FILE NAME: Oil Industry and American Petroleum Institute (API)

DATE: 1941 Oct

DOC#: API175

DOCUMENT DESCRIPTION: The Medical Bulletin Article - Occupational Eye Hazards with Special Reference to Hazards Other than from Foreign Bodies and Traumatic Injury

THE MEDICAL BULLETIN

Vol. 5 OCTOBER, 1941 No. 2

C O N T E N T S

OCCUPATIONAL EYE HAZARDS WITH SPECIAL REFERENCE TO HAZARDS OTHER THAN FROM FOREIGN BODIES AND TRAUMATIC INJURY

THEIR OCCURRENCE, EFFECTS ON THE EYES, AND NECESSARY PROTECTIVE MEASURES *

Roy S. Bonsib, M.A., E.M.
New York, New York.

Introduction

Industry, in its efforts to obtain maximum efficiency for its national defense effort, must recognize that "eye cripples may become unwitting saboteurs," Doctor Hedwig S. Kuhn told the Industrial Nursing Section meeting of the recent National Safety Congress in Chicago.

Industrial efficiency now demands the utmost of human efficiency, consequently, since vision is essential to human efficiency, the early recognition of occupational eye hazards and the prompt provision of protective measures is of prime importance.

Score of this Discussion

Eye injuries occur over a wide range of industrial occupations, and virtually none are exempt unless adequate measures of prevention are in effect. The most frequent cause of eye damage is the direct injury produced by foreign materials such as solids and corrosive substances such as acids or alkalies entering the eyes. Accidental injuries occur according to the kind of work done, though they may be classified as contusions, punctures, incisions and lacerated wounds with or without infection, and the presence or absence of foreign bodies; and burns of the various structures of the eyes and its surrounding area. (3) Since these types of eye injury or damage are generally recognized and have been discussed frequently and voluminously, they will be excluded from this discussion. Although not as prevalent, there are other serious occupational eye hazards, which, unfortunately have not received adequate consideration. It is important to recognize the fact that poisonous dusts, gases and vapors may

*Presented at the Session on "PROTECTION FOR THE EYES OF WORKERS IN INDUSTRY"-12th Annual Greater New York Safety Convention and Exposition-New York,N.Y. Hotel Pennsylvania 4/23/41

directly or systemically affect the eyes and vision; that radiant energy in the form of ultra-violet and infra-red rays, may damage the eyes of the industrial worker: that certain parasitic and bacillary diseases may affect the eye and produce damage of this delicate organ; and finally that lack of proper illumination may produce Miners' Nystagmus and other diseases of the eye due probably to unusual effort as a result of abnormal physiological condition.(4)

Due to time limitations it will not be possible to discuss all of these occupational eye hazards; neither will it be possible to discuss those war gases and war materials which have a marked effect on the eyes, such as chloracetophenone, and which industry will probably be called upon to produce within the next few months. However, we shall attempt to briefly consider some of the more commonly encountered hazards, especially those from a few of the extensively used industrial poisons; because the growing use of poisonous chemicals in industry now presents one of the most serious hazards to the eyes of workers.(5) This hazard is aggravated by the fact that thousands of men and women who are working with these poisons, are wholly unaware of that fact, wholly unaware of the disease hazards to which they are exposed, and unaware of the steps they should take to guard against the harmful effects of these poisons. Some attention will also be devoted to the eye hazards produced by welding operations due to the widespread and ever increasing use of this process.

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DISTINCTION BETWEEN OCCUPATIONAL DISEASE AND ACUTE INDUSTRIAL INJURY - The definition of a subacute or chronic occupational disease as distinguished from an acute industrial injury due to a single accident has been considerably broadened by state legislatures. (1)

Effects of Gases, Vapors, Fumes and Dusts in the Eyes

Toxic gases, vapors, fumes and dusts are met in a great many industries, both casually and as a constant menace to the eyes. They are encountered notably in chemical, acid, alkali, and solvent manufacturing and handling plants in textile industries involving the production of artificial silk, bleaching and dyeing, singeing in print works, in

sulphur plants and in smelting operations. Some of them act only locally upon the eyes, like the fumes of acids and alkalies; others, like wood alcohol act upon the eye indirectly. That is, their effect follows absorption and general poisoning and is exerted upon the retina and optic nerve and not upon the outer structures of the eye. Others, like lead, may act in both ways, according to the mode of entrance into the body. The fumes of molten lead may irritate the eye locally, causing an inflammation of the delicate membrane that lines the eyelids, or some time after absorption may cause total blindness through inflammation of the optic nerve, and retina. (6) Again they may cause temporary immediate effect through the circulation, producing double vision.

Irritant Effects

The effects vary with the agent in operation from excess of blood in the delicate membrane that lines the eyelids to severe inflammation. Such a condition is frequently caused by acid vapors, especially hydrochloric, and by the halogens, notably chlorine and bromine, and by ammonia; the latter being very penetrating. It may also arise from exposure to hydrofluoric acid, hydrogen sulphide and sulphur dioxide. Diethyl sulphate vapors cause eye affections to those exposed to them. (7)

Some of the most active types of eye irritation have been produced by certain industrial dusts. For example, the fulminate of mercury and silver used in the manufacture of percussion caps and Christmas fire-crackers respectively have been responsible for outbreaks of a severe type of conjunctivitis accompanied by much pain and discharge of tears. The basic aniline dyes, methyl violet in particular, may produce inflammation of the cornea as well as conjunctivitis. Other aniline compounds producing conjunctivitis are tetryl and paranitroaniline. Chimney-sweeps suffer from conjunctivitis owing to the irritation caused by the soot. Pitch dust may cause severe conjunctivitis in those exposed to it. Spicules of pitch may penetrate the cornea, giving rise to corneal ulcer or an accumulation of pus in the anterior chamber of the eye. The dust from grinding asphalt produces serious injuries to the cornea. Nitronaphthalene gives rise to corneal opacities, either as the result of long continued exposure to the vapor, or as a result of accidental splashing of the liquid into the eye. Workers in pitch or asphalt

dust, especially those breaking up pitch, should be supplied with goggles of the proper type. (7)

Systemic Effects of Industrial Poisons

A large variety of industrial poisons gives rise to transient affections of the eyesight, and some of them to permanent effects. Various poisons may give rise to any one or more of these conditions, depending upon the strength of the poison and duration of the exposure. Especially hazardous are the fumes of dinitrobenzol which is used in the manufacture of high explosives. Other substances which formerly produced much eye trouble have been eliminated from modern processes of manufacture or the operators are better protected by the wearing of respirators and goggles, as well as by the installation of exhaust fans. Such substances are iodoform, volatile coal tar products used in dyeing, and arsenic, formerly used in cosmetics and in the coloring of wall papers, artificial flowers, and paints. (6)

Prominent among the group of protoplasmic poisons which produce blindness through inflammation of the nerve behind the eyeball, acute or chronic, are: alcohol, nicotine, carbon disulphide, tri-chlorethylene and the arsenical compounds. There is another group of internal poisons which produce blindness through other forms of inflammation and disease of the retina. Poisons of this group, instead of acting directly on the nerve fibers affect the nerve secondarily through contraction of the small blood vessels of the nerve or retina, or through changes in the blood. In this group may be found lead, quinine, cocaine, sodium salicylate, snake venom, silver salts, mercurial preparations, amyl nitrite and nitrous oxide gas. (8)

Toxic Amblyopias

Toxic amblyopia is a partial or complete blindness caused by a poisonous substance which interferes with the function of the retina, the optic nerve or the more central optic pathway. Every new drug used in medicine and every new chemical used in industry is a possible cause of toxic dimness of vision so that this subject is constantly growing in scope. Victims are becoming more and more compensation-conscious and the ophthalmologist, in order to be fair to both employer and employee, must have a thorough understanding of this subject. (9)

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Classification of Toxic Amblyopia

Carroll (9) divides toxic amblyopias into three groups, I - Those caused by poisons which produce cortical or central blindness, II - Those caused by poisons depressing the entire visual field, but more especially the peripheral fields, and III - Those caused by poisons depressing exclusively or chiefly the central visual field. (9)

> "In cortical blindness there is a complete or almost complete loss of vision but the pupils react to light because the lesion is above the light center. One of the several causes of this condition is uremia (presence of urine constituents in the blood). Acute carbon monoxide poisoning as a cause of toxic amblyopia is a definite entity, but whether chronic carbon monoxide poisoning ever causes optic nerve damage is questionable...Complete blindness in a person suffering from acute alcoholism whose pupils react normally to light is probably due to acute alcoholic amaurosis (blindness occurring without any apparent injury to the eye). The prognosis (prospect of recovery) is excellent and the patient is usually well in 25 hours. It is important to differentiate this type of poisoning from methyl alcohol amblyopia.
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> "The second group of toxic amblyopias are those caused by poisons depressing the entire visual field but more especially the peripheral field. Barbiturates are usually a cause of amblyopia only when used in very large doses. A cause found among makers of artificial leather, rubber cementers, dry cleaners, engravers, lacquer makers and vulcanizers is BENZOL (Benzene). Dinitro-Benzol also may be a causative agent. Blood loss which occurs in patients whose general health is below par or whose red blood cell count and hemoglobin are markedly reduced sometimes causes this condition. ...Carbon tetrachloride which is used both for cleaning purposes and as an anthelmintic (remedy for worms) may be a causative poison in some cases of amblyopia.
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> "Methyl alcohol is a recognized cause of optic

atrophy (a wasting or diminution in size) as evidenced by the occurrence of this condition among painters who, when working in closed spaces, inhale the fumes of wood alcohol. The same danger exists for persons using wood alcohol in lamps...

"In the third group of toxic amblyopias are those poisons which depress, exclusively or chiefly, the central visual field. Carbon disulphide, used widely in the rayon industry and also in the preparation of rubber, explosives, hides, insecticides and in the wool industries produces this type of amblyopia. It is usually accompanied by polyneuritis...and other evidences of toxemia. Lead poisoning is found to be a cause of amblyopia in patients who are compositors, plumbers, storage battery makers and even in children who have eaten the paint from their cribs.

"Thallium which is used by women having excessive hair growths as a depilatory and in industry as a rat poison usually produces peripheral neuritis preceding any visual disturbance.

"Tobacco-alcohol poisoning is the most common and the most important toxic amblyopia seen in this country. ...Recent research has shown that it is possible for patients with this condition to continue smoking and drinking and recover completely providing an adequate amount of vitamin B is taken."

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Effect of Lead

Lead poisoning, which is the greatest poison hazard in all industry may be acquired in a great many trades, is particularly liable to injure the eyes of painters, file cutters, plumbers, electro-typers, typesetters and cleaners, pottery glazers, storage battery makers, paint grinders, and makers of red, white, orange and yellow lead, makers of lead pipe, tinsmiths (solderers) and cutters of sheet lead or various lead article manufacturers. (6) The effects of poisoning by lead are very widespread in the body, but tend particularly to be localized in the nervous system. Inflam-

mation of the optic nerve of one or both eyes is not uncommon in chronic lead poisoning and is associated with inflammation of the retina which may produce total blindness. Paralysis of the ocular muscles and dimness of vision has also been found in lead poisoning; recovery usually occurs. (7) Lead causes serious central, as well as peripheral, eye diseases, such as inflammation back of the eyeball and paralysis. It may be inhaled in fumes, or may enter the system through the mouth.

Effect of Volatile Substances

Many volatile substances when they reach the blood through absorption may seriously affect vision acting either directly upon the structure of the eyes or affecting it through cerebral deficiency in quality or quantity of blood in brain vision centers. Of this group of volatile poisons, wood alcohol forms the most striking example, as it produces almost instantaneous, and frequently, permanent blindness when inhaled in quantities. (6) Vapors of some of the volatile solvents are absorbed through the lungs and cause damage to the body, the eyes included. Any substance that will cause swelling due to accumulation of a fluid in the tissue of the brain and other organs will cause a similar response in the eye tissues. This may cause dilation or constriction of the blood vessels and if prolonged or repeated may result in damage to the eyes. The eye is the only window through which we can actually look inside the body and see the physiological changes which are taking place as the result of the poisonous material, not only in the eye, but elsewhere in the body, particularly in the brain.

Effect of Alcohol

The alcohol which is usually responsible for blindness is methyl or "wood alcohol". Ethyl alcohol also produces blindness through its action on the optic nerve. However, only chronic alcoholic individuals are likely to suffer from severe amblyopia, and even then it is well known that persons who combine the use of alcohol and tobacco to excess are the most frequent victims from these poisons. In the past few years our conception of dimness of vision due to ethyl alcohol and tobacco has been modified. Certain investigators have shown that a deficiency of the vitamin B_1 and vitamin B_2 complex in regular diet is actually responsible for

the blindness, inasmuch as alcohol and tobacco may be continued in the usual quantities after blindness has set in and yet complete recovery will follow the administration of adequate amounts of these vitamins. (8)

Wood Alcohol

Wood alcohol is soluble in such lipoid substances as are found in nerve tissues, and after death the brain retains a large percentage of this alcohol. A highly differentiated nerve substance like that of the optic nerve is therefore particularly liable to be affected by it. (6) It has been thought for a long time that wood alcohol attacks the eyes especially, but recent researches have demonstrated, exclusively that this is not a special attack on the eye but that the eye is merely indicative of the response that goes on in the brain and other tissues, and that the blindness produced or the affect on the vision is simply discerned more readily. There is nothing so outstanding or dramatic as any effect on the eyes.

Effect of Carbon Disulphide

Used in rubber and rayon industries, and in refrigerating plants, carbon disulphide produces a vapor which injures vision by affecting the retina or optic nerve....A large number of eye injuries occur in the rayon industry to workmen in the spinning room where irritations are caused by a combination of mist containing about eleven per cent sulphuric acid in addition to the carbon disulphide. British investigators found that, as the result of an isolated exposure to a concentration of only one part of carbon disulphide by volume in 3,000 parts air of a few hours duration, severe headache and mental dullness or confusion usually result. If such exposures are of daily occurrence, the symptoms become increasingly severe with inflammation of the nerves, distorted vision and mental disturbances. (10)

Effect of Dinitro-Benzol

Used in manufacturing aniline dyes and the production of high explosives, injures the vision by inhalation and produces a distinct toxic effect on the vision similar in many respects to that caused by carbon disulphide. Its effects are found in varying degree in all those who suffer periodically from

subacute attacks of poisoning. Susceptibility may aggravate the symptoms, but no worker can claim perfect immunity. Comparatively few complain of any impairment to their sight, but probably about one in ten are unknowingly affected. Snell (11) In all cases absence from exposure removes these symptoms in a varying length of time, and usually a restricted exposure will alleviate them. (12)

Effect of Carbon Monoxide

Carbon monoxide produced by the imperfect combustion of gasoline may be so prevalent in garages and automobile repair shops as to produce disturbances of the optic nerve and the retina. (13) The literature on carbon monoxide asphyxia contains a fair number of reports of permanent damage to vision. Drinker (14) has found that as a rule, serious eye injury requires severe poisoning, that is, poisoning in which there is a long period of unconsciousness. But there are rare cases which are exceptions to this rule. We are told that in most instances of visual disturbance following carbon monoxide asphyxia, the injuries (lesions) are in the vital part of cells of the different ocular nerves. The effects may be permanent, as in the case of other cerebral damage due to carbon monoxide, or they may be quite transient. When permanent, they are to be distinguished from hysterical phenomena, so often found after mild poisoning, by the presence of nervous or mental symptoms indicating damage to the nervous system, or by definite lesions in the eyegrounds.

The term "chronic monoxide poisoning" as usually used, very loosely describes the permanent after-effects of severe exposure of an acute nature or it is used just as freely to describe the ill health resulting from repeated minor exposures of an acute nature but where certainly very seldom any symptoms remain when the exposure ceases.

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Occupational Superficial Punctate Keratitis

An occupational superficial punctate keratitis is an inflammation marked with points or dots on or near the surface of the cornea produced by occupational exposure. Davidson (15) states that the symptoms of superficial punctate keratitis, without the use of the slit lamp, may give rise to

the diagnosis of acute, subacute or chronic conjunctivitis. This condition has been found among workers with lacquers in the furniture and metal industries, in the rayon industry, in mushroom canning, among workers in the straw hat industry and in agricultural workers on reclaimed marsh lands in California. Rankine (16) who reported on 1,598 workers in the acid house in the rayon industry, listed the symptoms as blurred vision and halos, grittiness, abnormal intolerance of light, discharge of tears, eyelid muscle spasm, aching back of the eyes and headaches. Burning and stabbing pains increase toward the end of the day and working week and the symptoms are most marked during the winter months when the ventilation of workrooms is poorest. All writers stress evidence of individual predisposition in the form of frequent recurrences in some persons and immunity of other neighboring workers. (15)

The outstanding offending agents appear to be hydrogen sulphide, principally in the rayon and sugar industries, also mines and tunnels, benzol and similar solvents and diluents of varnishes, shellacs and lacquers. Many writers, such as Klein (17) and Büchlers (18) stress the effect of drops of chemicals on the cornea, and the drops scattered by spinning and spraying rather than the gases involved in artificial silk industrial processes as the factor responsible for the eye conditions found. According to McDonald (19), hydrogen sulphide containing droplets of the acid bath are responsible for keratitis among the workers in the rayon industry; he found the condition more marked in damp weather and stated that a concentration of ten parts per million is permissible. Others of the important agents considered in textbooks and in the literature are hydrogen fluoride, tar, pitch, mercury and silver sublimate, certain kinds of wood and lead nitrate. The victims all get well with change of occupation, and there is complete return to health in from seven to ten days. (15)

Occupational Dystrophy

Davidson (15) asserts that true occupational dystrophy such as is reported in textbooks and in the literature, has not been observed. Cases of dystrophies as after effects of accidents have, however, been encountered. For example, examinations prove that a degenerative process goes on in the cornea with lime incrustation in the course of years in connection with lime burns. These manifestations may be

delayed and present problems in the differential diagnosis between injury and disease.

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Occupational Cancer of the Eye

At the 1936 meeting of the American College of Surgeons, Dr. Lane (20) of the University of Michigan presented a report on an occupational study of cancer of the eye, lid, tear apparatus, etc., setting forth the results on 1,000 patients. The cases were divided equally between malignant tumors or cancers and tumors characterized by abnormal pigmentary deposits. These studies were continued and a later report issued (21) from which we learn that oils produced in the United States except in the middle west oil region where oils have a higher paraffin and asphalt base, do not have such high cancer-producing properties as do foreign oils. American oils contain less sulphur than do foreign oils. Refining in the United States is largely a closed process; the workmen have little contact with the oil. One of the largest oil companies, employing thousands of workers, with records extending over many years show a surprisingly small number of cancers. Occupational groups exposed extensively to sunlight and the elements at the same time being exposed to known cancer-producing agents such as pitch and tar have more than 2.8 times the total number of cases found in all the other groups. Special attention was called to the large number of farmers and laborers having carcinomas, as well as a large number of carpenters having tumors or growths which can either be benign or malignant. It is believed that the occupational hazard in the case of the carpenters is due to the handling of creosoted shingles, of composition roofing which contains much tar and asphalt, and of building papers, also other lining products in addition to the sunlight. Painters have a potentially increased distribution of ocular cancer. Chrome is a decided chemical irritant and frequently enters into the composition of paint. A small distribution of ocular cancer was found among those whose occupation involved a considerable use of chemicals. Concentrated coal products such as pitch and tar derived by distillation of coal are potent cancer-producing agents. Gashouse workers show a rather high cancer incidence in other parts of the body but not in the eye. As a rule it takes from ten to fifteen years' exposure to an irritant before

precancerous or cancerous injuries (lesions) develop.

Doctor Lane's report is evidently a very interesting statistical study of the occupational background of a series of cases showing cancerous changes in the eyes. However, it is questionable whether the figures given make any particular case as to the occupational origin of these cancers. The distribution of the cancer cases among the occupations mentioned is so varied and of such low order in those occupations having a known exposure to cancer-producing materials as compared with the cases not so exposed, it is doubtful that this study shows any particular occupation to be a causative factor in the location of cancer in the eye.

Effects of Heat on the Eyes

One of the most frequently reported causes of the occupational type of cataract or the crystalline lens of the eye becoming opaque is exposure to intense heat as in the removal of molten material from the furnace. However, heat is apparently being discounted more and more as a cause of cancer per se. Glass workers are probably the best known victims of this type of occupational eye hazard. Mehöfer (22) believes that the excessive perspiration of glass makers plays an important part in producing this change in the lens. A third cause may be the brilliant white light that dazzles workers in glass and which, by fatiguing the retina of the eye, reflexly influences the lens. Molten iron and working near electric and other types of furnaces expose workmen to excessive heat which burn the lids and cornea and cause cataracts and degeneration of the retina. Protective glasses and helmets may prevent such occurrences. (23)

Effects of Radiant Energy

Radiation from an intensely heated solid or vapor may be divided into three portions: (a) invisible infra-red rays, (b) visible light rays, and (c) invisible ultra-violet rays. The presence of the infra-red rays, although they are invisible, may be recognized by the sensation of heat which they produce on the skin. The visible light rays enable us to see; but we have no sense that detects the invisible ultra-violet rays, so we know them only by their effects. Exposure of the unprotected eyes to very intense light sources, rich in ultra-violet radiant energy, produces an acute and painful inflammation of the eyes. Long continued exposure or frequent short

exposures to ultra-violet rays of even moderate intensity may have a similar effect on the eyes. The disease produced is a form of inflammation of the lining of the eyelids commonly called Electric-Ophthalmia or Photophthalmia. (13) Black (24) says that the effect upon the eyes is practically the same as a sunburn when the unprotected body is exposed to the sun's rays, and, like a sunburn, is not noticed until several hours after exposure. The heat radiation from work where the radiant energy hazard exists is so great that heat insulating material is required for all parts of the protectors which touch the face of the operator.

A series of experiments have been made by the United States Bureau of Standards upon various kinds of colored glasses. It was found that most black, amber, green, greenish-yellow and red glasses are efficient for protecting the eyes from ultra-violet light. For shielding the eyes from infra-red rays: yellowish-green, sage-green, gold-plated and bluish-green glasses are the most serviceable, although color is no criterion of efficiency. Glasses having a gray or neutral tint are the most agreeable, as they do not alter the color of objects. It has also been found that workmen in welding processes prefer a yellowish-green glass to any other color. The cobalt glass so commonly used by furnace men is not effective in providing protection from ultra-violet radiant energy.(25) In fact the cobalt blue is the least suitable color for this protection. (13)

Photophthalmia

Photophthalmia is an inflammation of the conjunctiva produced by the burning effect of the harmful ultra-violet rays of radiant energy.(2) It is likely to develop in workers exposed to intense light or heat and is quite similar to snow-blindness. It is not a serious disease in itself but if a person is exposed for long periods or frequent intervals, it may lead to severe trouble. A peculiar form of this disease, known as "Klieg Eyes", is found among motion picture actors to a certain extent. In this case it is caused by exposure to the intense studio lights which are rich in ultra-violet rays. (13)

Occupational Cataracts

According to Hannum (13) continued exposure to intense light and heat may cause a slow development of cataracts.

Because the disease is especially associated with workers in molten glass, it is commonly referred to as "Glass-Blowers' Cataract", although it has been found to occur in other industries such as chain-making, smelting, tin plate making, gas welding and cutting. There seems to be considerable difference of opinion and controversy as to whether or not cataracts may be formed from such exposure. However, it is reported (13) that the development of a cataract, which is an opacity of the crystalline lens, is so gradual that often the vision is reduced to one-tenth before advice is sought. Such a condition can be prevented by the continuous use of suitable goggles or other visual protective devices during periods of exposure. (13)

Eye Hazards Due to Electric Arc Welding

There is a high localized energy discharge with emission of light and a temperature as high as 6300°F. (3482°C.) in the field of an electric arc. Thus one would expect radiant energy, volatilization of materials, gaseous fixation and decomposition products, and molten metal spray to be the most serious hazards present.

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Eye Exposure in Welding

The changes in the eye due to radiation exposure have been discussed frequently and have been ascribed to various wave lengths. The welding flame, as encountered in the course of work, presents but little, if any, exposure to either infra-red or ultra-violet, but it is now believed to injure the eyes chiefly through intense glare or radiation within the visible range. The length and intensity of exposure is of course important as is the distance from the sources of radiation. It must be remembered that the sources of radiation include not only the welder's own work, but also direct or reflected rays from neighboring workers. Lipkovitch (26) has estimated that the welder has a potential exposure of 30 to 60 per cent of his work day from his own or his neighbor's operation. Pozzi (27) has reported inflammation of the cornea and the lining of the eyelids due to ultra-violet radiation occurring in an individual 30 feet lateral to the welder. The minimal safe distance has been estimated at 200 feet. (28) According to an abstract from the American

Journal of Ophthalmology (September, 1935), Natason states that 35 per cent of 210 welders examined had inflammation of the conjunctiva, and 203 out of 295 eyes had diminished corneal sensitivity.

Acute Eye Injuries Due to Ultra-Violet Rays

The usual injuries produced by ultra-violet rays from the electric arc during welding operations are typically a blepharitis (inflammation of the eyelids) and keratoconjunctivitis. Symptoms occur from four to eight hours after exposure and last from 24 to 48 hours. Prolonged exposure or secondary infection may cause prolongation of symptoms and even the development of corneal ulceration. This type of eye injury is rather common among welders and may result in the development of chronic inflammation of the lining of the eyelids. Most welders have noted a severe inflammation of the eye by rays beyond the violet of the spectrum at one time or another but have lost no time from work because of the difficulty. Tho exposure necessary to produce this condition is variable, a mere "flash" has been reported to cause discomfort. Certainly individual susceptibility and the presence of chronic eye diseases predispose to the development of such conditions. (29)

Chronic Eye Injuries

On repeated exposure a chronic indefinitely localized inflammation of the outer layer of the sclera has been reported. Other eye conditions reported to occur as a result of welding exposure are inflammation of the retina, pigment changes in the retina, inflammation of the cornea, and even detachment of the retina. Color blindness, blind or partially blind areas in the visual field, weakness or speedy tiring of the visual organs, attended by pain in the eyes and headache, dimness of vision and other visual derangements have also been reported. Sudden intense stimulation of the unprotected eye by the welding arc may produce blindness similar to snow or ice blindness (due to ultra-violet and visible rays) or electric, eclipse or flash blindness (due to the entire spectrum, ultra-violet, visible and heat rays). These conditions may be only temporary; however, in the case of infra-red rays a permanent heat, death or destruction, of the retina may occur. Roy (30) and Wurdemann (31) have reported permanent retinal damage and blindness in individuals

watching electric welders at a distance of a few feet with the unprotected eye.

Cataracts

The occurrence of cataracts due to exposure in welding is not easily disposed of. Opinions are divided; it is generally agreed that the shorter ultra-violet radiation does not reach the lens (some of the longer ultra-violet rays may be absorbed and produce changes in the lens proteins) and that shorter infra-red rays do reach the lens and are transformed into heat and may cause some damage to the lens nutrition. However, one usually finds a combination of causes such as general disease or nutritional states of the body also may play a role.(29)

Eyestrain

Eyestrain due to fineness of the work, the diminished luminosity and sudden changes in light intensity are described in the literature.(32) Chautin (33) noted some delay in visual adaptation in a small group of welders. Others deny that such a condition exists, and that protective screen and colored glass effectively protect the workers' eyes by absorbing ultra-violet, visible and infra-red rays as is shown in their examination of visual acuity and visual fields of many welders. They found no more abnormalities of vision in groups of welders than is found in any average group.(29)

Other Eye Injuries

Another source of eye damage is the transference of infections from one worker to another by exchange of goggles and other protective equipment. Each welder should be furnished with his own visual protective equipment which must be sterilized at intervals. Equipment which has been sterilized will be much more acceptable among the workers, since goggles are a very personal piece of protective equipment and workmen do not care to use such an article that has been worn by others. It has been found that giving each person his own equipment, and having it sterilized frequently, adds immeasurably to the worker's acceptance and use of the equipment. Foreign bodies in the eyes occur not only from molten metal and slag from his own or neighboring work but also from sharp fine slag particles which break off when the brittle

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slag is cleaned or removed from a bead. (29)

Protective Equipment

Because of the intensity of ultra-violet and infra-red rays from the electric arc, it is imperative for the operator and his assistant to use a hand-shield or helmet which protects the skin of the face and neck, and which is also equipped with a suitable filter lens (shades 6 to 14) that will provide adequate eye protection. In the selection of these lenses, it is necessary to depend upon laboratory tests as the transmission of ultra-violet and infra-red radiation cannot be determined by visual inspection. Depth of color does not necessarily indicate removal of the invisible rays which may be injurious to the eyes. Reliable dealers are able to supply filter lenses which have been shown by tests to conform to requirements of the American Standard Code (ASA Z2-1938) for the "Protection of Heads, Eyes, and Respiratory Organs of Industrial Workers" (Handbook H24, National Bureau of Standards, Washington, D.C.)

Effects of Insufficient Illumination

Perception of detail depends upon the size of the image cast upon the retina of the eye and upon the power of accommodation of the eye; for these reasons it is important that the illumination should be sufficient to make all necessary detail not merely visible, but easily seen. If this cannot be done the eyes will be brought closer to the work, with consequent eyestrain and headache may be increased. (7) The theory that near-sightedness may be caused by insufficient illumination has been pretty well exploded. Nystagmus is one of the most frequent and best known indirect results of insufficient illumination.

Nystagmus

Nystagmus is the term applied to a singular twitching or constant oscillation from side to side of the eyeball, usually accompanied by considerable dimness of vision. It is often found among workers who constantly subject their eyes to abnormal and unaccustomed motions, such as miners, painters, locomotive drivers, draughtsmen, jewelers, typists, and textile workers. (34)

Necessary Eye Protective Measures

Since eye damage may be due to the direct action of substances such as solids or corrosive liquids, toxic gases, vapors or dust which produce occupational poisonings (intoxications); or to various forms of radiations or to infectious or parasitic agents, or, finally, to fatigue and occupational eye strain, it is obvious from a consideration of these causative means that the control of toxic gases, dusts, and vapors in industry will control the eye damage due to such toxic substances. Toxic materials in industry should therefore be controlled by proper enclosure or isolation, ventilation and substitution. Protective goggles and shields of various types should be provided to prevent the entrance of solid material into the eyes. Special types of goggles are now available to protect the eyes from acids and alkalies and their vapors. Protection against radiant energy, as has already been indicated, may be achieved only by the use of suitable radiation-filtering screens and goggles. In the case of infectious and parasitic agents, protection may be achieved by the methods usually employed by health authorities against parasites of man and animals and, finally, in the case of occupational eye fatigue and eyestrain, protection may be achieved chiefly by the provision of suitable illumination in adequate amounts.

According to Resnick (35) preventive hygiene when toxic substances are used in industry consists mainly of complete cleanliness in all parts of plants where the poisons are used or stored. Floors, walls, machinery, clothing and skin of exposed workmen should be thoroughly cleaned as often as practicable. When the toxic substance is in the form of fumes or vapors, adequate ventilating systems should be installed, and all pipes, tanks and receptacles of any kind should be absolutely leak-proof. Close-fitting, airtight goggles are advisable when other means of protection cannot be employed. When the toxic substance is a liquid, floors, should be made of cement or of some other relatively inert material, and should be protected by paint resistive to the liquids present. They should also be so constructed that the liquid, escaping from a receptacle, will not present danger to nearby workmen.

Certain employees are abnormally susceptible to certain poisons; such workers should be transferred to other employment. Men and women with respiratory diseases or skin diseases, or who use alcohol to excess or who are generally allergic, are usually predisposed to the harmful effects of

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many poisons. (35) Considerable interest is now being taken in the psychological and psychiatric problems raised by workers having eye injuries, and especially those working under poor light. This is a most interesting problem, a satisfactory solution of which should aid in reducing eye injuries and visual impairment.

Conclusion

Good vision is an important factor in industrial efficiency; consequently, the protection of the eyes and the correction of defective vision, as well as the maintenance of lighting and ventilating conditions appropriate to the work performed is of considerable importance to industrial managements. Through the organization of eye examinations and adequate treatment of injured eyes, as well as the protection of the eyes under abnormal working conditions, much can be accomplished in the protection of the health and working efficiency of employees, prevention of accidents, reduction of absenteeism, savings in compensation costs, and improvement in the quantity and quality of products. The full cooperation of employers, plant physicians, plant engineers, industrial nurses, and department foremen is required if these ends are to be served. (3)

As industry comes to be held responsible more and more for the effects of the ever-growing use of poisonous materials through their designation as compensable occupational disease hazards, progressive employers will find it profitable and advisable to make use of every known means to protect their workers exposed to these poisons. Meanwhile, it is the responsibility of every safety engineer, of every physician or surgeon having any industrial practice, and of every industrial nurse, to become familiar with all the poisonous substances used in their respective plants and to take all possible steps to protect the employees who are exposed to these poisons. (5)

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