's trajectory could be directed into the end of the second container. All LP gas containers should be placed non-perpendicular or parallel to other vessels and should be headed in the same direction.

2. In designing fuel storage locations, make sure that the ends of the vessels are not directed toward buildings. A ruptured vessel usually travels in the direction in which the head is pointed.

3. Loading and transfer operations should be located at least 50 feet from the storage containers themselves and at least 50 feet from any open-fired vaporizer. Should there be a leak of a valve or a transfer hose rupture, this distance could mean the difference of the driver or operator having time to shut off the valve before the gas reaches the open flame. These 50-foot distance requirements help to limit the exposure when a transport or bobtail unit is on fire by being separated by adequate distance from the storage itself.

4. Concrete or steel bulk heads at transfer locations must be directed away from all storage facilities. Why? Because, should the driver drive off with his hose connected, the escaping gas (or fire, should it ignite) would then be directed away from the storage containers.

5. All thermal-acting automatic shut off valves located at the concrete or steel bulk heads should be extended to a level above the top of the bulk head, high enough to expose them to the quickest heat should a fire occur. Too many times a bulk head is designed with the thermal-acting shut off valve located behind the bulk head in a position where heat from the fire cannot actuate the fuse which controls the valve for shut down. Considerable monetary cost is involved in such thermal valves not to have them work as they were designed.

The LP gas standby storage installations must exceed the minimum standards of today to survive the possible accidents of tomorrow and not add to the industrial plant's liability.

Proper training of maintenance and operating personnel in the characteristics of LP gas and the necessary emergency steps to be taken to shut down the operation should be the safety engineer's priority. This training should also include local, municipal, and voluntary fire personnel who could be called to assist in an emergency.

All personnel other than those assigned to such emergency shut down operations crews must be evacuated. Evacuation routes must be directed away from areas where emergency personnel and equipment will be responding. This removes congestion from the area, saving precious time needed by emergency crews.

Designated emergency routes to the plants must be established when preplanning to insure the quickest avenue to the storage area for emergency vehicles.

Don't Put All of Your Eggs In One Basket

Many industrial plants place priorities on production when laying out the new plant site, leaving one of the most important parts of the operation to last, that is the fuel storage.

Knowing the hazard potential of fuel in general as a flammable product, they place it all in one corner, any corner that is left after the buildings are erected, and they then try to cut corners on the state and local safety standards by saying, "Well, we don't have any other place to put it;" or, "This is all the property we have."

After placing the LP gas standby system in one corner of the plant, one which barely meets the minimum distance requirements, they find themselves backed up to adjoining property which could be developed at any time. They also continue to add to this already hazardous area with storage of gasoline, diesel fuel, lubricating oils, and even chemicals in the same area.

In the minds of some plant management, anything considered hazardous should be placed in the area designated for dangerous commodities, with no thought to their compatibility. No consideration is given to the fact that should there be an accident in this area which results in a fire, a possible explosion could occur, setting off a chemical reaction of the other products stored here, thereby resulting in total disaster.

Fuels as well as chemicals must be stored with utmost care. This is an area where the plant safety engineer must be part of the internal and initial planning. He can then continue to monitor future growth of the plant, making sure that hazard control is a part of the corporate structure.

The safety engineer must also make sure that LP gas storage is located away from other static fuels, such as aboveground diesel fuel, oil, and gasoline tanks. Second, he must insure that should a leak develop in the static fuel tank it would not flow under the LP gas storage installation. Dikes, diversion curbs, or grading of the area are just a few of the ways to prevent such fuel from flowing toward or under an LP gas installation. A leaking gasoline or diesel oil line can create a very hazardous condition, and without necessary precautionary steps prior to this break, our chain of events can result in total disaster to the plant.

When an industrial plant has installed a battery of large LP gas storage containers at one location and later decides to add additional containers, consideration should be given to locating the new battery of containers in an area separate and remote from the first storage location. Should one battery of tanks be involved in an accident, the plant could avoid a long shutdown by utilizing the secondary battery until necessary repairs can be made. More importantly, this would reduce your exposure potential.

Emergency personnel can usually handle a small battery of LP gas containers with success; however, when there are more than four containers in any given area, the fire and emergency personnel can not be as effective as they might be on a small storage installation. This is basically due to the limited availability of water supply, when a concentration is needed to cover all the vessels involved at one time.

When LP gas transport units or bobtail trucks are not being used, they should not be left parked side-by-side or next to a storage container. LP gas trucks when not in use should park at least 25 feet from each other. This provides for protective space if one is involved in a fire, without destroying the whole fleet.

All liquid valves should be in a closed position on all LP gas trucks unless the unit is transferring product.

Leaving an LP gas transport or bobtail truck connected to an LP gas storage following the transfer of fuel adds to your exposure. A transport left connected means that in the event of a fire precious time could be wasted in disconnecting from the filler valve to move this unit to a safe location. Persons not realizing that the unit was still connected to the bulk storage might try to drive the unit off in an emergency situation and break off the hose or fitting on the truck, creating another fire thereby, adding to the al-

ready bad situation.

Finally, another exposure which is created in shops and warehouse areas of industrial complexes is personnel without adequate knowledge of the seriousness of the hazard permitting spare LP gas cylinders to be stored inside an already congested area. A small warehouse or shop fire could result in total loss in the event the fire reaches these LP gas cylinders. Only those properly mounted on the industrial forklift unit should be allowed inside the shop or warehouse area and only while the driver is in attendance. When a unit is not in use, it should be parked on the outside dock or ramp in a well-ventilated area.

The storage of these spare cylinders could prevent evacuation or exit from an area should a fire occur and could likewise keep emergency fire service personnel from entering the building. These DOT LP gas cylinders have spring-loaded pressure relief valves in the vapor area which are subject to discharge in the event of increased pressure, which may be caused by temperature increase of the contents. All unnecessary exposure should be avoided. Areas outside of warehouse and shop buildings must be provided for this storage of spare cylinders. You should refer to the NFPA and other state and local standards for proper safe distance and location of such containers.

DESTRUCTIVE TESTING OF CRANE BOOMS

By C. A. BROLIN
Asst. Chief Engineer,
Link-Belt Speeder Div., FMC Corp., Cedar Rapids, IA

The presentation of these test results is intended to provide additional loading data for failure analysis by all persons interested in mobile crane usage, and thus promote effective, safe application of these versatile machines in industry. The FMC engineering management particularly, and company management generally, have wanted to run such a series of tests for as long as ten years or more. A company must have compelling reasons for such a steadfast commitment to such a project—we did. Further, growing influence for establishing crane ratings from sources outside our company, indeed from the industry, placed further emphasis on "getting the job done."

The specific questions we hoped to resolve by this work are as follows:

1. Establish the actual, ultimate strength of our lattice type crane booms under known, controlled loading.

2. Establish a valid correlation between the predicted and the actual ultimate strength of our lattice type crane booms under known, controlled loading.

3. Establish the mechanism of failure of lattice type crane booms; that is, failure of the overall boom as a beam column versus failure of the unsupported chord length within the total boom.

4. Demonstrate fully to ourselves and the crane-using industry the effect of side loading such structures, particularly long booms.

5. Establish that the high-strength alloy quenched and tempered steel tubing that we purchase has at least the buckling strength we estimate from the SAE J987 critical stress curve.

6. Establish whether or not the strength margin (N) and tip deflection limitations suggested in SAE J987 are good engineering criteria for limiting the capacity of a boom.

7. Determine if the proposed SAE Recommended Practice, "Latticed Crane Booms—Analytical Determination of Stress and Critical Loads," method of establishing overall structural competence, at maximum ratings, is a good engineering practice.

Conclusions Deducted from Tests

1. The actual, ultimate strength of lattice type crane booms can be determined under controlled loading conditions, using the methods we employed. Such testing is very costly, requires very careful planning, excellent mathematical analysis in advance, excellent experimental stress analysis techniques and instrumentation, the complete cooperation and dedication of many skilled and experienced people, along with good weather and a full measure of good luck.

Fortunately, we had this combination in adequate measure; we suffered no injuries to people and no damage to equipment other than that expected.

Our boom strength analysis was based on the material presented by Vroonland,[1] and the experimental stress analysis techniques used were those proposed by Brolin.[2]

2. Table 1 shows two points very clearly. First, the actual ultimate

TABLE 1
Results of Tests to Ultimate Failure

Boom Length, ft (meters)	Predicted Ultimate Stress, psi (mN/m²)	Actual Ultimate Stress, psi (mN/m²)	Predicted Ultimate Load, lb (kN)	Actual Ultimate Load, lb (kN)
80 (24.4)	85,500 (590)	98,850 (682)	171,387 (761)	176,800 (785)
160 (48.8)	85,500 (590)	84,750 (584)	51,193 (227)	53,710 (238)
200w (61.0)	85,500 (590)	87,000* (600)	28,769 (128)	32,145 (143)
200w/o (61.0)	85,500 (590)	87,000 (600)	27,428 (122)	28,410 (126)

*By extrapolation of curve to failure load.

stress, at the points measured, was very close to the predicted ultimate stress or exceeded it. Second, in every case the actual ultimate load exceeded the predicted ultimate load. These data, we feel, are significant and impressive, but not nearly so much as the curves plotted. As the boom approaches failure, the slope of these curves increases extremely fast. Small changes in load make dramatic changes in boom tip deflection and chord stress.

It is gratifying indeed to achieve such respectable correlation in this fast-changing stress and deflection region, and it is comforting to know that in the slightly above-rated load region the correlation is even better. In many instances the predicted and experimental values are superimposed in this region.

Our years of testing and mathematical study long ago established excellent correlation in the rated load and less than rated load regions; therefore, these tests did not repeat any of this work.

3. To our knowledge, the technical friendly argument of how a lattice type crane boom fails has been going on for at least 15 years. Undoubtedly, the same controversy was discussed 50-100 years preceding this investigation. Hopefully, the results we present here will help to eliminate or reduce the future need for discussion of this matter.

The results in Table 1 show clearly that the individual unsupported chord span fails at a value of stress equal to or greater than that which we would predict from the SAE J987 critical stress curve.

The data show these failure stresses as well as the stresses as the last loading condition before failure. These data establish fully that "a boom does not fail (utter collapse) when any chord stress exceeds the critical stress at the KL/r of the entire boom!" The boom fails when the critical stress of the individual, unsupported chord span is reached.

The critical stress for the unsupported span is two to four times the "critical stress" for the entire boom, provided the individual unsupported chord span (KL/r) is much smaller than the entire boom, KL/r; specifically, when the individual unsupported span is in the 20-60 KL/r range and the boom in the 80+ KL/r range. A further limitation on this truism is that we restrict its use to the modern 100,000 psi (689 mN/m^2) minimum yield strength, steel-chord boom.

We are readily willing to concede that if the boom chords were made of mild steel, the factor of 2-4 might not hold, since the critical stress for this material does not change greatly throughout the entire KL/r spectrum.

We added a "superlong" boom (KL/r of 123) to our original planned test to explore further the elastic behavior of such a structure. We did not take this boom to collapse. It was loaded with hook load and side load as well as with hook load only. We felt that with 12 ft. (3.65 m) of tip deflection, we had adequately demonstrated that elastic instability can occur and is observable; it is also a little frightening. We are thoroughly convinced that if the boom had been taken to collapse, its eventual failure would be just like the others; that is, the stress would continue to increase until the individual unsupported chord span reached its critical value; then it would buckle and that would be the finish.

4. Side loads beyond design values are bad news! This has been stressed to operating personnel through seminars and service books and in individual sessions for years. We felt that it would be worthwhile to show its real effect here also. The results on a 160 ft. (48.8 m) boom with 0, 1, and 2 per cent side load show a dramatic change in tip deflection and stress with increasing side load. These curves show fully why a crane should be carefully leveled in both directions and swung carefully when making heavy lifts. The closer the crane is operated to rated capacity, the more particular the skilled operator and job superintendent is and must be.

5. We use the SAE J987 critical stress versus KL/r curve for design and test purposes. The curve we use is that for the 100,000 psi (689 mN/m^2) minimum yield strength steel modified to consider a 15,000 psi (103 mN/m^2) residual stress.

Our own purchase specification addresses itself to the issue of residual stress but does not require a thermal-stress relief operation as a distinct, separate mill operation.

Our estimated critical stress was 85,500 psi (590 mN/m^2). The actual stresses measured on the high chord (average of two gages) was 84,750 psi (584 mN/m^2), 87,000 psi (600 mN/m^2), and 98,850 psi (682 mN/m^2). Further, we admit that the gages we monitored at failure were displaced from the actual failure location in three out of four tests by a considerable distance. The gages monitored during the 80 ft. (24.4 m) boom collapse were only one panel (span) away. However, this critical stress was 98,850 psi (682 mN/m^2).

These data, considerable thought on the possible influence of residual stress and its distribution in a round tube, residual stress information supplied to us by our tubing vendors along with the measured properties of the tubing removed from the failed boom sections lead us to conclude that the curve is probably wrong but conservative! The data suggest the possibility that the real curve is flat until it intersects the Euler curve and that the K factor on this construction may be approximately 0.85-0.90.

6. We find that the actual 160 ft. (48.8 m) boom with its actual published rating has an "N" of 2.18. The load ratio exceeds 1.60 before failure when "N" equals approximately 1.0.

Assuming that we would allow tip deflection to limit, we would find that for a 160 ft. (48.8 m) boom, the deflection could be approximately 38 in. (0.97 m). This would require about 40,000 lb. (178 kN) with a two per cent side load. This is a load ratio of about 1.20, and "N" would be about 1.72. The failure load on this boom was 53,710 lb. (238 kN) with a two per cent side load. The load factor would be 53,710/40,000 = 1.34.

Using "N" = 1.6 as the limiting value, we find that the load ratio is approximately 1.27, which says that 42,400 lb. (188 kN) could be the published rating based on this limit only. This value results in a load factor of 53,710/42,400 = 1.27. The tip deflection under this condition would be approximately 46 in. (1.17 m).

With this particular test boom and machine combination, the tip deflection limit controls and results in a rating that must be exceeded by 34 per cent before the boom fails, including the two per cent side load. The "N" factor of 1.6 results in the necessity of a 27 per cent "overload" to fail the boom, including side load of two per cent.

This brings up the questions: "How much safety (under failure load) do you want?" "What is adequate reserve strength?" "Is 27 per cent and/or 34 per cent too risky?" "What is good practice?"

Let us examine some current and possibly old rules for adequacy in comparison.

We believe that the ratings of many European cranes are based on 75 per cent of stability and the requirement that the boom and machine must withstand a 25 per cent straight-pick overload. In this instance, let us assume the "rating" was 42,400 lb. (188 kN). The stress is approximately 30,000 psi (207 mN/m^2) with "0" side load. The "overload" pick would be 53,000 lb. (235 kN). The stress would be approximately 37,000 psi (255 mN/m^2).

The stress in the boom was approximately 52,000 psi (359 mN/m^2) under the 42,400 lb. (188 kN) loading with two per cent side load. Failure occurred at approximately 84,750 psi (584 mN/m^2) at the point measured. This indicates the "highest possible" SAE J987 rating, 42,400 lb. (188 kN), would pass the European requirement.

Using the SAE boom tip-deflection limitation load of 40,000 lb. (178 kN) results in all values being more conservative. The "European proof test" pick of 50,000 lb. (222 kN) results in a stress of 34,000 psi (234 mN/m^2). There is no doubt that the 40,000 lb. (178kN) SAE J987 rating would pass the European requirement easily and be a more severe test on the structure!

Currently, ANSI B30.5, Section 5-2.2, Paragraph 5-2.2.2. states:

(a) "Prior to initial use all extensively repaired or altered cranes should be tested by or under the direction of an appointed or authorized person.

(b) "Written reports shall be fur-

nished by such persons showing test procedures and confirming the adequacy of repairs or alterations.

(c) "Test loads shall not exceed 110 per cent of the rated load at any selected working radius."

In view of the slow change of stress and deflection with a straight pick loading, we question that this requirement is adequate to prove competence after such work has been performed. This would be particularly true when the rated load is limited by structural competence. When this is the case, it is so noted on the capacity plate.

It appears that rated load plus two per cent side load in both directions, or at least 25 per cent straight pick overload, is needed. We are concerned that latent damage might go unrevealed with such a 110 per cent straight pick test and cause trouble under rated conditions while swinging or hoisting. We believe further study should be given to this matter.

Note: These tests were performed to compare our calculated values to test values, and slight differences do exist between our test procedure and a strict application of SAE J987 to these booms. Nonetheless, we feel the application of these results here are worthwhile and valid.

7. For many months now the mathematical experts from the crane industry (PCSA) have been working separately and jointly with SAE (Ad Hoc Committee of Subcommittee XVII) to develop a mathematical method for establishing general or overall competence of a lattice type crane boom. This document was out for ballot in early May 1972. Since this document was in nearly finished form, we wanted to "plug" our data into it and see if our boom and ratings would be satisfactory. Table 2 gives these results.

We see from Table 2 that, in general, the allowable maximum ratings in the proposed SAE Recommended Practice are somewhat higher than current L-BS ratings. The L-BS ratings were shown earlier to be somewhat conservative with respect to the allowable rating under SAE J987 rules. Still, when we compare the allowable rated loads under either system with the actual failure load, they provide adequate strength margin against failure and lie well within the linear portion of the stress and deflection versus load portion of the curves.

TABLE 2

Crane Boom Criteria

Boom Length ft (meters)	Actual Ultimate Load, lb (kN)	L-BS Load Rating, lb (kN)	Maximum Load Rating by Proposed SAE Recommended Practice, lb (kN)
80 (24.4)	176,800 (785)	94,558 (420)	112,000 (497)
160 (48.8)	53,710 (238)	33,298 (148)	40,600 (180)
200w (61.0)	32,145 (143)	17,068 (76)	20,000 (89)
200w/o (61.0)	28,410 (126)	16,900 (75)	19,600 (87)
230 (70.1)	— (-)	12,433 (55)	14,000 (64)

Our understanding of the proposed SAE Recommended Practice mathematical competence rating system is that the maximum allowable rating is based on one of two criteria: Scr ÷ 1.67 at the K(L/r) of the unsupported span (Scr from SAE J987) or the ratio of the proposed SAE Recommended Practice (ultimate buckling load) ÷ (rated load) must be equal to or greater than 1.75. There is no computed tip-deflection limit value in this method of checking competence. The ultimate, total boom, column-buckling load in this system is a value calculated without a purposely applied side load. This "industry" approach to the problem gives values reasonably close to our own "house" values, and both give adequate margin against failure.

Hopefully, the day is approaching when it will be practical to rate a crane boom against ultimate load rather than against ultimate stress, which is current and past logic and practice. We are confident that the entire industry would favor this new system when fully developed.

Future Projections and Recommendations

Where should we (crane manufacturing industry) go from here? We feel that the results presented herein are timely and accurate, and have valuable significance for ourselves and the crane industry throughout the world. We also admit that everything did not happen as perfectly as it was planned and that additional questions are raised as a result.

It is our recommendation and hope that other builders of mobile construction type cranes will perform additional tests such as these and present their results to the world through such organizations as SAE. If this is done, we believe the individualist "art" of crane design can be replaced with the worldwide "science" of crane design. When this is accomplished, the full utility of these versatile machines can be realized on a worldwide scale.

Should others accept this challenge, we suggest that the following areas be explored:

1. Investigate similar modern structures that will, hopefully, corroborate our data.

2. Investigate similar structures with both lower and higher strength chord material.

3. Investigate structures that differ in design detail construction to evaluate its influence. Such structures as crane booms made of structural angles would be good candidates.

4. When running such tests, either utilize more gages or spread them out over a great length of chord. Hopefully, this may get closer to the actual failure location.

5. Include additional straight pick loads (overload compared to rated load) for additional data due to this type of load test. This may help establish a sound basis for this type of competence testing.

6. Explore the elastic instability area in the large K (l/r), total boom, region for the purpose of personally seeing the phenomenon occur.

Review of Test Preparation and Safety Measures

As with most good testing, it seems that 40 per cent of total test time is spent in preparation, 20 per cent in accumulating the data, and 40 per cent in reducing, plotting, writing, and wishing you had done several things differently. This project was no exception.

The following list summarizes preparatory work for performing these tests.

1. Establish the expected failure load for the booms.

2. Check all components in the system for adequacy.

3. Select the machine that would handle the booms at failure loadings.

4. Select the "catch" or "safety" crane and establish its necessary configuration.

5. Check its adequacy under expected loading and unexpected loading.

6. Plan the sequence of testing the booms.

7. Mathematically analyze each boom for expected failure location.

8. Establish the parameters to be measured during test.

9. Establish what was to be measured before test.

10. Predict the weather.

11. Schedule the test for machine availability. Four machines required.

12. Schedule the test crew force and assign specific responsibilities to each.

13. Arrange for and establish photographic needs.

14. Plan each step in the test sequence and design data forms for ease of use.

15. Establish and promulgate extra safety rules for the testing area during the testing.

16. Design and build special force-measuring transducers.

17. Build special long-tip-deflection measuring scale.

18. Establish method and means for measuring initial boom straightness.

19. Establish what would be measured after tests were complete.

These comprise at least the major problems that required adequate thought and solution before testing.

During the test (item 8 above), the following parameters were measured:

1. Tip deflection.

2. Chord and lattice strains at selected points (approximately 45 channels total).

3. Main pendant force (both sides).

4. Midpoint pendant force (both sides).

5. Boom foot out-of-levelness (due to deflection under load).

6. Side load force.

7. Radius of load.

8. Approximate wind velocity and direction.

9. Test loads (preestablished).

The following list of items were

measured before testing began (item 9 above). Note: All items used in the test were standard production units. No attempt was made to select items on any basis; however, the following measurements were made to avoid surprises, if possible, and to be able to evaluate their importance if such did occur.

1. Straightness of each chord span on each section.
2. Wall thickness of each chord span on each section.
3. Live mast actual length.
4. Length of all pendants.
5. Center-to-center distances on bridles and bails.
6. Straightness of each boom before testing.
7. Midpoint pendant length adjustment.

After testing, we selected chord and lattice samples from the sections that actually failed, for mechanical property verification. In addition, considerable metallurgical work was done on the connection lugs and lug-to-chord welds, for quality control verification and other possible future needs (item 19 above).

We are sure that after reviewing these lists, you will agree that we attempted to cover all eventualities. The planning was worthwhile, since (as mentioned previously) no unexpected surprises occurred and no injuries were suffered.

We have provided herein some startling new information about these complex structures. Our hope is that others will accept the challenge and further develop this science in the years ahead. We acknowledge again that such work takes much time and the cooperation and skill of many engineers. We are grateful to many people in our organization for the opportunity to participate in such a test program and to present the results here. Special thanks must be given to our management, our test crew, our design sections, our engineering computer section, and our photographic department for their total cooperation and participation.

REFERENCES

1. E. Vroonland; "Analysis of Pendant-Supported Latticed Crane Booms," *SAE Transactions*, Vol. 80 (1971), paper 710697.
2. C. A. Brolin; "Comments Regarding SAE J987 as related to Methodology, Instrumentation, and Personnel," *SAE Transactions*, Vol. 77 (1968), paper 680620 (SP-342).

CONSUMER FACTORS IN PRODUCT SAFETY

By CAMILLE HANEY
Executive Director, Consumer Concepts, Milwaukee, WI

The consumer challenge can be simply summed up by quoting the well-known phrase coined by the crazed anchorman, Henry Beal, in the popular movie, *Network*: "I'm mad as hell and I won't take it anymore!"

Each of us is a consumer and, furthermore, each of us is a consumer advocate or activist, given the right issue. For example, have you experienced any of the following consumer frustrations recently: Taken the afternoon off to wait in vain for a TV repairman who didn't show up? Had your insurance policy cancelled (they call it non-renewal) or increased substantially because of your zip code? Bought an Oldsmobile only to discover it had a Chevrolet engine? Had a new washer break down? Experienced a blow out of the Firestone 500 tire, currently being recalled? Had two buttons drop off your shirt after a second washing? Been bumped from an airline on which you had a confirmed reservation? Been denied a hotel reservation even with a printed confirmation? Had a car repair made only to discover it really wasn't fixed after you went through all the logistics involved in taking it into the shop? Been unable to get credit because, as a woman, your entire credit history is in your former husband's name? Been upset because your electricity rates were increased to make up for utility revenues loss due to decreased use of energy through conservation? Had the run around when you tried to get someone to listen to and help you settle a complaint?

The list goes on. *Consumerism at the Crossroads*, the recent Lou Harris survey on the consumer movement, showed that the consumer movement is broad and it is deep—and will continue to be because it is based on individuals with basic questions about how they're treated in the marketplace, and they're starting to fight back.

Too many businesses look at the consumer movement as a direct threat, best handled by a strategy designed to avoid it altogether or by responding in a hostile, defensive manner. Such companies love customers but hate consumers. Customers buy; consumers complain.

There are many business strategies used to deal with the consumer challenge. Yankelovich identified five of the most common ineffective ways in recent research. In a way, they're like the bad news in a bad news/good news joke. Let's review them as background:

1. A call for more economic education. This is very popular and appealing to business. The assumption is that people mistrust business because of the public's "economic illiteracy." The public exaggerates business profits, doesn't understand competition, doesn't realize that the cost of additional safety or environmental government regulations are just passed on to the consumers.

Yankelovich's research concludes that while more economic education is desirable and can be useful and informative, it is not responsive to the basic problem, which is one of mistrust.

We're learned a lot in recent years about what inflames mistrust. If someone mistrusts you and you fail to address the cause of the mistrust, you end up making it worse. What people are saying to business is this: "You don't have to lecture to us on the merits of the private enterprise system. We believe in it as much as you do. Why are you avoiding the real issue, which is that you are willing to take chances with my health and with my safety, and to take advantage of me for the sake of your own profits? Our understanding of the private enterprise system is that you're supposed to

make profits by offering a real service and by not exploiting people. That's the difference between legitimate profit making and profiteering—and we think you are profiteering. Prove to us that you are not!"

2. The Mobil approach. A second type of action program is represented by the approach of the Mobil Oil Company—be bold in telling your side of the story.

Research on the effects of Mobil's program shows it does have impact, but only on those who agree with business to begin with. Mobil's program doesn't significantly improve the company's standing with the public at large or with the media, and it doesn't dispel the mistrust. It does help boost morale of those already committed to the business point of view, and makes them feel they are fighting back.

The ads being run by a few insurance companies on the product liability issue is another interesting example of this attack. One ad for Crum & Forester Insurance Companies is headlined: "The jury smiled when they made the award. They didn't know it was coming out of their own pockets." Another of their ads repeats as fact the story about the man who tried to cut his hedge with a lawn mower. The same ad states, "In 1976 an estimated one million product liability claims were filed," which, according to the Federal Interagency Task Force on Product Liability is not true.

Aetna Life & Casualty has also tried the direct approach. One of its ads is headlined, "Too bad judges can't read this to a jury," referring to these words: "When awarding damages in liability cases, the jury is cautioned to be fair and to bear in mind that money does not grow on trees. It must be paid through insurance premiums from uninvolved parties, such as yourselves."

In the opinion of *Consumer Reports*, these ads won't work because they are "insulting and misleading."

Yankelovich finds that this approach is not a solution to the problem of the public misunderstanding business, although a company should tell its side of the story if it's being incorrectly perceived.

3. The legal adversary approach. A third approach is the legal adversary approach, similar to the Mobil approach. Here business takes the position: "Let's fight the so-and-sos every inch of the way—don't give any ground until you are forced to." Even more than the Mobil approach, this is great for the male ego. It gets the adrenalin flowing. It makes people feel good when they're fighting back rather than knuckling under to Nader's disciples in the regulatory agencies. This approach is a great boon for the lawyers, but it only sharpens the confrontation. Again, this strategy, like the Mobil public relations offensive, may be a part of a defensive effort, but it won't win acceptance or support.

The Firestone tire, for example, as outlined in August, 1978 *Fortune* shows how "successfully" this works. At each stage of the legal maneuvering between Firestone attorneys, NHTSA, and Congressional committees, the public was exposed to additional copy about what was perceived as the company's disregard for public safety.

4. We may call the fourth approach the "in unity, strength" position. You often hear businessmen say, "Businesses ought to stick together as a single unified group and take concerted action. We're only strong if we're unified."

This position can be very controversial. It isn't that we suggest that business or industry associations dissolve, but we believe that no company should seek to defend its own image, its own actions, through a trade or business organization. Business is not homogenous. Companies and industries have different interests. I think the reason the business roundtable is so effective on Capitol hill is that real people from real companies are the activists behind it.

5. A fifth strategy is to keep a low profile—the "no comment" about anything approach. You know as well as I, from your own experiences or that of others, that the low profile approach won't do the job. Silence on the part of business seems like complicity.

This may seem like a contradiction to the Mobil strategy, but it's really a matter of stressing what you're doing to address questions the public wants answers to rather than just editorializing about what the company wants the public to hear. (The Shell Oil Answer Book series is a positive example of this approach. Shell listened to what consumers were asking and planned a program to respond to these questions, a much more believable approach.

All these strategies share one great failing in common: they reflect the needs of the business more than they reflect solutions to the problems; they seem better designed to reduce management's level of anxiety than to reduce the public's level of mistrust.

So much for the bad news about how companies are trying to deal with the public and their own customers. Let's talk about the good news—the positive things business is doing. Over the past several years, a number of enlightened business executives have discovered that by using creative approaches to working with consumers they could save money, improve their effectiveness with government agencies and the media, and also gain respect—if not love—in the marketplace.

In increasing numbers, business is trying, at the very least, to learn what consumers are thinking. They know now that their support of consumer rights does not necessarily compromise their companies' objectives, just as responsible consumer leaders know that their advocacy is not inherently anti-business.

Why have some companies chosen to work aggressively and positively with the consumer movement? Motives vary, but perhaps all companies that are developing consumer affairs efforts have one thing in common: they perceive the consumer movement as a phenomenon that will inevitably have an impact on their business. It's a fact of life. Regardless of understanding it or liking it, it must be dealt with, and they've chosen to do it in a positive rather than negative manner.

Several CEO's who I've worked with have simply sensed the strength and impact of the consumer movement based on personal observations—they want to "get a handle on" what's happening and want to gain some degree of control in dealing with it.

Most consumer affairs programs, however, have evolved from identifiable circumstances. I've categorized these experiences into four groups, based on motivation.

1. Complaint Handling. The first motivation is an instinctive recognition that a traditional complaint handling service could be improved, or even better, turned into a positive marketing tool. Or occasionally, a particularly articulate complaint letter which managed to reach the president's desk can provoke an entire program. (General Mills Consumer Response System, Ford Third Party Complaint Reservation, and Whirlpool's Cool Line.)

2. Concern for Public Relations. Publicity and public relations that emphasize a company's understanding and concern about consumer problems make consumers "feel good" about such a company. Institutional advertising, of course, can be effective, but nothing beats good news, which stands out because of its rarity. *Consumerism at the Crossroads* was such an example. Public opinion research can provide the "news peg" for such publicity. Furthermore, messages coming out of such research show that consumers have this knowledge and often prompt development of activities in the company to respond to these needs.

3. Legislative and Regulatory Pressure. The threat of government action, or the actual experience of legislative and regulatory pressure is the third motivation. Few businesses are unaffected by the growing involvement of government in their operations. In fighting back, companies are realizing that consumers can be strong allies as well as adversaries. (DSA, AT&T, Allstate, EEI.)

4. Prior Experience—Good or Bad. The fourth motivation is some prior experience with a consumer issue that proved either disastrous or surprisingly positive. Companies are increasingly thrust into situations which in retrospect could have been better handled with more knowledge or sensitivity to consumer feelings. On the other hand, business persons have found themselves working with consumer or special interest leaders at their own initiation because they were forced in-

to it, and discovered they not only survived, but indeed benefited.

I'll give an example of this category, because I was personally involved in it, serving as a catalyst to bring all the parties together. About three years ago, officers of the TYME corporation, a group made up of representatives of four major Milwaukee banks, formed an industry committee to develop a way for providing shared electronic funds transfer (EFTS) capabilities, too expensive to pursue alone. They were persuaded by the successful experience they had had in working with consumer leaders and government officials in developing a state consumer credit code several years before that.

I suggested that consumer input be sought before the system was developed, while there was time for serious consideration to be given to consumer concerns.

A series of working meetings between the bank representatives, consumer leaders, government representatives, and educators resulted in the development of an EFT system which included far-reaching safeguards sought by consumerists. It was workable for the financial community as well. Regulators, concerned with providing as much consumer protection as possible, were pleased to learn that consumers and business had worked together to develop the system.

The Wisconsin experience in facing the complex issues involved in the development of EFT has provided a model for many other states as well as for proposed federal legislation currently before the Senate Banking Committee.

The early warning system employed by the TYME Corporation shows what can be accomplished by seeking consumer input early enough to head off confrontation and resulting costs of government regulation. Had the credit card industry listened to consumer leaders prior to the mass mailing of unsolicited credit cards in the mid-1960's, subsequent government prohibition of unsolicited cards could likely have been avoided.

Corporate consumer programs must be meaningful to each company's goals. They can be modeled after others, but the good ones are innovative and well tailored. There is no "quick fix" gimmick, and just "talking a good game " won't work. While much of the work can be delegated, the accountability cannot. The consumer movement touches many areas of a business and can only be monitored by the executive with overall responsibility for marketing, product quality, legislative relations, public affairs, and corporate planning.

Some steps you might consider in developing your own consumer programs include: develop a consumer division; analyze and answer consumer complaints; meet with use-oriented customers and consumer leaders; appoint consumers to corporate boards of directors; develop special interest advisory panels, ad hoc dialogue sessions or sounding boards on new issues, products, or services; and initiate an independent company-wide consumer affairs audit.

While a great deal has been done to open the doors of corporate decision-making to input from consumers within the last few years, the challenge has just begun to be recognized. My former experience as a consumer advocate and government consumer official, and now as a consumer advisor to business, indicates clearly that the opportunities for these three segments to work together to solve mutual problems and reach mutual objectives will continue to grow. Although the primary growth during the late 60's and early 70's was in the governmental area, the pendulum is now swinging to provide greater recognition of the roles of consumers and business working together, cooperating in a joint venture to make our economic system responsive to the profitability and credibility goals of the 1980's.

PRODUCT SAFETY/LIABILITY PREVENTION METHODS

By RICHARD M. JACOBS, P.E., C.S.P., C.Q.E., C.R.E.
Consultant Services Institute, Inc., Livingston, NJ

Until a person or one of his family is injured, most of us take safety for granted. Then a transformation takes place, and an avid safety advocate is born.

As a consultant in quality and safety-related matters, we have observed some interesting statistics based on ten years of independent experience during which we have had over 750 product-related litigation reports, claims, trials, etc. We have found only one instance where a citation was made prior to an accident. However, after the accident over 80 per cent of the employers received citations or warnings prior to citations.

Workmen's compensation insurance company safety specialists report on their observations and recommendations, and we have found two instances in ten years where a recommendation was reduced to writing, requesting the company to do something about an unsafe condition.

We have observed that the property owner or employer very seldom takes any action save for a chicken wire fence, a sign, and a painted line around the hazard which may have contributed to an injury. Most continue to do business the same old way. Why, we have asked, isn't something done? The usual answer is that it costs more to prevent than to have the accident!

This is the atmosphere in which those of us who try to defend companies must work. Where do we go? What do we depend upon?

1. Heavier OSHA penalties.
2. Pressure from insurance companies.
3. Pressure from unions.
4. Pressure from industrial goods manufacturers.
5. Pressure from state labor departments.

Each of these has drawbacks and advantages. However, let's look at other elements of the confusion.

The Insurance Service Office reported in 1977 that 11 per cent of all bodily injury claims by employees command 42 per cent of the bodily injury dollars paid out (average: $97,000).

The American Mutual Insurance Alliance reported earlier that 70 per cent of the claims where defendant paid out over $100,000 were employee injuries which were satisfied by either third party strict liability suits or by subrogation suits. Half of these claims were subrogated. These data require our careful scrutiny and most rapid action.

Some courses of action that each employer can do without too much difficulty or expense are:

1. Request a retired safety engineer, a professor, or a working safety professional from another company to exchange a day or two with you. Ask him to inspect your operation as if he were personally going to buy the place. Sign a confidentiality agreement with whomever you select and have an independent audit of your own place. We cannot look at our own places, but we sure can see a lot of everyone else's operation. Let's use that human trait to full advantage.

2. Insist that your workmen's compensation carrier send a safety professional to your plant for inspection, not a History or English major who became a loss control specialist in ten wonderful days!

3. Ask your lowest supervisors to identify problems before they occur; but when you do this, you must be prepared to act on most of them.

Each seller of industrial products can make the following contributions to this grass roots effort of safety improvement:

4. Train sales representatives to be able to identify unsafe practices in factories on any equipment they observe (10-day wonder courses; if there are enough trained salesmen, maybe they will make a dent in the project).

5. Direct sales representatives to inspect potential customer's facility before accepting an order. If the buyer says no, make sure the acceptance of the order states; "Customer declines to advise how and where unit will be used. Advice on safety of application(s) is therefore not possible. Accidents in which unit is involved cannot, therefore, be seller's fault"—or words to this effect. Consult your corporate counsel. In other words, remove the potential causes of liability foreseeability, lack of instruction, warning, guards, etc. by passing the onus onto the buyer. It is a good, but not an absolute, defense.

6. Direct sales representatives to visit every customer in their territory periodically and check how your machine is being treated—and used.

7. Send notices of improved safety to trade publications owners and the used-machinery brokers, sellers, and refurbishers.

An interesting situation has come to my attention which I'll pass on to you for whatever it's worth.

A company became aware of a potential defect and came to the conclusion that it would sell a retrofit kit for $15. It has had 50 claims in the past five years, including two deaths. It produced the kits and sold only five; the rest didn't want them because it took two hours to install. The lowest claim paid was $106,000. The loss would have paid for 7,066 kits, and it had produced only 4,200 units to date. The company sold none. Wouldn't it be wise for it to give the kits away—even provide the labor to reduce the potential liability in the years to come?

Another company in Pennsylvania did give the kits away without installation labor, and 62 per cent of their known customers took them. Which was cheaper?

Safety must be organized so that it pays for itself, and the result must show up on the bottom line.

A few techniques that designers and manufacturers can use that have resulted in bottom line improvements are identified in the balance of this presentation.

1. Formal Synergistic Design Review. The most important is the subject of conducting formal synergistic design reviews to remove the unreasonably dangerous products and the unreasonably dangerous element from a product. We find that the most singularly valuable tool is a synergistic and formal design review superior to any other method or technique; that includes quality control or inspection. You can inspect all you want, but if the design is poor, you're not going to get a safe product. The most valuable tool is design review.

In addition to removing potentially defective elements from a product by the use of formal synergistic design review, the process is evidentiary in nature. A good set of design review minutes is admissible evidence that the corporation has given thought and taken action on its designs, and it shows good faith. It also shows that you took action when it was apparent that action was needed. If nothing else, FSDR can mitigate the award to a plaintiff.

2. Predict the failure frequency and the severity of your product's potential difficulties. Failure frequency is another term for reliability—how long will your product last failure-free? Estimating the potential failure frequency of a product and the potential severity of the injury resulting from that failure is a mathematical analysis. The life of a product can be predicted within five, six, or seven per cent after a little experience. With regard to the severity aspects of prediction, the jury verdict research reports, which is a court reporting activity usually available to attorneys, tells you how much every part of a body is worth every six months. Therefore, take your product liability or reliability information in terms of a prediction, translate that into body part (what kind of an injury can you expect), take the dollar figure from the jury verdict research report, multiply them together, and come up with an estimate. It's a very soft estimate, but it's better than a guess of how much you are talking about in the way of liability exposure for a year. This enables you as executives to make a good, educated, business decision. Which is going to cost you the least—fixing or continuing production? This kind of information is available—make use of it.

3. Conduct failure mode effects analysis and fault tree analysis. Failure mode and effects analysis can be done by computer or it can be done manually. Failure mode and effects Analysis is the "bottoms up" analysis, taking all the component parts, saying how it's going to fail, determining how that failure is going to be seen by the customer, etc. That's one way. The other method, the fault tree analysis, is looking at what the customer sees in the way of your product and then trying to figure out what the probable causes of these failures are. One of the major advantages of these two tools, if you use them together, is if they don't cause a failure of the system that the customer sees, you can probably eliminate the product and thus save some money; and they are very, very valuable tools in this direction.

4. Develop data feedback systems. Collect, analyze, and react to data from the field. Most products, unfortunately, do not contain elapsed time meters; and one of the major criteria in the products liability area and in product reliability and warranty analysis is how much or how long did the customer use the product. There are elapsed time meters that will sell for two dollars and a few cents all the way up to $75; and if you use them judiciously and put them into sample units and control the information coming back to you, you can gather valuable and necessary information for both the courtroom as well as for proposal work in contractual obligations.

5. Auditing the quality at the point of sale. Many of you, including my exemployers, have excellent products when they left the factory; but because of handling, transportation, and the clerical staff in the retail establishments, the product may be almost destroyed, and we find that under strict liability the manufacturer is responsible up until the first sale. If the manufacturer is going to be responsible through the distributor's distribution system, through the retailer's distribution system, up to this point of sale, a look at how the product arrives at the customer's facility at the point of last sale is necessary. My point is to get your quality control people out into the field and open their eyes a little bit—tunnel vision is causing a problem.

6. Test all lots of product at zero time. In other words, test your product before you ship it out; but the most important thing is testing your product continuously over the most adverse conditions forseeable. Unfortunately, most of us, including myself, design products for the average person—150 lbs. Take a look at the chair you're sitting on. It is designed to support 150 lbs. Put your hands underneath it and see what is supporting you. There are four welds. This is wonderful when you're sitting by yourself; but fortunately once in a while you're at home and we are sitting with our wives or our girlfriends or children, and they're sitting on our laps (in the static state). And once in a while we're in the dynamic state. The question that I have is, how much should the chair be able to support? There are no standards for chairs in these United States, for how much they're supposed to support. In fact, it's so bad that the Air Force, the Army, and the Navy have put out an all-points bulletin for a certain manufacturer of secretarial chairs—all of the chairs have to be destroyed (there are 26,000 of them that have been supplied to the government over the last 12 years)—because the shafts holding up the seat are failing at the point of the weld. Therefore, should you design a chair for 150 lbs. or 600 lbs. or 1,000 lbs.—what safety factor?

7. Review your record retention program. There is a considerable difference of opinion on this question. Some attorneys say get rid of the data as soon as the IRS is finished with it. Other attorneys say get rid of your data as soon as your product is finished with its useful life. I often represent manufacturers in the defense commu-

nity as a defendant expert, and I use the term very loosely. The problem here is that equipment has been out in the field for 40, 50, 60, or 70 years. If we don't have the data, we have difficulty in defending you. And if we have the data, even if the data shows that the product was defective, at least we can say that you inspected it, you made an analysis, and you did something about it. If you throw the data away, a good plaintiff attorney will make mincemeat out of your defense. Take a look at your retention program and be very, very careful of it. It would be my recommendation that you should be considering something in the area of retaining pertinent information for 50 years. I know that it's a horror to think about, but take a look at the situation in a realistic way. Just because the IRS says keep them for three years—forget it. The FAA just finished a suit against a manufacturer for $146,000 for equipment that was manufactured in 1951, supplied to the government in 1952, destroyed by fire in 1974, and they wanted full price for it. We were able to defeat the case by asking for the data which the customer had; and when the customer (government) looked at the data that they had to supply to the defendant, they decided that they had better withdraw the suit completely. The defendant had the data; and if the plaintiff produced their data, it would have shown that the item was not at fault nor worth the claimed amount.

8. Review and test the adequacy of your warnings. I mentioned the warning before—"deliquescent product." We have a problem—what is a deliquescent product?

9. Revise your instructions and warnings to include all users. Can the user understand the warning that you put on? Remember, you have 11 different languages for domestic sales, and the product that you sell can be used by any one of these people in the United States.

10. Establish a product recall system. I don't mean how you get it back after you identify the problem. I mean how do you plan to get it back so that the designer and the manufacturing organization can do something before you have a problem? It costs a few thousand dollars, actually about $7,000 in places we've already done it; so plan in advance, and you can eliminate a lot of your problems if you have to have a recall. Establish a safe warning system. Can you identify when the end of safe life occurs and can you put in a timing mechanism or a signalling system or an advisory system to advise the user of this situation?

11. Review your supplier contracts for expressly stated responsibilities. Can they provide you with a "hold harmless agreement" should their product cause a failure in your end-product?

12. Consider yourself in the courtroom. Consider yourself in court for the slightly out-of-specifications escapees that get through your defense system. Don't forget, the president of Acme Markets, Inc., a supermarket chain, was given a personal fine and a suspended sentence for not following the rules and regulations of a regulatory agency. It happened to be a food problem where the chief executive officer ended up paying a fine and receiving a suspended sentence because he didn't consider himself in the courtroom.

Just as a reminder, in the Ford Motor Company's defense of the Pinto case, $125,000,000 punitive damages was reduced to $3,500,000. The Beech Aircraft Corporation a number of years ago also received a large punitive damage judgment against them. The Admiral Corporation paid a substantial punitive award. There are other punitive damage situations. The frequency and their value is increasing daily because we in the manufacturing community do not have the evidence, hard evidence, to show that we have done something with the information collected. The technical community is ready to assist in the prevention of liability and is not willing to rely on legislation changes as the sole remedy. However, one major consideration that we see in defending liability cases is that the using manufacturing employer is more often the negligent party. They take the safety devices off, modify equipment, do improper or inadequate maintenance, take shortcuts in repairs, rarely refer to the instruction manuals, and literally contribute to or cause the accident for which their workmen's compensation carrier pays. Then we observe the plaintiff seeking additional compensation in a strict liability suit or the workmen's compensation insurance carrier subrogating against the manufacturer to obtain indemnification from the manufacturer.

The cause of the liability problem is, in our opinion and as reported by AMIA in November 1976, the 70-80 per cent of the accidents that occur in the occupational environment. If we in the manufacturing community can look for a solution to the product liability problem, we should look for a revision in workmen's compensation cases which would allow a defending equipment manufacturer to name as a joint tortfeasor the emplover of the injured party. *Dole* vs. *Dow,* New York, 1973 or 1974, is now in some ten states. OSHA is not working because the teeth are not sharp enough, because the inspectors are not completely adequate in training, understanding and experience.

The effort of current legislators to develop legislation limiting the statutory time after sale is, I expect, a situation which will be declared unconstitutional, as happened in South Carolina on February 13, 1978 involving A & E's and their 10-year limit.

The problem will not be solved by any one of these recommendations, but it won't go away. We cannot legislate it out of existence. We must do something to prevent. It is hoped that we have given you some food for thought.

HOW TO SELL INDUSTRIAL MANAGEMENT ON AN OFF-THE-JOB SAFETY PROGRAM

By JERRY HEBB
Mgr., Off-the-Job Safety, Gulf Oil Corp., Pittsburgh, PA

For several years, management's attention has been focused on work-related safety in light of federal regulations, as well as the emphasis by labor and government. In addition, safety practitioners can take a large share of the credit for reducing work-related accidents, injuries, and deaths. This, in turn, had the effect of containing the trend of work-related accidents, injuries, and deaths. I think it's a reasonable assessment that, unless drastically new technological or behavioral breakthroughs occur for safety on the job, we will not see dramatic reductions in work-related accidents, injuries, or deaths. By contrast, then, a concentrated off-the-job safety program presents an increasing opportunity not only to reduce costs but to improve the health and safety of American families, by applying safety principles similar to those which have provided a safer work environment.

Typically, we find management is inclined to feel little if any responsibility for the employees once they leave the place of employment. Even when management is concerned about employee safety off the job, persuading them to allocate the necessary funds to operate an effective program is difficult. Many of you at this point are saying to yourselves, "We already know that—we want to hear how to turn around the current management attitudes toward off-the-job safety." I believe, at the end of this presentation, you will at least have some different ways or ideas on how to turn around current management attitudes toward an off-the-job safety program.

There's no doubt about it, selling the man who is drawn like a magnet to the bottom line is tough. One way to approach a manager who wants the most "bang for his buck" is to essentially start backwards, i.e., show him what he will get out of the program. I tend to talk to management and use terms like "thinger," "grabber," or "touchy/feelie." This is to say, if what you have to present doesn't have a thinger or a grabber he can identify with or if he can't touch or feel the benefits of the program, then we haven't done our job. He must visualize immediately where his hard-won budget monies will go, as well as what he gets for his monies. I'd like to use the same approach here—give you some things to take back to your work situation.

Losses are as devastating to the corporation when they occur off the job as when they occur on the job. Before we can evaluate and quantify these losses, we need to determine what "off-the-job" entails. The only importance of any definition, however, is that there is one and that everyone is aware of what it contains and describes and what it does not. Although I continue to be bothered when I see off-the-job described in negative terms, we've not found any definitions that were more appropriate for our purposes than one which many of you may also use: "Any accident, injury, or death occurring outside the workplace which causes a worker to be absent from his job is considered off-the-job."

By thinking of this definition in its broadest context, anything occurring to the worker or his family could conceivably make the worker absent. Consider a working mother whose child is injured. You can usually expect an absent worker under these circumstances. Therefore, an accident, injury, or death in a worker's family can cause this worker to be absent.

The costs resulting from absence associated with off-the-job injuries are itemized in the National Safety Council's Off-the-Job Safety Data Sheet 601 as direct, indirect, and insurance costs.

Direct costs are the wages paid to the injured worker while he is off the job.

Indirect costs can range from one to 10 times direct costs, depending upon the type of industry or organization involved. A conservative estimate would be an amount equal to the value of wage losses.

Insurance costs of companies that are insured by an outside carrier could use the premiums paid on that portion of health and accident policies which covers accident experience. Companies that are self-insured should take the amount of claims paid for the off-the-job injuries plus the cost of administering their program (wages of benefits administration might be included).

Of course, deaths are especially costly, both to the worker's family and to the organization, whether they occur off the job or on the job or whether they are a result of disease. Lawrence R. Zeitlin, BFS Psychological Associates, analyzed replacement costs including recruiting, hiring, training, and re-establishing the level of effectiveness and performance to that which had existed while the employee was alive. A tabulation of these items indicates that as the job skills of employees become more sophisticated, the indirect cost associated with their death increases dramatically to the point that death of an executive may cause catastrophic damage to an organization.

In both cases, injuries and deaths, the estimated costs exclude any payments made by insurance policies held by the worker's family or the organization—for example, a policy on the death of a worker. Nor has any attempt been made to quantify the estimated costs of pain and suffering experienced.

Even the roughest calculations show that many benefits can be derived by implementing a vigorous, carefully designed and tested off-the-job safety program. These benefits include:

Fewer off-the-iob accidents; reduced absenteeism; reduced per cent of payroll allocated to sickness and accidents; reduced operating costs; improved work efficiency and performance; improved employee-supervisory relationships; improved employee supervisory communications; increased participation of employees in their communities through family involvement in off-the-job safety; positive, visible demonstration of the organization's commitment to the well-being of employees and to social issues affecting employee behavior.

This quick review of the ramifications of off-the-job accidents, injuries, and deaths, led us to establish an objective to reduce the costs of absences associated with off-the-job accidents, injuries, and deaths to employees and their families to promote and enhance their continued well-being.

Thus far, our reasoning is rational and positive. Who could be against promoting the well-being of another human being and reducing these many visible and hidden costs?

An astute manager, however, will look for specific data on causes and probabilities for reductions based on his needs and problems. Some organizations collect detailed data on absences: their cause, their cost, actions taken. Then, it is quite simple to survey a sample of records and analyze the off-the-job situation in detail. However, often the cost of obtaining such data if it is not readily available may well drain the function of both funds and staff time. So a note of warning—don't spend a lot of time and money on data collection. It may not be cost effective!

An alternative is to review national data from various sources to obtain statistics on accidents, injuries, and deaths off the job. Sources we use include the National Center for Health Statistics reports; National Safety Council's *Accident Facts*; Bureau of Labor Statistics; Consumer Product Safety Commission's NEISS system; National Highway Safety Administration reports; and many more. Sometimes, professional and trade associations disseminate data pertinent to this area.

We synthesized these data and analyzed them in several different ways. For example, we pinpointed the leading cause of death by age or by geographic location because, after all, a

death is the most costly off-the-job incident. As most of you know, for instance, the leading cause of death over 34 is heart disease; for persons 34 and under it is accidents. Motor vehicle accidents account for more than half these deaths.

We also reviewed injury causes. For example, statistics for the total U.S. population in 1975 show that over 50 per cent of accidents occurred in and around the home. Another 38 per cent could be categorized as off-the-job also. Less than 12 per cent of accidents occurred in a work-related environment.

After these broad breakdowns, we investigated specific types of accidents and injuries and their results for the family to whom they occurred.

So, what to do about changing and improving the situation? Unlike the on-the-job environment, face-to-face communications, integration into performance responsibilities, and legal sanctions, communicating off-the-job safety requires practical persuasion—interesting approaches to gain the audience's attention and commitment.

In a nation where some magnificent promotional and educational feats have been accomplished, we determined it would not be necessary to rediscover the wheel. Thus, we set about contacting (and continue to contact) others in industry, government, trade and professional associations, and academia to determine their successful activities and ideas in exchange for keeping them informed of our program developments. To date we have written, telephoned, and/or visited about 200 such organizations.

The types of activities others had found to be successful within environments similar to those in off-the-job safety led us to develop our off-the-job safety concept: Maximize communications avenues to employees and their families. We targeted four major avenues of communication: (1) personal —those communications reaching employees through private, social channels; (2) public—those national, media-centered communications directed toward the general population; (3) peer/supervisor — those communications obtained at work; (4) corporate —those formal communications reflecting the corporate policy and guidelines.

Based on this concept, our strategy was to provide a variety of stimulating messages promoting off-the-job safety which reflected the many successfully implemented campaigns from others. Formats for these messages include a reference booklet, calendar, poster, and contest.

A reference booklet provides certain distinct advantages to employee safety.

It is permanent and can serve as a reference for safety questions; for example, what should I do in an emergency? It can provide ways to test the reader's knowledge; for example, multiple choice quizzes. It can be structured to provide information for each member of the family; for example, it can contain coloring pages for small children and story-form information for older youth. It provides an excellent vehicle for promoting national efforts; for example, safe boating week in July, when many organizations communicate water safety via television, presentations, and in printed communications. It can be mentioned or referred to in other promotions. As an example of the organization's concern with its employees' well-being, it is an indirect promotion or image builder.

Calendars offer ways to get across timely safety information.

A calendar provides space for family members to note coming events such as school activities, sporting events, and appointments for family members. Thus, it can encourage involvement by doing. Since a calendar is referred to constantly, it can provide ample opportunity to reinforce safety messages. It is practical and useful: the employee does not need to purchase next year's calendar.

Posters are often quickly seen, and their easy-to-read messages long remembered.

A poster is usually permanent in the home, especially when the poster contains its own calendar. It can summarize major safety messages, thus reinforcing the more detailed "how-to" information. Recent promotion of celebrity-type posters indicates posters are a viable way to gain recognition.

Historically, one of the most successful incentives for promoting information retention and/or a particular kind of behavior is to provide a competitive situation in which the winner receives something of relatively great value. A contest can put fun into learning, as well as add zest and vitality. In addition, participation and involvement usually insure a more thorough and complete knowledge of a concept or idea.

Using this strategy we anticipated the following results: First, creation of safety awareness in specific risky off-the-job areas. Second, information would pinpoint ways to improve safety behavior. Third, families could assess their own safety off the job.

Putting it all together, we developed a colorful focal point for the 1978 program, with top management's visible endorsement. The final products, the *Gulf Off-the-Job Safety Date Book* was mailed to 39,200 employee and annuitant families December 21, 1977.

To reinforce, amplify, and provide further variety for the monthly themes contained in the *Date Book*, monthly information packets are sent to safety representatives throughout U.S. locations. An information sheet, poster, and supplemental information are printed in bold black and white so they can be reproduced on almost any kind of machine. The cover letter announces monthly contest winners; describes other publications and audio-visuals and where they can be obtained for what cost, if any; and describes any corporate communications scheduled to complement the monthly theme. One such communication is the internal employee publication, the *Oilmanac*. The back cover is usually devoted to health and safety, and often contains an off-the-job safety feature supplementing the *Date Book's* monthly emphasis.

Based on this year's experience and the positive feedback we have received, our 1979 plans called for increased emphasis on involvement within the Gulf organization. Content will focus on self-reliance, "learning and doing—the right way."

Only time will tell if the results we anticipated are achieved. We have determined it will take from three to five years to see a downward trend. However, saving one life is a goal worthy of attainment!

Now I'd like to turn to my last point and tell you some of the details of how we sold our 1978 program.

Prior to 1977, emphasis on off-the-job safety was practically nonexistent. In early 1977 the Medical and Health Resources Division received a commitment from corporate management to accomplish two tasks: (1) initiate 1977 off-the-job safety activities, and (2) develop a 1978 off-the-job safety program.

The 1977 activities were initiated by distributing promotional materials concerning the National Safety Council's promotion of the NBC television program, "The National Disaster Survival Test." Specifically, each company (we have eight) was appraised of the increasing costs of off-the-job accidents, injuries, and deaths. We suggested they might wish to communicate their concern for employees' off-the-job safety. Further, as a demonstration of their concern for employees' off-the-job safety, they might distribute copies of the survival test to employees and their families. Other 1977 activities centered around national themes promoted by others, such as boating safety in July, back-to-school safety in August, and home fire safety in October. In each case, Gulf locations received packets of information containing brochures, sample posters, programs developed by others specific to the national theme, as well as where to get additional copies and/or information.

Activities leading to development of the 1978 program included:

Assessing previous and ongoing off-the-job safety activities at all levels within the corporation; soliciting suggestions and ideas from all organizational levels concerning what location management would like to see in a program; surveying outside organizations to learn what programs worked, as well as learn from their experiences in off-the-job safety programming. This process is a continuing part of

our program responsibilities.

Internally, location, as well as staff management, were asked about previous and ongoing activities, as well as suggestions and ideas. The National Safety Council, other industries, trade organizations, academia, government, and consultants were contacted, requesting information concerning their off-the-job safety program and offering to share the results of our information gathering exercise. To date, approximately 200 organizations have been contacted using mail, telephone, and visitation methods.

Concurrent with the internal and external information gathering exercise, the 1978 program was developed.

Our first step in selling the program was to organize our ideas into a proposal. This proposal outlined the objective of the 1978 program; the content of a published communication, the *Gulf Off-the-Job Safety Date Book*; format; implementation procedures; and evaluation.

A cover memo containing a schedule for implementation was prepared. In essence, we proposed to write, design, print, and distribute a *Gulf Off-the-Job Safety Date Book* to the homes of employees and annuitants before 31 December 1977 so they would be received no later than the first week in January 1978. Hopefully, Christmas gifts would be cleared away by this time, and the necessity of a 1978 calendar would be recognized.

(The December issue of our internal communication, the *Oilmanac*, which was received the first week in December 1978, carried a bright back cover describing the Date Book and alerting employees to their receipt of a calendar or appointment book.)

As you can appreciate, our schedule was very tight. We had 14 weeks to gain approvals and concurrence by company officials, to print and distribute the Date Book and, most importantly, to introduce the concept to management throughout the corporation so they could make the *Date Book* part of their ongoing program efforts.

The approach we used to get management approval was to set up an appointment with our top executive to present the *Date Book* proposal. We presented our proposal along with comparable costs of other approaches, and on a per employee basis the costs were comparable. We received a qualified approval. That is to say, yes, produce the *Date Book*, but only after the other company executive officers expressed support for such a program. In order to receive the other company executive officers' comments and support, a letter was written stating it was a corporate decision to have a program [*Date Book*]; however, each company would have an opportunity to review program details and comment on its contents before deciding whether or not to support the program.

Telephone contact was made to each company executive officer following up the letter. Appointments were set up to brief them on the program, review comments, and hopefully gain support. In fact, all companies supported the program for 1978—over 39,000 employees and annuitants residing in the U.S. No attempt was made to even try to include non-U.S. employees.

What is the reason for our success? We have listed several key issues which we felt certainly helped in selling management on an off-the-job safety program:

1. We developed a proposal which presented what we recommended in a business-like manner.

2. We tried wherever possible to quantify costs and let's not kid ourselves—not all costs are quantifiable. In those cases, we estimated a cost based on data and information provided by recognized authorities, i.e., National Safety Council, HEW's Public Health Service, to name a couple.

3. We attempted to play down motherhood-and-virtue type of benefits because pain and suffering are not easily quantified.

4. We utilized proven and recognizable techniques, tested and proven reliable by others. For example, every item, calendar, poster, contest, have been used by others and found to produce measurable results.

5. We got management participation —management was not surprised by what we proposed. We also gave them opportunity to change, modify, or comment before changes were made.

SLIPS AND FALLS: HIGH RISK POPULATIONS

By STELLA GORE LANSING
Public Health Analyst & Occupational Therapist,
U.S. Consumer Product Safety Commission,
Bethesda, MD

Slips and falls and their relationship to at-risk populations are of particular interest not only to me but to my coauthor, Peter L. Armstrong. Before proceeding any further, however, it is necessary for me to emphasize that I speak only for myself and Pete Armstrong, as employees of the Commission. The information I'm sharing with you should not be considered Commission policy.

We hope not only to cover characteristics of slips and falls and increased vulnerability factors of certain populations, we also hope to provide you with a few strategies that can be used to reduce the incidence of falls in both the home and work environment.

Millions of people a year are injured, disabled, or die from fall-related accidents. Let me start by giving you a brief overview about where the Consumer Product Safety Commission (CPSC) obtains its information about injuries and death.

NEISS: In order to carry out its mandate for identifying and eliminating unreasonable risks of injury, the Commission set up a nationwide data collection system which provides it with basic information about product-related injuries. The system is the National Electronic Injury Surveillance System, better known as NEISS. It is comprised of roughly 120 hospitals located throughout the country. These hospitals report daily all consumer product-related accidental injuries treated in their emergency rooms. These hospitals were selected statistically from a stratified random sample. They allow the Commission to make demographically valid projections from the NEISS injury data to emergency room-treated injuries nationwide. At present, the Commission is changing the set of hospitals in the network in order to keep pace with demographic changes which have taken place in this country since the original hospital network was set up.

The injury reports submitted to the Commission include basic information about the victim (name, age, sex, body part injured, type of injury and so on). Since 1977 an additional comment line has been available. This line is often used to describe the accident scenario or the product involved, which is enormously helpful in giving meaning to the codified injury data.

In-depth Investigations: In order to determine whether a product is causing injuries directly or indirectly we need much more specific information about the relationship and interaction between victim, product, and environment in a specific accident. It is necessary to ascertain whether the product was casually involved or merely an innocent bystander. Ultimately, we are interested in finding out whether injuries can be prevented through redesign of a product. In order to obtain this additional information, our Directorate of Hazard Identification selects a number of NEISS cases for in-depth investigation. Cases for in-depth investigation may also come from other sources (e.g., consumer complaints). The in-depth investigations are conducted by trained field investigators who visit the site of the accident and interview victims in order to obtain highly detailed information about the products involved and the circumstances surrounding the accident. In-depth investigations often provide the data required to determine how an accident can be prevented.

Death Certificates: All 50 states and four health jurisdictions (Puerto Rico, Virgin Islands, Washington, D.C., and New York City) send copies of death

certificates from accidents involving consumer products. This information is kept in a closed data system not available to the public.

Medical Examiners and Coroners Alert Project: This is a voluntary system where medical examiners and coroners report product-involved fatalities to the Commission by phone, usually within 48 hours.

Hotline: The Commission has a toll free number so that consumers may call for product-related safety information or to voice safety-related complaints.

Newspaper Clipping: The Commission does obtain some information through its clipping service. Newspapers and journals from around the country are clipped regularly for articles pertaining to product safety.

Types of Falls: Falls can be categorized into two general groups: those which occur while ambulating and those which involve a fall from one level to another. The latter category, such as the falls of babies from furniture or falls of people from windows, will not be discussed here. The former category can be divided into: slipping —when an individual loses traction between his foot and the walking surface; tripping—when an individual's foot unexpectedly hits a protrusion on the walking surface.

I will only briefly discuss where falls happen in the home:

1. Bathrooms. Many accidents occur when someone slips in a wet tub or shower. Accidents also occur when a bathroom floor is wet and the individual is barefooted. Accidents occur on dry floors when a throw rug slips out from under an individual's feet, because it may not contain or have a worn slip-resistant backing.

2. Kitchens. Floor-related accidents may occur when the floor is wet from water or floor polish. It also may occur when the floor is dry and covered with foreign matter.

3. Laundry Rooms. Falls in this room are generally related to a wet surface.

4. Stairs. These accidents occur on both interior and exterior stairs and are often related to lapses in the stair user's attention, distractions, carrying objects, and unstable or cluttered stair surfaces.

5. Floors. Many accidents appear related to the changing surfaces, such as going from a carpeted surface to a resilient surface, or from a dry to a wet surface.

6. Furniture. There are an astounding number of accidents related to furniture which result from slips and trips where the victim impacts against a table or bed or other piece of furniture.

I would like to focus on two areas where slips and falls take place and discuss some of the common injury patterns.

Floors. There are a number of factors that are related to floor accidents. These include flooring materials, shoes, environmental factors, and consumer behavior. The following are descriptions of common injury scenarios:

Usually an adult victim is walking; they generally are not running, jumping, or doing anything that could be considered particularly hazardous. Some factors that may help explain these accidents are:

1. Most floors where accidents occur are wet (i.e., bathroom, kitchen, laundry rooms, garage, front steps, etc.). Those who slip on a wet floor can be barefoot or wearing shoes.

2. When an accident occurs on a dry floor, there are several factors which help to explain the slips. The floor may be freshly waxed. The footwear can be considered slippery (e.g., worn leather soles, nylon stockings), or the victim may be wearing highheeled or platform shoes where there is poor ankle support and spinal or pelvic changes in body alignment, and less sensory feedback to the body where the feet are in space. The victims may slip just after they have stepped from a slip-resistant floor covering such as carpeting on to a waxed vinyl, linoleum, or wood floor surface. Victims appear to slip when they make a slight change in the direction they are walking.

A second accident pattern occurs when victims are stepping out of a bathtub onto a wet bathroom floor. All are barefooted. The accidents occur to victims of all ages. About 35 per cent to children under five years and adults over 65 years. The flooring material may be vinyl or ceramic tile, either polished or unpolished.

A third accident pattern occurs when victims are running. Most are young children who slip while running on either wet or dry surfaces. If they slip on a dry surface, generally they are wearing socks.

A fourth accident pattern involves young women who are mopping floors in the kitchen. There does not appear to be any particular pattern to the accident except that the floors are usually wet where the falls occur.

To summarize the accident patterns, invariably the victims are moving, most are on wet floors, occasionally the wetness involves a cleaning or polishing agent. The most common areas of accidents are those with sources of water. Many victims are barefooted and the rest are wearing a variety of footwear. On dry floors, the floors are usually polished, victims either are running, moving quickly, and may be changing direction or are stepping from one flooring surface to another.

Stairs. This can be considered a major contributor to accidents in the home. It has been estimated that between 1½-2 million disabling injuries may have occurred last year involving stairs. CPSC data indicates that the most vulnerable populations are the very young (0-4 years old), and females who in one study were estimated to have sustained 60 per cent of the total injuries (within this group the most vulnerable group appeared to be those 10-19 years old). Another group at-risk are individuals 65 years of age. Although they accounted for about 10 per cent of the population and nine per cent of the reported injuries in 1975, they accounted for 57 per cent of the death certificates on file at the time.

Two separate studies, one by the National Bureau of Standards (who videotaped several thousand subjects in order to determine what happens when there is an accident on the stairs) and an unpublished study by Mike Oliver of the U.S. Public Health Service, have provided some insight into factors that influence falls or slips on stairs. In addition, a cursory review of in-depth investigations have provided additional insight.

Basically, a description of factors includes: a subject will approach stairs with an expectation of what will be there; the subject generally will test these assumptions on the first few steps. The subject generally accepts the feedback information gained from assumptions; depending on their familiarity with the particular stairs, they may modify their behavior if necessary. If during this process an infrequent, unexpected, or unfamiliar combination of factors occurs, it may trigger an injury. These factors may be environmental, human, or product related. Examples may include: inappropriate footwear, environmental distractions, carrying objects, obstacles on stairs, physiological impairment (especially in the elderly), non-use of stair handrails, unattended children, plus stair design and conditions. Examples of scenarios including one or more of the factors stated earlier are: (1) a users' attention is drawn away from attributes of the stairs that may be hazardous (i.e., carrying a large object that may cut down on visualization or a pet on the stairs) (2) a user's ability to discriminate the specific location of stairs may be affected by light glare, shadows, inadequate lighting, carpet patterns that produce a play on figure-ground (confusion of background-foreground), and loose or protruding stair carpeting; (3) nonuniform tread and riser sizes and protruding nosings (especially dangerous for the handicapped with short leg braces); (4) poor slope traction and undesirable climatic conditions; (5) design of stairs may not take into account the age range and motor abilities of potential users; (6) users of stairs may find themselves entrapped by unmarked one-way doors; (7) stairs may be structurally unsound and be unable to maintain heavy weight-bearing: (8) there are other material and structural factors (i.e., sharp edges) that can increase the severity of an injury.

As we discuss generally the area of slips and falls, it is important for us to be aware of some human factors that need to be considered. These aspects

are not readily considered in the discussion of slips and falls and the literature does not clearly focus or explore these possible contributory factors.

There are numerous neurophysiological factors that contribute to our ability to maintain our equilibrium or balance. These factors interact with one another and are constantly adjusting and readjusting to our body's changing demands. These factors are sensory and motor in nature. Sensory involves all the simultaneous information taken into our central nervous system by all the senses, both from outside the body and from internal sources. This information is processed and integrated by the central nervous system at various levels. The body's decision to respond is demonstrated by motor output and/or motor action. The human being responds to motor information continuously. New information is combined with old or past information; the result is the ability of the body to be adaptive to changing demands. Some factors to be considered include: (1) vision (both seeing and perception); (2) hearing; (3) proprioceptive-position in space; and (4) muscular-skeletal balance, including the ability of muscles to work together, muscle strength, tone, coordination, or adequate range of motion in joints, stability, and strength. Another area of consideration is developmental patterns. Basically these affect the way a foot contacts the floor surface and the area it covers in relation to the position and balance of the rest of the body as it moves through space.

Let's discuss how some of these factors just mentioned and others relate to at-risk populations. Generally, the populations to be mentioned have an increased vulnerability because of their level of development, deviations and/or modifications from the norm that are forcing them to adapt or readapt to basic functions.

Children. The child of nine to 18 months who is learning to walk will demonstrate a wide-based gait (the feet are apart and away from body-midline), they are flat-footed, have a tendency to hold their arms in a flexed position near the shoulder for balance when walking; and are head-heavy. The center of gravity is different from the adult who has a proportioned body, a midline heel-toe gait, and reciprocates the arms when walking. The young child tends to propel with mass muscle movements rather than the refined segmental movements of the adult, who in Western cultures tends to glide when walking.

The toddler (usually considered 15 months-2½ years) has a high-stepping descriptive toddle or wiggle gait. Movements are characteristically fast and not refined. Frequently these children turn corners by bouncing off walls.

At about 2½-3 years of age the child begins to develop a free-swinging stride, the feet are closer to body midline, and the arms are beginning to reciprocate. Over the period of the next two to three years the child will develop from the one-step at a time approach to stairs to a continuous movement of alternating feet while ascending and decending stairs. The child of three years may still turn a corner by bouncing off a wall or may learn to hook his inside hand on a wall or piece of furniture and swing himself through the turn.

It is not until a child is about six years of age that he truly has a refined gait. The young child is structurally immature, uncoordinated, and growing at a rapid rate. In addition, he perceives his world differently from adults. For instance, toddlers have difficulty dealing with large spaces and frequently search out smaller confined areas they can manage. They see the adult world from underneath (tables, sinks, etc.). Young children have limited experience to draw on and think in concrete terms. The concepts of time and space go through a maturational process. It is interesting to note that at six years of age for developmental reasons about 80-90 per cent children are far-sighted.

Adolescents. The teenager often goes through periods of growth when movements are awkward. Often the feet and hands far outdistance the rest of the body in size; all of a sudden the trunk will grow, the spine will modify its curve, the center of gravity shifts, and the body must readjust.

Pregnant Women. The pregnant woman often experiences changes that are most marked in the last trimester. Postural changes include: (1) lordosis —"sway back"—in which the curve of the spine is modified, gravity changes, and frequently a "waddle" wide-based gait; (2) orthostatic hypotension, where there is a decrease in blood pressure with a change in body position; this is caused by the pressure of uterus on the aorta and can cause some disorientation or dizziness; (3) pelvic congestion, caused by the weight and pressure of the fetus in the lower abdominal area. There can be a pooling of blood in the lower extremities, causing a possible decrease in sensation, numbness in toes and feet and edema (swelling).

Elderly. As people begin to age, chronic problems set in. Often the gait again becomes wide-based in order to accommodate to the structural body changes. Often some form of arthritis sets in (affecting an estimated 80 per cent of the population by age 65 years). For some this can result in a loss of muscle strength and tone, decrease in joint range of motion, and a decrease in sensation. Often the individual will begin to round the shoulders and thrust the head forward rather than maintaining a straight axis. The individual may begin to shuffle or circumduct when walking rather than gliding.

Chronic problems that may affect the elderly can be broken down into three areas:

1. Muscular-skeletal. As mentioned above, these can be arthritis-related changes which result in decreased strength both in hand-grip strength and also more generalized in lower back, legs, and arms. Spinal changes from a variety of causes (i.e., osteoporosis-decalcification of bones). Slowing down of the protective reflexes that protect the trunk and head from damage.

2. Cardio-vascular. There are two common conditions that can result in a reduction in the cerebral flow of blood: orthostatic hypotension, which results in a decrease in blood pressure—an individual who changes position too fast may stumble, lose orientation to space, or in extreme cases faint; hypertension, which results in an increase in blood pressure due to arteriosclerosis—an individual may have a series of small strokes, some of which may result in neurological changes.

3. Sensory changes. These changes may include: decrease in visual acuity; decrease in hearing; proprioceptive change—the position sense can be affected, the individual may not know where their feet are in space, particularly if carrying something that interferes with visualization; calcification of bones in the middle ear—this may result in vertigo.

Oliva found in his study of falls that the elderly have an increased risk when one or more of these conditions were present, in addition to a history of falls. Falls are a severe problem for the elderly population, since often when they fall they may fracture a bone. Often this fracture may be the head of the femur (hip), which is slow healing. This age group is susceptible to secondary problems due to various systemic changes. Pneumonia and embolisms (clots) can be a secondary complication of a severe fall.

Handicapped. There are many types of handicapping conditions that occur to various degrees. Two people with the same diagnosis may experience different levels of disability. Examples of some of the more common conditions which may pose some limitations to "normal" function and thereby possibly increase the vulnerability to injury are as follows:

1. Arthritis in its various forms may cause pain, physical changes to joints, limitation in joint range of motion, decrease in muscle strength, decrease in sensation, and so on. One or more of these limitations can affect the ability to adapt to changes in the environment rapidly, by affecting function, coordination, speed of response and, in some people, attitude.

2. Strokes. There are various types of strokes and resulting severity. People who have had a stroke may have very mild or no residual effects, while others may have profound sensory and motor limitations. In some of the more severe strokes, an individual may not only be wheelchair bound or be

using some adaptive device in order to walk (i.e., crutches, walkers, braces, and so on), but may have distortions in their perception of space. They may only see half a visual field which may have a slight rotation to it. Feeling may be lost on one side of the body, balance may be affected, and communication skills may be limited or altered.

3. Other types of conditions which may produce various types of sensory or motor limitations include cerebral palsy, multiple sclerosis, visually impaired or blind, and deafness. Those who suffer a high level of amputations have to readjust their balance. If the amputation is to the lower extremity, the individual will wear some type of prosthetic device.

Other Populations At Risk. There are people who may be temporarily or permanently at-risk and may not be aware of it. This includes: (1) those on various types of medication (i.e., anti-hypertension drugs, which can slow responses because of the sedation effect, cold and allergy remedies which may have a side affect of decreasing the perception of a hazard); (2) foot disorders (i.e., plantar warts, corns, etc.)—if pain or discomfort is present an individual may protect the site of such a growth and modify the gait and body alignment; (3) varicose veins—these can result in a decrease in sensation in the lower extremities; (4) non-English speaking populations and those who are illiterate—the obvious implication is the inability to read and comprehend written instructions.

The last two areas I'd like to discuss are common to home and public areas that may contain potential hazards and pose particular barriers to those who are at-risk. Also we will examine some possible preventive measures that can reduce the risk of injury.

Floors. As we have already discussed, water and other liquids can greatly increase the risk of slipping. It is important to watch uneven floor and subfloor surfaces as this may pose a tripping hazard. This is especially important when talking about the elderly who may have a shuffling gait and reduced visual acuity.

Both home and public b[illegible] should not only be clean and [illegible] free from obstructions. If an [illegible] is used in the home, it is imp[illegible] check the backing to make [illegible] rubberized and not worn f[illegible] quent laundering.

It is sometimes very useful [illegible] slip-resistant treads in front of [illegible] mode to aid an older or ha[illegible] person to have increased trac[illegible] der their feet as they change [illegible] sitting to a standing position. In [illegible] buildings, wall washbasins sho[illegible] accessible to wheelchair-bound in[illegible] uals and children. By five or six y[illegible] children often go to public bathro[illegible] by themselves. All appliances should [illegible] accessible to them. Often the hand[illegible] capped need water controls on sinks that can be operated by one-hand; in addition there should be a built-in temperature control. Securely mounted diagonal grab-bars are a must in every public bathroom and are valuable in homes where there are populations at-risk.

Tubs and Showers. Securely mounted grab-bars would be a real safety addition to any home and should be usual in public places (e.g., motels). The tub and shower surface if not slip-resistant should be retrofitted with slip-resistant appliques. It has been my experience, after years of working in rehabilitation, that the safety mats that are sold to provide a slip-resistant surface may not be dependable if not properly cleaned and maintained (soap buildup or fungus growth can reduce a mat's suction qualities). Another possibility is that a temperature control fixture can be installed or the water heater turned down to avoid scalds that may cause a fall.

Stairs. Any carpeting applied to stairs should be tight fitting. In selecting carpet, avoid those that have a pattern (e.g., some diamond or bamboo patterns) that may cause perceptual confusion. It can be very helpful to have the ends of the stairs marked in such a manner as to distinguish one step from another. On exterior steps that are exposed to the elements, it is useful to use carboundum slip-resistant treads. These treads should not protrude in such a way as to pose a

[illegible]ing hazard.
[illegible]ividual steps should have a con[illegible]t height and length and should [illegible] have too steep an angle. Risers [illegible]ld not be greater than 8" and [illegible]s not less than 10". Beware of [illegible]rading nosings on steps which can [illegible] a leg brace.
[illegible] possible, handrails should be con[illegible]s and on both sides of a stair[illegible]. It is useful if the rail is slightly [illegible]ctured for those who have weak grip [illegible]rength in their hands. Public build[illegible]gs with wide staircases should al[illegible]ways have a stair rail available for all to use. It may be necessary to provide a continuous rail in the middle of the staircase that is anchored to the steps. It is advisable to consider a lower second rail with a smaller dimension for small children.

Lighting should be adequate and environmental distractions and light reflections should be minimal. People in any environment should be cautioned about the hazards associated with carrying large objects that may interfere with their perception of space. Stairs should be kept clean of obstructions (toys, pets) and dirt.

Furniture. In both public and home environment one needs to be aware of hazards associated with furniture (sharp edges, projecting legs, etc.), and weigh this against design and performance factors, as well as the populations who may most frequently be in contact with the furniture. A description of some injury patterns associated with various age groups may be useful in this discussion.

1. Older Infants and Toddlers. Often these children walk into furniture sustaining head injuries. This is related to the height of the child as compared to the furniture, coordination limitations, and immature perception. Particularly watch glass top tables, which apparently may not be totally visible or comprehensible to the young child.

2. School Age Children. Often these children are running and trip over furniture. They fall and may hit the floor or a corner of a piece of furniture. This is also the age when children may be "horsing" around with another child and fall off the furniture.

3. Older People. Often those who are older may lose their balance. This can happen if one has been asleep and then stands up too rapidly. They can forget to turn on a light. This can result in tripping over furniture and falling.

Safety hazards that often are present in or around public buildings will be briefly discussed, since they pose particular barriers to those at risk: curbs and steps that are too high and have no ramp excess for the handicapped; ramps that exceed more than a 10°-15° degree angle; uneven sidewalk surfaces; front doors that pull open or require too much strength to open—sliding doors with a time lapse electric eye are the most practical; all glass doors should be safely glazed and have decals; elevators should have time lapse doors, be sensitive if touched while closing, have low placed light touch and/or Braille coded buttons; escalators need visual clues such as color reinforcement to increase visual recognition, especially where an individual steps on or off; telephones and water fountains should be lowered and have simple controls that require minimal hand strength coordination; grates and vents should be perpendicular to the flow of traffic to avoid heels and crutch tips from catching; visual cluing such as large symbols and large color coded simple language signs are useful and minimize embarrassment to the elderly, handicapped, illiterate, and non-English speaking populations who may be reluctant to ask for assistance; lastly, it is useful to have Braille coded signs and/or auditory direction units available for those who are blind.

In the design or modification of any environment it is useful to utilize the expertise of an occupational therapist and/or a specially trained architect or engineer.

In summary I'd like to suggest some possible ways to focus on prevention.

1. Increase the awareness of the populations who are at highest risk by informing them of common injury patterns and factors that increase their vulnerability to injury.

2. Increase the awareness of those who are direct providers of service, caretakers (parents), industry safety officers, public health officials, and so

on.

3. Review building codes to make sure they reflect adequate safety measures in new buildings.

4. Retrofit and correct unsafe areas.

5. Design buildings and environments incorporating many of the safety features already available to the handicapped.

PREGNANT WOMEN IN THE WORKPLACE – FEMALE AND FETAL RESPONSES TO TOXIC EXPOSURES

By RICHARD L. O'CONNELL, M.D.
Director Corporate Health Affairs, Olin Corp.,
Stamford, CT

Inasmuch as between 40 and 50 per cent of the work force today in America are women, it seems particularly appropriate to address and identify those unique characteristics and qualities that distinguish women as such. The work force for generations has been made up almost completely of men and the rules, laws, and regulations that exist or have existed have been devised with men primarily in mind. Throughout the centuries woman's place has "been in the home." As the Germans would say it—*kinder, kirche, und kuchen.* While no one pretends for a minute to minimize the traditional role of the woman and her place in the family and household, current times recognize and provide for her demonstrable intelligent energies and capabilities to learn and perform most, if not all, tasks that men perform as well as their male counterparts. To many it has seemed a great waste that the brains, intelligence, and physical capabilities of women have been a resource that had been largely gone untapped and certainly underutilized. The fact that there is concern over an equal rights amendment, that there are specific laws regulating the allocation of funds for women's athletic programs, and an increasing percentage of women not only in the workplace but in the various professions attest to the fact that the country recognizes that it is no longer acceptable to waste these resources.

Any discussion about women in the workplace essentially must bear in mind two fundamental conditions—the non-pregnant woman and the pregnant woman.

Ergonometric considerations that address the basic mechanics of bodily adaptation to the workplace, in its infinite variety, should be borne in mind. Fat distribution in the woman is different, concentrated in hips and thighs and to varying degrees in the breasts. Muscle mass by and large in women is less than in men. While it is apparent that many slender, light women are capable of performing heavy lifting, moving and difficult tasks—in many instances in a more superior fashion than some of their male counterparts —in general, the muscle mass of women is less than those of men and renders them somewhat at a disadvantage in performing work in the physical sense of moving large masses various distances. There are distinct bony variations that must be recognized. The bony structure of women is much lighter but not necessarily more fragile. Bones tend to be slender, of smaller mass but their tensile strength, particularly prior to the menopause, is such that they may be lighter but perhaps equally strong. The pelvis is relatively larger to accommodate the child-bearing function. The angles of certain bones such as the thigh bones to the pelvis are different, making her somewhat more vulnerable to back injury.

There are definite soft tissue variations. The bladder, the reproductive organs, and the rectum are literally slung by ligaments in the floor of the pelvis and are attached to the rim. After childbirth the supports for these organs can be weakened and their function affected adversely. Urinary difficulties, dropping of the uterus, and rectal protrusion are just examples of difficulties that can arise as a result of

childbirth. Jobs that require heavy lifting or straining can aggravate these anatomical abnormalities that follow childbirth.

Psychological considerations that must be borne in mind include especially premenstrual irritability and menopausal depression. Many, if not most women, approach the onset of menses with a sense of irritability—even depression—that can be associated with salt and water retention. This by and large resolves itself with the onset of menstrual period, but premenstrual tension and its attendant psychological irritability are factors that health professionals should bear in mind when dealing with the woman in the workplace. At the other end of the reproductive scale, at the time of the menopause, there can be extreme emotional instability—usually characterized by depression of varying degrees. This latter disorder can be quite severe and incapacitating. Fortunately, it can be treated, both by drugs as well as electro-shock therapy, if indeed it is serious enough.

There are physical and chemical exposure responses that must be borne in mind. The woman, like the male, is subject to disturbances of reproductive capacity as well as potential malignancy when exposed to ionizing radiation. Non-ionizing radiation such as microwaves are less well understood but there may well be significant implications in this area revealed by research in the future. Vibration is a new and fascinating aspect of job exposure that is just beginning to be appreciated and is as yet little understood. Vibration may be of high frequency, such as noise with its impact upon hearing, or low frequency, such as might be encountered with the use of a jackhammer. In the future this area will be explored at great length and expounded upon. The woman, particularly the menopausal woman, is uniquely susceptible to thermal environmental changes. The vasomotor instability of menopause that creates "hot flashes" makes such a woman vulnerable to extreme temperature changes.

Between the age of approximately 13 and 45 women potentially can become pregnant, and there is no subject that is more fraught with emotional anxiety or hysteria, than the subject of the pregnant woman in the workplace. I think it is extremely important to emphasize and underline one basic fact that the pregnant woman probably is healthier during her pregnancy than she would be during any other time of her life. In this case let us consider some of the changes taking place that are of special concern in the work place.

The biomechanical or ergonometric changes have been especially well described by Dr. E. R. Tichauer. There is a progressive change in the center of gravity with an accentuation of the curve of the lower back or lumbar lordosis. There is a progressive concomitant change in body contour with enlargement of the abdomen as the uterus and breasts enlarge. Changes in contour and shift of center of gravity may produce changes in gait and postural instability that may place the pregnant woman increasingly at risk in certain categories.

There are soft tissue changes that are characteristic of pregnancy. These are chiefly in the ligaments that bind bones together. Softening and lengthening of these ligaments are essentially designed to anticipate the process of labor and delivery and to facilitate same, but the same processes of ligamentous lengthening and softening can leave the individual unusually susceptible to certain injuries, for example, back injuries. Other soft tissue changes include softening and lengthening of the pelvic supporting tissues that may tend to aggravate urinary difficulties or bowel problems and under extreme circumstances, if a pregnancy is tenuous, blood supply to the uterus may be adversely affected and endanger the pregnancy.

The early months of pregnancy are the most critical and there are a number of conditions that must be considered. Many, if not most, women suffer from some degrees of morning nausea, which in its extreme form can be life-threatening. This latter condition is called *hyperemesis gravidarum* or pernicious vomiting, with severe damage to the liver. Fortunately, this condition, which was previously grounds for therapeutic abortion, has been found to be treatable and usually subsides as pregnancy proceeds. Common problems early in pregnancy are threatened or incomplete abortion. The term abortion in this sense is the broad one, which implies any interruption of pregnancy rather than the relatively recent understanding of artificial interruption. Roughly 20 per cent of pregnancies are threatened. The reasons for spontaneous abortion are not completely understood by medical science at this time. A defective ovum, an inhospitable implantation site in the uterus or some other extraneous factor that interferes with the pregnancy, or a combination of factors usually results in a certain percentage of "pregnancy wastage." After the abortion becomes inevitable and there are products of conception passed, the obstetrician usually considers the abortion incomplete and performs a scraping of the uterus to assure that no fragments of placenta remain that could ultimately cause bleeding or hemorrhage. Finally, influences that might produce abnormalities in fetal development, teratogenesis and transplacental carcinogenesis must be a concern of early pregnancy.

In the middle and late stages of pregnancy or the second and third trimester the major concern is bleeding. The term *placenta previa* refers to a "cart before the horse" situation whereby the placenta or link between baby and mother is implanted over the exit to the uterus and, in time, separates causing some bleeding. This is a potential obstetrical emergency to be watched and handled very carefully and appropriately if baby and mother are to survive. A similar and equally threatening disorder is *abruptio placentae* or premature separation of the placenta. This is usually characterized by bleeding during the middle and late parts of pregnancy and accompanied by a tense, painful uterus. This is frequently if not always accompanied by a severe impairment of the blood clotting mechanism. It is usually characterized by a sharp drop in the blood fibrinogen levels. Both of these conditions must be considered serious threats to mother and baby and handled appropriately. Health professionals in the work place that accommodate pregnant women, should bear these conditions in mind as the woman goes about her job.

The previously described ligamentous lengthening and softening can result in extreme pain in the pubic area. The cartilaginous joint in the front of the pelvis (symphysis pubis) can separate and become extremely painful, even to the degree of impairing the individual's ability to walk, much less work. This is part of the process of anticipation of pregnancy that is designed to make room in the birth passage for the maturing fetus in the process of labor.

There is a group of disorders of pregnancies that are lumped together and called toxemias of pregnancy. These disorders are characterized by sudden elevation of blood pressure, accumulation of fluid in the tissues (particularly in the ankles and fingers), excessive weight gain, and elevated uric acid. If the process proceeds unchecked and untreated, convulsions and even death may ensue. Most obstetricians are acutely aware of this disorder and the prenatal care bears this particular problem in mind in their observations.

Pregnancy can cause and be complicated by certain medical problems. Heart disease that may well be no problem in the non-pregnant woman, can be seriously aggravated by pregnancy. The most notable example of this is rheumatic heart disease. Traditionally at the end of the third month and in the second stage of labor the heart may suddenly become inefficient and the individual go into heart failure. The obstetrician and the health professional who has a pregnant individual with a history of rheumatic heart disease must bear this in mind. Diabetes and pregnancy may be described as oil and water—totally incompatible.

Diabetes is aggravated by pregnan-

cy and pregnancy can be adversely affected by diabetes. The diabetic woman may find that her insulin requirement goes up and that her labor and delivery become complicated by a larger than normal baby. The incidence of toxemia of pregnancy and premature separation of the placenta, as described earlier, is much greater in the diabetic. Indeed any diabetic pregnant woman is considered a high risk pregnancy and is monitored as such.

Kidney disease can be either aggravated or induced by pregnancy. Women with borderline kidney function may find their kidneys decompensating with the additional burden of pregnancy. Similarly the urethers or tubes from kidney to bladder may be dilated either physiologically as a result of hormones or mechanically by virtue of the pressure of the enlarging uterus upon the structures as they enter the pelvis to join the bladder. Hence, the pregnant woman is much more prone to kidney infections than her non-pregnant sister.

Psychiatric problems of pregnancy range all the way from conscious to subconscious rejection of the pregnancy to severe postpartum depression. It's not at all uncommon for a woman to go through her pregnancy apparently without difficulty, deliver normally, and return to work at an appropriate time; then she may suddenly demonstrate behavioral changes indicative of depression. This is a particularly tricky problem and the health and safety professional should bear this in mind whenever a pregnant woman delivers and returns to work, the possibility of postpartum depression or mental illness is a distinct possibility. Prematurity is an obvious complication of middle and late pregnancy. The premature rupture of membranes and the inevitable onset of labor with the delivery of a premature infant is something that has to be borne in mind constantly. Nobody knows the reasons why such things happen. Obstetricians postulate an incompetent lower uterine segment or cervic or excessive strain as possible causes. Usually, if a woman does this once she may do it again and subsequent pregnancies should be monitored especially closely for this particular problem. One rather severe life-threatening problem is the condition known as amniotic fluid embolism. The baby normally rests in a fluid medium, which by itself would be no problem, but in the course of nine months gestation, infant skin sloughs off, hair particles are cast off, occasional urine and fecal contamination of the amniotic fluid as well as that lubricating cheesy material known as *vernix caseosa* can abruptly enter the maternal bloodstream and "shower" itself particularly to the lungs and can precipitate sudden collapse. For reasons that are not completely clear, there may be lowering of the blood fibrinogen levels with concomitant impairment of the blood clotting mechanism. This process is potentially life-threatening and must be borne in mind whenever premature rupture of membranes takes place.

Of a special concern these days are problems of embryo toxicity that include abortifacients, or a tendency to interrupt the pregnancy. A number of substances can have this effect—notably lead and nitroglycerin. Another matter of prime concern is teratogenicity—an interference in the orderly development of fetal parts and organs. An outstanding example of this would be the impairment of the development of limbs as caused by thalidomide. Mutagenicity is the term applied to the alteration of germ plasm both in males and females induced by a variety of physical and chemical processes whereby future generations are impacted. And finally, a relatively unique situation known as transplacental carcinogenesis has recently come to the fore as a major concern. The best known example of this was during the late 1940's and early 1950's when diethyl stilbestrol was used in an effort to avoid abortion in women who were threatening to miscarry. In those pregnancies which survived, resulting in female offspring, roughly 10 to 20 years later, changes in vaginal tissue either suggestive of premalignant or malignant

changes have taken place. This is an example where an environmental influence does not affect the individual directly but her developing female fetus. Physical factors producing problems for developing infants include especially ionizing radiation, which can produce severe deformities. Thermal changes and vibration can bring about abortion and possibly certain changes in tissue development. Chemical factors are notable by their relative paucity in terms of hard scientific data. The following materials, derived from the NIOSH list of possible teratogens, are considered to be known teratogens in their effects. When one considers the myriad of influences both physical and chemical upon the developing fetus, it is remarkable that so little is really known in terms of hard scientific data on impairing this developmental process.

With increasing numbers of fertile women taking their rightful place in the work place, special consideration must be given to the physical and biological differences that distinguish them from men.

REFERENCES

1. Benzene—Pushkina, N. N., V. A. Gofmelker, and G. N. Klevtsqua, "Changes in Content of Ascorbic Acid and Nucleic Acid Produced by Benzene and Formaldehyde." *Bulletin of Experimental Biology and Medicine*, Plenum Publishing Co., 277 W. 17th St., New York 10011. Vol. 66, pp. 868-870, 1968.
2. Cadmium—Ferm, V. H. and S. J. Carpenter, "Teratogenic Effect of Cadmium and Its Inhibition by Zinc." *Nature*, Macmillan Journals Ltd., 4 Little Essex St., London WC2R 3LF England. Vol. 216, pp. 1,123 only, 1967.
   —Mulvihill, J. E., S. H. Gamm, and V. H. Ferm, "Facial Formation in Normal and Cadmium-Treated Golden Hamsters." *Journal of Embryology and Experimental Morphology*, Cambridge University Press, 200 Euston Rd., London NW1 2DB England. Vol. 24, pp. 393-403, 1970.
3. Lead—Angle, C. R. and M. S. McIntyre, "Lead Poisoning During Pregnancy: Fetal Tolerance of Calcium Disodium Edate." *American Journal of Diseases in Children*, American Medical Association, 535 N. Dearborn St., Chicago 60610. Vol. 108, pp. 436-439, 1964.
   —Cantarow, A. and M. Trumper, *Lead Poisoning*, 1944. Williams and Wilkins, 428 Preston St., Baltimore 21202. pp. 84-86, 142-144.
   —Ferm, V. H. and S. J. Carpenter, "Developmental Malformations Resulting from Administrations of Lead Salts." *Experimental & Molecular Pathology*, Academic Press, Inc., 111 Fifth Ave., New York 10003. Vol. 7, pp. 208-213, 1967.
   —Murakami, U., Y. Kameyama, and T. Kato "Basic Processes Seen in Disturbance of Early Development of Central Nervous System." *Nagoya Journal of Medicine Science, Nagoya University*, School of Medicine, Nagoya Daigaku Igakubu, 65 Tsurimai, Showa-ku, Nagoya 466, Japan. Vol. 17, pp. 74-88, 1954.
   —Ridgway, L. P. and D. A. Karnofsky, "The Effects of Metal on the Chick Embryo: Toxicity and Production of Abnormalities in Development." *Annals of New York Academy of Science*, 2 E. 63rd St., New York 10021. Vol. 55, pp. 203-215, 1952.
4. Mercury—Matsumoto, H., G. Koya, and T. Takeuchi, "Fetal Minimata Disease: A Neuropathological Study of Two Cases of Intrauterine Intoxication by Methyl Mercury Compound." *Journal of Neuropathology and Experimental Neurology*, 630 W. 168th St., New York 10032. Vol. 24, pp. 563-574, 1965.
   —Murakami, U., "Organic Mercury Problem Affecting Intrauterine Life," 1972. *Proceedings of the International Symposium on the Effect of Prolonged Drug Usage on Fetal Development*, M. A. Klingberg ed., Plenum Publishing Co., 277 W. 17th St., New York 10011.
   —Snyder, R. D., "Congenital Mercury Poisoning." *New England Journal of Medicine*, Massachusetts Medical Society, 10 Shattuck St., Boston 02115. Vol. 5, pp. 181-190, 1971.
   —Spyker, J. M. and M. Smithberg, "Effects of Methyl Mercury on Prenatal Development in Mice." *Teratology*, Wistar Institute Press, 36th St. at Spruce, Philadelphia 19104. Vol. 5, pp. 181-190, 1972.
5. Carbon Tetrachloride—Adams, C. E., M. F. Hay, and C. L. Lutwak-Mann, "The Action of Various Agents Upon the Rabbit Embryo." *Journal of Embryology and Experimental Morphology*, Cambridge University Press, 200 Euston Rd., London NW1 2DB, England. Vol. 9, pp. 468-481, 1961.
6. Oxides of Nitrogen—Fink, B. R., T. H. Shephard, and R. J. Blandau, "Teratogenic Activity of Nitrous Oxide." *Nature*, Macmillan Journals Ltd., 4 Little Essex St., London WC2R 3LF England. Vol. 214, pp. 146-148, 1967.
7. 4-Dimethylaminoazobenzene—Sugiyama, T., H. Nishimura, and K. Fukui, "Abnormalities in Mouse Embryos Induced by Several Aminoazobenzene Derivatives." *Okajimas Folai Anatomy Japan*, Department of Anatomy, School of Medicine, Keio University, 35 Shinanomachi, Shinjuku-ku, Tokyo 160 Japan. Vol. 26, pp. 195-206, 1960.
8. Paraquat—Khera, K. S. and L. L. Ehitta, and D. J. Clegg, "Embryopathic Effects of Diquat and Paraquat." *Pesticides Symposia*, Interamerican Congress on Toxicology and Occupational Medicine, Halos and Associates, Inc., Medical Book Division, 9703 S. Dixie Hwy., Miami 33156. pp. 257-261, 1970.
9. Polychlorinated Biphenyls—Funatsu, H. *et al.*, "Polychloribiphenyls (PCB) Induced Fetopathy, 1. Clinical Observation." *Kurume Medical Journal*, Kurume University School of Medicine, 67 Asahi-Machi, Kurume 830, Japan. Vol. 19, pp. 43-50, 1972.
   —Miller, R. W., "Cola-Colored Babies, Chlorobiphenyl Poisoning in Japan." *Teratology*, Wistar Institute Press, 36 St. at Spruce, Philadelphia 19104. Vol. 4, pp. 211-212, 1971.
10. Nickel and Compounds—Schroeder, H. A. and M. Mitchener, "Toxic Effects of Trace Elements on the Reproduction of Mice and Rats." *Archives of Environmental Health*, Heldref Publications, 4000 Albemarle St., N.W., Washington, D.C. 20016. Vol. 23, pp. 102-106, 1971.

NON-MEDICAL ISSUES PRESENTED BY THE PREGNANT WORKER

By LEON J. WARSHAW, MD, F.A.C.P.
Vice Pres. and Corporate Medical Dir.,
The Equitable Life Assurance Society of the United States,
on loan to
The Mayor's Office of Operations,
New York, NY

Several years ago, I was privileged to serve as chairman of a small group of extraordinarily knowledgeable and hardworking occupational physicians and obstetricians who were concerned about the health of the pregnant worker and the child she was bearing. We were helped by a dedicated staff provided by the American College of Obstetricians and Gynecologists (ACOG), financial support from the National Institute of Occupational Safety and Health (NIOSH), and the generous contributions of two expert panels: one of clinicians and scientists from all of the relevant fields and disciplines; the other, of people who could reflect the views of labor, management, the women's movement, the law and other groups with vested interests in this problem. Quite arbitrarily, we decided to limit our focus to the period of pregnancy and delivery and our concern to the purely clinical aspects of the potential impact of work and the work environment on the health of the worker and her fetus and the outcome of her pregnancy. For more than a year, we studied and discussed the latest scientific information and the best current practices in obstetrics and occupational medicine and, finally, produced the report, "Guidelines on Pregnancy and Work," that was published by ACOG in 1977 and subsequently reprinted by NIOSH.[1]

Aimed primarily at the physician providing prenatal and obstetrical care, the Guidelines offer a format for assembling the necessary information about the health of the pregnant worker and her fetus, the status of her pregnancy, and the potential hazards of her job. Then they provide a logic for using that information to develop the most appropriate recommendations about whether or not she should continue to work and any job changes that might make her work less hazardous and less burdensome. Limited information about specific occupational hazards was included; as expected, some of this is already out-of-date. Nevertheless, the validity of the philosophy and the logic embodied in the Guidelines is unimpaired. I commend them to those concerned about any aspect of pregnancy and work.

This presentation will focus on some of the problems and issues that, by design, were not covered in the Guidelines. Those who expect definitive solutions will be disappointed; they just do not exist. Scientific information about the influence of environmental exposures on reproductive capacity, child bearing, and the health of the fetus is very limited, and much of what we have is based on anecdote and inference whose validity is subject to challenge. The issues are sensitive and fraught with emotion; this leads to dogmatic, doctrinaire attitudes and adversarial positions that make rational discussion difficult if not impossible.

We are in the throes of a social revolution marked by new concepts and changing value judgments with respect to women's rights, the meaning of work, and employers' responsibilities to their workers and the consumers of their goods and services. These are reflected in a profusion of laws and regulations that are often confusing and sometimes conflicting. And all

this is an era of world tension, uncontrolled inflation and economic stress.

No, I have no solutions to offer. But since decisions will not wait, it is my hope that an objective discussion of the problems will facilitate acceptable compromises that will hold until definitive solutions can be evolved.

The Pregnant Worker

In the words of the Guidelines, "a normal woman with a normal pregnancy and a normal fetus in a job presenting no greater potential hazards than those encountered in normal daily life in the community may continue to work without interruption until the onset of labor, and may resume working several weeks after an uncomplicated delivery." This is applicable to the great majority of women in the work force.

There are, however, some jobs that a pregnant woman cannot perform, and there are some that she should not attempt because they involve exposures that are hazardous to her and her fetus or endanger the progress of her pregnancy. There is some work that a well-conditioned pregnant woman who has learned the knack of the job can continue to perform but which should not be attempted by a pregnant woman to whom it would be an entirely new activity. In most instances, the determination that a pregnant woman should not continue in a particular job can be made with reasonable validity only after careful consideration of the stage of her pregnancy, the state of her health, the condition of the fetus, and the kinds and amounts of the hazards to which she would be exposed. An additional consideration is the possibility that these hazards can be eliminated or satisfactorily controlled or that she can be temporarily transferred to another job or location in which they do not occur. If this cannot be done, she might have to stop working.

There are some pregnant women who are quite capable of continuing to work at a particular job without any significant risk. Yet, because of minor discomfort, a desire to stop working, or a disinclination to accept reassignment, they seek to have themselves declared "disabled" in order to claim monetary or other benefits. The evaluation of such disability is sometimes quite evident, but most of the time it requires individualized consideration of the particular constellation of circumstances presented by the pregnant worker at the particular time.

Either judgment (that the pregnant woman may work or is disabled) raises a host of non-medical problems. Is the judgment valid or merely an excuse for discrimination? If disabled, what benefits are available to help pay for health care services and to maintain her income? Will her right to return to her job with no loss of seniority or other benefits be maintained? For how long? If temporarily transferred to a job with a lower rate of pay, will she retain her higher pay rate and the levels of benefits it provides? Will her transfer be blocked if it involves bumping a co-worker with equal or greater seniority?

Such issues can only be resolved on a case-by-case basis within the framework of objectivity, fairness, and equity and in accord with established policies, negotiated agreements, and relevant laws and regulations.

Reproductive Capacity

Successful human reproduction requires mature, healthy male and female germ cells, bringing them together through adequate and timely sexual performance, and the proper implantation of the fertilized egg cell. In recent years, we have become painfully aware that environmental exposures may affect these processes and, it is becoming increasingly evident, this can occur in men as well as women.

Sexual activity is strongly influenced by emotional, cultural, and physical factors. Marital counselors report that over 50 per cent of apparently happily-married couples have sexual "hang-ups." Yet, Shakespeare observed that alcohol increases desire but inhibits performance, pharmacologists have noted that certain drugs affect sexual capability, and recent data indicate that impotence may occur in men exposed to toxic agriculture chemicals.

Over 2000 genetic disorders have

been identified. They represent inherited chromosomal abnormalities that can cause fetal wastage, anatomic malformations, and developmental disorders. Some are carried by females, some by males, and some by either or both sexes. However, chromosomal damage can also be produced by environmental agents—mutagens—and, presumably, lead to similar effects. At the same time, every test system has a spontaneous mutation rate, i.e., a low-level background rate of mutation that appears in the absence of known mutagens. Space does not permit a discussion of the implications of chemical mutagenesis; for this, I would refer you to the recent paper by Claxton and Barry.[2]

Human fertility is poorly understood. Diminished fertility and sterility are more easily demonstrated in males, but in many instances of infertility, no abnormality can be detected in either partner. Even conception is no guarantee of successful reproduction, since over one-third of early embryos fail to survive.[3] While environmental exposures can cause loss of fertility, much more research is needed to delineate the frequency and the magnitude of such effects.

The point here is that exclusion of women from exposure to agents that affect reproductive capacity will not solve this problem. Male workers must be protected as well. The critical problem is that we do not know which chemicals and physical agents affect reproductive capacity or, for those that do, the levels to which exposure must be reduced to obviate such effects. Laboratory studies require extrapolation to man which is not always reliable, while the validity of some human studies may be challenged on the basis of sample size and selection, accuracy of exposure records, method of statistical analysis, and adequacy of controls. Human monitoring may involve procedures that are unpleasant, somewhat hazardous, or culturally unacceptable, while epidemiologic studies raise questions of invasion of privacy. Nevertheless, it is desirable to eliminate exposures of both men and women to agents known to have or to be highly suspect of having such effects or, when this is not possible, to monitor exposures to them to maintain the lowest possible level compatible with the circumstances.

Child-bearing Capacity

A comprehensive review of current knowledge by Messite and Bond[4] makes it quite clear that normal women are no more susceptible to work-related exposures than their male counterparts. However, pregnancy changes this. Hazards that the normal woman might tolerate with impunity threaten the progress of the pregnancy or the development of the fetus. For example, the pregnant woman, her fetus, and the newborn infant are particularly vulnerable to the effects of low concentrations of carbon monoxide.[5]

The fetus is most susceptible to toxic exposures during the earliest weeks of pregnancy—the crucial period for organ formation—even before the signs of pregnancy appear or it can be detected by any currently available tests. About 15 percent of recognized pregnancies abort spontaneously and, among those surviving to birth, about three per cent manifest developmental defects. With increasing age, another six per cent become detectable.[3] A growing list of environmental agents is being implicated in this "fall-out," and increasingly it is being appreciated that the levels of exposure that lead to such effects may be considerably lower than those regarded as safe for adults.

The ideal solution is to make the workplace safe for all workers, even those who are pregnant, and for the fetus as well. But this is purely theoretical at this time. We don't have the necessary information, we don't have the technical capability and the cost is often prohibitive.

When possible, the employer should make adjustments in the job to make it safer and less burdensome for the pregnant worker. When these are inadequate or not feasible, she may have to be temporarily transferred to a different job. When none is available, she may have to be placed on maternity leave.

Some employers with women in jobs where potentially toxic exposures are unavoidable require them to report for reassignment at the first indication of pregnancy. Other employers, following the rule suggested by Swartz and Reichling,[6] assume that women in the productive years may be pregnant unless it can be proved otherwise, and arbitrarily exclude them from certain jobs.

These attempted solutions raise many issues: policies for medical transfer, retention of pay rate if transferred to a lower paying job, seniority rights and "bumping," definition of maternity leave, and the eligibility for disability benefits. The exclusion of pregnant workers and women of childbearing age from jobs for which they would otherwise be qualified raises accusations of discrimination. The mandatory reporting of early pregnancy and requiring proof of inability to bear children have been alleged to be invasions of privacy.

The multiplicity of government agencies involved and the lack of clarity and consistency among their regulations and rulings add to the confusion. The Occupational Safety and Health Administration (OSHA) has regulatory authority to protect workers from occupational hazards, but is severely handicapped by the fact that mutagenic and teratogenic information has been recorded for less than one per cent of the 16,000 chemicals listed in the Registry of Toxic Effects of Chemical Substances, and much of that is not yet validated for humans. Under the Toxic Substances Control Act of 1976, the Environmental Protection Agency is required to ban or restrict the use of any chemical presenting an "unreasonable risk" of injury to health or the environment. A generally acceptable definition of "unreasonable risk" has yet to emerge. The Equal Employment Opportunity Commission is charged to protect the employment rights of women but has yet to set a policy on discriminatory practices related to pregnancy and risks of fetal damage.

Employers are being whipsawed by a "Catch 22" situation in which they are subject to complaints and claims no matter what policy they establish. Unions, too, are facing a dilemma. They want to protect the rights of their female members, but this might result in their exposure to potentially toxic hazards.

Employers are rightfully concerned about their potential liability for alleged intra-uterine injury to the fetus. Awards to adult workers are limited by workers' compensation laws, but suit can be brought on behalf of a child. Case law is ambivalent about the legal status of a still-born fetus within the wrongful death statute, but recovery for prenatal injuries suffered any time after conception by a child who was born alive is permitted under common law.[7] In fact, in a recent malpractice case, the Illinois Supreme Court ruled that a child may have an action for injuries resulting from damage inflicted on its mother years before it was even conceived.[8] The pathetic plight of the thalidomide babies and reports that, in a country not known for generous legal settlements, the British distributor of that drug paid out over $50 million in awards to the victims of its teratogenic effects provide ample motivation to protect female employees from such risks.

As I said earlier, there are no definitive solutions. Decisions will have to be made on a case-by-case basis, balancing one issue against another. In the absence of validated information, policies, regulations, and rules will be promulgated and standards set on the basis of debate and discussion. Union representatives and environmentalists will push for more stringent and rigidly enforced controls. Advocates for women's rights will argue against any limitations of job opportunity and earning capacity. Industry will opt for more lenient standards and voluntary compliance. Hopefully, the result will be responsive to the most reasoned rather than the most strident voices.

I do have some recommendations to offer:

1. The health of the worker and her child and of future generations should always be given prime consideration. In the absence of firm scientific proof, evaluation of risk will necessarily be based on extrapolation, inference, and assumption. It should be tilted toward

wider rather than narrower margins of safety.

2. Since no standard or rule is likely to protect all people, there should be sufficient flexibility to provide for those at the extremes of the distribution curve.

3. Each worker should have access to the best available advice with respect to family planning, and each pregnant worker should have proper prenatal and obstetrical care by health professionals with knowledge of the effects of work exposures on the course of the pregnancy and its outcome. This will be facilitated by providing them with the ACOG Guidelines and having the principles they embody accepted as a standard of practice.

4. A system should be developed to provide workers with understandable, objective, and timely information about potential work place hazards and training in their recognition and control of avoidance. In a recent paper, Blum describes the statutory duty of employers for supplying workers with such information and notes a trend to make failure in this duty an independent cause of legal action, entirely apart from any consideration of injury.[9]

5. An educational program should be aimed at all female workers of childbearing capacity and a special effort made to reach those who are pregnant. It should provide information and motivation to avoid or control the hazards they might encounter in their home life, personal habits and recreational and community activities: e.g., alcohol, cigarette smoking, use of drugs and medications, and exposure to household chemicals.

6. Research should be expanded and accelerated in the toxic effects of known and new chemicals, and their dose-response relationships individually and in combinations. New technology should be developed and put in place for minimizing exposures, monitoring their levels in the work place, and detecting toxic effects in workers as early as possible. The results of this research and their implications should be divulged in appropriate fashion to the workers who may have been exposed and to occupational health professionals. Reduction of risk and control of potential hazards should outweigh the preservation of trade secrets.

7. Full information should be given to each worker about her own situation and the relative merits of alternative courses of action so that she can participate in any decisions relating to herself and her job. When decisions have to be imposed, their rationale should be explained and honest responses made to any challenges she might offer. Proper written policies should be elaborated and published, preferably with involvement of and endorsement by any unions, as guidelines for such decisions. Both management and labor have been guilty of pursuing vested interests at the expense of the worker, sometimes without her knowledge. Such exploitive behavior should be exposed, decried, and corrected.

8. Companies and unions should endorse the codes of professional ethics recently promulgated by the American Occupational Medical Association and the American Association of Occupational Health Nurses and insist that all health professionals employed or retained by them conform to their precepts.

All of this is eminently possible when employers are sophisticated and affluent enough to hire properly qualified health and safety professionals or when workers are represented by unions that set a higher value on the health of an individual member than on "brownie points" for hard bargaining or guarding against justifiable encroachment or prerogatives. But this would cover only a portion of the working population. The majority work in non-unionized small plants where both knowledge and sophistication in applying it are sadly lacking, and resources are limited. We must find ways to reach and protect them.

Let me close by urging that women workers, pregnant or not, and their male colleagues as well, be treated with honesty, dignity, equity, and compassion. This will not solve all of the problems but it certainly make it much easier to live with them.

REFERENCES

1. American College of Obstetricians and Gynecologists, *Guidelines on Pregnancy and Work* —Chicago, ACOG Publications, 1977.
2. Claxton, L.D.; and Barry, P.Z.; "Chemical Mutagenesis: An Emerging Issue for Public Health." *Am. J. Pub. Health* 67:1037-1042 (Nov.) 1977.
3. *Human Health and the Environment—Some Research Needs.* Research Triangle Park, North Carolina, National Institute of Environmental Health Sciences DHEW Publication No. (NIH) 77-1277, 1977.
4. Messite, J.; and Bond M.; "Consideration for Women at Work," in Zenz. C. ed. *Occupational Medicine—Principles and Practical Applications.* Vol II. Year Book Publishers. In press.
5. Longo, L.D.; "The Biologic Effects of Carbon Monoxide on the Pregnant Woman, Fetus and Newborn Infant." *Am. J. Ob. Gyn.* 129: 69-103 (Sept. 1) 1977.
6. Swartz, H.M.; and Reichling, B.A.; "Hazards of Radiation Exposure for Pregnant Women." *J.A.M.A.* 239:1907-1908 (May 5) 1978.
7. *Simon* v *Mullin,* 380 A.2d 1353 (Conn. Super. Ct., Nov. 2, 1977).
8. *Renslow* v. *Mennonite Hospital,* 367 N.E. 2d 1250 (Ill. Sup. Ct., Aug. 8, 1977; rehearing denied Oct. 3, 1977).
9. Blum, J.D.; "Revealing the Invisible Tort: The Employer's Duty to Warn." In Egdahl R.H. and Walsh D.C. ed., *Health Services and Health Hazards: The Employee's Need to Know.* Springer Series on Industry and Health Care, #4 New York, Springer-Verlag. 1978.

PREGNANT WOMEN IN THE WORKPLACE— A COMPANY PROGRAM TO CONTROL TOXIC EXPOSURES

By LEONARD A. KRAUSE, Sc.D.
Director of environmental hygiene and toxicology.
Olin Corp., New Haven, CT

Toxicologists, physicians, occupational health specialists, and the safety practitioner should consider the effects of exposure to toxins found in the workplace upon the pregnant female and the fetus. Currently, about 45 per cent of the 110 million females in the U.S. are in the labor force. Previously, many females became employed after their reproductive years. If 60 per cent of the female work force today is between 16 and 45 years of age, and the fertility rate is 76 births per 1,000 women, there is a possibility of 2.2 million pregnancies among those women employed each year.

Not all pregnancies or fetuses are endangered by exposure to the environment, but some potential hazards are becoming more evident. Each year, as our knowledge of the toxicity of the chemicals to which women of child-bearing age are exposed to increases, the risk becomes a little greater. New chemicals are being used to improve our life styles. At the same time, the risk of harmful effects increases unless industrial safety and health specialists keep a constant vigil on the total effect of these possible work hazards.

In-house control of the workplace, however, is not simple for any industry. During the past 10 to 12 years there have been substantial changes made in the employment of females in industry. A review of the hiring practices of many of the larger industries shows that where previously many jobs were reserved for male workers, the present atmosphere is to hire females to work in almost any job for which she may be qualified and apply.

The Equal Employment Opportunity Commission (EEOC) enforces Title VII of the *Civil Rights Act* that prohibits any discrimination based on sex, race, color, religion, or national origin. This law gives women the right to be considered for jobs on an *equal* basis with men. This law also allows them to be exposed to the same hazards in industry as men.

We must accept the premise that women in industry may work anywhere her male counterpart may. However, females do become pregnant, and it is this phase of a natural phenomenon that has created problems. We find ourselves "in a riddle wrapped in a mystery, inside an enigma." We can protect the female, but we cannot absolutely protect the fetus, because we know so little about the toxicology of many chemicals as they relate to fetal damage.

The problem appears to be of some concern to employers at this time for several reasons. The majority of working women are in the child-bearing years. It is common practice in some plants *not to hire* women who are known to be pregnant, and it is almost equally common to discharge them as soon as the pregnancy is discovered. Such a policy, however, encourages women to conceal their pregnancy as long as possible and continue to work at a job that offers considerable hazard not only to her health and safety, but to that of the fetus she carries.

The first three months of pregnancy, which are the most easily concealed, are also the period when the fetus is the most vulnerable—more so than the next three to six months. At this early date women particularly need protection, but unless there is a policy in the plant that will encourage them to report their condition, they cannot avail themselves of protection. And, even in this "enlightened age," many women are pregnant for four to six weeks *before* they know it.

The points to be considered for such a company maternity policy are:

- The importance of judging each case individually;
- The time at which a woman should stop work before the birth of her child;
- How soon after delivery she may return to work;
- The types of jobs that should be avoided because of danger of physical strain or injury to herself or the fetus as a result of exposure to toxic substances;
- The preservation of seniority rights;
- The opportunity to return to her job;
- The length of hours and rest periods;
- Other conditions of work.

For instance, types of work women do or their job classifications can be ranked in terms of potential exposures. Within the broad category of the nursing profession, for example, operating room nurses are exposed to significant levels of ethyl chloride, nitrous oxides, isopropyl alcohol, ethyl ether, halothane, UV (ultraviolet radiation), and infectious diseases. Additionally, they may be exposed to radiation, and of course, the physical strain of standing for long periods of time. The effects of these exposures on the fetus are unknown at this time, but they could be substantial.

In Michigan, 33 nurses out of 600 showed malignancies, three times the normal rate. The American Society of Anesthesiologists has reported that their female members have experienced 1.3 to 2.0 times the normal expected spontaneous abortion rate. Generally, the problem is that the anesthetic gases are vented into the operating room and inhaled by the operating team for long periods of time.

During pregnancy the concentration of red cells in the blood (and, therefore, hemoglobin) falls because of the increase of plasma. This is commonly referred to as physiological anemia of pregnancy. If there is an exposure to benzene or lead during this time, the problem is compounded because both of these chemicals affect the blood forming mechanism.

The National Institute of Occupational Safety and Health *Beryllium Criteria Document* states, "the delayed onset of pneumonitis is often precipitated by acute stress (*i.e.*, pregnancy, respiratory infections, surgery, etc.)." Harriet Hardy's 1965 paper on beryllium poisonings shows that of the 95 females in the beryllium registry, 63 could be identified as having pregnancy as a likely factor.

In 20 cases of CO poisoning during pregnancy the mother survived in only 10 cases, eight infants developed neurological disturbances, and three died later of brain damage.

The major thrust in any control program must be in the first trimester of pregnancy during the organogenesis—when the fetus' vital organs are first developed.

The theory that the placental barrier protects the fetus in all cases has been shown to be false. By simple diffusion, many of the smaller molecules pass through the placenta from the mother to the fetus. Therefore, if the mother is exposed to toxic materials through ingestion, skin absorption, or inhalation, there is potential for fetal damage.

We do not know the exact concentration of known toxic substances that will affect the fetus in a deleterious way or what can be tolerated. All of this, of course, presents problems for management:

1.) If management decides to remove or bar all women of child bearing age from a particular job or work site, the company may be faced with discrimination litigation. Title VII of the 1964 *Civil Rights Act* and the EEOC protects workers.

2.) If a pregnant female is allowed to stay on a particular job without warning, and aborts or delivers a damaged child the company may be open to very costly medical claims.

3.) If management attempts to

change a process or procedure, they may alter the economic feasibility of producing the product.

4.) If management establishes a policy of transferring women to other jobs at no pay loss, they may be opening the Pandora's box for other workers who seek the same arrangement for different reasons.

This problem should be approached in a way that is scientifically correct. The knowledge of both the industrial hygienist and the toxicologist should be utilized along with consultation with the safety specialist in ascertaining the potential hazards of all jobs. Each job site should be examined for possible toxic hazards that can be chemical or physical.

This knowledge of the exposure levels to the pregnant female and the fetus must be correlated:

1.) Is there any evidence that the material in question is a feotoxin in any form (*i.e.*, mutagen, teratogen, or carcinogen)?

2.) If so, is the concentration of a level of concern?

This is an ongoing, continuing evaluation. It will never end because jobs change, processes are altered, new facilities are used, and new products are made.

In each case, line management, legal staff, safety personnel, and the industrial relations personnel have the opportunity to review the recommendations to look for and forestall possible problems. The final word or bottom line responsibility, however, rests with the staff of the environmental hygiene and toxicology department and the corporate medical director. A corporate policy should be established on this subject. The policy has to be one that can be applied reasonably to all facilities, be palatable to plant management personnel, and also be protective to the fetus.

Olin Corporation has established three categories for the placement of women of child-bearing age in any job—restricted, controlled, and unrestricted.

To protect female employees who are capable of bearing children and any who may be carrying a fetus, against potential hazards in the work environments, the guidelines are:

Restricted: A restricted job is one that involves use of any chemical a female of child-bearing age might come into contact with that is extremely hazardous to her well-being. And by definition, there is a restriction put on her on being allowed to work in that area. The nature of the work may require contact and exposure to known or suspected abortifacient or teratogenic agents. Pregnant females and non-pregnant females capable of bearing children shall be prohibited from working at a job classified as "restricted." Females who cannot bear children may be permitted to work at such a job. The decision to allow a female to work at a restricted job should be made only after consultation with the medical doctor to confirm that she cannot bear children and that she will sustain no other adverse physiological effects from the environment.

Classifying a particular job into the "restricted" category is not based wholly upon the chemical itself. The category classification is also based upon management's ability to reduce the exposure level and exposure time to the chemical. If this is possible, it may also be possible to classify the job to a lower risk category. Therefore, we may restrict the female from working on a continuous basis at a particular job site, but allow her to enter the area infrequently for short time intervals, *i.e.*, to obtain samples for quality control. In this case, we feel that the risk is low, but to work eight hours per day, 40 hours per week is not acceptable as the risk then becomes too great.

Controlled: Any job that may require limited contact with abortifacient or teratogenic agents is classified as "controlled." Under normal conditions, contact and exposure, in most cases, should *not* pose an unacceptable risk. Non-pregnant and pregnant females may work at jobs classified as "controlled." The latter only after an individual case-by-case evaluation. Programs for employee hazard education, personal environmental monitoring, and medical supervision shall be provided for *all* females. Personal protective equipment may be required. Each female in this category will read or have explained, *Information concerning pre-natal chemical or physical exposure.*

This category is the most prevalent, the most difficult for management to accept and yet the most logical. If we analyze it, we see that it allows for a considerable amount of latitude and discretion by the physician in charge.

Unrestricted: There is no restriction placed on any job where the exposure to chemical or physical agents does not constitute a hazard to the pregnant female or the fetus.

Exposure to the chemical or physical agent does not constitute a hazard to the pregnant female or the fetus. A high proportion, obviously, of jobs fall into this category.

Each category is specific and can be adhered to without undue jeopardy to the female and her right to work. We feel it protects the rights of the fetus as well as fulfills a strong moral obligation to do what we feel is correct for both mother and child.

There is a common underlying theme through all of this, and it extends beyond the simple statements or definitions and that is *the education of the female employee.*

It is essential that all industries set up a series of employee orientations by the safety and health professionals for the purpose of educational discussions with all employees (both men and women) to review all the potential hazards of a facility to enlighten the employees and to carry through a mandate of involving all levels of employees in their safety and health. An informed employee is a better, safer, and healthier worker.

Standards must be established that guarantee to the best of our scientific ability that both male and female workers will not be harmed by exposure on the job and that their ability to produce normal, healthy children will not be threatened, nor will a fetus in the workplace be placed in unnecessary jeopardy.

REQUIREMENTS FOR AN ENVIRONMENT, SAFETY, AND HEALTH ASSURANCE PROGRAM AT THE WORKING LEVELS OF ORGANIZATION

By M. S. TIERNEY and A. C. ELLINGSON
Sandia Laboratories, Albuquerque, NM

Previous papers have addressed the need for ES&H assurance, what functions are required to obtain it, and how the performance of such functions might impact ES&H program organizations at the corporate level (the latter using Sandia Laboratories as a model). One other major concern in assessing the practicability of an approach to ES&H assurance, such as that described in an earlier paper, is the potential impact that such a program might have on line organizations. Because of the flexible, decentralized character of the program, it is clear that an ES&H assurance program would have maximum line impact at the working levels of organization.

Working levels of organization will, for the sake of brevity, be called departments throughout this paper. By a department, we mean an organizational unit of an institution that is primarily devoted to some technical activity at a working level. At Sandia Laboratories, a department is a formal organizational unit comprised of 20-100 staff members and technicians.

To begin to define requirements for an ES&H assurance program at the department level, the model assurance program is examined, and elements of the model program that appear to require participation at the department level are identified. There are 34 elements of the model assurance program, all of which could be interpreted as requiring some departmental action. But by analogy with proven quality assurance programs in other areas and using common sense to anticipate feasible ES&H activities at the working levels, we have identified only nine of the 34 elements to be ones that require significant participation on the part of a typical department's management and staff. These nine elements provide a rough framework for constructing a department-level ES&H program. They are: list and classify facilities/projects; identify hazards; prioritize risk assessment; assess existing risk; record information on hazard/risks for each facility/project; and monitor known hazards, control methods and procedures, potential new hazards, and changes in facilities/projects.

Each item is self-explanatory except that "prioritize risk assessment" and "assess existing risk" require an elaboration of their meaning. Obviously, these two activities can mean different things at different levels of organization.

To be feasible at the department level, "prioritize risk assessment" must mean a subjective classification of identified hazards according to acceptability of their attending risks. For example, three categories of hazard might be considered:

1. Hazards commonly encountered and accepted by the public (automobiles, appliances, regional natural hazards, etc.).
2. Hazards commonly encountered and accepted by trained construction workers (trucks, tractors, power tools, etc.).
3. Unusual hazards (all hazards not manifestly falling into categories 1 or 2).

Category 3 hazards would, if they exist in a department, have the highest priority for risk assessment, not because categories 1 and 2 are unimportant, but because (a) department supervision and personnel are often the only persons who are aware of the existence of Category 3 hazards and are capable of devising effective controls and procedures (see below); and (b) Category 1 and 2 hazards are probably most cost-effectively controlled by education and training programs at the institutional level.

The activity "assess existing risk" must also be carefully qualified if it is to be feasible or, indeed, even meaningful at the department level. To assess the risks attending a hazard, one identifies all adverse effects, defines conditions of exposure to those effects, and then appraises the degree of harm resulting from a given effects/exposure combination. In fact, such an assessment is routinely and almost always subjectively performed by technical staff who are engaged in a project. A more important activity is the provision of controls and procedures that minimize harm to personnel and the public in the event that a hazard is realized. The provision and maintenance of hazard controls should be the major ES&H activity at the department level.

An Idealized Department Program

Using the framework provided by the model assurance program, it is easy to identify some elements of an ideal department assurance program. These elements are: policy; operating rules and procedures for hazard identification and control; records of the department facilities/projects, hazards of each facility/project, and controls for each major hazard; reviews by department management, safety committees, and institutional ES&H; and audits by line management, institutional ES&H, and safety committees.

Department management sets policy (within the limits allowed by institutional or agency constraints), keeps up-to-date records of department facilities/projects and known hazards and their associated controls, and also reviews compliance with operating rules and procedures. Management would usually be assisted in the last two of these tasks by a department safety committee whose members are drawn from the staff and serve during fixed terms. In fact, the keeping of up-to-date records, and reviewing performance against these, would be the major responsibilities of the departmental safety committee. The minimal set of records would consist of a list of the facilities and projects for which the department is responsible, identified hazards associated with each facility/project, and the specific nature of the controls and procedures applied to mitigate each major hazard. In addition, these records might profitably contain statements of any training sessions and department safety meetings. For lack of a better name, we will call the combined records "department safety notes." The safety notes, if kept up to date, would provide an essential link between departmental ES&H assurance and the overall institutional assurance program.

It would be the responsibility of institutional line management, the safety committees, and ES&H organizations to conduct structured audits of the department's program by periodically comparing the department safety notes with the observed status of department operations. In addition to judging the existence and use of the departmental programs, the auditors would pass on the adequacy of prescribed controls and procedures.

Testing the Idealized Program at Sandia Laboratories

We have partially tested the feasibility of applying the idealized department ES&H program sketched above to a real organization by attempting to compile a set of department safety notes for a Laser Physics Research Division at Sandia Laboratories, Albuquerque. Before discussing the results of this "experiment," we review the elements of existing ES&H compliance structures for a typical Sandia department.

Operating rules and procedures at Sandia are promulgated in three formal ways: (1) Sandia Laboratories instructions (SLIs); (2) safe (or standard) operating procedures (SOPs); (3) special directives from management. Informal guidance toward achieving safety is provided in special manuals and through advice from the Safety Standards and Engineering Department (3440), the Environmental Health Department (3310) and a Fire Protection Organization, which were discussed in the two previ-

ous papers. Record keeping and monitoring functions are accomplished through reviews and revisions of SOPs (by 3440 and 3310), submission of Area Inspection Report forms by informal department safety committees, and by inspections by the Facility Safety Appraisal Committees (FSACs), an independent, director-level safety committee appointed within each vice-presidency at Sandia Laboratories. Responsibility for keeping records is jointly shared by working level supervision, line management, Organizations 3340 and 3310, and the FSACs.

Sandia has an excellent record in operational safety. Thus, the rather informal ES&H structure described above has been more than adequate for meeting safety requirements in the recent past. But it is not clear that the present structure is adequate to meet requirements of a safety assurance program in the future, owing to diversification of the Laboratories' tasks, the increasing contact with exotic hazards, and an increasing public concern with safety, health, and environmental quality.

Accordingly, we have proposed certain changes in the present compliance structure of a Sandia department that would come nearer to meeting the needs of an assurance program if such were ever implemented. The proposed changes are:

1. Formal department safety committees (DSCs).
2. Requirement for records of; facilities/projects; unusual hazards of each facility/project; controls and procedures specific to each unusual hazard (SOPs).
3. Requirement for structured audits by the DSC (facility list and hazard update) and the FSAC (independent of DSC).

The most radical departures from present procedures are the requirements for structured record keeping (the Department Safety Notes) and for structured audits of departmental safety status.

To begin to see whether the proposed changes are feasible, we have taken the existing SOPs for a Laser Physics Research division at Sandia and have written a set of prototype department safety notes. The facility/project list provides concise answers to the questions: What is the nature of the department's operations? Where are those operations carried out? When were they initiated?

The list also provides an index to the hazard classification list. The hazard classification list states the nature of the hazard, its major adverse effects, and keys the specific hazard to the facilities/projects in which it occurs and the sections of the department safety notes in which the measures taken to analyze and mitigate the hazard are described.

This limited exercise on a real organization has so far led us to make the following conclusions concerning the merits of an assurance program at the working level. The disadvantages of a structural approach lie mainly in the diversion of a department's time and resources from programmatic work and the dilution of the procedures integrated for an entire project in the present version of the SOPs. The latter disadvantage could, of course, be removed by keeping integrated project SOPs in addition to the department safety notes; but then there would be further time and resources required of department supervision and staff. Our limited experience suggests, however, that effort required in preparing Department Safety Notes, and in preparing SOPs, is comparable. Careful scheduling of Safety Note preparation to correspond to the required SOP update schedule would minimize impact on line organizations. Up-dates thereafter should require no more time than current SOP up-dating. Thus, the major impact on line resources, after this front-loading effort, should arise from formal DSC activities. If the DSC for a department of, say, 50 people were composed of five persons who were active about one day each two weeks (5 man days/2 weeks) then DSC time would be about 130 man days per year. This effort is only one per cent of the approximately 13,000 man days per year expended by a 50-man department, a very reasonable number. This estimate is, of course, an average; some organizations would invest more, and some less, time relative to ES&H matters.

The advantages of a structured approach are seen to lie mainly in the emphasis placed upon hazards and hazard control (rather than control of personnel) and the provision of records that could easily be audited and also incorporated into institutional or agency safety data systems. This latter advantage would, if implemented, make it possible for working level organizations to share experience through an information system and might result in an overall decrease in time and effort required for ES&H compliance and assurance.

A structured audit of the subject division's activities using the prototype department safety notes has not yet been conducted, and little can be said about problems that might arise. The effort involved in an audit, however, does not appear to be excessive or even beyond present levels of such activities. The results of structured audits derived from Department Safety Notes should be more meaningful than the relatively unstructured audits now conducted. But this claim remains to be tested.

We tentatively conclude at this point that an ES&H assurance program at the working levels of organization does seem practicable if a certain degree of flexibility is allowed to account for different needs of different organizations. Since flexibility, as described earlier, is characteristic of the approach, we anticipate no significant difficulty in its implementation from the point of view of working levels of organization.

Against this optimistic background, the Department of Energy has begun to take first steps toward implementing the approach to ES&H assurance described earlier.

BACKGROUND, AND THE NEED FOR "ASSURANCE" IN THE DOE ENVIRONMENT, SAFETY, AND HEALTH PROGRAM

By H. HOLLISTER
Director, Div. of Operational and Environmental Safety,
U.S. Department of Energy, Washington, DC

Background

The history of ES&H concerns and efforts of mankind is one of continual evolution. Looking back just the last three-quarters of a century in the U.S., I believe that one can see that great strides have been made in promoting the safety and protecting the health of the public and the worker. This progress has resulted from a number of factors, among which are growth in the understanding of hazards, public concern and pressure as a result of this, and Federal, state, and local regulations arising from public concern. Many of the hazards are "natural" in character—e.g., relating to disease or nutritional deficiency—while others result primarily from human activity, but are relatively unsophisticated in character.

As protection of health and the promotion of safety has progressed, so also has the sophistication of both the nature of new hazards and our comprehension of them. Imagine a concern for recombinant DNA research or some of today's complex aromatic chemicals in 1900, for example. We live in an evolving technical world in which an increasing awareness of, and concern for, the hazards around us exist. Nowhere is this more evident than in the evolution of Federal legislation in the last, say, 15 years. Again, one observes a continuing acceleration of concern and complexity.

Let me turn now to the Department of Energy (DOE) within this evolving framework. As I am sure you know, the DOE has itself been subject to evolutionary forces. The original organization, the Atomic Energy Commission (AEC), was established in 1947. Its primary concern was inherent in its title and, in fact, the major focus of activities conducted and sponsored by the AEC was in the nuclear area. In 1974, the Energy Research and Development Administration (ERDA) was created. At that time, the perspective of the organization was vastly broadened from an ES&H point of view. For example, under the AEC, our activities that related to public health and safety were almost exclusively concerned with radiation hazards—and indeed, with great hindsight, our early understanding of these was quite limited. With the advent of ERDA, many new areas of activity were required. What are the hazards associated with new fossil, solar, and energy conservation technologies? How can risks be controlled? These were areas which were almost totally new to the old AEC staff, and they were faced with them at a time when public concern for technological hazards was at its historical peak.

The details of how ERDA might best manage its ES&H responsibilities in the new and rather complex setting were never fully developed before further organizational evolution took place. Last year ERDA became the central part of a new organization, the Department of Energy, with even more greatly expanded responsibilities. These now include energy production regulatory functions, regional power generation, maintenance of oil reserves, and so on. Thus, further expansion has introduced more hazards with which to be concerned and has broadened the scope of concern both geographically and in terms of the number of persons engaged in DOE business. The DOE currently has about 20,000 Federal employees and over 100,000 prime contractor employees subject to ES&H regulation by the DOE. These persons are at about 270 separate locations within the United States, and the facilities owned by the DOE have a total value of approximately $30 billion.

Becoming somewhat more specific, the Division of Operational and Environmental Safety (OES) of the DOE is responsible for the development of ES&H policy and regulations and the overall DOE ES&H program under which all DOE operations are conducted. The objective, of course, is to provide a regulatory framework in which DOE operations are conducted with a high regard for the health and safety of the DOE and DOE contractor personnel and the public and for protection of the environment and property. When I assumed the position of director of OES in early 1977, it was very apparent that the role of OES and the means for carrying it out needed to be reexamined. Under the AEC, the precursor of OES was placed at a high level within the organization and had a strong regulatory function over AEC activities. Under ERDA, the OES analogue was placed less visibly and never reached the same position of regulatory strength. In the larger DOE, the organizational visibility was even more obscure, and needed regulation was certainly no clearer.

It seemed to me that OES was faced with the choice of arguing for considerable expansion or of finding a better approach to ES&H regulation. My decision to look for better approaches was motivated by several things. In early 1977, the actual ES&H regulations that OES administered within the DOE differed relatively little from those that had existed under the AEC —and these were a collection of manual chapters that had evolved as the need arose and emphasized nuclear energy. Some had existed for 15 years without change. Our system of management of ES&H programs in the field operations was little different from that found in the AEC, but was not generally applicable to other additions to the DOE or to the evolving management structure of the DOE itself. Finally, the DOE Organization Act and policies of the current administration suggested that a new approach would be needed.

The Need for "Assurance" in the DOE ES&H Program

To pursue the last point just mentioned, for a moment, the DOE Organization Act of 1977 reflects the growing national concern over ES&H matters discussed earlier. Specifically,* the Congress finds that "a strong national energy program is needed (that is) consistent with overall national, economic, environmental, and social goals." To this end, one purpose of the Act is "to assure incorporation of national environmental protection goals in the formulation and implementation of energy programs and to advance the goals of restoring, protecting, and enhancing environmental quality, and assuring public health and safety."

To gain this assurance, one of the functions that must be assigned to assistant secretaries is "Environmental responsibilities and functions, including advising the secretary with respect to the conformance of the Department's activities to environmental protection laws and principles. . . ."

In addition, the secretary is required to submit to the President an annual report which contains "(a summary of Departmental programs which shall include) a description of activities the Department is performing . . . necessary to guarantee that technological programs funded by the Department are undertaken in a manner consistent with and capable of maintaining or improving the quality of the environment and mitigating any undesirable environmental and safety impacts."

In terms of administration policy, some indications of the DOE obligation to consider ES&H factors in the energy field come from the National Energy Plan (NEP). One of the five "principles" that define the context in which energy policy is to be formulated is ". . . National policies for the protec-

*Much of the following material is taken from *Planning for a DOE ES&H Assurance Program*; C. A. Trauth, Jr., Sandia Laboratories, SAND78-1887.

tion of the environment must be maintained."

Later, in a discussion of energy RD&D, the NEP states: "The groundwork for eventual commercialization should generally be laid during the RD&D stages. Before embarking on costly research projects, the government should have the best possible information on prospects for . . . institutional acceptance . . . support of scientific research and development does not constitute a commitment to subsequent demonstrations of technologies that do not meet health, safety, and environmental criteria."

It was perfectly clear to me that because of the nature of OES activities and the regulatory and organizational changes that had occurred during the last decade, OES was not in a position to provide the assurance required by the DOE Organization Act. Indeed, precisely how one might do this was unclear. About a year ago, I asked Sandia Laboratories, the DOE national laboratory with the major responsibility for quality assurance in the area of nuclear weapons, to investigate the possibility of borrowing, either directly or philosophically, from their quality assurance experience to develop a program that might be termed an "ES&H assurance program." The objective of their activity was to develop and test an assurance approach to ES&H that would provide:

1. OES with an approach that would satisfy the requirements of the DOE Organization Act and administration policy for assuring public health and safety and for assuring environmental protection.
2. An ES&H program structure in which priorities were more readily apparent.
3. More flexible approaches to ES&H regulation within the DOE, consistent with the diversity of DOE activities and the particular needs of each.
4. More accurate indications of ES&H performance for OES use, and especially those that relate to management performance rather than, e.g., results of detailed emissions measurements.
5. An ES&H management system and information system design that would accomplish this without requiring large additional expenditures of the taxpayer's money.

The following speakers will describe the efforts that have been made to develop and actually test an ES&H assurance program that fits the DOE structure and needs.

AN APPROACH TO INCORPORATING PROVEN QUALITY ASSURANCE, RELIABILITY, AND HUMAN FACTORS PRINCIPLES INTO ENVIRONMENTAL HEALTH PROGRAMS

By WILLIAM D. BURNETT
Mgr., Environmental Health, Sandia Laboratories, Albuquerque, NM

Sandia Laboratories, under contract to the Office of Operational and Environmental Safety of the Department of Energy (DOE), is investigating how the disciplines of Quality Assurance (QA), Reliability (R), and Human Factors (HF) might be used in support of Environment, Safety, and Health (ES&H) programs. A portion of this effort, the development of an ES&H assurance program based on tested QA, R, and HF principles, is theoretical in character, and will be described elsewhere.[1] This theoretical effort, like any abstraction, needs to be compared with reality—which in this case is the ES&H program at Sandia. This comparison has three purposes:

1. To determine whether the model ES&H assurance program has elements which are deficient, excessive, or impractical.
2. To determine whether an ES&H assurance program would benefit Sandia Laboratories.
3. To determine those changes, if any, that would be needed in our existing ES&H program if it were to become an assurance program.

The greater part of Sandia Laboratories' ES&H program is administered by three separate organizations: The Safety Standards and Engineering Department; The Environmental Health Department; and The Plant Engineering Planning Department (Fire Protection). This report summarizes our findings resulting from a comparison of the Environmental Health Department with the abstract ES&H assurance program.

With regard to the conclusions reached in this report, it must be noted that the total existing ES&H program is not included in the comparisons made in this report and, further, the feasibility and effectiveness of the recommendations will be tested in a work setting before they can be regarded as anything but preliminary. Thus, the conclusions drawn should be regarded as tentative. Also, the current program(s) administered by Sandia Laboratories' Environmental Health Department are quite effective. Thus, this study is in no way intended as a criticism of current programs—it is intended only to answer the question: How might our current environmental health programs be modified to take greater advantage of proven QA, R, and HF principles? Although specifically addressing this question in the context of Sandia Laboratories' environmental health program, the approach taken in this study would appear to be generally applicable. It is presented here in the hope that others may find it useful.

Environmental Health Department Activities and Responsibilities

In analyzing the activities and responsibilities of the Environmental Health Department we have identified 29 activities given in the Environmental Health Program documentation. The activities listed have been defined in such a manner that the fact that they have been performed is (abstractly) capable of verification, and it is intended that the activities include all major on-the-job elements of the Environmental Health Program administered by the department. We have investigated all of these activities to some extent and have explored some

of them in detail.

The 29 activities and the manner in which they are performed by the department are discussed below. Although details are omitted in some cases, this description presents the major aspects of the Sandia Environmental Health Program.

1. Provision of an environmental health program. In the words of Sandia Laboratories Instruction (SLI) 2001, "Environmental Health Department is primarily responsible for supplying technical guidance to supervisors and employees to aid them in working safely with toxic materials, nonionizing radiation, and ionizing radiation. It has line authority to suspend any operation in these three general areas where the immediate hazard to personnel necessitates such action. Additionally, it maintains surveillance programs adequate to document personnel and environmental exposure arising from the Laboratories activities in these three areas." The program is defined somewhat more broadly in the Introduction to Section IV of the Sandia Laboratories Manual for Industrial Safety, Fire Prevention, and Environmental Health[3] as being "primarily concerned with the recognition, evaluation, and control of those environmental factors arising from the work place which may cause sickness, significant discomfort, or inefficiency among Sandia employees."

2. Provision of training in environmental health areas. The Environmental Health Department provides training of several types, both for its own personnel and for those of other organizations. The Health Physics training is particularly important because of DOE requirements for work with the Sandia reactors.

Environmental health training is provided for security guards, apprentices, special groups such as those involved in transporting hazardous material, and others by special request. Emergency preparedness training is provided in specific cases, such as in remote, high hazard areas. Training in the use of respirators is provided. (Fitting of the respirators is also done.) Self-contained breathing apparatus training is conducted once each month, and a refresher program is also conducted. The department makes a practice of reviewing personnel transfer listings in order to determine who needs training.

Training of department personnel utilizes a variety of methods, including training department courses, courses provided by organizations outside of Sandia and, of course, on-the-job training. Sandia reactor health physicist certification training and testing is also provided. There is no separate budget for training.

3. Development of guidance for line environmental health functions. The basic guidance provided to line organizations is that included in Section IV of the Safety Manual.[3] Included in this section is material on toxic materials, nonionizing radiation, radioactive materials and radiation machines, the personnel dosimetry program, respirators, and occupational noise. Guidance is also provided through bulletins on various environmental health topics, as well as through formal control documents, such as Sandia Laboratories Instructions.

The guidance function is, of course, involved in all interactions between the Environmental Health Department and the line organizations. These include facility specification reviews (Activity 12), the preparation of safe operating procedures (Activity 6), instrumentation control, continuing consultation (Activity 4), and other activities which crosscut those listed numerically, such as surveys, investigations, and health physics controls in reactor areas. Through these interactions, the line is advised on the control of health hazards in both design and operations.

4. Provision of consultation to line organizations. Environmental health personnel serve as consultants, both to line organizations and to outside agencies for operations interfacing with Sandia activities. The guidance provided by such consultation assists the line organizations in minimizing risks, purchase of required equipment, eliminating hazards, training of personnel in the environmental health areas, and preparation of safe operating procedures, safety analysis reports, and safety assessment documents.

Consultation is an activity involving interaction between parties and is useful because of information received as well as because of information given. The information received during consultation enables environmental health personnel to maintain an awareness of existing hazards, identify new hazards, and make judgments on relative degrees of risk. Although much of consultation is on an individual basis, it also occurs in other forms, such as committee meetings.

5. Participation in safety committees. Environmental health personnel are active participants in the various safety committees, such as the Facility Safety Appraisal Committees (FSACs), the Reactor Committees, and the Reactor Safeguards Committee. As noted above, committee work includes both acting as consultants to the committee and also collecting information useful for hazard identification and risk assessment.

6. Development of guidelines, provision of input, and final approval of safe operating procedures. Line organization personnel prepare SOPs, with guidance and support from Environmental Health when environmental health factors are involved. The SOPs are checked by walk-throughs of the procedures and must be approved by Environmental Health before actual use. SOPs are reviewed each year and are rewritten after every two years of use. SOPs are required for all hazardous operations. The definition of "hazardous" is quite broad in perspective; however, the Department provides guidance for determining when an operation is hazardous and an SOP is needed.

7. Conduct of investigations for hazard identification and evaluation. Possible hazards are called to the attention of the Environmental Health Department, particularly on new projects, through communication from the line organizations and feedback from the instrument pool when equipment items are submitted for purchase. However, knowledge of potential hazards is also brought to light during informal audits or consultations. Priorities are assigned to the hazards thus identified, and investigations are then conducted on these possible hazards to identify precisely and to evaluate the actual hazards. Hazard investigations vary in depth, depending on the potential consequences. In the radiation area, a formal list of known hazards is maintained. Chemical hazards are identified by operational audits and through a mandatory approval authority for chemical purchases. Biological hazards are identified through line SOPs and controlled through updates, committee work, and consultation.

The conduct of hazard investigations serves one additional purpose: it assists in the assignment of priorities. Hazards are evaluated qualitatively, and a determination made that (a) no further effort is required; (b) a modest (perhaps verbal) SOP (see Activity 6) is required; (c) a rigorous SOP with careful monitoring by the Department is required; or (d) a safety assessment document (SAD) or a safety analysis report (SAR) is required.

8. Conduct of continuing program for hazard evaluation and elimination. In addition to the immediate investigation conducted when a potential hazard is discovered, there is a continuing program for studying known hazards and searching for methods of eliminating or mitigating them. The relatively small staff in the Environmental Health Department places a limit on the effort that can be applied in hazard evaluation, but studying the basic problems is considered an assigned task throughout the organization. This tends to be an informal activity for most classes of hazards, however.

9. Conduct of audits of all environmental health-related activities. A variety of audits and monitoring activities is conducted by the Department in the radiation area:

a. Building radiation surveys, in which dosimeters are mounted in a building for a prescribed interval. By comparison with previous survey results, changes in radiation levels may be detected.
b. Building area radiation surveys, usually at four-month intervals. These consist of taking "swipes"

in areas involving radiation equipment or material in order to check them for contamination. Records are maintained of the surveys made, and numerical data are filed only when radiation counts are above normal.

c. Sealed source leakage checks. These checks are conducted at six-month intervals and include reviews of the source log books.
d. Periodic monitoring of shipping and receiving areas, reclamation areas, and company vehicles. Such monitoring checks for inadvertent movement of radioactive materials.
e. Health physics support in the reactor areas. Although the chief purpose of this activity is control, the observations inherent in the task provide invaluable monitoring data.

Monitoring efforts in other hazards areas are much less formal, and most often are conducted as part of the consultation activity (see Activity 4 above).

10. Investigation of accidents and suspected overexposure to health hazards.

As in the case of accidents in the industrial safety area,[4] accidents involving environmental health are investigated extensively, in accordance with DOE guidelines and requirements. Serious accidents are formally investigated by investigation boards made up of a variety of specialists, while lesser accidents are investigated more informally. Near-accidents are investigated also, when information is available.

11. Provision of input to safety analysis reports and safety assessment documents. Safety analysis reports are prepared by line organizations for new or modified facilities which present potential hazards. Smaller projects may require safety assessment documents, as specified by the DOE. For either document, the Environmental Health Department furnishes guidance in formatting, assistance in hazard identification, and assistance in the minimization of hazard effects.

12. Review of facility specifications and recheck at time of occupancy. The Environmental Health Department is in the review loop for new facility specifications and reviews the monthly construction status reports issued by Plant Engineering. Review of new facility specifications is not always productive, since it is the equipment installed in the facility which usually causes environmental health hazards and such equipment is not defined in all facility specifications. For this reason, the Department depends more on informal reviews at the time of occupancy and on notification from the instrument pool of radiation instruments obtained for identification of potential hazards.

13. Evaluation of effectiveness of safety criteria and techniques. The statutory and regulatory criteria, particularly those specified by the DOE, are the basic requirements for environmental health activities. The Environmental Health Department considers these statutory criteria to be only the minimum acceptable for Sandia operations and reviews and evaluates all procedures and specifications by this philosophy. The "as low as practical" (ALAP) concept is used as the ultimate standard for an exposure criterion. Among the measures of effectiveness used is the number of people who report occupational disease to the Medical Department.

14. Specification, evaluation, and development of standards for use of protective equipment. Although protective equipment can include such things as the instrumentation which warns of unsafe conditions, this discussion is limited to protective equipment worn by the individual. Instrumentation is covered in Activity 21, below. The protective gear provided for Sandia's use is evaluated and approved by OSHA, but the Environmental Health Department reviews these evaluations and chooses between options for Sandia use. Since the amount of protective equipment used at Sandia is relatively small, there is little recycling of used equipment back into the system. Repair work is performed on hard-to-replace items and also on request from line organizations. Respiratory equipment available for emergency use is serviced on a monthly schedule.

15. Coordination with external agencies and information sharing with professional contacts. Coordination in safety matters, with DOE as well as with agencies such as OSHA, is required by DOE. Such required coordination is quite formalized. A less formalized type of coordination, which nevertheless is extremely useful, is the exchange of information with professional contacts. The informal contacts provide information on improved techniques long before the formal system can react.

16. Operation of environmental health laboratory and counting laboratory. The laboratories operated by the Environmental Health Department provide support to industrial hygiene, health physics, and medical. Typical of the support provided to these groups is the analysis of a variety of environmental and biological samples for the presence of toxic and/or radioactive material. The activity here deals with the quantification of trace amounts of contaminants by means of sophisticated automated equipment.

17. Control of chemical and radioactive waste disposal program. The department provides direction, procedures, and control methods for the disposal of hazardous waste.

18. Assistance to line organizations in decontamination activities. Decontamination operations are critical for hazard mitigation. Environmental Health provides guidance for these operations, monitors them to assure the effectiveness of the activity, and supervises the subsequent waste disposal.

19. Specification of restrictions for personnel with regard to health hazards. Restrictions are imposed on personnel, both on an individual basis and in an overall sense, to limit exposure to health hazards. Individuals may be limited in work activities when accumulated exposure approaches regulatory limits. General restrictions include the establishment of restricted zones which limit access when toxic materials or radiation are present. Controls on restricted zones vary from posting warning signs to complete access control such as that in the reactor areas where Environmental Health and Security maintain padlock control.

20. Control of personnel dosimetry program. In accordance with DOE requirements, all personnel entering areas where radiation exceeds certain levels are required to wear dosimeters. Assurance that personnel exposure limits are not exceeded requires a program for controlling the issuance of the dosimeters, the taking of the dosimeter readings, and the cumulative recording of individual exposures. The program, as conducted by the Environmental Health Department, includes not only the mechanics of issuing, reading, and recording, but also involves monitoring and evaluating dosimeter logs, which allows control of exposure before limits are reached.

21. Control of installation, maintenance, and calibration of instrumentation used for measuring health hazards. Identification and measurement of health hazards is dependent upon accurate instrumentation. The Environmental Health Department is involved in the procurement, calibration, maintenance, and use of such instrumentation and exerts a high degree of control.

Procurement of environmental health instruments requires Environmental Health approval on the purchase requisition. Most of the portable instruments are charged to the Environmental Health budget, while fixed equipment is charged to line budgets. The department provides receiving inspection, calibration, and maintenance on all radiation monitors. A computerized calibration recall system is used, with most of the equipment on a four-month cycle. Fixed equipment is calibrated on an annual basis. Instrument records are kept to certify calibration and to identify equipment which needs replacement.

The formal controls on instrumentation are supplemented by random checks on the instruments in use and by committee and consultation assignments.

22. Control of procurement of se-

lected hazardous materials. Procurement control is exercised through the purchase requisition approval requirements. These requirements are imposed on specific materials, such as toxic chemicals, and also on equipment which may cause radiation hazards.

23. Determination of bioassay requirements for radioactive and toxic materials. The Environmental Health Department determines when potential exposures to radioactive or toxic materials have occurred and specifies the taking of bioassay samples as deemed necessary.

24. Leak testing and disposal of radioactive sources. The control of radioactive sources is in accordance with DOE directives. Of particular importance is the check for leaks, which is done every six months. At the time of the leak test, the log book for the source is reviewed in order to identify any abnormal use.

25. Provision of adequate and timely incident response and incident consequence control. Incidents involving the release of materials which are hazardous to personnel or to the environment are reported immediately to the Environmental Health Department, usually by Security but in some cases directly by the line organizations. In reactor areas, a department representative is present during operations, and the reporting is thus more direct.

Response to such incidents includes, first of all, measurements of the extent of the hazard involved. Provision is also made for notification of the organizations needed at the scene of the incident, such as Medical. The consequences of the incident are mitigated through decontamination operations, waste disposal activities, or (in extreme cases) evacuation of personnel. In all of these mitigating actions, the department is involved in directing efforts and providing advice.

26. Provision of an environmental monitoring program. Environmental releases are monitored by the Environmental Health Department, with the aim of characterizing the releases and determining the degree of hazard involved.

27. Submission of reports. DOE and other Federal and local agencies' directives require the submission of many types of reports in the environmental health area. The requirements for these reports are quite specific and well defined.

28. Provision of information to management. In addition to the external reports required by DOE, the Environmental Health Department provides much information to Sandia management in the form of investigation reports, statistical data, and special reports on specific hazards.

29. Assistance in the updating of the industrial safety, fire protection, and environmental health manual. The Safety Standards and Engineering Department is charged with maintaining and revising the Industrial Safety, Fire Protection, and Environmental Health Manual.[3] However, the Environmental Health Department provides reviews and information for keeping the environmental health portion of the Manual up-to-date.

In addition to the 29 assigned activities described above, the Environmental Health Department devotes as much effort as possible to the improvement of the environmental health program. Activities aimed at improvement include research in new techniques and the development of special instrumentation.

Environmental Health Department Activities Compared to a Model Environmental Health Assurance Program

A generalized model of an ES&H assurance program is an abstract representation of an operational ES&H program based on quality assurance, reliability and human factors principles. If all elements of the program are in place, such a program should lead to assurance (in the technical sense) that ES&H requirements are being met. In the analysis of the Sandia Environmental Health Department operation, it is useful to first determine the relationship of the 29 activities of the Department to the components parts of the model. The relationship of the Department program to an ES&H assurance program can then be evaluated in the overall

terms of the model.

The model contains six major components: provision or safety requirements, facility and project status information, identification of hazards and assessment of risk, identification of factors affecting risk, compliance assurance, and information systems. Under each of these major components, the Department activities pertinent to each subcomponent of the ES&H assurance model will be discussed. General conclusions for each of the major components are also included.

Some of the activities performed by the Department are universal in the sense that they span nearly every block in the model. This spanning occurs in two basic ways: actual performance of parts of nearly all of the ES&H assurance functions given in the model, or providing support that will enable others to perform these functions. Those "universals" that basically provide support are: provision of training in environmental health areas (Activity 2) and provision of an environmental health program (Activity 1). The latter is included here because the provision of a program does not perform the functions per se. On the other hand, provision of consultation (Activity 4) and participation in safety committees (Activity 5) are designed to perform nearly all of the ES&H program elements, sometimes on an informal basis. Efforts in the development of guidelines and provisions of inputs and final approval of SOPs (Activity 6) in the development of guidance for line environmental health functions (Activity 2), and in the performance of audits for hazard identification (Activity 7), provide activities in most of the program areas. A chart was prepared giving an indication of the intersection between department responsibilities and activities and the elements of the model safety assurance program. An "A" intersection indicates that the department activity in that column contributes in a major way to the function required in an assurance program. It does not indicate that the function is performed "completely" from an assurance point of view. A "B" intersection indicates a minor contribution to the associated assurance function. In evaluating the contributions of all department activities to a given assurance function, only its "A" activities are considered. One immediate conclusion drawn from the chart is that all elements of an assurance program are performed to some degree by existing department activities. Thus, should it be desirable to institute a safety assurance program, the chart indicates that, at most, some modification of existing activities might be required. Modifications that might be required are discussed next, under the assurance function headings.

Provision of Requirements

1. Listing of requirements. The ES&H requirements which must be documented range from broad Federal, state, and local mandatory requirements to specific management guidelines. The general requirements are listed primarily through Activity 29, but partial listings are found under Activities 2 (training), 14 (protective equipment), 19 (personnel restrictions), 21 (calibration control), and 22 (procurement of hazardous material). Associated with Activity 6 (SOP guidelines) is a documentation of SOPs, which is one form of specific requirements. The other activities intersecting this function relate in some manner to the listing of requirements, but do not directly produce the documentation.

Documentation is quite complete in the case of mandatory requirements, particularly those promulgated by DOE. The SOPs are formally documented, as are the guidelines and requirements presented in the safety manual. There are some gaps in the documentation of requirements; for instance, much of the guidance provided in the industrial hygiene area is provided informally through consultation, although the safety manual also documents necessary guidance in a more general form.

2. Correlation of requirements with hazards and classification. Specific requirements are strongly correlated with hazards for processes involving

radiation and some of the toxic materials, since rather accurate measurement of the degree of hazard is possible in these cases. The correlations are made through Activities 6 (SOPs), 7 (investigation of hazards), 8 (hazard evaluation), 9 (audits), and 5 (safety committees). Where measurement is more difficult or the correlation is more complex (because of the number of types of toxic materials and the number of body organs affected, for instance), the correlation and classification is less complete. The correlation with general requirements is less well documented.

3. Identification of gaps and inadequacies in requirements. Formal plans to search for inadequacies in the requirement system do not exist. However, inadequacies in requirements are identified through the consultation process (Activity 4), reviews (9, 12, and 13), and investigations (7 and 10). Reviews of SOPs (6) and the safety manual (29) are also aimed at correcting inadequacies. A more formal system of identifying gaps in requirements, with direct relationship to hazards, would be desirable in an assurance program.

4. Risk research. The review and investigation activities which identify gaps in the requirements often point out the need for risk research. When a need is thus recognized, research is often initiated either by line organizations or by the Environmental Health Department. However, such research is usually on an ad hoc basis (except in instrumentation), and there is not an adequately structured effort, with assignment of priorities, such as would be provided by a formal assurance program.

5. Development of new requirements. DOE requirements or national consensus standards are, of course, not developed by the Department. However, safe operating procedures (SOPs), safety analysis reports (SARs), and guideline documents such as new sections of the safety manual are continually being developed, either by the Department or through joint efforts with the line organizations. Through activities such as the development of guidelines and inputs for SOPs (Activity 6) and the provision of input to SARs and SADs (Activity 11), this function is well defined and documented.

6. Comparison of facilities/projects with requirements on hazard risk basis. The comparison of facilities and projects to the applicable requirements on the basis of the risk involved is generally performed in a qualitative manner. In projects involving radiation sources, the amount of attention devoted to procedures and other requirements as well as the formality of the procedure development is varied roughly in accordance with the intensity of the source. The review of SOPs (Activity 6) and consultation with the line organizations (Activity 4) provide the major input for comparisons. More formal reviews and more systematic comparisons would be desirable in an assurance program.

7. Storage of requirements/hazards as classified. Information on requirements in relation to hazards is quite complete, particularly in the radiation projects. However, there is no single formal list of all hazards, their risks, and how these compare with requirements. Since this element of an assurance program is essential for judging compliance, it is clearly needed in such a program.

8. Monitoring of changes in requirements. Changes in requirements are monitored quite closely, particularly those imposed by DOE directives. Independently, the development or implementation of other Federal laws is watched informally. SOPs are reviewed annually, and guidance-type documents are generally monitored quite closely.

Requirements Summary. The Sandia environmental health program is relatively strong in the requirements area. As exemplified in the correlation of requirements with hazards and projects, the chief need is one of formality when compared with the model assurance program.

Greater use of specialist support would improve the requirements developed. Human factors input would benefit the SOPs, and the use of additional reliability/statistical techniques would determine more accurately where new or improved requirements are needed.

In moving toward an assurance program, the greatest need in the requirements area is for a unified data base in which all requirements and their relationship to hazards would be stored. Such a data base would provide part of the documentation against which audits and reviews could be conducted and provide a formal means of determining whether line activities comply with environmental health requirements. Such a base would also provide a framework in which the need for changes in requirements and the priorities for action could be determined.

Facility and Project Status Information

1. Listing and classification of facilities/projects. The listing of facilities is quite complete in the Sandia environmental health program and is accomplished primarily through Activities 11 and 12. Classification of facilities is a more difficult task because environmental health hazards are caused more by the equipment in the facility (associated with projects) than by the facility itself, and the classification is therefore more qualitative and less well documented. Supplementary means of identification and classification, through audits and consultation (Activities 3, 4, 5, 6 and 7), also tend to be nonuniform, as will be discussed later.

2. Storage of facility/project information as classified. As with requirements, the information system is quite complete in the identification of facilities and projects, but covers classification of them only in a qualitative manner.

3. Monitoring of changes in facilities/projects. Monitoring of changes in facilities and projects is accomplished through audits and consultation, and is thus rather informal. Monitoring of major changes in facilities is accomplished by Activity 12 (review of facility specifications), which includes reviewing monthly construction status reports, although some monitoring may be accomplished through Activity 11 (provision of input to SARs and SADs).

Facility/Project Summary. Facility and project status information could be improved through more formality, particularly in the classification function. The identification of facilities and projects is most nearly complete for radiation hazards and presents the greatest problem in the case of the types of hazards associated with Industrial Hygiene activities.

Identification of Hazards and Assessment of Their Risks

1. Identification of Hazards. Identification is again the basic function, since an ES&H assurance program cannot be directed without a target. Identification of hazards may be made through almost all of the functions, but it is most effective when it occurs during the design period, such as in the review of facility specifications (Activity 12). Similar formal reviews are generally not performed on projects, reliance being placed on line organizational perceptions of hazards—which tend to be nonuniform. Guidelines for SOPs suggest that hazards be identified but this is not required and, again, the line organization is responsible for determining the need for SOPs. Audits and reviews (Activities 9 and 13) also assist in the identification of hazards and are quite effective in the radiation area, where hazards tend to be somewhat self-identifying. There is no unified data base containing all serious corporate environmental health hazards. Such a data base is an essential component of an assurance program. Although provision of this data base can be a substantial task, we feel that the approach presented later in this report can help reduce the job to manageable proportions.

2. Prioritizing Risk Assessment. Priorities must be assigned to the identified hazards for the next step in the process—risk assessment. This prioritizing is quite judgmental in the current program, and only facilities which require SARs are subjected to quantitative risk assessment efforts. Other priority levels assigned to hazards include that which requires spe-

cial SOP preparation, that for which a "standard" SOP will suffice, and that for which an SOP is not required (see Activity 7).

3. Assessment of existing risk. Risk assessment currently varies from highly qualitative to quantitative. However, there is a lack of a formal overall risk assessment framework, which means that corporate management has only a qualitative overall view of risk. Risk assessment is based largely on Activity 10 (investigation of accidents and suspected overexposures) and on Activities 20 and 21 (personnel dosimetry and control of instrumentation), providing mostly after-the-fact types of information (Activity 21 provides a basis for continuous radiation risk assessment). Risk assessment activities would require some change if an assurance program were adopted. Methods and guidelines for assessing risk in ways that proportion effort to risk are needed before these changes could be implemented. Note that rather simple risk assessments are effective in most cases. The need is generally for organization and formality in the assessment rather than for greater precision.

4. Identification of gaps in risk information. The completeness of risk information is checked by a variety of activities, including particularly Activity 7 (conduct of investigations for hazard identification and evaluation). Such information is, again, qualitative in nature, and no compilation of the gaps identified is made.

5. Prediction of future risk. Prediction of future risk would use the same guidelines as those for assessing existing risks. Prediction is, of course, most difficult in state-of-the-art projects such as DOE programs and may lack the accuracy of the evaluation of present risk; nonetheless, prediction is a desirable component of an assurance program since it assists in prioritizing audit/appraisal schedules. Again, currently there is no unified attempt to predict future risk.

10. Storage of hazard/risk information per facility project. Although hazard/risk information is documented to some degree, it is not compiled in such a manner that it could be used for project comparison. There is no unified hazard/risk data base.

Hazards/Risk Summary. The identification of hazards and the assessment of risk are the foundation upon which an environmental health assurance program rests, but they are difficult to systematize. Involvement in design is required for both identification and assessment. In the Sandia program, the department reviews facility specifications and construction status reports, but it generally depends upon supplementary means, such as consultation, for information on project design. The support of specialists, such as from reliability or human factors areas, is not used to the extent possible. Operationally, there are gaps in the present system, including the nonuniformity of hazard identification, the often qualitative nature of risk assessment, and the lack of a unified hazard/risk data base. The SOPs provide the most nearly formal approach, but the identification of hazards is only suggested in the guidelines. This area would need to be formalized if an assurance approach to environmental health were adopted.

Identification of Factors Affecting Risk

1. Listing of risk factors. In the current program, the factors affecting risk are identified in specific cases but usually in a subjective way, as in the process of developing SOPs, for example. Often, risk factors are identified only after-the-fact (during accident investigations, Activity 10). In some areas, such as radiation work, factors affecting risk have been identified very completely in a technical context, while other factors (administrative, operational, human) are less well developed. Many activities provide helpful input to the identification of factors, including committee work (Activity 5), investigations and audits (Activities 7 and 9), input to SARs (Activity 11), reviews of facility specifications (Activity 12), monitoring, dosimetry, and instrumentation (Activities 20, 21, and 26), work with radioactive sources (Activity 24), and determination of bioassay requirements (Activity 23).

2. Relating factors to risk. When risk factors have been identified, the relationship to risk is generally known in a qualitative way, and quantitatively in some areas through Activity 20 and 21. However, very little has been done toward quantifying the relationship, and even less has been done to use risk factors as a basis for an environmental health control program or an assurance program.

3. Storage of risk factors and relations. Information on risk and risk factors, where available, is generally documented as individual items in reports and has not been collected into any unified data base.

Risk Factors Summary. For this component of an ES&H assurance program, very little is being done in a patterned way, although many of the necessary data are known in a qualitative sense and some are known quantitatively through test data.

Compliance Assurance

1. Monitoring of facility/project status for potential new hazards. Facilities and major projects are first monitored for potential new hazards through the design reviews of Activity 12. During the construction and operational phases, environmental health inspections are conducted by line organizations, although guidance is provided through the safety inspection guide.[5] Even with this guidance, the inspections tend to be nonuniform. In day-to-day operations, SOP review (Activity 6), hazards audits (Activities 7 and 9), safety committee participation (Activity 5), and consultation (Activity 4) provide the monitoring information. Again, this is less structured than would be required by an assurance program, although the radiation monitoring is an exception to this.

2. Monitoring of methods and procedures. Safe operating procedures are reviewed and updated on a periodic basis. During consultation (Activity 4), the use of procedures and their adequacy are evaluated informally. This area receives less formal attention than many others.

3. Monitoring of risk factors. Since the identification of risk factors is quite subjective, the monitoring of these factors is necessarily qualitative except where Activities 20 (personnel dosimetry) and 21 (control of instrumentation) give quantitative data other monitoring is accomplished primarily through the audits (Activity 9) and consultations (Activity 4), and is fairly ad hoc in character. If an assurance program were adopted, more uniformity and organization would be essential.

4. Determination of change in risk. The monitoring activities discussed above are intended to alert the system when a change occurs. After a change is identified, the determination must be made as to its effect on the overall risk. This is a form of risk assessment and it is performed, again, qualitatively and somewhat informally in the existing environmental health program. More formality would be desirable in an assurance program.

5. Determination of optimal change in risk factors. When it is determined that a change in risk has occurred, the risk factors should be changed to reverse the effect (unless, of course, the change in risk is in the desired direction). At Sandia, as elsewhere, the economic and technical cost of changing a risk factor is balanced against the benefit of the desired change in risk in determining the optimal change. Because of the lack of uniformity and gaps in risk and risk factor determination described above, the determination of optimal change is particularly difficult. Some judgment is always involved in such determinations, but the availability of structured information will decrease the dependence upon judgment.

6. Determination of compliance status. Determination on a continuing basis of the compliance of a system with requirements must be accomplished without excessive cost and, to be useful, the degree of compliance must be quantified. The existing environmental health program normally determines compliance qualitatively and thus avoids the excessive costs. Compliance is checked primarily through reviews and inspections (Activities 5, 7, and 9, for example) and consultations (Activity 4). Some of

the reviews and inspections are fairly formal, but are often nonuniform because of the reliance on line inputs without a formal uniform assurance program.

7. Requirement of change implementation. The responsibility for implementing changes, when such changes have been determined to be desirable, rests with the line organizations. The environmental health organization, through its reporting-to-management function, does have influence on change implementation and can, in severe cases, require than an activity be suspended.

Compliance Summary. Compliance assurance consists of monitoring for change and determining the effect of the change. The current environmental health program requires specific monitoring actions in the radiation area, but in other areas it requires only that activities and equipment be observed, without specification of how much or by whom. However, if decisions are to be made based on the monitoring results, the results should be measurable and comparable to others. This means that monitoring should be uniform, or consistent, and should provide reproducible results which are independent of the audit organization or person. The current program lacks complete uniformity in some areas, where the monitoring is performed by different orzanizations, and the results are quantified only to the extent of differentiating between adequate and inadequate.

Summary of Analysis

This analysis of the Environmental Health Program and observation of the resultant safety record leads to the conclusion that the program is effective in its goal of preventing accidents, injuries, occupational disease, damage to equipment, materials and property, and work interruption. We believe however, that the program as currently constituted cannot be regarded as an assurance program, based on generalized model and Reference 1.

Identification is, as perhaps expected, a problem (excepting, again, the strong hazard identification program in the radiation area). While identification of requirements, facilities, and projects is thought to be quite complete, a more systematic method of identification could be devised in these areas which would provide more assurance of completeness. The identification of hazards is a major problem, particularly in the industrial hygiene area where there is little experience to use as guidance.

After hazards have been identified, it is necessary to evaluate them, to determine the relative risks involved, and take action to minimize them. Although the Sandia Environmental Health Program does include hazard analysis, it is generally qualitative in nature and does not make maximum use of support from specialist areas, such as reliability and human factors.

Another major area in which the environmental health program does not completely possess the characteristics of an assurance program is that of compliance assurance. More uniformity would be needed for the monitoring function in the nonradiation area, and the monitoring results would need to be better quantified so that optimum decisions can be made for subsequent operations.

When the degree of compliance has been measured, the final step to correct whatever noncompliance exists. The environmental health organization, in performance of its staff function, does generally have enforcement authority; however, it normally operates on the basis of reporting noncompliance to upper management and verifying when corrective action is taken. The existing information reporting systems would need to be made more formal if an assurance program were instituted. Management can make more effective decisions when there is objective comparison information available.

One decided need that must be met if the current program were to be altered to conform more nearly to an assurance program is for a unified—and rapidly accessed—data base. Such a data base would need to contain those elements identified in the generalized model: Requirements, Facilities and Projects, Hazards and Risks, Risk Factors, and Assurance Data. Many of these data already exist but are not centrally referenced for all types of environmental health hazards.

An Approach to the Incorporation of Assurance Into the Sandia Environmental Health Program

The analysis of the Sandia Environmental Health Program presented in the previous sections led to the conclusion that the program has been very effective in preventing injury, illness, and environmental damage. However, it was also concluded that the program would require some changes in order to become an assurance program. Characteristics of the program which were specifically noted as requiring such changes include:

1. Complete identification of facilities/projects and serious hazards is not assured.
2. Risk assessment is normally qualitative, often incomplete, and too little consideration is given to risk factors (quantitative risk analysis does not necessarily imply that each analysis is exhaustive, but only that the results are formalized and documented to allow comparison).
3. Assurance of compliance with requirements is incomplete in some areas.
4. The information and reporting systems are generally informal and, because of the lack of assurance, do not contain some of the information desired for effective enforcement or for accurate risk evaluation by management.

These characteristics are all those of an assurance program, which supports the conclusion that the current program is not an assurance program. Some of the benefits that would accrue from incorporation of the characteristics of an assurance program include:

1. Reduction in the likelihood of accidents through improved assurance of compliance with requirements.
2. Reduction in the likelihood of accidents through more effective assessment of risk, and a closer relationship between mitigation actions and risk.
3. More effective management through the availability of quantified, objective data for use in decision making.

Based upon this investigation and the results of concurrent investigations of the Sandia Industrial Safety Program,[4] the Sandia Fire Protection Program,[6] and the potential usefulness of an assurance approach,[2] it appears that the assurance function could profitably be added to the currently effective Environmental Health Program administered by the Sandia Environmental Health Department. The following discussion is concerned with a proposal which represents one way that the Environmental Health Program could incorporate quality assurance, reliability, and human factors techniques and principles based on the generalized model and the general approach of Reference 1.

This proposal is based upon a QA analogue, as illustrated by the first two columns of Figure 1 (see Reference 1). Under a typical QA program, there is a line quality control (QC) function which defines and implements a quality plan at the program/project level. By analogy, there should be a line environmental health control function to define and implement an environmental health plan at the program/ project level. In both cases, the line organization should have its own assurance function at the program/ project level to make sure that the QC program, or the environmental health control program, is both adequate and used.

Both the control function and the assurance function at the program/ project level are oriented toward the needs of the line organization and are conducted within the line structure. Over these line structures, for quality or environmental health, there are institutional structures which are independently responsible to the management of the company or the sponsor of the work. In the case of quality, the institutional structure consists of a quality group responsible for general definition of QC and QA programs, uniformity and coordination of programs between projects, and provision of status and information and assurance to top management. In discharging these responsibilities, the basic function of the institutional group is assurance (shown as program quality

assurance in Figure 1) and is performed through independent reviews and audits. Figure 1 also shows the environmental health analogues of these institutional functions.

The institutional environmental health assurance organization has responsibilities and functions similar to those of an institutional quality group. Again, assurance is the basic function. Other functions required of the institutional environmental health assurance organization are:

1. Management of the Environmental Health Assurance Program.
2. Coordination of environmental health programs across program lines to ensure uniformity of both the programs and the criteria by which their adequacy and use are judged.
3. Maintenance of institutional status information.
4. Environmental health support to line organizations. This is a vitally important function and is the primary means of promoting a "helpful" rather than a "policeman" image for the institutional environmental health assurance program.

The proposed modification of the Sandia Environmental Health Program would implement the view of environmental health assurance as an analogue of quality assurance, but would do so within the existing Sandia structure. The third column of Figure 1 illustrates how the present structure would be matched to the quality assurance and environmental health assurance analogue presented in the first two columns.

Under the proposal, the first level of control would be the division supervisor. There would be essentially no change in the general responsibility at this level, the supervisor still having the basic responsibility for safety and health activities, and also being responsible for the tasks delegated by the next level (line department), including the development of an environmental health plan for the organization.

The division control function operates under the direction (requirements) of the line department. The line department then, has the dual function of providing performance requirements for the division and assuring that the requirements are met. This latter function would be performed by (normally) existing line department safety committees. In the environmental health area, it is proposed that the requirements be developed by a specific individual in the line department. The requirements would be documented in a line department environmental health plan (LDEHP), which would include

1. Identification of all facilities and projects with which the line department is involved.
2. Identification of the serious environmental health hazards existing in the line department.
3. Assessment and classification of the risks involved in the major hazards.
4. Provision of environmental health control requirements to the division.
5. Provision for the detection and correction of inadequacies.
6. Definition and guidelines for the performance of the assurance function by the line department safety committee.
7. Identification of training requirements for committee members.

The personnel of the Environmental Health Department would provide the same support in LDEHP preparation that is now provided in SOP preparation in order to assure that the requisite expertise is applied to the planning. The identification of a single individual within each line department is intended to emphasize coordinated plans at the department level that are suitable for formal audit at this same level and by facility safety appraisal committees (FSACs); provide a focal point for communication between the Environmental Health Department and each line organization; and emphasize that ES&H activity is a line responsibility.

The management of the institutional environmental health assurance function, under this approach, would be performed by the Environmental Health Department. The formal institutional compliance reviews and audits, which determine the degree of compliance with all environmental health requirements, would be per-

QUALITY ASSURANCE	ENVIRONMENTAL HEALTH ASSURANCE	PRESENT SLA ENVIRONMENTAL HEALTH STRUCTURE
Line Production, etc.	*Line* DOE Activities, etc.	*Line* Projects (Staff)
Program/Project Quality Control Define QC Implement QC Program Responsible to Line at Project/ Program Level	*Program/Project Environmental Health Control* Define Environmental Health C Program Implement Environmental Health C Program Responsible to Line at Project/ Program Level	*Project Environmental Health Control* Division Supervisor
Program/Project Quality Assurance Assure Adequate Assure its Use Responsible to Line at Project/ Program Level	*Program Project Environmental Health Assurance* Assure Adequate Environmental Health C Program Assure its Use Responsible to Line at Project/ Program Level	*Project Environmental Health Assurance* Department Manager Department Safety Committee
Program Quality Assurance Adequate and Used QC/QA Compliance Responsible to Institution	*Program Environmental Health Assurance* Adequate and Used Environmental Health A/C Programs Compliance Responsible to Institution	*Program Environmental Health Assurance* Facility Safety Appraisal Committees (FSACs)
Institutional Quality Assurance Institutional Q Program Management Coordination Status Reporting Support to Line	*Institutional Environmental Health Assurance* Institutional Environmental Health Program Management Coordination Status Reporting Support to Line	*Institutional Environmental Health Assurance* Environmental Health Department

Figure 1. Environmental Health Assurance Management Plan (an analogy)

formed for the Environmental Health Department by the FSACs, as shown in Figure 1. All audits and reviews would be based on the line department environmental health plan—judging both adequacy and use. Other functions performed by the Environmental Health Department would include.

1. Coordination of environmental health requirements, as received from the DOE and elsewhere, and as developed at Sandia.
2. Provision of guidance and training in environmental health matters to all employees, but more importantly to those responsible for environmental health functions.
3. Data collection, analysis, and reporting. The data collected include quantified results of audits as well as data on facilities/projects, hazard identification, and risk assessment.
4. Identification of the need for and performance of risk research, environmental health research, etc.
5. Physical inspection and laboratory analysis functions to supplement the FSAC audits.
6. Overall program appraisal and reporting to top management.
7. Consultation.

This proposal would incorporate into the Sandia Environmental Health Program the characteristics of an assurance program, not by adding new assurance organizations but by somewhat redefining and redirecting the function of the existing organizations. Referring to the current program characteristics which deviate from the assurance program model, implementation of this approach would provide, through the LDEHPs, complete identification of facilities/projects and serious environmental health hazards; provide, also through the LDEHPs, for more formal hazard and risk assessment as required; provide compliance assurance through redefinition of FSAC and line department safety committee roles and the existence of a fundamental document against which environmental health activities may be judged; provide an effective information system through the greater availability of pertinent data (although effort in information system design and in implementation will be necessary).

It must be stressed that the LDEHP, as the basic building block of the assurance program, must be a dynamic document. Changes will continually occur (in requirements, in facilities/projects, and hazards), so the plan will need updating. Other activities, particularly the assurance audits and reviews, must be synchronized with the plan in order to always provide up-to-date information. In a related sense, an important part of the assurance function is the assessment of how changes are accommodated.

It is believed that implementation of this approach will entail few, if any, additional costs. The institutional environmental health organization would see only a minimal increase in workload, since (for example) much of the safe operating procedure reviewing could be replaced by the reviewing of the LDEHPs. There may be some increase in the FSAC and line department safety committee's workload, because auditing would have to be conducted more frequently, would have to be more in-depth, and would have to be reported more completely. These efforts would be somewhat offset by a more formal structure which would facilitate reviews and reporting. The largest increase in effort would be for the line department individual assigned responsibility for the line department environmental health plan. In this case, the initial development of the plan would be the most time consuming—after the plan is in being, it is expected that this would be a maintenance and coordination effort. Initial development should be expedited by the existing SOPs.

There are three implied characteristics of the above approach which would still be useful, even if the total approach is not implemented. One is that environmental health audits, whether by the FSACs, line department safety committees, or the institutional environmental health organization, make use of structured auditing procedures and sampling techniques. Structuring is provided through the use of prepared procedures or checklists, criteria for judging acceptability, and plans for scheduling and reporting. Such structuring, together with the use of sampling techniques, allows the audit results to be quantified while at the same time using only that number of audits needed to assure compliance at a predetermined confidence level. The sampling techniques used would, of course, be tailored to the specific application. For instance, stratified sampling would probably be used, so that in highly hazardous areas the sample might be 100 per cent, while in less hazardous areas a very small sample might suffice.

The second characteristics of the approach which is generally useful is that the approach utilizes the support of specialists. Human factors and reliability specialists can help in risk analysis, prescription of mitigation procedures, data formatting, more effective use of data, and training, while quality assurance specialists can assist in the development of sampling plans and auditing techniques. All can help in the critical area of design—both of hardware/facilities and operations. As discussed earlier, more formalized reliability and human factors design support could be very beneficial. Such support might consist, for example, of reviewing design requirements from the reliability or human factors viewpoint and of providing reliability predictions, life cycle costs, maintenance data, and human performance/error data. Such support activities are presently accomplished to some degree, on some projects, at Sandia, but more routine and complete use of such support would be extremely beneficial to the environmental health program.

Third, and especially important in the design process and to other specific areas, as discussed in this report, an information system containing basic hazard/risk and compliance data is highly desirable. The system must be capable of keeping up with the many changes and allow management of the basic data from the time they are originally defined in baseline design or start-up until decommissioning, disposal, or termination.

In closing, we would like to reiterate that this study is not intended as a criticism of the existing Sandia Environmental Health Program. The authors feel that a new approach to environmental health has been developed (see Reference 1) in the course of our work which offers considerable potential for more effective environmental health programs without a great deal of additional effort for already good programs. This new approach is based on quality assurance, reliability, and human factors techniques and principles. What we have determined in this study are: (1) those areas of our current environmental health program which could be reoriented to correspond to the requirements of this new approach to environmental health; (2) the specific nature of this correspondence; and (3) an approach for incorporating into our current environmental health programs those desirable aspects of an environmental health assurance program without appreciably disturbing the existing environmental health responsibilities or management structure.

This is only one part of a multifaceted study to determine how quality assurance, reliability, and human factors techniques and principles might be used to benefit environment, safety, and health programs. The approach presented here for incorporating aspects of an assurance program into the Sandia Environmental Health Program is a preliminary proposal and is to be tested in a real-life situation to better understand both feasibility and cost-effectiveness before it is formally recommended for adoption.

REFERENCES

1. C. A. Trauth, Jr.; "Planning for a DOE ES&H Assurance Program." Sandia Laboratories, Albuquerque, NM (to be published).
2. A. C. Ellingson and C. A. Trauth, Jr.; "An Application of Quality Assurance Principles to Major Safety Incidents." Sandia Laboratories, Albuquerque, NM (to be published).
3. Anon.; "Manual for Industrial Safety, Fire Prevention, and Environmental Health." Sandia Laboratories, Albuquerque, NM, SC-M-70-889, January 1971.
4. A. C. Ellingson, C. A. Trauth, Jr., L. M. Jercinovic, and D. E. Farr; "An Approach to Incorporating Proven Quality Assurance, Reliability, and Human Factors Principles in Industrial Safety Programs." Sandia Laboratories, Albuquerque, NM, SAND78-0581, 1978.
5. J. E. Davidson; "Safety Inspection Guide." Sandia Laboratories, Albuquerque, NM, SAND77-0857, June 1977.
6. A. C. Ellingson, et al; "An Approach to Incorporating Proven Quality Assurance, Reliability, and Human Factors Principles in Fire Protection Programs." Sandia Laboratories, Albuquerque, NM, May 1978.

THE STATUS OF DOE IMPLEMENTATION EFFORTS AND SOME THOUGHTS ABOUT BROADER APPLICABILITY

By H. HOLLISTER
Director, Div. of Operational and Environmental Safety,
U.S. Department of Energy, Washington, DC

In attempting to implement a new approach to ES&H management, there are basically three needs. The first of these is to define what must be done and by whom. The second need is for a set of clear guidelines for how those things that must be done might be done. Finally, there is a need for specifying how the needed activities are to be managed within a diverse system.

As described earlier by Dr. Trauth, the fundamental element in the "What needs to be done?" area is a structured ES&H assurance effort at the working level. The technical elements of such a program have been identified, and these constitute a major part of what needs to be done at the working level. As you have heard, one possible approach to actually implementing a program with these elements is being developed and tested. However, many of the details are, as yet, unknown. How, for example, should one scale risk assessment efforts to the needs of his or her specific activities? No really comprehensive scale of methods exists. No decision criteria exist for determining where on such a scale a given activity might lie. What are the risk factors in a given activity, and how might they be determined? Again, only part of this question can be answered at the present time. Thus the guidelines that OES needs to provide on how to perform the tasks recognized as necessary cannot be completely developed currently.

However, OES is attempting to develop methods that may be used by line organizations. To this end, we have a number of contracted activities:

1. The National Bureau of Standards (NBS) is working under DOE contract with OES to develop an ES&H standards information system which, ultimately, should provide a means of readily determining what specific Federal mandatory or voluntary consensus standards are applicable to an activity based on the identification of the hazards associated with that activity. In addition, the NBS has analyzed those steps needed in the feedback cycle if the resultant requirement is a Federal mandatory or voluntary consensus standard.

2. The Systems Safety Development Center of EG&G at Idaho Falls, Idaho, is developing an information system that will handle current OES data requirements in such a way that as these change, the system can be easily modified to accept new types of data. This organization is responsible for the development of MORT. This organization will also participate in our efforts to develop more flexible approaches to risk assessment and means for risk factor identification.

3. The Mitre Corporation is under contract to OES to investigate possible new measures of performance.

4. Through Sandia Laboratories, acknowledged national authorities on risk assessment are addressing the question of how to develop a scale of risk assessment methods and what criteria to use to determine which methods are appropriate to what situations.

The question of "What needs to be done, and who should do it?" at other management levels is also being addressed in conjunction with defining a means of managing the program in the diverse DOE setting. It is apparent that if the objective is to have a structured assurance program at the working level, then line management needs program plans which require and support this concept. In addition, a tiered audit/appraisal program is also required. Some of the specific functions required by OES to support this approach have been identified.

Finally, some initial regulatory steps have been taken to implement this approach within the DOE. A new management directive has been written and approved which requires line organizations to identify those hazards in their operations which are not routinely encountered and accepted by the public (unusual hazards); perform a safety analysis of these hazards (this is a flexible concept, permitting line judgment on the amount of effort that need be expended); provide an independent review of safety analyses; and provide for change control in the system.

Under this directive, OES can perform further independent review functions, as it deems appropriate. To complement these requirements, a new audit/appraisal policy has been proposed. The requirement for specific ES&H plans, their review (for adequacy), and the audit of their use is now provided for unusual hazards. For other hazard classes, there are general program requirements which are holdovers from the past that need revision. In this area, however, there are audit and appraisal requirements that can assure adequacy and use. Thus, considerable progress toward implementing an ES&H Assurance Program has already been made at the management level, and the areas in which further effort is needed have been identified and efforts begun.

General Applicability

It seems to me that we have a good start on developing an approach to ES&H regulation that possesses some very desirable features. It provides a high degree of flexibility at the working level because more general requirements are possible due to the existence of a logically structured approach. The assurance is provided in this structured setting through reviews, audits, and appraisals that address questions of program adequacy and use. This approach, with varying degrees of specificity, is applicable at the Federal level and also to corporate programs. The responsibility for ES&H performance throughout is a line responsibility, with regulatory bodies only responsible for general program requirements and performance-type standards. Because of the flexibility at the project level, there is no stifling of creativity. At the same time, the specification of a structured approach makes general regulation possible without opening up too great a possibility for confusion over details—the objectives of the details are clear—and without losing any ultimate assurance that ES&H matters are properly handled.

Finally, because of the existence of a logical structure, it is possible to use detailed audits (to assure use) only as statistical samples—thus requiring much less detailed auditing while providing any predetermined level of confidence desired that adequate plans are actually used. For the mathematically inclined, the assumption involved here is that all samples (audits) are of the same random variable—and the ES&H controls at a given management level are necessary, along with the structured nature of the program, to insure as far as possible that this assumption is correct.

Under these circumstances, one comes as close as possible to a uniform approach which is tailored to the needs of line organizations, or operating units, at the detail level. By providing uniform line review and appraisal at a high level, say the corporate level, the line organization at each level below that should uniformly have adequate programs which have all the elements required but which may be very different from one another in terms of specific requirements and their placement of emphasis on activities. Because of the management requirements and line audits at this level, knowledge that one subprogram has an adequate ES&H plan and uses it provides confidence or assurance that other subprograms do also.

The philosophy of the assurance approach, then, involves structure to provide uniformity, a means for defining controls, and a rational means of judging adequacy, and reviews and audits

to actually assure adequacy and use. Because of the structure, the need for reviews and audits can be determined statistically and a sampling approach has validity. Furthermore, only general ES&H requirements are needed—to impose the structure and, to the extent permitted by law, to impose only performance standards. Program or project specific requirements are generated at the program or project level and are subject to independent review. Thus, an assurance approach is capable of permitting considerable flexibility, tailoring, and creativity, while in my opinion, providing a higher degree of assurance to top management or Federal agencies that ES&H matters under their jurisdiction are adequately handled. In addition, this approach can, if properly implemented, provide the same type of confidence at the working level without undue economic stress—primarily because the structure is well-defined.

I would like to close, as I opened this session, on a positive note. I believe that the AEC/ERDA has been a leader in the ES&H field—both in terms of performance and in the development of new and timely approaches to ES&H management. This is evident in past work to develop systems safety approaches for nuclear weapons and the sponsorship of the development of MORT techniques for ES&H risk management and, more particularly, accident investigation.

We seem to me to be at an ES&H crossroads, once again, as a nation. We have reached a point where our knowledge of hazards and our concern for them has outstripped our ability to handle them. The result has often been over-regulation or vague, legally vulnerable regulation without an adequately defined structure for its implementation. I would like to believe that OES' current efforts within the DOE, in keeping with our innovative history, may lead to a general, structured approach to ES&H regulation that may solve some of these problems—permitting adequate and rational regulation without undue economic stress. At least let me leave you with the thought that there are those of us in the Federal government who are genuinely concerned over ES&H needs, but who, at the same time would like to achieve such a goal.

MACHINE AND EQUIPMENT SAFEGUARDING TECHNOLOGY

By JOHN PROCTOR
Deputy Dir., Directorate of Safety Standards Programs, Occupational Safety & Health Administration, Washington, DC

I believe that it is most appropriate for the subject of machine and equipment safeguarding technology to be introduced by a representative from OSHA. Experience since 1971 would seem to indicate that much of the credit for surfacing the problems of safeguarding can be traced to either the current OSHA safety standards or, where they are not specifically detailed, then the CSHO's reliance on the general duty clause of the Act or the general performance requirement for machine guarding in 1910.212.

The current revolution to devise new concepts and techniques for safeguarding employees from the many hazards of machines was initiated upon the promulgation of the standards on May 29, 1971. These initial standards represented the state of the art for safeguarding available in existing approved national consensus safety standards and established Federal standards.

OSHA believes that these interim occupational safety standards will protect employees until we have greater knowledge on which to base permanent standards. Our ultimate goal shall be to promulgate safety standards that are essential to the safety of the employee rather than to the present capability of employers, machinery builders, or CSHO. OSHA has the resources to identify hazards through research, detect unsafe conditions by inspection to the standards, require abatement and correction under penalty provisions, assist employers with the SBA loan program, and provide consultation services on request.

If you are like me you have probably stopped reading the Act believing that all its provisions are being implemented and administered by the Occupational Safety and Health Administration. Let me refresh your memory by highlighting some of the Act's major provisions. The Act has established goals and objectives and a program for achieving them. The stated purpose and policy of the Congress provides for the use of its power to regulate commerce to be directed to assuring as far as possible safe and healthful working conditions for every working man and woman. The Act authorizes the secretary of labor to promulgate occupational safety and health standards, conduct research, develop innovative methods, techniques, and approaches for dealing with safety and health problems, creates a commission to carry out adjudicatory functions, provides for the development of occupational safety and health standards, and allows for appropriate reporting procedures to help achieve the objectives of the Act and to accurately describe the nature of occupational safety and health problems.

The Act further establishes duties for each employer and employee. Section 5 states, "(a) Each employer—(1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees; (2) shall comply with occupational safety and health standards promulgated under this Act. (b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct."

Section 3 states: the term "occupational safety and health standard" means a standard which requires conditions, or the adoption or use of one

or more practices, means, methods, operations, or processes, reasonably necessary or appropriate to provide safe or healthful employment and places of employment.

In Section 6(b)(8) the secretary is obliged to state his reasons for promulgating rules which differ substantially from an existing national consensus standard. The statement of reasons must explain why the rule will better effectuate the purposes of the Act than the existing national consensus standard. In Section 6(g) the secretary in determining priority for establishing standards shall give due regard to the urgency of the need for particular industries, trades, crafts, occupations, businesses, workplaces or work environments. He shall also consider recommendations for priorities by the Secretary of HEW.

In Section 9, Citations, the secretary is authorized to provide procedures for the issuance of a notice in lieu of a citation with respect to de minimis violations which have no direct or immediate relationship to safety or health. Section 17 provides penalties for serious violations and for the determination that violations are not of a serious nature.

In Section 21 provisions are made for informational programs on the importance of and proper use of adequate safety and health equipment. It further orders the establishment and supervision of programs for the education and training of employers and employees in the recognition, avoidance, and prevention of unsafe or unhealthful working conditions. The secretary shall consult with and advise employers and employees and their organizations as to effective means of preventing occupational injuries and illnesses.

And last but not least, in Section 24 the secretary shall develop and maintain an effective program of collection, compilation, and analysis of occupational safety and health statistics. He shall compile accurate statistics on work injuries, including all disabling, serious, or significant work injuries.

There is the Act to follow to solve the problems of machine and equipment safeguarding technology. Read the Act!

A joint venture has been launched enlisting OSHA, NIOSH, BLS, OSAHRC, machine builders, safeguard equipment manufacturers, employers, employees and their organizations, and federal and state agencies in the war against occupational injuries. With so many allies how can the employees lose?

The present general industry standards for machine safeguarding technology appear mainly in Part 1910, Subparts P — Powered Platforms, Manlifts, and Vehicle-Mounted Work Platforms; M—Compressed Gas and Compressed Air Equipment; N—Materials Handling and Storage; O—Machinery and Machine Guarding; P—Hand and Portable Powered Tools and Other Hand-Held Equipment; Q—Welding, Cutting, and Brazing; R—Special Industries; and S—Electrical.

The most specific rules in the general industry standards which are cited and contested quite often are: 1910.212, 1910.219, and 1910.308.

The general duty clause is also cited and contested frequently when used to require abatement of a hazard associated with machines.

What is the state of the OSHA revolution to provide the needed machine and equipment technology? Time will only permit a brief explanation of our present programs. First, the Directorate of Safety Standards Programs is scrubbing provisions of the machinery regulations which have no direct or immediate relationship to safety. Information-gathering meetings held in 1976 and 1977 have produced supporting evidence for the amending of the safety standards. A White House Task Force report has furnished OSHA with a "new approach" to safety standards. Another White House Task Force is working on incentives to complement safety standards. The OSHA manual on machine safeguarding technology is being revised.

NIOSH has furnished OSHA with several reports to help us set priorities for research and standards development, such as "The Assessment of Need for Machine Guarding" and the recommended standard for mechanical power presses. The Office of Mechanical Engineering Safety Standards continues to receive and analyze reports of injuries to operators of mechanical power presses. Field staff investigate many of these injury reports.

The statistical branches of OSHA and BLS are experimenting with programs to develop causal factor data on machine-related injuries and fatalities. Safety standards staff partieipate on voluntary standards committees working on machine and equipment safeguarding.

Training and education efforts are increasing to provide for publications to complement both new and older safety standards. OSAHRC and court decisions are reviewed for guidance in future amendments. CSHO violation statistics are evaluated to assist in planning for future change as well as set priorities for additional rules. Research proposals may be forthcoming from OSHA as well as the newest NIOSH contracts. Petitions for more new standards as well as variance applications are used to set priorities for standards. One demonstration variance is in force for machine safeguarding of mechanical power presses.

Interpretations of standards and program directives continue to aid persons affected by the standards.

The new national office, Directorate of Technical Support, is being staffed with engineers of all types to provide information on engineering control solutions to the many problems faced by employers and others seeking to protect employees from hazards of the workplace.

SAFEGUARDING OF MACHINES AND EQUIPMENT

By W. ATKINSON
Safety Dir., National Machine Tool Builder's Assn., McLean, VA

What's new in safeguarding of machines and equipment? The answer is, "Nothing." Most safeguarding techniques known today have been around for many years; however, progress has been made in improving the sophistication and reliability of some safeguarding methods.

In this presentation I will try to relate some of the improvements, or at least put forth what I believe to be the current state of the art, in safeguarding of machines and equipment. First, I would like to review some important definitions. You may not agree with all of these definitions as stated, but they are the basis for my later comments.

1. Point of operation refers to that area of a machine where work is actually performed upon the material being processed.

2. Point of hazard includes the hazard at the point of operation and other sources of hazardous actions or motions which may occur on machines or equipment.

3. Four groups of mechanical actions and/or motions are punching, shearing, bending, or drawing; revolving, reciprocating, oscillating, and transverse mechanisms; cutting actions; and in-running nips. (These may be point of operation or other than point of operation hazards).

4. Four basic types of safeguards are: Guards, Devices, Distance, and Location. (Safeguards should provide protection to workers from a point of hazard).

Guards (high injury risks) are barriers that prevent access to hazardous actions or motions of machines or equipment by preventing workers from reaching through, over, or around.

Devices (intermediate risk) are designed to counteract the unsafe action or position of a worker's body in relation to machines and equipment by one or more of the following methods: restraining, pulling back, occupying hands, preventing or stopping motion, and blocking entry.

Distance (lesser risk) is the measurable reference to the position of parts of a worker's body to a point of hazard on machines or equipment.

Location (operator action) refers to the position of a worker which provides protection from a point of hazard.

Now that I have listed the four basic types of safeguards (and attempted to define each), I would like to discuss some reasons why many people have difficulty in selecting effective safeguarding means for machines and equipment.

1. They try to safeguard the machine itself without first studying the process or application for which the machine is being used.

2. They fail to determine the method of feeding material into the machine, such as manual, semi-automatic, and automatic (continuous).

Unless consideration is given to these important ingredients when evaluating the type of safeguards to use on machines and equipment, you will often select safeguarding means that will be bypassed or removed by workers or vetoed by line supervision and, in some instances, do more to cause worker injury than prevent worker injury.

To my knowledge, no single safeguarding means will solve all of your problems; often it takes a combination of safeguarding means to provide effective and realistic protection for workers. (There followed a presentation of slides depicting some of the safeguarding means previously listed and at the same time providing insight into the magnitude of the problems of determining effective safeguarding of machines and equipment for all processes or applications.—Ed.)

THE HUMAN ELEMENT IN SAFETY MAN-MACHINE SYSTEMS

By JULIEN M. CHRISTENSEN, Ph.D.
Prof., Dept. of Industrial Engineering & Operations Research,
Wayne State University, Detroit, MI

In a modern technological society, all systems, whether they deal with services such as communication, health and transportation, with the production of goods, are man-machine systems. Each system represents the integration of sub-systems composed of humans and hardware interacting with environmental features.

The development and operation of systems in a safe, effective manner requires careful attention on the part of management, personnel specialists, design engineers, safety specialists, and, last but far from least, the workers themselves. Sixteen considerations of importance in the development and operation of safe, effective, systems are: management considerations—commitment to safety, open communications, stable workforce, good housekeeping, motivation; personnel considerations—careful, unbiased selection and placement, training and maintenance of proficiency, opportunities for self-improvement, opportunities for advancement; hardware considerations—design for human use, removal from hazardous environments, guards, warnings, maintenance; environmental considerations—physical stressors and their alleviation, psychological stressors and their alleviation.

The design of a particular workplace is determined not only by the characteristics of the individual human and hardware components but also by the nature of their interactions with each other and with the environment in which these components operate. These interactions are determined to no small extent by the design of the interfaces, or "points of contact," among workers, equipment, and the environment. The proper design of these interfaces is central to effective human factors engineering, or ergonomics.

Other equally important determinants of effectiveness are training and motivation. Careful consideration of these three factors; viz., human factors engineering (including biomechanics), training, and motivation in the design and support of workplaces will do much to assure safe subsystems which contribute positively to the effectiveness of production systems.

Before proceeding to design features, let us consider some of the performance characteristics of the worker who will interact with the hardware elements of the workplace. This brief treatment of some characteristics of humans as sub-system elements will be followed by consideration of the design of the interfaces that facilitate the interactions between workers and their workplaces.

After a brief treatment of reliability and maintainability, consideration will be given to the general effects of environmental stresses.

Some Characteristics of People

The human can be considered as a component of the workplace sub-system. He receives inputs in the form of physical energy through his senses (vision, hearing, etc.) which are processed by his nervous system. If the input has, or can be made to have, meaning to him, we say that he has received information. He may use the information directly, he may store it for a short time (such as a telephone number that he expects to use only once), he may store it for an indefinite period (such as his home address), or he may combine it with previously stored information immediately or later to generate new information.

The results of this processing usually lead to a decision by the human. If the decision requires some action, he then interacts with the environment through his "effectors"—his voice, his hands, etc. A model that can be used to describe this process is the "input—processing—output" model. As mentioned previously, the proper design of the interfaces, or points of contact, between man and his environment on both the input and output sides is extremely important because it directly affects reliability. This facet of the design engineer's responsibility has been termed "human factors engineering."

Input: The sensory sub-system. Before examining the nature of these interfaces, let us briefly examine some general characteristics of man as a sensing-processing-effecting component. Each of man's senses is sensitive to a limited range of a particular type of energy. For example, in the electromagnetic spectrum, man's eyes can sense directly only the range from approximately 400 to 700 millimicrons. He cannot, for example, directly detect energies in the radar range. The ears of a normal young adult can sense physical energies between approximately 20 and 20,000 Hertz. He cannot directly sense radio waves. (It is interesting to consider that what most people consider "reality" is based on an interpretation of the energies to which their senses can respond; yet these energies represent only a small fraction of the total surrounding us.)

Even appropriate energies must be present in certain amounts or people cannot detect them. These minima for the various senses are termed *absolute thresholds* and demonstrate the exquisite sensitivity of the senses. For example, the dark-adapted eye can detect .000001 millilamberts of brightness (absolute threshold) after 10 to 12 hours in the dark. At the upper limit it can accept as much as 16000 millilamberts, if light-adapted. This is a ratio of approximately 1 to 10 billion!

Energies that are qualitatively similar must differ by a certain amount in order to be distinguished. These amounts are termed *differential thresholds.* These differences are fairly constant over a rather wide middle range; however, the constancy breaks down at the extremes. The safety engineer and the design engineer should acquaint themselves with absolute and differential thresholds because signal detection and differentiation depends directly on them. Chapter 2 of the HEGED (Human Engineering Guide to Equipment Design) presents additional information on this important topic.

Processing: The Central Decision-Making Sub-System. What is generally termed a person's judgment is based to a considerable extent on these thresholds. The number of *absolute* judgments a person can make (i.e., make without reference to any physical comparative standard) is rather limited. Chapter 2 of HEGED also contains such data. A rule of thumb termed Miller's "Magic Number 7 + 2" provides a convenient way to remember *approximately* how many absolute judgments can be made along any single dimension such as brightness, weight, etc.

While limited on an absolute basis, people are fantastic comparators. The number of differences that can be detected if the observer can compare the stimulus directly with another of similar quality can run into the tens or hundreds of thousands. This is a very important principle to remember in the design of an inspection station, for example. The human can detect very minute differences if he has a standard present with which he can directly compare the item in question and does not have to compare it with material in his memory bank.

The amount of information that a person can process depends upon many variables—experience, memory, time available, learning ability, motivation, and so on. Not the least of these is the way that the information is presented to the person—again, human factors engineering.

Current information, properly integrated with information stored in memory ("experiences"), enable people to make decisions. While far from being completely understood, much is known about this complex process that makes people such desirable components in systems. They are preeminent in this area. (See Chapter 2 of HEGED for additional information).

Output: The Motor Sub-system. Man's motor (muscle) sub-system performs the important functions of stabilization, rotation of segments around the body joints, and the transmission of energy to objects outside the body. It is this latter function that is of special importance in human factors engineering. The nature of the static and dynamic control systems that are used to effect a person's intentions will be discussed later.

Feedback: (Knowledge of Results). A person needs to know how he is doing to learn effectively; it is also important for continued excellence in performance.

Some Characteristics of Men and Machines

The qualities of people that were discussed in the previous section make them unusually well suited for certain activities. There are other activities that man's inventions (machines) can do better than he.

Some things people do comparatively well are: detect signals in "high noise" fields, recognize objects under widely different conditions, perceive patterns, sensitive to a wide variety of stimuli, long-term memory, handle unexpected or low-probability events, reason inductively, profit from experience, exercise judgment, flexibility and improvision, creativity, select and perform under conditions of overload, adapt to changing environmental conditions, appreciate and create beauty, express emotion, perform fine manipulations, relatively compact, perform when partially impaired, relatively maintenance-free.

Some things machines do comparatively well are: respond quickly to signals, sense energies outside human range, perform precise, routine, repetitive operations, recall and process enormous amounts of data, monitor men or other machines, reason deductively, exert enormous power, relatively uniform performance, rapid transmission of signals, perform several acts simultaneously, expendable, resistance to many environmental stresses.

Obviously these principles are not absolute principles and must be applied with discretion and sound engineering judgment to the solution of any specific workplace design program. You may note that, comparatively, man is predominant in the higher order, or cognitive areas. If properly used in this respect, man the decision-maker can contribute much to the safety and effectiveness of workplaces.

Design of the Man-Machines Interfaces

A General Model. A four-element model has been found useful in the development of safer products and workplaces:

1. Design (design the workplace or product to be as safe as possible).
2. Remove (remove the worker from the points of high risk; e.g., handle materials in a hot cell with remote manipulators).
3. Guard (insofar as possible, provide guards against contact with remaining points of danger).
4. Warnings (if any residual danger exists after application of the above three steps, warn against residual danger).

Displays. While information can be displayed to all the senses, in most workplaces the visual and auditory channels are the two generally called upon to receive most of the information. However, the designer should always be alert to the possibilities of using the other senses (touch, heat, cold, pain, smell, taste, orientation, and movement) as independent or redundant channels. Redundancy is beneficial in many applications; for example, flashing the word "danger" and having it transmitted via the auditory channel is more effective than using either channel exclusively.

Information relating to the design of displays is much too voluminous to be included in this short essay. The reader is urged to refer to Chapters 3 and 4 of the HEGED for excellent treatments of displays for vision, hearing, and some of the other senses. These chapters give design recommendations for displays in terms of conditions of use (viewing distance,

illumination, noise, etc.) and function of the display (systems control, monitoring, etc.). Other important considerations such as integration, the use of symbology, number of users, scaling, etc., are also treated.

After you have made a careful analysis of the type and amount of information required by the worker, you will find these chapters indispensible for the design of the actual physical characteristics of the displays to be used in specific workplaces. Remember that you may seriously degrade the worker's reliability if you give him too much information or information that he cannot conveniently, easily, and accurately use—the information has become noise. Here we are talking not about redundancy (the injection of essentially the same information through two or more separate channels) but, rather, about resisting the temptation to include certain items just because it is convenient to do so or because there is a remote chance that the worker sometime may find use for it.

Controls. Controls are the means by which a worker carries out his intentions. It is convenient to classify controls according to their function, e.g., activation (on-off) (power switch for grinder); discrete position selector lever for automatic transmission; data entry (telephone dial or pushbutton); quantitative (rheostat); and continuous (steering wheel).

As with displays, the designer should make a careful analysis of the control requirements for a particular workplace as a basis for his selection of the most appropriate control(s) and their specific design characteristics. The analyst should consider such factors as function (what is to be controlled), importance (a prime determinant of control location), precision, speed of response, force, relation to other controls in the same workplace, sequence of use, frequency of use, and consequences of inadvertent or erroneous operation.

Chapters 6 and 8 of HEGED contain considerable information on the details of design for individual controls and for the optimal use of the worker or operator in continuous control tasks employing feedback (e.g., steering of vehicles, operation of lathes, etc.). The referenced chapters provide information regarding criteria for selection of controls, coding of controls, optimum control-display ratios (i.e., sensitivity) and type of control (switch, knob, etc.).

A special, intriguing control problem arises when one is using remote manipulators as, for example, in the operation of a hot cell. Here one quickly gains respect for the magnificence of the design the human hand. The designer usually will find it profitable to redesign the objects to be manipulated so that they can be handled efficiently by the relatively crude "hand" of the manipulator.

Decision-Making. If the informational requirements for a specific workplace sub-system have been carefully determined, if displays have been designed so as to allow the operator to obtain that information quickly and with minimum chance of error, if controls have been designed so as to allow the operator to carry out his intentions quickly and accurately, and if the displays and controls are properly placed in the workplace, errors that might lead to accidents will be reduced and reliability will be increased. Reliability will be further enchanced by appropriate training and motivation.

In addition, however, knowledge of how the operator makes decisions is helpful. Decisions are made under conditions of certainty, under conditions of risk, and under conditions of uncertainty. A decision to perform an act that is certain to lead to an accident suggests a psychopathological condition; there is very little that the designer can do about such accidents.

Decisions under conditions of risk imply that the operator knows the probability of an accident associated with each of several alternatives. He may then decide that to save time or effort he is willing to take some action (e.g., remove a guard that impedes his actions) that he knows carries with it some probability of an accident—he is willing to "take a chance." Certainly, management has a responsibility to inform their workers of all risks and to set up conditions of work and reimbursement that carry with them no reward for taking unnecessary risks.

Decisions under conditions of uncertainty imply that the operator knows neither the nature nor number of alternatives that might lead to an accident. (And, presumably, neither does management, for if they do, they have an obligation to convey such information to the operator.) Under such conditions, the operator is quite apt to set up a hypothesis regarding the possible occurrence of an accident should he take a certain action. If he is injured the first time, he generally will not repeat that action. If he is not injured the first time, he may be tempted to increase the risk on future trials, especially if he derives any benefit from such increase. If reward increases with each increase in risk, an accident lies somewhere in the future. The writer once knew an individual who in driving home from work, increased his speed around a certain corner one mile per hour each evening! When he got to 54 miles per hour the car slid into the ditch. Fortunately, the major damage was to his billfold. The driver wisely decided to terminate his hypothesis testing at that point.

If there are attractive alternatives in the performance of a job and if the probabilities of an accident associated with these alternatives are unknown, management should conduct tests to establish them. Such information is helpful also in the calculation of the reliability of the workplace.

Guards. If complete safety cannot be built into equipment, or if the operator cannot be physically removed from potentially dangerous points of contact, the designer then has responsibility to design appropriate guards for the equipment. Since operators have shown remarkable ingenuity in defeating guards, considerable skill on the part of the designer is required to assure that they fulfill their purpose and cannot be defeated. Guards should be permanent and non-removable if at all possible. The operator should be able to use the equipment as easily and effectively with the guards in place as without them. Training programs should emphasize the importance of guards and how effectively they reduce hazards.

Warnings. If a particular hazard cannot be designed out of a piece of equipment, if the operator cannot be removed physically from the potentially dangerous point of contact, and if effective guards cannot be installed, then warnings are necessary to help counteract any residual hazard. Guidelines for the design of warning labels, which the writer derived from a number of sources, are:

1. Conspicuous; attention-getting; urgent; emphatic!
2. Clear (comprehensible) and complete for all potential users, regardless of degree of literacy or native language.
3. Tell what to expect, why it is a hazard, and what to do if injured.
4. Include hazards of use and foreseeable misuse.
5. Durable and legible; affixed to product as well as to case or container.
6. Pictures, symbols, and diagrams OK if universally understood and adequate.
7. Conform to standards, but consider them as minimum requirements.
8. Test effectiveness, using representative sample of potential users.
9. Keep warnings current—reflect design changes and user experience.
10. Use redundancy.

Warnings are of two types: dynamic, and static. Dynamic warnings consist of such things as warning lights, audible sounds, etc. A summary of design recommendations for auditory alarms and warning devices can be found on page 126 of HEGED, while design recommendations regarding visual warning devices can be found on pages 77 and 300-302 of HEGED.

Human Reliability

The reliability of a specific workplace depends on the 16 considerations listed at the beginning of this presentation. If all of the points are given adequate attention, reliability will be high. Designers have been somewhat slow to recognize the contribution of the operator to the overall reliability of a system or sub-system—perhaps because of the difficulty in dealing with the subject. Authors of most books on

systems reliability make little or no reference to the contributions of human operators and maintenance men to systems reliability. Operations research models that adequately treat the reliability of interacting human and hardware components await development.

Thanks to the efforts of groups such as Swain and his colleagues at Sandia, significant progress has been made in the calculation and measurement of human reliability. Once job tasks have been defined, various techniques can be applied in computing human reliability. (Procedures for performing task analysis can be found in Chapter 1 of HEGED). These techniques include the employment of data from task banks and on-the-job measurements. Practical, useful data can be obtained by resort to expert opinion if on-the-job measures cannot be made. The reader interested in techniques for computing human reliabilities is referred to Swain.

As mentioned previously, the human has many characteristics which, if properly integrated into the design of a workplace, can do much to enhance overall reliability. Among others, the human is an excellent back-up component and an effective source of redundancy. If properly trained and if experienced, he is incomparable in handling emergencies and unforeseen events.

Human Factors in Maintenance

Workplace reliability is a function also of the quality of maintenance performed on the equipment in the workplace. Crawford and Altman treat this topic in HEGED (Chapter 12).

Studies have shown that diagnosis of the cause(s) of malfunctions absorbs the majority of the time of the maintenance man—up to 70 per cent, with the remaining 30 per cent spent almost equally between correction and verification (verification of the corrective action was effective).

There are several reasons for what seems to be the inordinate amount of time spent in diagnosis. One is accessibility. Designers of workplaces generally give first priority to the performance requirement of the operator, almost entirely neglecting those of the maintenance personnel. This may not always be the most cost-effective solution. One large company had its machine and shop tools designed with the "plumbing" on the outside instead of hidden inside. Managers reported an immediate improvement in the quality of maintenance and a significant reduction in cost.

One manufacturer of commercial airliners found that approximately 50 per cent of the components diagnosed as faulty had nothing wrong with them. This can be a serious matter, since removal and replacement of non-faulty components will, in themselves, tend to induce failures, particularly since the careful handling of delicate equipment does not seem to be a universal trait among maintenance men.

Unnecessary removal due to faulty diagnosis can frequently be traced to poor preparation of maintenance manuals. One study showed the comprehension level required to understand materials in U.S. Army maintenance manuals to be that of college sophomores, whereas the maintenance men actually read at the level of ninth or tenth graders. In other words, the material was written at a level of difficulty four to five years beyond the reading ability of the user. Studies have shown that a simpler text, supported by clear, well-labeled diagrams and pictures, is of significant benefit to maintenance men. This is an easy, relatively inexpensive way to increase workplace reliability.

For very complex equipment, studies have shown that simulators are often an aid to diagnosis. The maintenance man enters the symptoms into the simulator and uses that for his diagnostic analysis. This saves not only time but also wear and tear on the actual equipment.

Since several industries are finding that maintenance costs constitute on the order of 30 per cent of their operating budget, this is an area that is ripe for consideration. Results directly impact reliability and profit.

Effects of Environmental Factors on Performance

A stress (or stressor) is some physical or psychological feature of the environment that requires the operator unduly to exert himself to continue performing. Such exertion is termed *strain*—"stress and strain." Common physical stressors in industrial workplaces are poor illumination, excessive noise, vibration, heat, and the presence of excessive, harmful atmospheric contaminants. A considerable amount is known about the effect of individual stressors. Unfortunately, much less is known about their effects when they occur simultaneously, in rapid sequence, or over extended periods of time. Available studies suggest, however, that such effects often are not simply additive but are synergistic, thus compounding their detrimental effects. And, unfortunately, when physical environments are unfavorable, generally two or more stressors are present—hot *and* noisy, for example. The solution is easy to specify but costly to implement: design the physical environment so that all physical characteristics are within an acceptable range. However, as implied above, this can be costly. It has been estimated, for example, that a reduction in allowable noise levels in industry from 85 to 80 decibels will cost industry two to three billion dollars.

Alternatives to redesign of the ambient environment include providing individual protection (e.g., ear defenders), removal from the offending environment, and schedules that require workers to remain in the offending environment for shorter periods. The human body has remarkable recuperative powers, at least with respect to some stressors, if exposures are not allowed to continue until serious fatigue and/or physiological damage have occurred.

Psychological stressors can be every bit as debilitating as physical stressors. These are complicated by the fact that they frequently are as much a product of the non-working environment as of the working environment and, while they undoubtedly do affect productivity and safety, managers must be very cautious about interfering in any way with a worker's private life. Good training and motivational programs will do much, however, to relieve psychological stress on the job. The reader is referred to the HEGED for additional information regarding some of the more common physical stressors encountered in industrial environments (noise and illumination, for example). McCormick is also a source of additional information.

Summary

Safety, reliability, effectiveness—these characteristics are determined, often indirectly, by attention to the details of workplace systems design. This paper has treated a topic, human factors engineering, that is concerned with design for human use. Proper attention to human factors considerations, including biomechanics, and to training and motivation will do much to improve workplace reliability and thus the safety and effectiveness of the residents of those workplaces.

THE "STATISTICS" OF SAFEGUARDING SYSTEM RELIABILITY EVALUATION

By JAMES H. CAPPS
Corporate Consultant—Safety, General Electric Co., Fairfield, CT

Statistics is defined as "a branch of mathematics dealing with the collection, analysis, interpretation, and presentation of masses of numerical data." That reasonably well covers my presentation. We do have to collect masses of data and analyze and interpret it.

The interpretation problem arises because of the diversity of American industry and because we cannot measure injury risk directly. In other words, we have no meter which quantifies the hazard or exposure, nor can we measure with a meter the effectiveness of the counter-measure—that is, the hazard control. For reference, this is different than in occupational health assurance because health risks are stated in terms of exposure measurements which are also used to evaluate the effectiveness of the hazard control.

This is not to say that we are without capability for evaluating safety hazards or hazard controls. Bill Atkinson, in his discussion of the state-of-the-art of machine and equipment safeguarding systems, makes the point that there is a great deal of technology which has been developed. Chris Christensen has pointed the way to the future—that there is a system reliability technology developed by the aerospace industry which can be applied to factory work situations and which can be the basis for improving safeguarding systems.

My purpose here is to discuss the "statistics" needed to adapt system reliability technology to our use in designing and evaluating safeguarding systems. I want to identify that the state-of-the-art of this part of reliability technology has been well-enough developed and show that we can readily adapt it to greater use in our day-to-day practice of safety, particularly in manufacturing industry.

My presentation will be in three parts. The first part will discuss how we can adapt reliability mathematics concepts to our use to provide a framework for development. The second part will discuss collection of data. The third part of the discussion will center on the conclusions which can be drawn if safeguarding systems are viewed as a less than perfectly reliable man/machine system. This viewpoint is offered as the best alternative to the recognizably unrealistic seeking of safeguarding which "eliminates the hazard."

Conceptual Model (Physical Picture)

To introduce the "statistics" concepts, a manually-operated bench-mounted drill will be used as an example. The operation involves the drilling of several holes in a plastic switch component. The component is located in the drill fixture for the actual drilling operation, with the "get" and the "place" from and into the bins which are conveniently located. After the part is placed in the fixture, the operator moves the drill head down by use of the operating arm with the right hand while locating the fixture with the left. After the last hole is drilled, the arm is released, and the drill chuck retracts behind the shield.

With reference to Bill Atkinson's presentation on safeguarding systems, you will recognize that the point of operation safeguarding is provided by distance, because the basic safeguarding is the distance from the end of the drill bit to the edge of the fixture, with the operator holding the fixture at the edge. As Bill pointed out, the maintenance of the distance during the downward motion of the drill relies upon the operator, and thus this is a system of safeguarding which has a machine and a human element. Let me note, in passing, the plastic shield over the drill bit in the rest position to guard against hair entanglement.

The machine element of the safeguarding system has three main aspects which control its effectiveness or, in our terms, its reliability. The first is the physical equipment design, with the major concern being the suitability of the equipment for the whole range of products to be processed. The next is the physical equipment reliability. This relates to the unexpected failure which might cause a point-of-operation injury even though the drill has been reasonably maintained. Maintenance, of course, is the third cause of lack of reliability.

Similarly, the human element of the safeguarding system can be segregated into three parts much like the machine element just described. Here again, the first to be considered is the workstation design. As an example, the part-holding fixture may be less than adequate for some fraction of the product to be processed.

The next aspect is similar to that discussed for the machine element and arises because no humans are perfect. The operator reliability is controlled by the design, the layout of the workstation, the illumination, length of the drill's operating arm, and so forth, and through development of good habit patterns of motion, which requires training and awareness of the hazard. More specifically, while training is required to maintain optimum control of motion, it does not eliminate the possibility of error, and thus the reliability can never be 100 percent.

Maintenance also figures heavily in the human element because human error rate is significantly influenced by maintainable items such as capability—in this case, highly developed motion-habit patterns.

The two main elements of safeguarding system reliability can be reasonably assumed to depreciate with the passage of time. This means that, with its passage, an injury-producing accident becomes increasingly probable. This probability is limited as the result of preventive maintenance programs or by action triggered by cost or quality problems.

I should also reiterate the point that the initial safeguarding system reliability is not perfect. This is because perfection does not exist, and if it did exist we would not know it because there are no measurements available as indicators. This means, then, that there is always a finite chance of an injury-producing accident.

Conceptual Model (Reliability Concepts)

System reliability can be expressed mathematically. The three mechanical aspects and the three human aspects which we discussed can be combined into a single equation. The techniques are described, for example, in B. L. Amstadter's book entitled *Reliability Mathematics*, published by McGraw-Hill.

The generic statement of the reliability of the safeguarding system is $R = R_o e^{-\lambda t}$. You will recall that an exponential term such as this one, $e^{-\lambda t}$, equals 1.000 at $t = 0$, and therefore, the initial reliability is R_o, that which is limited by both the design of the machine and the human part of the system. The Greek letter, lambda, is the failure rate. As time progresses, the product is an increasingly smaller number—a reduced reliability.

The other side of the reliability coin is the chance of failure. If we express reliability in terms of 1.000 being perfect, the difference between this and the actual reliability is the chance, expressed in decimals, of a failure. The mathematical expression is $Q = 1 - R_o e^{-\lambda t}$. The symbol Q is used to denote the chance of failure. Again, lambda is the failure rate. We should be reminded that chance of failure relates to safeguarding system failure which, in our case, means an injury-producing accident.

Before leaving the formula, we can make a major simplification by recognizing that chances of failure are invariably small numbers. Because of this, the exponential term can be replaced by the exponent. The formula becomes $Q = Q_o + \lambda t$. This simplification will be used for the rest of this presentation.

Conceptual Model (Risk Quantification Concept)

We need to introduce one other con-

cept at this time, which quantifies risk. Risk, it seems logical to assume, has two elements: the significance or seriousness of the injury which we would expect from the hazard, and the repetitiveness with which the exposure to the hazard occurs. Remember again that I am presenting concepts and not specifics.

As an analogy to that used by aerospace people, who quantify reliability in terms of mean days between failures, we can quantify a hazard in terms of mean days between the injury it would produce. For example, I suspect that all of us have exposure to paper cuts at our offices. These probably occur once a week for the exposure, the kind of paper we use, and the care we take. We can say that the number of mean days between paper cuts is five. The "5" quantifies a hazard of paper cuts as limited by the safeguarding in place. We accept this risk; thus, a paper cut is an injury which we would accept if it repetitively occurred every five days.

We then can imagine the next more serious injury and, I am sure, can agree on an acceptable mean-days-between-occurrences for that class of injuries, and so forth, until the ultimate is reached—a fatal injury. And while each of us instinctively objects to the idea that fatal injuries are acceptable, practicality dictates that this number does exist. This enables us to define a finite scaling of acceptable mean days between injury occurrences as a system design goal.

Now, that scale relates to seriousness of injury and the days between them. What if the exposure occurs several times in a day or, as in the case of the drill being discussed, hundreds of times, or, as in the case of the point-of-operation of a power press, thousands of times? The exposure obviously increases the risk and therefore is a factor to be multiplied by the mean-days-between-injuries to provide a measure of the basic risk which must be reduced by the safeguarding system to an allowable level.

Here's how the risk numbers work out for the bench-drill example I have been using. Let's assume a puncture wound which has an allowable mean-days-between-injuries of 250 work days and an exposure rate of 100 parts per hour over a seven-hour day. This gives us a basic risk of 250 x 100 x 7, or 175,000. We should note that a basic risk is one which occurs when there is no safeguarding whatsoever. Few, if any, basic risks exist in our plants because some sort of safeguarding invariably exists.

It is the basic risk that the safeguarding system is required to reduce to an allowable value at the time established as the allowable mean days between injuries. Residual risk is determined by multiplying the basic risk value by the chance of failure at any time.

The design value for the residual risk at the allowable mean days between injuries for any safeguarding system should be 1.0, although values ranging from 0.5 to 5.0 would be acceptable. The physical significance of the 1.0 value is that, after a passage of time equal to the acceptable mean days between injuries, risk due to the chance of failure of the safeguarding system remains acceptable, even though there was no maintenance performed on the safeguarding system which would have reduced it.

Conceptual Model (Summary)

Following are the formulas with representative values established by making some reasonable assumptions.

Example Calculations

$$\text{Residual Risk} = \text{Basic Risk} \times \text{Chance of Safeguard Failure}$$
$$= (\text{Hazard} \times \text{Exposure})\,(Q_o + \lambda t)$$

Where:

Hazard = 250 (Acceptable Mean Days for Puncture Wound)

Exposure = 100 Operations/Hour, 7 Hours/Day

Q_o = Initial Failure Probability —Assumed to be 1% of λt @ t = 250 Days

λ = Failure Rate (to be determined)

Substituting:

$$\text{Residual Risk} = (250 \times 100 \times 7)\,(0.01 \times \lambda \times 250 + \lambda t)$$

To evaluate λ, adopt strategy that residual risk = 1.0 at acceptable mean days for the injury (250).

$$\text{Residual Risk} = (250 \times 100 \times 7)\,(0.01 \times \lambda \times 250 + \lambda \times 250) = 1$$

$\lambda = 2.26 \times 10^{-8}$ Failure Rate Per Operation

Substituting:

$$\text{Residual Risk} = 0.004\,(2.5 + t)$$ Risk Per Operation Weighted by Type of Injury

*Calculated Values**

Time (days)	Residual Risk	Chance of Injury (per Operation)**	Chance of Injury (per Day)**	Accumulated Chance of Injury
0	.01	$.06 \times 10^{-6}$	$.4 \times 10^{-4}$	0
125	.50	3×10^{-6}	20×10^{-4}	.1
250	1.00	6×10^{-6}	40×10^{-4}	.51
375	1.50	8.5×10^{-6}	60×10^{-4}	1.12
500	2.00	11.5×10^{-6}	80×10^{-4}	2.00

*Assuming no maintenance of safeguarding system
**Chance of injury is equal to chance of safeguarding system failure.

From the formulas and the calculated values shown, I would like to call your attention to several calculated values. First, the residual risk value at $t = 0$, that is, the initial risk, is 0.01. On the 250th day, when the residual risk is 1.0, there are six chances in a million of safeguard failure (per exposure) or four chances in a thousand of an injury on that day. The accumulated chance of safeguard failure at this time is 0.51, which appears to quite high, but remember that 175,000 exposures have also occurred by this time.

These values define one of the problems with which we in safety have to contend. The chance of injury on any one day is so low that it is difficult to maintain recognition that there are "hazards out there" but that over a period of time, accident-producing injuries are inevitable. Thus, we can deduce that our job is to limit the rate of injuries to something acceptable.

Now, let's lean back for a moment and reflect on the ground we have covered so far. First, we defined a bench-drill workstation as an example and pointed out that its point-of-operation guarding was a human/machine system; that each part—that is, the human and the machine element of the system—had reliability depending upon design suitability, inherent reliability, and on maintenance. It was noted that neither the human or the machine element of the safeguarding system were perfect and that both parts of the system deteriorated with the passage of time.

From this, we introduced the mathematical expression of reliability, which is an exponential function, decreasing with time from an initial value of less than perfection. The difference between the actual value of reliability at any point in time and perfection is denoted as the chance of failure Q. Because chance of failure, alone, will not adequately describe the risk to an employee resulting from the failure of a safeguarding system, the concept of quantified hazard and exposure was presented, with their product quantifying the basic risk—that is, the risk without any safeguarding whatsoever.

The actual, or residual, risk is that to which the employee is exposed as the result of less than perfect safeguard reliability. An allowable risk results from a safeguard whose failure rate limits the injury time interval to that which has been established as being allowable. In other words, the length of time is the allowable mean days between injuries. For the example bench drill, on the 250th day, which is the allowable mean days between injuries for the puncture wound used as an example, the risk is 1.0. On that day the chance of an injury is quite low, 4 in 1000.

Conceptual Model (Multiple Hazards)

Before we begin a discussion of the recognizably complicated problem of determining the data, let us broaden our view to include the other hazards which coexist at a workstation. The acceptability of risk at a workstation is determined by the total risk to which the operator is subjected.

As I mentioned earlier when discussing the bench drill, another hazard at the workstation is the possibility of entanglement of clothing or hair in the drill bit. You will recall that a plastic shield had been placed to enclose the drill bit when in the rest position. While this safeguarding of this particular hazard is more machine oriented than the point-of-operation safeguarding, I am sure we recognize that

it has both a machine and a human element. We can go through the same analysis as suggested before and derive another equation for the residual risk for the hazard of hair entanglement.

This residual risk and that of the point-of-operation are simply added together, because it can be assumed there is no interaction between the two hazards or the safeguarding techniques. Other hazards can be added on if their effects and safeguarding systems are independent, which is the usual case.

Conceptual Model (Apportioning Residual Risks)

As noted above, the objective is balanced residual risks with total limited to an allowable value. The techniques defined to this point provide a way of quantifying the basic risk and for quantifying chance of failure of the safeguard system. Their product is the residual risk. Values of 1.0 are chosen to indicate an acceptable residual risk for the conceptual models used.

Since most workstations have a number of hazards, each, when properly safeguarded, will have an acceptable residual risk. The total risk, when summed, may be quite large, exceeding the value of 5.0 which was discussed above as being a limit. This means that the total risk at the workstation is too large and, therefore, safeguarding of some of the hazards would need improvement to keep the total to an acceptable value.

Taking another bit of guidance from the reliability concepts developed for the aerospace industry, any one of several strategies can be used for allocating the residual risks. For example, if there are two or three highly significant hazards at a workstation, the sum of the residual risks of these hazards can be limited to 2.0, with another 1.0 of residual risk allocated to the minor hazards.

Neglecting the minor hazards is not recommended as a strategy because, across a complete plant, the total risk due to a minor hazard may be large enough that attention is demanded. A typical example is plant-wide use of safety glasses.

Additional discussion of apportionment of residual risks is not warranted at this juncture. It is sufficient to note in summary that techniques are available for use when the need arises.

Again, let us lean back and reflect for a moment on what has been covered. A means of quantifying risk and of expressing the chance of safeguarding system failure has been suggested. The product of these defines the residual risk, the total of which must be limited and reasonably apportioned at a workstation. The remaining issue is development of the data.

Data Development

Development of data which yields the specific constants for the equations discussed above seems rather difficult, but I hasten to add that it does not seem impossible. The task is very similar to that undertaken by most of our product engineers in the last two or three decades. Their approach was exactly that which will be suggested here. First—define a concept which is basically correct in theory. Then use the concept with the best data available but keep working to improve it. This is exactly the approach I used in developing motor design techniques in the General Electric Company in the early 1950's. What was an art based upon engineers' "guestimate" in 1950 became a computerized cut-and-try approach by 1955 and is now completely automated. This development led to improvements in design accuracy which resulted in smaller and/or more efficient motors.

We can do the same thing for safeguarding system design. We do not have an unsurmountable number of variables. We can categorize potential injuries and achieve agreement on the hierarchy of acceptable days between injuries. We can define exposures. We can also categorize the three kinds of safeguarding discussed by Bill Atkinson and make "guesstimates" of their reliability under various operating conditions that we find in our plants. These safeguarding systems will, of course, be applied to each hazard at a workstation. Granted, some effort will be required to organize the information suggested, but when complete, we will have the basis for refinement of the concepts and the collection of more precise data.

Collection of the more precise data probably needs to be a two-phase activity—one which can be characterized as safety research, the other as normal injury-producing accident investigation effort. I will discuss the latter because I believe it will be of more use to you. Safety research will require an effort by some organization like the National Safety Council or NIOSH.

The basic concept for the accident investigation is the focus on the whole system which "delivers" an acceptably safe workplace. The results of the accident investigation could be a change in a safeguarding system, but a prior question, which must be disposed of in every case, relates to use of the safeguarding system in place, the design of which may very well have been the result of the exercise of considerable judgment.

Following are the questions which I feel should be asked during each accident investigation: What happened? What was supposed to prevent it? Why didn't that work? How long ago was the last incident at the same workstation and involving the same hazard? How does the period of time compare to the estimated acceptable mean-days-between-injuries for the injury being investigated? Which of the following actions is needed, based on the answers given above: (1) none, except to review the safeguarding system with all concerned; (2) take maintenance action on machine and/or human part of safeguarding system (and upgrade maintenance system); (3) redesign safeguarding system because injury rate appears too high (for current operating situation).

This accident investigation approach will result in separation of some of the variables with which we in safety have to work. It will first set out information by type of hazard and will provide an evaluation of its seriousness in terms of the injury it is likely to produce and the extent of the exposure. It will also identify the safeguarding system which mitigated the risk and will insist on a best judgment evaluation of the effectiveness of that system before conclusions are made concerning the need for augmenting the system.

Mathematicians will recognize this as being similar to the Bayesian approach for designing statistical experiments. It makes best use of professional judgment. Collection of data developed in the manner suggested will lead to improved information for our use. Also, I believe that a more balanced effort will result because we will have a broader range of data to work with.

Conclusions

To demonstrate the possibility for adapting reliability technology to our use and to validate the concepts discussed, here are some observations which can be made from mere examination of the formulas for safeguarding system reliability. The first two or three have been discussed here but are restated for emphasis.

1. No safeguarding system is perfect. It reduces the risk of an injury-producing accident but does not eliminate it.

2. Chances of safeguarding-system failure increase as time passes to the point where eventually an injury-producing failure is probable unless system maintenance controls or limits the increase. Maintenance involves not only physical plant maintenance but maintenance of employee capability and of adherence to methods.

3. We can define acceptable injury rates by class of injuries as a goal for a safeguarding system design.

4. Singular injury-causing accident information by itself does not adequately indicate lack of effectiveness of a safeguarding system. Auxiliary information is required. Similar failures on equivalent workstations may be, but are not necessarily, instructive because the systems are independent.

5. The techniques defined above will not make safety hazard control technology equivalent to that used for health hazard control, because health hazards are stated in terms of exposures which can be measured. The system defined above will, however, catalog need for and correlate the effec-

tiveness of safeguarding, thus making it a more precise technology.

In closing, let me recall the specifics with which we have to work. An injury, obviously, is a specific (its rate is not). Similarly, hazards are generally well enough recognized that their existence can be identified and classified, provided, of course, we do not fall into the trap of thinking that a safeguarded hazard has been eliminated.

Safeguarding systems, on the other hand, are less of a specific because the human element is often not recognized as part of the system. And certainly, we cannot be very specific about the effectiveness of a safeguarding system, particularly when we attempt to measure effectiveness in terms of mean days between injuries or reliability in terms of chance of failure. This does not mean, however, that we are without judgment as to safeguarding system effectiveness. Much of this judgment has been catalogued and published as ANSI and OSHA standards.

Chris Christensen points out, however, that there is a significant amount of system reliability technology which has been developed by the aerospace industry, which is readily available to augment the use of the professional judgment and the ANSI and OSHA standards.

Then I discussed the "statistics" technology which has been developed and how it could be adapted to our use. Use of this technology to catalog the need for and characterize the effectiveness of safeguarding systems will supplant the heavy use of personal judgments which are so difficult to "package" into machine and equipment safeguarding technology.

While use of this technology will not give us a direct hazard evaluation and hazard control measurement, it will give us a much more transferable technology to help us achieve more balanced injury hazard control in our plants.

SUPERVISING HANDICAPPED WORKERS FOR SAFETY

By WAYNE T. BROOKS
Consultant, Applied Leadership Technologies, Inc.,
Washington ,DC

It cannot be gainsaid that employment—being employed—the availability of jobs, constitutes one of the major, if not indeed the major, economic, and social forces of national life. When the national government expresses as public policy its sense of the public will, jobs are frequently the device chosen to make the policy effective. Thus, it has been with such laws and regulations as Fair Labor Standards Act, National Labor Relations Act, Equal Employment Opportunity Act, Occupational Safety and Health, and thus it is with the laws and regulations which require that no qualified handicapped person shall, on the basis of handicap, be excluded from employment.

The laws and regulations regarding employment of handicapped persons are not novel departures into unexplored undertakings. Voluntary efforts to encourage employment of handicappeds have long been carried forth by the President's Committee on Employment of the Handicapped, one of the sponsors of this particular program, the counterpart Governor's Committee in most states, and the many organizations which devote their efforts to a specific type of handicap.

From their successes and failures a body of experience has been assembled which can be of assistance to any employer who is accommodating a specific employment situation for some specific handicap. The law and the regulations were written in the light of workplace experience. Employers, veterans' organizations, unions, handicapped persons—those who were employed as well as those who had been frustrated in seeking employment—representatives of organizations of handicapped persons, and representatives of the President's Committee on Employment of the Handicapped, participated in the public hearings of the legislative and the rulemaking process. The law and its regulations codify practical experience, but they do not accept status quo as the final level of achievement. To some the law may echo that axiom: "The difficult we will do at once, the impossible will take a little longer."

Employment of handicapped has been facilitated in principle, if not always in fact, by the administration of that feature of Workmen's Compensation Acts known as "Second Injury Law." The whole subject of workmen's compensation has been under intense study ever since the National Commission on Workmen's Compensation was established in the Occupational Safety and Health Act of 1970. Several bills establishing federal standards for state workmen's compensation acts have been considered in both the House and Senate; "second injury" as an aid to employment of handicapped has been emphasized.

An increasing number of colleges and universities are being accredited to offer graduate school programs for Masters degrees in Rehabilitation Counseling. This human service profession, rehabilitation counseling, is defined as the process of providing disabled and/or disadvantaged persons assistance to achieve their maximum vocational, social, and personal functioning through the use of professionally recognized interactional skills, and other appropriate services.

This body of knowledge, experience, and professional counseling and the operating supervisor's concern for handicapped workers in his group of employees comes to very practical application in the provision that "employers shall make reasonable accommodation to the known physical or

mental limitations of a handicapped applicant or employee unless the employer can demonstrate that the accommodation would impose an undue hardship." This quotation is not meant to introduce a discussion of the law or the many shades of meaning which can be attributed to the word accommodation, but rather to consider worker safety and health as one of the aspects of accommodation.

Accommodation in employment is not novel as a concept. The first application of a machinery guard, a ventilating fan, or when the first Irish hod carrier lacquered and reinforced his bowler as a hard hat, then job accommodation was being made. Job placement of employees according to limitations of a medical examination, either as a new hire or upon return to work after recovery from illness or injury, is again an application of accommodation and an experience of almost every employer.

The word "discrimination" is used in discussions of employment of the handicapped. There is a certain repugnance to the word when used in a social setting, of discrimination against a race, sex or creed, but discrimination against the handicapped in employment is more likely to result from non-accommodation of the tools, equipment, work procedures, and access routes and facilities. The act of discrimination is more mechanical than personal. The achievement of mechanical and procedural accommodation may well be an involvement: multi-departmental and multi-disciplinary in most plants.

Reasonable accommodation of the work place, its procedures and access, to the physical or mental limitations of a worker is an assignment for which the safety professional is preeminently qualified. In other contexts he has been practicing accommodation in almost all of his professional undertakings.

Job safety analysis and safe work procedures are devices for eliminating or reducing work hazard to minimize worker risk. These devices are directly transferable to the process of accommodation. Training in safe work procedures will be important in accommodating the job for the handicapped.

Training will be needed by both the supervisor and the handicapped worker. Here the rehabilitation counselor's background and experience will be of great help. Undoubtedly some supervisors and some handicapped, employed for the first time, will approach this new experience with a sense of apprehension despite all best intentions. The handicapped person may be wearing some prosthetic device, be in a wheel chair, blind or deaf, and, as it will likely be such person's first venture into a workplace, it will likely be the first time the supervisors or fellow employees have been associated with a handicapped worker. The discrimination may be mechanical and procedural, but accommodation may well be attitudinal among all who are involved. The handicapping feature may be obvious and that is that; the handicapping feature may be hidden—say, epilepsy—and accommodation includes preventing embarassment and invasion of privacy.

The safety professional has chosen his professional involvement along the line of concepts that: there must be a better way. It can be said of him as was said of Robert Kennedy: "Some people see things as they are and wonder: Why? Others see things as they might be and wonder: Why not?"

It is totally antithetical to good safety doctrine to protest, "But this is the way we have always done it." It is likewise totally antithetical to accommodation to similarly protest.

As medical knowledge expands, the application of the word "handicapped" is expanding. We are learning that work registers a bio-decrement on some persons and not on others. In some persons, medical examinations will disclose susceptibilities and immunities to certain workplace insults. Certain markers, precursors of disease, may be observed and by accommodation—change of assignment—the onset of disease may be arrested or reversed.

Writing in the *New York Times* of May 14, 1978, Professor Lionel Tiger was considering "how the 200-year-old industrial system interacts with the three million-year-old human model." Tiger wrote:

"Perhaps humans are indeed re-

doubtable hunter-gatherers, discontented with the prosaic predictability of the industrial system, chronically aggrieved at its interference with the daily, seasonal and life-cycle rhythms of existence.

"Do low birth rates in mature industrial countries reflect a growing incompatibility between the complex need of babies and the productive system, and the relatively inflexible requirements of the production system?

"Can biologically oriented scientists offer useful guidelines to architectural planners as they seek to provide structures that reflect humanity rather than coerce it?

"Is there a costly discontinuity between the biological reality of human life—cycles and the career patterns of modern society—a discontinuity at least partly reflected by the controversy over retirement ages?"

Those statements bring to mind the testimony of Secretary of Labor Willard Wirtz to a Senate Committee considering the Occupational Safety and Health Act: ". . . as knowledge expands more diseases will be traced to the workplace."

As we turn the safety professional's vast skill and ability to accommodation this may in fact be a step of unfolding significance broader than had been foreseen.

Medical science is identifying traits in people which, while not disabling in themselves, would require careful accommodation—assignment in the interest of protecting such persons' safety and health. May we not add to the Wirtz statement ". . . as knowledge expands more diseases will be traced to the workplace. . ." the words "and more accommodation to protect safety and health will be required."

Advancing medical science will entrain advances in workplace technology and workplace engineering. And here it is most important that the safety professional be an integral participant. He is the biologically oriented scientist who, to use Professor Tiger's expressions, can "help provide structure that reflect humanity rather than coerce it."

Mechanical engineers will learn to build equipment with work stations and controls which are accommodatable, with low noise and glare levels and without exposed hip points.

Chemical engineers will design and build chemical plants which are without open vats and airborne contaminating dust and fumes.

Methods engineers will learn to accommodate procedures, will devise the several optional ways which will accommodate to the worker with a missing member or the worker with an acute sensitivity to some toxic substance.

Job worth evaluators will learn to distribute task elements between jobs to accommodate to some workers' limitations and at the same time preserve the principal of equal pay for equal work, and not create new red circle rates.

To foresee that these multi-discipline fields, which combine as workplace technology, will themselves accommodate is not to be critical of shortcomings but to recognize that medical science has outdistanced technological forms which continue to reflect dispensary medicine rather than preventive medicine.

The safety professional must accommodate and integrate these various disciplines into doctrine which will emerge as supervising all employees and designing and operating the workplace compatible with worker limitations, handicaps, susceptibilities and immunities in "structures that reflect humanity rather than coerce it."

PHYSICAL FITNESS IN THE WORKPLACE: IMPLICATIONS FOR HEALTH & SAFETY

By ROBERT E. DEDMON, M.D., F.A.C.P.
Staff Vice-President, Medical Affairs,
Kimberly-Clark Corp., Neenah, WI

It's becoming more and more apparent that medicine and technology alone cannot adequately prevent or treat the major diseases of modern society: cancer, heart trouble, and stroke. Instead, we have to recognize that how we live can determine how long we live. Kimberly-Clark Corporation's comprehensive new Health Management Program for salaried employees is therefore aimed at changing people's ingrained habits that are detrimental to their mental or physical well-being. The accent is on wellness, not illness.

Kimberly-Clark hopes, of course, that the program will improve productivity, reduce absenteeism, and hold the line on mounting costs of medical insurance for the 2,100 men and women at our corporate offices and other facilities in or near Neenah, Wis. The ultimate goal, naturally, is to help employees maintain or improve their health instead of providing medical assistance only after they become ill. The employees have the opportunity to participate voluntarily and without cost in one of the most extensive programs of illness prevention ever conducted in a company's own facilities for a large group.

Briefly, here is how the Health Management Program at Kimberly-Clark works: First, an evaluation is made of the health risks of each employee through an extensive medical history, a series of health tests, complete physical examination and a treadmill test. The employee then receives an individualized health prescription—such as supervised exercise, health education, or counseling—to reduce those risks. The program also is intended to motivate participants to accept the health prescription as an important part of their daily lives.

In order to conduct the entire program on our own premises, Kimberly-Clark spent $2.5 million to build a 7,000-square foot multiphasic health testing facility and a 32,000-square foot physical fitness center, including a running track, Olympic-size swimming pool, exercise room, sauna, etc. The complex, known as the Health Services Center, is manned by a staff of 23 full-time health care personnel.

So far, more than 1900 employees have enrolled. Upon enrolling, the employee fills out a 40-page medical history which is analyzed by computer and which compares the individual's health status with actuarial standards for people of the same sex and age. Next comes the multiphasic screening —tests including hemoglobin, blood sugar, cholesterol, and triglycerides; liver and lung function; urinalysis; chest x-ray; skin-fold thickness and body density to determine the per cent of body fat; electrocardiogram, and hearing, vision and blood pressure checks. A complete physical examination and treadmill stress test is next. Then the employee has a health evaluation review with a staff member and gets a "health prescription," which is prepared with approval of the employee's personal physician. That prescription may call for jogging, swi aming, walking, cycling, or another activity the person enjoys.

Besides exercise, the health prescription may also recommend counseling or attendance at after-work seminars on subjects such as obesity, nutrition, alcohol and drug abuse, and stress. Special exercise fitness programs are also available for employees who have had heart problems or emphysema.

To determine the effectiveness of our Health Management Program, we will use an ongoing analysis of risk factors, absenteeism, and health costs.

For the success of a company fitness program you must have qualified, dedicated, and enthusiastic people running the program. And the employee must be ready to take some responsibility for his health and come into the program on his own. It also is important that company executives participate visibly in the fitness program. Incidentally, Kimberly-Clark's Health Management Program has additional resources in an advisory board of six local physicians.

When employees come to work, they bring more than just a skill. They bring their "total person," whose ability to function is determined largely by health. Health means much more at Kimberly-Clark than taking medicine or occasionally visiting the doctor. We try to convince everyone that eating, drinking, exercise, and other habits greatly influence not only their job performance but also their home life and everything they do.

SELF-EVALUATION FOR OSHA COMPLIANCE

By FRANK W. GODBEY
Industrial Hygienist, National Institute for Occupational Safety and Health, Cincinnati, OH

The concept of self-evaluation originated when the NIOSH, Division of Technical Services, through their many contracts with business and industry, recognized that most places of employment needed a realistic program of assistance to improve the safety and health of their worksites. The numerous problems faced by these employers have been compounded by certain corrective actions being implemented, primarily because of lack of expertise, when they were not directly related to the cause of injuries and illnesses. This resulted in the improper and inopportune utilization of scarce financial and manpower resources and actions that experience has shown did not in fact contribute to a reduction in their injury and illness experience.

What type of program is needed? It was felt that employers might be willing to accept advice and assistance toward developing comprehensive occupational safety and health programs that would permit early identification, evaluation, and timely control of potential problem areas if there was reasonable assurance of compatibility with priorities and resources. This was initiated on a limited basis by the NIOSH, Occupational Safety and Health Programs Branch (OSHPB). That is, NIOSH representatives consulted with individual and groups of corporations, upon their request, and provided information and expertise in the development of occupational safety and health (OSH) programs. It became readily apparent that with such limited resources it would be necessary, in order to be effective, to wholesale provisions of this type of expertise. The former NIOSH director and DTS director were receptive to this proposal and suggested that the OSHPB develop a program that all interested industry could use in evaluating their existing programs and in the development of programs designed to bring their establishments into compliance with existing federal and state OSH regulations. In-house planning sessions were held in early 1976 to discuss the pros and cons of this course of action and the possible impact on occupational safety and health. Background development was accomplished in mid 1976, and the decision made in October, 1976, to develop a self-evaluation program.

NIOSH experience indicated that any industry could utilize two types of assistance: OSH program development, and an instrument for self-evaluation. Since NIOSH has the inhouse capability for program development it was decided to develop the program portion of the self-evaluation concept inhouse by the NIOSH representatives and the self-evaluation instrument (SEI) jointly with an association of employers. Because of the national energy priority and the increasing importance of electrical energy and related impact on American fossil fuel resources, NIOSH determined that the electric utility industry (EUI) would be the first choice in which to develop and test the self-evaluation instrument. Association selection and receptivity criteria was developed, and the American Public Power Association (APPA) was approached with the final NIOSH proposal for a joint self-evaluation development and testing project. The APPA board of directors enthusiastically endorsed the project, and the joint effort began.

We are going to relate to you information concerning this joint effort which has just culminated in the publication of two documents: "Self-Evaluation of Occupational Safety and Health Programs," the core document applicable to all industry; and "Self-Evaluation Instrument—EUI," applicable to this industry. The program is divided into the various segments of self-evaluation of interest to you, namely, background and development, testing, validation, working experience, and the impact of self-evaluation on compliance.

BACKGROUND IN DEVELOPMENT OF AN OCCUPATIONAL SAFETY AND HEALTH SELF-EVALUATION PROGRAM FOR ELECTRIC UTILITIES

By P. G. RENTOS, Ph.D.
Senior Scientist, National Institute for Occupational Safety & Health, Cincinnati, OH

The goal all of us share is to provide a work environment that is free from hazards to safety and health. This is a difficult task involving more than 85 million people, 314,000 of whom, according to the 1975 census, work in electric utilities throughout the country. Although there has been considerable recent progess, new techniques and new approaches are necessary if this goal is to be realized in our lifetime.

It has been said that most successful safety and health programs translate internalized commitment and individual awareness into action. But this can only come about through dedication, sacrifice, and shared responsibility.

The annual rate of injury and illness, and the economic loss these represent, has sensitized employees and employers to the work environment, and safety and health has become a priority for both. This, of course, engenders a spirit of cooperation, and it is within this framework that innovative techniques such as self-evaluation are most productive.

Self-evaluation for the improvement of occupational safety and health services is not a new concept. However, it has never before been attempted in any systematic, well-coordinated way. Its success is based on several assumptions:

1. That employee and employer awareness and involvement are the key to program success.
2. That safety and health are paramount and will take precedence over all other considerations.
3. That every attempt will be made to reduce the possibility of an accident or harmful physical or chemical exposure.
4. That all safety and health laws will be complied with and there is willingness to go beyond their minimum requirements.

Behind these statements must lie a total safety and occupational health program including: analysis and periodic reassessment of all operations and procedures that may produce injury or illness; development and application of safety and health standards for equipment and work methods; education and training in safety and health principles; accident investigation to determine future preventive action; accident records and accident-cause analysis to determine trends and provide targets for corrective actions; personal protective equipment to prevent injury and illness; health maintenance activities such as injury and disease prevention, early detection and treatment of illness through medical monitoring and surveillance, emergency medical care and rehabilitation of disabled workers; medical records containing complete information on employees' physical conditions; health education and counseling; and immunization programs.

If approached voluntarily, there are a number of appealing characteristics to this concept:

1. Self-evaluation stimulates the cooperation of industry with OSHA and other regulatory agencies, thereby reducing the need for and impact of compliance investigations.
2. It allows for the dissemination of safety and health information to a large segment of industry in a single, easily understood format, making it possible for management and employees to work cooperatively toward OSHA compliance.
3. Self-evaluation will achieve a safe and healthful work environment at a lower cost-benefit ratio as needed company changes in work practices, administrative controls, and engineering schedules can be planned to fit the employer's production requirements and budget allocations.

The benefits of voluntary, self-evaluation leading to compliance include the measurable economic effects of: reduction of worker compensation insurance premiums as the injury/illness experience improves; decrease in absentee and injury rates; fewer OSHA citations and lower penalties; increased number of attendees at safety and health training sessions; and reduction of worker grievance over safety and health issues.

If self-evaluation is indeed a viable approach to OSHA compliance and development of comprehensive occupational safety and health programs, a field test had to be conducted to determine, first, management's acceptance of the procedure, and second, the validity of the instrument designed for that purpose. The industry selected had to meet the following criteria: must contain relatively consistent and well understood processes and hazards where necessary controls can be readily implemented; must be sensitized to safety and health problems; must contain a well-organized trade association already aiding its members with OSHA compliance.

A number of industries qualify, but the electric utility industry's knowledge of high voltage hazards and sensitization shown in protecting against these hazards make it a suitable choice. Operations and procedures in fossil fuel generation, transmission, and distribution of electricity are consistent regardless of the ownership of the utility. Utilities are relatively sophisticated about environmental controls because of the requirements imposed by the Clean Air Act and the Federal Water Quality Act. This sophistication greatly reduces the difficulty of implementing environmental and preventive medical programs.. Electric utilities in the public and private sectors maintain strong associations which already provide assistance to their membership in complying with OSHA. Both have been involved in the study: the American Public Power Association in the construction and subsequent testing of the field-survey instrument; the Edison Electric Institute as a participant in its final review.

The construction and testing of the field-survey instrument was a mutual undertaking by occupational safety and health professionals and member companies of APPA and professional staff of the National Institute for Occupational Safety and Health, Division of Technical Services. Their separate and collective contributions are acknowledged in the NIOSH publication, "Self-Evaluation Instrument — Electric Utility Industry."

Self-evaluation encompasses the belief that industrial operations or procedures, regardless of their complexity, can be separated into a number of individual components, each of which may have potential for producing injury or illness if improperly performed. This step-wise analysis is ordinarily carried out by experienced professionals in occupational safety and health. The same analysis, however, can be performed by less trained persons if proper professional guidance is provided.

The simplest and most direct way of accomplishing this is to develop a question or series of questions surrounding each process or procedure. A "yes" answer indicates appropriate engineering or administrative controls are in place. A "no" answer suggests changes may be necessary, that controls are absent or ineffective, or that a good work practice is being violated. If relevant state and federal OSHA standards are cited, as was the case in development of the SEI-EUI, a level of compliance with OSHA requirements can be assumed. Necessary corrective action and periodic reassessment should provide assurance of immediate and continued compliance.

The operations, procedures, and potential hazards of fossil fuel power generation, transmission, and distribution are especially adaptable to this type of analysis. Aside from the elec-

trical hazard, this industry has basically all of the generally common types of safety and health problems. Some potential safety problems areas include: walking and working surfaces, hazards primarily associated with housekeeping and working heights involving ladders, ramps, stairs, and platforms; emergency exit identification, route delineation, sufficiency, and clearance; storage and handling of potentially hazardous material such as acids, caustics, and compressed gases; provision and utilization of personal protective equipment such as eye, face, head, and foot protection; fire protection equipment adequacy, maintenance, and training for their use; machinery and equipment guarding; maintenance and use of hand and portable powered tools and equipment; welding, cutting, and brazing ventilation, shielding, and protective equipment; exposure to electrical hazards.

A number of operations and procedures are associated with potential health hazards. But, unlike safety, these tend to be more subtle and frequently less well understood. The most common potential health hazard in all fossil fuel power generation plants, irrespective of size, is noise. Noise is present at significant and sometimes excessive levels at the shaker house, crusher house, pulverizer, furnace room, boiler room, and turbine area. Exposures are often occasional or intermittent. Thus, ear plugs or earmuffs generally provide satisfactory protection.

Exposure to particulates is the second most important potential health hazard. Excessive exposure to coal dust and fly ash can occur at a number of locations, including coal storage pile, crusher house, conveyor belt walkways, and furnace hopper unloading. Equipment maintenance, increased engineering controls, such as enclosing conveyor belts, and improved housekeeping can markedly reduce airborne dust evolution and reduce such exposures.

Significant exposure to vanadium pentoxide can occur during boiler descaling. Appropriate personal respiratory, eye, and ear protection should be worn at all times during this procedure. In addition, the boiler should be purged with clean air and checked periodically to be certain that an adequate supply of oxygen is available if other than a self-contained breathing apparatus or airline respirator is used.

Radiant heat stress is an important potential health problem at boiler and furnace locations. Within large steam generating power plants, these units are elevated and separate from other operations. Exposures are occasional and intermittent. This is not the case with smaller diesel fuel operated turbine plants where all equipment is housed on the main floor of the plant and, consequently, potential radiant heat exposures tend to be more localized and continuous.

Due to inefficiency of combustion on start-up, smoke and gases, including carbon monoxide and sulfur dioxide, can be liberated in furnace room work areas. Although acute exposure to these gases is possible, chronic, low-level exposures probably do not occur.

Ion exchange resins and sodium chloride are used in water softening and present no significant health hazard. Water treatment, on the other hand, does since large quantities of sulfuric acid, caustic, and sometimes hydrazine and morpholine are used. Contact dermatitis is a potential problem and can be satisfactorily controlled by the use of protective clothing including face shields and impervious gloves. Wherever needed, engineering controls should be used to maintain concentrations of hydrazine and morpholine in the air at acceptable levels.

Contact dermatitis can also occur in the handling of organic cleaning solvents such as methyl chloroform in preventive maintenance of generating equipment, and appropriate care must once again be exercised.

The use of a low-grade crude petroleum product for steam generation, generally referred to as number 6 fuel, presents a potential exposure to benzene during filtering and filter cleaning. When this occurs, approved respirators for benzene and protective clothing should be worn to prevent excessive inhalation and skin contact.

On occasion, large transformers are

connected and entered through holes to conduct needed repair. fore this occurs, the transformer ld be purged and tested for possi- reduction of oxygen content. A life- should be used, and a second work- should be stationed outside to ren- assistance, if necessary.

Thirty-four sections, each devoted to separate occupational safety or lth operation or procedure, five dical sections, and an estimated to- number of 1,500 questions have n developed concerning these issues and are contained in the document referred to earlier; "Self-Evaluation Instrument—Electric Utility Industry." The SEI-EUI is not intended to stand alone but is designed to be used with a companion NIOSH publication, "Self-Evaluation of Occupational Safety and Health Programs," which will answer most of the questions that may arise in completing this instrument, clarify a number of potential hazards, and aid in implementing a comprehensive occupational safety and health program.

TESTING OF THE SELF EVALUATION INSTRUMENT FOR THE ELECTRIC UTILITY INDUSTRY

By WILLIAM E. BRAMMER
Supt., Safety Service Dept., Memphis Light, Gas, & Water Div., Memphis, TN

It was an honor for me to be asked to participate in the development of a self evaluation instrument for the electric utility industry. My contribution was threefold: (1) to develop specific questions for certain assigned sections of the self evaluation instrument; (2) participate on the APPA-NIOSH survey team; and (3) participate in the selection of the utilities to be involved in the testing of the SEI. Actually, this phase of the development process involved three testing procedures: testing of the utilities to be selected, testing of the SEI, and testing of the use of the SEI by the utilities selected.

NIOSH established certain criteria for selection of the utilities in which the SEI would be tested: they must be a member of APPA; they should be representative of both the small and large utilities in order to minimize size variables; they must be located in different areas of the United States to minimize geographical variables; they must all have fossil fuel as part of their electric generation capabilities; they could not be utilities which were represented by any member of the site survey team; they must all have volunteered to participate in the program; they must all have generation, transmission, and distribution capabilities; they must agree to allow NIOSH members of the survey team to visit their utility during the site survey; they must not be in an OSHA abatement mode; and they would ensure cooperation of their employees in the project.

With these criteria, it was not an easy task to select eight utilities. That is the number which NIOSH determined was optimal for statistical purposes, with time and financial constraints. I will not name the utilities or their representatives at this time; however, this information appears in the SEI document.

The SEI contained 1500 questions. In order to assure validity of the testing procedure, a random sample was used to select 10 per cent of the questions in such a manner that at least two questions appeared from each of the 34 sections that could be factually observed by the site survey team.

The next step was to forward two copies of each of the two documents to the eight participating utilities. The utility manager was advised to distribute the various sections to the appropriate superintendent for his dissemination and completion, with the request that they be as objective as possible in their responses. When the sections were completed, the superintendents for generation, transmission, and distribution collected their respective responses and discussed the results with those involved in the evaluation process. Next, they prepared an analysis of the responses, including recommendations for corrective action, and discussed this with the utility manager. In actual use, the utility manager must then place priorities on the corrective actions and make plans for budgeting and scheduling requirements.

The eight utility managers returned their responses to the 1500 questions to NIOSH, where they were coded to protect confidentiality. A site survey team, consisting of at least one member from NIOSH and one member from APPA, then visited each utility to compare what they observed with the company's response to each of the

questions selected in the random sample.

In every utility I visited, the self evaluation instrument and the site survey team were enthusiastically received. Some utilities were so impressed that they adopted the self evaluation concept prior to our visit, which did not help the study but may have demonstrated its value. One utility immediately employed a safety director. Another was in the budget planning cycle and was motivated to include safety and health as a line item in their budget. A third utility employed an occupational nurse. The other utilities made plans to develop a more comprehensive occupational safety and health program.

I enthusiastically recommend that you consider adopting this concept for your safety programs. I view it as a very valuable tool, both for the company that does not have an effective safety program as well as the company with a well-developed program. It can be used effectively as a method of auditing your safety program to determine if it is as comprehensive as you believe it is.

VALIDATION Self-Evaluation Questionnaire for OSHA Compliance Electric Utility Industry

By LOREN L. HATCH, D.O., Ph.D.
Medical Officer (Occupational Medicine) National Institute for Occupational Safety and Health, Cincinnati, OH

The Survey Utilities

Included in the study were all sizes of utilities from one of the largest to one of the smallest electric utilities in the United States. Each utility was a complete system with generation, transmission, and distribution capabilities.

The eight utilities were selected from different areas of the United States to minimize the effects of geographical variables. Further, the volunteer utilities were limited to those which used fossil fuels as part of their energy-generating capabilities. All utilities had additional sources of fuel, but the study design was confined to those divisions using coal, gas, and oil. While such a small sample could not be controlled to be necessarily representative of all electric utilities, nevertheless it is believed by the authors the eight utilities are generally representative of all electric utilities. This cautious statement is based upon the assumption of homogeneity of generation, transmission, and distribution of electric energy across the industry.

Questions Validated

The Self-Evaluation Instrument contains 1510 questions divided into 33 different sections common to power generation, transmission, and distribution. To reduce the 1510 questionnaire validation process to manageable size, a random number generator was used to produce approximately a ten per cent sample from among all the questions in the SEI. This sample (151) was adjusted slightly to ensure questions that could be objectively observed by the research ingestigators and to include questions from each section, hereinafter called observers. The medical category is discussed later.

Specific questions were included eliciting a fixed response of fact on the part of utilities, called respondents (R), which could be factually determined by the research investigators, called observers (O).[1] This process was also used for the medical portion of the SEI questions, although this section required medical judgment as well, for validation. Each question is designed to be answered "yes" if the utility is in compliance to regulations.

Validation Process and Results

After the utilities had completed the self-evaluation process, a team of observers visited each utility to verify that the sample questions had been answered appropriately.

Data were summarized according to the types and numbers of matched or unmatched answers by the respondents and observers. The mean of the total number of matches is 84.64 per cent across all utilities. Excluding the utility with the highest total number of matches and that with the lowest number of total matches, to eliminate bias, the mean is 85.26 per cent. This small difference (84.64 per cent vs. 85.26 per cent) indicates lack of significant bias. Those utilities with a score of 80 per cent or better can believe they have a good understanding of the questions and properly interpreted them.[2]

Validation of Sample Questions

If the objective observations of the research investigators matched those of the utility for each question, whether yes, no, non-relevant or other, it is presumed the question was properly understood. Obviously, not all questions are relevant for all utilities. For example, some utilities never blast and others always contract out this work. Nevertheless, the questions should remain for those utilities who will use the SEI so they may better prepare contractual agreements with their blasting contractors and judge their safety performance as part of their obligation to the public they serve.

An individual question is considered valid if there is a 75 per cent or better match between the responses of all eight utilities per question and that of the observers (O). This is a very conservative approach.

Of the 122 sample questions, there was an 81 per cent validation. Of the remaining 19 per cent (100 per cent total) of the questions not validated, ⅓ of these are in the construction category. Eliminating this category of questions increases the validation to 87 per cent.[3]

In addition to consideration of total matches, it is useful to examine the more detailed nature of matches and non-matches. Total "no" responses by the observers indicated the extent of potential hazards found in the questions sampled. Overall, the results show a "non-performance" rate of 33 per cent on the applicable questions. For the individual utilities this ranged from 17 per cent to 51 per cent, indicating a wide variation in the presence of potential hazards.

The per cent of hazards found by the observer which were also found by the respondents (NR NO/NO) indicates the ability of the SEI to assist respondents in locating potential hazards. This ranges from a low of 31 per cent to a high of 89 per cent, with a mean of 69 per cent. The low of 31 per cent is extreme, since the next lowest value is 61 per cent. These results suggest that the SEI indeed provides significant potential hazard-finding assistance.

An SEI is not very useful if it causes the utility to devote scarce resources to the correction of false hazards. Thus it is desirable to have a very high rate of agreement on "yes" responses. The per cent of questions on which the observer answered "yes" and on which the respondent also answered "yes" (YR YO/YO) is generally high, ranging from 86 per cent to 97 per cent, with a mean of 93 per cent. It is worth noting that the firm with the highest percentage of matches here is the same as that with the lowest score (31 per cent) in the "no" aforementioned discussion above. This suggests that particular respondent has a strong "yes" bias.

Medical Category

Each of the eight utilities completed the sample questionnaires for medical and three medically-related noise questions for a total of 19 possible responses. Upon review of the utility responses it was apparent that something was wrong with either: (a) the language of the questions or (b) the respondent's understanding of the question. A medical observer was a part of the validation team, but due to constraints of time and money was only able to visit seven of the utilities (87 per cent); however, the situation became clear as the observer medical officer interviewed the utility physician.

The mean of the total number of matches across all utilities according to the original respondents (R) is 50 per cent. Excluding the utility with the highest total number of matches and that with the lowest number of total matches to eliminate bias, the mean is 52 per cent. This small difference once again indicates lack of bias in the match according to the original response (R). Reviewing the total match with the company physician (D), however, we have a mean of 98 per cent. Once again eliminating the highest and lowest matches according to the company physician the mean becomes 99 per cent, indicating absence of bias.

This discrepancy between the respondent (R) answers and that of the company physician (D) with those of the medical officer (O) can be explained in two ways: (1) one obvious fault with the questionnaire was that it was not made specific enough that the medical portion should be completed by the company physician; (2)

the language was such that lay persons could not adequately answer.[4]

Since the seven utilities validated by the medical observer all received a matched score of 94 per cent or better, as explained above, it is apparent that, projecting the responses of the seven utilities to the general population of APPA members, if there is homogeneity of electric generation and occupational medical competence, the company physician working with the utilities can develop good preventive health programs.

Validation of Sample Medical Questions

The same discrepancy occurs when an attempt is made to validate the sample question. All questions in this section were designed to be affirmative on all utilities; however, due to interpretation two questions of the sample will have to be rewritten to accurately reflect the higher quality of health care. Validating each question as before at 75 per cent or better match, there is an 89 per cent validation of the medical category questions compared with 81 per cent validation for the other sample questions. This variation may be explained by the difference in the numbers of questions compared. Comparing the company's original response with that of the medical officer, there is only a 21 per cent validation, pointing out that it is necessary for the company physician to answer the questions and that more detailed definitions must be provided for the terms used.

Because of the small sample size it is not appropriate to enter into discussion with the matched yes of the respondents, the matched no of the respondent, and the matched yes of the doctor and the matched no of the doctor.

It is apparent, in medical summary, that the SEI is very useful in assisting respondents' physicians to locate potential hazards. However, it is readily apparent that lay persons must work closer with their company physician in understanding the issues involved with worker health recognition. This would correct a common complaint among physicians interviewed that if the company knew the problems they would allocate more resources to preventive health which the physicians are apparently competent to perform but do not because of: (a) lack of instructions by the company, (b) lack of payment for preventive health services.

It is also apparent that the lay respondents answered on the conservative side (N), which was probably due to their unfamiliarity with the language.

Analysis of the data suggest that the medical category has a useful place in the SEI and that the questions are valid.

Plans for the Future

1. The self-evaluation instrument is valid in providing significant hazard-finding assistance.
2. The self-evaluation instrument may be a useful and valuable adjunct to OSHA compliance and consultation mechanisms for improving the safety and health of American workers.
3. Additional self-evaluation instruments will be developed with other industries or associations of industries.

REFERENCES

1. NIOSH-APPA, industrial hygienists, safety professionals, and a medical officer.
2. Computing the standard error and using "Student's 't' distribution" we have a better than 90 per cent confidence that the mean across utilities is 80 per cent or more matches. For an individual utility, we can be 90 per cent confident that an individual utility has at least 74 per cent matched responses.
3. Construction category may need further clarification.
4. The final document will be modified to indicate that the company physician should answer the questionnaire and in addition detailed explanation of terms used will be provided in the definition section.

A WORKING EXPERIENCE

By GARY McCORMICK
Supvr., Loss Control, Salt River Project, Phoenix, AZ

More than any other time in the history of the world, the utility business today is aware and conscious of the need to serve its customers, plan and finance new generating stations to meet the future needs of the people, maintain financial solidarity, develop better management, manage its energy needs, be aware of the environment, find the role it plays in the sociological needs of the community, and address the problems of providing a safe working environment.

Industry has never been more regulated by government as to what it can and cannot do. With these ever-increasing regulations, we must search to improve our performance and still keep the costs of the service to the customer within reason.

In compliance with what could be called a "nightmare" of OSHA regulations production tends to take a backseat, and getting the job accomplished becomes more of a hope and a prayer than a reality. But I happen to believe that people in industry are creative, imaginative, and ambitious enough to overcome compelling bureaucracy and over-regulation. Industry and bureaucracy can instead be used to solve the problems both have created. It was from this challenge that the APPA-NIOSH utility self-evaluation instrument for OSHA compliance was born. These people tried to deal with a massive law which was written for only one purpose: to ensure a safe working environment and to save lives. We are concerned and, as concerned people, we will never stop trying to save lives at any cost and effort! Being the best is not good enough when lives are at stake.

This is what the OSHA law is really all about—it is a challenge for us to operate better. This becomes difficult to see and understand when we are buried under a barrage of forms, reports, fines, and court hearings that have been put into effect to carry out the law. This is what has brought us together at the National Safety Congress—improving, doing it better.

The previous speakers have told you about the background, testing, and validation of the instrument, but all of that is like practicing for the Super Bowl—the only thing that counts is having the most points on the scoreboard when the final gun is fired.

What counts is how well this instrument will work in your organization. It won't stop all of your accidents; it won't replace a supervisor's personal interest to provide a safe workplace and safe work procedures; it won't replace the need for a safety, loss control, or risk management activity in your organization. In fact, this instrument is of absolutely no value to you unless you want to improve your operations, comply with the law, and reduce losses within your company.

If you think these objectives are worth achieving, then this instrument will: (1) provide you with a tool to systematically approach the recognition of hazards in the workplace and an inventory of those hazards; (2) give your supervisors and loss control management groups an evaluation guide for follow-up on your most significant hazards; (3) provide a plan to control and correct the recognized and evaluated hazards which will assist in compliance with prescribed work practices, lead to recommended control procedures, establish required personal protection equipment and work clothing, provide for required medical monitoring (pre-employment, annual exit physicals, and emergency medical treatment), outline required employee educational programs, and fulfill the record-keeping required for compliance. Most important of all, it will provide the capability for data corre-

lation and analysis to ensure compliance and control of hazards in the workplace.

The instrument is a working handbook to be administratively handled by the risk management, loss control, safety, or whatever you call that department in your organization.

How can it best be used? I see it having many significant uses:

1. Your safety department can use it as an annual audit evaluation guide.
2. Your supervisors can use it as a guide for periodic inspections in specific areas of concern, such as material handling and storage, flammable and combustible liquids.
3. Your training department, safety group, or supervisors can use it in organizing programs for employee education needs.
4. It can serve as a guide to evaluate the knowledge level of your workers on hazards in their work environment, allowing you the opportunity to identify and improve the area of training where most needed.

Helping the employee and the supervisor see and understand how they can work within the standards and still improve the total operation is what the APPA-NIOSH self-evaluation instrument is all about. Just as a surgeon's knife is used to accomplish the removal of unwanted cancerous growth, so this tool can be used for the removal of unwanted hazards and improper work procedures within our respective organizations to make productive, safe work not a faint glimmer from the past, but a clear light focused on the future.

THE RISK AVERSIVE SOCIETY

By WILLIAM D. ROWE
Office of Radiation Protection,
U.S. Environmental Protection Agency, Washington, DC

Individuals have always been exposed to risks of injury to health and safety and have demonstrated a consequent safety consciousness. The last few years have evidenced rapid increases both in the levels of risk to which Americans are exposed and in the public's concern with risks, especially those resulting from new technological developments. Awareness of both immediate and long-term risks affects the manner in which American society undertakes to control such risks.

Cigarette smoking provides an illustration. Decades ago, our society surmised that smoking fails to improve health but had no medical data demonstrating actual ill effects on health. Smoking was considered a strictly voluntary risk. Despite medical evidence substantiating the hazards of smoking, the Department of Health, Education, and Welfare (HEW) continued to treat smoking as a voluntary risk and merely required a health warning on cigarette packages. Today, however, smoking is recognized as something more than a purely voluntary risk. The demonstrable ill effects of smoking to nonsmokers who inhale cigarette smoke, as well as the cost of supporting patients with lung cancer and other diseases related to smoking, are now acknowledged as involuntary consequences of smoking. Many states now forbid smoking in public buildings, and efforts to develop "healthful" cigarettes are underway.

Recognition that many risks have voluntary and involuntary components and increased concern with regulation of risks that are imposed inequitably on parts of society are changing the manner in which American society approaches risks. Traditionally, ethical and legal questions about the appropriate extent of governmental regulation of risks have been addressed implicitly rather than explicitly. Thus, many problems in setting acceptable levels of risk for societal activities, especially those activities whose risks are imposed inequitably on risk agents* who are not the direct beneficiaries of the risk-creating activity, are just beginning to receive attention.

As a result, society is becoming increasingly risk aversive, and anxiety concerning risks is increasing. The role of the safety engineer must increase in scope to deal with the broadening of the spectrum of risk and safety problems.

The Process of Risk Assessment

The process by which risks are assessed increases in importance as society becomes more cognizant of risk, particularly risk that is inequitably imposed on individuals by the technological activities of their society. The term "risk assessment" is used here to describe the total process of risk analysis, which embraces both the determination of levels of risk and the social evaluation of risks. Risk determination consists of both identifying risks and estimating the likelihood of their occurrence. Risk evaluation measures both risk acceptance, or the acceptable levels of societal risk, and risk aversion, or methods of avoiding risk, as alternatives to involuntarily imposed risks.

Risk identification is of particular interest because modern technology has created many new risks that are either irreversible or of global proportions. Though risk identification is an endless task, until now little effort has been made to identify even major types of risk prior to their imposition.

Risk Determination: Identification.

*A "risk agent" is defined as the human object of risk. The term is synonymous with "risk-taker," though the latter term connotes an object of voluntary rather than involuntary risk.

If risk is defined as a potential threat to man, his environment, and his well-being, the manner in which new risks are perceived and identified is a major consideration in coping with them. Estimating changes in the levels of both man-made and natural hazards requires both measurement of changes in levels of risk and evaluation of the perception of such risks. The two are mutually dependent; the former process identifies new risks, while the latter determines social and cultural response to such risks. Changes in the levels of risk are identifiable in three circumstances: when a new risk is created; when the magnitude of an existing risk changes; and when perception of an existing risk changes. All three circumstances may occur simultaneously.

A new risk is a risk that did not previously exist, not a new identification of existing risk. Man almost always orginates new risks, usually as a result of a new technology often for which nature has no natural defense. As one commentator has observed: "Our scientists and technologists have learned to compound substances unknown to nature. Against many of them, nature is virtually defenseless. There are no natural agents to attack and break them down. It is as if aborigines were suddenly attacked with machine-gun fire: their bows and arrows are of no avail. These substances, unknown to nature, owe their almost magical effectiveness precisely to nature's defenselessness."[1]

A new perception of existing risks may occur because the hazard was previously unidentified, because the magnitude of the hazard changes suddenly, or because a slow change in the hazard's magnitude crosses some threshold of societal concern. Such changes in perception occur increasingly in the context of developing technologies. As Schumacher has stated: "Because [synthetic compound substances] have no natural enemies, they tend to accumulate, and the long-term consequences of this accumulation are in many cases known to be extremely dangerous, and in other cases totally unpredictable."[2]

Alternatively, public perceptions of existing risks may change whether or not the level of risk is changing in an objective sense. This change may occur when a more dominant risk is eliminated or reduced, such as when the reduction of contagious diseases transfers public concern to chronic diseases.

For example, the relatively recent elimination of cholera, poliomyelitis, yellow fever, and diphtheria had such an effect. Or public concern with risk may be stimulated by communications media, or by the threat certain hazards pose to particular individuals or groups rather than statistically to the population at large. Individuals satisfied with the status quo may view the hazard as a threat to their present condition.

A morphological approach to detecting hazards can be constructed in the form of a diagram based on the manner in which risks are identified and the types of risks considered. In this diagram, the vertical column describes processes of perceiving new risks, and the horizontal row shows different types of risks. Types of risk include risks to health and life, such as those resulting in pain, disability, or premature death; risks to the environment, either local or global and having either reversible and irreversible effects; risk to the economic well-being of groups and individuals; risks to the social well being of groups; and risks of changes in the status quo of certain individuals or groups. A third dimension might reflect the types of systems that cause risks, such as manufacture of chemicals, including drugs and pesticides; production of energy, including fossil and nuclear fuels; systems of transportation that create hazards to people and environment; methods of construction that create fire, flooding, and earthquake hazards; disposal of organic and inorganic waste products; and manufacture of ferrous and nonferrous materials and plastics.

The morphological structure of such a diagram facilitates determination of whether significant risks exist in each area of potential hazard. If certain types of risk and risk perceptions are charted, analysis of intersecting points may reveal areas of risk previously not considered. The degree of

detail in each area and the method of aggregating information are important factors in determining both the scope of risk covered and the practicality of using such a diagram in the screening of risks.

Risk identification efforts in the United States currently focus on screening chemicals for toxicity and carcinogenesis and identifying technological threats to geochemical systems. In the former area, the newly enacted Toxic Substances Control Act authorizes the EPA to obtain from industry data on the production of chemicals, their user health effects, and other matters relating to chemical substances and mixtures. EPA may regulate, when necessary, the manufacture, processing, distribution, use, and disposal of particular chemical substances or mixtures. In the latter area, studies are underway to identify technological threats to geochemical systems, such as the threat posed by fluorocarbon gases and high altitude jet travel to the ozone layer of the earth's atmosphere, by thermal and carbon dioxide loading to the earth's climatology, and by new toxic materials to the unprotected environment.

Risk Determination: Estimation. The process of risk estimation has five steps: identifying the cause of risk, measuring its effects, determining risk exposure, defining the consequences of exposure, and valuing the consequences of exposure.

The first step in risk estimation is identifying causative events, or events that create a probability of risk occurrence. Each causative event may lead to several possible outcomes. In the second step, these outcomes are defined and their relative probability determined. The causative event and outcome do not of themselves constitute risk until the exposure of humans, institutions, and the natural environment to the outcomes is considered. The probabilistic relationship between events and their outcomes can be measured through scientific experiments, statistical design of experiments, and hypothesis testing. If such experiments require exposing humans or the environment to risk, however, then the risks of conducting experiments must also be evaluated.

The third step in risk estimation is defining exposure pathways, the means by which risks are transmitted. Exposure pathways can be defined explicitly; for example, a pesticide may reach man through food, water, and aerosol pathways after application to a food crop. The probability of various exposure pathways and of resultant exposures is also determined in this step. The fourth step is defining the possible consequences of risk exposure and determining for each risk the probability that consequences will occur. The final step in risk estimation considers the value placed by affected individuals on the consequences of risk exposure. Some individuals, for example, may be unconcerned about consuming trace amounts of pesticides in food because they consider the effects remote; others may be sufficiently concerned to eat only organically grown foods.

The probability of risk occurrence and the value placed on risk consequences by affected individuals determine the public's response to risks. Thus, the process of risk estimation requires two basic determinations: a consequence probability determination and a consequence value determination.

The relationships among these elements can be expressed mathematically. The probability that a consequence P_c will occur is a function of the combined probabilities of the causative event P_e, its outcome P_q, and its exposure pathway P_x:

$$P_c = f\,(P_e, P_q, P_x)$$

The value placed on the consequence $C(v)$ is a function of both the definition of the consequence C and the probability of the consequence occurrence P_c:

$$C(v) = f\,(C, P_c)$$

Thus, the expected risk R of a particular consequence is a function of the probability of the consequence P_c and the value of the consequence to the risktaker $C(v)$:

$$R = f\,(P_c, C(v))$$

Expected risk, however, cannot be fully equated with actual risk because probability and consequence estimates may be inexact. The probability that a

consequence will occur may be determined by direct measurement of repeated trials of a causative event. When the number of trials is large, the estimate of probability is properly considered objective, because it represents an empirical estimation. On the other hand, if probability estimates are made on the basis of one or a few trials or by conjecture, then the probability estimate is subjective. These definitions comport with classical definitions of objective and subjective probability. Between these extremes lies another estimate, here termed "synthesized probability," for which the probability of a consequence is not measured directly but rather is extrapolated from the objective probabilities of causative systems that are expected to behave similarly. For example, the Nuclear Regulatory Commission's study on reactor safety uses an estimate of probabilities computed from tests on parts of the reactor system and synthesized into a total model.

A similar range of certainties exists in calculating consequence value. An objective estimate of consequence value consists of a consequence that is directly observable and measurable, and a consequence value that is expressed explicitly. For example, the accounting value of the pay-offs of a gambling establishment represents an objective consequence value. Subjective consequence value, on the other hand, occurs when the consequence value to a particular risk agent depends completely on the risk agent's personal value system and situation. Between these two extremes is a value estimate, here termed "observable consequence value," in which the behavioral response of groups in society to objective or subjective risk consequences is ascertained and measured by studying actual behavior.

A relationship between the nature of probability and the nature of consequence, both of which range from the objective to the subjective, can be illustrated in a diagram in which probability is diagrammed vertically and consequence horizontally. The combination of probability and consequence defines risk. Thus, the combination of objective probability and objective consequence defines objective risk. Most scientific studies of risk have concentrated on objective risk because such risks are easiest to define and measure. As the diagram moves toward synthesized probability or observable consequences, it defines an area termed "modelled risk." Such risks are not directly observable or objective, and the usefulness of computing modelled risk depends on the degree to which the model corresponds to reality. Risk may be modelled by using synthesized probability, or observable consequences, or both. All other risks are subjective because they are computed on the basis of subjective estimates, subjective valuations, or both.

The science of risk estimation traditionally used scientific experiments and empirical measurements to compute objective risk. Recently, the concept of synthesized probability has developed extensively, just as measurement of observable consequences has gained major importance in the behaviorial sciences. By contrast, societal decision-making relies on subjective risk estimates; in practice, emotional considerations are more compelling than objective scientific knowledge. Objective estimates of the risks of nuclear reactors, for example, are usually lower than public perception of them, yet public perception may have greater impact on governmental decisions on whether and how to utilize this form of fuel production than scientific estimates. Because objective risk estimates provide a sounder basis for governmental decision-making, administrators should try to persuade the public to accept such measurements. This can be accomplished either by educating the public to understand objective risk or by making subjective risk estimates and valuations more explicit and visible so that the public understands their fallibility.

The difference between objective and subjective human behavior—illustrative of the subjective nature of consequence value—is well known to behavioral psychologists who have examined, for example, the objective and subjective probabilities with which reward and punishment affects human behavior.[4] One element of the objective probability of reward or punishment is the objective value of reward or punishment. The punishment for driving one's automobile at an excessive speed on a certain portion of road, for example, may be loss of license and an expensive fine. If, at a given time, no police are patrolling that highway, the objective probability of punishment is near zero. The subjective probability for reward and punishment, on the other hand, involves the subjective value of punishment. The speed with which an individual is willing to drive his automobile on a particular road may be governed by his subjective estimate of the probability of punishment. His lack of knowledge concerning the presence of police on the road results in some expectation that police might observe his speeding. Thus, despite the absence of an objective probability of reward and punishment, human behavior generally is based on subjective assessments of reward and punishment.[5]

The subjective nature of consequence valuation implies considerable variability in such measures. A variety of factors can affect the assignment of value to a particular consequence. The purpose of classifying risk factors is to provide a means of defining and comparing different types of risks and risk behavior under different conditions. Study of each factor can provide considerable insight into individual and societal behavior toward risk acceptance by clarifying the characteristics of particular risks.

One cannot evaluate risk without considering human responses to risk acceptance and avoidance. Man is by nature risk aversive, tending to avoid acts or situations whose consequences may threaten his health and safety.[6] Although man may choose to take or accept risks to achieve specific benefits when such choice is under his direct control, he will avoid risks imposed on the human population by man or nature that have no direct benefit.[7] That human society is more concerned with the adverse consequences than the benefits of risk is illustrated by the reporting of news, which reflects society's news preferences. Reporting of disasters, crimes and other disagreeable news far outweighs description of positive human achievements and other beneficial events.

The risk aversive nature of society, together with increasing awareness of new risks created by new technology, has focused attention on technological risk. The growth of public awareness and concern for risk is probably irreversible because the knowledge required for technology assessment and risk identification is now available to all levels of society. Consideration of societal risk in all technological decisions is becoming accepted practice, and increased regulatory attention is focused on risk assessment.[8] A methodological approach that assures a reasonable perspective in evaluating risk is necessary if the government's regulatory apparatus is to work responsibly and visibly.

The degree to which risks are voluntary affects both their public acceptability and the degree to which governmental regulation is appropriate. Purely voluntary risks need not and probably should not be regulated by government, for such risks result only in direct gains and losses to the risk-taker. Unfortunately, purely voluntary risks are rare. Most voluntary risks impose some indirect risk on others who do not share the concomitant benefits. For example, the act of suicide has consequences not only to the suicide victim, but to his survivors, his insurance company, his creditors, and his society. The benefit of suicide to the individual who chooses to kill himself is subjective, situational, and emotional. Moreover, both religion and government regulate the act of suicide in such a way as to make it as unattractive as possible. Thus, government and other societal institutions may regulate voluntary risks that incur some indirect losses, as well as involuntary risks that incur purely involuntary losses.

When indirect losses associated with a voluntary risk are imposed on significant numbers of the population or on identifiable recipients, the risk may become unacceptable, and regulatory action to ameliorate the risk inequity becomes necessary. A methodology for

determining levels of risk acceptance must consider the effects of these involuntary risks. The purpose of a risk acceptance methodology is not to balance direct gains and losses of risktaking, but to reduce inequities in indirect gains and losses. Risk acceptance is analyzed only when direct and indirect losses are favorably distributed. Thus, a risk acceptance methodology is neither a cost-benefit analysis nor a substitute for such analysis. Its purpose, recognizing that some levels of risk always exist, is to determine when risks imposed on segments of a society are low enough to be acceptable. The weighing of indirect gains to society against imposed risks is an element of risk acceptance; higher levels of risks may be acceptable when society receives indirect benefits along with losses from risktaking. For this reason, total societal equity in risk imposition is rarely achieved in practice.

A methodology for analyzing risk acceptance involves four distinct steps: direct gain-loss analysis; indirect gain-loss analysis; cost-effectiveness of risk reduction; and reconciliation of risk inequities. First, direct gains are compared to direct losses; this analysis constitutes the classic cost-benefit analysis conducted before a new project or program is sponsored. The individual or institution undertaking the project receives project benefits and accepts project costs, and has full responsibility for making an initial, primarily economic, cost-benefit analysis. At this stage, voluntary risks are taken to achieve specific results. If the direct gain-loss balance is negative, motivation for proceeding with the new project disappears. Unless the balance is changed or new factors, such as economic subsidization, are introduced, the project will be discontinued. A balance in favor of gain, on the other hand, will provide incentive for the program. Institutional factors such as legal constraints, tax incentives or disincentives, and public opinion are not always quantifiable at this stage. Direct gain-loss analysis is open-ended, because additional direct costs from subsequent steps may affect the gain-loss balance, and new factors that may change the balance must be evaluated as they occur. The sponsor, as the recipient of direct gains and losses, will continually review his position from the project's inception through its completion, if only for economic reasons.

The second step in determining risk acceptance is analyzing the indirect gains and losses of risk. The indirect societal gains of a proposed activity are balanced against its indirect losses; risks themselves constitute one aspect of the societal losses. This indirect gain-loss analysis is the type of overall cost-benefit analysis sought in environmental impact statements under NEPA and is a goal of most technology assessment activities. Such a balance must be made, at a minimum, for local, national, and world levels of impact. Because of difficulty in quantifying indirect gains and losses, this type of analysis usually includes qualitative value judgments rather than numerical estimates. At the governmental level, a sponsoring agency is usually responsible for preparation of such analyses.

The third step in evaluating risk acceptance is determining the cost-effectiveness of risk reduction. Because society is generally risk aversive, the risk in obtaining a particular gain or benefit must be minimized to the extent feasible, even where indirect gain-loss balances favor gain. Thus, the costs of risk reduction must be computed in the analysis of both direct and indirect gains and losses. The central question in this risk reduction analysis is determining the point at which risk has been sufficiently reduced. In a direct gain-loss analysis, the practicality of risk reduction is one limiting consideration. The "as-low-as-practicable" limit can be defined as the point at which the incremental cost-per-risk-averted is such that a very large expenditure must be made in return for a relatively small decrease in risk, compared to the cost of previous risk reduction efforts. Thus, the cost-effectiveness of risk reduction is relative, depending on the particular risk in question.

A determination of the "as-low-as-practicable" limit on risk reduction is as arbitrary as a determination of the level of risk acceptance. Some other more stable reference is required to determine when risk reduction is cost-effective or when risk reaches an acceptable level. Thus, the development and use of such a reference, based on acceptable levels of inequitably imposed risk, is the heart of an effective methodology of risk evaluation.

The fourth and most important step in evaluating risk acceptance is reconciliation of identified risk inequities. Even when an indirect gain-loss analysis is favorable, various inequities may still be imposed on specific groups in society. Such inequities occur when those who assume risks fail to receive benefits, or when risks are unevenly distributed among recipients of their benefits. In such circumstances, a risk that is otherwise acceptable because its gains outweigh its losses may become unacceptable because it is imposed inequitably. To determine acceptable levels of inequitably imposed risk, the risk in question must be identified and the type of risk ascertained.

Inequities in risk imposition must be measured against some referent representing the amount of acceptable risk. One method of establishing such a referent is to compare a particular risk to the level of risk that society is experiencing for similar types of risk; that is, to establish a set of societal risk references. This approach involves a societal value judgment concerning the amount of additional risk society should assume in order to obtain its indirect benefits. Such risk references are static and ordinarily historic. Dynamic or future risk-aversive behavior must also be considered in establishing risk references to assure their validity. For example, the systemic degree of risk control included in a new project is an important factor in determining whether unacceptable risks can be controlled properly in the future.

Another method of establishing a risk reference is balancing risks to determine net risk. The risks of a new program, including its indirect costs, are weighed against its indirect benefits to obtain net risk. The life-extending capabilities of radiation therapy in medical treatment of cancer, for example, and the increased risk of cancer induced by radiation therapy can be balanced. The resulting net risk is the risk to be evaluated in deciding whether to use radiation therapy. If the net risk is negative or zero, that is, if the risks balance each other, then no risk inequity exists, and a risk acceptance comparison is unnecessary. Risks can only be balanced, however, if they are measured on the same scale. This is frequently impossible; risk balancing therefore has limited application and should be used only when appropriate.

In sum, a methodology for risk evaluation is proposed here that reconciles risk inequities, measured against acceptable levels of risk in the form of risk references or other external criteria, after the initial three steps in risk evaluation are performed.

Problems in Institutionalizing Risk Assessment

The institutionalization of risk assessment in governmental decision-making requires a variety of administrative determinations. Such determinations include identifying individuals or agencies that should evaluate risks for society; determining the type of regulatory agencies that can evaluate risk credibly and defining their respective roles; and devising credible methods by which the value judgments necessary to the risk evaluation process can be made. In the following discussion of risk evaluation, a valuing agent is defined as an individual or group that directly evaluates the consequence of risk to which risk agents are subjected. A risk evaluator is an individual, group, or institution that seeks to interpret a valuing agent's risk evaluation for a particular purpose.

The scope of risk evaluation is more complex than the preceding discussion implies when many risk agents exist, each with his own set of subjective values and relationships to externalities. The evaluation of risk, moreover, often incorporates value judgments made by a risk evaluator on behalf of valuing agents under circumstances in which it is impossible to poll or reconcile all the individual judgments of the

valuing agents. A government agency's interpretation of the needs and values of individuals in setting a regulation is an example of such decision-making. In making such value judgments, a risk evaluator is always subject to question concerning his expertise and ability to make the proper judgment, his personal biases, and the fairness of his judgment.

Perhaps the greatest difficulty in governmental risk evaluation lies in the imprecision of the intrinsic human values on which decisions are based; such decisions are often expressed in explicit, objective terms that belie the subjectivity of the value judgments employed in making them.

The value judgments required in risk evaluation fall into three classes: technical, societal, and managerial. Where hard technical information or data is absent, or when information gathering is too costly or time-consuming, technical value judgments concerning risk are made by technical experts who may disagree on the consequences of particular activities. Scientific bodies, such as the National Academy of Sciences, therefore usually make technical judgments by consensus, as in the BEIR Report on low-level ionizing radiation.

A societal value judgment of risk weighs the benefits and costs of risks and attempts to minimize inequities in the cost-benefit balance. Scientists and technical experts have no more expertise in this area than other well-informed members of society. Interested individuals, societal groups, or governmental agencies themselves may express value judgments on behalf of the public in governmental proceedings. By contrast, the managerial value judgment of risk interprets and modifies the societal value judgment to implement and enforce the public opinion concerning acceptable risk. The state implementation plans mandated by the Clean Air Act, for example, require managerial value judgments and mandate the participation of lawyers, law enforcement personnel, scientists, engineers, and government administrators, as well as technicians. All three types of value judgments—technical, societal and managerial—must be made and considered in governmental decision-making concerning new technologies.

A regulatory agency that sets standards of acceptable risk for society is responsible for making the required value judgments on behalf of society. Consequently, it must employ standard-setting procedures which ensure that all affected parties have an opportunity to present their views; that the best available expert testimony and technical information are used; and that the agency's value judgments concerning risk are made in a visible and reportable manner and are documented for future reference. Such procedures not only preserve the basis of governmental decision-making for public scrutiny, but also maximize the credibility of governmental decisions concerning risk.

The process of risk regulation does not guarantee "right" decisions, only decisions made openly in a credible manner that assure all interested parties an opportunity to present their views and all issues fair consideration. If governmental decisions are made openly, those who remain subject to inequitable risks are more likely to understand and accept the predominance of societal interests over their own. If such a process produces regulatory decisions acceptable to a substantial majority of our society, it will fulfill successfully the expectations of democracy.

REFERENCES

1. E. Schumacher, *Small Is Beautiful*, Harper, 1973.
2. *Ibid.*
3. Kates; *Risk Assessment of Environmental Hazard*. 8 SCOPE Report 161 (1976). International Council of Scientific Unions, Scientific Committee on Problems of the Environment.
4. V. Reynolds; *The Biology of Human Action*. (1976).
5. *Ibid.*
6. Kates, *op. cit.*
7. *Ibid.*
8. *Ibid.*

REGULATION AS A MEANS OF CONTROLLING OCCUPATIONAL HEALTH AND SAFETY

By LEONARD A. SAGAN, M.D.
Electric Power Research Institute, Palo Alto, CA

Interest in the question of risk is recent, but shows rapid growth. A full consideration of risk requires answers to a number of questions which include:

1. How should risk be measured?
2. How do perceptions of risk differ among individuals and how these perceptions affected by demographic variables such as age, sex, race, and socio-economic status?
3. Under what circumstances should society intervene to reduce risk? To what extent is this intervention the responsibility of government?
4. Which techniques are available for risk reduction and what are the circumstances under which each is appropriate?
5. Which techniques are available for evaluating the effectiveness of risk reduction strategies?
6. What special considerations are conferred by situations where risks are voluntary, occupational, where there are no counterbalancing benefits, where the risks are borne not by the contemporary population but by future generations?
7. How would estimates of risk interdigitate with other national priorities in decision making, and what is the appropriate framework in which this should be carried out?

Clearly these questions, impinging on the disciplines of law, political science, philosophy, and even religion, tax the wisdom of any one individual or group and require a broad based approach from those concerned.

Efforts to use techniques of cost-benefit analysis to evaluate regulatory efforts have recently been stimulated by Executive Order 12044, published March 23, 1978, which requires Federal agencies to publish an economic impact statement (EIS) when the likely impact of a regulation will exceed $100 million per year. There has also been established a Regulatory Analysis Review Group (RARG) within the Council on Wage and Price Stability which shall review EEI's when the regulatory analysis appears incomplete or when the economic consequences appear to be large.

RARG has recently carried out two analyses specifically related to proposed OSHA regulations which were in both cases felt to be inadequate. These deserve attention since in both cases they illustrate the propensity of OSHA (and of the government generally) to neglect costs imposed by regulation and to recommend standards the costs of which greatly exceed those justified by even the most generous cost of life estimates. The first of these is the RARG review of the OSHA proposed regulations for acrylonitrile exposure. This paper addresses only one narrow element of the larger issues raised previously, namely, how well is government doing in its effort to reduce occupational risks? Emphasis will be placed on the regulatory effort that is the major approach taken by government. Whether that effort has been successful and under which circumstances alternative strategies might be preferable are the major questions to be addressed.

The purpose of the paper is to evaluate the effectiveness of the recent Federal effort to reduce occupational health and safety hazards. It is concluded that the exclusive use of regulation as a tool for reducing risk has been costly, may actually increase rather than decrease hazards, limits personal freedom, and is lacking in requirements for controlling costs and evaluating outcome.

Growth of Regulation

The past 40 years have seen enor-

mous growth in Federal regulation of American society. Charles Schultze[1] notes that the fraction of national income consumed by the cost of the Federal regulatory effort was one per cent in 1930, four per cent in 1960, and eight per cent in 1976. There are now 77 Federal regulatory agencies whose growth rate, in numbers of employees, is more than four times greater than the Federal establishment as a whole. The Nuclear Regulatory Commission is growing at a rate twice that of other Federal regulatory agencies and 10 times as fast as Federal employment as a whole. This occurs at a time when orders for new reactors is sharply falling, there being only two new U.S. reactors purchased last year.

The total cost of this regulatory effort is born not only by the Federal Treasury but by the industry which must comply and the customers to whom those costs are passed. Murray Weidenbaum estimates the total costs for 1976 both direct and indirect, to be $65.5 billion, but concedes that much of the costs of compliance (such as those of the NRC) cannot be calculated and are not included.[3] Chase Manhattan Bank estimates the total cost of regulation in 1977 as $100 billion.[4] The costs of regulating the environment and occupational health and safety alone reduce our annual economic growth rate by 1.4 per cent.[5]

Control of the environment and of the occupational workplace has been a conspicuous target for this regulatory effort. Over the past 10 years much legislation markedly expanding Federal control in this area has been passed. Although some of this legislation requires consideration of economic impacts and costs, much does not, and where balancing of costs is recommended, this mandate has rarely been carried out with vigor.

Cost-Benefit Analyses

Evaluation of the impact of health efforts are frequently carried out through the use of cost-effectiveness studies for which a dollar value is attached to a life-saved. The technique is controversial in that it appears to some to imply a callousness to life and a crassness in costing health in marketplace terms.

Those who favor the use of "cost of life" estimates point out that economic resources are always limited, that many human needs compete for these resources, and that assigning a greater value to risk aversion than individuals would themselves assign reduces overall welfare by misallocating resources. For example, if government is to intrude into the implicit health and safety "market" in which the employee is the seller and the employer is the buyer, then they should be guided by the cost of life which the employee himself would (implicitly) assign to life; otherwise, government will be imposing its own priorities on those of its citizens and in its attempt at benevolence will be depriving its citizens of other goods or services to which they themselves would give a higher value.

There is no consensus as to what this nominal dollar value of life should be, and indeed it may vary, depending on the particular population at risk. For example, a life saving effort directed at young vigorous adults would likely be accorded a higher life valuation than an effort at preventing further deterioration in an already elderly and chronically ill population.

Generally, there have been two approaches to estimating the value of life.[6] The first, economists refer to as "discounted future earnings," a calculation of anticipated income lost due to early death, discounted to the presented value and adjusted variously by different investigators. The other technique examines the amount of money, either implicit or explicit, which individuals are willing to pay or accept for lengthening or shortening their lives. One approach to this issue has been through direct interview, e.g., "How much additional tax would you be willing to pay to have available an ambulance service which would increase survivability of a heart attack?" Another approach investigates the implicit wage differential paid to various occupations depending on risk.[7] Predictably, estimates derived in various studies vary enormously.

Another technique used to evaluate health and safety efforts which avoids the criticism attached to the use of value-of-life determination is the calculation of the dollar cost of increasing longevity. Richard Schwing[8] has recently presented data on the dollar cost of added longevity for some 37 different medical and safety programs. These vary from $50 (mandatory seat belt usage) to several hundred thousand dollars per year for highway improvement.

Cost-effectiveness refers to analyses in which various strategies are tested to determine which is the most effective in achieving a desired outcome. The following table, taken from the RARG review, shows their estimates of the cost implied by three levels of permissible concentration of acrylonitrile.

Incremental Cost Per Unit Reduction In Cancer Cases and Deaths (millions of dollars)

	Cases	*Deaths*
2.0 ppm TWA	1.37	3.52
1.0 ppm TWA	11.51	28.78
0.2 ppm TWA	70.51	169.22

Note that the highest level considered by OSHA implies a value of life of almost $170 million. A second OSHA proposal for coke oven emission control was estimated by another reviewer to create control costs equivalent to a life valuation of $4.5 million.

The above considerations imply that federal intervention into the area of health and safety control has followed the government-wide tendency to select a regulatory strategy. Secondly, that effort has ignored cost-benefit analyses and has therefore required very expensive compliance costs that imply life valuations far greater than those which would be agreeable to employees should they be required to pay them themselves.

Cost-Effectiveness

Given the benefit and the willingness to pay, one must then inquire into the effectiveness of the strategy, i.e., cost-effectiveness analysis—was the regulatory strategy as effective as its proponents hoped? Was it as cost-effective as alternative strategies? Was it effective at all?

It is clear that there has been a long term decline in industrial accidents. It is an assumption, fairly easily documented, that there is a strong association in cross sectional studies between industrial accidents and industrial disease. It would seem reasonable to assume that this same relationship prevails historically, i.e., that there has been a steady decline in occupational disease. Based on the latter assumption, both industrial health and accident experience have been steadily improving for a number of decades, long preceding direct government intervention on the major scale which exists today, and showing no demonstrable effect from the latter. It must be conceded, however, that reduction in occupational exposures may not produce beneficial effects for decades because of the long latent period.

What then are the operative factors that are responsible for this effect? Data does not exist on such questions as increasing caution of workers, increased concern of employers, union demands, and other elements of attitudinal change among the various parties, but all of these must contribute to declining mortality rates and presumably a decline in occupational disease as well. Certainly further educational efforts directed to encouraging these attitudes is to be emphasized. Undoubtedly, OSHA regulations themselves will have such an effect of consciousness-raising.

Still another potent factor in occupational hazard reduction has been the introduction of workmen's compensation. Workmen's compensation dates back to the early part of this century. It represented a considerable advance for the injured employee in that he no longer was required to demonstrate, as he previously was, that the employer had been negligent. It was the predecessor of no-fault insurance in that it was only necessary for the employee to demonstrate that he or she had been injured. The employer was also required to have adequate insurance to cover his risk. The employer also gained an advantage, namely, that the employee accepted a limitation on the magnitude of damages. Both parties gained the advantage of avoiding expensive, costly, and prolonged legal

controversy.

The economist values workmen's compensation since it provides an economic incentive for hazard reduction without specifying performance standards; the manager is permitted flexibility in selecting those procedures and techniques in which he is persuaded that there is cost-effectiveness, thereby allocating resources to where they are of greatest utility. Yet, the economic penalty associated with increased injury claims constrains hazards of the workplace and protects the employee against undue risk. Should the employer be criminally negligent, the injured employee has recourse to the legal system for redress.

Recent governmental intervention into the workplace implies that the compensation system described above is not adequate. True, the ceilings on death benefits are often paltry, but then the remedy would be to press for liberalization of such limits.

Implicit in the current regulatory thrust is the assumption that society will not permit risk taking in the workplace, even when such risks are recognized. In other words, the employee shall not be permitted a hazardous occupation even when he willingly accepts such risk-taking and presumably has bid up his salary to compensate for that level of risk.

The counter-argument is that the employee does not have perfect information nor does he or she have perfect freedom to select an occupation. The son of an illiterate West Virginia coal miner is constrained by cultural, educational, and geographic bounds that severely limit his occupational choice. But is this view realistic? In an age of network television, universal education, and free movement, is the stereotype of the illiterate immobile coal miner realistic? Does he not perceive the risks of coal mining? Is he not free to avoid those risks should he choose to do so? And does the government have the perfect information necessary to intervene in a cost-effective manner?

Clearly, risks among occupations vary enormously. To achieve equally some minimal level of risk throughout all occupations, given two orders of magnitude differences among occupations, is impossible without prohibiting certain industries and without extravagant expenditures. Rather, to "ratchet down" on each industry to a "best available technology," applied and enforced throughout the industry, regardless of concern for cost-benefit analyses, appears to be the guiding strategy. Responsibility for this strategy rests not only with OSHA.

In addition to questions of economic efficiency, governmental restriction of risk taking without question interferes with the opportunity of each individual to make choices regarding his own willingness to accept risk and bargain for his own services and skills. Controversy regarding mandatory seat belts and motorcycle helmets suggests that Americans may increasingly reject such constraints on their choices and life styles.

REFERENCES

1. Schultze, Charles; *The Public Use of Private Interest. Harpers*, May 1977.
2. Editorial: "New Federal Budget Calls for More Regulators." *Regulation*, Mar/Apr 1978.
3. Weidenbaum, M.L.; and DeFino, R.; *The Cost of Federal Regulation of Economic Activity*. America Enterprise Institute, Washington, D.C. Reprint #88, May 1978.
4. Willard C. Butcher, President, Chase Manhattan Bank; Speech to Commonwealth Club. San Francisco, Sept. 15, 1978.
5. Dennison, Edward F.; *Effects of Selected Changes in the Institutional and Human Environment Upon Output per Unit of Input.*
6. Rhoades, S.E.; "How Much Should We Spend to Save a Life?" *The Public Interest*, Spring 1978.
7. Thaler, R. and Rosen, S.; "The Value of Saving a Life: Evidence From the Labor Market." Presented at the NBER Conference on Income and Wealth, Household Production and Consumption, Washington, D.C., Nov. 30, 1973.
8. Schwing, R.C.; *Expenditures to Reduce Mortality Risk and Increase Longevity*. General Motors, Research Publication GMR-1353.

controversy.

The economist values workmen's compensation since it provides an economic incentive for hazard reduction without specifying performance standards; the manager is permitted flexibility in selecting those procedures and techniques in which he is persuaded that there is cost-effectiveness, thereby allocating resources to where they are of greatest utility. Yet, the economic penalty associated with increased injury claims constrains hazards of the workplace and protects the employee against undue risk. Should the employer be criminally negligent, the injured employee has recourse to the legal system for redress.

Recent governmental intervention into the workplace implies that the compensation system described above is not adequate. True, the ceilings on death benefits are often paltry, but then the remedy would be to press for liberalization of such limits.

Implicit in the current regulatory thrust is the assumption that society will not permit risk taking in the workplace, even when such risks are recognized. In other words, the employee shall not be permitted a hazardous occupation even when he willingly accepts such risk-taking and presumably has bid up his salary to compensate for that level of risk.

The counter-argument is that the employee does not have perfect information nor does he or she have perfect freedom to select an occupation. The son of an illiterate West Virginia coal miner is constrained by cultural, educational, and geographic bounds that severely limit his occupational choice. But is this view realistic? In an age of network television, universal education, and free movement, is the stereotype of the illiterate immobile coal miner realistic? Does he not perceive the risks of coal mining? Is he not free to avoid those risks should he choose to do so? And does the government have the perfect information necessary to intervene in a cost-effective manner?

Clearly, risks among occupations vary enormously. To achieve equally some minimal level of risk throughout all occupations, given two orders of magnitude differences among occupations, is impossible without prohibiting certain industries and without extravagant expenditures. Rather, to "ratchet down" on each industry to a "best available technology," applied and enforced throughout the industry, regardless of concern for cost-benefit analyses, appears to be the guiding strategy. Responsibility for this strategy rests not only with OSHA.

In addition to questions of economic efficiency, governmental restriction of risk taking without question interferes with the opportunity of each individual to make choices regarding his own willingness to accept risk and bargain for his own services and skills. Controversy regarding mandatory seat belts and motorcycle helmets suggests that Americans may increasingly reject such constraints on their choices and life styles.

REFERENCES

1. Schultze, Charles; *The Public Use of Private Interest. Harpers*, May 1977.
2. Editorial; "New Federal Budget Calls for More Regulators." *Regulation*, Mar/Apr 1978.
3. Weidenbaum, M.L.; and DeFino, R.; *The Cost of Federal Regulation of Economic Activity*. America Enterprise Institute, Washington, D.C. Reprint #68, May 1978.
4. Willard C. Butcher, President, Chase Manhattan Bank; Speech to Commonwealth Club. San Francisco, Sept. 15, 1978.
5. Dennison, Edward F.; *Effects of Selected Changes in the Institutional and Human Environment Upon Output per Unit of Input*.
6. Rhoades, S.E.; "How Much Should We Spend to Save a Life?" *The Public Interest*, Spring 1978.
7. Thaler, R. and Rosen, S.; "The Value of Saving a Life: Evidence From the Labor Market." Presented at the NBER Conference on Income and Wealth, Household Production and Consumption, Washington, D.C., Nov. 30, 1973.
8. Schwing, R.C.; *Expenditures to Reduce Mortality Risk and Increase Longevity*. General Motors, Research Publication GMR-1353.

National Safety Council

A Membership Organization Dedicated to Protecting Life and Promoting Health

March 21, 2001

Baron & Budd, P.C.
The Centrum
3102 Oak Lawn Avenue, Ste. 1100
Dallas, TX 75219-4281

To Whom It May Concern:

The attached records are kept and maintained in the regular course of business of the National Safety Council, and it is the regular course of business of the National Safety Council to keep and maintain the attached records.

The attached photocopied material is an authentic reproduction of an original file copy of :

NATIONAL SAFETY COUNCIL CONGRESS TRANSACTIONS 1978, VOLUMES 1-5, 7-15, 16, 19-22, 28.
National Safety Council, Chicago, IL.

Respectfully,

Robert J. Marecek

Robert J. Marecek
Manager, Library

Marilyn P. Pettersen

"OFFICIAL SEAL"
MARILYN P. PETTERSEN
Notary Public, State of Illinois
My Commission Expires 10/26/03