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SAFETY CODE SERIES

CODE OF LIGHTING: FACTORIES MILLS AND OTHER WORK PLACES

PREPARED UNDER SPONSORSHIP OF
ILLUMINATING ENGINEERING SOCIETY
NEW YORK, N. Y.

AMERICAN STANDARD
Approved December 31, 1921, by
American Engineering Standards Committee

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ILLUMINATING ENGINEERING SOCIETY.

The Illuminating Engineering Society was organized in 1906 to advance the theory and practice of illuminating engineering and to disseminate knowledge relating thereto. The society now has about 1,200 members who are interested in the subject of lighting from various standpoints: Engineering, economic, hygienic, esthetic.

The society has no affiliation with any commercial organization. Any one interested in its objects may become a member.

NOTE ON REVISION OF CODE.

The present code was revised under the rules of procedure of, and has been officially approved as an "American Standard" by, the American Engineering Standards Committee. For this purpose it was first submitted to and approved by a "sectional committee" made up of representatives officially designated by the following societies and organizations:

American Gas Association.
American Institute of Electrical Engineers.
American Society of Mechanical Engineers.
Association of Edison Illuminating Companies.
Illuminating Engineering Society.
International Association of Industrial Accident Boards and Commissions.
National Association of Cotton Manufacturers.
National Electric Light Association.
National Safety Council.
National Workmen's Compensation Service Bureau.
United States Bureau of Standards.
United States Department of Labor.
United States Public Health Service (Department of Industrial Hygiene).

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CODE OF LIGHTING: FACTORIES, MILLS, AND OTHER WORK PLACES.

INTRODUCTION.

The accompanying code of lighting for factories, mills, and other work places [1] has been prepared and issued by the Illuminating Engineering Society in order to make available authoritative information for legislative bodies, factory boards, public-service commissions, and others who are interested in enactments, rules, and regulations for better lighting. The code is intended also as a guide for factory owners and operators in their efforts to improve lighting conditions in their factories.

Part I contains rules arranged in convenient form for legal enactment or governmental regulations.

Part II contains a discussion of the rules of Part I—that is, the legal requirements which must be met where a code is in force—and also suggestions and general information as to desirable practice in factory lighting.

Part III takes up the advantages of proper and adequate illumination, both natural and artificial, and discusses such lighting particularly from the standpoint of economics.

Since the first edition of this code was issued, a number of the States of the Union, recognizing the beneficial effects of adequate illumination on the health and safety of the employees, have adopted factory lighting codes. As a rule these codes stipulate the minimum illumination permissible for different classes of industrial operations. They also indicate the desirable as distinguished from the minimum illumination values and the kinds of lighting equipment which will avoid glare and give a good distribution of light.

The preface to the Wisconsin Industrial Lighting Code explains as follows why the State is concerned in the regulation of factory lighting:

> Insufficient and improperly applied illumination is a prolific cause of industrial accidents. In the past few years numerous investigators, studying the cause of accidents, have found that the accident rate in plants with poor lighting is higher than similar plants which are well illuminated. Factories which have installed improved lighting have experienced reductions in their accidents which are very gratifying.
>
> Of even greater importance, poor lighting impairs vision. Because diminution of eyesight from this cause is gradual, it may take the individual years to become aware of it. This makes it all the more important to guard against the insidious effects of dim illumination; of glaring light sources shining in the eyes; of flickering light; of sharp shadows; of glare reflected from polished parts of the work. To conserve the eyesight of the working class is a distinct economic gain to the State, but regardless of that, humanitarian considerations demand it.

[1] American Standard. Approved Dec. 31, 1921, by American Engineering Standards Committee.

Finally, inadequate illumination decreases the production of the industries of the State and to that extent the wealth of its people. Factory managers who have installed improved illumination are unanimous in the conviction that better lighting increases production and decreases spoilage.

Mr. R. E. Simpson, of the Travelers' Insurance Co., is authority for the statement that during the year 1919 there were more than 2,000,000 industrial accidents causing loss of time; of this number 25,000 were fatal. The following extract from an article in the Travelers' Standard by Mr. Simpson gives some interesting data on the relation between lighting and safety:

There is some foundation for assuming that 18 per cent of our industrial accidents are due to the defects in lighting installations. On that basis the services of 108,000 men for one year are lost annually because the illumination provided is not adequate for the safety of the workmen. That this condition could exist year after year is all the more reprehensible because of the fact that the remedy is so easily applied and has beneficial results in many ways other than the safety involved. Accidents caused by carelessness, inattention, or ignorance can be eliminated only by a long-continued, painstaking, educational campaign, often involving a change in long-established habits. Elimination of accidents due to inadequate or improper lighting is simply a matter of purchasing the proper equipment and installing it under competent directions. In fact, it seems proper to include illumination in the list of mechanical safeguards, for the reason that the lamps and reflectors provide a guard; illumination points out the hazards just as effectively as a railing points out the danger of and provides protection against the hazard of a revolving flywheel.

PART I.—RULES.

NOTE.—Attention is called to the fact that the requirements given in the rules are minimum specifications and are not to be interpreted as sufficient to insure good lighting. See Part II.—Suggestions and general information.

General Requirement.—Traversed spaces, during the time of use, and work in process, shall be supplied with light in accordance with the following rules:

Rule 1.—Illumination Required.—The illumination maintained shall be no less than given in the following table:

TABLE I.

MINIMUM FOOT-CANDLES ON THE SPACE OR AT THE WORK.

(*a*) Roadways; yard thoroughfares	0.02
(*b*) Storage spaces; aisles and passageways in workrooms, excepting exits and passage leading thereto	.25
(*c*) *Where discrimination of detail is not essential* Spaces, such as—Hallways, stairways; exits, and passages leading thereto; toilet rooms; elevator cars and landings. Work, such as—Handling material of a coarse nature; grinding clay products; rough sorting; coal and ash handling; foundry charging.	.5
(*d*) *Where slight discrimination of detail is essential* Spaces, such as—Stairways, passageways, and other locations where there are exposed moving machines, hot pipes, or live electrical parts. Work, such as—Rough machining, rough assembling; rough bench work; rough forging; grain milling.	1
(*e*) *Where moderate discrimination of detail is essential* Work, such as—Machining; assembly work; bench work; fine core making in foundries; cigarette rolling.	2
(*f*) *Where close discrimination of detail is essential* Work, such as—Fine lathe work, pattern making; tool making; weaving light-colored silk or woolen textiles; office work; accounting; typewriting.	3
(*g*) *Where discrimination of minute detail is essential* Work, such as—Watchmaking; engraving; drafting; sewing dark-colored material.	5

Rule 2.—Avoidance of Glare; Diffusion and Distribution of Light.—Lighting, whether natural or artificial, shall be such as to avoid glare, objectionable shadows, and extreme contrasts, and to provide a good distribution of light; in artificial lighting systems, lamps shall be so installed in regard to height, location, spacing, and reflectors, shades, or other suitable accessories, as to accomplish these objects.

Bare light sources, such as exposed lamp filaments or gas mantles, located within the ordinary field of the worker's vision, are presumptive evidence of glare.

For a specification of definite requirements under this rule, reference should be had to Tables III, IV, V, and VI in Part II.

Rule 3.—Exit and Emergency Lighting.—The lighting to be provided under rule 1 in all stairways and exits of factories and in the passageways appurtenant thereto shall be supplied so as not to be subject to failure, because of the failure of the room or work space lighting from internal causes, and preferably from an independent connection extending back to the main service entrance for the building. In case of unusual danger which may exist on account of type of building, nature of the work, crowded conditions, or lack of suitable exit space, an independent service shall be insured by connecting to a separate source of supply without or within the building.

PART II.—SUGGESTIONS AND GENERAL INFORMATION.

NOTES ON RULE I—ILLUMINATION REQUIRED.

The illumination values given in Table I are minimum requirements dictated from the viewpoint of safety. Table II given below is intended to indicate the order of illumination values that are considered desirable for different classes of work. Letters in parentheses following foot-candle values refer to the corresponding subdivisions of Table I. Persons of advanced years and those with defective eyes require more light than those having perfect vision. The foot-candles in good lighting practice are as a rule several times those specified as minimum requirements. A range of foot-candle values is given in Table II for each group of operations; in modern practice it will usually be found desirable to select values in or even beyond the upper portion of the range.

TABLE II.

APPROXIMATE FOOT-CANDLES IN GOOD LIGHTING PRACTICE ON THE SPACE OR AT THE WORK.

$\frac{1}{20}$ TO $\frac{1}{4}$ FOOT-CANDLES. (a)

Roadways and yard thoroughfares.

1 TO 2 FOOT-CANDLES. (b)

Storage spaces: Aisles and passageways in workrooms, excepting exits and passages leading thereto.

2 TO 5 FOOT-CANDLES. (c) and (d)

Auditoriums and assembly rooms.
Assembling: Rough.
Boilers, engine rooms, and *power houses:* Boilers, coal, and ash handlings, storage-battery rooms, auxiliary equipment, oil switches, and transformers.
Chemical works, hand furnaces, boiling tanks, stationary driers, stationary or gravity crystallizing, mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizing, bleaching.
Clay products: Grinding, filter presses, kiln rooms, molding, pressing, cleaning, and trimming.
Elevator, cars and landings: (Freight and passenger).
Forge shops and *welding:* Rough forging.
Foundries: Charging floor, tumbling, cleaning, pouring and shaking out.
Glass works: Mix and furnace rooms, casting.
Hallways: Stairways, exits, and passages leading thereto.
Leather manufacturing: Vats, cleaning, tanning, and stretching.
Locker rooms.
Meat packing: Slaughtering.
Machine shops: Rough bench and machine work and rough assembling.
Milling and grain foods: Cleaning, grinding, or rolling.
Packing: Rough.
Paint shops: Dripping, spraying, firing.

Paper manufacturing: Beaters, machine grinding.
Plating.
Receiving and shipping.
Soap manufacturing: Kettle houses, cutting, soap chip and powder.
Steel and iron mills: Charging and casting floors, muck and heavy rolling, shearing (rough by gage), picking and cleaning, soaking pits and reheating furnaces.
Storerooms and stock rooms: Rough.
Textile mills: (Cotton) opening and lapping, carding, drawing-frame, roving, dyeing; (Woolen) carding, picking, washing and combing.
Toilet and wash rooms.
Woodworking: Rough sawing and rough bench work.

5 TO 10 FOOT-CANDLES. (e) and (f)

Assembling: Medium fine.
Chemical works: Tanks for cooking, extractors, percolators, nitrators, electrolytic cells.
Clay products: Enameling, coloring, and glazing.
Cloth products: Light goods.
Electric manufacturing: Storage battery, molding of grids, coil and armature winding, mica working, insulating process.
Engine rooms and power houses: Switchboards, engines, generators, blowers, compressors.
Forge shops and welding: Fine forging and welding.
Foundries: Fine molding and core making.
Glass works: Grinding, glass blowing machines, cutting, polishing, inspecting.
Glove manufacturing: Light goods: sorting, stitching, trimming, and inspecting.
Hat manufacturing: Dyeing, stiffening, braiding, cleaning and refining, forming, sizing, pouncing, flanging, finishing and ironing; sewing—light goods.
Ice making: Engine and compressor rooms.
Inspecting: Rough, medium.
Leather manufacturing: Cutting, fleshing, and stuffing, finishing and scarfing.
Leather working: Pressing and winding, grading, matching, cutting, scarfing; sewing—light goods.
Machine shops: Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing, and polishing.
Meat packing: Cleaning, cutting, cooking, grinding, canning, and packing.
Milling and grain foods: Baking, roasting.
Office: Private, general.
Packing: Medium, fine.
Paint shops: Rubbing, ordinary hand painting and finishing, fine hand painting and finishing.
Paper manufacturing: Calendering, finishing, cutting, and trimming.
Polishing and burnishing.
Printing industries: Matrixing and casting, miscellaneous machines, presses; proofreading, lithographing, electrotyping.
Rubber manufacturing and products: Calenders, compounding mills, fabric preparation, stock cutting, tubing machines, solid-tire operations, mechanical goods building, vulcanizing, bead building, pneumatic tire building and finishing, inner-tube operation, mechanical goods trimming, treading.
School: Classroom, study room, library.
Sheet-metal works: Miscellaneous machines, bench work; punches, presses, shears, stamps, welders, spinning.
Shoe manufacturing: Hand turning, miscellaneous bench and machine work; inspecting and sorting raw material, cutting, lasting, and welding—light goods.
Soap manufacturing: Stamping, wrapping, and packing, filling and packing powder.
Steel and iron mills: Bar sheet and wire products; automatic machines, rod light and cold rolling, wire drawing, shearing, fine by line.
Storerooms and stock rooms: Medium, fine.
Structural steel fabrication.
Textile mills: (Cotton) spooling, spinning, drawing in, warping, weaving, quilling, inspecting, knitting, slashing. (Silk) winding, throwing, dyeing, quilling, warping, weaving, and finishing. (Woolen) twisting and dyeing; drawing in, warping; weaving; knitting machine—light goods.
Woodworking: Sizing, planing, standing, machine and bench work, gluing, veneering cooperage, finishing.

10 TO 20 FOOT-CANDLES AND ABOVE. (g)

Assembling: Extra fine.
Cloth products: Dark goods.
Glass works: Glass cutting (cut glass); inspecting, fine.
Glove manufacturing: dark goods—sorting, stitching, trimming, and inspecting.
Hat manufacturing: Sewing—dark goods.
Inspecting: Fine.
Jewelry and watch manufacturing: Engraving, stone setting, fine repairing.
Leather working: Grading, matching, cutting, scarfing, sewing—dark goods.
Machine shops: Fine bench and machine work, fine automatic machines, fine grinding, fine buffing and polishing.
Office: Drafting room.
Paint shops: Extra fine hand painting and finishing (automobile bodies, piano cases, etc.).
Printing industries: Linotype, monotype, typesetting, imposing stone, engraving.
Shoe manufacturing: Inspecting and sorting raw material, cutting, stitching—dark goods.
Textile mills: Woolens; weaving—dark goods.

In Tables I and II the illumination requirements are specified in foot-candles. The term "foot-candle" may be explained by saying that it represents the illumination on a surface 1 foot distant from a standard candle; two foot-candles would represent the illumination supplied by two candles at the same distance, etc. In this illustration it is assumed, of course, that in each case the surface is perpendicular to the direction of the rays of light falling upon it.

At first sight it might appear from Tables I and II that there is a sharp line of demarcation between those operations for which one foot-candle is specified and those which require two foot-candles, etc. In reality no such well-defined classification exists and in applying the tables the inspector will find that in certain cases, because of the degree of fineness of the work carried on in a particular plant, one grade higher or one grade lower than that which first suggests itself may be a more reasonable requirement.

Again, it should not be overlooked that there are occasional operations which need to be performed practically without light, such as photographic and photometric processes in dark rooms. Again, there are some operations which are best observed by their own light, as in certain parts of the process of working with glass. In all cases in which work must be performed under very low illumination, special precaution should be taken to safeguard the workers from accident.

In applying the illumination requirements as given in Tables I and II the foot-candles specified should not be construed as referring only to a horizontal plane; the illumination should be measured on whatever plane the work or operation is carried on, whether it is on a horizontal, vertical, or intermediate plane. With most artificial lighting systems the foot-candles measured on a vertical plane are about one-half the illumination in the same location measured on a horizontal plane. Attention is also called to the fact that the values in Table I are minimum values; that is, they apply to measurements of the lighting system in ordinary operation, not simply when the lamps and reflectors are new and clean.

Natural lighting.—The foot-candle values given apply to natural as well as to artificial lighting. In practice it will be found that the natural illumination on clear days is frequently many times these figures; in fact, an illumination of a hundred foot-candles can be found in almost any shop if measurements are taken near the window, and

FIG. 1.—Saw-tooth roof construction, with glass facing the north sky, usually results in well diffused daylight illumination.

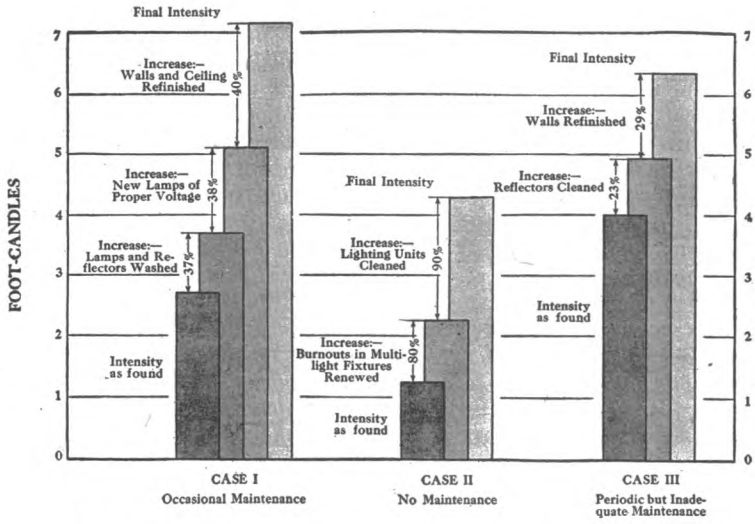

FIG. 2.—Chart showing the importance of prompt renewal of burned out lamps and systematic cleaning of the lighting equipment. These particular tests were on semi-indirect and indirect lighting systems.

very often mechanics find it worth while to avail themselves of this illumination by walking over to the window whenever extremely accurate measurements are to be made. In this connection it is of interest to note that the range of illumination under which the eye can function with some degree of success is extremely wide, varying from a few hundredths of a foot-candle in the moonlight up to as much as 10,000 foot-candles out in the sunlight on a clear day. However, wide extremes in illumination are ordinarily not conducive to best vision.

Most factory owners are particularly interested in making the best possible use of their daylight facilities, so as to render useful and valuable all parts of the floor space; and, also, to shorten the periods when artificial lighting is needed. The saw-tooth sky windows of modern factory construction (fig. 1) permit of an adequate and nearly uniform daylight illumination of the entire floor area, and are desirable when practicable. When rooms are illuminated through side windows, it is often difficult or impossible satisfactorily to light all parts of the floor space, or to furnish adequate illumination to some of the workers without furnishing too much to others, or without subjecting the latter to objectionable glare. In some cases the use of prismatic glass which redirects the rays of light so as to admit more daylight into the room, especially into the parts of the room remote from the windows, is worth while. As a rule it is better to confine the prismatic glass to the upper sash of a window, as its use in the lower sash is likely to cause objectionable glare; moreover it cuts off all view of out of doors.

Windows should be equipped with adjustable devices so that the illumination may be accommodated to changing exterior conditions. Translucent window shades of light tones constitute the most important of these devices. Window shades or other daylight adjusting devices should not be left to the mercy of those workers who may be nearest the windows, but should be controlled by the room foreman. He should readjust the window equipment for the varying daylight conditions, and he should also decide when the use of artificial light to make up for a deficiency in daylight in any location, is permissible.

Because of the time required for the adaptation of the eye to its surroundings special danger is present when one steps from outdoor sunlight into a dimly lighted storage space; for example, a passageway connecting two well-lighted areas must be well illuminated. Again, where the eye has been afforded the advantages of a high level of illumination throughout the day and artificial light is turned on to reinforce the failing natural light, a higher total illumination is ordinarily needed than at night under artificial lighting alone.

Maintenance of illumination.—The proper and adequate maintenance of equipment for both natural and artificial lighting is essential. Systems which are adequate when first installed will soon deteriorate unless properly maintained. The factory owner should establish a regular, definite system of maintenance so as to insure that sky windows, side windows, lamps, and accessories are at all times kept clean, in proper adjustment and in good repair. Means should be provided for easy access to all lighting units by the employee in charge of their maintenance. Walls and ceilings should be repainted, preferably in light tones, at regular intervals, particularly where, as in indirect systems of lighting, a large part of the illumination comes

from the ceiling. It should be kept in mind that the illumination requirements given in the tables apply to the lighting equipment under adverse operating conditions, not simply new and clean as when first installed.

Figures 2 and 3 show the very considerable loss in illumination which results from the collection of dirt on lamps and lighting fixtures. To insure that a given level of illumination will be maintained even where conditions are favorable, it is necessary to design the system to give initially at least 25 per cent more light than the required minimum. In locations where the dirt will collect rapidly and where adequate maintenance is not provided the initial value should be at least 50 per cent above the minimum requirement, and it is evident from a study of the charts that even this allowance may prove insufficient.

Especially in connection with the maintenance of lighting systems attention is called to the desirability of having available in the factory

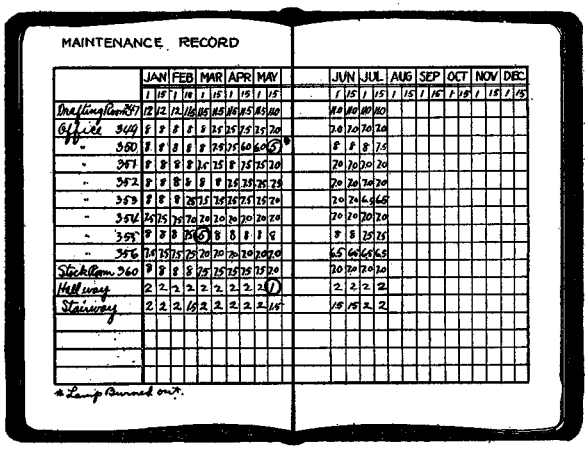

FIG. 3.—Lighting maintenance record.

some instrument with which the foot-candles of illumination received at any point can actually be measured. There are a number of such instruments on the market, some of which, in the hands of experienced men, are capable of a high degree of accuracy. One instrument, the foot-candle meter (fig. 4), is not designed for precise measurements, but nevertheless, has a considerable field of usefulness because its determinations are easily made and are accurate enough for many practical purposes. The foot-candle meter is small, light in weight, and does not require technical training for its operation; foot-candle illumination is read directly from the scale without computation or adjustment. In one large establishment where the superintendent uses a foot-candle meter systematically as a check on his maintenance department, readings of illumination are taken at regular intervals at fixed stations throughout the plant. These readings are recorded in such a way that the successive readings are readily comparable. When any inconsistency appears in the records an investigation is made and the remedy applied. The illumination in that establishment is never allowed to fall below 6

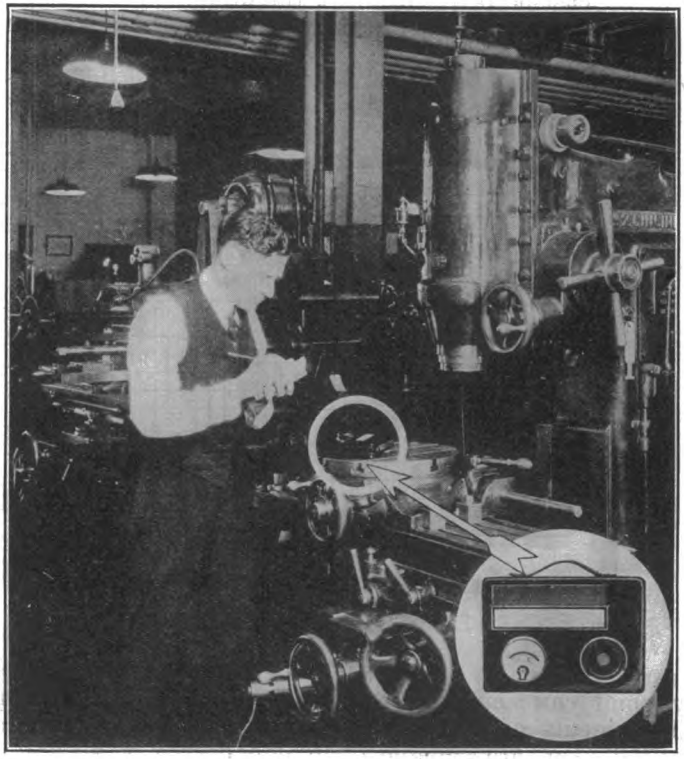

FIG. 4.—A survey of actual lighting conditions can readily be made with the foot-candle meter. This instrument is very useful in "checking up" a lighting system to see that it is being properly maintained.

foot-candles without immediate correction. By measuring light actually delivered to the work the foot-candle meter automatically reveals the combined effect of all possible causes of depreciation. Ignorance of the magnitude of depreciation has often been the cause of inadequate maintenance. Soap and water cost less than gas and electrical energy.

Locating switches and controls.—The switches which turn on and off the light in the entrances and halls of a building should be located near the points of entrance. Likewise switches which control at least one circuit of lamps in a room should be located near the principal points of entrance to that room.

In locating switches or control devices in factory and mill aisles, care should be exercised to arrange them systematically; that is, on columns situated on the same side of the aisle and on the same relative side of each column. This plan materially simplifies the finding of switches or control devices, by those responsible for turning on and off the light.

Control parallel to windows.—The light from the lamps most distant from the windows will usually be required at times when the natural light near the windows is entirely adequate, thus making it advantageous to arrange the groups of lamps in circuits parallel to the windows. The advantage of this method is further apparent when it is considered that if the lamps are controlled in rows perpendicular to the windows all lamps in a row will necessarily be on at one time, while a portion only may be required.

NOTES ON RULE 2.—AVOIDANCE OF GLARE.

Glare may be defined as any brightness within the field of vision of such a character as to cause discomfort, annoyance, interference with vision, or eye fatigue. Always a hindrance to vision, it often, like smoke from a chimney, represents a positive waste of energy as well. It is one of the most common and serious faults of lighting installations; the code properly requires the shading of lamps in industrial plants to guard against glare.

Glare is objectionable because (1) when continued it tends to injure the eye and to disturb the nervous system; (2) it causes discomfort and fatigue and thus reduces the efficiency of the worker; and (3) it interferes with clear vision, and thus reduces the efficiency and in many cases increases the risk of accident or injury to the worker. From both a humanitarian and a business viewpoint the owner or operator of a factory should be interested in avoiding glare, whether caused by daylight or by artificial light. On the other hand, in interpreting and enforcing the glare rule the inspector is not expected to insist upon what he may believe to be desirable practice in the given case. His duty is only to insure the absence of a condition which is prejudicial either to the health or to the safety of the worker.

If a simple instrument were available for measuring glare the task of the inspector would be comparatively easy. However, there are so many factors entering into the situation that it has not been found practicable to develop any instrument which will properly evaluate them all. To arrive at an intelligent judgment in any given case, therefore, the inspector must be reasonably familiar with the principal factors in or causes of glare.

FIG. 5.—Whenever local lighting is used it should be supplemented by some general illumination. Note the absence of glare and contrast between light and dark areas in this room as compared with Figure 7, where there is no general illumination. In the above photograph, although a local lamp is supplied for each machine, the individual sources of light are scarcely apparent, because of the general illumination.

CAUSES OF GLARE.

There are five principal causes of glare:

1. *Brightness of source.*—The light source may be too bright; that is, it may give off too high a candlepower per square inch of area.

A glance at the sun proves that an extremely bright light source within the field of vision is capable of producing acute discomfort. Light sources of far lower brightness than the sun, such for example, as the filament of an incandescent electric lamp or the incandescent mantle of a gas lamp, may also cause discomfort, although the annoying effect is usually not quite so marked.

2. *Total volume of light.*—The light source may be too powerful for comfort; that is, it may give off too great a total candlepower in the direction of the eye.

Too frequently glare is assumed to be entirely a question of the brightness of the light source; of equal importance is the question of its total candlepower. Experience has shown that a 500-watt lamp in a 10-inch opal globe, or a mercury-vapor lamp of an equivalent light output, hung 7 or 8 feet above the floor and a similar distance ahead of the observer will prove quite as glaring as the exposed filament of a 50-watt incandescent lamp in the same location. The brightness of the opal globe unit is only a few times that of a candle flame, but its total candlepower and consequently the quantity of light which reaches the eye is altogether too great, so that its effect is worse than that of the bare filament of lower candlepower, although the latter may have a brightness as high as 3,000 candlepower per square inch. An unshaded window often causes glare, due, of course, to the large volume of light rather than to the high brightness of the sky.

3. *Location in the field of view.*—A given light source may be located at too short a distance from the eye or it may lie too near the center of the field of vision for comfort; that is, within too small an angle from the ordinary line of sight.

The 500-watt opal globe unit discussed in the previous illustration would seldom cause discomfort if placed, say 80 feet away from the observer, for at this distance the total quantity of light entering the eye would be only one one-hundredth of that received at 8 feet. Again, the same light source would probably be found quite unobjectionable at a distance of 8 feet from the eye provided this distance was obtained by locating the lamp 4 feet ahead of the observer and 7 feet above the eye level; in this case the lamp would scarcely be within the ordinary field of view.

The natural position of the eye during intervals of rest from any kind of work is generally in the horizontal direction, and it is desirable that during such periods the worker should be freed from the annoyance caused by glare. Glare is the more objectionable the more nearly the light source approaches the direct line of sight. While at work the eye is usually directed either horizontally or at an angle below the horizontal. Glaring objects at or below the horizontal should especially be prohibited. The best way to remove light sources out of the direct line of vision is to locate them well up toward the ceiling. Local lamps—that is, lamps placed close to the work—if used at all, must be particularly well screened.

4. *Contrast with background.*—The contrast may be too great between the light source and its darker surroundings.

It is a common experience that a lamp viewed against a dark wall is far more trying to the eyes than when its surroundings appear relatively light. A light background requires, first, that the surface should be painted in a color which will reflect a considerable portion of the light which strikes it; and, second, that the system of illumination employed should be such as to direct some light upon the background. In many cases the ceiling appears almost black under artificial light simply because no light reaches it. With daylight, on the other hand, the walls of a room are often so well illuminated that they appear brighter than the work itself and this, also, is a condition which is not conducive to good vision. In general, a light tone for ceilings and high side walls and a paint of medium reflecting power for the lower side walls will ordinarily be found most satisfactory under both artificial and natural lighting.

Where strictly local lighting systems are employed—that is, where individual lamps are supplied for all benches and machines—and no overhead lighting is added, the resulting contrasts in illumination will usually be found so harsh as to be objectionable even though the lamps themselves are well shielded. The eyes of the workman looking up from his brightly lighted machine or bench are not adapted for vision at low illuminations; hence, if adjacent objects and aisles are only dimly lighted, he will be compelled either to grope about losing time and risking accident, or to wait until his eyes have become adapted to the low illumination. Glancing back at his work, he again loses time while his eyes adjust themselves to the increased amount of light which reaches them. If long continued, this condition leads to fatigue, as well as to interference with vision, and to accidents. In other words, where local lamps are employed, there should also be a system of overhead lighting which will provide a sufficient illumination of all surrounding areas to avoid such undesirable contrasts.

5. *Time of exposure.*—The time of exposure may be too great—that is, the eye may be subjected to the strain caused by a light source of given strength within the field of vision for too long a time.

Where an operator is seated and his field of vision is fixed for several hours at a time, light sources of lower brightness and lower candlepower are required than where the operator stands at his work and shifts his position and direction of view from time to time. In the first case the image of the light source is focused on one part of the retina for considerable periods of time and is obviously more likely to cause discomfort and eyestrain than when present for short periods only. Those who are forced to work all day at desks facing the windows are particularly likely to suffer from this form of glare.

RATING LIGHT SOURCES FROM THE GLARE STANDPOINT.

It is evident that the first two factors mentioned as causes of glare, namely, excessive brightness and excessive candlepower, concern the light source itself, the third factor concerns its location in the field of view; and the fourth and fifth depend upon the conditions of its use.

In Table III a means of rating light sources (into Grades I to X) has been provided which takes into account both their brightness

and their candlepower. Light sources in Grades I and II may be termed soft or well diffused; those in Grades VIII, IX, and X are harsh and likely to cause glare. It is seen from Table III that a light source of high intrinsic brightness but of low candlepower—for example, one that would be classified under the fifth line of the first column (less than 20 candlepower, and 100 to 1,000 candlepower per square inch) has the same rating, Grade V, as a source of lower brightness but of greater total candlepower (2 to 5 candlepower per square inch and 500 total candlepower) which falls in the second line of the fifth column.

TABLE III.

CLASSIFICATION OF LIGHT SOURCES FROM THE STANDPOINT OF GLARE.

Grade I indicates sources of maximum softness; Grade X indicates sources of maximum harshness.

Maximum visible brightness (apparent candles per square inch).	Total candlepower in direction of eye.				
	Less than 20	20 to 50	50 to 150	150 to 500	500 to 2,000
	Grade.	*Grade.*	*Grade.*	*Grade.*	*Grade.*
Less than 2	I	I	II	II	III
2 to 5	II	II	III	IV	V
5 to 20	II	III	IV	VI	VII
20 to 100	IV	V	VI	VII	VIII
100 to 1,000	V	VI	VII	VIII	IX
1,000 and up	VI	VII	VIII	IX	X

In accordance with the plan of Table III, measurements of brightness and candlepower have been made on a number of light sources found in every-day practice, both natural and artificial, and grades have been assigned to them as shown in Table IV. While engaged in his work, the inspector will, of course, find other light sources in use which are not included in the table; however, from those which are given he should be able to estimate closely in what grades the others should be placed. In cases of doubt, it is, of course, possible to have actual measurements made to determine both the brightness of the lighting unit and its total candlepower. The unit can then be rated in accordance with Table III.

TABLE IV.

SPECIFIC CLASSIFICATION OF LIGHT SOURCES FROM THE STANDPOINT OF GLARE AS DERIVED FROM TABLE III.

NATURAL LIGHT SOURCES.

(As seen through windows or skylights.)

	Grade.
Sun	X
Very bright sky	V
Dull sky	III
Sun showing on prism glass	IX

OPEN GAS FLAMES	II

Incandescent Mantle Gas Lamps.

	Mantles consuming 2–5 cubic feet per hour.	Mantles consuming 5–8 cubic feet per hour.	Large single mantle or cluster 8–12 cubic feet per hour.	Large single mantle or cluster 12–20 cubic feet per hour.	Cluster or high pressure lamp consuming above 20 cubic feet per hour.
	Grade.	*Grade.*	*Grade.*	*Grade.*	*Grade.*
Clear glassware	V	VI	VII	VIII	IX
Frosted globes	III	IV	.....	.....	.....
6-inch opal globe	II	III	.....	.....	.....
8-inch opal globe [1]	I	II	IV–VI	.....	.....
10-inch opal globe [1]	.....	.....	III–V	V–VII	.....
12-inch opal globe [1]	.....	.....	.....	.....	VI–VIII
Dome reflector:					
Mantle visible	V	VI	VII	VIII	IX
Mantle not visible	I	II	III	IV	IV
Bowl reflector:					
Mantle visible	V	VI	VII	VIII	IX
Mantle not visible	II	II	III	V	V
Totally indirect [1]	.....	.....	I–II	II	III
Semi-indirect bowls [1]	.....	.....	II–III	II–IV	III–VI

[1] Where a range is given, the best grade, that is the lowest, applies to globes that are evenly luminous, and the poorest to globes which have a decidedly bright spot in the center.

Arc Lamps.

	Grade.
Inclosed arcs, clear globes	IX
Flame arc, clear globes	X
Flame arc, opal globes	VII–VIII

Mercury Vapor Tubes VI

Carbon and Metallized Filament Incandescent Lamps.

8 candlepower	V
16 candlepower	V
32 candlepower	VI

Tungsten Filament Incandescent Lamps.

	Watts.					
	10 to 25	40 to 60	75 to 100	150 to 200	300	500 to 1,000
	Grade.	*Grade.*	*Grade.*	*Grade.*	*Grade.*	*Grade.*
Bare lamps	VI	VII	VIII	IX	IX	X
Frosted lamps or frosted globes	II	III	VI	VII	VIII	.....
8-inch opal globes [1]	I	I-II	II-IV	IV-VI	.....	.....
12-inch opal globes [1]	.....	.....	II-III	II-V	IV-VI	VII-VIII
16-inch opal globes [1]	.....	.....	.....	II-V	IV-VI	V-VII
Flat reflectors—filament visible	VI	VII	VIII	IX	IX	X
Dome reflectors—steel or dense glass:						
Filament visible from working position	VI	VII	VIII	IX	IX	X
Filament not visible from working position	I	I	III	III	IV	VI
Bowl reflectors—steel or dense glass:						
Filament visible from working position	VI	VII	VIII	IX	IX	X
Filament not visible from working position	II	II	III	IV	VI	VII
Dome reflectors—bowl-enameled lamps	.....	.....	IV	V	VI	VI
Semi-inclosing units [1]	.....	.....	III-IV	IV-VI	IV-VII	VI-VIII
Totally indirect lighting [1]	.....	.....	I-II	I-II	II	III
Semi-indirect bowl [1]	.....	.....	I-III	II-III	II-IV	III-VI

[1] Where a range is given, the best grade, that is the lowest, applies to globes that are evenly luminous, and the poorest to globes which have a decidedly bright spot in the center.

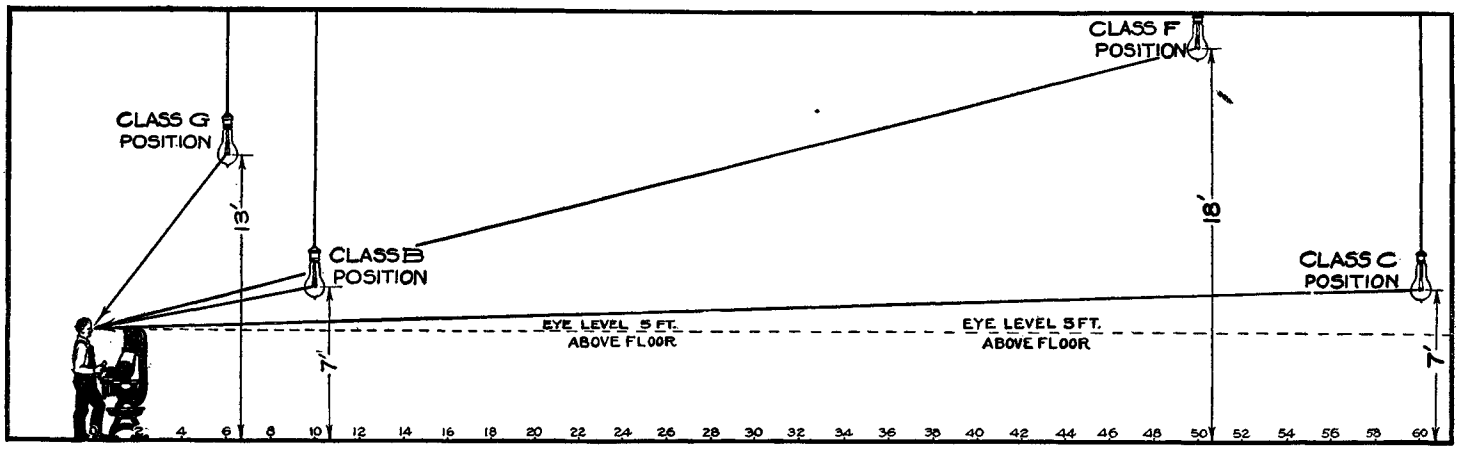

FIG. 6.—Diagram illustrating typical position given in the chart of the field of view. (See Table V.)

TABLE V.

CHART OF THE FIELD OF VIEW.

CLASSIFICATION OF POSITION OF LIGHT SOURCE WHICH TAKES INTO ACCOUNT THE DISTANCE FROM THE EYE AND THE ANGLE OF THE LINE OF VISION.[1]

Height above floor, in feet.	Horizontal distance of light source from observer, in feet.															
	1	2	3	4	6	8	10	12	16	20	25	30	35	40	50	60 and up.
6.5 or less	[2]A	[2]A	A	A	A	A	A	A	A	A	A	A	B	B	B	B
6.5 to 7	G	E	D	C	C	B	B	B	B	B	B	B	B	B	B	C
7 to 8	G	G	F	E	D	D	C	C	C	C	C	C	C	C	C	C
8 to 9	G	G	G	F	F	E	D	D	C	C	C	C	C	C	C	D
9 to 10	G	G	G	G	F	F	E	E	E	D	D	D	D	D	D	D
10 to 11	G	G	G	G	G	F	F	F	E	E	E	D	D	D	D	D
11 to 12	G	G	G	G	G	F	F	F	F	F	E	E	D	D	D	D
12 to 13	G	G	G	G	G	G	F	F	F	F	E	E	E	E	E	E
13 to 14	G	G	G	G	G	G	G	G	F	F	F	F	E	E	E	E
14 to 15	G	G	G	G	G	G	G	G	G	F	F	F	F	E	E	E
15 to 16	G	G	G	G	G	G	G	G	G	F	F	F	F	E	E	E
16 to 17	G	G	G	G	G	G	G	G	G	G	F	F	F	F	E	E
17 to 18	G	G	G	G	G	G	G	G	G	G	G	G	F	F	F	F
18 to 19	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	F
19 to 20 and up	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G

[1] See Fig. 6.
[2] Classified as A unless light source is so nearly above the head of operator as to be quite outside of field of view, in which case classify as E.

TABLE VI.

SHOWING LIMITING GRADES OF LIGHT SOURCES PERMISSIBLE FOR VARIOUS SOURCES.

Classification of position.	Space or work to be lighted.			
	Roadways and yard thoroughfares.	Storage spaces, aisles, stairways, handling coarse material.	Ordinary manufacturing operations.[1]	Offices and drafting work and certain manufacturing operations.[2]
	Limiting grade.	*Limiting grade.*	*Limiting grade.*	*Limiting grade.*
A	VI	V	III	II
B	VII	VI	V	IV
C	VIII	VII	VI	V
D	IX	VIII	VII	VI
E	IX	IX	VIII	VII
F	X	X	IX	VIII
G	X	X	X	X

[1] For the present the limits set in this table can not be rigidly applied to portable lamps used for temporary work, such as setting up machines, repairing automobiles, etc.
[2] Those operations in which workers are seated facing in one direction for long periods of time.

Background.

Where the background and the surroundings are very dark in tone, a light source of one grade softer than that specified in Table VI may be required. Where the background and surroundings are very light in tone, one grade more harsh than that specified in the table may sometimes be permitted.

From a study of Table IV it will be observed that incandescent lamps equipped with reflectors which do not completely hide the light source have been assigned to the same grade as the corresponding sizes of bare lamps. It is true that the addition of a reflector somewhat increases the total candlepower in the direction of the eye and therefore the argument might be advanced that a 100-watt lamp with a flat reflector should be classified in Grade IX whereas

FIGS. 7 and 8.—Adjoining rooms in the same factory. The upper figure illustrates a strictly local lighting system of the poorer sort. The lower figure illustrates a lighting system consisting of 150-watt bowl enameled lamps equipped with dome reflectors spaced 10 feet apart; the average illumination is 9 foot-candles.

the bare lamp is Grade VIII. On the other hand, from the standpoint of glare, the effect of the light background furnished by the reflector at least compensates for the increased candlepower which it gives; the rating is therefore kept at Grade VIII.

Charting the field of view.—It has already been pointed out that the distance between a light source and the eye, and its angle to the line of vision have much to do with determining how bright a light source may be used without discomfort. In Table V, which is a chart of the field of view, the possible locations of light sources are classified in seven groups, A to G inclusive, depending upon their distance from the eye and their proximity to the line of vision. Light sources in positions designated A, B, or C, are close to the eye or close to the line of vision; hence they are most likely to be the cause of discomfort, and the greatest care must be exercised in their selection. In positions F and G, on the other hand, the use of relatively bright sources is much less harmful.

Limiting grades for specific installations.—Table VI shows the harshest grade of light source which should be permitted within the field of vision for fixed conditions as to location of lamp, brightness of background, and character of work performed.

The grades named in Table VI are definitely limiting values and in each case the use of softer light sources is to be recommended; that is, where Grade IV is permitted, the installation of a lighting unit of Grade II or of Grade III will be conducive to better results as regards both accuracy of vision and eye comfort.

From Table IV the majority of bare incandescent lamps are seen to have a relatively poor rating—that is, most of them fall in Grades VII to IX—and it is evident from Table VI that Grades VII to IX are never to be permitted in workrooms in positions A, B, or C; that is, the use of bare incandescent lamps is prohibited in working areas except when they are located at considerable heights above the floor or when they are so placed as to be out of the field of vision. At the present time it will be found necessary from a practicable standpoint to delay the strict enforcement of this provision in a very few instances, particularly in the case of extension cord lamps used in temporary work, such as in setting up machinery and in repairing automobiles, etc.

It will be noted from Table IV that the sources of natural light, side and ceiling windows, usually fall in Grade IV. This means (see Table VI) that no mandatory rules are established as to the use of shades, awnings, etc., except in those cases where the sky is visible through portions of the sash in position A; that is, less than 6.5 feet above the floor, or where the sun itself comes within the range of vision.

However, Grade II is the limiting value for light sources less than 6.5 feet high, in offices, and other locations where the workers are seated facing in one direction for considerable periods of time. Hence in these cases, to comply with the table, the work must be so arranged that the employees are not required to face windows where the sky is visible through the lower sash; that is, less than 6.5 feet above the floor.

Prism glass when so located as to catch the sun's rays ordinarily has a very much poorer rating than clear glass; hence, where it is used the installation of window shades or curtains should ordinarily be required.

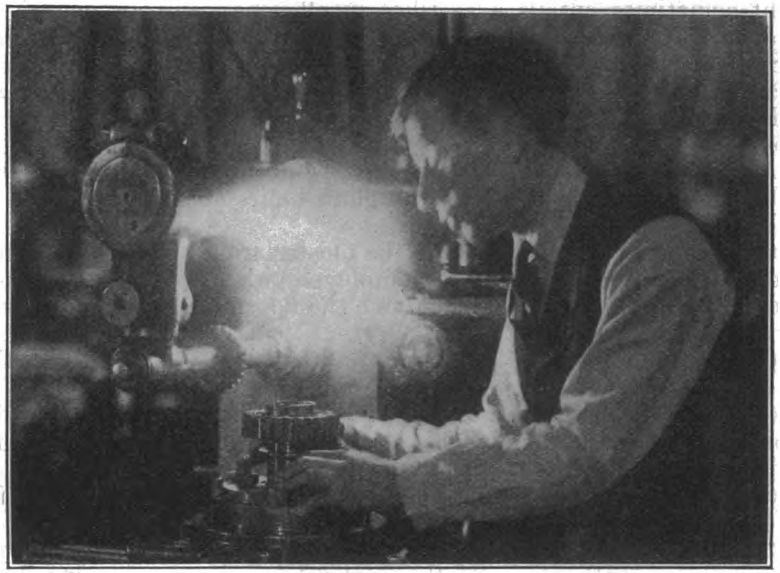

FIG. 9.—Glaring light from unshaded local lamp which is a menace to safety and to vision, and is one of the evils which the Lighting Code is expected to eliminate.

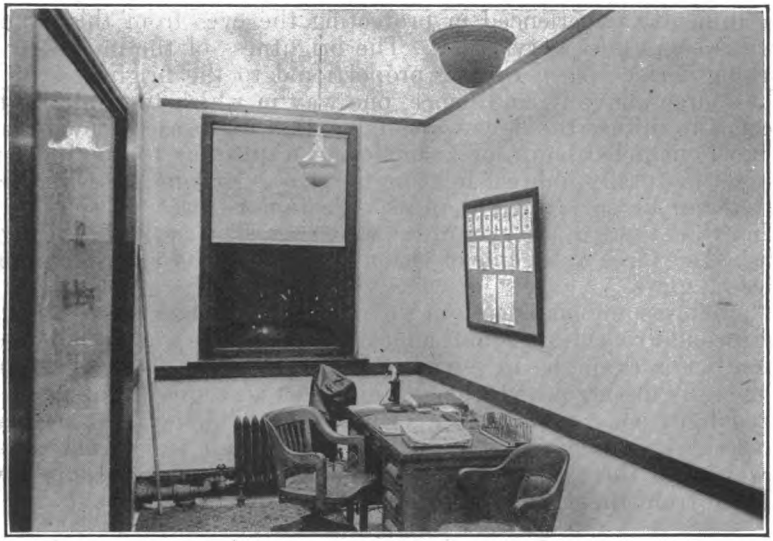

FIG. 10.—Lighting an office by means of indirect units. Illumination approximately 6 foot-candles.

The question naturally arises why, if glare is so objectionable, should not all sources capable of producing glare be prohibited everywhere. The answer is that to attain a maximum softness of light sometimes entails a sacrifice in efficiency and an increase in operating expense. If a worker chooses unnecessarily to gaze directly upward at bright skylight or at an artificial lighting unit so located that it is not a factor in glare under ordinary circumstances, it is scarcely within the province of code a of lighting to protect him from the consequences.

How to use Tables IV, V, and VI.—To determine whether a given lighting installation is within the glare limits specified, proceed as follows:

(1) Select what appears to be the most glaring light source within the field of view of any of the employees when at work. Measure the height of that light source above the floor and its horizontal distance from the worker.

(2) With the height and distance find in Table V how this location in the field of view is classified (position A, B, or C, etc.).

(3) With the classification of the position fixed from (2), determine from the proper column of Table VI the harshest grade of light source ordinarily permissible for this location.

(4) If surroundings are very light or very dark, apply a correction of one grade (plus or minus) to the value found in (3).

(5) From Table IV find the classification of the light source in use and compare with (4). (If the particular source is not listed, its grade may be estimated or may be determined by actual photometric measurements.)

Glare by reflection.—Another way in which glare is produced is by the reflection of light from polished surfaces in the field of vision. The difficulty experienced in protecting the eyes from this kind of glare is sometimes very great. The brightness of the image on the working surface is, of course, proportional to the brightness of the light source above it, and hence, one way in which to minimize this effect is to diffuse the downward light; that is, to use a bowl-frosted or bowl-enameled lamp, or an inclosing fixture, or to employ semi-indirect or totally indirect lighting fixtures. In some cases the light source can be so located that its reflection is directed away from, rather than toward, the eyes of the workers. The avoidance of highly polished surfaces in the line of vision is another good way to minimize reflected glare.

There are some instances, on the other hand, where sharp shadows and specular reflection from the materials worked upon actually assist vision. For example, in sewing on dark goods the thread is much more easily distinguished when illumination is secured from a concentrated light source, such as a brilliant lamp filament, which casts sharp shadows and gives rise to a distinct glint from each thread. However, in these cases the light source must be particularly well shielded from the eyes of the worker.

NOTES ON RULE 3.—EXIT AND EMERGENCY LIGHTING.

The employer is to be held responsible for the proper lighting of passageways, stairways, and exits, in so far as his premises are concerned, which means such parts of buildings, floors, or rooms as are controlled by the employer, including entrances thereto, but exclud-

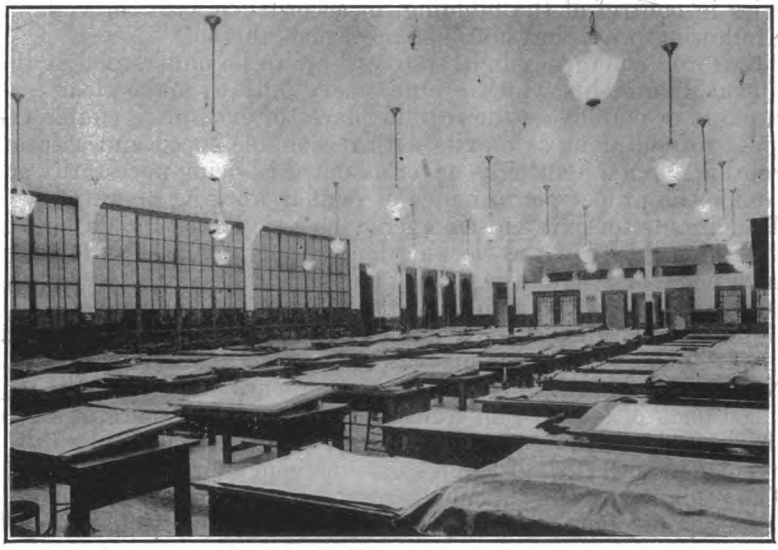

FIG. 11.—Drafting-room lighting, using dense semi-indirect units and 200-watt lamps

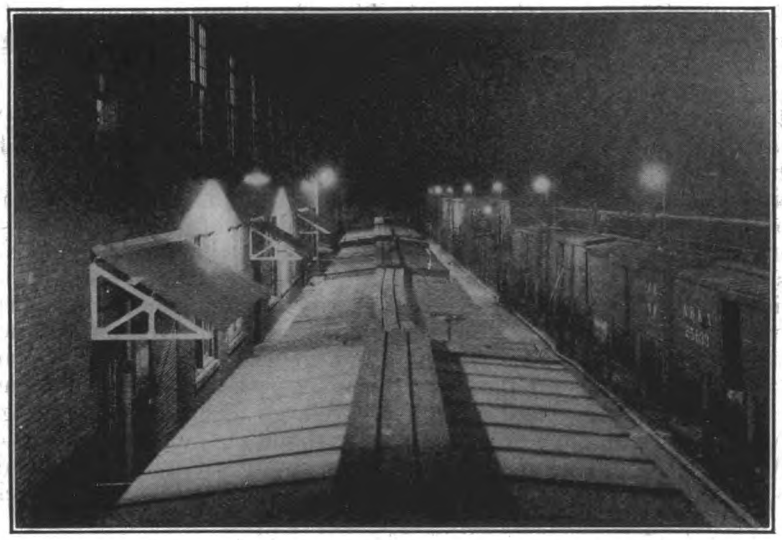

FIG. 12.—A yard lighting installation consisting of 150-watt lamps in shallow bowl reflectors, mounted 20 feet from the ground. The units in each row are spaced 60 feet apart, and the two rows are 30 feet apart.

ing hallways, passageways, and stairways giving access to other floors, or to spaces on the same floor, and used in common by the tenants of the building. These latter shall be lighted by the party or parties in control of the building, in accordance with the code, and the following provisions and interpretations thereof:

"Exit and emergency light sources" are to be understood as those artificial illuminants which are necessary only to make clear to the occupants or employees the regular places of exit, or to enable them to pass to and along safe exits with reasonable speed and assurance of footing. Such lighting is never assumed as being necessarily sufficient for the proper performance of regular working operations.

The circuits for exit and emergency electric lamps should be wired to be independent of the working lamps, back at least as far as the branch panel or distributing board, and should be separately fused, so that any failure of the regular working lamps through causes arising within that working space will not also cause failure of the exit, stairway, or passageway lamps.

No fuses smaller than those of the emergency branch circuits shall be used back of (that is, on transformer, meter, or generator side of) such circuits, and no power machinery, portable extension cords, or convenience outlets shall be on such emergency circuits.

The "main service entrance" may be interpreted to mean the entrance point (meter or distributing panel) of lighting feeders for the building, floor, loft, or particular space in question. In gas lighting it may be considered to be the main gas feeder for the building, or the main gas riser for the floor or loft in question. Where several factory spaces are grouped in the same building, each with its own exit or exits, the emergency electric circuits for any one space are not required to run to the main building panel board or main switch nor are the emergency gas pipes expected to extend to the main gas meter nor to the building feeder from the street main, except as explained below.

Under specially dangerous conditions, where in the opinion of the recognized authorities the failure of the main and entire regular lighting supply would leave the employees without assured means of seeing the outgoing passageways, the exit and emergency lamps should be fed from an entirely separate source of energy, such as a storage battery, or, in case the regular lighting system is electric, from gas or other reasonably dependable illuminant. Under normal conditions, however, the phrase "separate supply" shall, in electric service, be interpreted to mean a separate branch circuit which will afford lighting as long as transformers, generators or main lighting feeders are intact; and in gas service, interpreted to mean branch piping extending back to a sufficiently large feeder to insure a gas supply unless stoppage occurs near or outside of the main gas meter.

As indicated in the general requirements under Part I of this code, the exit and emergency lamps should be lighted whenever artificial lighting is required in the work spaces.

It is the obvious intent of Rule III to insure reduction of accident hazard, and inasmuch as this end is as beneficial to the industrial operator or owner as to the State, the detailed interpretations of this order, for the various and sundry types and situations of working spaces, must be reached through mutual cooperation of the owner and the State authorities.

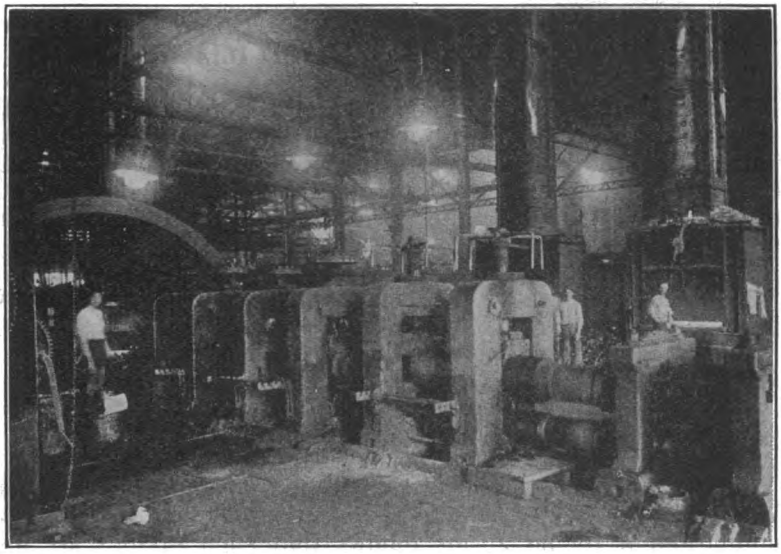

FIG. 13.—Lighting of steel rolls. Illumination provided by five mantle inclosed gas arc lamps, equipped with opaque reflectors.

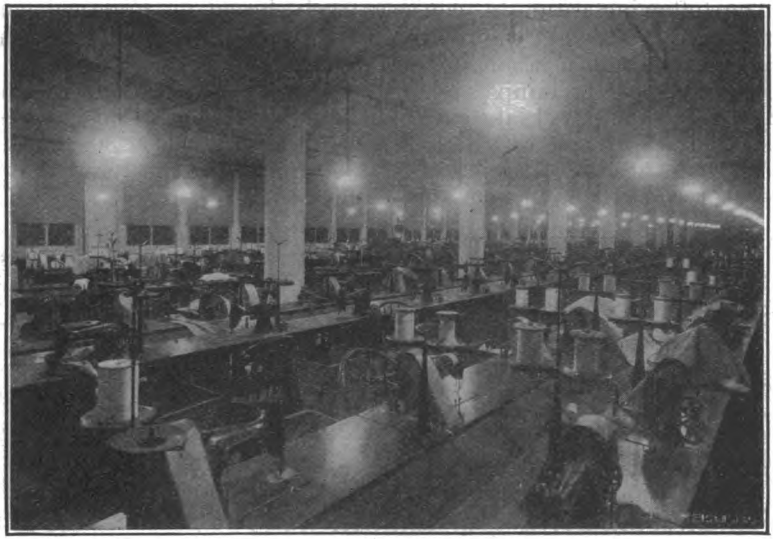

FIG. 14.—Shirt-waist factory, sewing-machine lighting. Illumination provided by single-mantle gas lamps, equipped with prismatic reflectors. Lamps spaced 9 feet apart, with a clearance of 5 feet above working plane.

PART III.—ADVANTAGES OF GOOD ILLUMINATION.

While the advisability of good natural and artificial illumination is so evident that a list of its effects may seem commonplace, these effects are of such importance in their relation to factory management that they are worthy of careful attention. The effects of good illumination, both natural and artificial, and of bright and cheerful interior surroundings, include the following:

1. Reduction of accidents.
2. Greater accuracy in workmanship, resulting in improved quality of goods.
3. Increased production for the same labor cost.
4. Less eyestrain.
5. Greater contentment of the workmen.
6. More order and neatness in the plant.
7. Supervision of the men made easier.

While it is difficult to place a definite money value on the savings effected in increased production and improved quality, by good illumination, it by no means follows that such savings are insignificant or unsubstantial. The factory owner who ignores them neglects his own interests. Other items in the foregoing list, even more difficult to value definitely, are none the less real; taken together, they constitute a powerful argument in favor of the best available illumination in the factory.

The following estimate, conservatively based on practical conditions, gives an idea of the relative costs of good illumination by artificial means, and of labor, in the factory.

Assume that the lamps are so spaced that one 100-watt incandescent electric lamp will take care of one operator; that in this particular case the lamp burns on the average 2 hours per day, 300 days per year; that the life of the lamp is 1,000 burning hours; and that the operator works 8 hours per day, 300 days per year.

Investment:	
Cost of lamp (list price)	$1.10
Cost of enameled steel reflector (list price)	2.50
Cost of wiring per outlet	8.00
Total investment	11.60
Cost of operating per annum:	
Interest on investment, $11.60, at 6 per cent	.70
Depreciation on reflector and wiring, at 12½ per cent	1.31
Renewal of lamp $\frac{600}{1,000}\times\$1.10$	.66
Cleaning, at 3 cents per cleaning, two per month	.72
Energy, at 5 cents per kilowatt-hour	3.00
Total annual cost of maintaining good illumination:	
Per man per year	6.39
Cost of labor: Annual wages per man per year:	
8 hours, at 45 cents per hour; $8\times300\times\$0.45$	1,080.00

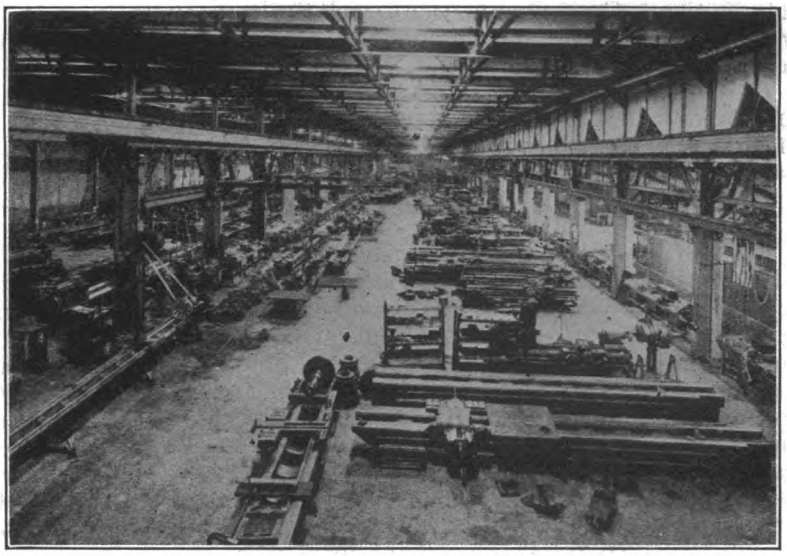

FIG. 15.—A plant where machine tools are manufactured, using mercury vapor lamps spaced 20 feet apart at a height of 25 feet above the floor; approximately 1 watt per square foot.

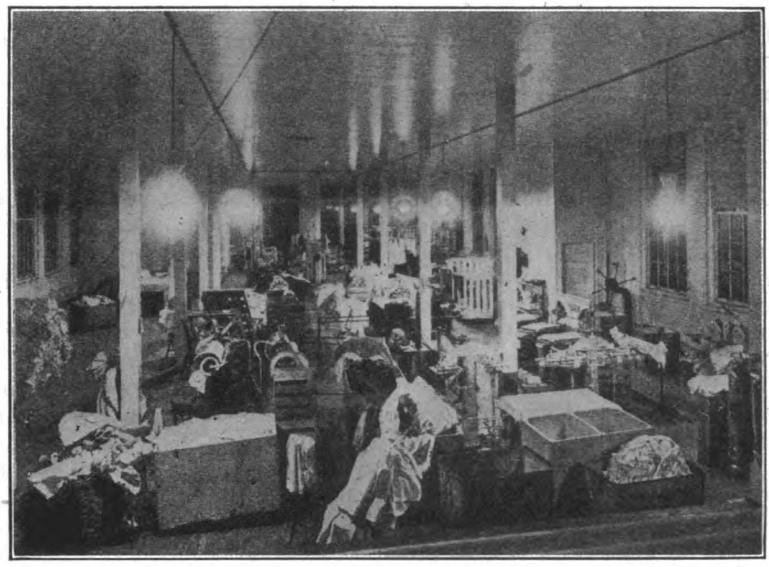

FIG. 16.—Laundry lighting. Illumination provided by five mantle gas arc lamps, inclosed type, equipped with diffusing glass globes.

If an operator, because of the good illumination, saves—in more production, or better quality of product—the equivalent of only three minutes per day for 300 days, he will offset the annual cost of the illumination. Good illumination is, relatively speaking, inexpensive, and its introduction and maintenance are good investments on the part of the factory owner.

These estimated figures, illustrating the low cost of good lighting compared with the cost of labor, also illustrate how large may be the losses unconsciously sustained by the factory owner from the use of a poor lighting system. An operator losing, say, 30 minutes per day, loses more than $60 per year, or about ten times the cost of giving him good illumination.

The factory owner, when approached by the gas or electric lamp salesman, should weigh carefully any argument in favor of a change in his lighting system which is based solely upon a resultant saving in energy consumption. The example given above shows how greatly the gain in increased output, due to good lighting, overbalances any possible saving in energy consumption effected by changes in the system of illumination. If the proposed new system sacrifices anything in the quality of illumination, or if it merely substitutes one inadequate system for another, it should be rejected, and the factory owner should insist that if his lighting installation is changed, the new system must meet the requirements of good illumination even though this involves the consumption of more energy than before. First a good lighting system, and then as much economy in energy consumption as is consistent with the illumination requirements—such a policy is the wise one for the factory owner.

ACCIDENT INSURANCE COSTS.

Compensation insurance premiums for a given plant are based on the amount of the pay roll, and the rate is determined by the accident experience of a given industry, modified by the experience of the particular plant under consideration. With a rate of 1 per cent the annual premium in the case of 1,000 employees at an average wage of $40 per week would be $20,800.

An insurance carrier might pay the claims resulting from two accidents per month (on an average) in this plant, and meet his own overhead costs, and still have a slight margin of profit. An experience of three accidents per month, one-third of them due to poor lighting (a not unlikely event), would probably leave the insurance carrier no option but to increase the rate, by, say, 50 per cent. The premium would then be $31,200—an increase of $10,400. If the lighting costs only $3 per employee or $3,000 per year total, the owner's annual expense for poor illumination actually amounts to $13,400—of which $10,400 is required by the insurance company to meet accident claims. An expenditure of $6 per year per employee for lamps and energy might save a large portion, if not all, of the latter amount.

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