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Wood Products Sessions

RESEARCH ON WOOD DUST AND ITS EFFECTS ON MAN AND INDUSTRY

By JOSEPH D. WENDLICK
Weyerhaeuser Co., Longview, Wash.

Since time immemorial, man has utilized wood to fill his basic needs for fuel, implements for work and hunting, shelter and protection. In more recent times, man's utilization of wood has been vastly expanded to include such diverse uses as paneling, flooring underlayment, automobile door panels and head liners, pulp, paper, reinforcing fibers for tires (rayon), laminated beams, a variety of chemicals (including the controversial dimethyl sulfoxide—DMSO), food packaging, cardboard containers, ice cream thickeners, cattle feed, clothing, photographic film, piling, poles, and railroad ties.

Diversity of use, utilization of more wood species, increased production and exposure of increasing numbers of the working population to wood and wood dusts have brought to light potential health effects from these exposures in the form of cancer, dermatitis (skin inflammation), respiratory disease, and miscellaneous ailments. Medical evidence suggesting a causal relationship between certain types of cancer and wood dust exposures has been reported only in studies of cabinet and chair makers and wood machinists in the furniture industry in Great Britain.[10, 12] The overwhelming majority of potential health problems relating to wood dust exposures embrace the toxic manifestations of dermatitis, respiratory impairment (temporary or permanent) and a variety of miscellaneous symptoms such as nausea, anorexia (loss of appetite), vomiting, headache, asthenia (weakness), vertigo, epistaxis (nose bleed), etc.[9]

Albeit many articles and papers have been written on the toxic effect of exposure to certain wood dusts, a dearth of information correlating toxic manifestations with specific environmental exposure levels still exists. McCord [2] captured this impression of the state of the art with "Regardless of the continent involved, the knowledge of the toxic properties of wood is fragmentary. Nothing is final and complete." In fact, the prime purpose of his paper was to point out that a superb opportunity for investigative work in this field was afforded and should be conducted in order that this branch of industrial toxicology might become more extensive. Toxic effects of wood dusts have been described by several other authors in terms of the dusts' tendency to provoke a dermatitis or pulmonary response. Sosman, et. al.[3] has suggested that respiratory disease resulting from prolonged exposure to wood dusts may be due to a hypersensitivity reaction in addition to the non-specific toxic or irritant effects of the inhaled materials.

Physiological reactions produced in workers exposed to wood dust most often occurred among those who were in an environment heavily saturated with wood dust [8], those who had a long and heavy exposure to wood dust [22], those exposed to very high concentrations of wood dust [9] and those exposed to massive daily exposures.[1] In only one case did the authors attempt to define what is meant by heavy, very high or massive exposures, and these values were mere conjecture. Hanslian and Kadlec [57] of Czechoslovakia, on the other hand, devoted considerable attention to the subject of what constitutes typical wood dust levels in a furniture factory, which led to the discovery that peak values may approach 200 milligrams per cubic meter (mg/m^3) with average levels of 40 mg/m^3. These authors found that at high concentrations of wood dust, 90 per cent of the wood particles were smaller than five microns (μ). Methodology of sampling (personnel, area, etc.), analysis of wood dust, and particle size counting procedures from which

their data were derived were not available.

Dermatitis resulting from mechanical trauma was described by Weber, [1] although most authors support the hypothesis which implicates particular chemical constituents endogenous to the wood. Furthermore, Weber states: the effect on the skin from repeated mild trauma (either chemical or physical) varies considerably according to individual predisposition. Occasionally, a mechanical or traumatic dermatitis is the forerunner of sensitization dermatitis. Most cases of allergic dermatitis (dermatitis venenata) resulting from exposure to native woods occurred after a daily massive exposure of a moderately sensitized person to sawdust derived from such woods of low-sensitizing capacity. Cutaneous sensitizers among the native woods are acacia, alder, ash, beech, birch, chestnut, cedar, creosote bush, elm, maple, oak, pine, poplar, prune, and spruce. While Dr. Weber notes that poplar most frequently produced allergic reactions in his practice, he also indicates only about one per cent of workers exposed to massive amounts of airborne wood dust derived from native woods become sensitized after working with it many years.

Suskind [13] explored the "intriguing diagnoses" of cedar, pine, spruce, hemlock, and fir poisonings which appeared in medical records and on occupational disease claims in the Pacific Northwest. He noted that "most of the diagnoses of wood poisoning are usually made by the local general practitioner, who, as a rule, has neither the time nor the inclination to study such problems in any detail." Extracts of red cedar, Douglas fir, grand fir, hemlock, and pine were prepared in acetone, ethyl ether, and ethyl acetate and used on guinea pigs and 82 human cases who had eczematous hand dermatitis. Of the 82 cases selected for this study, only two instances of occupationally significant reactions to Douglas and grand fir were in evidence. Allergic reactions to common Pacific Northwest woods appear to be uncommon, Suskind concludes. He was also unable to elicit reactions in any patients to antigenically active extracts of cedar and hemlock. Cohen et. al.[22] could find no antigens demonstrable in pine, fir, or beech sawdust.

A review of current information, including industrial compensation insurance data, does not indicate that there is any specific respiratory hazard associated with normal work exposure to the conifer wood dusts.[4] Vallander [7] reported on a Norwegian study of 81 men who had been employed in the timber industry for 10 years or more and exposed to abundant quantities of wood dust throughout that period. Only two showed positive clinical and radiographic findings: one had asthma and one fibrosis. Findings were completely negative in the remainder. Albeit the possibility cannot be ruled out, there was little probability of the wood dust having been an etiologic factor in either of the two positive cases. With regard to dermatitis induced by wood dust exposure, Weber [1] states: "freshly cut woods usually give rise to trouble. This observation is true in the experience of nearly everyone, although exceptions can occur." This is in direct contrast to McCord's [2] findings: "It has been proven that, in some instances, trees as cut are harmless, but at a later time, in the process of drying and curing, chemical alterations take place leading to damage only long after cutting operations."

Even though imbroglio exists between investigators and studies of native woods, good agreement has been reached regarding the much greater incidence of toxic effects among handlers of tropical or exotic hardwoods. Tropical trees stand out as predominant in number of those trees possessing properties injurious to man. A handful of reports have been published during the last 20 years describing contact dermatitis from several varieties of teak, [11] mansonia wood, Australian silk oak, and coco-bolo wood. [13] Hunter's [17] text on *Diseases of Occupations* lists additional, potentially hazardous woods including East Indian satinwood, ebony, olive wood, rosewood, Cuban sabico wood, partridge wood, South African boxwood, and iroko. East African camphorwood, balsa wood and Oregon pine were also implicated. Morgan, et. al.[14] felt that the increased use, since the war, of exotic timbers for furniture manufacture has given rise to a number of problems due to the dust created during machining processes such as sanding and sawing. Outbreaks of dermatitis at local furniture factories in the High Wycombe, Bucks area of Great Britain afforded an opportunity to carry out investigations on the nature of the toxicity, the wood responsible and, when possible, the sensitizing constituents present. A substitute for Rio rosewood and an African mahogany were firmly established as the causative agents producing the outbreaks. Kejaat wood was shown by Ordman [16] to cause both contact dermatitis and bronchial asthma. Allergic coryza was also listed as a possible symptom of kejaat wood exposure; a physiological response, in persons sufficiently sensitized, allegedly elicited from exposure to boxwood, orangewood, iroko, pine, spruce, cedar wood, mahogany, birch, and tamarack as well. Douglas fir extract was included in a series of scratch and intradermal sensitivity evaluations, with negative results.

Bronchial asthma resulting from an immunological response in a hypersensitive person to wood dust is characterized by two clincial patterns: characterized by immediate onset and rapid reversibility of asthmatic symptoms, and a more delayed onset and more gradual reversibility. [3] Reports in the literature have suggested that inhalation exposure to wood dust may lead to the development of reversible bronchial obstruction disease resembling asthma. Sosman, et.al.[3] observed that "despite the ability to explain the exact mechanism of wood dust hypersensitivity, our observations indicate that an immunologic process is involved in this disorder." Prognosis in the cases of asthma precipitated by inhalation of wood dust is very good.[16] Michaels [8] submitted case histories of two woodworkers who had been exposed to wood dust for many years. Pathologic changes in the lungs were described, with the inference being that wood dust may have been the irritant. Michaels inculpation of wood dust is tempered by his statement: "Whether the emphysematous lesions described in these two patients are the direct result of the repeated previous aspiration of wood dust cannot be determined in the light of our present knowledge. Both patients expired from non-respiratory causes." Response to a query in the November 18, 1944 issue of *J.A.M.A.*[5] states: "It is doubtful whether significant quantities of wood dust can be inhaled into the depths of the lungs because the particle size is too great and, because being easily wetted, they are retained in the nose and throat. However, certain kinds of wood dust are highly irritating to the skin and upper respiratory tract, and some persons may become sensitized so that they react violently to contact with such dusts."

Species autochthonous to the United States generally regarded as capable of inducing immunologic or allergic response among exposed workers are primarily western red cedar and redwood. Many papers have been written on the occupational asthma and rhinitis caused by inhalation of western red cedar (thuja plicata) dust. Gandevia and Milne [20] found that while both immediate and late skin reactions to extracts of western red cedar were mild or absent, positive bronchial reactions, reflected in several estimations of ventilatory capacity, occurred in response to provocative inhalations of extracts of cedar dust. In some instances, a single provocative exposre to the nebulized (spray mist) extract over 90 seconds was shown to produce exacerbations of asthma for two or three successive nights. A Japanese study of furniture factory workers exposed to western red cedar dust showed specific clinical features characterized by delayed onset of asthma attack and mild skin sensitivity. [21] Prevalence of asthma and dyspnea was highest among those subjects engaged in processing while conjunctivitis was the primary symptom manifest in subjects sawing western red cedar. The results of the Japanese study further showed that hypersensitivity to western red cedar antigen was marked in groups of subjects showing positive reaction to common inhalant antigens such as house dust, pollens, and molds. This implicated atopic (hereditary) constitution as an important factor in the development of an asthmatic condition due to inspiration of cedar dust. Consequently, it was found to be difficult to ascertain occupational asthma through clinical analysis, even when a patient suffers from asthmatic attacks shortly after beginning on his daily job. Ergo, subjects having asthmatic and other allergic symptoms were initially indentified during routine annual checkup

regardless of correlation with western red cedar dust.

Sometimes, however, the employee does not realize the significance of an occasional change in the timber on the production line (perhaps not affecting his own work), or he is reluctant to associate nocturnal symptoms with his day's work. In these cases, the diagnosis depends on the doctor's awareness of a specific hazard and his perseverance in investigating the occupational background.[20] Chan-Yeung et. al.[19] conducted a study of 22 Canadian woodworkers exposed to western red cedar dust, who exhibited the symptoms of asthma and rhinitis. The clinical picture of western red cedar asthma presented by this group of patients was found to be reasonably characteristic. Most patients, with the exception of those who worked in the red cedar sawmills, were exposed to a variety of woods (yellow cedar, spruce, hemlock, Douglas fir, grand fir, etc.) for many years without respiratory symptoms. Eighteen of the 22 patients participating in this study gave positive reaction to inhalation provocation with red cedar extract. With only one exception among the 22 participants, all patients showed insignificant changes in FEV (forced expiratory volume in one second) and FVC (forced vital capacity) following inhalation of a fir (species unspecified) extract. Corroborating the work of Gandavia and Milne,[20] Chan-Yeung et.al.[19] found that skin tests are of no value in diagnosis since positive immediate skin reactions to red cedar extract were infrequent and mild. At present, inhalation provocation testing is the only method of confirming the diagnosis.

Cohen et.al.[22] described a granulomatous pneumonitis associated with redwood dust inhalation which bears a strong resemblance to other vegetable dust pneumoconioses, e.g., farmer's lung associated with moldy hay,[23, 29-47] maple bark disease associated with fungal spores[24-28], and others.[48-52] Prior to this paper, wood dust had not been reported as a factor potentiating granulomatous pulmonary disease. Redwood inhalation disease has tentatively been termed Sequoiosis. The sawmill worker case study discussed by Cohen represented a 17-year exposure to heavy airborne concentrations of redwood sawdust. Unfortunately, no specific workplace dust levels were mentioned in the paper to relate to limits proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) or to define what the author meant by heavy exposure. "The immunologic similarity between two of the fungi isolated from redwood and our redwood antigen A suggests that the antigenic content of the inhaled dust may come from its flora, as is proposed in farmer's lung and maple bark disease." It would appear then, on this evidence, that redwood dust per se is not the causative agent in producing this pulmonary disease (Sequoiosis), but rather fungi or fungal spores exogenous and associated with redwood dust.

As mentioned above, severe bronchial asthma with clinical manifestations of cough, dyspnea, and pyrexia are present in the vegetable dust pneumoconioses: farmer's lung disease, maple bark disease, and bagasse disease. Towey et. al.[24] in 1932 related the history of a large group of men working in a railway tie plant who presented asthmatic symptoms. The etiologic factor definitely established by Towey and his co-workers causing the respiratory distress among these employees was a fungus spore acting apparently as a sensitizing antigen rather than as a parasitic infection. Approximately 75 per cent of the wood being operated at this tie plant and an automobile plant (also included in this report) in the same locality was maple. Furthermore, in most of the maple trees and logs used there was a black dust of the consistency of lamp black beneath the cork layer of the bark. Spores were released into the air during drum debarking,[26] ring debarking, and sawing operations. Affected men recuperated over the weekends, but on resuming their work the symptoms were immediately aggravated.

On investigation it was found that these patients were working where they came in contact with dust from maple logs that had been cut for more than a year. The dust proved to be spores of a fungus, tentatively classified as Coniosporium corticale.[27] Proper heat and moisture must be present to promote the growth of the fungus, apparently not found in freshly cut or green logs. The

question may be raised concerning the role of wood dust in this condition. Towey et.al.[24] feels, however, that the prompt disappearance of symptoms following the removal of workers from the sawmills to other parts of the automobile body plant where they come into contact with the wood rules that out."

As Chan-Yeung et. al.[19] pointed out in the case of western red cedar allergic response, Tewksbury[25] found that inhalation provocation testing is the most effective clinical tool in eliciting response in sensitized individuals or animals to spores of Cryptostroma corticale (same as Towey's Coniosporium corticale). Exposure to an airborne suspension of the spores caused nine out of a group of ten guinea pigs to develop a precipitating antibody which forms complexes with the antigen. Evidence in both animals and humans indicates that a very high spore concentration is required to produce hypersensitivity.[26] An epidemic of maple bark disease at a paper mill in northern Wisconsin in 1962 was reported by Emanual.[27, 28] Clouds of spores could be seen each time an infected maple log entered the saw area, a situation which became very serious in the winter when the woodroom was closed. The two-month period (January-March) over which these very high airborne spore counts existed was sufficient to provoke incipient inspiratory impairment.[29] "The condition may easily be confused with tuberculosis, particularly when there is definite mottling throughout the lungs, with a history of cough, night sweats, loss of weight, rise in temperature, etc."[24] Signs and symptoms of maple bark disease cannot be differentiated from those produced by other types of interstitial pneumonitis.[28] Differential diagnosis[29] in the case of maple bark disease describes physiological response to pigeon breeder's disease, silo filler's disease (primarily the pulmonary effects of nitrogen dioxide poisoning), asthma (differentiated from farmer's lung and maple bark disease by formation of evanescent wheals at subcutaneous injection site of responsible antigen), chronic bronchitis and emphysema, farmer's lung, pulmonary aspergillosis, (caused by saprophytic fungus), sarcoidosis, infectious diseases (viz., tuberculosis, histoplasmosis, etc.) pulmonary embolism, bagassosis (sugar-cane fibers), sequoiosis (redwood dust) and byssinosis (cotton dust, raw). A large number of good articles are available on farmer's lung disease as a useful supplement to the clinical picture for maple bark disease.[23, 29-47]

Cancella[48] reported in 1963 an occupationally-derived pulmonary malady arising from inhalation of cork dust, termed suberosis. Patients described in this report all had worked in manufacturing departments where cork dust was generated in great abundance, so that a relationship between the inhalation of cork dust and the pulmonary disease seemed plausible. Once established, the lesions characterizing suberosis are aggravated by continued exposure to the dusty atmospheres, but they improve after prolonged removal from the cork dust environment. After some years, such as 20, of gross exposure, the chronic stage develops and is of pronounced clinical significance, although seldom totally disabling or fatal. Much of the damage in cork workers' disease (suberosis) relates to mechanical impairment, but specific injury is induced by some unknown factor.

In view of the information presented to this point, it seems appropriate to examine and comment on the ACGIH proposed limit of five milligrams per cubic meter (mg/m^3) wood dust (non-allergenic) documentation in some detail. The fundamental basis for relegating wood dust, non-allergenic (hereafter to be known simply as wood dust unless designated otherwise) to a category separate and distinct from either the OSHA nuisance dust standard or the ACGIH recommended nuisance dust standard was the evidence from studies in Great Britain that showed a potential connection between wood dust exposure and certain types of cancer.[10, 12] Acheson et. al.[10] confirmed and amplified their own preliminary reports suggesting an excessive risk of adenocarcinoma of the nasal cavity and sinuses among woodworkers in a 1968 paper describing 36 case histories of the disease. From their studies, it seems clear that the risk is greater among woodworkers in the furniture industry than among the other workers, who include French-polishers, laborers, upholsterers, packers, clerks, etc. In rebuttal to Morgan's[14] comments noted earlier, Acheson et. al.[10] feel that their findings

indicate that the cases of nasal adenocarcinoma reported in their 1968 paper cannot be due to a substance introduced to the industry since World War II. On this ground alone it is possible to exclude a number of exotic hardwoods, and synthetic glues, stains, and varnishes. Acheson concedes, however, that "further characterization of the component or type of wood dust concerned is complicated by the fact that it cannot safely be assumed still to be present in the dust of contemporary furniture factories. The environment which it is necessary to reconstruct is that of the furniture industry in the period 1920-1939."

These studies represent the only such cases recorded in the available literature linking exposure to airborne wood dust with the development of malignant neoplasms. As pointed out in the second page of the documentation, "All of the reports of responses to wood dust exposure from Great Britain are marked by the lack of information on the level, type, and duration of exposure." If it can be assumed that the estimates of in-plant wood dust exposures performed by the Czechoslovaks (viz., 40 mg/m^3 on the average, with peaks as high as 200 mg/m^3) are indicative of exposure levels which may cause cancer, then it would appear that massive, very high, extremely high, or uniquely high wood dust concentrations over long duration (20+ years) are required to potentiate the malignancies described by Acheson et. al.[10] Similarly, it is very probable that other so-called nuisance particulates (e.g., mineral wool or fibrous glass) in "massive" concentrations equivalent to those estimated by the Czechoslovaks for wood dust in furniture factories could also produce cancer in exposed, unprotected workers.

Mechanical trauma, as suggested by Weber,[1] for "uniquely high" exposures seems more plausible than chemical trauma as a chronic irritant mechanism which might culminate, after long (secular) and continuous exposure, in adenocarcinoma. Hodgkin's disease, a chronic, infectious disease producing enlargement of lymphoid tissue, spleen, and liver, has also been mentioned in a possible relationship with wood dust exposure. Acheson[11] concludes that while the material reported in his survey of the Oxford, England area does not exclude a slight increase in risk of Hodgkin's disease in woodworkers, it excludes a marked increase at least in this neighborhood. Exposure to wood seems unlikely to account for an appreciable proportion of the total cases of Hodgkin's disease in the Oxford area. A review of 500 death certificates filed over a short period of years in the insurance office of one of the largest conifer wood products companies in the United States did not show any correlation to sarcoidosis or the Hodgkin's type of disease or to cancer of the lung.[4] The lack of any studies within the United States correlating wood dust exposure with development of a malignancy, together with the data presented later in this report, betoken little, if any hazard associated with today's wood products and operations typical wood dust exposures.

Types of wood implicated from the British studies of adenocarcinoma among woodworkers are oak, beech, mahogany, African walnut, Indian lamel, elm, chestnut, African cherry, cherry, walnut, deal, ash, and plywood. The latter species of wood (plywood) is not only unique but also involves a variety of gluelines, many of which are themselves potent cutaneous sensitizers. Adhesives are known to be far more hazardous in terms of skin sensitization than any of the domestic woods, and will be discussed later under dermatitis. No evidence available at this time would substantiate implicating Douglas fir as a potential carcinogen, as suggested in the documentation, since only one of the 36 cases reported by Acheson et. al.[10] even occasionally worked with Douglas fir.

"Diseases of the respiratory system that have been attributed to wood dust are suberosis, maple bark disease, sequoiosis, and certain miscellaneous conditions." This statement appears in the second page of the documentation and is erroneous as written. Suberosis, as previously seen, is a form of pneumoconiosis which develops over many years' exposure to gross concentrations of cork dust, not wood dust. Maple bark disease is an affliction precipitated by extensive inhalations of Cryptostroma corticale spores, a black fungus which grows immediately beneath the cork layer on maple logs stored for

long periods of time (six months or longer) in dry land sort areas. It is not caused by maple wood dust, otherwise freshly-cut maple would present the same hazard. Sequoiosis, as in the case of suberosis and maple bark disease, is an adverse pulmonary condition brought about by inhalation of certain fungi growing in the redwood bark, not the wood itself. The appropriateness of documenting a proposal on a wood dust (non-allergenic) limit in part on diseases caused by agents totally exogenous of the wood itself is dubious.

Dermatitis which develops through immunogenic routes (cell-mediated) to produce a delayed, six to 48 hour, response in the form of urticarial eruptions (hives) can be generated by the action of certain woods, containing some sensitizing chemical, on the skin. Contrast the delayed response with an immediate (allergic) response to an inhaled wood dust, such as with western red cedar, in the form of anaphylaxis (sudden onset of asthmatic conditions). Both of these could be construed to be allergenic, in terms of response to a sensitizing agent. The wood dust limit proposed by the ACGIH, however, specifically applies only to those woods which are non-allergenic.

Conspicuous by its omission in the documentation is a reference to the use of various adhesives throughout the wood products industry for such products as plywood, particleboard, hardboard, and laminated beams. Literature describing allergic response to glues, especially formaldehyde-based glues, is voluminous and much too cumbersome to be discussed at length in this report. Suskind[13] remarked: "The most common hazards are the formaldehyde resin glues and their hardeners, used in exterior plywoods, and alkalis which are commonly added to the animal proteins in interior plywood." Suffice it to say that certain of our industry's wood products operations have experienced dermatitis problems due to formaldehyde glue sensitizations which far exceed similar problems with wood dusts.

Another apsect of dermatitis which went unmentioned in the documentation deals with worker sensitivities to forest plants, mosses, or lichens. Poison oak, sumac, and ivy are the most notorious of the poison plants, being capable of producing extensive vesicular trauma on the skin of the affected worker. These reactions and the causes are readily recognized and generally not attributed to contact with wood or wood dust. Some of the lesser-known mosses and lichens[51] (i.e., Frullania,[49] a genus of liverworts), however, produce sensitizations with concomitant dermatitis which frequently appears in employee compensation records as "cedar, fir, or hemlock poisoning." Mitchell[49] found that workers who were sufficiently sensitized to Frullania frequently developed a dermatitis which was so pronounced as to be physically incapacitating. Since sensitization to Frullania, etc., can be effected during clinical patch testing,[56] screening of employees for logging jobs or debarking operator jobs to avoid exposing a hypersensitive individual to a potentially hazardous situation is ill-advised. A better method is to assign such an individual to an exposure-free job at the first positive indication (dermatitis) of sensitized response to Frullania. Once sensitization occurs in a worker, that individual will likely become adversely affected by contact with any member of Compositae (daisy family), due to the commonality of sensitizing chemicals within the plant family.[50, 52, 54, 55] The particular chemical of interest is alantolactone, a sesquiterpene lactone with an exocyclic double bond conjugated with the carbonyl group. Lessening or elimination of the conjugation appears to reduce the immunogenic character of the compound. Dr. Storrs of the University of Oregon Medical School is actively engaged in research into Frullania as it relates to cases of dermatitis among loggers.

The single, provisional limit of 5 mg/m^3 total proposed by the ACGIH Airborne Contaminants Committee was based primarily upon the British studies indicating a correlation between high wood dust exposures and incidence of adenocarcinoma among furniture workers. From the documentation, it would appear that the 5 mg/m^3 limit value was extracted from the 1968 Czechoslovakian study of Hanslian and Kadlec[57] as the recommended limit for woods with high toxicity, as shown below:

1. Woods with low toxicity (relatively non-toxic): oak, beech, maple, and ash.
2. Woods with high toxicity: pine, larch, mahogany.
3. Strongly allergenic woods: yew, mansonia.

Corresponding recommended limits were (1) 10 mg/m^3; (2) 5 mg/m^3; and (3) 1 mg/m^3. These classifications of different woods were based upon chemical and biological studies which divided wood into three groups, depending upon the degree of toxicity of their component substances. Michaels'[8] report referred to on the second page of the documentation discussed the wood dust levels in a furniture factory described by Hanslian and Kadlec. Peak levels ran as high as 200 mg/m^3, with the average level circa 40 mg/m^3, in which 90 per cent of the wood particles were smaller than five microns. Both of these airborne wood dust concentrations were far above the maximum level which they state should be allowed: 10 mg/m^3.

USSR health authorities have adopted maximum allowable concentrations of 2 mg/m^3 for wood dust containing 10 per cent or more of free silica, and of 4 mg/m^3 when the free silica content in wood dust is below 10 per cent.[9] Silica has a long history of well-documented and positive medical evidence showing unequivocally the debilitating consequences of frequent or continuous inhalations. Wood dust, on the other hand, has no such fund of medical evidence linking long-term exposures to permanent physiological injury. The values adopted by the USSR health authorities, therefore, appear to have been based on sound factual evidence.

In contrast to the USSR wood dust limits where free silica may be present, the ACGIH proposed limit on wood dust, non-allergenic of 5 mg/m^3 total appears to have been based on more arbitrary and less well-defined evidence. Certainly the supportive wording for the proposed limit, viz., "a single, provisional limit of 5 mg/m^3 (time-weighted average) is suggested as a TLV which, if it does not serve to prevent all forms of wood dust disease in all workers, would appear on available evidence, to greatly minimize the risk" must perforce, be concurred with in principle in keeping with the spirit of the Occupational Safety and Health Act.

However, a limit established at levels lower than necessary to adequately protect the health of the industrial worker may impose unnecessary economic constraints on the Industry to control an airborne contaminant no more hazardous than a nuisance particulate.

Alternate Proposal to the ACGIH Proposed Wood Dust, Non-Allergenic Limit.

Based upon the available evidence, it is proposed that the limit on wood dust, non-allergenic be established at 10 mg/m^3, the same as for the ACGIH recommended limit on nuisance particulates, total. This proposal is based on the following information:

1. While there does appear to be factual evidence linking wood dust exposures with incidence of adenocarcinoma among British woodworkers, "it cannot be safely assumed that the component of wood dust concerned is still present in the dust of contemporary furniture factories."[10]

2. Many cases of cedar, hemlock, and fir "poisonings" are very likely attributable to a sensitizing moss or lichen indigenous to the geographical areas where these species are commercially harvested, as indicated by research presently under way at the University of Oregon Medical School.

3. Instances of occupationally-derived dermatitis in plywood, particleboard, and laminated beam plants can most often be ascribed to a sensitizing adhesive or glue (i.e., formaldehyde-based adhesives).

4. Limits on mineral dusts are based primarily on physiological response; nuisance particulates fall under the nuisance dust standard TLVs, whereas fibrogenic mineral dusts such as asbestos, silica, and fibrous talc have limits in accordance with the nature of the hazard, generally far more stringent than nuisance dust limits. The analogy to wood dust would be the establishment of the basic nuisance particulate (10 mg m^3 total) limit on wood dust, non-allergenic with required more stringent limits on particularly hazardous species or on innocuous species which, because of soil conditions at a specific locality, becomes chemically more hazardous than a nuisance wood dust.

5. Mention of the lack of knowledge regarding the relation of cigarette smoking to wood dust diseases was inappropriate and discriminatory in view of the blatant disregard of this hazardous practice in the presence of a multitude of airborne contaminants other than wood dust. Even where there is a preponderance of knowledge indicating a very definite correlation between corporeal insult and cigarette smoking in the presence of other contaminants, this fact does not enter into the setting of a limit. Cases in point are the asbestos standard and the carbon monoxide standard, especially the change proposed in the NIOSH criteria document on carbon monoxide to a 35 ppm TLV.

6. There is a paucity of data interrelating wood dust exposure with response, a situation which bespeaks either (1) very few problems, medically, with exposures now common throughout the industry in the United States, or (2) problems which are not reported or thought to be due to causes other than occupationally-incurred exposure to wood dust. Evidence collected from within one of the largest wood products companies in the United States indicates that the former situation holds.

Wood Dust Measurements

To characterize typical wood dust levels occurring in various wood products operations, samples were collected in the breathing zones of plant personnel to enable assessment of vulnerability vis-a-vis the applicable standards. A summary of the results of these measurements is given in the following table.

Operation	*No. of Samples Taken*	*Airborne Wood Dust Concentrations (total), mg/m^3*			
		0-5	5-10	10-15	Above 15
Sawmills	14	12	2	-	-
Planer mills	16	13	-	-	3
Plywood plants	12	12	-	-	-
Hardboard plant	6	6	-	-	-
Particleboard plants	9	6	2	-	1
Miscellaneous	6	4	1	1	-
Totals	63	53	5	1	4

A simple calculation reveals that 84 per cent of the samples taken fall within 5 mg/m^3 (total), over 92 per cent of the samples included in this study would comply with standards in effect at this time.

Each of the samples collected for this study were taken using MSA cyclonic separators and MSA Model G, pulse-dampened, personnel gravimetric sampling pumps. An MSA 1106 BH glass fiber filter, preconditioned (oven-dried at 105°C) and tared, was used in the cyclonic separators to capture the respirable portion of the dust. Where no listing for respirable fractions of the dust samples appears in the tables, those samples were collected in the plastic casettes (total dust only). All wood dust samples were collected at a flow rate of 1.8 liters/minute, which had been preset during laboratory calibration using a one-liter burette and an identical filter (1106 BH) for flow resistance. Monitoring was conducted in the breathing zones of each employee participating in the study continuously (over breaks and luncheon period) for a minimum time of four-six hours. Grit pot contents were flushed from the cyclonic separator with a fine water jet through a tared filter, oven-dried on the filter, and reweighed to determine weight difference. Efforts to remove the dust mechanically from the grit pot were frustrated by the electrostatic charges on the nylon core.

Active Programs

Because the wood dust (non-allergenic) limit should be synonymous with the ACGIH recommendation on nuisance dust, total, viz., 10 mg/m^3; because more information on the health effects of wood dust inhalation is needed to support the alternate proposal to raise the existing limit; because work place environmental data from only one company within the industry is insufficient to properly establish representative worker populations within the very low (0-5 mg/m^3), low (5-10 mg/m^3), and moderate (greater than 10 mg/m^3) exposure ranges, a program of broader scope has been initiated on the West Coast to:

1. Establish the existence or non-existence of the hazard associated with wood dust exposures.

2. If indicated by the environmental data, actuarial evidence, and medical evidence, establish a more realistic limit on wood dust, nonallergenic (namely: 10 mg m^3 total).

3. Assist in the establishment of appropri-

ate limits for various allergenic species, i.e. western red cedar, where possible.

To accomplish these goals, it was recommended that:

1. Various West Coast industry members who are interested and who wish to contribute information directed toward the establishment of a more realistic limit on wood dust, non-allergenic, examine their company's records (both medical and actuarial) for any possible correlations with occupationally-experienced wood dust exposures. These data would then be extracted from various company's files, without specifically identifying the participating company, and sent to Peter Breysse of the University of Washington Environmental Health Department for compilation. The University will act as an independent third party for this program serving to coordinate the statistical inputs and oversee the environmental test programs soon to be initiated.

2. Where possible, West Coast member companies who participate in the above should also conduct environmental testing of their various operations to develop exposure data. Absenteeism records for each employee participating in the company's testing program should be reviewed to determine if any correlation exists between wood dust levels measured and the populations described previously.

3. If positive correlations are found to exist between, for example, the moderate exposure (greater than 10 mg/m ^{3}) of wood dust and an increased rate of absenteeism, the next step in this wood dust program would be to conduct pulmonary function tests (FEV_1 and FVC) on employees at the start of, and periodically throughout, their work shift. These medical tests would further be correlated with the environmental exposures to develop the maximum safe level for the employees affected, to be recommended to the ACGIH for their consideration.

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PROGRESSIVE SAFETY EDUCATION

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"What's new in safety?" is the question that frequently arises whenever concerned people congregrate. This emphasis on the search for new horizons has been accelerated of late by the advent of OSHA and new workmen's compensation legislation.

A considerable number of new concepts and tools have emerged over the years, such as total loss prevention, zero defects, systems safety, and latterly, the participation concept by Scott Meyers, the MBO concept by George Odiorne, the module system by Tanaka and Waters.

This quest for new information and knowledge is imperative in a progressive safety education program, as things that remain the same give non-progressive results; however, it is essential that your fundamental groundwork in accident control be effectively infused in your operations to allow new innovations to be smoothly integrated into that groundwork.

What is an effective fundamental program? This appears to be a redundant question—or is it? Perhaps we should analyze this more closely.

It is reasonable to conclude that many organizations have been basing their safety education largely on regulatory aspects, due to regualtions brought about by such legislation as OSHA. Education based primarily on the regulatory aspects will tend to focus the psychology of the program upon policing and discipline. Such psychology tends to place safety as a separate and divided part of the total management process. Policing based upon traditional authority also creates counterforces predicated on beating the system.

We concede that regulatory education is necessary as a part of an effective fundamental program, but it should not be the underlying basis and expectation of the program. An effective safety education program should be a series of building blocks based upon individual and team motivation and commitment, since it follows that the regulatory area will only be as successful as the people involved wish to make it. This focus on people will center the psychology of the program on people motivation and commitment based on sound leadership, rather than on discipline based on traditional authority.

How would we plan our safety education to obtain a fundamental program which would be capable of smoothly accepting into it any new program innovations? We suggest the following basic prerequisites to meet this objective:

1. Top management commitment and support.
2. Supervisory indoctrination and leadership training.
3. Supervisory development in basic safety management (skills training, tools training).
4. Employee education and commitment.

Before looking at our strategy in some detail, have you ever wondered why certain companies and supervisors, while employing identical tools (commonly referred to as the "safety program") are more successful than others?

Why are we always looking for something new each time our results are less than desirable? Are we looking at the total management concept as the safety program, or, are we just looking at a series of tools?

Identical tools can take on completely different activities and reactions, dependent on the concept or psychology behind it. A tool managed under the concept of authority and

discipline will in no way resemble the same tool managed under the concept of people-motivation and commitment. This is the basic reason for differing results among companies and supervisors using "the same tools."

An effective fundamental program, a basis for effective innovation, must be completely integrated within the entire management process. Let's look at a strategy of implementing this concept.

Concept for Integration

Top management commitment and support must support with strong policy decision on total concept, must give priority to safety as a key part of the production process, must provide direction and recognition for results, must have a comprehensive manpower planning and development program, must clarify specific managerial job limitations so that people may effectively function in their area of freedom.

Supervisory indoctrination and leadership training should familiarize all supervisors with their key responsibility areas and the overall company objectives of which they are part; clarify their specific job limitations in such areas as policy, budget, legislations, relationships etc., so that they may operate effectively and freely in their area. They should, in turn, know and recognize their superiors' limitations, to promote understanding and truthful interchange. All supervisors should be given the development opportunity to sharpen their leadership skills: understanding of the essence of leadership; understanding of human needs and behavior; recognizing frustration symptoms; learning to understand and improve attitudes and morale; learning communications and listening skills; learning to apply positive discipline; understanding the basis of management effectiveness; understanding self.

This training and the use of learned concepts will have a significant impact on the form the safety tools used will take and in the results that these tools will generate. It is, therefore, of paramount importance that the company management concept be such that it will allow supervisors to function freely with the learned concepts.

Supervisory skills training in basic management is a necessary part of an integrated safety program concept: development of hiring standards; development of interviewing skills; development of the initial induction program as the first step of integrating the employee into the organization; development of training strategies for each job; development of job instructing skills; understanding of the use of graphing and pathing techniques; development of record-keeping and reporting skills; understanding the development of goals and standards; understanding and learning conference discussion skills; understanding of specific job limitations and standards for himself and subordinates, these to be communicated to enable the team to operate effectively in its area of freedom.

Supervisors' tools training to assist supervisors in organizing with their people a sound Safety program includes: use of meetings for analyzing, appraising, and decision-making (Where are we presently in terms of results? What are our goals? What key problems? What strategies will solve? What new goals?). Use of accident investigation for the purpose of developing future standards. Mutual development and use of an inspection tool with the crew, containing key result areas of the operation and standards or criteria for each key area, for the purpose of determining key problem areas for immediate action or further crew discussion for resolution. Understanding of safety legislations.

Employee training includes indoctrination with understanding of concept; job training with defined job limitations; goal setting and standards development; complete supervisors' tools training; understanding of control systems used, such as records, graphs, etc.; leadership and supervisory skills training, where advantageous.

All are integrated into total organizational goals under the concept of management designed to integrate individual and group goals as closely as possible with those of the organization, by managing, not under the concept of traditional authority, but rather by the concept of leadership for motivation and commitment.

The concept will lend itself towards establishing the same system for all parts of the total supervisory responsibility: overall operation's goals, department goals, key result areas of each department, key opportunity or problem areas, strategy development, and appraisal of results.

The total concept of employee motivation becomes acutely important, as Scott Meyers, the well-known lecturer, author, and behaviorist, stresses that people have ingenious ways of causing any program or system to fail, however well conceived, if they do not understand it, if they do not agree with it, if they have no influence or control over it, if they can see no stake in the outcome.

As managers, we must understand the need for changes in our own conceptual thinking and behavior if we are to achieve successful results in the future.

With sound leadership and progressive management organizations and concepts, our fundamental program will be one of integration based on communications, responsibility, and commitment, rather than on traditional authority relying on discipline, posters, contests, and giveaways.

Which route will you take?

SAFETY AND HEALTH IN EQUIPMENT TODAY AND TOMORROW

By CHUCK GARDNER
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The stated goals of this year's Congress are: Take time to be safe. Use time and judgment creatively to prevent accidents and the waste they cause.

We recognize that many owners and operators of equipment used in the wood products industry don't have the time, or think they don't have the time, or just plain don't take the time necessary to conduct a safe operation. As manufacturers, we are in no position to compel the operator to take more time to be safe. So what we try to do (for which we hope to make a reasonable return on our investment—profit, if you please) is to try and sell the operator some of *our* time, along with the judgment of our engineers and the creative talent of our product specialists, coupled with the latest improvements in the state of the art.

We manufacturers sell this time, knowledge, and creativity to the user in the form of more modern equipment, which usually costs more money. The object of this modern equipment is to remove the operator from what has proven to be an unsafe environment and put him in a place that is relatively safer. At the same time, we try to raise his productivity in a greater proportion than the cost increase of the safer equipment.

We must recognize the effects of both climate and environment when we consider man and the mechanization trend in the forest products operation. The woods is not an easy place to get around in. There are all sorts of tripping obstacles, sharp stabbing limbs, and a host of other living things that do not appreciate the intrusion of man. There is often a lot of ground debris and thorny growth which tear at a man's clothes and flesh. If the weather isn't too hot, then it can be too cold, with a little snow to add to the discomfort and increase the accident probability. The man certainly cannot see what is down around his feet—slipping and falling becomes a real problem. While moving around, using a chain saw to delimb a tree and cut in into shorter lengths a man can stumble over debris or stumps. This is a very dangerous operation for him. Even with the best of care, we find that experienced men with many years of service can have accidents under these conditions.

Heavy equipment manufacturers have developed a complete system for working in the woods. They have taken the man off the forest floor itself and placed him up in a machine that will accomplish the same things he did previously. Now, when this man enters the forest, he is reasonably well protected from most of the hazards he formerly faced. He has no contact with the ground unless he decides to leave the machine. Let us see how this system makes the operator's work safer and increases his productivity.

Consider the tree harvester. From his comfortable and relatively safer compartment, the operator skillfully performs his work. He has good visibility while approaching the tree and can place the harvesting attachment where he wants. By the simple manipulation of some power-boosted controls, he effortlessly cuts the tree and lifts it from the ground. Protection against falling objects is provided. The tree is completely under the operator's control and can be placed where wanted, instead of being allowed to fall at random. Quite often, the movement of a single lever causes several things to happen. The sequence of the operation is built into the circuitry of the machine, rather than leaving it to the operator.

The remaining stump is almost flush with the ground, making it much easier and safer for following transport machines to pick up the logs and travel at faster speeds. During travel periods, the tree can be left in the upright position or tilted to any desired angle. The ability to change the angle of the tree may be necessary during some conditions. It can be carried low when stability is a problem. When turning and steering are problems, it can be carried in the straight up position.

Upon reaching his desired location, the operator moves some additional levers that activate the mechanical delimbing operation, in direct contrast with his struggling to accomplish the same operation with a chain saw or an axe. The top is cut off, and finally the tree is placed in a convenient pile for further handling. Man and machine can now go back in the woods for another cycle.

Many of the dangerous operations previously performed by a man or men while on the ground have been eliminated and productivity has been greatly increased. With the trees located in a small convenient pile, another machine can come in and haul them away. Generally, this is the skidder. Modern equipment allows the operator to hook on to the trees and skid them away again without leaving the comfort and safety of his operating compartment. When ground conditions are slippery and soft underfoot, skidding can be better handled by a track-type machine, which has more ground contact area and traction capabilities.

Depending on the operation, it may be possible to complete this last operation with a fork equipped machine. In any event, it is this type of machine that finally puts the trees on a truck, which hauls them to another processing area.

After the trees have been removed, along comes a tractor pulling an offset harrow which disturbs the ground sufficiently so that it will be mechanically plantable. This also helps remove competition, allowing the young trees to get a healthier start. Another tractor pulls a mechanical planter. One man operates the tractor; another, the planter. Both operators are relatively well protected from hazards of their environment.

Getting the man off the floor of the forest was just the first step. We must now do what is necessary to protect him from hazards in his new environment. Construction can be carried on under reasonably safe conditions. Machines can be equipped with a suitable ROPS and other protective devices. Protection like this for the operator will help prevent injuries and probably save lives.

The large expense kept many machine owners in the past from installing a ROPS. Today, most employers are no longer allowed to make this decision here in the United States. The U.S. Department of Labor, through OSHA regulations, has made the use of ROPS mandatory in most operations.

Manufacturers have spent hundreds of thousands of dollars verifying that a ROPS equipped machine will give necessary additional operator protection. ROPS are now available for practically every piece of heavy equipment produced in the United States. They can be obtained in an open version or in totally enclosed arrangement, and when a ROPS is installed the installation and use of a safety belt also becomes required under OSHA and should be used.

To attain required noise exposure goals, the ROPS usually must be fully enclosed and treated with sound barrier and absorption materials. This in turn more likely necessitates the installation of an air conditioner to maintain comfortable temperatures.

Then we give the man convenient power boosted controls to make his days work less tiring. He is now off the floor of the woods and situated in a comfortable seat in a relatively quiet and air conditioned compartment. We think he is considerably safer, and he certainly is a lot more productive.

But our job doesn't end here. He must be given adequate instructions on how to operate his machine. Again, safety is stressed. Safe operating procedures are called to his attention, and many fail safe controls and warning devices are built into the machine.

Even the best of machinery requires some lubrication and maintenance, and these guides which give correct procedures are sent along with each machine. They also contain safety hints and checks to make this job also safer. Additional features are built into the machine in order to facilitate servicing of some hard to reach areas.

Along with each machine shipped from

the factory, practically all U.S. manufacturers of large equipment include a copy of the appropriate safety manual. These books have been prepared by the staff at CIMA (Construction Industry Manufacturers Association) with the combined help of safety and operating experts from all the major manufacturers. These are quite worthwhile books, and every operator should be acquainted with the contents of the one applying to his particular machine.

CIMA is a national association of almost 200 companies that manufacture construction equipment and related components and supplies. It serves as a central coordinating body for the construction manufacturing industry in the field of safety and environmental performance standards.

My company, as well as some other manufacturers, make available some very dramatic films on the subject of safety. These films are non-commercial in nature and certainly more than dramatically demonstrate the dangers of unsafe practices. These films are available for your use on a free loan basis and will make good material for safety seminars and meetings. Award winning films are *The Roll of Drums, Color of Danger, Challenge of Safety,* and *Everything to Lose.* They are in 16 mm color sound.

We have come a long way from the early days of working in the woods, and I am positive that the manufacturers of today's modern machinery allow a man to get more done with less chance of accident.

SAFETY IN INDUSTRIAL TRUCK OPERATIONS

By LESTER K. JENSEN
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Although powered industrial trucks were in use prior to 1920, the industrial forklift truck, as we know it today, started its popularity rise during World War II. The wartime problems of handling tremendous quantities of material and speeding the turn-around of vessels were solved, to a large extent, thru the use of the forklift truck. Both military and civilian people have learned a great deal about materials handling since that period, and the use of powered industrial trucks has experienced tremendous growth throughout the world.

Powered industrial trucks have also made a major contribution to the reduction of accidents associated with the handling of materials. According to the limited information available, the incidence of manual handling injuries such as hernia, crushed hands and feet per ton of material handled has been reduced by mechanical handling even with the ever-increasing quantity of material to be handled.

It was after World War II that it became evident some type of safety code for powered industrial trucks was needed. Therefore, the American Society of Mechanical Engineers formed a committee to develop a safety code for powered industrial trucks. The first issue came in 1950, and subsequent revisions in 1955, 1959, and 1969. All have become national standards, first under the American Standards Association procedures and, later, under American National Standards Institute procedures. The B56.1 scope "Safety Requirements Relating to the Elements of Design, Operation, and Maintenance of Powered Industrial Trucks, not Including Vehicles Intended Primarily for Earthmoving or Over-the-Road Hauling," provides the guidelines under which the committee operates.

Beginning with the 1969 edition, it was determined to be worthwhile to highlight manufacturer and user requirements by separating them. Thus, Part II is "For the Manufacturer" and Part III is "For the User."

It is important, before we start a disucssion of B56.1, for you to know that companies using powered industrial trucks are fortunate, because the B56.1 standard has been in existence for over 20 years. This means that if you have been using the equipment manufactured by reputable and reliable companies, your equipment probably meets or exceeds the requirements in B56.1-1969. This should be very satisfying.

Part I of B56.1 covers very general information such as scope, purpose, interpretation, committee membership, etc. and I will not go into detail, except to note that B56.1 is one of a series formulated under ASME sponsorship. To meet the requirements for a consensus standard under the American National Standards Institute procedures, the committee membership consists of manufacturers, purchasers or owners, employees affected by the standard, governmental bodies having regulating power or influence in the area, specialists such as consulting experts with no business affiliation or educators, insurance representatives, installers and directors and utility. No more than one-third of the membership of the committee can be from any one of the above categories.

Part II is for the manufacturer, and sets forth requirements for the design and construction of powered industrial trucks. All trucks manufactured after the effective date of OSHA must meet these requirements.

When manufacturers establish a rated capacity for their trucks, depending upon the type, it must be established at a specified load center and for a specified fork height, de-

termined by the manufacturer. For example: The rated capacity of a high lift counterbalanced fork lift truck must be established at a 24 inch load center. The fork height for which the truck can lift the rated capacity load at the 24 inch load center is established by the manufacturer from his testing.

Do not confuse rated capacity with capacity. Simply, "capacity" is the load the truck will handle as it is equipped, and is what will appear on the nameplate. If you need a truck to handle a load with a 30 inch load center and to lift to 189 inches, that is the capacity or working load of the truck and will appear on the nameplate.

Manufacturers must affix nameplates to their equipment. The nameplate should give the capacity, truck weight, serial number or model of the truck, and indicate whether the truck is accepted by a nationally recognized testing laboratory. The nameplate must identify attachments shipped on the truck and show the capacity of the truck and attachment combination.

The nameplates on electric trucks must provide the maximum and minimum weight of the batteries to be used and also the amp-hour capacity and voltage. In conjunction with this, the nameplates on batteries must give battery weight as well as voltage and battery identification.

Removable attachment nameplates must show serial number, the weight of the attachment and the attachment capacity or rated capacity. In addition, the nameplate must indicate that the capacity of the truck and attachment combination may be less than the capacity shown on the attachment nameplate, therefore the truck nameplate must be consulted.

One of the most significant results of the B56.1 work has been the development of the tilting platform tests for determining truck stability. These tests are static tests intended to duplicate dynamic conditions. If a truck has passed these tests, it is recognized as being acceptable for operation in general industry use. Four stability tests are required for counterbalanced trucks.

Test No. 1 is for longitudinal stability stacking. If a truck can be tilted to a slope of four per cent without overturning, it passes the test.

Test No. 2 is for longitudinal stability traveling. The truck, carrying rated capacity load at 12 inches, is placed on the platform with the mast tilted all the way back. If the truck maintains stability at a slope of 18 per cent, it passes the test.

Test No. 3 is for lateral stability stacking. The truck, with the upright fully elevated and fully loaded, is tilted back. If the truck withstands a six per cent slope without overturning, it passes the test.

Test No. 4 is for lateral stability traveling. This test duplicates the truck traveling empty. The truck is tilted to determine the platform slope. The required slope value is determined by truck speed. By knowing the speed of the truck, the required slope value can be determined from a graph in the test procedure. The slope of the curve in per cent is 15 + 1.75 V, with a maximum of 50 per cent.

B56.1-1969 also has stability tests for narrow aisle and reach trucks. I will not go thru these; however, since these trucks are non-counterbalanced, it takes eight tests to determine their stability. Some of the tests are similar to the counterbalanced tests; others are conducted with the truck placed on the platform in a rearward position.

B56.1 also includes stability tests for order picker trucks. These trucks are a new type, where the operator not only raises and lowers himself from a platform affixed to the lifting carriage or forks, but also controls the truck horizontal travel. Order pickers are popular in the grocery and furniture industries. I will not go thru the eleven tests required to determine their stability.

It is expected the 1974 revision to B56.1 will include stability tests for other types of trucks, such as single side loading trucks.

Part II also covers steering arrangements for sit-down rider and motorized hand/rider trucks, and includes those using steering handwheels, and steering tongues or tillers to insure that when the same type of truck is purchased from any manufacturer, it will steer in the same manner. .

Steering controls on all rider trucks except motorized hand/rider trucks must fall within the plan view outline of the truck. The steering handle on motorized hand and hand/rider trucks must be provided with a means to protect operators' hands against injury from swinging doors, walls, etc.

An important requirement covers service braking performance of all powered industrial trucks except industrial towing tractors. The service brakes are required to develop a percentage of gross vehicle weight in drawbar drag equal to three times the velocity, but not to exceed 30 per cent. For example: The brakes on a six-mile per hour truck must develop a drawbar drag force equal to 18 per cent of the gross vehicle weight, with a pedal effort not to exceed 125 pounds.

Hopefully, the next revision will include braking requirements for industrial towing tractors. There are several sections covering safety control and brakes for sit down and stand up internal combustion engine powered trucks, sit down and stand up electric trucks, motorized hand and hand/rider trucks, and order picker trucks. These sections include requirements for.accelerator location, parking brake requirements, brake location, travel control arrangements, service brake system strength requirements, etc.

Section 417 covers the location and direction of movement for load handling controls. The function of the control should also be clearly indicated.

Overhead guard strength requirements consist of a static load test and a hardwood cube drop test. The static load tests the overall structural strength of the guard, while the 100 pound cube drop test measures the guard's resistance to small falling objects which may fall on the guard above the operator's head. Most industrial truck manufacturers also meet the Oregon drop test for overhead guards. I cannot speak for all of them, but I know ours do.

Load backrest extensions when used, which should be whenever the type of load being handled presents a hazard, should be large enough and strong enough to keep the load from falling backward toward the mast.

The section on operator platforms also covers operator enclosures. Operator enclosures are not recommended for stand up end-control trucks because rapid and unobstructed ingress or egress for the operator is more desirable. Trucks of this type work on the loading docks and are used in and out of trucks. The operator is frequently required to get on and off the truck, and operator enclosures severely restrict the operation.

Reach and narrow aisle trucks may have operator enclosures in conjunction with the platform, providing they do not restrict ingress and egress. It is also necessary for the operator to frequently get on and off these trucks, and he must be free to do this with ease.

Most motorized hand/rider trucks are steered with a steering tongue, and any operator enclosure in conjunction with the platform would restrict their use. A major use for these trucks is in the grocery industry, where it is desirable to have the walking ability to pick orders, and also the flexibility of riding in order to transport loads several hundred feet.

Removable platforms on order picker trucks should be provided with means for attaching them securely to the lifting device. Guard rail or means for securing a tether are also required.

The section on warning devices requires every truck or tractor to have a warning horn, whistle, gong, or some other device.

This concludes the general requirements imposed upon the manufacturer by compliance with Part II.

Of significance to the user is Part III. Much of Part III was also picked up by OSHA in Section 1910.178 without specific reference. Part III contains broad safety standards applicable to users and operators.

Experience has shown that high lift trucks which comply with the stability standards in Part II are stable when properly operated. However, if they are not operated or maintained properly, this is not only beyond the control of the truck manufacturer but may produce a condition of instability and defeat the purpose of building them to a standard.

A user must be aware of conditions which affect the stability, such as ground and floor conditions, the grade on which he has to operate, the speed at which the trucks are permitted to operate, the truck loading. A truck equipped with a big, heavy attachment is already a partly loaded truck and should be

driven accordingly. The battery weight, the dynamic and static forces imposed upon the truck during its operation, and above all the judgment exercised by the operator in the operation of the truck also affect stability. Operators should be trained to adhere to the operating instructions covered in section 6, which will be covered later.

Users must keep ramps, aisles, and floors in first class condition and free of loose objects. It should be noted that most powered industrial trucks are manufactured for general industry use, and thus the stability tests do not take into consideration those operations which might require excessive forward tilt at high elevations, or the operation of trucks requiring excessive off-center loads or excessive rear tilt. Such conditions must be taken into consideration when ordering the truck.

Modifications or additions which affect the capacity and safe operation of the truck should not be done by the customer or the user without written approval from the manufacturer. This just makes good sense. You should always consult with the truck manufacturer so he may advise you. Whenever a modification is made, capacity plates and all operation and instruction decals must be changed accordingly. If an attachment is added in the field, the manufacturer of the truck should be consulted for advice and a new truck nameplate to identify the attachment and indicate the capacity of the truck-attachment combination.

Almost all manufacturers ship trucks today with overhead guards as standard equipment; however, the manufacturer cannot keep the guard on the truck and in place for its intended use. Only the user of the truck can do that! A major cause of accident is falling loads on trucks without overhead guards. You should see that overhead guards are used under all conditions. If low headroom area restricts the use of the guard, effort should be made to obtain a retractable overhead guard, or the restriction should be eliminated. I believe the next revision of B56.1 will have more specific instructions for the user regarding overhead guards.

NFPA 505 now (B56.2) covers requirements for the handling and storage of gasoline, diesel, and LPG fuels, and fuel containers. There are also maintenance requirements for trucks used in hazardous areas. The section on charging and changing storage batteries is similar to Section 506 in Part III, and OSHA Section 1910.178. One troublesome item pertains to the servicing of batteries. It is important when mixing electrolyte to always pour the acid into the water, never water into the acid. However, this does not restrict adding water to batteries already in service. The instruction pertains only to the mixing of electrolyte.

Whenever powered industrial trucks are operated in hazardous areas, the truck shall be of the types recommended in NFPA Standard No. 505, type designations, areas of use and maintenance of powered industrial trucks. The trucks should also be recognized as being built in accordance with the pertinent paragraphs of UL standards 558 and 583. These standards have been adopted as American National Standards and are designated B56.3 and B56.4. OSHA covers both of these items in some detail.

Aisles, roadways, or passageways should be marked according to the USA Safety Standard color code for marking physical hazards and identification of certain equipment, Z53.1-1967. This national standard is included in OSHA.

Item 509 suggests that powered industrial trucks be painted a color to comply with the recommendations of Z53.1-1967. As a result, many users wanted their trucks painted yellow. However, item 509 was not adopted by OSHA; therefore, the Department of Labor issued a letter of clarification indicating that there are no requirements to paint industrial trucks any specific color.

Part III includes general recommendations on lighting for operating areas where powered industrial trucks are used. It also covers dockboards and bridgeplates. It is suggested you review these items to determine how they affect your operation. OSHA has also covered these same areas. Troublesome interpretation areas will be clarified in the 1974 revision.

Paragraph 511, covering control of noxious gases and fumes, recommends that the concentration levels of carbon monoxide gas created by powered industrial truck operation should not exceed the levels specified in Z37.1-1941. This is no longer valid. OSHA recommends ambient air concentrations be limited to those specified by the American Conference of Governmental Industrial Hygienists. There is some indication the National Institute for Occupational Safety and Health will establish new criteria for carbon monoxide concentrations for places of employment in the near future. However, OSHA presently limits the concentrations to 50 parts per million. The user must provide adequate ventilation in enclosed areas if they expect to maintain the specified levels. This is important! Ventilation is the only answer! Again, there are no OSHA requirements on emission from industrial trucks, only the ambient in-plant air.

Whenever a user has operating conditions which dictate specific types of warning devices, he must make sure they are provided thru the manufacturer upon special order.

Perhaps of most significance in Part III is Section 6, "Operating Safety Rules and Practices." This section covers operator training, and general operating instructions for traveling, loading, and operator care of the truck. Operators of powered industrial trucks must be physically qualified, and an examination should be made annually to include such things as field of vision, hearing, depth perception, and reaction timing.

The operating instructions in Section 6 are a result of experience associated with the operation of industrial trucks. It is important these be reviewed carefully and operators made aware of their importance in safe operation. Most training programs will include same or similar instructions.

OSHA requires trained operators and, although it is not specific as to what constitutes a good training program, it says means shall be devised for assistance. It is recommended you consult with powered industrial truck manufacturers. A good operator training program should:

1. Start with a careful selection of the operator.
2. Acquaint him with the equipment and how it works.
3. Teach him fundamental rules before he operates any of the equipment.
4. Include carefully supervised practice, driving on a planned course.
5. Include knowledge and performance test before graduation.
6. Have a continued emphasis on safe driving after graduation.

As indicated, lift truck manufacturers, large companies, and several material handling associations have operator training programs available. My company has a driver training manual, a safe driver award program, plus a small booklet called "The Professionals," and a small handout called "In Plant Driver Training." In addition, many training films for safe driving instruction are available. Many manufacturers help conduct driver training programs either in the customer's plant or at their own facility.

Experience indicates that approximately 70 per cent of the accidents associated with powered industrial truck operation are people-oriented. Therefore, enough emphasis cannot be placed on the importance of operator training.

The National Safety Council conducted a survey on industrial truck accidents two or three years ago. It might be worthwhile for you to review the common causes of accidents mentioned there. The state of California has a similar study.

Section 7 covers maintenance safety. A large number of accidents occur while performing truck maintenance. These range from slipping on oil to failing to block the truck or upright before working on them. Section 7 covers instructions for leaving the truck and instructions while working on the truck. Maintenance people should also be instructed in the safe operation of trucks, so that any operational checks can be made safely and in an authorized area.

Fire hazards should be avoided at all times by maintenance people. Open pans of cleaning fluids or other flammable liquids in the maintenance area are forbidden. It is important that work areas be properly ventilated, particularly when internal combustion engine trucks are being operated.

Maintenance checks should include a complete and thorough check of all truck safety items. The overhead guard, load backrest extension, steering mechanism, brakes,

lights, warning horns, etc., should all be checked carefully before operating the truck. When maintenance people perform maintenance on trucks approved for hazardous area operation extra special precautions should be taken in order to maintain the original safeguards built into the truck. Fuel systems should be checked for leaks, and hydraulic systems should be regularly inspected and maintained in conformance with good practice.

The maintenance department should make sure capacity, operation, maintenance, and instruction plates or decals are maintained in a legible condition. Industrial trucks should be kept clean to reduce the possibility of fire hazard and to facilitate the detection of loose or defective parts or leaks. Again, the maintenance department shall not make modifications or additions to the truck which might affect capacity or safe operation without permission of the truck manufacturer. All replacement parts should be interchangeable with the original truck parts, and above all they should be of a quality equal to that provided in the original truck manufacture.

This summarizes Part III of the B56.1 Standard. Questions concerning the meaning or the interpretation of the standard should be sent to the American Society of Mechanical Engineers. They will forward the inquiry to the chairman of the committee, and you should expect to hear from him.

Textile Sessions

TECHNIQUES FOR REDUCING TEXTILE MACHINE NOISE

By PAUL D. EMERSON
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Textile machines are noisy, but they didn't become that way overnight. They started out in a quiet sort of way as simple aids or tools designed to facilitate hand operations in the making of textiles. As they grew more and more complex, as their productivity increased, as their useful life extended, as their maintenance requirements decreased, and as their economic usefulness improved, the noises they introduced increased markedly. Very few textile machines of today can be considered quiet, and those that are somewhat quieter generally cost somewhat more.

Since early 1971 when the Occupational Safety and Health Act of 1970 went into effect, the standards which apply to the Act have demanded a re-evaluation of textile machinery design with respect to both safety and health considerations. In the case of safety, textile machinery guarding in many instances will need to be improved. In the case of noise, there exists a health hazard which has been generally recognized but which has been difficult to correct. In spite of the fact that fully adequate protection in nearly all cases can be achieved through the use of hearing protective devices, either plugs or muffs, the secretary of labor has issued a standard which requires that engineering controls be utilized to reduce noise. Administrative controls are acceptable as an alternate method for controlling exposure to noise. Protective equipment is permissible for control of employee exposure during the period required for institution of engineering or administrative controls. If engineering control is demonstrated to be not feasible, protective equipment is acceptable and mandatory.

With respect to the problem of noise, today's textile mill manager is confronted with the necessity of making at least three decisions, all based on economics. First, he has to decide whether to replace present equipment with new equipment. Certainly noise is not the only consideration here but, other things being equal, it is important to consider. Second, he must decide what to do with his present equipment. Can it be repaired or maintained, or can retrofixes be applied in order to reduce noise? Third, a decision must be made as to how far to go into a program of noise control. This decision involves establishment of a level of feasibility for an individual company. Such a level can be established only by careful engineering and economic studies.

Replacement of equipment by new machines is only a partial solution. While the new machinery may be quieter, it seldom is sufficiently quiet to meet the requirements of the standards. Repairs, modifications, rebuilding or extensive maintenance programs may be more effective in the long run. These programs are, however, not without cost, and since they seldom increase productivity they are viewed with little enthusiasm by most mill managers. For this reason the decision on feasibility is a pressing one. It is necessary to come to a definite conclusion on how much money can be committed to a program of noise control. For this reason it is essential that a manager secure the greatest noise reduction per invested dollar that it is possible to achieve.

According to the present standard for occupational exposure to noise, it is necessary to implement engineering or administrative controls whenever an employee can be subjected to a daily noise dose exceeding 1.0. Dosage is determined by dividing actual exposure by permissible exposure. If the result is less than 1.0, the employee exposure is within permissible limits. If the exposure dose exceeds 1.0, the employee is exposed be-

yond permissible limits and engineering controls or administrative controls must be implemented.

Engineering control of noise has been defined as any procedure other than administrative control or personal protection that reduces the sound level either at the source of the noise or in the hearing zone of the employee. Since the transmission of sound requires a source, a transmission medium, and a receptor, it follows that engineering control must concern itself with control of noise either at the source or by interfering with the transmission of the sound. Ear protective devices, while actually interfering with transmission of the sound, are not considered as engineering controls in the strict sense of the definition. Some engineering controls are feasible. That is to say, they are technologically possible and economically practical. Other engineering controls are not feasible because they do not meet the criteria of technological possibility or economical practicality. In the most recent draft of a proposed standard for occupational exposure to noise, as developed by the Standards Advisory Committee on Noise, it is stated that "Engineering controls will be deemed feasible if there is substantial evidence that practical and economically sound methods exist for reducing noise sufficiently to meet the criteria. . . . " In view of the fact that feasible engineering controls will be required, it is essential for the textile industry to become aware of those techniques which have been proven feasible for use in the textile industry.

What are some of the feasible techniques for engineering control of textile machine noise? Fundamentally, there are only five sources of noise, each one of which has appropriate corrective measures. These are: impact, mechanical vibration, electromagnetic vibration, friction, and fluid motion.

Source control of noise requires that individual noise generators be isolated, identified, and characterized so that applicable corrective noise control techniques can be applied. Expected noise attenuation can usually be estimated or determined experimentally. Cost of the corrective procedure can be determined, and a cost per decibel (db) of expected attenuation can be calculated.

There are really only two ways textile machine noise can be transmitted: in air, and through solid materials. Partial interference with sound transmission is often highly effective. It is accomplished by use of baffles, curtains, or shields. Even more effective is total enclosure.[1] Generally speaking, enclosures provide the lowest cost per db of any control technique.

The word "retrofix" is a relative newcomer to the field of noise control. Its actual meaning implies use of corrective measures more or less as an afterthought in the revision of present machinery configurations with the express intent of reducing the noise generated by individual machine elements. The technique is concerned primarily with control of noise at the source. Only in rare instances will it be found to be usable in control of transmitted noise. Of necessity, the textile industry must concern itself increasingly with the application of retrofixes for the problem of noise control. Several examples of successful retrofixes are described below:

In a noise control training project at North Carolina State University, two students were assigned the responsibility for developing a noise control technique on typical spinning frames.[1] Their first attack on the problem was to make a determination of the primary source of noise on a small spinning frame in the School of Textiles. Because the frame is short, approximately 20 feet in length, the vacuum end collection system on one end of the machine was readily found to be the predominant noise source. This condition is not necessarily representative of most production areas, but in this particular case it was of interest. A calibrated tape recording was made and subjected to real time analysis, where it was determined that the 99 dbA noise level generated by the vacuum end collection system was dominated by a peak at 400 Hz. By a process of elimination, it was found that the fan blade passage frequency corresponded almost exactly with 400 Hz. This was actually no surprise, but the correlation was definite. Since the noise was obviously being caused by passage of the individual fan blades, control at the source was obviously impractical, and ways to interfere with transmission of the sound, or to contain it, were considered. Simple modifications were made, consisting of a shroud around the outside of the flange and a duct which directed the flow of air downward over the drive motor. Total cost of this design was estimated to be something less than $20. Sound levels were again measured at the same position as before the corrective measures and were found to be 81 dbA, an effective reduction of 18 dbA. There was no noticeable difference in the performance of the vacuum end collection system over the entire length of the machine. Subsequent blocking of the top grill work in the fan enclosure resulted in an apparent additional noise reduction which was not measured.

As a result of an extensive investigation conducted by a graduate student, John D. Evans, a candidate for the MS degree in the School of Textiles, a detailed study on "Noise Radiated by an Eccentrically Rotating Bobbin" was conducted.[2] Evans reached two fundamental conclusions: (1) He demonstrated that eccentricity of a rotating bobbin resulted in generation of noise and that this noise was proportional to the degree of eccentricity; (2) He also demonstrated that imbalance, caused by the method of bobbin manufacture, was a contributory factor in causing eccentric rotation. Since most bobbins are manufactured with a built-in clearance between the lower bobbin ferrule and the spindle acorn, there is an unavoidable lack of control over degree of eccentricity. As a result of the work conducted by Evans, it is believed that noise levels can be reduced by as much as four decibels in spinning rooms, using a carefully balanced bobbin with closely controlled clearances between bobbin and spindle.

A particularly effective vibration control technique for large surfaces is constrained layer damping. The technique utilizes a layer of visco-elastic material sandwiched between the vibrating structure and a constraining member. The technique has been demonstrated to be effective in control of spindle vibration transmitted to spinning frame structures.[3] This work was conducted under the Noise Control Research program at the School of Textiles at North Carolina State University. The program was supported by 10 industrial sponsors and the American Textile Machinery Association. One of the studies consistently showed that constrained layer damping was effective in control of spindle noise transmitted to machine structures; addition of bobbins to the spindles resulted in a considerable loss of control. It was for this reason that the studies described previously were undertaken. Constrained layer damping has proven to be quite effective in control of noise radiated by large panels such as air conditioning ducts, drive enclosures, and power transmission guards.

Of major concern to a large segment of the textile industry is the fly shuttle loom. In a research program presently being conducted at North Carolina State University School of Textiles, a conventional shuttle-type loom has been modified for test purposes.[4] Whereas shuttle looms are normally driven through a crankshaft, in the modified loom the reed mechanism is driven by means of a pair of cams so that a dwell is imparted to the reed in its backward position. This allows greater time for propulsion of the shuttle across the shed and a consequent reduction of force required to perform the picking function. With a reduced energy requirement, there is a consequent reduction of energy loss in the form of sound, and it is anticipated that noise will be reduced measurably. With this modification it is no longer necessary that the shuttle boxes move with the reed, so the experimental loom has had the shuttle boxes immobilized. The immobilization provides for the possibility of a revised picking mechanism without lost motion, and a consequent elimination of impact noise. Further, it provides for the possible installation of a complete enclosure around picker stick, shuttle box, and picker mechanism. While this research work has been postponed temporarily, it is planned to renew the attack on this problem in the near future.

Maintenance has been proven to be a highly effective noise control technique. Perhaps the three most important noise control tools are a screw driver, a wrench, and an oil can. An example of this was recently demonstrated in a mill of an outstanding textile manufacturer. On one spinning frame operating on a week end, with the rest of the mill

shut down and no air conditioning in operation, average noise level near the test spinning frame was 98 dbA. After regreasing, the noise level fell to 86 dbA. It was noted that nearly all of the reduction occurred in the octave bands above 2,000 Hz. Greasing of spindles is certainly a feasible procedure, and as demonstrated in this case, is highly effective.

A small cotton and synthetic yarn manufacturer in South Carolina has achieved a nearly uniform two dbA reduction in all spinning areas during the past two years by careful attention to maintenance procedures. Spindle bearings are checked regularly. Spindle tapes are repaired whenever they show evidence of incipient failure. Cylinder shaft bearings are monitored regularly, head-end drive enclosures are prevented from vibration by means of rubber gaskets, and defective bobbins are rejected for use. The vacuum end collection modification described above is planned for early installation.

Monsanto Company's Textile Division at Pensacola, Florida, has successfully demonstrated that the noise level between two operating draw twisters can be reduced from 102 to 91 dbA by use of a Monsanto designed ball bearing, soft mounted, tape driven spindle assembly. The single spindle noise level is 67 1/2 dbA, operating at a speed of 10,000 rpm. Estimated cost of the modification is $40 per spindle.

In conclusion, it is readily apparent that noise control in the textile industry is here to stay. Noise is going to be reduced steadily in textile manufacturing operations. While dramatic reductions are not expected in the near future, continuous effort will be expended by machinery manufacturers, acousticians, engineers, and maintenance personnel. There are numerous success stories now. There will be more later. As these case histories accumulate, there will develop an appreciable background of noise control engineering information which will be readily available to any textile mill manager or maintenance supervisor for application to existing machinery. While progress toward quiet textile mills is perceptible, there is a long way to go, and there is a real need for more engineers and scientists to perform the necessary research and development required for effective noise control of textile machinery.

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INDUSTRIAL SAFETY PROGRAMMING FOR FEMALE EMPLOYEES IN FIBERS MANUFACTURING PLANTS

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The purpose of this study was to analyze existing data relevant to injuries sustained by female employees in fibers manufacturing plants, relate these data to changes in federal and state legislation governing work done by females, and determine through experimental study what changes in safety programming might be warranted.

Statistics indicate that there has been an historical rise in the proportion of women to men in the work force in the United States. This proportion has grown, from one-sixth in 1890 to one-fourth during World War II to almost one-third in 1959. In 1960, 22 1/2 million workers were women.

The U. S. Labor Department has made projections of changes in the total working population from 1955 to 1975, based on the absence of war, favorable economic conditions, and other assumptions. At the beginning of this 20-year period, there were some 22 1/2 million women workers, comprising less than one-third of the labor force (namely, 30%). It is anticipated that by 1975, the number will have increased by close to 12 million. More than half of this increase is expected to take place in the first ten years, and most of this expansion will be accounted for by young women under age 25 and women over 34. In a study done by Sappington involving 452,000 employees in 54 plants, it was shown that women sustained more serious injuries than men when subjected to similar exposure for a like number of work hours.[1] The frequency, severity, and sick absences were higher for women during the period studied. The study done by Sappington indicated this trend held true throughout the entire period investigated.

Accident rates tend to rise when there is an influx of new workers into industry or wide-scale shift among occupations. High turnover and part-time availability are also associated with women. This was particularly true during the period 1942 to 1946, when women were recruited to fill the vacancies created by military-bound males. Safety training is especially essential for these two labor groups in order to achieve a downward movement of work accidents.

This rising number of women in the labor force and their importance to the national economy prompted the U. S. Department of Labor to do a comprehensive study on this subject in 1965.[2] This report indicated that many changes have taken place in women's employment over the last 50 years and that the rate of change is still accelerating. The report further indicated that in a number of industries such as household furniture, textile, dairy, and leather products, the frequency rates for injuries to female employees exceeded the all-manufacturing average.

The trend in recent legislation has been to remove any inequities in opportunity for women to compete with men for similar positions. As a result, more women are entering the work force and assuming positions heretofore done by men. Many of these positions require physical exertion and manipulative skills at the periphery of the limits previously deemed appropriate for women.

A government study of 4,000 injuries to workers in shipyards indicated a difference between men and women in the same occupation working under the same conditions. The investigation began early in World War II because of the high injury rates of inexperienced personnel. It was found that, on the average, women's injury rates were noticeably higher than men's, but the differences seemed to depend on the nature of the work.

In the electrical department, where operations were routine and light, the number of injuries were about equal for women and for men; however, in the heavy jobs—welding, ship assembly, etc.—where work in an awkward and strained position was required, women had more accidents than men. One possible reason is that the men had had more experience than the women in this type of labor. However, several studies have shown that tasks requiring weight lifting or load carrying result in female employees sustaining more medical incidents than males. In its publication dealing with maximum weights to be carried by women, the International Labor Organization states: "Since it is the muscular apparatus which does the work necessary for load-carrying, the quantity of work which a person can perform is related to his muscular mass. There is thus a certain connection between the weight of a worker and the weight of the load he can carry. It should be noted, however, that in women the ratio between body weight and muscular mass is less favorable than in men."[3]

In summarizing the research done for his book, Sappington states: "The more extensive use of women counselors, women physicians, and women safety directors is suggested, and this might include gynecologists for referred cases. It is realized that comparatively few of these are available, but training programs should be so arranged that more will be available. Personnel, medical, and safety courses could well be devised to admit and graduate more women as it seems obvious that women employees will more readily unburden their personal difficulties to professional women in these phases of industrial life than to men."[2]

An initial pilot study within the Celanese Corporation textile manufacturing plants indicated that women were sustaining a disproportionately high percentage of injuries where handling of product or equipment was involved. This was particularly true in the departments where the weight of the material handled increased or the difficulty in pushing or pulling of transports was encountered.

In order to obtain optimum results from a safety program for a population having female employees, it must be determined if the safety programming and methodology previously used for a predominantly male population should be amended to reflect this change in worker exposure. Prior to the suggestion of any proposed changes in approach, it was necessary to determine if changes in method would have a beneficial effect on the accident frequency and severity of this changed work force. The intent of this study was to determine the effect of these changes under controlled experimental conditions.

Primary emphasis of this study was placed on the safety education and training aspects of safety programming. However, the differences in average height, weight, and stature between females and males may require extensive modifications to tools, machinery, and equipment if females are to use this equipment without sustaining injury. Murrell[5] wrote extensively about the need for different sizes, shapes, and design for equipment based upon differences in body configuration between females and males.

All research into related literature accomplished thus far supported the contention that female and male workers are not comparable subjects in the area of safety programming requirements. These studies indicated that there are differences in psychological and physiological limits for females and males and that changes in safety programming may be required in order to prevent accidents and injuries where known limitations are a contributing factor.

Sappington states that: "Except in instances where women have been used for a period of 20 to 25 years continuously in industrial establishments, it is not possible to even approach a standardization of policy with respect to personnel, medical, and safety. These supervision programs take time, effort, and consideration, but pay excellent dividends, according to those who have them."[6]

The purpose of this study is to determine whether there are basic differences in the textile industry in the safety incidents occurring to females versus males, and what effect modification of safety programming would have upon this ratio.

The need for effective safety programming increases proportionately to our technological advances. Grimaldi indicates: "In the presence of almost endless lists of patent hazard correctives (most accidents, it would appear, should be corrective), most accidents, it would appear, should be preventable. That they are not has been evident frequently. The resulting frustrations probably account substantially for the popular emphasis on safety awareness programs, since errant behavior may be the most visible explanation for accident prevention failures. The rationale seems to be plain: given a source for countering established accident causes, only ignorance of its applicability or benefits will limit its use."[7]

To help bridge the gap between the voluntary and often sporadic measures taken by employers to provide adequate safety programs for their employees, Public Law 91-596 was passed in 1970. This law affected approximately 4.1 million employers and 54 million employees. It required that every employer with one or more employees (other than immediate family or domestic help) is to provide basic safety and health measures in his place of work. Section 2 of Public Law 91-596 reads as follows: "The Congress finds that personal injuries and injuries and illnesses arising out of work situations impose a substantial burden upon, and are a hindrance to, interstate commerce in terms of disability compensation payments. The Congress declares it to be its purpose and policy, through the exercise of its powers to regulate commerce among the several states and with foreign nations and to provide for the general welfare, to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources."

Elkow states: "While research and empirical observations have not provided us much information about safety and the part that one's sex plays in it, the availability of new highspeed computers will enable the handling of enormous amounts of data. Future research may pinpoint some areas where sex significantly relates to safe behavior. It will then be possible to focus on problems associated with sex and safety and make recommendations for modifying educational programs to meet the needs of the young, middle aged, and advanced aged members of both sexes."[8]

In order to comply with the new federal and state laws as well as the ever present desire on the part of most employers to minimize the frequency and severity of incidents, research is required to determine what changes in safety programming will combine the best facets of education, engineering, and enforcement to obtain optimum results. Grimaldi indicates that: "The reports of research workers and observation of industrial operations tell us that industrial fatigue effects are not wholly the result of heavy muscular effort. In fact, fatigue is particularly dependent upon motivation. The problem of providing motivation is assuming dominant importance in industry, as means are sought for overcoming the effects of fatigue on production and safety."[9]

In a recent article, Henschel, a science consultant of the National Institute of Occupational Safety and Health, states: "Most people reach an efficiency peak during the third hour of their morning work and the third hour of the afternoon. If they work beyond that amount of time, efficiency may be down 25 to 30 per cent. To me, that reflects strain, so safety becomes a concern. Susceptibility to such factors is affected by age, by sex, even by the weather. In addition, every individual undergoes daily and cyclical mood and body variations. You really have to individually tailor each job to each worker, as far as possible."[10]

A pilot study made in several fibers manufacturing plants indicated that females were sustaining a disproportionately high frequency rate of medical incidents. This initial research indicated that changes in safety education, engineering, and enforcement might result in a reduction in the frequency of these incidents.

Two plants were selected for this study on the basis of their similar safety programs, management policies, end product, work environment, and exposure to injury. There are in excess of 2,000 employees at each plant. The experimental plant, at Rock Hill, South Carolina, was to undergo a modified safety program. The control group, at a Cumberland, Maryland plant, continued with the

existing safety program. The study was designed to compare accident data for a six-months period in each plant with data for a three-year control period in each plant.

The experimental safety program was designed after analysis of data pertaining to the control period. Frequency and severity of incidents were determined. Current labor and safety laws were examined to determine their effect upon changes in risk or exposure to injury. Safety programs in other textile manufacturing plants were reviewed and heads of safety departments in these companies consulted. Three female supervisors were chosen from departments having the best safety record in the experimental plant. These females were encouraged to assist in the design of the experimental program. Their ideas were solicited, discussed, and incorporated as warranted and feasible. The program derived its uniqueness from the special emphasis placed upon: (1) education of female employees, using material designed or prepared by females; (2) consideration of potential structural, machine, and equipment hazards to assure that the physiological differences of females had been considered; (3) amendment of programs for safety investigation and enforcement so as to include participation by female employees.

The new safety program was reviewed by plant personnel and implemented. After the experimental period, the medical records were reviewed and these data were correlated with the data for the control period. Analyses were made in terms of the factors of age, length of service, part of body injured, time of day, day of week, and work department.

Results of the analyses indicated the following trends in the frequency and severity of incidents incurred by the two work groups:

1. The frequency rate for females in the experimental group declined while the rate for females in the control group increased.

2. The frequency rate for males in the experimental group declined. The rate for males in the control group also decreased, but to a lesser extent than the males in the experimental group.

3. The severity rate for females in the experimental group increased, but less than the increase in rate for the females in the control group.

4. The severity rates for males in both groups decreased significantly.

From these data, it can be inferred that modifications in safety programming so as to make these programs more compatible with the needs and motivations of females will have a beneficial effect upon the frequency of incidents sustained. Results with respect to severity rates may depend on or be clarified by a longer period of program implementation.

The design of this study was intended to provide additional research into one or more of the factors affecting the occurrences of safety incidents involving female employees in a textile manufacturing plant. Through a better understanding of these factors, a more effective safety program can be designed and implemented for these employees. If this study is supplemented and the findings substantiated by further research, extrapolation of these data to female employees in other types of industries may be warranted.

Development of the Experimental Safety Program.

In order to coordinate the projected changes to the experimental safety program, a study was made of the program existing prior to the experimental period. Although this safety program was detailed and comprehensive in scope, analysis of each part indicated that participation by females was totally lacking in the design, preparation, and presentation of program. This was found to be true of the education, motivation, investigation, inspection, and all other segments of the program, even though the number of females in the hourly work force exceeded the number of males.

It had been determined that experimental changes would be concentrated on work situations which had produced the highest frequency and severity of incidents. These changes would also reflect major types of exposure (i.e., pushing, pulling, cutting) and the action required to reduce the probability of recurrence of incidents.

Simultaneously with the research and data gathering portions of this study, action was initiated to establish a series of meetings with

personnel at the experimental plant. These meetings were designed to provide a sounding board for female supervisors to participate in the planning of the experimental safety program. The two female nurses and the three female supervisors having the best department safety record were invited.

As a result of the discussions at the five meetings, the experimental safety program was formulated for use at the South Carolina plant.

The program was based upon the premise that female employees would respond more affirmatively to a safety program in which they were actively involved. With this basic principle in mind, the following is an outline of the highlights of the program.

1. *Awareness.* Interviews of female employees by the three female supervisors to ascertain near misses and any unsafe acts or conditions observed. Video tape presentations of actual or staged injuries and other safety messages. Presentations of statistics illustrating the frequency and severity of injuries in each department in the plant.

2. *Engineering.* Modification of a test group of transports to incorporate changes needed to allow for physiological differences between female and male. If trial sample proved successful, all transports would be modified to lower the hand grips, provide bumper strips at the bottom, and mark the direction of travel for each transport.

Knife modifications were made so as to make it easier for females to use the equipment safely.

A reinspection of the entire plant was made to find and eliminate hazards which might have been overlooked previously. Particular attention was directed to the machinery and equipment which could be construed as difficult for females to use due to weight, location, position of handles or controls, or the accessibility of related equipment.

3. *Personal Protective Equipment Program.* The following were included as part of the educational and motivational efforts required to assure female employee acceptance of the personal protective equipment program: statistics of plant injuries affecting various parts of the body over the three-year period; films provided by various vendors; posters; displays; video tape interviews of employees who have experienced accidents at this plant.

4. *Safety Meetings.* In conducting routine safety meetings, department representatives utilize, on a formal or informal basis, the female employees who have accompanied the foremen on accident investigations. The departments are responsible for organizing their safety topics and promotional campaigns under the guidance of the plant safety department, which will assist them in securing whatever material is needed.

5. *Accident Investigation.* The "First Aid Pass and/or Accident Investigation Report" would be completed by the departmental foreman covering the investigation of each minor injury occurring in the plant. In the extrusion and textile departments, a female employee would be appointed on each shift to assist the foreman in preparing the accident investigation. Whenever possible, the accident investigation would be completed within a 24-hour period. A female employee was selected by the area supervisor/safety coordinator to work with the union-management safety committee. Each female employee would participate in accident investigations for a three month period and be provided with training by the plant safety department regarding the purpose of these investigations.

An investigation team was established composed of a nurse, a safety representative, a maintenance representative, and a union-management representative to review and discuss the worst injury occurring in the plant each month. This would include discussions in detail with the injured employee and witnesses.

6. *Facility Inspection.* A female representative was assigned to the union-management safety committee for both textile and extrusion departments. This enables a female representative to accompany a safety department representative on periodic facility inspections as well as having the departments utilizing their services. In addition, as the experimental safety program evolves, all departments will expand their soliciting of information regarding unsafe acts and unsafe conditions.

7. *Safety Directives.* A new safety program directive was issued to implement the issuing and use of individual protective equipment in conjunction with this experimental study. This plant directive was reviewed by management committees and, when approved, was the subject of several meetings of management/labor groups. All first line supervision was given an opportunity to participate in the discussion and implementation of the program. The information obtained during the previous meetings with the female supervision was incorporated in the policy in such areas as hair net, safety shoes, and safe work practices.

Summary

The purpose of this study was to ascertain what effect modifications in safety programming would have upon the frequency and severity of incidents involving female employees in a fibers manufacturing plant. The following is a summary of the principal findings of this investigation:

1. In textile manufacturing plants, the highest frequency of incidents to females involves injury to the hands. This is due to knife cuts, contusions, and lacerations sustained while handling transports and to lacerations caused by faulty textile bobbins. Modification of this equipment effectively reduced the frequency of incidents incurred by females during the period of this study.

2. There was no significant difference in the frequency of incidents to females or males by shift worked. This suggests that no special emphasis or reinforcement of programming is warranted for this group due to shift worked. As previous research has shown, the periods of highest frequency of incidents are just prior to the noon hour and late afternoon. This study indicates that this cycle is equally applicable during the evening and early morning hours of the second and third shifts.

3. There was no significant difference in the frequency of incidents to females or males by day of week. Since the plant operates 24 hours per day, seven days per week, an equal exposure existed on all shifts and all days of the week. It can be inferred from these data that no further modifications in the experimental program are required to adjust for any particular day of week.

4. Injuries to the hand resulted in the highest average frequency and severity rates among women. Amputation of fingers and severe cuts to the hand and arm resulted in the highest number of days lost. From these data, it can be inferred that major emphasis should be placed on the elimination or control of hazards to the hands, feet, and body. Although not to be neglected entirely, only secondary concern need be shown for eye, head, and back protection. If the most stringent engineering, education, and enforcement programs are concentrated in the areas of greatest risk enumerated above, frequency and severity rates should decrease.

5. Foot injuries resulted in the highest average severity rate among the males tested. Crushed metatarsal bones from falling material accounted for the majority of injuries listed. As a result of this study, a new survey is being made of the plants to determine the female and male personnel who require protection beyond that provided by the steel toe in safety shoes. Metatarsal guards are being considered and will be worn where the hazard is of sufficient probability to warrant the inconvenience of wearing this protection.

6. In the control group, the females and males in the age group 25 to 35 had the highest frequency rates. In the experimental group, the younger group of workers under 25 years of age had the highest number of incidents. These data reinforce the conclusions drawn in previous research that young employees tend to have the highest frequency of incidents. In response to this research, the plant has initiated a more comprehensive new employee safety training program presented as an integral part of the total job training indoctrination. Reinforcement of safety awareness was increased to quarterly, with females participating in the preparation and presentation.

7. The females over 35 years of age sustained the highest severity rate in both groups tested. This would indicate that although the younger employees have more frequent incidents, when the older employee is injured, it tends to be of a more serious nature.

8. Male workers under 25 had the highest severity rate. This follows data established in previous experiments in this field.

9. Females and males with less than one year of service had the highest frequency of incidents in both plants. This also follows the trend of data previously established. For safety programming purposes, these data indicate that an effective new hire safety indoctrination program is a vital part of the overall program.

10. The highest severity rate in females occurred to workers in the over-15 years service. This would indicate that although the new worker sustains many minor injuries, the older worker may sustain the more serious. This may be attributable to the gradual diminution of physical response and the sense of over confidence with the ability to cope with existent hazards.

Conclusions and Recommendations

As a result of this investigation, the following conclusions and recommendations seem warranted:

1. The significant reduction in the frequency of incidents involving females suggests the experimental safety program was effective in motivating female employees to more actively participate in the plant safety program. Through this participation, a greater number of potential unsafe conditions and unsafe acts were identified and either eliminated or controlled. That is to say, physical changes were actually made to a number of tools and operational equipment. For example, the knife which had a sharpened edge the full length of the blade was replaced with a knife having a dull point. Transports were modified to provide an indentation in the handles which protect the hands from being crushed when two transports strike each other. Machinery was marked with yellow lines to identify a point beyond which bobbin threading should not be attempted. In addition, engineering modifications were made to tools, equipment, and machinery so as to accomodate to expressed needs of the female employees.

2. As identified in previous research, this study reinforces the knowledge that workers with less than one year of service sustain the highest frequency of incidents. This would suggest that new employee indoctrination and on-the-job training should include greater emphasis on the safety requirements of the work. Female supervisory and training personnel should participate in this indoctrination whenever new female employees are involved.

3. Injuries to the hands caused by improper handling of knives, transports, and other equipment can be reduced at least temporarily by employee awareness programs. Longer range reductions in frequency and severity require elimination of the hazard through engineering changes or control of the hazard through proper guarding. When the hazards were identified and marked, the frequency of incidents decreased. For example, it was only when the hazard was eliminated through change of knife blade and modification of hand guards on the transports that incidents decreased for six months or longer. Related data indicated that when hazards were marked but not eliminated or controlled, subsequent incidents had a tendency to be of greater severity. This suggests that employees may become more complacent when working with equipment which they no longer deem an immediate hazard.

4. Females over 35 years of age sustained the lowest frequency rates and the highest severity rates in both plants tested. This would suggest that as the employees' bodily functions such as reaction time, perception, and vision decrease in acuity, greater reinforcement of safety programming may be required if serious injury is to be avoided. Programs should be periodically reviewed to assure that hazards are assessed in relationship to the employees' physiological and psychological capabilities and limitations.

5. Safety programs in textile manufacturing plants employing females should be reassessed to assure that all segments of the program have been designed and implemented with full acknowledgment of the distinctive characteristics of female workers, their physiological capabilities, and limitations. Pilot studies should be conducted in each plant to determine the motivational media most effective for the females in the work force. Research of frequency and severity of incidents

over a two or three-year period would provide a sound base upon which to make changes in tools, equipment, and protective clothing.

6. Modifications should be made in programs, procedures and job safety analyses to assure that the directives are designed for females as well as male employees. A safety program audit form was prepared by this investigator for use at the plants involved in this study. The form includes specific references to female participation in the programming as suggested by the conclusions derived from the data collected. The safety audit form would appear to be of assistance in monitoring a unified program as described in this study.

7. Similar studies should be conducted in manufacturing plants other than those concerned with fibers, but having a high percentage of female workers, to determine if the findings of this study have implications in other manufacturing areas.

8. An extension of the present study should be conducted to determine the long-range effect of the experimental safety program upon the severity of injuries to females.

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TRAINING FOR SAFETY

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From its very beginning in 1802, the Du Pont Company has been involved in safety. Because it manufactured only gun powder and explosives for its first 100 years, positive safety thinking and action actually represented survival. Although the early incentive for safety consciousness was survival, it wasn't long before the company realized that good safety was also good business. Therefor, management paid continuous attention to safety, much the same way that it handles the more obvious aspects of its business, such as planning, production, research and development, scheduling, quality, and costs.

There are many incentives for making safety a management objective. There is the desire not to subject employees to pain and suffering caused by injuries. There is the desire for improved profits, higher quality work, improved productivity, and improved employee-management relations. And, of course, there is the Occupational Safety and Health Act of 1970.

Once safety has become a management objective, it is essential to clearly establish it as a line organization responsibility. Safety should become an integral part of every job. To whatever extent an employee is responsible for his company's activities, he is responsible also for the safety of such activities. A plant manager, a laboratory director, or a department head must be accountable for the safety of all employees in his organization. When a person is given the job of supervising an operation, the responsibility for the safety of those performing that operation goes with the assignment. But in the chain of an organizational structure, the individual employee must also assume the responsibility for working safely. The extent of responsibility and accountability of all people in an organization should be as systematic as it is in other job functions. This approach results in a safe working organization identical with the normal organization.

Behind every effective safety program there must be a specific safety philosophy. Many philosophies could be stated. One that I like and that has proved itself over many years is the one used by Du Pont. It contains five principles:

1. A positive belief that all personal injuries can be prevented.

2. An acceptance on the part of management, supervisors, and foremen of their responsibilities to prevent personal injuries.

3. A conviction that it is reasonably possible to safeguard all construction and operating exposures which may result in injuries.

4. Acceptance of the fact that the prevention of personal injuries is good business, both from the standpoint of efficiency and of economy.

5. A recognition that it is necessary to train all employees to work safely and to understand that it is to their advantage, as well as the company's, to work safely; further, that they have a definite responsibility to do so.

These excellent principles cannot be implemented, however, without a safety organization complete with a management safety committee to originate, guide, and coordinate the overall safety effort. The committee should follow the line of organization and be headed by the highest members of management assigned to a location. When management forcibly conveys its convictions about safety to the organization, you and each supervisory person in the organization will begin to carry out an effective safety effort as an integral part of your daily activities.

A brief word about Du Pont's safety performance and profit benefits. The number of

disabling injuries per million employee-hours of exposure during 1971 was less than 0.3. For the first 10 months of last year, it was less than 0.2. In contrast, the injury frequency rate for all manufacturing for 1970, as reported by the U. S. Department of Labor, Bureau of Labor Statistics, was 15.2. For 1971 the frequency rate for all industries, as reported to member firms of the National Safety Council, was 9.37. For the chemical industry, it was 4.76.

It is significant that of those reporting to the National Safety Council for 1971, the average industrial firm had 31 times as many injuries per man-hours worked as Du Pont. Firms in the chemical industry had 16 times as many injuries as Du Pont.

A closer look at injury frequency rates clearly shows how profits can increase from improved safety performance. A few years ago, we conducted a study which showed that the average lost-time injury costs about $10,000. While the cost per injury varies greatly from company to company, the following table illustrates the savings to Du Pont for one year, compared to the cost we would have incurred if our frequency rate had been the same as the experience of all industry, based on National Safety Council statistics.

Item	*Du Pont Record*	*Industry's Record**
Frequency rate (injuries per million man-hours)	0.29	9.37
Injuries durng year	54	1674
Average cost/injury	$10,000	$10,000
Total injury cost during year	$540,000	$16,740,000

*National Safety Council Members.

You don't have to be an accountant to see that good safety saved Du Pont over $16 million! It is important for each company to realize that poor safety is expensive and that long-term savings are available through good safety.

Let us concentrate on the fifth principle of our safety philosophy, namely: management's responsibility and need to train all employees to work safely.

By way of background, over the years much effort and emphasis had been placed on the improvement of physical environment and control of manufacturing techniques to provide the employee with the safest materials, methods, and places of work. Money and technology were poured into equipment design, building construction, and chemical safeguards.

As you know, OSHA standards are directed primarily at the physical aspects of safety. We analyzed our company injuries from 1954 to 1963 and found that over 90% were caused by unsafe acts of people rather than from physical deficiencies in buildings and equipment. So it was and is agreed that major improvement in safety performance can result from the elimination of unsafe acts of people.

Various training methods were employed. Previous plant efforts in establishing formal supervisory training courses of the academic lecture type had failed to produce significant upgrading in hazard recognition and corrective activity.

A few years ago, while a survey engineer and a plant safety engineer were engaged in an annual plant inspection, they were asked to spe d several days each in a supervisory on-the-job safety training effort. They worked out a formalized introduction of the lecture and discussion type. Then they scheduled themselves into the field for a period of time with each supervisor in his own and other areas for on-the-spot training.

It was soon apparent that this method was doomed to a short life and unfulfilled objectives. Manufacturing area noises made comment difficult and prolonged discussion impossible.

This led them finally to the use of programmed instruction and development of S-T-O-P which stands for Safety Training Observation Program. These self-study courses have become an important part of our supervisory safety training program and have been taken by over 30,000 supervisors outside of Du Pont.

S-T-O-P was planned and prepared by three members of the Fabrics and Finishes Department Safety Committee, Safety & Fire Protection Division, Supervisory Training Section, Engineering Services Division and safety representatives of several plants. The training objective was determined by analysis of company and department data of injuries and unsafe acts which show that 96 percent of injuries are the responsibility of people.

The authors of S-T-O-P decided to use the programmed instruction technique of training. This was logical, since Du Pont had pioneered in its use to train employees in industrial craft skills for over five years. During that time over $3 million were spent in preparing over 200 vocational courses which provided better training at less cost.

Let us review programmed instruction briefly.

Course Characteristics. The training subject is broken down into a logical learning sequence, in small steps requiring active responses. The correct answers are provided for immediate confirmation. This active response plus immediate knowledge of whether he is right or wrong stimulates the learning process in the same way as a personal discussion between a teacher and a student. The trainee proceeds at his own pace, and there is a very low error rate in responses.

The courses are developed in the following order: definition of the objective in terms of the target people being trained; behavioral analysis of the task to be performed; writing of the course, test and revisions; field validation and final revisions; and final course production. Many courses were developed.

The objective of S-T-O-P is to make skilled safety observations on people a sustained habit in line management. The objective will be achieved when no unsafe acts are committed in each member of management's area of responsibility. It does this not by itemizing or check-listing detailed unsafe practices and operations, which would discourage the most interested student, but by teaching observation techniques in very broad fields under such headings as personal protective equipment, positions of people, actions of people, tools, equipment, procedures, and orderliness. These seven subjects, along with an introductory unit describing the background and reasons for the course, comprise the eight basic training units.

Each training unit contains programmed instruction training in the techniques, checks and actions of a skilled observer; application of the field observation cards for on-the-spot job application of the fundamentals taught; and follow-up observations and discussions.

The administration of such a program is very important. To be successful, the full backing of management must not only be obtained but demonstrated. The administrator's guide-book strongly recommends that the administrator be the assistant plant manager. At the least, he should be a person whose position in the organization is highly respected, in order to insure the proper emphasis and dignity for the program. The leader's job falls into three categories: motivating, guiding, and testing.

Motivating. The administrator should talk very briefly at the beginning to emphasize that this program will only be as effective as each supervisor makes it. Another aid to motivation at this time is the expression of the plant management's view on the importance of the program, preferably made by the manager or assistant at the time.

Guiding. In the initial talk, the use of programmed instruction should be covered briefly, including:

1. Programmed instruction is the presentation of small bits of information followed by important question... All questions should be answered in the sequence presented.

2. Emphasize the fact that the trainee should take the time necessary to work the program thoroughly—he is not being timed, there is no time limit, and there is no reward for speed.

3. The correct answer is provided for each question. The trainee, however, should not look at that answer until he has selected and written his own answer on the course. The trainee should check every answer immediately with the correct answer, even though he feels sure he is right. When he finds he has made a mistake, he should immediately find out the reason his answer is wrong.

4. The trainee may review previous material when he runs into difficulty in answering

any question. He should never look ahead in the course.

The administrator should observe all trainees as they start the course to insure that they understand how to proceed and how to use the answer sheet.

Testing. Each programmed instruction unit is followed by a written test. The administrator will grade each test and inform the trainee's supervision whether or not he received a satisfactory grade.

The training also includes the techniques on how to observe, checks on what to observe for, and actions to take. In the application of the observation technique on the job using observation cards, the supervisor must follow this cycle: decide—stop—observe—act—report. The observation report covers the act observed and the action taken.

To summarize, each unit is followed by observations on the job by line organization, discussion by line organization, and reports using the observation cards.

The follow-up discussions provide an excellent opportunity to establish uniform understanding and agreements on objectives, policies, and principles throughout the organization and usually results in discovery of areas requiring clarification.

Who should take each training unit, and when? The answer is that every member of the plant's line organization supervisory staff, starting with the plant manager and including the line foremen, should take all of the eight units. While the material is primarily designed for completion at the plant, several of our plants had supervision complete the P.I. course at home, with the initial and follow-up discussions held at the plant.

With the exception of Unit 1, which covers a two-week period, each of the units are scheduled to be taken over a three-week period—starting with the administrator and plant management level first and ending with the foremen level, with each level being led by their immediate supervision. It should be emphasized at this point that this proposed plant schedule is offered as a guide for you, and that you should review your plant's ability to absorb this training schedule. For example, smaller plants may wish to take only two weeks for each unit, while larger plants may need to expand to a four week cycle for each unit (except Unit 1). Recognizing your own plant's ability to absorb this training schedule, you should then prepare a specific plant schedule covering every supervisory member on your plant staff. It is extremely important that everyone within a specific plant area, starting with the area supervisor, then to supervisors, to foremen, complete each unit in sequence, because each training unit builds upon knowledge taught and applied in previous units.

The leader of each group is the immediate supervisor of the group level being trained. He has the responsibility of following each unit being taken by his group through to completion. According to the recommended unit schedule the leader must conduct two directed group discussions; make at least one 1/2-hour observation with the trainee in the trainee's own area of responsibility; and make certain that all daily safety observation cards be received at the end of each shift.

The total course time away from the job is about 12 to 16 hr. It is recommended that everyone start each unit on Monday and complete the unit by Friday. This should be followed by one to two weeks of on-the-job application while subordinate levels of supervision cover the same material. Therefore, total plant time to take the complete course runs from 16 to 32 weeks, depending on plant supervisory population and number of levels of supervision.

The administrator's responsibility is not an easy one. He must initiate the action, fully coordinate the efforts of all leaders, and follow up to assure discussions are held and the program is being used.

A tremendous boost can be given to safety performance by improving supervisory recognition and correction of unsafe acts of employees. It matters little whether violation of safe procedure, such as failure to wear eye protection or use of the wrong tool, or carelessness, such as leaving a hose or electric cord stretched across a walkway, is involved. The result could very well be the same—someone injured. Prompt assignment of responsibility and elimination of the hazard is paramount in preventing such a result.

Furthermore, action should be taken to prevent a recurrence of the situation. The S-T-O-P program is designed to enhance supervisory efforts in observing, correcting, and preventing recurrence.

Following the success of S-T-O-P, Du Pont developed the New Employee Safety Training Course for new employees and the Safe Practice Series for hourly and wage roll employees. The courses alone are not a panacea for solving all safety problems. They do, however, provide a valuable, fresh approach to safety training in pursuit of an elusive but attainable safety performance record; namely, not a single accident or injury to any employee.

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