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W. N. DOAK, Secretary
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ETHELBERT STEWART, Commissioner

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SAFETY CODE SERIES

CODE OF LIGHTING: FACTORIES, MILLS AND OTHER WORK PLACES

REVISION OF 1930

AMERICAN STANDARD

Approved by the
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CONTENTS

Illuminating Engineering Society

The Illuminating Engineering Society was organized in 1906 for the advancement of the theory and practice of illuminating engineering and the dissemination of knowledge relating thereto. The society now has about 2,000 members who are interested in the subject of lighting from various standpoints—engineering, economic, hygienic, and esthetic.

The society has no affiliation with any commercial organization. Anyone 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 Standards Association. 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:

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AMERICAN INSTITUTE OF ARCHITECTS: LeRoy E. Kern, technical secretary, Structural Service Department, The Octagon, 1741 New York Avenue, Washington, D. C.

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THE NATIONAL ASSOCIATION OF COTTON MANUFACTURERS: F. M. Gunby, 201 Devonshire Street, Boston, Mass.

NATIONAL BUREAU OF CASUALTY AND SURETY UNDERWRITERS: R. E. Simpson, Travelers Insurance Co., Hartford, Conn.

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BULLETIN OF THE

U. S. BUREAU OF LABOR STATISTICS

NO. 556 WASHINGTON OCTOBER, 1931

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

Introduction

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

Parts 1 and 2 of this code discuss the advantage of good illumination and describe the essentials of such illumination. Part 3 contains a set of regulations suggested for adoption by State authorities.

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 employees, have adopted factory lighting regulations. These regulations 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 in 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 workers is a distinct economic gain to the State, but regardless of that, humanitarian considerations demand it.
>
> 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.

[1] Revision of original code which was approved as American Standard by American Engineering Standards Committee, Dec. 31, 1921. Revision approved Aug. 18, 1930.

Part 1.—Advantages of Good Illumination

The advisability of good natural and artificial illumination is so evident that a list of its effects may seem commonplace, but these effects are of such importance in their relation to 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.
4. Less eyestrain.
5. Greater contentment of the workers.
6. Greater cleanliness.
7. More order and neatness in the plant.
8. Supervision of the employees made easier.

Reduction of Accidents

The National Safety Council in its publication "Accident Facts—1929" estimates the number of fatalities in the United States arising out of or in the course of gainful employment as 24,000 for the year 1928, and also that during the same period the *lost time* nonfatal accidents reached the staggering total of 3,125,000—about 1 accident for every 4 persons engaged in industry, or 1 for every 14 persons gainfully employed.

According to R. E. Simpson, of The Travelers Insurance Co., there is warrant for assuming that defective vision and deficient or unsatisfactory lighting installations are contributing factors in 18 per cent of these accidents. Simple computation will show that from these causes industry is being deprived of the equivalent of the services of 35,000 men throughout each entire year due to the lost-time nonfatal accidents, and that the accepted actuarial methods of evaluating fatal accidents will bring the total loss to 125,000 men annually. This is indeed a high price to pay for neglect of light and vision.

That these conditions 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. On the other hand, elimination of accidents due to inadequate or improper lighting is simply a matter of purchasing the proper equipment, installing and operating it under competent direction. In fact, it seems logical to include adequate illumination in the list of safeguards, for the reason that lamps and reflectors act as a guard because the resultant illumination points out the hazards and aids in avoiding them just as effectively as a railing points out the danger of and provides protection against the hazard of a revolving flywheel.

Compensation-insurance premiums for a 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 1½ per cent the annual premium in the case of 1,000 employees at an average wage of $40 per week would be $31,200.

An insurance carrier might on an average pay the claims resulting from four accidents per month in this plant and meet its own overhead costs, and still have a slight margin of profit. An experience of five accidents per month, one-fifth of them due to improper lighting (a not unlikely event), would probably leave the insurance carrier no option but to increase the rate by 25 per cent. The premium would then be $39,000—an increase of $7,800. If poor lighting costs only $3 per employee, or $3,000 per year total, the owner's annual expense for poor illumination actually amounts to $10,800, of which $7,800 is required by the insurance company to meet additional accident claims. An expenditure of $6 to $8 per year per employee for more adequate illumination might save a large portion, if not all, of the latter amount. The important point here is the fact that the cost of accidents due to poor illumination greatly exceeds the cost of providing adequate illumination.

Economy of Operation

While it is difficult to appraise 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)	$0.35
Cost of enameled steel reflector (list)	2.50
Cost of wiring per outlet	8.00
Total investment	10.85
Cost of operating per annum:	
Interest on investment, $10.85 at 8 per cent	.87
Depreciation on reflector and wiring at 12½ per cent	1.31
Renewal of lamp $\frac{6}{1000} \times \$0.35$	.21
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	6.11
Cost of labor, annual wages per man per year:	
Eight hours at 45 cents per hour; $8 \times 300 \times \$0.45$	1,080.00

If an operator, because of the good illumination, saves—in more production or better quality of product—the equivalent of only 3 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 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 10 times the cost of giving him good illumination.

The factory owner, when approached by the lighting 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.

Part 2.—Suggestions and General Information

Measurement of Illumination

The *foot-candle* is the unit of illumination, in terms of which lighting requirements are specified. A general idea of the amount of illumination represented by foot-candle values can be obtained by holding a newspaper at different distances from a bare 25-watt tungsten filament lamp so that the light rays fall perpendicularly upon the surface. For 16 foot-candles the distance should be 15 inches; for 8 foot-candles, 21 inches; for 4 foot-candles, 2½ feet; for 1 foot-candle, 5 feet; for one-fourth foot-candle, 10 feet.

In this connection it should be realized that the brightness of the surface will depend not only upon the foot-candles of incident illumination but also upon the nature of the surface. That is, with equal illumination, white paper will be much brighter than cast iron.

It is impractical and frequently misleading to attempt to estimate foot-candle values simply by viewing an illuminated surface. The simplest instrument for measuring these values is a foot-candle meter (see fig. 8), with which foot-candles can with a little practice be read accurately enough for ordinary purposes.

Points at which measurements should be taken.—In checking recommended or required intensities of illumination with an instrument such as the foot-candle meter, it is extremely important that the

measurement be made at the point and in the plane where the given illumination is needed. Thus, for any operation the illumination should be measured on the plane on which the work or operation is performed, whether it be horizontal, vertical, or at some intermediate angle. The illumination over an area such as a hallway or aisle refers ordinarily to the floor level and is measured in the horizontal plane.

Recommended Levels of Illumination

Table 1 gives the range of illumination values that are considered desirable for different classes of work. These values are based upon practice established through years of experience. Persons of advanced years or with defective eyesight require more light than do those having perfect vision. A range of foot-candle values is given 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.

It is recognized that any specified process when carried on in different factories is performed with different degrees of fineness and with other variations, so that one factory may need more illumination than another for the same class of work. In the table, ranges of foot-candle values are given to correspond to the variations actually existing in practice.

Attention is called to the fact that the values in Table 1 are *operating* values; that is, they apply to measurements of the lighting system in ordinary use, not simply when the lamps and reflectors are new and clean.

TABLE 1.—*Recommended levels of illumination for industrial interiors*

Class of work	Foot-candles recommended
Aisles, stairways, passageways	3–2
Assembling:	
Rough	8–5
Medium	12–8
Fine	20–12
Extra fine	100–25
Automobile manufacturing:	
Automatic screw machines	15–10
Assembly line	15–10
Frame assembly	12–8
Tool making	20–12
Body manufacturing—assembly, finishing, and inspecting	100–25
Bakeries	12–8
Bookbinding:	
Folding, assembling, pasting, etc	8–5
Cutting, punching, and stitching	12–8
Embossing	15–10
Candy making	12–8
Canning and preserving	12–8
Chemical works:	
Hand furnaces, boiling tanks, stationary driers, stationary or gravity crystallizing	5–3
Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizing, bleaching	6–4
Tanks for cooking, extractors, percolators, nitrators, electrolytic cells	10–6
Clay products and cements:	
Grinding, filter presses, kiln rooms	5–3
Molding, pressing, cleaning, and trimming	8–5
Enameling	10–6
Color and glazing	15–10
Cloth products:	
Cutting, inspecting, sewing—	
Light goods	15–10
Dark goods	100–25
Pressing, cloth treating (oil cloth, etc.)—	
Light goods	12–8
Dark goods	20–12
Coal breaking and washing, screening	5–3
Construction—Indoor general	5–3
Dairy products	12–8
Electric manufacturing:	
Storage battery, molding of grids, charging room	10–6
Coil and armature winding, mica working, insulating processes	20–12
Elevator—Freight and passenger	8–5
Engraving	100–25
Forge shops and welding	10–6
Foundries:	
Charging floor, tumbling, cleaning, pouring, and shaking out	8–5
Rough molding and core making	10–6
Fine molding and core making	15–10

TABLE 1.—*Recommended levels of illumination for industrial interiors*—Contd.

Class of work	Foot-candles recommended
Garage—Automobiles:	
Storage—	
Dead	3–2
Live	8–5
Repair department and washing	15–10
Glass works:	
Mix and furnace rooms, pressing and lehr, glass-blowing machines	10–6
Grinding, cutting glass to size, silvering	12–8
Fine grinding, polishing, beveling, inspection, etching and decorating	15–10
Glass cutting (cut glass), inspecting fine	50–15
Glove manufacturing:	
Light goods—	
Cutting, pressing, knitting	12–8
Sorting, stitching, trimming, and inspecting	15–10
Dark goods—	
Cutting, pressing, knitting, sorting, stitching, trimming, and inspecting	100–25
Hat manufacturing:	
Dyeing, stiffening, braiding, cleaning, and refining—	
Light	10–6
Dark	15–10
Forming, sizing, pouncing, flanging, finishing, ironing—	
Light	12–8
Dark	15–10
Sewing—	
Light	15–10
Dark	100–25
Ice making—Engine and compressor room	10–6
Inspecting:	
Rough	10–6
Medium	15–10
Fine	25–15
Extra fine	100–25
Polished surfaces.[1]	
Jewelry and watch manufacturing	100–25
Laundries and dry cleaning	12–8
Leather manufacturing:	
Vats	5–3
Cleaning, tanning, and stretching	6–4
Cutting, fleshing, and stuffing	10–6
Finishing and scarfing	15–10
Leather working:	
Pressing, winding, and glazing—	
Light	12–8
Dark	15–10
Grading, matching, cutting, scarfing, sewing—	
Light	15–10
Dark	100–25
Locker rooms	6–4
Machine shops:	
Rough bench and machine work	10–6
Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	15–10
Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing	20–12
Extra fine bench and machine work, grinding (fine work)	100–25
Meat packing:	
Slaughtering	8–5
Cleaning, cutting, cooking, grinding, canning, packing	12–8
Milling—Grain foods:	
Cleaning, grinding and rolling	8–5
Baking or roasting	12–8
Flour grading	25–15
Offices:	
Private and general—	
Close work	15–10
No close work	10–8
Distribution of mail in post offices	15–10
Drafting room	25–15
Packing:	
Crating	6–4
Boxing	10–6
Paint manufacturing	10–6
Paint shops:	
Dipping, spraying, firing	8–5
Rubbing, ordinary hand painting, and finishing	12–8
Fine hand painting and finishing	15–10
Extra fine hand painting and finishing (automobile bodies, piano cases, etc.)	100–25
Paper-box manufacturing:	
Light	10–6
Dark	12–8
Storage of stock	5–3
Paper manufacturing:	
Beaters, machine, grinding	6–4
Calendering	10–6
Finishing, cutting, and trimming	12–8
Plating	8–5
Polishing and burnishing	12–8
Power plants, engine rooms, boilers:	
Boilers, coal and ash handling, storage battery rooms	5–3
Auxiliary equipment, oil switches, and transformers	8–5
Switchboard, engines, generators, blowers, compressors	10–6
Printing industries:	
Matrixing and casting, miscellaneous machines, presses	12–8
Proofreading, lithographing, electrotyping	15–10
Linotype, monotype, typesetting, imposing stone, engraving	100–25
Receiving and shipping	6–4
Rubber manufacturing:	
Calenders, compounding mills, fabric preparation, stock cutting, tubing machines, solid tire operations, mechanical goods, building, vulcanizing	12–8
Bead building, pneumatic tire building and finishing, inner tube operation, mechanical goods trimming, treading	15–10
Sheet-metal works:	
Miscellaneous machines, ordinary bench work	12–8
Punches, presses, shears, stamps, welders, spinning, fine bench work	15–10
Tin plate inspection	[2] 25–15
Shoe manufacturing:	
Hand turning, miscellaneous bench and machine work	12–8
Inspecting and sorting raw material, cutting, lasting and welting (light)	15–10
Inspecting and sorting raw material, cutting, stitching (dark)	100–25
Soap manufacturing:	
Kettle houses, cutting, soap chip and powder	8–5
Stamping, wrapping and packing, filling and packing soap powder	10–6
Steel and iron mills, bar, sheet and wire products:	
Soaking pits and reheating furnaces	3–2
Charging and casting floors	6–4

[1] Usually require glint reflections from specially located light source.
[2] Special glint lighting recommended.

TABLE 1.—*Recommended levels of illumination for industrial interiors*—Contd.

Class of work	Foot-candles recommended
Steel and iron mills, etc.—Continued.	
Muck and heavy rolling, shearing (rough by gage) pickling and cleaning	8–5
Plate inspection, chipping	25–15
Automatic machines, red, light and cold rolling, wire drawing, shearing (fine by line)	12–8
Stone crushing and screening:	
Belt conveyor tubes, main-line shafting, spaces, chute rooms, inside of bins	3–2
Primary breaker room, auxiliary breakers under bins	5–3
Screen rooms	8–5
Store and stock rooms:	
Rough bulky material	3–2
Medium or fine material requiring care	8–5
Structural-steel fabrication	10–6
Sugar grading	25–15
Testing:	
Rough	8– 5
Fine	15–10
Extra fine instruments, scales, etc	100–25
Textile mills:	
Cotton—	
Opening and lapping, carding, drawing-frame, roving, dyeing	8–5
Spooling, spinning, drawing-in, warping, weaving, quilling, inspecting, knitting, slashing (over beam end)	12–8
Textile mills—Continued.	
Silk—	
Winding, throwing, dyeing	12–8
Quilling, warping, weaving, and finishing—	
Light goods	15–10
Dark goods	20–15
Woolen—	
Carding, picking, washing, and combing	6–4
Twisting and dyeing	10–6
Drawing-in, warping—	
Light goods	10–6
Dark goods	15–10
Weaving—	
Light goods	12–8
Dark goods	20–12
Knitting machines	15–10
Tobacco products:	
Drying, stripping, general	3–2
Grading and sorting	25–15
Toilet and wash rooms	6–4
Upholstering:	
Automobile, coach, and furniture	15–10
Warehouse	3–2
Woodworking:	
Rough sawing and bench work	8–5
Sizing, planing, rough sanding, medium machine and bench work, gluing, veneering, cooperage	12–8
Fine bench and machine working, fine sanding and finish	15–10

Where the higher levels are specified for particular processes such illumination need not be supplied in all parts of a room, nor on all parts of a machine, but only at locations where work of the type indicated is likely to be performed. Thus, in a workroom, a general illumination providing the value specified for aisles and passageways or storage spaces might be supplemented at proper locations by higher illumination, specified for work of different degrees of fineness in the table. The high illumination may be required over small areas only, as in watchmaking and machine sewing, or over wide areas, as in automobile assembly and finishing. In practice the lower values required in the room will often be considerably exceeded, in order to provide conveniently for the higher values. The latter is fortunate, since it avoids the possibility of having extreme contrasts between the actual working area and the surroundings. (See p. 13.)

Natural Lighting

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. In planning a new factory building or other work place the design should be such that the foot-candle values for daylight should be at least twice those stated in Table 1. The natural lighting is frequently many times these figures; in fact, illuminations of a hundred foot-candles or more can be measured near the window in almost any shop. However, wide extremes in illumination are

not conducive to best vision. The window openings should be so designed as to admit the greatest amount of light possible without producing objectionable glare.

Factory owners in most industries 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 period when artificial lighting is needed. The saw-tooth, monitor, or skylight windows of modern factory construction (fig. 5) permit of an adequate and more 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, furnishing adequate illumination to the workers without subjecting some of them to objectionable glare. In some cases the use of refracting or diffusing glass which redirects the rays of light so as to improve the distribution of daylight in the room, especially in the part of the room remote from the windows, is desirable.

If only one side wall contains windows, the width of the room perpendicular to this wall should be less than twice the height of the top of the windows above the floor; if windows are in two parallel side walls, the width of the room between these walls should not exceed six times this window height. A monitor gives best results when its width is about half the width of the building and the height of the windows in the monitor is one-half of the monitor width. The height of the windows in saw-tooth construction should be at least one-third of the span. In general, single-story industrial buildings should have a window area of at least 30 per cent of the floor area.

Reflection of daylight from surfaces outside a building has an important effect upon the lighting of a room. Faces of structures, walls of courts, and roofs of saw-tooth buildings should be finished in the lightest practicable colors and so maintained. The possibility of glare from such surfaces should, however, be considered.

Windows should be equipped with adjustable devices so that the illumination may be accommodated to changing exterior conditions. Window shades of light tones should be used, for at night they will reflect artificial light back into the room; shades transmitting diffusely a large part of the natural light they receive will generally improve the daylight illumination. When practicable, shades should be mounted so as to permit of covering any desired parts of the windows. Venetian type blinds are effective means to control the distribution of natural illumination as well as the glare from windows, if properly finished and adjusted. Any devices for adjustment of natural lighting should be controlled by some specified individual.

Rapid changes in illumination levels result in dangerous, even though temporary, inability to see, due to the time required for adaptation of the eyes. An example of this is when one steps from bright sunlight into a dimly lighted interior. A passageway adjacent to a highly illuminated area, therefore, needs relatively high and graduated illumination. 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.

Maintaining the Level 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 6 and 7 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 an instrument with which the foot-candles of illumination received at any point can be measured. One instrument, the foot-candle meter (fig. 8), while not designed for precise measurements, has a wide field of usefulness because with a little practice determinations are easily made with it and are accurate enough for most practical purposes. The foot-candle meter is small, light in weight, and entirely self-contained. Illumination is read directly from the scale without computation or manipulation. 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 six 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 electrical energy.

Avoidance of Glare

It is not a particularly difficult problem to supply a factory or office with the amount of light specified in Table 1, and reflectors

are available which provide these levels economically. There are many installations, however, where poor conditions for vision exist in spite of an adequate foot-candle level. This is usually because precautions were not taken to provide illumination without 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.

There has been considerable call for a simple instrument for measuring glare. If such were available a forward step would be taken in educating users of light through quantitative comparisons. However, there are so many factors entering into the situation that it has not been found practical to develop any instrument which will properly evaluate them all, and such glare data as can be assigned to a particular light source must be based upon the impression which it creates upon the eye itself. The eye has the quality of estimating, with a fair agreement among different observers, which of two light sources is the more glaring, taking into account both brightness and candlepower when the two sources are located side by side and viewed against the same background. This quality of the eye has been used as the basis of a relatively simple system of glare rating.

If a series of comparison standards is supplied, using respectively 10, 15, and 25 watt lamps and also larger sizes, each placed in a 6-inch frosted ball globe, then a light source can be judged as to comparative glare by placing these standard globes beside it one by one and finding which one appears to be equally glaring. For example, it might be found that a 16-inch semi-indirect lighting unit containing a 300-watt lamp appears to the eye just about equal from the glare standpoint to a 50-watt lamp in the 6-inch frosted ball globe. The 300-watt unit would then be classified arbitrarily as Grade E. (See Table 2.)

TABLE 2

Grade	Standard
A	10-w. tung. fila. lamp in 6" frosted ball globe.
B	15-w. tung. fila. lamp in 6" frosted ball globe.
C	25-w. tung. fila. lamp in 6" frosted ball globe.
D	40-w. tung. fila. lamp in 6" frosted ball globe.
E	50-w. tung. fila. lamp in 6" frosted ball globe.
F	60-w. tung. fila. lamp in 6" frosted ball globe.
G	100-w. tung. fila. lamp in 6" frosted ball globe.
H	150-w. tung. fila. lamp in 6" frosted ball globe.
I	300-w. frosted lamp.
J	500-w. frosted lamp.
K	1,000-w. frosted lamp.

The above classification is identical with that given in the I. E. S. Residential Lighting Equipment Specification. It will be observed that Grade K is representative of light sources which are extremely bright and glaring whereas Grade A (a 10-watt lamp in a 6-inch frosted ball) can be placed almost anywhere in the field of view without causing discomfort.

Where lamps are located at considerable heights above the eye level relatively bright light sources can be tolerated, and this is particularly true in locations such as out of doors at night where little close discrimination of detail is required of the eye. On the other hand, where light sources are hung low and are constantly in the field of view of a worker seated at a table or work bench, then the light source should be of Grade A or B.—i. e., very soft and free from glare. Again, the effect of glare is cumulative; therefore in a long room where a considerable number of light sources are in one's field of vision it is necessary to have better diffused sources than in a room of limited area where only one or two units are visible to a man seated at his desk.

TABLE 3.—*Grades of light source glare which should not be exceeded for good conditions of vision*

Height of light source above floor in feet	Space or work to be lighted [1]			
	Roadways and yard thoroughfares	Storage spaces	Ordinary manufacturing operations	Offices and drafting work and certain manufacturing operations [2]
6.5 or less		D	C	A
6.5 to 7.5		D	C	A
7.5 to 9	F	E	D	C
9 to 11	G	G	E	D
11 to 13	H	G	G	E
13 to 16	H	H	H	F
16 to 20	I	I	I	G
20 and up	J	J	J	H

[1] Where backgrounds are very dark in tone, a light source 1 grade softer than above is recommended for interiors.

[2] Those operations in which workers are seated facing in one direction for long periods of time.

For convenience a number of more common light sources have been rated for glare in accordance with the classification given in Table 2. The grades assigned to them are shown in Table 4.

TABLE 4.—*Specific classification of common light sources from the standpoint of glare, as derived from Table 2*

	Grade
Natural light sources (as seen through windows):	
Sun	K
Bright southern sky	G
Dull or northern sky	C
Sun shining on prism glass	J
Mercury vapor tubes	G
Carbon incandescent lamps:	
16 candlepower	F
32 candlepower	G

TABLE 4.—*Specific classification of common light sources from the standpoint of glare, as derived from Table 2*—Continued

	Watts					
	40	60	100	150 to 200	300	500 to 1,000
Tungsten filament lamps:	*Grade*	*Grade*	*Grade*	*Grade*	*Grade*	*Grade*
Bare lamps	G	H	I	J	J	K
Frosted lamps or frosted globes [1]	D	F	G	H	I	J-K
8-inch opal globes	C	E	F			
12-inch opal globes			E	G	H	I
16-inch opal globes				F	G	H
Flat reflectors—filament position visible	G	H	I	J	J	K
Dome reflectors—steel or dense glass:						
Filament position visible from working position	G	H	I	J	J	K
Filament position not visible	B	B	D	D	E	G
Dome reflectors—white bowl lamps				F	G	G
Bowl reflectors—steel or dense glass:						
Filament position visible	G	H	I	J	J	K
Filament position not visible	C	C	D	E	G	H
Totally indirect lighting [1]			B	B-C	C	D
Semi-indirect bowl [1]			B-D	C-D	C-E	D-G

[1] Where a range is given, the best grade—that is the lowest—applies to bowls that are of dense glass, and the poorest to bowls which have a decidedly bright spot in the center.

Factors Affecting Glare

In order that the various factors affecting glare may be better understood, the principal causes are outlined below:

1. **Brightness of Source.**—The light source may be too bright; that is, it may have 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 have 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 in front 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 candles 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.

FIGURE 1.—Cotton-mill lighting using 200-watt white bowl lamps in R. L. M. Standard dome reflectors. The average illumination is 8 foot-candles

FIGURE 2.—An office lighted by 200-watt lamps in semidirect units. Average illumination is 12 foot-candles

FIGURE 3.—Lighting a drafting room by 500-watt lamps in semidirect units. The average illumination is 30 foot-candles

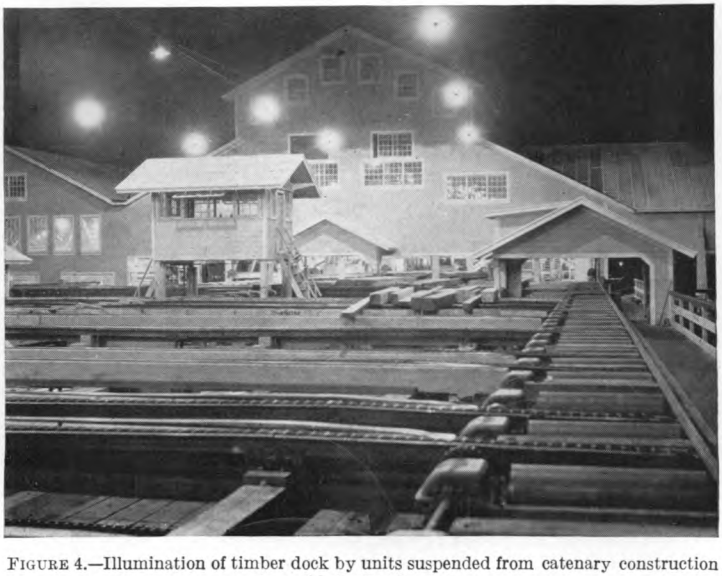

FIGURE 4.—Illumination of timber dock by units suspended from catenary construction to avoid obstructing poles

FIGURE 5.—Saw-tooth roof construction, with glass facing north sky, usually results in well-diffused daylight illumination

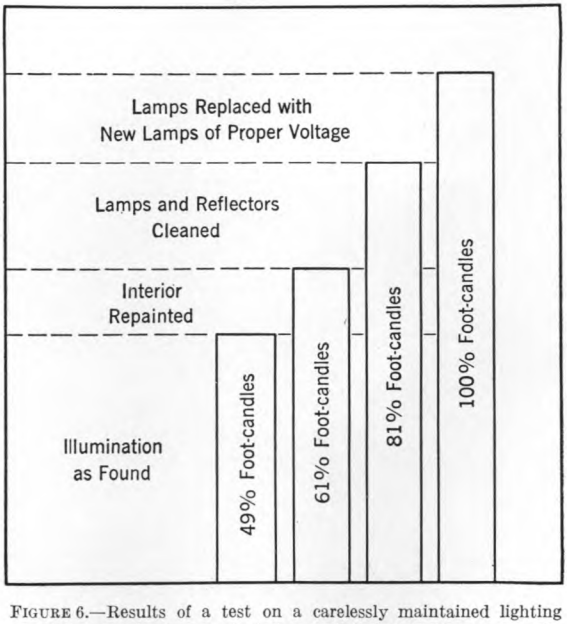

FIGURE 6.—Results of a test on a carelessly maintained lighting system, showing how each factor contributed to the poor result. Illustrates the importance of using lamps of the proper voltage, cleaning equipment systematically, and repainting interior at reasonable intervals

MAINTENANCE RECORD

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15	1	15
Drafting Room 347	12	12	12	16	15	15	15	15	15	10	10	10	10	10										
Office 349	8	8	8	8	8	25	25	25	25	20	20	20	20	20										
" 350	8	8	8	8	8	25	25	60	60	5*	8	8	8	15										
" 351	8	8	8	8	25	25	8	25	25	20	20	20	20	20										
" 352	8	8	8	8	8	8	25	25	25	25	20	20	20	20										
" 353	8	8	8	25	25	25	25	25	25	20	20	20	65	65										
" 354	25	25	25	20	20	20	20	20	20	20	20	20	20	20										
" 355	8	8	8	25	5	8	8	8	1	5	8	8	25	25										
" 356	25	25	25	25	20	20	20	20	20	20	65	65	65	65										
Stockroom 360	8	8	8	8	25	25	25	25	25	20	20	20	20	20										
Hallway	2	2	2	2	2	2	2	2	2	1	2	2	2	2										
Stairway	2	2	2	15	2	2	2	2	2	15	15	15	2	2										

* Lamp Burned out.

FIGURE 7.—Lighting maintenance record

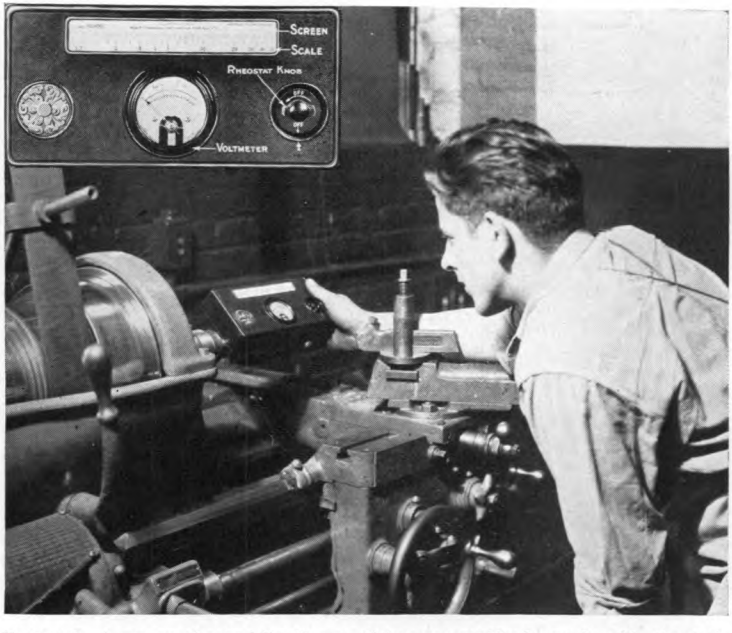

FIGURE 8.—A survey of actual lighting conditions can readily be made with the foot-candle meter. This instrument is very useful in "checking up" a lighting system to see that it is being properly maintained

9a

9b

FIGURES 9a and 9b.—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 Figure 9b as compared with Figure 9a, where there is no general illumination. In Figure 9b, although a local lamp is supplied for each machine and bench, the individual sources of light are scarcely apparent, because of the general illumination

10a

10b

FIGURES 10a and 10b.—The upper figure illustrates a strictly local lighting system. The lower figure illustrates the same location under general illumination. Observe the harsh shadows and glaring light sources with local lighting, and the absence of such shadows and glare under general lighting

FIGURE 11.—A textile operation (quilling) illuminated by means of mercury-vapor lamps

FIGURE 12.—An example of well-distributed general illumination applied to a modern machine shop. Here 300-watt lamps in glassteel diffusers are used on 12-foot centers, 15 feet above the floor. The illumination level is 12 foot-candles throughout. The diffusing equipment and the high mounting combine to eliminate glare and produce soft shadows

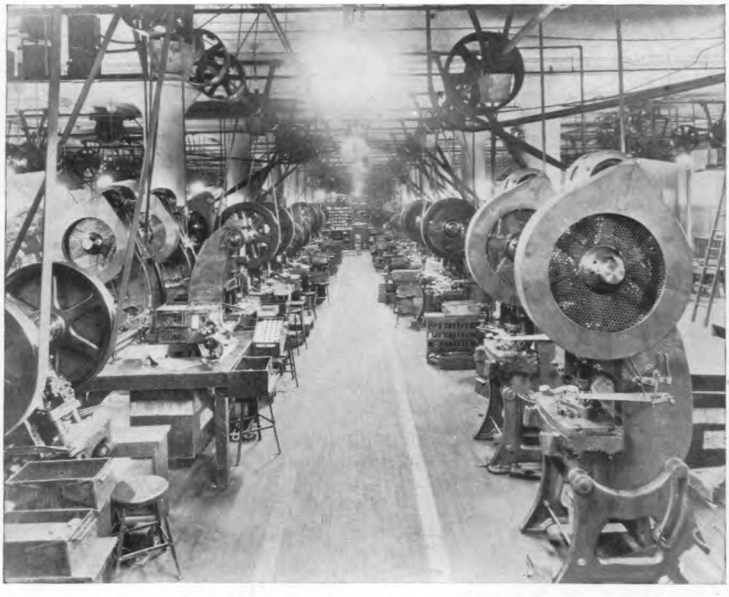

FIGURE 13.—A press department illuminated with mercury-vapor lamps

FIGURE 14.—A factory office lighted by 200-watt lamps in glassteel diffusers. The average illumination is 12 foot-candles

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 were 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 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. In order to provide a light background (usually ceiling or side walls) which will minimize contrasts, the surfaces should be painted a light color and 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.

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.

Importance of Adequate Electrical Wiring

In specifying electrical wiring for a new building, or the revision of old wiring, it is important to observe the following points:

1. The National Electrical Code regulations are intended to insure protection from fire hazard. but do not necessarily provide a wire size sufficient to permit of the most efficient use of lamps and equipment, nor do they make provision for future increases of illumination. To take them as a criterion of adequate capacity of a wiring system, therefore, in the interests of low first cost, is not good economy in the long run.

2. Wiring should provide for economical distribution of electrical energy.

Electrical wiring of inadequate size introduces a source of energy loss between the meter and the outlet, and at the same time causes a reduction in the voltage at the lamp socket, so that lamps (unless specially ordered for lower voltage) are operated at a voltage below that for which they were designed. Operation of lamps at reduced voltage means that the efficiency of light generation is lower, and the overall cost of light is higher, than when they are operated at rated voltage.

When wiring is inadequate, as more lamps are turned on, the voltage at each socket decreases. Thus as daylight fails and more artificial light sources are required the illumination secured from each lamp decreases, producing an annoying variation in illumination at different times and places.

3. Wiring should be of sufficient capacity to provide for future requirements. as the trend of lighting intensities is ever upward.

Recommended lighting practice and the appreciation on the part of factory owners and managers for the value of good lighting have

a distinct forward trend, and an installation considered up-to-date when made may be found quite inadequate at a later date. The cost of rewiring finished buildings is many times greater than the additional cost of providing capacity for future requirements in the original installation.

Specification of Adequate Wiring

The following paragraphs are abstracted from a specification prepared by the National Electric Light Association to express the quantitative requirements which good illumination practice imposes upon the wiring.

This specification is in conformity with the regulations of the National Electric Code, as regards current-carrying capacity and in addition makes reasonable provision for economical distribution of energy and the probable lighting requirements of the near future.

In this specification, it is assumed that each branch circuit will be fused for 15 amperes.

Branch circuits.—A single branch circuit should not be required to supply the general lighting for a work space greater than 400 square feet or a bay approximately 20 feet by 20 feet, nor should it be required to supply the overhead lighting for more than 800 square feet of hall or passageway or other nonproductive area.

Based on the wattage of outlets specified on the plans, branch circuits should be so arranged that the initial load on a single circuit will not exceed 1,000 watts, except in the case of a single lamp of larger size.

The smallest size wire that should be used is No. 12 gage, and for runs from a panel board to the first outlet of from 50 feet to 100 feet, No. 10 gage wire is the smallest that should be used, with No. 12 between outlets.

Runs exceeding 100 feet from panel board to the first outlet should be avoided by addition or relocation of panel boards. Where such runs can not be avoided, the lamp load should be limited to 600 watts for each branch circuit.

Convenience outlets should be placed on a circuit separate from that supplying general lighting. Such outlets should be of the duplex type, with not more than six grouped on one circuit. For runs from the panel board to first outlet under 100 feet, wire not smaller than No. 12 gage should be used and No. 10 gage where the runs must be longer.

Panel boards.—Panel boards should contain at least one spare circuit position for each five active circuits or fraction thereof. It is generally desirable to supply each circuit position with a switch.

There should be provided at least one panel board on each floor of the building. Wherever possible, panel boards should be so located that branch-circuit runs exceeding 100 feet to the first outlet can be avoided.

Feeders.—The current-carrying capacity of a feeder should be sufficient to supply 7.5 amperes (115 volts) to every 15-ampere circuit position provided for on the panel board or boards which it feeds.

The feeders should be of such size that the voltage drop from the service switch to the panel board will not exceed 1½ per cent with a

load of 7.5 amperes (115 volts) on every branch circuit provided for.

Conduits for inclosing feeders should be of sufficient size to permit replacing the original feeders with wires two standard gage sizes greater in capacity.

Locating Switches

The switches which turn on and off the light in entrances and halls of buildings should be located near the point of entrance. Likewise a switch which controls at least one circuit of lamps in a room should be located near each principal point 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.

For control purposes groups of lamps may constitute a square, a row parallel to the windows, or a row perpendicular to the windows. The arrangement on a square has the most to recommend it, as any worker within the area gets the benefit of several near-by lighting units. A row parallel to the windows is occasionally desirable, since when daylight fails those workers farthest from the windows can have one or two rows lighted to supplement the natural light. If two rows are used, the merits of the square arrangement are to a great extent retained. Control of rows perpendicular to the windows is usually to be avoided, as grouping in a square can almost always be applied to better advantage.

Part 3.—Suggested Minimum Regulation to be Established by State Authorities

Purpose

The purpose of this code is to make reasonable provisions for the safety of workers by requiring such illumination as may be necessary to conserve vision and to facilitate the utilization of eyesight for the prevention of accident.

Exceptions

In cases of practical difficulty or unnecessary hardship the enforcing authority may grant exceptions from the literal requirements of this code or permit the use of other methods but only when it is clearly evident that safety is thereby reasonably assured. 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.*

Scope

This code applies to all factories, mills, offices, storage buildings, yards, power houses, and other industrial and mercantile establishments and work places.

Rules

General Requirement.—Illumination, daylight or artificial light, in accordance with the following rules, shall be supplied for—

1. Traversed spaces such as hallways, roadways, etc., during working hours, and
2. Work when attended by operators.

NOTE: It should be recognized that the foot-candles specified represent minimum limits, and that tolerance for depreciation must be made in the design of the installation. The values are established to meet the needs of safety and are not to be interpreted as providing for effective and economical operation of processes. Higher levels representing good lighting practice are recommended in Table 1, and general suggestions for design will be found on pages 14 to 16. Information on the measurement of illumination values will be found on page 14.

Rule 1. Illumination Required.—The illumination maintained shall be not less than given in Table 5.

TABLE 5

1. Minimum foot-candles on traversed spaces

	Foot-candles
Roadways; yard thoroughfares	0.02
Storage spaces, aisles and passageways in workrooms, excepting exits and passages leading thereto	.5
Spaces, such as hallways, stairways, exits, and passages leading thereto	.75
Spaces, such as stairways, locker rooms, wash rooms, toilet rooms, and passageways where there are exposed moving machines, hot pipes, or live electrical parts, also elevator cars, and landings	1

2. Minimum foot-candles at the work

Where discrimination of detail is not essential	0.5
Work, such as handling material of a coarse nature; grinding clay products; rough sorting; coal and ash handling; foundry charging.	
Where slight discrimination of detail is essential	1
Work, such as rough machining, rough assembling; rough bench work; rough forging; grain milling.	
Where moderate discrimination of detail is essential	2
Work, such as machining; assembly work; bench work; fine core making in foundries.	
Where close discrimination of detail is essential	4
Work, such as fine lathe work, pattern making; tool making; weaving or sewing light-colored silk or woolen textiles; office work; accounting; typewriting.	
Where discrimination of minute detail is essential	8
Work, such as drafting; weaving or sewing dark-colored material; very fine inspection or inspection of very dark goods.	

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, 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 2, 4, and 6.

Rule 3. Exit and Emergency Lighting.—The lighting to be provided under rule 1 in all important stairways and all exits of work places 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. In the case of artificial illumination the service should be preferably from an independent connection or connections extending back to the main service entrance for the building. In cases of unusual danger which may exist on account of the type of building or 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. During the hours of occupancy, when daylight of the value given in rule 1 is lacking, this separate source of supply shall be connected so as to function continually or to come on automatically upon failure of the regular lighting service.

Notes on Rules

Notes on Rule 1. Illumination Required.—In Table 5 the lower values, up to 1 foot-candle, are required principally to enable employees to see well enough to avoid accident, while the higher values have the additional purpose of preventing eyestrain and so conserving vision. The values have been assigned on the basis of engineering experience and assume the average conditions found in practice. There are no sharp lines of demarcation. A specified process is carried on in different establishments with varying degrees of fineness. Where especially close attention to the fine detail is required, it is obvious that more illumination is needed than where the process is made more automatic or operated on a coarser scale. Where such special conditions exist the next higher or lower classification may be found the reasonable requirement.

Notes on Rule 2. Avoidance of Glare.—It is assumed that in interpreting the enforcing of the regulation against glare the enforcing officer will not insist upon what he might consider as pleasing or desirable practice in any given case. It is the intention of the rule merely to prevent conditions which are prejudicial to the physical welfare of the worker.

Table 6 shows the harshest grade of light source that may be used under any particular set of conditions. It is based on the system of glare rating described on pages 9 to 12, where an explanation of the symbols used will be found.

TABLE 6.—*Limiting grades of light sources permissible for various conditions*[1]

[The grades given in this table are limiting values; from 1 to 2 grades softer are recommended, see Table 3]

Height of light source above floor in feet	Space or work to be lighted[1]					
	Roadways and yard thoroughfares	Storage spaces	Ordinary manufacturing operations[2]		Offices and drafting work and certain manufacturing operations	
			Short rooms[3]	Long rooms[3]	Short rooms[3]	Long rooms[4]
6.5 or less		F	D	D	C	C
6.5 to 7.5		G	F	F	E	E
7.5 to 9	H	H	H	G	G	F
9 to 11	I	I	I	H	H	G
11 to 13	J	J	J	I	I	H
13 to 16	J	J	J	I	I	H
16 to 20	K	K	K	J	J	I
20 and up	K	K	K	K	K	J

[1] Where backgrounds are very dark in tone a light source of one grade softer than specified may be required in the case of all indoor classifications.

[2] 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.

[3] A "long" room is considered to be one in which the total length in feet is more than twice the height of the lamps above the floor; one having a length less than twice the height of the lamps above the floor is classified as "short."

[4] Those operations in which workers are seated facing in one direction for long periods of time. See also note 3.

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 excluding 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 should be lighted by the building owner.

Exit and emergency lighting are to be understood as those artificial illuminants which are necessary only to make clear to the occupants or employees the places of exit, or to enable them to pass to and along safe exits with reasonable speed and assurance of footing. Such lighting is not assumed as being necessarily sufficient for the proper performance of regular working operations.

The circuits for exit electric lamps should be separate branch circuits, including no other lamps, and containing no receptacles or convenience outlets for the attachment of portable or other devices. Being thus separately fused, trouble on other circuits which causes the blowing of fuses will be less likely to affect them.

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. Service from an independent street main, where available, is regarded as a separate source of supply; or a separate service from an independent transformer fed from the same primary wires will usually be considered sufficient. Factories supplied by an isolated plant should feed exit circuits from an independent source or utilize a separate generating unit driven by a separate prime mover. Such an independent supply as discussed in this paragraph is not considered necessary for typical conditions, but only where the large number of persons concerned or other special condition calls for special precautions. Such a condition may be recognized by the management, but if doubt exists a decision should be asked from the inspection department having jurisdiction.

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

It is the obvious intent of rule 3 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 types and situations of working spaces, can only be reached through mutual cooperation of the owner and the State authorities.

Subject Index