SAFETY INFORMATION PROFILE

Safety by Effective Illumination and Color

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PREFACE

The information in this profile was prepared in accordance with the provisions of NIOSH Contract #210-78-0130-0000 and is only one of twenty-seven Industry Profiles prepared under the contract. The reader should understand that this study is not intended to be an in-depth analysis, but rather, a limited overview of the industry. Each individual profile was prepared by a Profile Manager utilizing approximately 45 hours of professional time. Each profile is a reflection of the available literature, and other information obtained from industry, government, and labor contacts. Information Profiles are primarily intended for use in determining future study needs, priorities and directions. From this preliminary study may come various in-depth studies such as criteria documents, technology assessments, epidemiological studies, etc.

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EXECUTIVE SUMMARY

All industrial classifications are potentially covered by this profile topic. The profile describes safety and health hazards associated with the visible light spectrum and touches upon poor lighting, excessive light energy problems, and color with regards to its impact upon safety and psychological factors.

The prime requirements for industrial lighting are sufficient quality and quantity of light on all work surfaces. The control of glare is also an important factor in providing a safe work place. Color is used to provide contrast, brightness, and the proper psychological environment. Color coding has been used for years to identify hazardous conditions and to provide easy identification of safety signs.

Faulty illumination is a contributory factor in 20% of all accidents. Often the contribution of poor lighting conditions is not acknowledged in accident investigations. Lack of illumination does not cause organic disease of the eye, although light energy of great intensity can damage the eye. Poor illumination such as lack of light, glare, or extreme contrasts can cause "eye strain" characterized by headache, irritability, loss of attention span, nausea, etc. Very few actual statistics exist.

The idea of Vision Conservation Programs, similar to Hearing Conservation Programs, has been suggested as an important part of a modern safety program. Additionally, vision and lighting inspections should accompany the routine maintenance of lighting systems.

No OSHA standard has been promulgated for illumination, although various references to lighting, illumination and color are found in the 29 CFR 1910 and 1926 codes.

Studies should be conducted to determine regulatory needs.

A. Standard Industrial Classifications Included

Essentially all operations in all Standard Industrial Classifications could be included under the topic of this profile. The concept of illumination and color coding, as they affect the safety and health of employees, is applied horizontally across all industry and is not associated vertically with any one particular industry.

This profile covers the visible light spectrum. It does not cover safety hazards associated with ultraviolet radiation or infrared radiation, or other forms of radiant energy.

B. Profile Description

Light is electromagnetic radiation to which the human eye is sensitive. Light radiation has a wavelength of between 380 and 760 nm. However, the eye is not equally sensitive to all radiation within this band. Peak sensitivity is achieved for light at a wavelength of about 550 nm. The sensation of color is associated with the radiation wavelength. The physics of light is a very complex subject and beyond the scope of this profile. Therefore, further discussion of the quantities and units associated with lighting and lighting generations will not be discussed here. A description of light and color as they impact industrial safety is provided.

The seeing process depends on four basic variables which are associated with the object in vision:

(1) its size

(2) its luminance or brightness

(3) the contrast between the object and its immediate background

(4) the time available for seeing the object

These factors are mutually related and interdependent. Sometimes the deficiency in one factor can be compensated for by an adjustment by one or more of the other factors. Size is generally not adjustable unless the object can be moved closer to the eye. Of the adjustable factors, luminance and contrast provide the greatest degree of control by illumination.(1)

(1) Lighting

Prime requirements for industrial lighting and illumination are sufficient quantity and quality of light on all work surfaces. Under these conditions workers should be able to observe and control the operations and machines used in the various processes. In many industrial operations, a sufficient quantity of natural light is not often available, even during the most optimum of daylight conditions. Generally, to provide good seeing conditions, artificial lighting is normally required. It is considered essential that artificial lighting be designed and installed to continue a uniform level of illumination in areas adjacent to the windows or walls providing adequate lighting over the entire working area.

Three types of lighting are described in the literature: general lighting, localized general lighting, and supplementary lighting.

General lighting is designed to provide uniform illumination throughout the work area. Uniform illumination has been defined as the distribution of light where the maximum and minimum illumination at any point is not more than 1/6th above or below the average level in the area. Localized general lighting reinforces the general lighting in specific work areas by the use of additional lighting equipment. Supplementary lighting is used to provide high levels of illumination for small or restricted areas where high levels of light cannot be readily obtained by general lighting methods. Occasionally, supplementary lighting may be used to provide a specific brightness or color, or to permit special aiming or positioning of light sources.

- Quantity of Illumination

The amount of light required for any particular job depends primarily upon the type of work being done. The literature indicates that as the illumination of the task is increased, the ease, speed and accuracy of accomplishment are also increased. The Illuminating Engineering Society (IES) has recommended minimal levels of illumination for specific industrial areas through an ANSI Standard A11.1, Practice for Industrial Lighting. The quantity of illumination is normally stated in foot candles and is measured with a light meter to give a direct reading of the number of foot candles of light reaching the working surface. The quantity of light required may be measured by an instrument called the Visual Task Evaluator. In-depth discussions regarding these issues and the associated equipment can be found in the IES Lighting Handbook published by the Illuminating Engineering Society. (See reference 5)

- Quality of Illumination

The quality of illumination describes the distribution of brightness in the environment. Such quality factors as glare, diffusion, uniformity, color, direction, and brightness all have an affect on the ability to see easily, accurately, and quickly. Poor quality illumination is uncomfortable and considered to be hazardous. Moderate difficiencies are not readily detected by most people, although the cumulative effect of a slight glare can result in material loss of seeing efficiency, and in fatigue.(1, 3)

• Glare

Glare is defined as a brightness within the field of vision which causes discomfort, annoyance, interference, or eye fatigue. Glare may be direct or reflected light. Direct glare is caused by a source of lighting within the field of view. Reflected glare is bright images or brightness differences reflected from shiny surfaces such as ceilings, walls or desk tops within the visual field. Reflected glare is frequently more annoying than direct glare because it is so close to the line of vision that the eye cannot avoid it. Reduced brightness of light sources will reduce both direct and reflected glare.

Glare tends to reduce the efficiency of the eye and may cause discomfort, fatigue and contribute to hazardous conditions. It may reduce the detail of the visual task which seriously impairs vision, potentially increasing accidents and injuries.(1, 3)

(2) Color

Visibility and perception are improved by the use of suitable colors on work surfaces. The light reflecting qualities of adjacent surfaces contribute to the full utilization of available light, and properly chosen color helps eliminate sharp contrast and brightness in the workers field of vision, contributing to good "seeing", and hence to safe practices.

When floors and equipment are dark, i.e., reflecting 25-40% of the light, then upper walls should have a reflectance of 50-60%. White ceilings will give maximum brightness.

Colors can have a psychological effect on employees. Light shades are considered essential for most parts of an industrial plant. Blue and green tints have a cooling effect and are psychologically valuable where temperatures are high. Soft blue-green color is commonly used on interior walls. Cream and ivory colors are considered to be warm. Light gray is effective for machinery.

Color has been used extensively for safety purposes. Standard colors have been developed to identify specific safety hazards. These standards are summarized in the ANSI Standard Z53.1, Safety Color Codes for Marking Physical Hazards and the Identification of Certain Equipment. A brief summary of colors and their associated hazards are provided below:

- Red. Red identifies fire protection equipment, indicates danger, and identifies emergency stops on machines.

- Yellow. Yellow is used to mark hazards that might result in accidents from slipping, falling, striking against, etc. Yellow is also used on flammable liquid storage cabinets and on safety cans as a color band. Yellow may be used on materials handling equipment such as forklift trucks and cranes. The yellow color is often associated with black in a checker-board or striped pattern to identify differences in elevation on walking surfaces.

- Green. Green is used to designate the location of first aid and safety equipment.

- Black and White. Black and white are used for traffic marking and housekeeping signs. They are also used in the lettering of other safety items as contrast colors.

- Blue. Blue is used for informational signs and bulletin boards not of a safety nature.

- Orange. Orange is the standard color chosen to highlight dangerous parts of machines or energized equipment such as the exposed edge of a cutting device, the inside of movable guards and closure doors, and transmission guards.

- Purple and Yellow. Purple (magenta) and yellow are used to identify radiation hazards.

Color codes are used to identify piping in plants that carry harmless, valuable, or danger materials. The ANSI Standard A13.1, Scheme for Identification of Piping System, specifies standard colors for identifying pipeline and describes methods of applying these colors to the lines. The contents of marked pipelines are classified as follows:

- Red marks fire protection piping systems
- Yellow is used to designate dangerous materials
- Green is used to demarcate pipelines handling safe materials

- Bright blue colors are used to indicate protective materials such as inerting gases

Color coding is also used on accident prevention signs and for tagging and lockout procedures. Accident prevention signs are among the most widely used safety measures found in industry. It has been considered that uniformity of color and design is essential. Many employees may not speak English but may be able to react correctly to standard, color-coded signs. ANSI Standard Z35.1, Specifications for Industrial Accident Prevention Signs, specifies the standards suggested for color coding and standardization of accident prevention signs. The following discussion indicates major recommendations:

- Danger signs. Danger signs are identified by a red oval with black or yellow lettering in a lower panel.
- Caution signs. Caution signs are yellow with black lettering.
- General Safety signs. General safety signs have a green background on the upper panel with black or green lettering on the white background on the lower panel.
- Fire and Emergency signs. Fire and emergency signs are characterized by white letters on a red background.
- Information signs. Information signs are typically blue and white.
- Exit signs. Exit markings are normally red or green with white, one inch by 6 inch letters. Standards for exit markings are found in the NFPA Life Safety Code, Section 5-11.(1, 3)

C. Potential Hazards

(1) Safety Hazards

Light may have a direct effect on the safe working conditions in any industrial plant, and should be considered an important factor in providing safe and healthful working conditions. The light environment of the plant should be designed to compensate for the limitations of human capability. Each person's vision and seeing ability differs. These differences may be related to age, visual acuity, past eye injuries, congenital defects, etc.

Illumination, or light, is a factor that aids in the vision process. It is thought to increase the probability that the worker will detect the potential cause of an accident, and act to divert it. In most cases where accidents are attributed to poor illumination, the cause is described as "very noticeable poor quality of illumination", or, "practically no illumination at all". The specific factors associated with poor illumination are: direct glare, reflected glare, darkness, dark shadows, etc., all of which hamper seeing and together cause after-images, excessive visual fatigue, boredom, irritation, etc., which may contribute to accidents or injuries. Accidents may also be caused by delayed eye adaptation when coming from bright surroundings to dark ones. Some accidents that have been attributed to carelessness could probably be traced to difficulty in seeing.(3)

Shadows can result if luminaires (lighting fittings) are too widely spaced in relationship to their mounting height or if they are in the wrong position. Shadows are generally unobjectionable if the spacing/height ratio of the light fittings does not exceed the maximum recommended by the manufacturer which is normally between 1½ to 1 and 1 to 1 depending on the type of fitting concerned. An example of a poor lighting fitting is found in every situation where, in the normal working position, the worker is between the task and the main source of light provided for that task. And thus, works on his own shadow. Shadows should never be allowed on a staircase.(19)

Many areas of industrial plants are classified as hazardous locations by the NFPA/ANSI National Electric Code. These areas require the use of specialized lighting equipment such as vapor-proof, explosion-proof, and dust-tight lighting fixtures. Obviously, because each type of equipment is designed to meet certain requirements, the types of lighting used in hazardous locations are not normally interchangeable with lighting fixtures used in non-hazardous locations. Chapter 5 of the National Electric Code describes in detail the requirements for hazardous location lighting equipment. Many fires, explosions, and accidents occur when proper lighting fixtures are not used in hazardous locations.

Hazardous conditions may occur if originally installed, adequate equipment is not maintained. When a regular scheduled system of maintenance is not established to assure that luminaires and room surfaces are kept clean and in proper working order, conditions for serious accidents may be created. Even under adequate maintenance, the average lighting level may drop 25-35% during normal operating conditions. The amount of light depreciation depends upon (1) the decrease of light output of the lamps with age, (2) the rate at which dirt accumulates upon the light fixture, and (3) severity of dusting conditions in the area. Where maintenance is not well performed, it is not uncommon to find the light of the working surface to be 50% below the initial value of light at installation time.(3)

One obvious hazard associated with the lack of illumination is the situation where electrical systems fail placing the workplace in darkness. Without emergency electrical lighting systems, hazards greatly multiply, and injury and accident rates are likely to increase.(25)

The utilization of lighting equipment depends on the distribution system that carries the necessary electrical energy. When not properly designed, installed or maintained, hazards of shock and fire may occur which are directly related to the lighting equipment. The distribution system includes the transformers, feeders, panel boards, overcurrent protection and branch circuits, and lighting fixtures. Typically, electrical distribution systems within an industrial plant are governed by electrical codes given the force of law by local or state ordinances. Many have adopted the National Electric Code as a local mandatory standard. The essential function of an electrical code is to provide reasonable safety for persons and property. For example, the National Electric Code covers the general lighting loads by broad occupancies, but it does not give a breakdown for specific uses of space. Distribution systems should be of sufficient capacity to take care of reasonable and anticipated increases in future load.

Table 1 describes the percent of employees found to have defective vision by age. These deficiencies are naturally occurring and contribute to the need of an effective program of vision conservation and safety through good seeing conditions.

(2) Health Hazards

In March of 1975 NIOSH published the proceedings of a symposium pertaining to reduced levels of illumination that might be required by long range energy conservation programs. The primary objectives of the symposium were to ascertain the current level of knowledge of safety and health associated with low levels of illumination, to identify areas where research was needed, and to create an awareness of these areas for future research. With regard to the health hazards associated with illumination and color, one participant stated that no organic disease of the eyes results from low illumination. He stated that of the various opthalmic diseases which inflict man, none are influenced by the use of the eyes in so called "poor illumination". However, he indicated that headache, irritability, nausea and other symptoms may be brought on by continued visual tasks which are rendered difficult by refractive errors, insufficient illumination, or glareful conditions.(4)

It is known that light of sufficient brightness striking the eye over time may cause chronic degeneration of the retina. Full-time welders who work a lifetime at their occupation often find themselves with reduced vision which can be attributed to the welding arc, and is known as "welders blindness". The retina

TABLE 1

Defective Vision By Age Groups(1)

Age Group	Percent Detective Vision
15 years	23%
30 years	39%
40 years	48%
50 years	71%
60 years	82%
60+ years	95%

Source: (1)

is transparent and does not absorb light that is focused on it. But behind the retina is the pigment epithelium which is highly absorptive of visible and infrared radiation. The heat generated must be efficiently dissipated. For this there is a vascular membrane, the choroid, which presumably acts as a radiator. With the lowering of circulation with age, it is thought that this heat radiator may become less efficient and it is conceivable that the retinal degeneration which occurs may result from exposures to light that are harmless in younger persons.(4)

Dr. Glenn A. Fry, at the same symposium provided a summary of health effects, or eye strain, that can occur from faulty illumination. This summary is presented below:

> The term eye strain is used in its broad sense to cover all forms of ocular discomfort and associated health symptoms. These symptoms may be classed under three headings.
>
> a. Local irritation
>   1. sandiness-a conjunctival sensation. It includes hot, itchy, scratchy, dry feelings.
>   2. tired aching painful feelings in the eyeball, orbit or head.
>   3. blurring of vision
>   4. eye inflammation
>   5. photophobia
>   6. red and swollen eyelids which may amount to blepharitis
>
> b. headaches and fatigue of various sorts
>
> c. more remote and indirect symptoms including vertigo, digestive and psychic reaction

Eye strain and all of the symptoms associated with it arise from effort of the subject to keep his eyes adjusted for seeing. These adjustments include fixation, convergence, accommodation and control of the size of the pupil.(4)

It has been reported that physiological changes have been reported in people under different illumination levels. For example, Luckiesh and Moss observed greater decline in heart rates in a one-hour period when people read under one foot candle compared to reading under one hundred foot candles.(4)

The Journal of the American Medical Association reported in 1949 of ultraviolet burns associated with exposure to fluorescent lights. However, no other information has been detected concerning this potential hazard. Therefore, it might be assumed that whatever conditions existed in flourescent lamps which caused ultraviolet sunburn have been remedied.(14)

D. Existing Hazard Controls

Hazards associated with poor illumination can be corrected by any of a number of control schemes.

With regards to the quantity of illumination, the desireable quantity of light for any particular task depends primarily upon the work being done. Investigations show that as illumination of the task is increased, the ease, speed and accuracy of accomplishing the task is also increased. Presumably the ability to work safely also increases. Current minimum levels of illumination for industrial work areas are recommended by the Illuminating Engineering Society (IES), and are printed in the ANSI standards A11.1, Practice for Industrial Lighting.

As regards to the quality of illumination, the following steps might be taken to alleviate problems of glare, poor brightness ratios, etc:

Direct glare may be reduced by (a) decreasing the brightness of the light source, (b) positioning the light source so that it no longer falls within the normal field of vision, (c) increasing the brightness of the area surrounding the glare source and against which it is seen.

Reflected glare may be reduced by (a) decreasing the brightness of the light source, (b) positioning the light source or the visual task so that the reflected image will be directed away from the eye of the observer, (c) increasing the level of illumination by increasing the number of sources in order to reduce the relative brightness of the glare, and, (d) in special cases, changing the character of adjacent surface to eliminate the reflection and resultant glare.

Soft shadows from general illumination can accent the depth and form of various objects. Harsh shadows should be avoided since they may obscure hazardous conditions or interfere with the visibility of the work area because of the undesirable brightness contrast.(1, 3)

Proper design, installation, and maintenance of lighting fixtures and luminaires are essential control measures in providing adequate light which will assist in avoiding accidents and injuries.

As mentioned in paragraph B, the judicious use of colors can have a pleasing psychological affect on employees. Presumably a satisfied employee is one who will be more apt to detect hazardous conditions than one who's attention is diverted. Some guides for appropriate color use in industry are provided below:(1)

1. For working areas, colors for the most part should be light in tone and pale in hue. Too much richness or intensity will be a source of distraction because of the strong emotional interest.
2. Brightness is best concentrated and confined to important fields of hue on machines, work tables, etc. where the worker is expected to fix his attention. Where hazards need to be identified, brilliant color and strong contrast should make the object or area that is to be clearly distinguished.

3. Because many industrial tasks require prolonged and trying convergence of the eyes, end walls faced by employees may be pleasantly colored by soft gray blues or greens to provide desirable areas for visual relaxation.

4. The most suitable colors for walls or machines are soft grayish green, blue greens, blues, tans, and buffs. These should be subtle rather than aggressive. Loud aggressive colors, while cheerful at first, grow extremely monotonous after a time. Also strong colors tend to weary the eye and to form disturbing after images.

5. Where the working environment involves exposure to high temperatures, pale greens and pale blue are by far the best colors to use. They will afford psychological relief and by illusion will tend to lower the apparent temperature of the interior.

6. Where the environment is cold, ivory and soft cream colors are practical. It will contribute to a warm and sunny atmosphere and seemingly increase the temperature.

7. For employee service facilities, e.g., washrooms, restrooms, cafeterias, etc., stronger colors are appropriately satisfactory. Here the color affects should be contrasted with the rest of the plant. Such a change of pace will relax the mood and help to offset fatigue. Because of the inherent color preferences of men and women, blue is the best color for male facilities and pink and rose colors for female facilities. Peach color has proved to be a satisfactory color for cafeterias.

The proper selection of light sources may have a definite affect upon the resultant illumination and environmental conditions associated with the work operation. Light sources having widespread application in industry may be classified under the general heading of incandescent, fluorescent and mercury lamps. These groups of lights differ considerably in physical dimensions, electrical characteristics, operating performance, and maintenance requirements. Some have certain applications for which they are better suited than any other type. A short description of the different lighting systems and the most appropriate, safety related applications are presented below.

- Incandescent Lamps

An incandescent lamp produces light when a wire filament is heated to incandescence by the flow of electrical current. Incandescent lamps for industry are commonly designed for approximately 1000 hours of service life. Inside frosted and white coated lamps provide diffusion and thereby reduce high filament brightness. Reflectorized lamps have self-contained reflectors which are manufactured in a number of bulb sizes ranging from 30 to 1500 watts furnishing various distributions of light. Because of economic factors, reflectorized lamps are commonly designed to provide 2000 hours of service life. Reflectorized lamps provide better maintained illumination than other types because the sealed and reflective surfaces are protected from airborne dusts, and because dirt and dust do not tend to adhere to the bulb face. Rough-service and vibration-service incandescent lamps are also available. These lamps are made with extra filament support to withstand mechanical shock. One of the principal applications for these lamps is for use on extension cords. Thermal shock resistant or special service lamps are available in various wattages and bulb shapes. They are recommended for use in applications where moisture may fall on a hot bulb.

Infrared incandescent lamps are available in various types and sizes up to 1000 watts. These lamps are used in baking, drying and heating processes as well as for therapeutic purposes. They also have fire protection value. This is because a great amount of heat can be exchanged without an open flame. However, such lamps cannot normally be used in hazardous locations.

- Fluorescent Lamps

A fluorescent lamp is an electric discharge source in which light is produced predominantly by the fluorescence of phosphors activated by a low pressure mercury arc. While most fluorescent lamps are of conventional tubular design, there are some special types such as circular, reflectorized, jacketed, and panel-shaped lamps.

Fluorescent lamps are available in different shades of white and in a number of colors. The standard cool white is most popular for industrial lighting because of its cool appearance even though it is not quite as efficient as the standard warm white lamp.

Plastic safety sleeves for fluorescent lamp tubes should be used because they offer excellent protection against lamp breakage in areas where such breakage could endanger workers or cause broken glass and phosphor contamination of employees, processes, foods, etc.

- Mercury Lamps

Mercury lamps are electrically discharged sources. The basic difference between mercury and fluorescent lamps is that the operating pressure of the mercury arc is much higher in mercury lamps. Mercury lamps produce full light output only when full operating pressure has been reached, generally, several minutes after starting. Most mercury lamps have both an inner and outer bulb. The inner bulb is commonly made of quartz. The outer bulb is generally made of thermal resistant glass. A number of special mercury lamps are available, including semi-reflector, reflectorized and self-ballast. Because of their high brightness, mercury lamps require suitable luminaires (fittings) to provide adequate shielding of the light source. When fluorescent and mercury lamps are operated on alternating current circuits, the carryover of light on each half cycle depends on the fluorescent qualities of the coating. Since the light in effect goes on and off 120 times a second, it can create a stroboscopic affect on moving objects such as fly wheels, punch press parts, etc., which may even appear to be at a standstill if the speed is in synchronism with current frequency. This obviously can generate hazardous situations which must be recognized. Stroboscopic effects can be overcome by operating adjacent fixtures on a different phase, or by disrupting the repetitive nature of the rotating system.(3)

As mentioned above, mercury vapor lamps take some minutes to reach full light after being switched on. (And also require time to re-light if there is an interruption in electrical supply.) In the interest of safety, there is a need for a scheme of lighting that will provide a limited amount of instant light where the main installation consists of mercury lamps. It also makes sense to install emergency lighting circuits in areas where power failure would result in darkness, such as in windowless factories.(19, 25)

Health hazards associated with excessive light energy reaching the eye can be alleviated by providing light filters, shields, and by diverting the light from the eye. Welder's goggles and welder's masks are good examples of light filters. Canvas shields are good examples of bright and ultraviolet light barriers. Reflectorized aluminum sheeting is a good example of an infrared barrier.

The problems of "eye strain" can be alleviated by judicious selection of lighting levels, surface textures, control of reflecting surfaces, and selection of appropriate color. Additionally, training of employees in the proper use of lighting and lighting fixtures, coupled with medical examinations, can greatly alleviate potential hazards associated with light and color at the workplace.

It was suggested in an article in the National Safety News, in 1977, that industry might want to adopt vision conservation programs, somewhat similar to the hearing conservation programs being implemented now. It was suggested that too often the plant safety eye program consists of a short briefing in eye safety during an initial orientation program, with incidental follow-up by line supervisors to see that the proper eye protection is being worn. The suggested industrial vision conservation program included the following elements:

1. A working knowledge of regulations and recommendations pertaining to lighting, vision and seeing.
2. An in-depth pre-employment testing of a prospective employee's vision capabilities.
3. An appraisal of visual requirements for various jobs, and placement of new employees in the proper job according to their visual capabilities.
4. An inspection of lighting requirements for all areas of the industrial plant, including work spaces, stairways, etc.
5. Established policies for use of proper eyeware, including training and education.
6. Policies on the use of contact lenses and special eyeware, including prescription lenses and who pays for them.(21)

As a final safety measure, routine inspection of lighting systems and lighting values should be conducted by plant safety personnel. To do this, pocket light meters are an essential item of equipment for measuring existing light levels. At the same time the luminance values are being recorded, a number of visual checks should also be made:

- are all the lamps adequately shielded?
- is there enough upward light on the ceiling?
- are the walls well illuminated?
- is there reflected glare on important work surfaces?
- are there dark corners and/or deceptive shadows on stairways and elsewhere?
- how much light is being lost through side windows?
- are all the lamps and fittings clean and in reasonable condition?

A thorough investigation along these lines will reveal defects in all but the most exceptional lighting installations.(19)

E. Accident and Illness Statistics

No significant national statistics were located by the Profile Manager.

During the NIOSH Symposium of 1974, it was stated that according to the National Safety Council, insufficient lighting was the cause of 5%, and a contributory cause of 20%, of all accidents. However, these estimates provided by the National Safety Council are not corroborated by any good scientific study. It was conjectured that this estimate may be low because routine accident investigations are seldom thorough enough to determine whether factors associated with lighting or visibility were contributory to the incident or accident. Symposium participants indicated that very few studies have been undertaken to evaluate the role of lighting in accident and injury occurrence. Among the few studies noted, one showed a 32% decrease in accident frequency when the illumination was increased from 5 to 20 foot candles. A subsequent decrease of 11% resulted from repainting the work area to obtain a more favorable brightness ratio. This study was not carried out under well controlled conditions and was not statistically rigorous.(4)

In a nonpublished report prepared by the Regional Safety Office, Employee Services Branch of the Western Region of the United States Postal Service, located in San Bruno, California for the year 1977, some mention of accidents associated with lighting, seeing, or visibility were reported. The analysis covered 13,500 injuries experienced in the Western Region for the period 1977.

This particular document indicated that improper or insufficient lighting contributed to two-tenths of 1% of the injuries experienced in the region. Interestingly, when the personal injuries are ranked by unsafe personal factors involved, "didn't see" ranked first among specifically stated unsafe personal factors involved in the accident. Of 13,569 accidents, 23.6% were associated with problems associated with "seeing or visibility". No information was available to the Profile Manager with regard to the type of accident investigation performed, the criteria used in judging accident causes, etc. However, the contradiction between personal factors in accidents associated with visibility (rated highest) versus the hazardous condition of improper lighting (rated insignificant) as an accident cause, would lead one to believe that further standardized studies should be conducted.(23)

Contact with Mr. Howard Haynes, the Safety Advisor for the Illuminating Engineering Society indicated that no accident injury/illness related to lighting or color coding were available through the IES.(7)

No foreign statistics were available, however the British indicate that there is evidence that poor lighting contribute directly or indirectly to a significant portion of the falls which form a high proportion of the total number of industrial accidents. No specific data were available.(19)

F. Exposure Levels

No data applicable to this profile were uncovered in the literature search.

G. Related Studies

No ongoing, existing studies associated with lighting and color were identified. However, one related study, which is described in more detail in Paragraph I, is being conducted by the National Bureau of Standards for OSHA in determining signing requirements for safety purposes.

It should be mentioned that the Illuminating Engineering Society is constantly conducting studies which in one way or another are related to the safety and health aspects of illumination and color coding. For example, some types of commercial lamps, e.g., mercury vapor, fail to rendor safety colors identifiably, and so confuse their message. IES has recently conducted a study associated with the design of safety colors. Rather than fault the light source, the IES indicates that safety colors ought to be redesigned so that the burden of identifiability falls on them. Alternately, redesigned spectro-reflectance of safety colors and the addition of fluorescence have both been shown to allow the poorer rendering commercial lamps to render safety colors more reliably.(15) A current listing of IES research was not available for this profile. Mr. Howard Haynes, the Safety Advisor of the Illuminating Engineering Society indicated that the Color Committee was presently conducting studies which may address the problem of color coding for safety purposes. However, no further details were available.(7) Many IES sponsored studies may have limited application to safety, accidents, and injuries. However, any future study of this subject would certainly need to be in close contact with IES officials to determine ongoing research projects and their applicability to the study.

H. Industry Trends

Industrial management has not particularly preceived the importance of lighting and visibility with respect to its impact upon accident and injury rates. However, during the past decade, more attention has been focused upon this matter and the dissemination of information has begun to influence the awareness of both employees and employers to the importance of illumination and visibility.(9)

During the past two decades, many buildings were built which are windowless. The reason for these windowless buildings, it was claimed, was that it was easier to maintain a constant temperature and relative humidity if no windows were provided. Such buildings have required more attention to the installation and maintenance of artificial lighting. Additionally, auxiliary emergency lighting in case of failure of the primary system was often neglected, creating hazardous conditions when lighting systems fail. However, the future appears to indicate a return to buildings with windows. This change seemed to be motivated by the need to conserve energy, e.g., increasing natural ventilation, light, etc.(9)

The International Symposium on Illumination sponsored by NIOSH in 1974 was convened because it was felt that reduced energy availability and the expense of lighting would tend to drive down illumination levels in the workplace. No conclusions were drawn as to what affect reduced lighting may have, however, it was conjectured that increased accident and injuries might be experienced if lighting levels were lowered to below GSA recommended levels.

Installed lighting according to the FEA accounts for approximately 5% of the national total energy consumption and more than 20% of the electrical energy produced. Although lighting does not consume a major portion of the nations total energy, it does represent an area where conservation may theorectically be realized. Consequently, federal and state governments, as well as many private organizations are implementing programs to conserve lighting energy. The General Service Administration has initiated a policy for reducing the illumination levels in all federal office space.

Participants in the NIOSH sponsored symposium in 1974 indicated that the use of existing measurements of illumination are not effective in specifying present day lighting requirements. Both the International Commission on Illumination and the Illuminating Engineering Society are working toward the development of a system of effective measurement to account for several additional variables. Over the past few years, various standards or criteria have been proposed as a basis for providing adequacy of illumination for different human activities. These include visual acuity, heart rate, blink rate, muscular tension, opinions, critical level and others. Recently, various techniques have been devised for establishing illuminating standards. One example is the Visual Task Evaluator (VTE) which has been accepted by the IES for the basis of establishing illuminating standards. The development of methods or instrumentation, to evalaute effective illumination is considered essential both to safety and to energy conservation. The symposium encouraged this research.(4, 10)

The IES, through its transactions, have found that measurements of standard lamps have revealed that some proposed public health standards for ultraviolet radiation may be exceeded at relatively low foot candle levels. If increased illumination requirements were required by NIOSH or OSHA, it is possible that proposed standards for ultraviolet radiation could potentially be exceeded with traditional industrial lighting. This potential problem should be studied during any subsequent study.(28)

The Illuminating Engineering Society indicates that their revised fifth edition of the IES Lighting Handbook should be expected by late 1980 or early 1981.(7)

I. Existing Standards

The OSHA General Industry Standards promulgated in 29 CFR 1910 do not contain a specific paragraph solely devoted to lighting. Until recently there were two sections, 29 CFR 1910.144 and 29 CFR 1910.145 which specifically addressed color coding of safety signs, safety tags, and color coding. However, there are a number of references scattered throughout the OSHA standards in both 1910 and the 1926 Construction Standards which touch upon lighting and/or seeing requirements.

Ms. Joanne Slattery of the Office of Safety Standards Development, OSHA, Washington, D.C., indicated that no specific plans exist to develop a lighting standard in the Division of Safety Standards Development. She indicated that they do follow the developments of lighting criteria by the IES and various ANSI committees as they are developed. She indicated if any OSHA recommendations or standards were developed, that they would likely look to the IES and ANSI for directions. She knew of no known studies or research currently under way. She invites NIOSH to investigate the feasibility and need for such a standard.(32)

Minimum levels of illumination for industrial areas are currently recommended by the Illuminating Engineering Society (IES) and are promulgated through ANSI Standard A11.1 (1973), Practice for Industrial Lighting, and ANSI A132.1 (1973), Office Lighting. Table 2 presents recommended levels of illumination for various occupational tasks and provides a guide for efficient visual performance and safety, but should not be considered as regulatory minimum illumination standards. The levels listed in the table are taken from ANSI A11.1 (1973), published by the IES. They are based upon research conducted on young adults with normal and better than 20/30 corrected vision. More illumination may be provided for older workers to compensate for degeneration of vision due to age. Levels of 200 foot candles or more were obtained with a combination of minimal lighting plus specialized supplementary lighting. Consideration should be given to glare, objectionable shadows, color, contrast, and eye protection. Minimum illumination for safety of personnel at any time and any place where safety is related to seeing conditions are recommended as shown in Table 3.(3)

The National Electric Code specifies the minimum requirements for emergency lighting and power systems. The code requires that emergency lighting and power systems be: (1) completely independent from normal electric wiring, (2) tested and maintained, (3) provide with audible and visual alarms to warn of improper operation, (4) automatically activated when a failure of the regular lighting occurs, and (5) supplied with as nearly independent sources as possible, e.g., batteries, generators, etc.(25)

In the early 70's the Federal Energy Administration (FEA) and GSA established office lighting limits which were approximately 1/2 of the values recommended by IES and ANSI. These GSA recommendations had not been changed, as of the date of this publications.(4, 32)

Table 2

LEVELS OF ILLUMINATION RECOMMENDED FOR SAMPLE OCCUPATIONAL TASKS

Area	*Foot-candles*	*Area*	*Foot-candles*
Assembly—rough, easy seeing	30	Materials—loading, trucking	20
Assembly—medium	100	Offices—general areas*	100
Building construction—general	10	Drafting rooms—detailed*	200
Electrical equipment, testing	100	Corridors	20
Elevators	20	Paint dipping, spraying	50
Garages—repair areas	100	Service spaces—wash rooms, etc.	30
Garages—traffic areas	20	Sheet metal—presses, shears	50
Inspection, ordinary	50	Storage rooms—inactive	5
Inspection, highly difficult	200	Storage rooms—active, medium	20
Loading platforms	20	Welding—general	50
Machine shops—medium work	100	Woodworking—rough sawing	30

**From A132.1–1973, Office Lighting, published by the Illuminating Engineering Society. Others from ANSI A11.1–1973.*

Reference 3

Table 3

Minimum Illumination For
Safety of Personnel

Hazards Requiring Visual Detection	Slight		High	
Normal Activity Level	Low	High	Low	High
Illumination Level Foot Candles	0.5	1.0	2.0	5.0

Reference 3

Many federal government agencies have promulgated lighting and color standards for use by their employees. Examples of these are the "Forest Service Health and Safety Code", and the Tennessee Valley Authority "Hazard Control Standard for Warning Colors" #301.(27)

Until November 24, 1978 the OSHA General Industry Standards contained two sections specifically related to color coding, sign colors and tagging requirements.

OSHA has revoked almost in its entirety 29 CFR 1910.144 and much of Paragraph 145, which is related to color coding. Ms. J. Slattery of the Office of Safety Standards Development, OSHA, Washington, D.C., indicated that basically, OSHA thought the safety of workers were not influenced significantly by the use of color coding. This was a primary reason for their revocation. But no real data supported this decision. OSHA presently has a contract with the National Bureau of Standards dealing with the impact and standardization of signs. Part of the study will involve the impact of colors and also determine the effect of colors under various illumination. Reports concerning these projects are expected at the end of this year or early next year. Ms. Slattery indicated that present thinking dictates the development of a combined standard of signs and colors rather than a color coding standard.(32)

Although the OSHA standards have been revoked, the ANSI recommended standards from which the OSHA standards were developed are still available and are recommended in ANSI Z53.1 and ANSI Z35.1.

SUBJECT INDEX FOR 29 CFR 1910—OCCUPATIONAL SAFETY AND HEALTH STANDARDS—Continued

Subject term	Section No.	page No.
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Labor Camps	.142(g)	250
Laundries	.264(f)(2)(i)	466
Machinery, Basement Areas	.219(c)(5)	386
Manlifts	.68(b)(6)(iii), (14)	71
Operating Areas, Industrial Trucks	.178(h)	287
Pulp and Paper Mills	.261(b)(7), (c)(10), (k)	428
Pulpwood Harvesting	.266(e)(15)	485
Sawmills	.265(c)(5)(iii), (9), (23)	469
Spray Booths	.107(b)(10)	156
Storage Areas	.177(f)(1), .178(h)	282
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Air Contaminants	.134(g)(6)	244
Danger	.144(a)(1)(ii)	254
Effective Dates	.149	261
Fire Protection	.144(a)(1)(i)	254
Gas Mask Canisters	.134(g)(6)	244
Physical Hazards, Colors	.144(a)	254
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Blue		
Green		
Orange		
Purple		
Red	.144(a)(1)	254
White		
Yellow	.144(a)(3)	254
Respirators	.134(g)(6)	244
Specifications		
Standards Sources	.144(b), .147	254
Stop	.144(a)(1)(iii)	254
Signs and Tags: (see also Markings)		
Colors		

SUBJECT INDEX FOR PART 1926—SAFETY AND HEALTH REGULATIONS FOR CONSTRUCTION—Continued

Subject term	Section No.	Federal Register page No.
Illumination		
Demolition	.851(c)	22867
Table D-3 (Minimum Illumination Intensities)	.56	22810
Temporary Lighting	.401(j)	22832
Tunnels & Shafts	.800(d)	22857

Blanks indicate revoked standards.

With respect to the revocation of sections 1910.144 and 1910.145 the following comments were published by OSHA in the preamble to the revocation order:

> Section 1910.144 is concerned with the use of color only for equipment and surfaces of various structures. Employee safety is not enhanced by such necessarily detailed requirements for these various colors and applications. The majority of comments received, objected to the revocation of these requirements. OSHA disagrees with these commentors because the requirements in 1910.145 which are being retained will provide for adequate recognition of hazards...
>
> Upon reexamination of the evidence, OSHA has determined that in the best interest of the work protection the following provisions in 1910.144 should not be revoked: Paragraph 1910.144(a)(1)(i) - red; Paragraph 1910.144(a)(1)(ii) - danger; Paragraph 1910.144(a)(1)(iii) - stop; and Paragraph 1910.144(a)(3) - yellow...
>
> Section 1910.145 contains a large number of detailed requirements for design applications, use of signs, and symbols for accident prevention. Comments were received objecting to the revocation of any of the provisions contained in this section. Several commentors objected to the loss of the standardization of accident prevention signs and tags. Additionally, several objected to the possibility of employees not being able to

recognize the purpose of a sign because of a less specified standard. OSHA disagrees with these commentors because accident prevention signs and tags can be designed and applied in the manner different from that specified in the section and the new sign will be as effective as the sign designed in conformance with the detailed specification requirements section 1910.145.

Although illumination standards have not promulgated by OSHA, some citations have occurred under the General Duty provisions of the Act. The United States Steel's Environmental Monitoring Manual states that it is realistic to anticipate such standards at a later time. (See page 13-1, Reference 11)

It is interesting to note that regulations for lighting in Great Britain can be found in numerous rules, orders, regulations, recommendations, memorandums, statutes, etc. Lighting in public buildings such as schools, hospitals, factories and offices and shops is regulated by the British government. Further study should refer to reference 23 for more detail.

J. Associations and Other Interested Parties

American National Standards Institute, Inc.
1430 Broadway
New York, NY 10018
(212) 354-3300

American Society of Safety Engineers, Inc.
850 Busse Highway
Park Ridge, IL 60068
(312) 692-4121

Certified Ballast Manufacturers Association
2120 Keith Bldg.
Cleveland, OH 44115
(216) 241-0711

Color Association of the U.S., Inc., The
200 Madison Ave.
New York, NY 10016
(212) 685-5881

Human Factors Society, Inc., The
P.O. Box 1369
Santa Monica, CA 90406
(213) 394-1811

Illuminating Engineering Society (IES)
345 East 47th Street
New York, NY 10017
(212) 644-7913

Industrial Accident Prevention Association
2 Bloor St. East
Toronto, Ontario M4W.1A8
(416) 965-8888

Inter-Society Color Council, Inc.
Rensselear Polytechnic Institute
Troy, NY 12181
(518) 270-6458

Manufacturers Council on Color and Appearance
9241 Wood Glade Drive
Great Falls, VA 22066
(703) 759-3291

National Bureau of Standards
Dr. Robert Glass
(301) 921-2670

National Fire Protection Association (NFPA)
470 Atlanta Ave.
Boston, MA 02210
(617) 482-8755

National Research Council of Canada

Ontario, Canada KIA OR6

Dr. Allen Robertson

(613) 993-2478 or 993-9101

OSHA, Safety Standards Division

Washington, D.C. 20210

JoAnn Slattery

(202) 523-7234

K. Large and Small Companies

This paragraph is not applicable to the profile.

L. Summary Analysis of Data

Based upon the limited information available to the profile study, it appears the following conclusions can be made.

(1) Extensive information and recommended guides for safe and effective illumination and color exist and are readily available through the Illuminating Engineering Society, ANSI Standards, and various publications. The IES has contributed significantly to the body of information associated with the application of color and light to the workplace to provide safe working conditions.

(2) Very few statistics exist to demonstrate the relationship between illumination/visibility, and accident and injury rates.

(3) It appears that past accident investigations may have underrated the influence of visibility and illumination in determining the causes of accidents. (See Postal Study, Paragraph E)

(4) No existing standards have been promulgated specifically for the illumination of the workplace by OSHA. Standards which were promulgated related to standardized color-coding have been revoked, in some cases.

(5) The ANSI safety colors were designed to be identifiable at all times. This identification is intended to be possible without any other clues, i.e., it must depend on the identifiability of the single color alone. For the most part this result has been attained. (Especially when the colors are

illuminated by daylight for which the specifications are made and in general when they are lighted by any source which produces a continuous spectrum containing all wavelengths of light.) However, some exploratory experiments carried out by the IES indicated that some light sources have a large proportion of power in the spectral lines which could generate confusion between some of the colors. Future studies should investigate general lighting sources being used under which safety colors can be confused to an extent to prevent their performing their design function.

(6) The British have indicated that lighting and color coding is on the threshhold of important new developments. They indicate that these developments are so closely linked with the physiology and psychology of vision that it would be inadvisable for the lighting engineer to advance without the input of regulatory agencies. Further, once this is recognized, they suggest setting up courses of training in which those concerned with light and sight will develop an understanding of the total dicipline.(23)

(7) NIOSH may wish to explore the possiblity of supporting Vision Conservation Programs, as described in Paragraph D.

(8) Energy considerations may have a major impact on lighting levels.

REFERENCES AND SOURCES

1. Liberty Mutual Insurance Co., Loss Prevention Department, 1944, "A Review of Loss Prevention Information for Industrial Executives", Industrial Seeing - Subject 7, 12 pages. (Microfiche)

2. Vianna, J., 1976, Accident Prevention Manual, NIOSH - 00070224, CIS 77-291, 396 pages, (Abstract-Portaguese).

3. National Safety Council (NSC), 1974, Accident Prevention Manual for Industrial Operations, Seventh Edition.

4. Heins, Allen P., 1975, "The Occupational Safety and Health Effects Associated with Reduced Levels of Illumination," NIOSH publication No. 75-142, 113 pages.

5. Illuminating Engineering Society (IES), 1966, IES Lighting Handbook, the Standard Lighting Guide, Fourth Edition.

6. Asher, Janet K., 1977, "Toward a Safer Design for Stairs," Job Safety and Health, Vol. 5, No. 9, pages 27-32.

7. Illuminating Engineering Society, (telephone contact), Howard Haynes - Safety Advisor, January, 1979.

8. Standard Industrial Classification Manual, 1972, Executive Office of the President - Office of Management and Budget, Statistical Policy Division, U.S. GPO 1976 210-882/159.

9. Encyclopedia of Occupational Health and Safety, 1976 International Labor Office, MdGraw-Hill, New York, New York.

10. McCormick, Ernest J., 1970, Human Factors Engineering, Third Edition, McGraw-Hill Book Company, New York, New York.

11. United States Steel Corporation, 1973, Environmental Health Monitoring Manual, Catalog No. A 6810.00.

12. Jerome, C.W., 1977, Journal of Illuminating Engineering Society, "Rendering of ANSI Safety Colors", pp. 180-183.

13. Anderson, H.E., 1971, Supervisory Management, "A Color Scheme for Plant Safety", Vol. 16, pp. 39-41.

14. Bresler, R.R., 1949, Journal of the American Medical Association, "Cutaneous Burns Due to Fluorescent Light", Vol. 140, pp. 1334-1336, NIOSH - 00018278.

15. Thornton, W.A., 1977, Journal of Illuminating Engineering Society, "Design of Safety Colors", pp. 42-99.

16. Lamb, J.H., 1958, Archives of Dermatology, "Sensitivity of Fluorescent "Blue Green) Light", Vol. 77 pp. 519-525, NIOSH-00003383.

17. Garrett, D.E., 1956, Chemical Engineering, "Put Color to Work in Your Plant", Vol. 9, pp. 195-198, NIOSH-00002667.

18. NIOSH, 1973, Occupational Hazards, "Who's Right About the Guarded Light", Vol. 35, No. 1, pp. 49-50, NIOSH-00023419.

19. Industrial Safety Handbook, 1977, McGraw-Hill Book Company (UK) Limited, London, Second Edition.

20. Wright, W.D., 1975, Lighting Research and Technology, "Colour Vision Characteristics", Vol. 7, No. 3., pp. 158-168, NIOSH-00054319, CIS 76-104.

21. NIOSH, 1977, National Safety News, "A Vision Conservation Program", Vol. 115, No. 1, pp. 70-74, NIOSH-00075599, CIS 77-991.

22. NIOSH, 1972, National Safety News, "Let It Glow For Safety", Vol. 105, No. 2, pp. 94-96, NIOSH-00020428.

23. Hopkinson, R.G., 1969, "Lighting and Seeing", William Heinemann Medical Books Limited, London, 116 pages.

24. NIOSH, 1977, "Toward the Quantification of Visibility", HEW Publication No. 77-202.

25. National Safety Council, 1971, "Auxiliary Electrical Systems and Emergency Lighting", Data Sheet 248.

26. National Safety Council, 1972, "Reflecting and Luminescent Materials", Data Sheet 245.

27. Tennessee Valley Authority - Hazard Control Standard, 1972, "Criteria for Warning Colors".

28. Levin, R.E., 1977, Journal of Illuminating Engineering Society, "Ultraviolet Radiation - Considerations in Interior Lighting Design", Vol 6, No. 2, pp. 80-88.

29. NIOSH, 1955, Occupational Hazards, "Color ... It Reduces Eye Fatigue", Vol. 17, pp. 46-49, NIOSH-00009292.

30. GSA, (Telephone contact), January 1979.

31. OSHA, October 1978, Part 1910 - Occupational Safety and Health Standards, Selected General Industry Safety and Health Standards Revocation.

32. Personal communication with Ms. J. Slattery, Office of Safety Standards Development, OSHA, DOL, Washington, D.C.

33. U.S. Postal Service, "Personal Injury Analysis, 1977", Western Region, January 26, 1978, San Bruno, California.

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16. Abstract (Limit: 200 words)

A safety information profile is presented for the uses of industrial lighting and color. Different types of lighting and the uses of color for psychological benefits and hazard identification are described. Health and safety hazards are discussed in terms of inappropriate quantity and quality of light. Current controls for the proper use of light and color are reviewed, and statistics are given for accidents associated with insufficient lighting. Industry trends are discussed. Related and proposed federal standards are considered, and a list of names and addresses of associations and other interested parties is provided. It is concluded that the contribution of visibility factors to accidents is underrated, and that the primary considerations for industrial lighting are proper quality and quantity. Recommendations cite the need for routine inspection of lighting systems, federal adoption of a vision conservation program, and further study to determine optimum lighting conditions.

17. Document Analysis a. Descriptors

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