FILE NAME: Carrier (CAR)

DATE: 1962

DOC#: CAR011

DOCUMENT DESCRIPTION: National Safety Council Transactions

NATIONAL SAFETY COUNCIL

TRANSACTIONS

1-27

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1962

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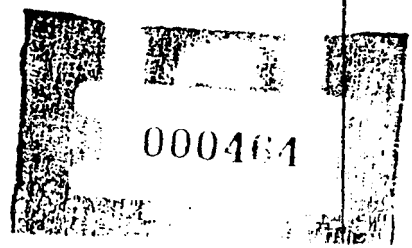


National Safety Congress
Transactions

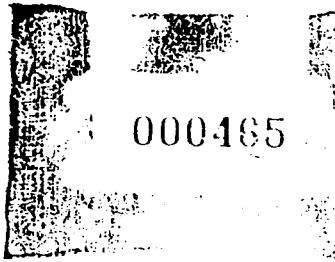
GENERAL SESSIONS

ANNUAL MEETING OF MEMBERS
CONGRESS BANQUET
LIST OF EXHIBITORS
GENERAL INDEX OF ALL VOLUMES

Beginning the Golden Anniversary Year of the

NATIONAL SAFETY COUNCIL

425 NORTH MICHIGAN AVENUE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VOLUME 1 OF THE TRANSACTIONS

of the

50th NATIONAL SAFETY CONGRESS

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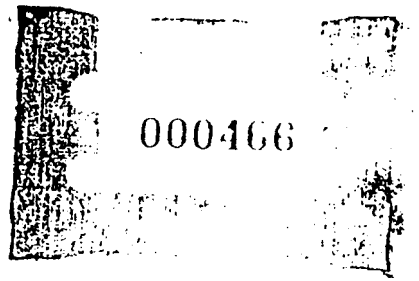

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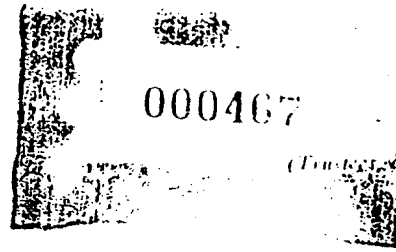

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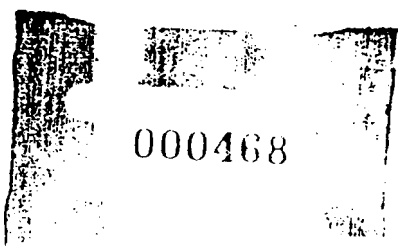

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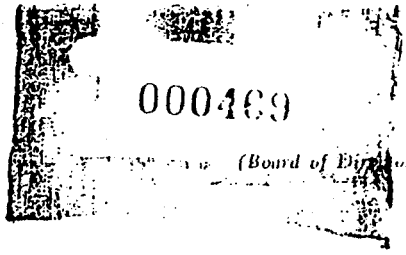

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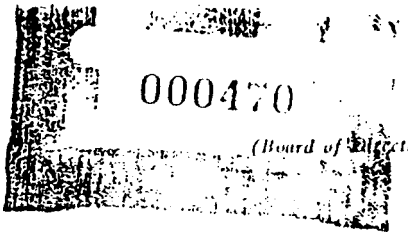

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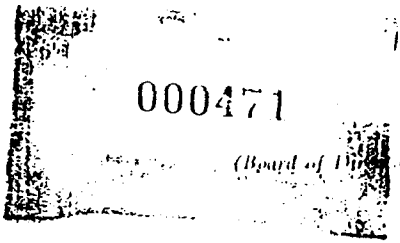

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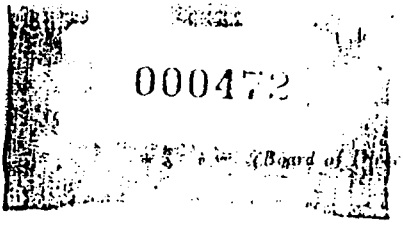

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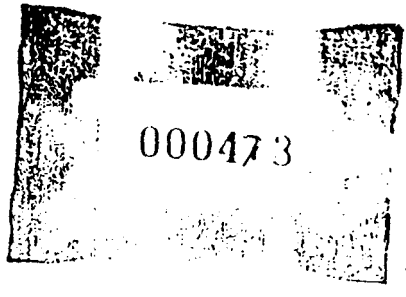

of getting an unexpected mouthful of corrosive or toxic chemical, some chemicals like benezene have a cumulative toxicity from the vapors alone.

Q. What are some of the important precautions in handling glassware?

A. Dispose of cracked or damaged glassware, protect the hands when assembling or fabricating glassware.

Q. What helps prevent electrical shock?

A. Insure equipment is in good repair and always grounded.

Q. What is danger of storing solvents in an ordinary refrigerator?

A. If solvent vapors escape and fill the refrigerator, the spark from its operation may cause it to explode. Such refrigerators can be explosion-proofed by removing the sources of ignition, such as the light bulb and controls.

Q. What is an important way to learn of the hazardous individual characteristics of chemicals and their reactions?

A. Checking available literature before beginning to work.

Q. Why is a shield placed in front of the reaction?

A. To prevent injury in case of flash, splash, or explosion.

The film may be purchased from the Manufacturing Chemists' Association, Inc., 1825 Connecticut Avenue N.W., Washington 9, D. C., for $100. It may be previewed for $10, which will apply against the purchase of the film if the order is received within 30 days.

NATURE AND INCIDENCE OF BERYLLIUM ASSOCIATED DISEASES

By JOHN F. ZIELINSKI, M.D.
Medical Director, The Brush Beryllium Co., Cleveland, Ohio

Certain physical and chemical characteristics of beryllium are presented, as they, under current evidences, are apparently significant in the potential toxicity expression and incidence of beryllium associated diseases.

Beryllium is classified as an amphoteric element but is principally a metal in its characteristics. Like aluminum, it demonstrates a spurious nobility because of its preferential strong affinity to chemically combine with oxygen, almost instantaneously forming a protective film of beryllium oxide. This hard film of oxide reaches maximum thickness of 10^{-4} centimeters (100A°, or 0.01 micron) in two hours and is very resistant to further corrosion under standard kinetic energies. The excellent corrosion resistance is attributed to the fact that the volume of oxide formed is greater than the volume of the metal consumed in the formation of the oxide. Above 815°C (1500°F) this film is disrupted by the effect of elevated temperature causing intra-crystalline separation in the metal, leading to further oxidation of the element. Intra-crystalline separation in pure beryllium is said to begin at 700°C (1290°F) and become rapid at 1000°C (1830°F).

It is the only light metal with a high melting point 1285°C ± 10°C (2345°F ± 18°F). Its boiling point has an extrapolated value of 2507°C (4540°F). It is interesting to note that the melting point for the oxide of beryllium has reported values of 2510°C to 2560°C (4550°F to 4640°F) and a boiling point of 4260°C (7700°F).

Chemically, beryllium is quite closely related to aluminum and its complete separation from this element is difficult.

Beryllium metals reacts readily with sulphuric acid and hydrochloric acids. Dilute nitric attacks the metal slowly, but concentrated nitric has but little effect. Boiling water and alkalies react with the evolution of hydrogen. The hydroxide, $Be(OH)_2$, is amphoteric. The beryllates, unlike the aluminates, are fairly easily hydrolized at boiling temperatures.

Solutions of water soluble beryllium normal salts, such as beryllium sulphate, chloride, and the nitrate are all acidic in reaction and are characterized by their ability to dissolve large amounts of beryllium hydroxide. However, these water soluble salts are not hydrolized to the same extent as other corresponding salts, such as aluminum and iron. The exact reason for this unexpected behavior of the beryllium ion has not been defined.

Fluorine gas reacts with beryllium at room temperature. Chlorine, bromine, iodine, hydrogen sulphate and nitrogen peroxide gases react with beryllium metal at elevated temperatures.

Medical Aspects

Recognition of the acute type of medical problems, encountered in the chemical and thermal refining of beryllium and beryllia from ore has existed in literature since 1933. The opinions of sundry observers that the acute reactions, involving either the skin and/or the respiratory tract, were due entirely to acid mists and acidic anions, were bolstered by an official report in 1943, emanating from the United States Public Health Service, to the effect that beryllium, per se, is not toxic. The basic error in this simplifying assumption arose out of the fact that the highly insoluble compounds did not evoke adverse acute responses in various experimental animals. Unfortunately, this assertion retarded the eventual full recognition of the role of the beryllium ion in the chronic phase of the beryllium associated diseases.

Recognition that the beryllium ion can express toxicity in the human being, predominently in the form of the chronic respiratory disability, did not attain acceptance until 1947. This recognition came 'out of an epidemic-like onset of respiratory abnormalities among employees of a fluorescent lamp manufacturer.

This latter recognition of a new occupational disease entity, of major medical and legal importance, stimulated a great deal of research into the epidemiological, medical, and experimental aspects of beryllium associated diseases. Literature on these aspects grew steadily. The lists include observations on human and experimental evidences. In both categories, there are data that are proving valuable in the proper evaluation of the specific problems.

On the other hand, there are articles wherein the use of simplifying assumptions, possibly in an attempt to rapidly finalize the problem, has led to conclusions that are not compatible with the current epidemiological, experimental, and medical evidence. Within all the background of confusion there does exist a definite orderly pattern of facts

The author of this report on the current status of the beryllium associated diseases does not intend to imply that this report will finalize the specific problem. It is his intent to apply knowledge gained during 20 years of experience in the beryllium industry against the evidences and thereby reach some tenable conclusion, valid within the evidences currently at hand.

Beryllium Associated Diseases: Acute Types

The eventual conclusions drawn by the author are based on the evidences of both the dermal and the respiratory adverse reactions manifested among some beryllium workers. It is, therefore, essential that at least brief descriptions of all these reactions be presented in order to substantiate the ultimate conclusions.

Contact Dermatitis

Causation is undue and/or prolonged contact with the soluble salts of beryllium. Causal frequency and severity are definitely a function of the type of salt. The most reactive salt as to frequency and severity, in the author's experiences, is beryllium fluoride. Ammonium beryllium fluoride reacts less in frequency and severity. Beryllium sulphate and beryllium chloride salts show a much lower frequency and severity rate. The gross pathological expressions are influenced by the radical.

Contact dermatitis has not been seen in workers handling pure beryllium hydroxide, pure beryllium oxide, and the present-day vacuum cast beryllium metal. Prior to 1950, the so-called "high purity" metal contained anywhere from 0.5 to 2 per cent of unreduced soluble beryllium fluoride salt within the structure of the metal mass, and as high as 5 per cent in the "technical" grade of metal.

A dermatitis identical to that caused by beryllium fluoride was seen among em-

ployees engaged in reworking this parent metal. This fact offers a logical explanation for the very early reports of acute dermal and/or respiratory adverse reactions in people working with this metal outside of the basic refineries.

"Allergic" Dermatosis

All the cases in the experience of the author have occurred within six to fifteen days after initial exposure to the fumes, mists, and/or dusts of beryllium fluoride. The frequency of attack is approximately 1 per cent of the population so exposed. This syndrome expresses itself in the rather sudden onset of intense inflammation of the skin with varying degrees of puffiness, usually only on the normally exposed areas of the face and neck, with superimposed discrete and confluent lesions, flat, elevated, and/or blistered in type.

Bilateral puffiness of the eyelids in varying degrees is a constant feature. Inflammation of the conjunctiva, if present, is minimal on contrast. Itching is an intense subjective symptom. Attempts to re-enter the employee into the fluoric phase of chemical production, after total remission of the described syndrome invariably resulted in recurrence. This necessitated a permanent transfer to another chemical or miscellaneous operation, without further ill effect, if an opportunity existed.

Chemical Ulcer

This lesion is usually the result of neglected superficial cuts or scratches contaminated with the fluoric compounds of beryllium. The sulphate compound can also be causal but incidence and severity are of lesser degree. It is an open lesion of the skin presenting a sloughing, irregular surface and scanty thin serous discharge. The edges are well defined and slightly elevated, showing inflammation with peripheral extension of varying degree. Pain is prominent when the lesion is present over points of flexion, extension, or bony structure.

Ulcerating Granuloma

This lesion is usually the result of an implant of beryllium sulphate salt under the skin surface. The lesion grossly resembles a soft "corn." It is well defined [illegible] smooth healing surface that occasionally are raised, firm, relatively dense, with little or no inflammation. The bulk of the lesion extends rather deeply, is well defined, with a fibrous resistance. Studies of excised specimens have shown the lesion to be dominantly a foreign body type of reaction but with considerable central destruction of cells. In several specimens a few isolated small granulomata had been discerned in the zonal section between the area of cellular destruction and the fibrous capsule.

Respiratory Aspects: Immediate or "Acute" Occupational Disease Potential

The acute respiratory occupational disease potential ranges in expression from rhinitis to a pneumonitis, i.e., inflammation of the membrances ranging from the nose down to the lung tissues, depending on the degree, duration, and compound type of exposure in the form of mists, fumes, and/or dusts of the soluble compounds of beryllium. The fluoride compounds are dominantly causal, although all the soluble compounds utilized in the basic industry have been incriminated at one time or another.

The rhino-pharyngitis, i.e., the nose-throat, phase usually resolves itself rapidly and spontaneously after temporary complete removal from the exogenous factors.

The tracheo-bronchitis phase necessitates a longer period of temporary complete removal from the exogenous factors. This industrial respiratory complication was usually the result of relatively high levels of exposure over a prolonged period of time. Modern industrial hygiene practices in the beryllium industry during the past 10 to 12 years have practically wiped out the incidence of naso, phyaryngitis and tracheo-bronchitis.

Of major concern to all involved is the acute respiratory disease potential of acute beryllium chemical pneumonopathy. Historically, such cases have been documented as being either of a fulminating or an insidious type. Basically, they are one and the same disease, being influenced by time-dosage factors. The fulminating type was usually due to relatively brief exposures to overwhelming levels of adverse exposure, with a relatively short latent period before expression of the lung tissue involvement. The insidious type was the result of continual exposure to relatively high levels over a relatively long [illegible] of time.

Cases documented before the application, in 1950, of current industrial hygiene controls, were dominantly of the insidious type. A typical case of the insidious type can be generally described in the following manner. Usually a relatively new employee would complain of a progressive non-productive cough, croupy in character, and aggravated when the afflicted was in the supine position. This subjective symptom was invariably associated with a symmetrically progressive burning type of pain under the breast bone, more or less constant, plus shortness of breath that was markedly aggravated on physical exertion.

Due to the intensity and persistence of the described symptoms the individual was unable to obtain regularly proper physical rest and developed the associated symptoms of general lassitude, physical weakness and loss of appetite, plus some weight loss. Objectively, the resting afflicted individual was noted to have a definitely increased respiratory rate with diminished chest expansion. Relatively mild exertion would readily induce shortness of breath and a reflex spasmodic cough. Some degree of blueness of the nail beds and/or mucous membranes would be apparent. The nose and throat mucosa would be inflamed.

Stethoscopic examination of the chest would reveal fine to medium abnormal rales, most noticeable in the lower lung fields. Occasionally the abnormal sounds were practically identical to those heard during an attack of asthma. The heart beat rate would be markedly accelerated. The temperature was normal or very slightly elevated except in the presence of a secondary infection. The clinical laboratory findings, in the uncomplicated cases, were essentially within normal limits.

Temporary increase of gamma globulin in the blood had been noted in most cases. The chest x-rays usually did not show any appreciable changes until from seven to twenty-eight days after the initial onset of the subjective symptoms. These changes varied with the stage and severity of the disease.

A typical case would first show a diffuse, symmetrical bilateral haziness. The very mild cases did not show progression beyond this aspect. The progressive case would then show irregular patches of soft-appearing infiltration, followed by discrete and/or confluent nodules. In the cases of recovery the resolution of these abnormal shadows to the individual's normal would be rather slow, from four to six weeks in the severe cases, but would be complete prior to the subsidence of the subjective symptoms. Complete recovery periods ranged from four to twelve weeks.

The fulminating type was basically similar except that the latency period between the known massive exposure incident and the onset of subjective and objective symptoms would be very brief, as little as six hours. The chest x-ray in such cases would invariably show the advanced stages, as described for the insidious type, in a period as short as 72 hours after the exposure. The complete recovery period in the fulminating cases, though more dramatic in character, was unexpectedly short by comparison, usually being complete in about four weeks.

In the series of 93 cases of acute beryllium chemical pneumonopathy documented in the pre-1950 experiences of two basic refineries in Ohio, there were ten fatalities, six coming to autopsy. The pathological reports were essentially negative, except for the lung disease and for acute cor pulmonale, i.e., acute dilation of the right or pulmonary side of the heart. The dominant abnormal cellular feature of the lungs was pronounced intraalveolar interstitial edema, i.e., involvement of the framework of the air sacs, with varying degrees of organization.

The pathologist remarked on the non-specificity of the reaction and its similarity to the reaction discerned in fatal cases due to phosgene or the oxides of nitrogen. He further indicated a similarity to the reaction seen with virus pneumonitis or with the pneumonitis associated with severe kidney function block. It is his documented opinion that the acute pneumonopathy is that of a chemical pneumonitis or peri-bronchiolar alveolitis.

The epidemiological, experimental and clinical evidences indicated 1) the dose-response curve in the acute type of occupational disease potentials associated with the soluble compounds of beryllium is the usual sigmoid seen with other toxic materials, and 2) the dose-response base line is different, both in frequency and severity, for different compounds of beryllium. This differential is

associated with the known and predictable differences in the physico-chemical characteristics of the involved compound.

From all these evidences it is reasonable to postulate that the acute types of disease are basically the result of the chemical activity of the involved compound, modified in its action by its bond with beryllium, and not due to the beryllium ion alone.

Chronic Types

Dermal Aspects: Latent or "Chronic" Occupational Disease Potentials

Dermal Granuloma

This type of disease potential was highly publicized through fluorescent lamp breakage and implant incidents. All the evidences indicate that only the very slowly soluble compounds of beryllium, principally certain forms of the oxide, evoke the granular unit lesion ascribed to the beryllium ion.

The gross skin lesion, limited to the area of implant, resembles a keloid or soft "corn." It usually reaches maximum expression within 4 months after an implant incident. The abnormal tissue expression is that of a localized foreign body reaction with a diffuse, somewhat loosely arranged distribution of the granular unit lesions. Rather simple surgical excision effects a cure.

The incidence of the skin granuloma in the basic industry has been much lower than one would expect. In fact, it is the exception instead of the rule. This may be explained, at least in part, by the fact that the industrial implant injuries receive medical attention. There are, however, relatively large numbers of permanent skin implant cases where the granulomatous reaction has not occurred.

Atopic Dermatosis

There are two cases diagnosed as recurrent eczema-like dermatosis at sites of previously prolonged irritation by the soluble salts of beryllium. A polysensitization factor is ascribed.

Respiratory Aspect

Probably no other disease entity having an exogenous inorganic factor has provoked as much controvery as that associated with the beryllium ion.

The term "berylliosis" was coined by [illegible] the reaction in experimental "acute poisoning" in animals. With the subsequent recognition of the "chronic or delayed" form of reaction in humans, the term was simply expanded to identify the two classes of pulmonary disease as either "acute berylliosis" or "chronic berylliosis."

This simplification unfortunately engendered confusion because it did not indicate the different abnormal tissue response in the two entities and, furthermore, fostered an erroneous interpretation that a time element is the sole point of difference.

VanOrdstrand and I are in agreement that the term "acute beryllium chemical pneumonopathy" is probably the most basically descriptive, from an epidemiological and clinical viewpoint, when discussing the acute type of pulmonary reaction. The term "berylliosis" has gradually become accepted, in literature and law, to describe the syndrome associated with somewhat more specific, chronic abnormal tissue changes in the lung parenchyma along with variable secondary systemic alterations.

Berylliosis

A satisfactory definition for this disease entity is currently virtually impossible. There are observers who prefer to classify the entity as a systemic disease or intoxication, the lung manifestations being only a part of the entire syndrome. They postulate their opinion on the existence in an appreciable number of cases of associated specific type of abnormal tissue reaction in other organs. However, there has been no documented case showing clinical evidence of "systemic berylliosis" without the lungs being the critical organ involved. From the evidence in literature it can reasonably be asserted that berylliosis may be considered a systemic reaction, induced by the beryllium ion, but consistently having its primary and major expression of disease in the lungs.

All current epidemiological evidences indicate that the major causation in the existing cases was beryllium oxide having certain physico-chemical characteristics. A refined experimental study, now in progress, supports this philosophy.

Subject Symptoms and Objective Findings

The subjective symptoms in chronic beryllium-associated pulmonary disease are nonspecific. The most prominent is that of

shortness of breath on exertion and in the severe cases, at rest. Cough, usually non-productive, occurs in the great majority of cases. A varying degree of weight loss has been determined in more than half of the cases. Subjective symptoms occurring in the minority include fatigue, chest pains, loss of appetite and weakness in descending order of frequency. Any or all of these subjective symptoms may be present, ranging in intensity from a very minor order to a very profound state.

Objective findings are relatively sparse, with less than half of the cases demonstrating abnormal breath sounds on stethoscopic examination. Blueness of nail beds and/or mucous membranes is noted in about 40 per cent of the cases, with clubbing of the fingers and/or toes in about 30 per cent. Liver enlargement has been detected in 5 per cent and spleen enlargement in 3 per cent.

Clinical Laboratory

Routine blood studies are usually within accepted normal limits. The red corpuscle sedimentation rate is commonly increased. A relative increase in red cell count, without increase in the white count nor appreciable alteration in the differential, has been noted in the more severe cases. A relative increase in the gamma globulin fraction of the blood serum has frequently been reported.

Standard urinalysis is non-informative. Increased excretion of calcium in the urine has been reported to have been noted in an appreciable number of cases. Extensive studies on active and inactive beryllium workers, both with and without evidences of the disease, have shown the constant elimination of beryllium body burden via the urinary tract, without any correlation to the degree of exposure nor to the presence or absence of the specific disease.

Respiratory Functional Abnormalities

Only about 6 per cent of the total documented cases of berylliosis have had any significant studies on the associated respiratory physiological changes. The only constant findings, in all the cases studied, were those of a) decreased vital capacity, b) decreased A–a O_2 gradient, and c) decreased diffusive capacity for oxygen. These were followed, in order of decreasing frequency, by findings of a) decreased resting oxygen saturation, b) increased physiological dead space, c) decreased maximal breathing capacity, d) data suggesting obstructive emphysema and e) polycythemia.

The results indicated that the chronic pulmonary lesions associated with beryllium caused an "alveolar-capiliary block" syndrome of rather profound degree.

Radiological Patterns

The x-ray changes seen in berylliosis cases were initially considered to fall into three distinctive stages.

The first stage is described as a diffuse, fine, uniform, distinctly particulate granularity.

The second stage was characterized as diffuse, reticular pattern superimposed on the initial granularity.

The third stage was characterized by the presence of uniformly distributed nodulations.

At a later date, a fourth stage, that of consolidation, was described.

This concept that there are stages of the disease has been questioned by some observers. They believe that although a progression pattern may exist, there are other evidences that these various x-ray changes represent types of disease rather than stages.

With the possible exception of the finely granular pattern, there is nothing in the other varieties that can be considered pathognomonic, i.e., peculiar to the specific problem.

Complications

Except for the development of cor pulmonale, complications of berylliosis have been few. The occurrence of local or sectional lung tissue collapse in about 15 per cent of cases and of kidney stones in about 10 per cent is considered a primary manifestation of the disease. The clinical evidences in two geographical areas do not fully support the relationship of kidney stones as a directly associated problem, as postulated by one group of observers.

The complication of cor pulmonale is probably of greater clinical significance than the primary disease entity itself. The evidences indicate that this complication is probably the prime cause of fatality in the cases.

Unlike silicosis, the occurrence of tuber-

culosis in beryllium cases has been correspondingly rare, particularly since many of such cases had been institutionalized in sanatoria for the treatment of tuberculosis as a result of misdiagnosis. There are six documented cases, reported as having this complication.

Lung cancer has been similarly rare. The current case registry report indicates one case among the chronic disease group and two cases in the acute disease group. There are no recorded cases of bone tumors in the case registry.

Extreme anxiety and reactive depressive states were rather common in the earliest and most severely afflicted cases. These were associated with the very gloomy prognosis that existed in those days.

Complications associated with the use of steroid drugs, as a beneficiating therapeutic agent, have been rare, occurring as stomach irritation, transient elevation of urinary sugar excretion level and psychological disturbances.

Therapy and Prognosis

Prior to the advent of ACTH and the adrenal steroids, the treatment of berylliosis was limited to the use of oxygen plus various supportive drugs. Sulfonamides, penicillin and cytochrome-C were tried without success. Experimental systematic use of various beryllium chelating agents was similarly ineffective. Except for the very mild and apparently stabilized cases, the prognosis was, at the very best, very guarded. Incipient death from pulmonary or cardiac insufficiency, or at best, permanent major physical disability was the usual course.

The current medical evidences indicate that the routine therapeutic use of adrenal steroid drugs are of definite benfit. In some cases the clinical improvement has been very dramatic. Some clinicians indicate cases showing both "complete" clinical and roentgenological reversions to normal. Whether this effect is permanent or merely a transient phenomenon is currently an equivocal question. A symmetrically improved prognostic attitude is currently the general rule.

Diagnosis

The diagnosis is originally a reasonably presumptive one when an individual, having known of reasonably possible exposure to [illegible] presents a diffuse alteration in the lung x-ray pattern, accompanied by a varying degree of evidences of capillary-alveolar block, i.e., interference with diffusion of oxygen through the air sac membranes. It is a reasonably probable one when the x-ray abnormality is that of a diffuse, bilateral fine granularity. It becomes a rather firmly documented one only when the other entities causing capillary-alveolar block are ruled out. Generally, the majority of these entities offer little, if any, problem. In some instances, it is necessary to resort to abnormal tissue identification by biopsy.

Positive chemical or spectrographic assay for beryllium in body fluid or tissue provides incontestable evidence of significant exposure to the element. However, the mere presence of the element in body fluids or tissues does not, in itself, indicate the existence of a specific disease process.

Differential Diagnosis

Any chronic diffuse pulmonary disease must be considered in the differential diagnosis of berylliosis. The granular type of reaction, on x-ray, must be differentiated from rheumatic pneumonitis, erythema nodosa, lupus and virus pneumonitis. The nodular type, from other pneumoconioses, sarcoidosis, miliary tuberculosis, mycoses, miliary carcinomatosis, malignant lymphoma, pulmonary adenomatosis, alveolar proteinosis, chronic interstitial fibrosing pneumonitis (Hamman-Rich), etc.

The major diagnostic problem has been that associated with sarcoidosis.

The x-ray changes and the histopathological pattern in the fairly recently described "farmer's lung" are currently considered as not distinguishable from berylliosis.

Industrial Hygiene Aspects

The prevention of undue exposure of respirable beryllium to both workers and the general public is the prime function of the industrial hygiene engineer.

What constitutes an undue level of exposure has never been unequivocally determined. In 1949, two consultants for the United States Atomic Energy Commission were requested to make specific recommendations for adequate industrial hygienic controls of beryllium air pollution.

Having some evidences that both acute and chronic types of respiratory occupational response had occurred due to exposures at levels above 100 micrograms of beryllium content in one cubic meter of air, they assumed the 100 microgram dosage as possibly being the minimal toxic dose for the most reactive compounds in use.

The first recommendation was intended for the prevention of any acute type of occupational respiratory disease. The first comprehensive survey on occupational operational levels of beryllium exposure were conducted by the A.E.C. at the Lorain, Ohio, beryllium refinery in 1947 and 1948. During this environmental survey, it was noted that there were no recorded cases of any type among employees in a specific area of the refinery. All the air pollution data showed results below 25 micrograms/M³. This observation fostered the initially recommended target of 25 micrograms/³ peak value, without a time factor.

Having absolutely no data that could be used as the target for the prevention of the chronic type of occupational respiratory response, they resorted to an "educated" guess. They made the assumption that beryllium was probably as toxic as the heavy metals, lead and mercury. They then reasoned that an atom-for-atom extrapolation was logical, taking the atomic weights of 200 for mercury and 207 for lead, they divided them by 9, the atomic weight of beryllium. They rounded out the results to the "whole" number 25. This constituted the comparative atomic weight factor. They then divided this factor of 25 into the previously assumed minimal toxic dose of 100 micrograms, yielding a figure of 4 micrograms. After more debate, they decided to apply an additional factor of safety and came up with the recommended target level, on a daily weighted average basis, of 2 micrograms of beryllium content per cubic meter of air.

The third recommendation is intended to prevent the occurrence of the chronic type of beryllium-associated respiratory disease in the general public living within the air pollution influence of the beryllium producing or using plant. Extensive air sampling was conducted in 1948 and 1949 in such an area of influence where non-occupational exposure cases of the chronic disease had previously occurred. The weighted average of the results was 0.1 microgram beryllium per cubic meter of air. Reasoning that the residents were potentially exposed on a continual basis, the consultants decided to apply a safety factor of 10. The recommended target of 0.01 micrograms was established. At first sight this seems to represent a 1 : 200 ratio on comparison with the recommended in-plant target of 2.0 micrograms. The time factor of 40 hours/week in-plant exposure versus 164 hours/week outdoor exposures reduces this ratio to approximately 1 : 50. This ratio is actually not as morbid in its connotation as it may appear at first sight. Such ratios in outdoor to workroom recommended maximum allowable concentrations exist for other potentially toxic elements or compounds. A ratio of 1 : 100 exists for inorganic arsenic, fluorides and HF, 1 : 70 for lead, 1 : 67 for hydrogen sulfide, 1 : 33 for manganese, and 1 : 30 for mercury.

These recommendations governing beryllium refinery operations became effective in 1949. Based on data and experiences gathered during the passage of time, modifications have been made in these original recommendations, involving both the concentration and the time factors. The following brief compend describes the current A.E.C. recommendations, issued in 1957.

In-Plant—Weighted Averages

1. The daily weighted average in-plan atmospheric beryllium concentration should not exceed 2.0 micrograms/M³.

2. This daily weighted average is computed on a quarterly experience basis.

3. A daily weighted average exceeding 2.0 micrograms/M³ but not in excess of 5.0 micrograms/M³ will not be permitted to exist for a period exceeding 60 days without A.E.C. specific approval.

4. A daily weighted average exceeding 5.0 micrograms/M³ calls for immediate corrective action on the operation in question.

Single Exposures

1. Any single air sample in excess of 25 micrograms/M³, within an operating area, but less than 100 micrograms/M³, must be reconfirmed within 10 days of the incident. If the condition is static, corrective action must be taken to reduce the level to below 25 micrograms/M³.

2. Concentrations above 25 micrograms/M³, but less than 100 micrograms/M³, will not be permitted to exist for a period exceeding 60 days without A.E.C. specific approval

3. If the single sample concentration exceeds 100 micrograms/M³, the finding must be reconfirmed in 10 days. If the condition is static, the operation in question is halted and corrective measures taken to reduce the level below 25 micrograms/M³.

Out-Plant

1. In the neighborhood of the plant handling beryllium compounds, the average at the breathing zone level should not exceed 0.01 micrograms/M³, calculated on a monthly basis.

2. A monthly average concentration in excess of 0.01 micrograms/M³ but not exceeding 0.05 micrograms/M³ calls for corrective procedures. Such concentrations will not be permitted to exist for more than 60 days without A.E.C. specific approval.

3. Monthly average concentration in excess of 0.05 micrograms/M³ calls for cessation of operations until corrective measures are taken to reduce the level to at least 0.01 micrograms/M³.

Incidence: Statistical Reports

A beryllium-associated disease case registry is sponsored by the United States Atomic Energy Commission in order to coordinate and evaluate the statistical data generated throughout the United States. The registry has been managed by Dr. Harriet L. Hardy, currently associated with the Medical Department, Occupational Medical Service, Massachusetts Institute of Technology, Cambridge, Massachusetts. The first published reports on the data came out in 1961 in a monograph entitled "Toxicity of Beryllium Compounds," authored by Drs. Tepper and Hardy and Mr. Chamberlin. Some alterations in these data have been presented by Dr. Harriet Hardy in her article entitled, "Beryllium Case Registry Progress Report: 1962," in the "Archives of Environmental Health" issue of September, 1962.

The data in the monograph on the incidence of the "acute" type of respiratory beryllium associated disease indicates a total of 249 cases. Case incidence distribution by the type of industry is documented as 214, or 89.9 per cent in beryllium refining, 18, or 8.4 per cent in metallurgy or metal working, 13, or 5.2 per cent in fluorescent phosphor use or production, 3, or 1.2 per cent in ceramics, and 1, or 0.4 per cent in toxicological research.

The monograph data further indicates an "acute disease" attack rate in the Lorain, Ohio, beryllium refinery from 1940 to 1948 among 1850 personnel of 7.1 per cent in 1613 male employees, 5.9 per cent in 237 female employees, with an averaged attack rate of 6.9 per cent. These rather symmetrical incidence data give support to the existence of a standard sigmoid dose-response curve in the acute type of disease. However, the attack rate for the chronic type, in the same group shows an incidence of 18 cases, with a 0.6 per cent incidence in the males, 2.9 per cent in the females, with a general incidence of 0.9 per cent.

The ratio of 1 : 5 prevalence in the female is symmetrically paralleled by the case incidence of 15 females and 3 males in the non-occupational group associated with the specific refinery. It is readily apparent that a dose-response curve will not apply. Dr. Lieben, currently doing an epidemiological study in the area of the major beryllium producer, has indicated an occupational incidence of 0.5 per cent and also has noted a predilection for incidence in the female. The medical director for a fluorescent phosphor producer, whose experience has produced the largest single group of chronic cases, indicates an over-all incidence of approximately 1 per cent. The predilection for female attack in the latter group would not be apparent because the labor force was predominantly female. The monograph data indicates an 83 per cent incidence in the female among the 46 non-occupational cases.

The author of this report has observed another rather unexpected feature in the 22 definite, probable or possible chronic cases on The Brush Beryllium Company roster. Puzzled by the absence of any evidence of chronic case disease incidence in long-term employees, a complete study of the exposure time factor was made on all employees. This study indicated, in the cases of chronic disease, a minimum of 56 hours exposure to a maximum of 1054 hours exposure, all prior to the adoption of modern industrial hygiene technology.

Two cases occurred in personnel whose job assignments were in non-production areas, but who had need or occasion to enter in or travel through high-level exposure areas. Although both were long-term employees, the study on their occupational activities elicited the fact that their high-level exposure time extrapolated to 320 and 515 hours.

The case registry data indicates a chronic case total incidence of 395. It is indicated that 28 of these had prior incidence of the acute type. The refinery case group contributed 8 of these. This would indicate that 20 out of the residual 35 cases diagnosed as "acute" in industries other than beryllium refining had lapsed into the chronic type. This would represent a 57 per cent incidence. This is in sharp contrast to the 4 per cent incidence in the Lorain refinery experience, 8 out of 169 acute cases.

There are possibly two reasonable explanations for such a marked discrepancy. First, the medical diagnosis could have been wrong in any given number of cases. The second possibility is rather provocative. It embraces the philosophy that if the diagnosis of beryllium associated respiratory disease was theoretically correct, the medical observer was actually seeing, not the acute type as described in this treatise, but rather an aprupt onset of the chronic type of beryllium-associated respiratory disease. This would be analagous to the insidious and fulminating classification applied to the acute beryllium chemical pneumonopathy.

The case distribution by sex is 200 male and 195 female. The case distribution by type of industry is listed as 236 or 56.2 per cent in the fluorescent phosphor production or use, 74 or 17.6 per cent in metallurgy and metal working, 46 or 11 per cent in the non-occupational group, 36 or 8.6 per cent in beryllium refining, 25 or 6 per cent in ceramics, and 3 or 0.7 per cent in toxicological research. The total of 420 is not in agreement with the total of 395 listed in the basic total incidence table. There is a footnote in reference to the indicated total of 420 to the effect that "25 exposed in more than one industry".

The case registry data on the age-onset factor is neither informative nor provocative. The data on ethnic and racial incidence is not informative nor provocative.

There is considerable comment in literature regarding the rather unusual labile latency or "incubation" period between last known exposure and the overt clinical manifestation of the chronic disease. Analyses of the early results in a current experimental probe suggest that this feature could well be the function of varying physico-chemical characteristics of the beryllium compound involved in the exposure. This factor could also give a reasonable explanation for the varying degrees of morbidity.

Summation

1. The acute types of beryllium-associated diseases are apparently not specific.

2. Berylliosis, as experienced in the human, expresses itself primarily as a diffuse disease of the lungs.

3. Other vital organs may show varying degrees of primary type of involvement.

4. The clinical syndrome is non-specific, and is that associated with "capillary alveolar block."

5. The chest roentgenogram is non-specific for the purpose of establishing a firm diagnosis.

6. The histopathological expression of granulomatosis offers a more reliable diagnosis criterion, but is not uniquely specific.

7. The detection of beryllium in body fluids or tissue is irrefutable evidence of exposure but, in itself, not diagnostic.

8. Epidemiological evidence indicate that berylliosis presents certain features that are indicative or suggestive of host-sensitivity. These evidences include:

a) a relatively low incidence, approximately 1 per cent, in three geographical areas where the exposure numbers were adequate for comparative studies.

b) a remarkable absence of a dose-response curve that would have to be present if the problem were simply that of an element or compound intoxication or poisoning.

c) a preferential incidence in the female sex.

d) a time-exposure factor as detected in the study of cases generated in a refinery, and

e) the reports of spontaneous reversions.

Only the latter evidence could be equivocal on the basis that such instances were erroneous diagnoses.

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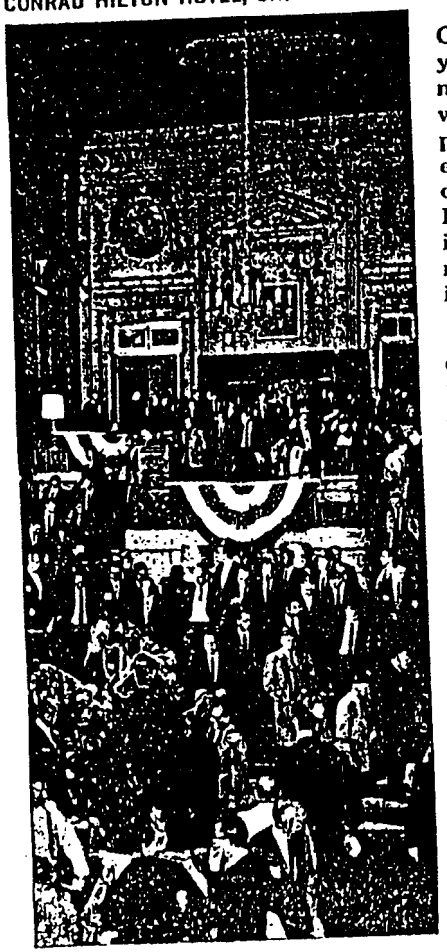

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INDUSTRIAL HYGIENE

By HENRY F. SMYTH, JR.
Mellon Institute, Pittsburgh, Pa.

Do you often see an industrial hygienist in your work place? They are not very abundant. In the United States there is one for about 40,000 employed persons, and there are even fewer in the rest of the world. We have more corporation presidents than we have industrial hygienists. An industrial hygienist need not be conspicuous when he is at work. There might have been one doing his job in your shop last week without your seeing him. But whether you've seen him or not, it is likely that you will live longer and be more useful if an industrial hygienist has looked over your shop, made recommendations to management about your working conditions, convinced them, and seen that his recommendations were carried out.

There is some disagreement about the name "industrial hygiene" and the professional title "industrial hygienist." On this morning's program Floyd Van Atta's remarks are titled occupational health, although his own title is industrial hygienist. My remarks are titled industrial hygiene, but the department in which I work is identified as chemical hygiene. Don Fowler is going to talk about industrial health, but his own title is industrial hygienist. An even wider variety of names might have appeared—environmental hygiene, or environmental sanitation would be considered appropriate by some people.

All of these names mean the same thing, the promotion of efficient, useful work with possibly harmful materials, without injury or ailing. There is some precedent for the physician speaking of his activities as directed toward health, while the engineer or chemist works at hygiene.

It seems to me that disability or disease must have been caused by occupation ever since mankind became sufficiently social for the division of labor, for specialization. Possibly the paleolithic makers of flint arrow heads suffered from silicosis half a million years ago. We know that some industrial diseases were recognized a long time ago. Writing in the fourth century before Christ, Hippocrates, the father of medicine, discussed the effects of lead poisoning among miners and metallurgical workers.

An early example of the preventive efforts we call industrial hygiene can be found in Pliny's description of industrial operations during the first century after Christ. He relates that workers refining mercury put bladders over the face to avoid breathing the dust. Agricola, describing the mining industry of the fifteen hundreds, related that some women in the Carpathian mountains had as many as seven husbands during their lifetime, the men dying of lung diseases from the dust they breathed in the mines.[2] He described machines which were sometimes used for forcing fresh air down into the mines to control temperature and humidity, and to reduce the breathing of dust.

The first comprehensive treatise on occupational diseases was written in 1700 by Bernardini Ramazzini, a physician of Modent, in Italy. He paints a rather dark picture of the health of workers, as follows:

> Various and manifold is the harvest of diseases reaped by certain workers from the crafts and trades that they pursue; all the profit that they get is fatal injury to their health. That crop germinates mostly, I think, from two causes. The first and most potent is the harmful character of the materials that they handle, for these emit noxious vapors and very fine particles inimical to human beings and induce particular diseases; the second cause I ascribe to certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the vital machine is so impaired that serious diseases gradually develop therefrom.[3]

After discussing earlier treatises which mention troubles of miners, he writes:

> We should not assume that miners in the mines nowadays are really better treated, for though they are well protected with clothes and nourished by suitable food, they come up into the untainted open air looking as ghastly as the retinue of the god of the underworld because of their stay in those foul dark places. Whatever metal they mine, they invite dreadful diseases which too often mock at every remedy, even supposing that some suitable remedy is duly prescribed; though it would seem to be a question whether it can be considered a pious duty to administer medical aid and thus prolong their lives to the bitter end.[4]

Although Ramazzini's book is primarily about the recognition and treatment of diseases caused by the occupations, scattered through it are descriptions of actions taken to prevent disease, such as: turning the face away from a source of dust or vapor, wearing a mask of bladder or glass to reduce inhalation of dust, working only short shifts in hot or particularly dusty locations, provision of fans to blow cool clean air over the workers, and provision of clean clothing to reduce the lead exposure of painters. It is not clear whether these precautions, which are among those now recommended by industrial hygienists, were devised by workers trying to increase their own comfort and safety, or by supervisers trying to obtain greater production. In any event, it is only recently that industrial hygiene has been the full-time concern of specifically designated and trained people.

Today the requirements of industry bring an adult worker for one-fourth of his life into a substantially constant environment, where hour after hour and day after day he performs the same task, often with the possibility of contacting and absorbing the chemicals with which he works. He handles not only the traditional dangerous materials of the medieval artisan, but also many newly created materials. Some, he uses in quantities which would have been incredible a few centuries ago; the total number of industrial workers today would have been incredible then, too.

It might be thought that the industrialization of trades would have increased the frequency of injuries from chemicals but such is not the case, largely because of the body of principles and experience known as industrial hygiene. The assembly of workers into factories where large groups handle the same materials for long periods can actually be beneficial to health, compared to conditions in the shops of the artisans. Problems are created but others are solved. Workers using potentially dangerous chemicals are now accessible to careful medical observation for the detection of adverse response at stages where the effects are still reversible.

Supervision is available for instruction in safe working methods. Installations are planned for safe operation and, when no other means will serve, protective equipment is provided and maintained by experts. [illegible] much less likely to be injured than was his ancient fore-runner in similar occupations. But the situation of today does not justify complacency. Much remains to be done. In particular, agricultural workers, maintenance and repair men have not benefitted in proportion to those in factories. Methods of communicating what is known have not been devised to reach these workers. Improvements in the health of workers are almost proportional to the size of the groups in which they labor.

The thing which was not done in Ramazzini's time, or until very recently, is to identify and measure each possibly injurious contaminant and stress in the working environment. With measurement it becomes possible to compare exposures in different shops doing similar work, and to maintain useful records of experience. By comparison of present measurements with recorded experience, or with the conclusions of research on new substances and situations, the industrial hygienist tries to anticipate and to prevent harmful conditions. He applies controls to potentially injurious situations, in order to prevent the occurrence of injury, or of discomfort sufficient to reduce working efficiency.

The accumulation of experience (records of measurements of substances and stresses in work places, related to the presence or absence of effects on health) has verified our conviction, that any substance or process can be safely utilized in industry, if its use is sufficiently important to be worth the cost of protecting the workers. This is the basic viewpoint of industrial hygiene, that anything can be safely used. The cost involved may be that of equipment, such as for ventilation, or it may be that of decreased productivity, perhaps because of the inefficiency of operation through remote controls, or when hardened with protective clothing, masks, or respirators.

The demand for persons trained to be industrial hygienists arose because of the passage of workmen's compensation acts. These laws could never have been written or enforced if people had not begun to lose the self centered attitudes of the jungle. Men of good will had not become common in all walks of life. It had to become accepted that the employer has a responsibility to see that the work he pays for can be done in reasonable comfort, without injury to the worker. The new laws implemented the already agreed upon responsibilities. The employer needed a specialist to help him discharge his responsibilities; governmental agencies needed specialists to guide some employers and to monitor all. Thus arose the need which the industrial hygienist fills.

The name "industrial hygiene" was sufficiently well-known early in this century for the American Public Health Association to establish an Industrial Hygiene Section in 1914, for the U.S. Public Health Service to use it as part of the name of a division in 1915, and for the Journal of Industrial Hygiene to be founded in 1919. Industrial hygienists had a sufficient sense of common interest and unique purpose to establish the American Conference of Governmental Industrial Hygienists in 1938, and the American Industrial Hygiene Association in 1939. The members of these organizations now regard themselves as constituting a profession. Like the older professions, they are taking various steps to assert their professional status. Through technical committees they are collecting, organizing and publishing for themselves the facts which they utilize in their activities. Through a certifying board they are conferring recognition on colleagues of demonstrated competence, hoping thereby to discourage the activities of incompetent pretenders. They are taking steps to set the standards for the education of their successors.

One distinction between a craft or trade and a profession is that the practitioners of a profession feel that their work is devoted in part to some high purpose in the public interest. The lawyer feels that his profession works for justice, the journalist for truth, the physician for individual health. Industrial hygiene is one of several non-medical professions which work together for public health; it concentrates on the not insignificant area of occupational health, on the control of the industrial environment to allow efficient and healthful work. Industrial hygiene has recently been defined as the science and art devoted to the recognition, evaluation, and control of those environmental factors or stresses, arising in or from the work place, which may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among the citizens of the community."[1]

The industrial hygienist is one member of the group whose joint efforts are required for the maintenance of occupational health. Others of the group are the physician, the nurse and the worker himself. Each has his unique responsibilities, and one cannot perform the functions of another. The industrial hygienist studies the work operations and processes; he knows all of the materials and equipment used, the products and byproducts, and their possibilities for injury to health. He measures the magnitude of the exposure of workers, or of the public, to possibly harmful substances or influences, or to nuisances. He is particularly attentive to:

1. Vapors, gases, mists or dusts in the atmosphere—both those which may be injurious and those which are only unpleasant.

2. Temperature, humidity and air movement.

3. Noise—both audible and supersonic—and vibration.

4. Radiations such as short radio waves, heat, light, ultra violet, x-rays, and those from nuclear decay.

The industrial hygienist likewise considers the less measurable conditions of the work itself, such as:

1. Physiological stresses from physical exertion and abnormal postures.

2. Psychological stresses from monotony or tension.

The industrial hygienist may analyze blood, urine, expired air, fingernails, hair, and like biological materials, when this will assist in determining the amounts of substances which the worker meets in the working environment as an index of the need for control, or of the success of controls already instituted. Similar tests which may be done to determine the state of health of the individual worker are the responsibility of the physician.

The hygienist interprets the results of his examinations in terms of the ability of the working environment, or of the working methods, to reduce efficiency, to impair health or to create nuisances. The data with which he compares his results to judge whether tolerable or undesirable conditions exist are the accumulated and recorded experiences of industrial hygienists, occupational physicians and research workers in the medical

sciences. Figures relating to the concentrations of substances that may be inhaled at work without effect are known as threshold limits.

I am not certain that industrial hygienists have sufficient agreement concerning their objectives to offer a sound guide to those who decide upon threshold limit values. I quoted an official definition of industrial hygiene to the effect that it is devoted to the control of factors that may cause impaired health among workers. I wonder if this implies the full WHO definition of health as the state of complete physical, mental and social well-being, not merely the absence of disease or infirmity? Furthermore, does industrial hygiene aim to protect every single working person, no matter how susceptible he may be? Or does it aim to prevent injury to 95 per cent of the working population, relying upon pre-employment examination by the occupational physician to keep the 5 per cent of most susceptible persons out of the working area? Until we have agreement on this point, we will have uncertainty among those trying to decide on safe exposure value.

I myself think that industrial hygiene aims to control exposure to the extent that almost no workman can suffer discomfort or adverse effect, and that effects in the most susceptible develop so slowly that they will be detected by the alert occupational physician before they are irreversible. The degree of control the rest of the world expects is illustrated by a possibly true story one hears from various sources. The foreign production engineer was being shown through an American storage battery plant. It was cool, scrupulously clean, without a trace of visible dust, windows sparkled, and workmen were dressed in absolutely clean white coveralls, caps and gloves. The visitor looked about in amazement. He said he had seen nothing like it at home, for after-all, "making lead batteries is not a tea party."

The industrial hygienist should report his conclusions directly to management. At times, his recommendations for new installations or changes in working procedures to reduce unhealthy stresses will be feasible without undue expense or reduction in productivity. In the most desirable situation, his assignment has been the study of blue-

modifications in layout which will allow control of possible hazards to health more economically than would be possible in a already constructed shop.

In regard to toxic substances required in the operation, the recommendation will consist of suggesting some way in which the amount of substance reaching the worker can be reduced, without reducing the output of the shop. This might be as simple as furnishing a cover for a vat of volatile solvent, to reduce vapors in the air, or providing a bland hand cleaner so that the worker can wash without using a harmful and expensive solvent. It might be as complex as installation of local exhaust ventilation to remove vapors or dusts at their source, before they can be breathed. As a last resort, efficiency of work may have to be threatened by recommending respirators and protective clothing.

I have been speaking as if industrial hygiene is practiced by a single man who knows all the answers himself. In some organizations this is the case. A single person is engaged in the comprehensive practice of industrial hygiene. He may have been originally trained as a chemist, a physicist, an engineer or even as a biologist; but he is sufficiently experienced in other areas to handle all the parts of most any situation himself—he identifies suspicious substances or stresses; he measures environmental conditions; he plans and recommends control measures; he monitors their continued successful operation. At times he encounters conditions which he realizes could be handled better by others, and then he secures specialized consultation.

In other organizations, industrial hygiene is handled by a group. One man, who specializes in the acoustical aspects of industrial hygiene, will be measuring noise levels, and distribution in octave bands, and may be recommending control measures. Another man may practice the air pollution aspects, primarily concerned with monitoring and controlling the air borne wastes of the plant that reach the surrounding areas. Another may concentrate on the chemical aspects, recognizing and measuring gases, vapors and dusts in the environment. An engineering specialist may be primarily concerned with illumination, with heat and with ventilation to control exposure to substances. A

with the invisible, but harmful, forces of x-ray and the newer nuclear degenerative both monitoring and control. Still another hygienist may practice the toxicological aspects, the effects of foreign substances on the body—ordinarily divided into toxicology, physiology, pathology, biochemistry and the like.

Different organizations may find it necessary or practical to utilize different combinations of these specialists within a specialty, depending on the possible hazards of the industrial operations being carried out. The profession regards a man whose experience has been almost entirely confined to one aspect of industrial hygiene as being every bit as qualified, as distinguished, as the man whose experience has been in the comprehensive practice of industrial hygiene. The latter may be personally familiar with a wider variety of possibly injurious factors in industry, but the former has a more detailed personal knowledge of a narrower range of factors.

I have tried to give you some idea of what industrial hygiene is, and what the industrial hygienist does to control the hazards and stresses of industrial operations. Like everyone else in modern civilization, the industrial hygienist is one of a team, and this team's success is related to the degree to which its members work together.

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INDUSTRIAL HEALTH ASPECTS OF LEAD COMPOUNDS

By DON G. FOWLER

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Many years ago and up until the early twenties in this country, the use of lead was extra hazardous in industry and poisonings were the rule. They were expected. Such is no longer the case. I am proud to be a member of the profession which had a great deal to do with the reversal of this situation. But we industrial hygienists were not alone in our efforts at reversing the lead poisoning trend, for this job was a good example of cooperation by industrial physicians, toxicologists and hygienists. Perhaps the key effort was that of toxicology, and as we proceed further we will understand better the reason for saying so.

Due to time limits, it will not be possible to cover in a complete manner all of the various lead-using industries and the various control methods required to prevent undue human exposure. Therefore, we will discuss some of our knowledge of the effect of lead on the human system with special reference to industrial exposure and then proceed to a philosophy of control for human exposure in industry which should apply generally.

Toxicology

Because lead exists everywhere and in all biological organisms of which we have knowledge, its control in the human system consists first in the recognition in quantitative manner of what is normal or usual and, following this, the measurement quantitatively of the additional body burden imposed by the particular exposure. Generally, toxicologists work with small experimental animals such as rats, guinea pigs and rabbits. This is necessary because they must overexpose in order to determine toxic ranges from harmless to harmful. Ideally, of course, toxicologists should be able to work with human beings since the effect of the material under investigation always must be related to a human and it is well known that no experimental animal approximates sufficiently

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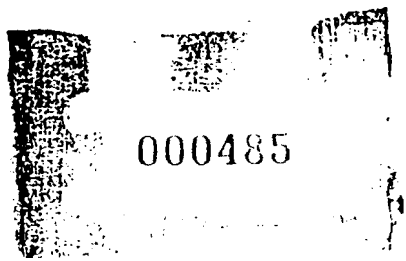
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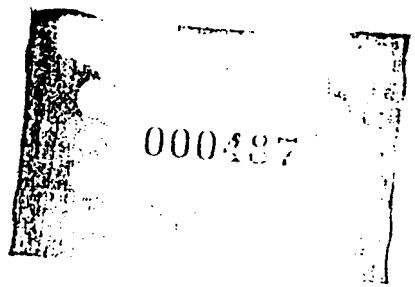

the men. The word also implies, "turn up the hearing aid," because men are unsure of themselves and need the therapeutic treatment of a supervisor who will listen.

The business world is a pretty grim place, and lurking in every shop and factory is the prospect of an accident, an injury, a catastrophy and death. These are the times that try men's souls, both on and off the job. But if you will help develop quality people, it follows that you will help develop a quality product. The quality product we are stressing today is safety attitudes, so that the world will be a better place to work and live. Safety is not a fad—safety is not a fancy; but . . . safety is an attitude.

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the application of sprinkling water applied to road surfaces to eliminate erosion and scouring of the surface by excessive amounts of water applied on grades is most important as is elimination of holes in level road surfaces caused by ponding of excessive water. Failure to clean up spill on main haulage roads is of course inexcusable, and in this connection it is suggested that inasmuch as this material is usually small, that a jeep equipped with a dozer blade would be a very effective unit to eliminate this hazard.

Safety is one of the first considerations in planning an open pit mining operation and begins with the original design of the pit. The choice of safe bench heights and bank slopes is one of the most important considerations in the early planning stages to adapt them to the physical conditions of the ground encountered. Naturally the higher the bench which can be used safely, the lower the pit development cost will be. However, physical weaknesses in the ore and waste are not always apparent at the start of the operation and dangerous falls of ground and slides may require reductions in both bench height and bank slopes to provide safe working conditions.

Haulage road grades are likewise an important consideration to safe operations. Excessive grades, above 8 per cent, result not only in higher truck maintenance costs but are a definite accident hazard. Berms placed on the crest side of ramps are helpful in minimizing accidents as is the use of left hand traffic on all pit roads so that down grade traffic is on the bank side of the road and in case of brake failure the conveyance can be run into the bank. Berms are likewise maintained to warn the driver and check the truck in backing into the dump position. Good supervision with strict attention paid to preventive maintenance go a long way in eliminating accidents in open pit operations.

DEVELOPMENTS AND ACCOMPLISHMENTS IN INDUSTRIAL SAFETY AND HYGIENE AT BRADEN COPPER COMPANY

By STANLEY M. JARRETT
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Braden Copper Company is a subsidiary of the Kennecott Copper Corporation, and it is located in Chile. The property is situated on the western slope of the Andes mountains approximately 90 miles S.E. of Santiago, the capital of Chile, and it is composed of several outlying camps which extend from Sewell—at an elevation of 7,200 feet, the highest camp—to Rancagua, a town in the central valley.

Sewell is the site of the mine and concentrator; the smelter is located in Caletones; the hydro-electric plants are in Coya and Pangal; the mill tailings are transported by a 36-mile flume line to Parrón. In Rancagua are located the general offices, foundries, shops and storage yards. Sewell, Caletones, Coya and Rancagua are linked by a 45-mile narrow gauge Diesel-electric railroad.

The climate in central Chile is generally mild without excessive variations in temperature; however, snowfalls in Sewell during the winter months range from 20 to 45 feet, while the other camps—at a lower elevation—are seldom affected.

The property is located in an area where its topography and climatic conditions present operational hazards as difficult as those found anywhere in the world.

The mine produces approximately 37,000 tons of ore per day. It is rated the largest underground copper-producing mine in the world. All ore is won through a system of progressive block-caving. The ore is dropped to the haulage level through numerous ore passes from the caving areas, a vertical distance ranging from 600 to 1,500 feet. From here it is transported by electric trains to the concentrator. The two hydro-electric plants produce an average of 55,000 [illegible] watts. Total payroll averages approximately 7,000 employees.

Accidents which injure workers, destroy machinery, burn plants to masses of twisted steel, constitute a formidable impediment to the prosperity of any enterprise. Our company considers that the prevention of industrial accidents is a vital objective of modern-day management.

The majority of accidents can be prevented by proper supervision, adequate training, and—principally—by the sincere desire on the part of management to instigate methods for accident prevention.

Braden has always had a safety program. The need for preventing industrial accidents was recognized and accepted together with the first ton of ore produced more than 57 years ago.

Prior to 1946, however, the safety effort was relegated to a service department, and the personnel entrusted with these activities lacked a most important tool: delegated authority to instigate measures necessary for the success of the program. When support was afforded, the safety personnel lacked the technical training to recommend proper control measures.

The application of safety rules was frequently resisted by the operators with the claim that production had priority over safety. Supervisors were not conditioned to accept their responsibility in the prevention of accidents, and only sporadic efforts were made to act upon safety directives.

Such lukewarm support to the safety campaign, and ineffective safety assistance to the operating departments, prevailed for many years. During this time the plant's operations experienced an average of 350 lost-time accidents per year, with approximately 15 fatalities, and frequency rates well above the national averages.

In the latter part of 1945, the General Manager of Braden issued a statement of policy, expressing that *"the prevention of industrial accidents must be an essential part of the job, and it must be the responsibility of all levels of supervision throughout the plant."*

The safety department was reorganized and placed in an autonomous position under management, and in an advisory capacity to all departments of the company. It was invested with the necessary authority to promote and carry out the many phases of an ambitious and far-reaching program, which had the following objectives:

1. Consolidate and improve upon the scattered efforts in accident prevention and industrial hygiene.

2. Preparation of comprehensive accident rates and analyses, based on internationally accepted standards, to serve as tools toward the planning and execution of the campaign.

3. Preparation and consolidation of safety rules with authority to control their compliance.

4. Training and orientation of supervisors and workers in safe practices, with special emphasis on new men.

5. Furnish and control personal protective equipment to workers exposed, and instigate a program of machinery safeguarding.

6. Field control of personnel and of working conditions, in order to eliminate accidents or industrial hygiene hazards, with recommendations and follow-up procedures.

7. Elimination of occupational disease hazards, and engineering and medical control of all personnel involved.

To this original plan we later incorporated the fire control organization and the loss prevention engineering sections, with the purpose of further consolidating all related activities.

To convince the personnel of their sincerity, management took the initiative to put their shop in order. To accomplish this, several measures were taken tending to provide the men with safer and more hygienic working environments. After this groundwork was completed, we placed ourselves in a more favorable position to solicit the cooperation of everyone to our campaign.

The following is the safety setup at Braden, both in regards to its position within the overall organization, as well as its internal structure.

Some important aspects of our program are:

Accident Statistics. A proper accident reporting system requires that each industrial injury be thoroughly investigated by the man's supervisor. In this manner we are assured of two things: (a) the supervisor will instigate corrective measures to prevent a repetition, (b) no "off-the-job" injuries

will be accepted as industrial accidents through improper control.

There is a tendency for accident statistical systems to pinpoint "unsafe acts" and "unsafe conditions," however our method tends to analyze accident trends to be used as guideposts for improving performance of men, machines and equipment. Our accident analyses are simple: they indicate *why, where, when, how* and *to whom* the bulk of the accidents are occurring. In this manner they provide a quick and up to date guide for directing our safety campaign with a minimum of time, effort and expense.

To attain the highest degree of adequate job placement, close control of every prospective employee is of paramount importance. Each man is placed on the job where his mental and physical attributes will assure his best performance. Pre-employment records contain complete information concerning the person's physical and mental condition as well as his occupational history, including the companies he has worked for, the kind of work he has done, his specialties, etc. This is necessary for a final appraisal of the man's fitness and proper job placement.

Our statistics indicate that inexperience is the greatest source of industrial accidents. Therefore every effort is made toward the early indoctrination of all new men by means of safety orientation courses, counselling, on-the-job training and constant control of their safety performance.

Safety rules are designed for the protection of the workers, and their compliance is followed through by the man's supervisor with the assistance of the safety inspector.

Other controls which guard against accidents and loss of production have been established. Personnel assigned to transportation are subjected to special safety training and required to pass annual physical checkups. This regulation comprises all locomotive engineers, cranemen, crane hitchers, hoistmen, drivers of motorized equipment, etc. Critical installations and equipment, such as pressure vessels, generators, boilers, cranes, shaft installations, cables, etc. are maintained under close control through periodic inspections and recommendations by our Loss Prevention Engineering Section.

Our principal goal is to create a safety consciousness of the personnel, so that they will be conditioned to accept their responsibility in accident prevention. We utilize safety meetings, on-the-job talks, posters and bulletin services, pamphlets, handouts, films, radio broadcasts, etc. The interest of the workers is motivated by incentive systems, such as inter-sectional safety contests, awards for good safety performance, public competitions, etc.

The entire promotional program is centered around the genuine interest of protecting workers against accidents and occupational diseases, and to make a sincere endeavor to maintain the best possible working conditions. To secure cooperation we encourage active participation of both supervisors and workers.

The fire control organization at Braden is placed under the loss prevention engineering section of the safety department on account of the close inter-relation which exists between the prevention of accidents and the prevention of fires. An industrial concern should operate with the assurance of effective safeguarding of lives, materials and installations.

Our property is spread over a wide area, with 20,000 people housed in various Braden communities. Diversified operations involve a variety of hazards, and our main concern is the adequate protection of industrial and non-industrial installations.

The underground workings, where an uncontrolled fire can have catastrophic consequences, have been suitably protected. Effective alarm systems (stench, light-flashing and telephones) permit the prompt warning and orderly evacuation of underground personnel in the event of an emergency.

"Mine Fire Procedures" have been developed, and practice fire drills are held twice yearly, in order to determine the effectiveness of alarm systems, familiarity of personnel with escape routes, isolation of the area, supervisor leadership in emergencies, etc. Under test conditions nearly 700 men scattered throughout 400 miles of workings are evacuated in less than 30 minutes.

Fire control measures introduced in our mine comprise numerous features, such as fireproofing of offices and storages, installation of concrete and steel sets in main adits carrying power lines, construction of underground shelters, sectionalizing the mine by means of steel fire doors and concrete bulkheads, etc.

Our fire control organization consists of two principal phases: fire control and fire-fighting. Through *fire control* we strive to minimize or eliminate fire hazards through constant inspection and recommendation of remedial measures; proper storage, transportation and utilization of flammable materials; constant training of workers and the general public to instigate fire-control consciousness, etc. Our *fire-fighting* facilities consist of appropriate alarm systems at all company camps; industrial fire brigades provided with all necessary equipment; automatic and portable extinguishing systems, and the accurate control of water sources and piping layouts.

The program outlined has given excellent results, and the measures described have brought about considerable savings and improvements, such as those derived from the reduction of fire insurance premiums, guarantee of continued operations, better protection of employees and their families, and improved safety attitudes on the part of the workers.

With its many diversified processes, which include mining, milling, smelting and foundries, Braden has problems of industrial hygiene which are typical to such operations. The safety department, as already mentioned, has an adequately staffed industrial hygiene section, fully equipped to render services to departments having problems falling under this specialty.

Our mine is comparatively dry. With more than 400 miles of underground workings, the mining of 37,000 tons of ore per day by the block-caving method, plus the drilling and blasting of about 3,000 shots daily, produce dust problems which are as difficult to combat as those found in any mining operation in the world.

Prior to 1945, our mine workers showed varying stages of lung fibrosis after relatively short periods of exposure. Studies conducted by the medical department indicated that the average exposure for an underground worker to show definite x-ray evidence of silicosis was approximately 7 years. At that time there were approximately 1,400 men working underground. A labor turnover of 200 men per year was envisioned, with a very high compensation and reemployment cost.

A mechanically controlled split system of ventilation was introduced. Fresh air is drawn through the various levels to the production areas, and distributed to the working places by a series of fans ranging in capacity from 175,000 to 50,000 c.f.m. All production areas have independent fresh air supply, and re-circulation of contaminated air is not permitted. Other refinements are auxiliary blowers for dead-end drifts, steel ventilation doors and air regulators, and the driving of numerous ventilation adits and chimneys.

Due to these improvements an average of 500 c.f.m. of fresh air per man per minute is now provided, which greatly exceeds the legal requirements. Dust counts well below the maximum allowable concentrations are maintained throughout the mine.

Ventilation maps are kept up to date. They indicate velocities and direction of air currents, dust and ventilation control stations, location of fans, fire and ventilation doors, refuge chambers, emergency routes of exit, and fire-fighting equipment. By utilizing conventional color codes, these maps are a valuable asset in perfecting the ventilation system, and determining what improvements will be necessary as new workings are advanced.

In addition to controlled mechanical ventilation, the following measures were instigated to minimize the production of dust in industrial environments:

1. *100 per cent wet drilling* was enforced in all underground operations.

2. All blasting of development headings and undercutting operations is regulated to the end of the shift. This method allows sufficient time for the ventilation to clear the atmosphere of dust and gases before the oncoming shift.

3. *Water foggers* are placed in all development headings and undercutting operations. Water is turned on prior to blasting. In addition to reducing dust concentrations, these foggers also dilute harmful gases from explosives, allowing men to return to the working surface with a safer environment and a minimum of delay.

4. In all mucking operations the muck-piles are thoroughly wet down to avoid dust dispersion.

5. Strenuous underground work in high

...titudes does not generally permit the extensive use of dust respirators. However, in isolated cases where dust concentrations warrant their use, approved-type respirators are provided and their use enforced.

Braden ore contains approximately 33 per cent free silica. Early in 1946 we collected composite samples of the airborne dust from both underground mining operations and the crushing plant. Samples were forwarded to the Industrial Hygiene Foundation of America, and the United States Public Health Service. These institutions were requested to separate the samples into two-size fractions, analyzing the minus 5-micron portion for free silica by the *x-ray diffraction method*.

Since 1946 dust samples are taken at 2-minute intervals per hour at established control points through all active production areas. Dust counts are reported in "particles of free silica under 5 microns per cubic foot of air," on an 8-hour basis. In addition, a total of 86 control stations were established throughout the mine, where dust samples and airflow readings are taken periodically for control purposes. Results are reported to the mine department with recommendations for maintaining dust concentrations within permissible limits. Regular surveys are conducted by technicians who are properly trained in modern sampling techniques, micro-projection and dust counting.

Due to water shortage, it is necessary to crush dry our total tonnages. To control the dust hazard at the crushing plant, four wet-type Utah dust collectors of 35,000 c.f.m. capacity each, and one 25,000 c.f.m. air-tumbler type dust collector, have been installed. These units require approximately 360 gallons of water per minute. In order to minimize water consumption, the sludge from these collectors is run into a settling tank, which permits clarified water to be recirculated through the system. The quantity of dust collected carries sufficient copper to pay for their power consumption. Monthly surveys comprise the checking of air velocities, pressures and temperatures of all branch lines at established control points, and in this manner we determine the efficiency of these dust collecting systems.

All crushers, conveyors, elevators and other dust-producing processes are enclosed, and dust counts are maintained below the maximum allowable limits.

...section extends technical assistance to all departments for the elimination of health hazards. Surveys are continually conducted to assure that all control measures provided for the elimination of health hazards are adequately maintained. Exhaust systems have been installed on all dust or fume-producing processes, such as arc welding, grinding, cleaning of castings, spray painting, sand blasting, reagent mixing, etc. This section assists in the design and control of proper maintenance of air conditioning systems, temperature control, illumination, and general ventilation of industrial and non-industrial installations throughout the property.

Modern techniques are being constantly introduced for the elimination of occupational diseases. With the aid of our medical staff and the cooperation of all departments, silicosis and other health hazards have been practically eradicated from our operations.

Since year 1947 we have won the Inter-American Safety Council's "Safety Plaque" *for 15 consecutive years*, for attaining the lowest frequency of accidents among all large-scale participating mining companies throughout Latin America.

Since May 28, 1958, to December 11, 1961, all departments of the company completed *three years and four months, with over 56 million man-hours of exposure and a production of nearly 40 million tons of ore mined and processed without a fatality.*

During the past five years the total plant has operated with a frequency rate of approximately 5.00 per million man-hours of exposure. The cost of compensations has decreased by about 80 per cent in the 10-year period 1951-1961.

When an enterprise attains *low accident and fatality frequencies*, accompanied by consistent reductions in the cost and the severity of industrial accidents, it is indicative of good safety performance, and that no *"juggling of statistics"* is either utilized or necessary.

Such records, which rank among the best in the metal mining world, indicate that accidents can be prevented if there exists the right climate for their elimination. To bring about this climate certain favorable factors were necessary.

The most important and effective of these factors has been *the acceptance by our management of their responsibility in accident prevention, and their sustained support of the safety program.* They have taken the initiative, and made it known—in no uncertain terms—throughout all ranks in the organization. They have applied the same executive ability to the prevention of accidents which they exercise in securing efficient production, and the elimination of waste and obsolescence.

In the safety program, management has taken the lead and set the pace for everyone in the plant. They rely upon department heads, and these in turn rely upon section supervisors (by assigning responsibility and authority) to carry out the policy set forth by top management. They are generous in their praise for good performance; however every man in the organization is made to feel that safety is a policy, not a convenience.

This is not the final solution. Safety's worst enemy is complacency, and we exercise a helpful and perseverant drive to keep supervisors and workers continually on their toes. Communications play an important part in our safety program—each and every man must be reached by personal contact. We discuss their problems and their jobs; we resort to every possible opportunity to motivate their thinking in creating a safety consciousness and a desire to work safely.

Communications cannot be achieved without a third requirement: *adequately selected and trained supervisors.* Our supervisors are trained in the basic fundamentals of *organizing, directing, coordinating, planning, controlling, counseling*, etc., so as to prepare them to become capable of properly utilizing the basic resources of management. We firmly believe that the front-line supervisor is the key-man for getting things done. He stands before his work group as a representative of management, and transmits directives to each one of his men by word and deed. It is not only a matter of what a supervisor knows, but what he is able to impart to his men that really counts in safety as well as in production. *He is ultimately responsible for the attitude and performance of the workers.* No one is considered for promotion unless he has demonstrated a good safety performance.

Our company has adopted a policy of selecting supervisors from the major departments for advanced safety training, for periods ranging from four to six months. These men are taught accident statistics, investigation of accidents, fire control, inspection techniques, ventilation, dust control, instrumentation, safety indoctrination of workers, conduction of meetings, report writing, etc. When these men return to their original departments, they naturally exert a strong influence in behalf of safety and industrial hygiene, and become the necessary multipliers of the safety effort among their fellow supervisors and workers.

We avail ourselves of all possible modern technical information that can be utilized in the improvement of working environments. We are members of the National and Inter-American Safety councils, the Industrial Hygiene Foundation of America, the National Fire Protection Association; we subscribe to numerous periodicals and have formed a large safety and technical library. In this manner we are constantly striving to introduce new techniques, equipment or training aids to our safety program.

We realize that no defense ever built was impregnable against a well-planned offensive, and our entire resources are geared to this end. Our industrial workers require more guidance and more technical know-how than the unskilled worker of ten years ago. The rapid technological advances in industry require men of higher mentality and better-conditioned attitudes. To develop safer industrial supervisors and workers we have instituted a constant training program capable of satisfying the ever-increasing demands of industry. Our training facilities are also extended to include fiscal and semi-fiscal institutions, managers and technicians from private companies, universities, technical and public schools, etc.

As a result of this policy, our safety program has had favorable response in the field of industrial and public relations. Furthermore, by pioneering in the field of safety, we—in some respects—have become a law unto ourselves. The very organizations and officials assigned to control the compliance of safety and industrial hygiene codes and regulations, often request our assistance and look to us for counsel and guidance.

At Braden, accidents and occupational diseases have been greatly reduced through proper application of a few basic principles of human engineering, the cooperation of the employees, and the honest desire of the management to make industry a safer place to work and to live.

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of its meaning. Now there are a number of things on which we can all agree.

1. In an enlightened work group there is little need for enforcement.

2. If we knew all there was to know about human behavior and could accurately predict human actions, we could eliminate unsafe acts by education rather than enforcement.

3. It is far better to stress the positive aspects of safety rather than the negative connotation conveyed by the word "enforcement."

4. When people are convinced that safety is in their own interest, then enforcement becomes less of a necessity.

While all of this is true, it represents an ideal state of affairs. It seems that so much emphasis has been placed on approaches which minimize one of the most disagreeable duties management has to perform—that of disciplining—that the responsibility of the individual workers for safety seems to get lost. After all, enforcement presupposes that the individual worker is held accountable.

What I am trying to say is that we in management have not been tough enough in enforcing our own safety standards. Perhaps we have been so busy trying to explain them, that we don't notice how often they are not followed. Maybe we spend so much time trying to understand our people, that we don't have enough time left to correct them. This is pure speculation on my part, but I am struck by the fact that one finds so few written reprimands on unsafe acts and clear violations of long standing and well publicized safety rules in most personnel files.

I am well aware that reprimands of this nature can be run into the ground rather easily, but wouldn't more of them have a beneficial affect on the safety program? Wouldn't they bring home to everyone that management is seriously concerned about the problem of unsafe acts? Until sociologists and psychologists have discovered more about why humans behave the way they do and, more important, until all of us in management become competent sociologists and psychologists, we must continue to rely on the older forms of enforcement—one of which is the reprimand, written or otherwise.

Traffic authorities obviously believe that stricter enforcement cuts down accidents, and they have a mass of evidence to prove this. We in industry have specialized problems, and the rules aren't as clear, in most cases, as traffic rules. However, we are dealing with the same causative agent—people

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SAFE HANDLING OF ADDITIVES IN THE PETROLEUM BUSINESS

By WILLIAM S. WOOD
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Additives are being used increasingly in many everyday commodities such as bread, toothpaste, steel and plastics. Usually they are intended to improve the product in some useful way, but sometimes they serve to modify or overcome the deficiencies of other additives. This discussion will be limited to additives used in products in the petroleum industry, where their growth has also been very rapid. Some heavy duty lubricants contain 20 per cent additive, and a recent estimate of annual consumption was 12 million pounds for the industry.

The following three lists show some of the many jobs that additives are expected to accomplish. Some typical examples of commonly used additives are also given.

Lubricant Additives
Anti-oxidants
Detergents
Dispersants
Pour point depressants
VI improvers
Anti-foam agents
Anti-wear agents
Anti-chatter agents
Anti-rust agents
Antiseptics
Tackiness agents
Thickeners
Odorants
Coloring agents
Emulsifiers

Motor Fuel Additives
Anti-knock agents
Anti-oxidants
Deposit modifier
Metal deactivator
Anti-icing agents
Anti-rust agent
Lubricants
Coloring agents

Jet Fuel Additives
Anti-oxidants
Metal deactivators
Corrosion inhibitors

Diesel Fuel Additives
Cetane number improvers
Stabilizers
Corrosion inhibitors
Odor masking agents

Heating Oil Additives
Combustion improvers
Dispersants
Stabilizers
Corrosion inhibitors
Metal deactivators
Ash modifiers

7 million pounds per year
Zinc dithiophosphate
Barium sulfonate
Similar
Reaction product of naphthalene & wax
Polymethacrylates
Silicones
Tricresyl phosphate
Tallow
Complex amines
Cresylic & phenolic compounds
Polyisobutylene
Polyisobutylene
Essential oils
Organic dyes
Sulfonates

5 million pounds per year
Tetraethyl lead
Phenylene diamine
Tricresyl phosphate
Disalicylal ethylenediamine
Isopropyl alcohol

Light lube oil
Organic dyes

Amyl Nitrate

Aluminum Soldiers

Our problem as safety engineers is to choose for each of these materials, used or proposed, the operating procedure and protective measures that will prevent injury to personnel and yet interfere as little as possible with production. A logical sequence in accomplishing this objective would be as follows:

1. Determine the hazardous properties of the material.

2. Provide the necessary environmental conditions.

3. Provide the necessary protective equipment.

4. Train the operators in the proper procedures and use of equipment.

The flammability hazard of an additive is inferred from flash point, vapor pressure flammable limits, ignition temperature, water solubility, etc. The familiar precautions used

with petroleum products of similar physical characteristics are to be used where applicable. Bonding, submerged discharge, and slow pumping prevent buildup of static electricity charges. Class I Group D wiring may be necessary. Good ventilation may be needed to prevent explosive concentrations of vapor.

Adequate fire extinguishers should be provided. The extinguishing agent must be effective and not react with the burning additive or form toxic gases. Highly reactive materials such as peroxides and nitrates must be stored and handled carefully to protect from heating, fire exposure or shock. The corrosive action of an additive may dictate frequent inspections and careful maintenance of lines, pumps, valves, etc. Preparation must be made to clean up effectively any spills of corrosive or otherwise hazardous material.

The toxic hazard of additives may be considered in relation to their modes of entry into the body.

Ingestion—Swallowing

Inhalation—Vapors, mists, dusts

Skin absorption—Systemic poisoning, direct or through clothing

Skin irritation—
Primary irritation
Sensitizing action

Sources of information on the hazardous properties of specific additives may be readily available, or not, depending upon how new or well-known the product is, whether the identity or composition is disclosed, and what the vendor has done to determine toxicity and other properties.

When the composition is known to be a fairly common material, the existing literature will usually yield most of the needed information. Sometimes, characteristics can be assumed on the basis of similarity to more familiar compounds. Sources of information on materials in this category include:

Sax, Dangerous Properties of Industrial Materials

NFPA Handbook of Fire Protection & Codes

Patty, Industrial Hygiene & Toxicology and other Texts

Industrial Hygiene Digest

Industrial Medicine & Surgery and other Journals

Data Sheets of Manufacturing Chemists Ass'n.

National Safety Council

American Petroleum Institute

American Industrial Hygiene Ass'n.

Information on the hazards and recommendations for handling can usually be obtained from the vendor. Often the descriptive brochure or the label on the package will serve adequately. An inquiry directed to the vendor may or may not elicit the desired data. A standard questionnaire has a fair chance of obtaining the maximum of useful information. Such a questionnaire could be submitted to the vendor's technical representative when a product is first discussed with R & D or purchasing department people.

Some of the larger manufacturers maintain toxicological laboratories to study new products before marketing; others have such studies done for them by consultants. Occasionally one receives only a brief letter stating that the product has been manufactured by them for 20 years without any difficulty. This may be more reassuring than is justified. It may be necessary for the user of an additive to make tests or have tests made by a consulting laboratory in order to be certain of the characteristics of a proposed material. Occasionally an additive will have been previously approved by a reliable agency such as the U. S. Dept. of Agriculture. Increasing use of industrial hygienists shows the best approach to collection and interpretation of such data.

Ingestion of additives is perhaps the most easily controlled in a plant situation. However, failure to wash an additive from the hands before eating, chewing gum or using tobacco can result in a sizable oral intake over a period of time. Insistence on ordinary cleanliness should be effective in most cases. Provision of an eating place separate from the working location would be very helpful in preventing ingestion.

Inhalation of toxic materials can be prevented by one of three basic alternatives:

1. Enclose the material—by closed systems, ventilated covers, etc.

2. Remove the toxicant—by ventilation, condensation, absorption.

3. Enclose the man—respirators, masks, etc.

Continuous blending devices, applicable to large scale use of an additive, enable the operators to avoid physical contact, from the time a tank car or truck is unloaded until the finished, diluted product is sampled for testing. Obvious examples are TEL handling and motor oil additive blending.

Smaller scale blends are made batch-wise and drums or smaller containers are frequently involved. Here the additive is open to the atmosphere and, if toxic, the vapor must be kept at a safe level, usually by ventilation. Mechanical agitation produces much less vapor and mist than air agitation, and low temperatures reduce vaporization. Methods for determining the concentration of a toxic substance in the atmosphere may be simple and straight forward or they may be difficult and unreliable. Here the services of a competent industrial hygienist could be invaluable.

Where it is impossible to keep the concentration of a toxic vapor below a known safe level, adequate respiratory protection must be worn by the exposed men. These may be any of the following depending upon the nature of the contaminant:

Dust respirator
Chemical cartridge respirator
Gas mask
Hose mask
Air line respirator
Self contained breathing apparatus

A few materials, used as additives in petroleum, can be absorbed through the skin in sufficient quantities to cause systemic damage. The outstanding example is TEL, but others which might be used are nitrobenzene and its homologs, amines, phenols, carbonyls, organic and inorganic salts of lead and other metals, and tri-orthocresyl phosphate. Protection from this hazard consists in preventing contact with the skin and providing for immediate removal in case of accidental contact. Rubber gloves and adequate eye protection are minimum in any case. The hazard of contaminated clothing is most effectively controlled if it is furnished and laundered by the employer.

Barrier creams can retard skin absorption but should not be substituted for protective clothing. Rubber or neoprene footwear is needed if these materials are likely to be spilled on the floor. Emergency showers should be located in the immediate area. Hot showers, proper solvents and change of clothing are needed close by in case of accidental contact. A medical check-up should follow a spill involving an appreciable skin area. Many of the materials in this category do not irritate the skin or cause any surface reaction.

These protective measures must include not only men doing the blending or handling operations, but also maintenance men opening up or otherwise working on the lines or equipment. They will be particularly vulnerable and may not be sufficiently informed of the hazards. The problem of skin irritation is by far the most predominant and is for several reasons the most difficult to handle. The experienced dermatologist is often unable to distinguish between an industrial contact and an exposure outside the working environment. Some people are extremely sensitive to materials that will have no effect on others. Sensitivity to petroleum products alone is not uncommon.

Primary irritants are those which commonly cause a dermatitis after a single contact. Acids, alkalis, amines, etc. require only short contact while less active materials require prolonged contact to have a harmful effect. Some sensitizing agents are innocuous to most skin but capable of producing dermatitis in a few susceptible individuals following repeated contacts over a long period of time. Sensitization can show up after years of contact. Eye irritants, such as alkalis and amines, can cause permanent damage very rapidly and require particular attention.

Barrier creams are of some benefit in protecting the skin against most irritants. Control of exposure, good housekeeping, personal cleanliness, frequent washing, daily showers, and frequent changes of clothing are most effective in reducing dermatitis. Rubber gloves and goggles are of course required when strong chemicals are involved. Housekeeping in the work area, proper storage, good equipment maintenance, good lighting, and good ventilation are all important factors in preventing dermatitis. Provision of good sanitary facilities is a must.

Training of supervisors, operators, maintenance men, laborers, laboratory personnel, and others having possible contact with haz-

ardous additives is a necessary part of the preventive and industrial hygiene activities. I believe we should find out all we can about each material, and then pass along all of the information that will be useful to the employees in recognizing hazards and protecting themselves.

The industrial physician should have prior knowledge regarding materials used in the plant, to assist him in recognizing and treating victims of accidental exposure. The supervisor should be alert to send to the physician employees having rash, reddening or itching of the skin, vomiting, headache, or any other symptoms that could be associated with the work. Contact of a sizable area of the body should be followed by medical checkup even if no symptoms are observed.

In turn the plant physician can be of great assistance to the safety engineer in deciding on the safety aspects of handling toxic materials and can help to sell the management on some of the needed facilities. Periodic medical examinations are of great assistance in recognizing changes caused by toxic substances. Knowledge of pre-existing conditions is often critical in the interpretation of observed symptoms. Individual health considerations may make it inadvisable for some employees to risk any possible toxic exposure.

The safety engineer, the industrial hygienist and the plant physician should work with the purchasing people and others in obtaining information on the possible hazards of additives. They should work with the engineering and maintenance departments to effect needed changes. Finally they must work with the supervisors and the men themselves to make sure that the protective measures are used effectively.

SAFETY—A WAY OF LIFE

By DR. S. L. RANKIN
Medical Advisor, Petroleum Chemicals Div., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

I have no intention of dealing with safety equipment or specific hazards; rather I would like to emphasize a philosophy, a way of thinking I feel is fundamental if we ever hope to reach our goal in safety. Safety is one of those things we think about, or rather should think about *all* the time. Until we train or discipline ourselves to do that we can't possibly achieve the fullest measure of success. Current regulations, rules, traffic codes are important; but an individual trained, thinking properly, cognizant of his responsibilities and willing to accept them, can work wonders.

Safety as a way of life makes for better living at work, at home and on the highways. It makes one thoughtful instead of thoughtless, careful instead of careless, polite instead of rude. It distinguishes between bravery and foolhardiness. It makes one a better worker, neighbor and citizen. It makes for a fuller and happier life. Life and safety are inseparable.

Last year, industry reaped a harvest of 15,000 dead. Thirty thousand died on our highways and another 30,000 were killed in our homes. Faulty equipment, mechanical failures, acts of God? No! Those were not the causes. Carelessness, thoughtlessness, lack of safety consciousness were the main causes. I've seen some of the mangled bodies, heard the cries of agony and pain, and tried to comfort the broken hearts of wives and children. And you say, being a physician, that's my job. You're right. But I say it's your job to work harder than ever to prevent the tragedies, this needless waste of life. What are you going to do about it?

At a recent meeting I heard this rumor, "Oh yes, safety is important but it's unattractive." Safety *is* important and it *is* attractive. To the man who is just for safety, it may seem unattractive; but to the man on the playing field, the game is [illegible] attractive. Get off the sidelines; put on your uniform, and get in the game. What can be more attractive than directing your interests and energies in safeguarding and protecting human life—be it at work, at home or on the highway?

Safety is an intangible quality that we can all have to the same degree. It's like patriotism. A man's job classification or social status has no bearing on the degree of patriotism he can enjoy. Safety is also a quality we can all enjoy equally.

When you publicize the fact that you work in a safe plant, just what are you inferring? That you have a safety program, that you post safety rules, that you hold safety meetings, that you give first-aid to the injured? No. When you publicize that fact, you infer a great deal more. You mean that your men are safe, they are in sound custody, they are protected from this ever present "monster," personal injury and accidental death.

But how can you hope to fulfill this obligation and keep the monster under control at all times? No safety director, no safety committee, and no single group is big enough or strong enough to do it. But through the combined daily jabs and punches of every man in the plant you can do it. Are *you* doing your share of the punching?

To be sure, if I asked this group how they felt about safety, I'd get a show of hands that, on the surface at least, would indicate that everyone was all out for safety. But I'm not too concerned about group response in a safety meeting like this, because men don't get killed in safety meetings. I'm much more concerned about your personal attitude toward safety when you're alone, out on the job where no one can watch you, or when you're out on the highway driving your car. That's the place to raise your hand high for safety, because that's the places where men get killed.

Unfortunately too many men look upon safety from the "necessary evil" point of view. Oh, they're for safety; think it's a good idea, provided it doesn't take too much time, provided it doesn't cost too much money, and provided it doesn't interfere with what they like to refer to as their personal liberties. In other words, too many of us are still "luke-warm" in the business of safety.

Many times we approach safety from the after the fact angle, after the accident the man has been injured. We shudder time before, but let tragedy strike we have time, then we're compelled to time. We investigate; write lengthy reports and make recommendations. This important and often beneficial. But about the near accidents, the close shaves the loose operating practices, the scarey chances you take every day and so far gotten away with. It's the attention you pay to those items in prevention that the true yardstick by which to measure attitude in safety. Silence is anything but golden when it comes to covering up unsafe practices. That is the time to shout, keep on shouting, until the unsafe condition or habit is corrected.

Recently I reviewed a series of 31 automobile accident reports. There were no fatalities, not even a so-called serious injury. But at least we can say that each of the 31 had the potential for a fatality or serious injury. I was interested in reviewing the reasons as listed on the accident reports. They ran something like this: car ahead had no tail light; car ahead stopped too suddenly; skidded on small patch of ice; shoulder of highway too narrow, and so on. Wait a minute—do you consider these as the real causes? How about the safety attitude of the driver? Does it not count for anything? I consider these, not as causes but the alibis. The *real* cause was the lack of adequate safety consciousness on the part of the driver.

We are truly our brother's keeper and whether we operate a truck, a department or an entire plant, we as individuals are constantly affecting the habits and lives of our fellow men. The casual word, spoken unwisely; the unsafe practice, that we secretly condone; our failure to give complete instructions; may prove some day to be a contribution to a serious injury involving one or more of our fellow men.

To be sure, we don't hurt people deliberately. We don't hit men with hammers, or trip them with rope, or send them into "gassy" tanks; but, through incomplete instructions, failure to set the proper example, or insincerity of purpose we can as

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make their working place safe. The first important tool is the committee set up. We have a general safety committee, consisting of top management people, which develops policies and devises ways to carry these to successful conclusion. All policies must be cleared through this committee. There are five sub-committees in the field to support the general safety committee. Policies are routed through each of these, and they are expected to find ways to implement them. The same policies become directives to the line organization.

Investigation is one of the most important tools any utility has to reduce injuries. At the district we investigate every accident that involved an injury requiring medical attention. We also investigate every automobile accident, regardless of extent of damage. In both types of investigation, the person who had the accident meets with his foreman or immediate supervisor; two or three other employees are also called in. These people constitute a study group, whose purpose is to determine the cause of the accident and recommend a way to prevent similar accidents in the future. All the persons present sign the report, which is transmitted through the division channels and then to the safety unit. Action is taken as required, by the various supervisors.

Inspection is made by a field inspector for the safety unit, by safety committee members and by the foremen and supervisors. The latter are constantly being stimulated for safety through staff meetings, written information from the safety unit, and committees. The entire responsibility for safety is a function of the line organization. The safety unit only assists them, by furnishing the mechanics of investigation, statistics, training classes, and forms of recognition.

Recognition is accomplished in several ways. Whenever an individual invents a safety device, it is displayed and discussed in committee and in the division that has a special interest in it. A board of director's award is given to any sizable unit which achieves one year without a lost time accident. These awards are presented at the general safety committee meeting by a member of the board of directors. The award is then displayed in the section receiving it.

Smaller units' achievements are recognized by use of the National Safety Council's Storm Flag. Whenever 1,000 days without a lost time accident are achieved, the unit receives a flag with their section name and 1,000 days stamped on it. Each time an additional 1,000 days is achieved, they receive another flag. Extensive use is made of the National Safety Council's Award of Honor. Whenever we receive one of these, the entire district is notified, the newspapers are notified, and the award is physically displayed in every section at the District on a scheduled basis. Finally, we have the American Water Works Association's award system, which we use in the same manner.

Education is accomplished through regular discussions about safe practices on the job between the foremen with his men. Pipeline conferences supply material for the foremen to use. Classes are held for foremen and supervisors. New employees are contacted by the safety unit, which checks their driving habits, discusses safe driving, and points out hazards particular to their own area of operation.

At the District, safety is considered an integral part of every job and is part of the planning for work operations and design. Accidents can be prevented; responsibility must be accepted by management, but also by supervisors, foremen, and the men. People are the only way to control injuries. They do not want injuries, and they must be helped to learn the causes of accidents and the methods of preventing them.

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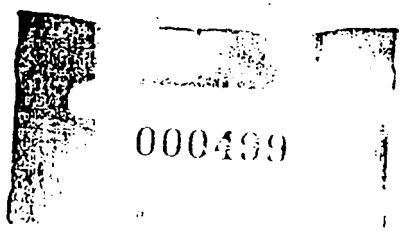
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does matter, an attitude that will reflect back on our own crews. If we let these jobs lag indefinitely, perhaps forgetting them, we are destroying the desired attitude, creating in its place a futile "what's the use?" mood.

Now we come to my real pitch. If we are to help on these problems, we must know first that a problem exists, and second we must know the degree of importance attached to the problem. The operating departments are the only ones able to furnish this information with any real degree of accuracy. I would like to interpose here the fact that in talking of departments, I am really talking of the supervisors in that department. Jobs are done by workmen, but it is the foremen, the tour bosses, the superintendents, that get things done. At least, that is the way it should be.

Say and do what we will about safety, production is the final goal. Even safety must be weighed with this in mind. Obviously, if the actions of the operating departments indicate a problem, whether production or safety, to be of minor importance, that job will be low on our priority list.

We all have a pretty direct channel for originating work, getting it done, or following up on it. But, how often is it used properly for items of safety?

Time after time we have been handed two work requests by one supervisor. One for an item of safety and one for an item of convenience. We might get great lip service on how important the safety item was, because he knows that Crossett stresses safety, and it was the proper thing to do. But he would ask then and several times a day thereafter, when we would get to the convenience item, but no further mention would be made of the safety item. Which job has he indicated to be the most important? Which job gets the highest priority? Obviously, the one he keeps pushing —the one he shows the most interest in—the convenience item.

Maintenance is a service, and we try to keep our customers happy. The squeaking wheel will get greased first. No matter what lip service he has rendered, his actions have proven to us which job is most important to him.

Although perhaps misled as to importance, we have in this instance at least been informed that a problem exists, and we can and do investigate and form our own opinion of urgency—an opinion which may, or may not, be correct. The problem is much worse when there is a hazard of which we have not even been made aware.

Once an operator becomes aware of a hazard, he should feel free to talk to his immediate supervisor with a certainty that the problem will be considered and corrective action taken where possible. This is a must if workers are to feel that safety is worthwhile, that it does mean something. Otherwise, a real "what's the use?" attitude develops.

But, it is so easy for a supervisor to take it aside, to tell the man to take it up with the safety supervisor, or have it reported to the safety committee. In other words, give the man the old run-around, pass the buck. After all, it is so much easier to let someone else do it.

There is a direct channel for getting other types of work done. Use it for safety work also, instead of letting ideas be batted around, passed back and forth, lost, dropped or avoided by all the roundabout evasive tactics that sheer laziness and unwillingness to assume responsibility can bring up.

We have a safety committee composed of representatives of the hourly men from each major department and a salaried representative of each department. The committee meets once a month to discuss difficult problems, and problems on which there seem to be no action. It's a good committee, and does quite a bit for morale. I recently looked over the notes of last year's meetings—78 items had been brought up during the year. 72 had been corrected, were being worked on, and the other few were too recent to have been started.

Statistically, that appeared excellent, but in reviewing the jobs themselves, another picture appeared. On at least two occasions when a committee member had been asked if he'd discussed it with his supervisor, he shrugged his shoulders and muttered he hadn't thought it would do any good. In several instances, the supervisor had told him to bring the job up at the next safety committee meeting. In one way or another about 60 of the 78 items represented supervisory failures.

Unfortunately, maintenance had its share of failures, too. Even so, there were approximately 55 jobs involving time but which we had never heard of until brought up by the committee.

Passing a job to the safety committee is but one way to side-step it. There are other ways to avoid responsibility, but however it is done, it damages the safety effort of the mill. It is damaging to my selfish interests, the safety of the maintenance crews.

Safety is considered so important that we have safety supervisors, safety committees, departmental meetings, and what-have-you. A lot of people get involved, and properly so. But it does make it so easy to pass the buck, to slide out from under, to let John do it, unless a great deal of care is taken.

The men on the job, the immediate supervisor and his superintendent are the ones most familiar with the area and its problems. Theirs is the responsibility for originating action and follow-up on matters affecting production. And theirs must be the responsibility for originating action on the normal safety items. And, usually they should go through the same direct procedures and actions that they would to obtain routine repairs.

The 90 per cent of safety I mentioned as being represented by attitude is fostered only by creating an atmosphere of safety. At almost any mill with a good safety record, safety can be almost felt by a stranger coming into the mill. It seems to be part of the atmosphere.

One definition Webster gives for atmosphere is, "A surrounding or pervading influence." This definition describes our desires very well. To keep a high level in our safety attitude, we must surround our people with the knowledge that we are interested in safety. We want thoughts of safety to pervade, to spread throughout all their thoughts and habits. If we can create this atmosphere of safety, we will have a safe plant. By lack of proper attention to the ten per cent of safety represented by the physical features, we can destroy this atmosphere and the other 90 per cent of safety.

Now, if I have created the impression that I think maintenance departments are good, above the average departments, it was because I wanted to create that impression. If you check thoroughly, you will probably find that it is true in your own mill. Normally, ours is the job having the greatest exposure to hazard. Yet, in our mill, in terms of frequency rate, the maintenance department ranks with the best. We have accumulated as much as 1,500,000 manhours between disabling injuries. As far as I know, no other single department within our mill has approached that.

That our mill is not unique in this matter is witnessed by the comments I have heard more than one safety director make to the effect that maintenance must lead the way to any effective safety program.

We of maintenance are not only willing to help, but selfishly eager to do so. But to do so efficiently, we must know first that someone has a problem, and second we must know how important that problem is considered to be, so that it can be given its rightful place in our work schedules.

SAFE CHEMICAL RECOVERY BOILER OPERATIONS

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The chemical recovery boiler has become an indispensable part of modern Kraft pulp mills. The recovery unit reclaims over 90 per cent of the chemicals used for cooking wood chips so that the reprocessed chemicals can be returned to the digesters and used over again. The heat reclaimed in high pressure steam from burning the waste black liquor can be used to generate approximately 50 per cent of the power requirements of the mill. The low pressure steam discharged from the back pressure turbines will supply approximately 50 per cent of the process

The incineration of these waste black liquors makes its unnecessary to discharge them and pollute the streams. Modern precipitators and scrubbers clean most contaminating material from the flue gases before they are discharged to the atmosphere, thereby minimizing air pollution. Because chemical recovery reduces the net cost of pulp, paper, and other related products, it is attractive economically. The aim of today's modern recovery units is to operate as economically and as safely as possible.

We cannot expect an installation to have all these rewards without encountering problems and hazards. The history of the development of modern day chemical recovery boilers, from the first refractory smelters fed with char formed in a rotary kiln, documents the hazardous problems which have been encountered and overcome.

Recovery of chemicals in the early use of the Kraft process consisted of drying and roasting the waste liquor in a rotary kiln until a char was obtained. This char, or so-called black ash, contained the nonvolatile portion of the constituents dissolved from the wood in addition to the inorganic chemicals of the original cooking liquor, and when discharged from the rotary kiln, was used as the fuel in a refractory smelter. The hot gases from the smelter were directed back through the rotary kiln where they dried and roasted the incoming waste liquor, making the process self-sustaining.

A reducing condition was maintained in the fuel or char bed of the smelter, and as the organic constituents burned away, the inorganic ash was chemically smelted, reduced, and tapped from the smelter in a molten state. The only heat utilized by this equipment was that which was needed to evaporate the moisture from the weak black liquor fed to the kiln and convert it into char.

Several pieces of equipment have been added to perform additional functions and contribute to the economy, efficiency, or safety of the process. A waste-heat boiler was added to the smelter furnace-rotary kiln combination, permitting recovery of a part of the heat from the gases discharged from the kiln. The development and use of multiple effect evaporators to deliver the waste liquor at higher solids content to the rotary kiln reduced the heat loss in evaporating the liquor. The disc or cascade evaporator was developed and installed after the waste-heat boiler and utilized the heat in the gases leaving the waste-heat boiler to further concentrate the black liquor before introduction to the rotary kiln.

The Murray Waern unit, introduced about 1930, substituted a water-cooled smelter in the place of the refractory smelter previously used in order to overcome the refractory maintenance difficulties. Elimination of the rotary drier or kiln in the Ross-Wagner unit, at about the same time, was the first step leading to the development of the modern recovery unit with its stationary furnace. The principal component of the Ross-Wagner unit was a vertical, cylindrical, stationary, refractory furnace. The liquor, at about 55 per cent solids content, atomized with compressed air, was introduced through the roof of the furnace and directed downward toward the furnace floor or hearth.

This unit was significant since it demonstrated the principle that all the steps of the recovery incineration process could be accomplished in a single stationary furnace. However, refractory maintenance was high and combustion conditions on the hearth were unstable and subject to frequent blackouts requiring excessive amounts of auxiliary fuel to maintain the process which resulted in low chemical recovery efficiency.

In the Babcock & Wilcox-Tomlinson unit introduced in 1936, the advantages of the Ross-Wagner unit were retained, but there were several important changes designed to eliminate the difficulties noted. Refractory maintenance was eliminated by the use of a water-cooled stationary furnace and a water-cooled flue connection from the furnace to the waste-heat boiler. To overcome the unstable furnace condition, the liquor was sprayed onto the walls of the furnace, where it was essentially dehydrated and remained until its thickness and weight were sufficient to cause it to break off and fall to the char bed below.

The spray nozzle directed at the furnace walls was oscillated, continuously depositing a relatively thin layer of liquor on a given area of the walls which dried before the spray was redirected to the same area to deposit additional liquor. Furthermore, and of considerable importance, the angle of oscillation of the spray was adjustable so the operator could use more or less wall area for drying the liquor, depending upon its water content. This spraying method stabilized combustion conditions on the hearth, reducing the frequency of black-outs, and increased the efficiency of chemical recovery.

By thus providing a separate adjustable means of evaporation within the furnace itself, it was possible to use the cooler water-cooled furnace, eliminating the high maintenance of refractory, and to establish stable furnace conditions with the relatively weak liquor available from the multiple effect evaporators of that day. The introduction of this type unit led to rapid developments in the efficiency of chemical and heat recovery from the furnace.

There have been many additional refinements to improve Kraft recovery units. Economized, steam coil air heaters, gas air heaters, electrostatic precipitators, venturi evaporator-scrubbers, cyclone evaporators, low level heat savers, demisters for vent stacks on smelt dissolving tanks, and various other pieces of equipment have been added to do the required job in a better manner.

One particular type of hazard that is found only in recovery boiler operation, the reaction between molten smelt and water or char and water, can create an explosion hazard in the dissolving tank and in the furnace. In the dissolving tank the reaction between smelt and water must be controlled by dissipating the energies in a harmless manner. At other points in the system proper, design and operation must be established to prevent smelt and water or char and water from coming in contact with each other.

The smelt dissolving tank area is one where controlled smelt water reaction must be attained to prevent injuries to personnel and damage to equipment. Thermal and chemical energies are released suddenly when the molten smelt comes in contact with the weak green liquor. In the early development stages, lack of shatter jets, inadequate venting, and insufficient agitation resulted in many violent smelt dissolving tank explosions which resulted not only in serious damage to the equipment but, in many cases, injury to operating personnel.

Explosions of this kind can be prevented if the smelt stream is broken up into small particles before penetrating the liquid surface in the smelt dissolving tank and if the green liquor in the dissolving tank is kept thoroughly agitated. On present day recovery units, steam shatter jets and green liquor recirculating sprays break up the smelt stream before it is submerged in the liquid and a propeller type agitator keeps the fluid in the dissolving tank moving. The tank is vented to atmosphere to eliminate any explosive gases.

As a safety feature in this area, the smelt shattering equipment is designed with considerable excess capacity over that normally required. Steam jets and liquor sprays to cover a wide flow area are backed up with auxiliary nozzles and reserve steam pressure. This reserve shattering capacity is required when upset operating conditions of the recovery boiler cause the smelt flow to be irregular, for smelt flow rates several times the normal quantity can be experienced.

While the shattering equipment is designed for abnormal conditions, the most effective way to provide safety is in proper operation by eliminating smelt spout plugging and the heavy rushes of smelt which follow. Recovery boiler burning techniques, black liquor fuel preparation system, unit controls and instruments have been improved so that operating conditions can be expected to be quite steady and the smelt discharge to flow at an even rate. These improvements have practically eliminated the incidence of dissolving tank explosions which were formerly quite numerous.

In spite of these improvements in equipment and operation, there may be times when, as a result of poor operating procedures, the smelt spout will begin to close off. Preventative action to be taken is as follows:

1. Allow sufficient time to burn the bed down properly during routine shutdown periods. The bed near the smelt spouts should be burned down below the smelt spout openings and accumulations of smelt and ash that fall from the upper screen tubes or furnace should be melted also. If this condition cannot be achieved during an emergency shutdown, the accumulation of ash in the vicinity of the smelt spouts in the furnace should be raked or shoveled away from the spouts before restarting the unit.

2. Operating a recovery boiler with black liquor concentrations which are too low can reduce bed temperature and cause the smelt spout to freeze over. The proper per cent solids in the black liquor to the furnace can be maintained by correct operation of the evaporators and other auxiliary equipment.

3. The amount of combustible material remaining in the char when it falls to the bed can be controlled by proper black liquor spray adjustments and primary and secondary air and tertiary air distribution. Proper adjustment of primary air flow in the vicinity of the smelt spouts will promote steady smelt flow.

4. Periodic cleaning of chilled smelt from the smelt spout is required to maintain steady smelt flow.

Proper design and operation of the water-cooled smelt spout must be established to prevent smelt water reaction. Frequent replacements may be required if the cooling water supply is contaminated or scale forming. This is one cause of smelt spout failures, corrosion, and cracking. A leak in the smelt spout allows the cooling water to mix with stream of smelt and the splattering caused by the reaction can injure nearby people. The chilling effect can also cause pluggage of the spout, resulting in abnormal flows from the other spout. This problem can be entirely eliminated by installing a recirculating condensate system as the cooling water supply. Excellent results have been achieved in this manner.

The failure of a furnace tube of a Kraft chemical recovery unit must be avoided as it may become a serious hazard. If the water from the leaking tube comes in contact intimately with the smelt, an explosion can occur. It if comes in contact with the hot char bed, explosive gas can be generated. All furnace wall tube failures do not result in explosions, but nevertheless, it is of major concern when a tube leak is noted in this area.

The common cause of furnace tube failures is scale formation on the inside of the tube. The importance of maintaining good boiler water conditions cannot be stressed too much. This importance increases as the chemical recovery units are designed for higher temperatures and pressures.

Another cause of tube failure is indiscreet use of air lances in air ports. An air lance directed across burning char and molten smelt at a tube can cause extremely high heat input rates which can elevate tube temperatures so that wastage of metal will occur. This blowtorch action if continued for some time at a given point may cause tube wastage to the point of failure. Therefore, if the rule, "Never fix the lance in position; always hold it by hand and keep it moving," is observed, there should be no danger of tube damage when air lances are used to clear ports which have been blocked out.

Pluggage of the smelt spouts or the formation of smelt ledges on furnace floor sometimes require manual probing with rods to open the smelt spout or knock down the ledge. When this procedure is required, extreme care should be used so that the furnace wall tubes are not damaged.

Molten smelt is formed in the furnace during the process of incinerating the organic substances in the black liquor. The smelt consists of approximately 25 per cent sodium sulfide and 75 per cent sodium carbonate. We have discussed the hazard of water spraying on smelt in the foregoing, however, keeping the accumulation of molten smelt in the furnace to a minimum is also a safety feature of design.

A recovery furnace designed with a sloping floor so that the smelt is discharged into the dissolving tank from the recovery bed as soon as it is formed minimizes this hazard. Fluid hot smelt leaks from the furnace form a hazard to equipment and personnel. Red hot flowing smelt can cut through pressure parts and enclosures. The furnace bottom and lower side wall must be tightly sealed in order to prevent smelt from flowing out between the tubes.

Early model water-cooled furnaces, relying upon a very thick layer of refractory lining inside the furnace to form the seal against smelt flow, used the tubes mainly as reinforcement and as a form. Pin studs welded to the pressure parts of the furnace were added to hold the refractory more securely in place and to extend the life of the refractory by lowering its temperature. Chill plates were later built on the outside tangent of tubes in an attempt to freeze molten smelt which might leak through the refractory.

The trend has been steadily toward using metal usage as a positive seal against smelt

leakage. The furnace wall tubes and floor tubes were moved to closer spacing. Pin studs and chrome ore refractories are required on the furnace side to protect the tubes from wastage in the sulfur reducing atmosphere of the lower furnace. Flat studs are added at the centerline of the tube and the ends of studs welded together. In addition, a steel plate membrane is welded between tubes, making a solid tight welded construction all the way to the primary air port level.

This construction is a positive metal seal against the flow of smelt. The joints of the wall to the floor are also welded tight and this construction has eliminated leakage from the floor. The transition to a completely sealed metal bottom has now been completed and the only path for the smelt to follow is out the spout. Smelt leakage, which was once a common occurrence in kraft recovery units, has now been made practically nonexistent on the modern recovery units. In addition, when extensive repairs are made to units 10 to 15 years old, some of these more modern features may be applied to the hearth zone so that the frequency of smelt leaks can be greatly reduced.

Prior to 1940, soot blowers were generally ineffective in recovery units. Multiple jet blowing did not dislodge hard deposits and fired furnaces were often operated under pressure as a result of plugging of the gas passages. Steam cutting due to misalignment was prevalent. Consequently, hand lancing was a necessary part of recovery unit operation. Hand lancing was not an extremely hazardous part of the operation but there was always a chance of personal injury either by being burned by the hot steam lances, or by having hot gases and soot blown from the lance ports and furnace doors which were used for lancing.

As the recovery units became larger, they became more difficult to lance by hand. This, plus increasing labor costs, forced the development of automatic retractable lance cleaning devices to cope with the tenaceous deposits that form in the hot gas regions of the recovery unit. The design of the recovery units has been changed to arrange surfaces so that the ash which was cleaned from the tubes falls into the furnace or into the boiler hoppers. Even with the most effective known cleaning equipment, the surfaces must be arranged with due respect to gas temperatures, gas velocities, and tube spacing in order to achieve a cleanable recovery unit.

The combination of proper arrangement of heat absorbing surfaces and the application of improved type soot blowers have virtually eliminated lancing on modern recovery units, thus increasing safety during operation.

Auxiliary oil and gas burners are used when starting up to bring the boiler up to pressure, put it on the line, to ignite the black liquor, and sustain furnace temperature until the black liquor burner has been stabilized. These burners are also used to melt down the char when the unit is to be shut down and to stabilize the furnace during upset operational conditions or black liquor fuel interruptions.

The recovery unit fired with a high moisture black liquor fuel may lose ignition if the air flow or fuel moisture content changes. Smelting over of air ports will affect the air flow distribution and erratic operation of multiple effect evaporators will affect the fuel solids content causing a black-out or loss of ignition in one area of the furnace, which will become accumulative unless corrected. Auxiliary oil or gas burners are placed in service to compensate for the loss of heat release due to the black-out. The operator must also rod the air ports to re-establish proper combustion conditions. Operation of auxiliary burners is a manual function because of the problems mentioned above. However, safety devices are being installed to help the operator with the auxiliary burners.

The problem of burning oil or gas in a recovery furnace is much the same as in normal power boilers. However, the primary purpose of the recovery boiler is to burn black liquor and recover the chemical efficiently, and as a result, the arrangement of air ports and air distribution is designed to accomplish this purpose. A typical oil or gas burner cannot be used in the hearth because of smelt conditions. The auxiliary burners are mounted around the unit on all sides to distribute the heat and are not as easily observed by the operators. Several Kraft recovery unit furnace explosions have been caused by improper use or improper functioning of auxiliary burners. Improved steam

atomizing type oil burners and gas burners that give better stability are now used.

The greatest contribution to the safety of auxiliary burners in recovery units has been the recent application of monitoring equipment to oil and gas burners. Monitored oil and gas burners are offered on new units and are recommended for all existing Kraft recovery units. Automatic monitoring systems will include: (1) flame failure detectors, (2) air flow permissives, (3) maximum air windbox pressure cut-out, (4) maximum and minimum gas pressure cut-outs, (5) minimum oil temperature cut-outs, and (6) fan failure interlocks.

Controls and instrumentation can contribute greatly to safe recovery unit operation. Temperature recorders, flow recorders, level indicators, density indicators, draft loss gauges, and other present day instruments can show the operator what is happening in the recovery unit without his having to leave his operating station. These very valuable guides can be used to detect the development of unsafe conditions long before it could be determined from other sources. Automatic controls can perform many functions of the operator so that he may be free to attend to other duties necessary to efficiency and safety of operation. Of course, all instruments and controls must be properly calibrated and checked to make sure that readings are true and they must be carefully maintained so that the operator can have confidence in them.

A good training program for operating personnel and supervisors is necessary for safe operation.

1. Knowledge of Equipment — When a new recovery unit is started up, time and effort spent to explain the features and objectives of the new equipment can prevent future accidents or operating mistakes.

2. Experience — Operating problems encountered during the initial starting up period may be a good school of hard knocks for the crews on duty at the time; but although straightening out upset operating conditions is good training, it is poor for production records. Shutdown and change over drills should be incorporated in a smooth running mill to give operators proper training in handling emergencies. These drills may well point out weakness in the established operating procedures and result in the prevention of accidents or improvements of operation.

3. Training Replacements — The turnover in operating personnel is greater than one would normally realize. Some operators are advanced to more responsible positions and turn over their duties to less experienced men. Men move on to other pulp and paper mills or into other industries. These changes reduce the number of experienced operators available to operate the chemical recovery boiler. Retraining of operators and supervisors is required to keep operation up to high standards of economy and safety.

A thorough and aggressive maintenance program can make valuable contributions to safe recovery unit operation. Many hazardous conditions are caused by mechanical or electrical failures. The chances of having accidents are much greater when abnormal conditions arise. Motor trip-out on an auxiliary pump, fan, or agitator, or other types of equipment failures can take the operator away from his primary responsibilities, thereby making the total recovery boiler operation less safe. A good maintenance and inspection program can do a great deal toward elimination of hazards caused by these failures.

Maintenance crews are always overworked during mill outages, but in the long run, complete maintenance during a scheduled outage pays off. Continued maintenance of spare equipment can be accomplished during normal operating periods to allow the men to do a better job during scheduled outages.

During the scheduled outage, particular attention should be paid to the inspection of the furnace hearth area for any signs of pressure part deterioration. Blisters, wasted tube metal, excessive stud burning, and tubes bowed out of position will indicate, generally, water treatment problems. The water side of the unit should be inspected for indications of scale and, if found, the unit should be acid cleaned to insure safety during the next operating period.

A chemical recovery room in which importance is placed upon neatness, freedom from debris, and dirt accumulations provides more safety for the operator. It is much easier for him to recognize developing troubles or hazards. Recognizing the existence of a dangerous condition is the first step toward eliminating it.

The old type chemical recovery units were difficult to keep clean. The pluggage conditions of the boiler passes caused a back pressure operation, resulting in fumes and sparklers being belched into the recovery boiler room. Ash hoppers which collected ash and smelt were dumped to the boiler room floors and then shoveled back into the furnace through the access door. The modern unit is designed to keep the boiler passes open and all heating surfaces that are subject to hard smelt deposits are located above the furnace so that these deposits fall to the smelt bed. The ash from the boiler hoppers is returned to the fuel system through the black liquor sluice system. This is a closed system and keeps the ash inside of the recovery unit.

Combined efforts in the fields of operation, maintenance, and design have done much to reduce hazards of the Kraft recovery process. Safety features that are built into the new units can be adapted to existing units. Ample reserve shattering capacity has improved smelt handling. Auxiliary burners are more stable and monitoring equipment is now provided. Automatic retractable soot blowers have improved boiler cleaning, thus improving boiler availability and minimizing hand lancing. Uniformly concentrated black liquor fuel and improved burning techniques maintain steady furnace conditions. Operators have better training and more instrumentation is provided to help them keep aware of operating conditions at all times.

The complex fuel, smelting, and cleaning problems of chemical recovery units make remote automated controls more complicated to apply than on power boilers. The paper industry and equipment suppliers, however, will continue to improve the safety of chemical recovery boilers.

DEVELOPING AND GAINING ACCEPTANCE OF SAFE PRACTICES

By ROBERT H. CARRUTHERS
District Safety Director, Lumbermens Mutual Casualty Co., Summit, N. J.

We are all aware that industrial accident prevention is a complex and many sided problem for which there is no short cut solution, no automatic panacea. We know that success in preventing personnel injuries and protecting plant facilities depends on a balanced program which recognizes and then stabilizes the problem of the policy of management and the philosophy of labor.

Please note I did not include the word rationalize between recognize and stabilize, as I am convinced there is no room for rationalizing or compromising, if you and I are to continue as important integral parts of private enterprise. Somewhere along the line we must strike a happy medium, or perhaps I should say create an atmosphere in which we can fuse management (the manager) and labor (the worker) into an effective accident prevention team.

Probably the most important aspect in developing and gaining acceptance of safe practices is a safety atmosphere in which you warm the cool spots and cool the hot spots, keeping in mind that the person who is against accidents is not necessarily for safety. In a given situation, regardless of management policy or of labor philosophy, you must let the manager know what is expected from him and you must inform the worker what is expected of him. Sometimes this area of cooperation, which you attempt to establish, becomes an arena of conflict—hence, the term, "creating an atmosphere."

For a moment let us think of a vacuum atmospheric vessel into which you draw everyone's ideas, thoughts and experiences —pro and con. Next, to develop and gain acceptance of safe practices, you warm up, cool down, add, subtract, smooth out, and round off the ingredients. As the solution begins to jell in this favorable atmosphere, you reverse the flow and expand outwards the resulting safe practices.

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