STANDARD CODE
OF
INDUSTRIAL HYGIENE

GENEVA
1934

Published in the United Kingdom
For the INTERNATIONAL LABOUR OFFICE (LEAGUE OF NATIONS)
By P. S. KING & SON, Ltd.
Orchard House, 14 Great Smith Street, Westminster, London, S.W.1
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PREFACE

According to the programme drawn up by the International Labour Conference at its First Session in Washington in 1919, the International Labour Office was instructed to pursue the task of protecting the workers' health, with which it was entrusted under Part XIII of the Treaty of Versailles, first of all by recommending suitable measures for safeguarding the health of workers whose occupations exposed them to specific dangers. The Office therefore undertook in the first place the study of special problems, such as those of industrial anthrax, the regulation of the use of white lead in painting, etc.

But however urgent and important this work might be, it did not absolve the Office from the duty of considering also the lot of those millions of workers employed in factories, workshops or offices, who, without incurring specific risks, are nevertheless exposed to all the dangers to health involved in unhygienic conditions of work. For this reason the Office has judged it important to engage without further delay in the study of problems of industrial hygiene from a more general aspect, both in the interests of the health of the workers and with a view to the improvement of production and the furtherance of social progress.

There is ample evidence that it was right in committing itself to such a course. Several countries have established committees of experts to bring up to date their industrial hygiene regulations, and recently the American Standards Association framed, under the auspices of the United States Public Health Service, a health code for industrial establishments (November 1933), which is about to be published.

Such is the justification of the standards presented in this volume. Without losing sight of the numerous climatic, political and economic differences between countries, the International Labour Office has sought to set forth in outline those principles on which any system of general regulation of industrial hygiene should be based.

The object has not been to produce a document which might serve as a basis for international Conventions or Recommendations, nor a standard system of regulations which the Office might submit to the States Members of the International Labour
Organisations in the hope that it might be adopted in its entirety. The purpose of the Office has rather been to focus opinion on rules which, in each State, might inspire either new measures or the amendment of existing provisions, and also serve as a guide for those concerned with the health of the workers. This volume is a summary of the results of the experience of certain industrial countries, supplemented by an explanatory note dealing with the scientific and practical aspects of the subjects considered.

The original text, which was drafted on the basis of information collected by the Office, was discussed by the Correspondence Committee on Industrial Hygiene, which appointed a small subcommittee for the drafting of the final text.

The Governing Body of the International Labour Office, at its Fifty-fifth Session (October 1931), adopted a resolution asking that the Standard Code of Industrial Hygiene be submitted to it before publication. This was done, and in consequence of various criticisms of the text and suggestions for improvements, the Office referred it yet again to the Correspondence Committee on Industrial Hygiene. During its session held in July 1933 this body requested a sub-committee to consider the final form to be given to the text. The final text so prepared was submitted to a plenary meeting of the Committee, which approved it by a majority vote.

All useful suggestions will be welcome by the Office and will be duly submitted to the Correspondence Committee on Industrial Hygiene.

Contrary to original intention, it has proved impossible, for reasons of economy, to provide illustrations for the passages dealing with various installations.¹

¹ In the absence of illustrations, readers are recommended to consult on this subject the German publication constituting the 49th special number of the Reichsarbeitsblatt, for an article by Professor Waffenschmidt on sanitary installations in factories and industrial establishments, or the following publications of the British Home Office: Messrooms and Canteens at Small Factories and Workshops (Welfare Pamphlet No. 2), 1931, 3rd ed.; and Cloakrooms, Washing Facilities, Drinking Water and Sanitary Accommodation in Factories and Workshops (Welfare Pamphlet No. 8), 1933, 3rd ed.; Ventilation of Factories and Workshops (Welfare Pamphlet No. 5), 1933, 2nd ed.; Lighting in Factories and Workshops (Welfare Pamphlet No. 7), 1930, 3rd ed.; and Welfare and Welfare Supervision in Factories (Welfare Pamphlet No. 3), 1931, 2nd ed.; all published by H.M. Stationery Office, London.
CODE OF INDUSTRIAL HYGIENE

1.—WORKING PREMISES SITUATED AT AND ABOVE GROUND LEVEL

I

Notification

In industrial and commercial establishments, all workrooms in which workers are engaged irrespective of their number should be made the subject of a notification. The notification should contain a description of the work engaged in, and whenever the type of work carried out changes a new notification should be required.

II

Responsibility

Employers or their representatives should be responsible for health conditions in working premises.

III

Posting of Notices

A notice should be posted in all working premises indicating the duties of employers and workers.

IV

Height

In new constructions, in which workers are more or less permanently employed, the height of the workrooms should be at least 3 metres (9 ft. 10 in.). Exceptions to this rule should not be admitted except on grounds of technical necessity.

V

Cubic Space

The cubic space of workrooms should be such as to afford, without deduction for benches, machines, furniture and material, at least 10 cubic metres per worker.

The calculation of cubic space may be based on the requirement of an area of 2 square metres (21.53 sq. ft.) per person, but in this calculation height exceeding 4 metres (13 ft. 1½ in.) should not be taken into consideration.

Compliance as regards cubic space does not obviate the need for adequate ventilation of the workroom.
VI

Area

The area of working places should be such that any worker employed therein has sufficient space to move about freely.

VII

Roofing

Roofing on working premises should be constructed so as to afford effective protection for the workers against heat or the inclemency of the weather.

VIII

Walls and Ceilings

Walls and ceilings in workrooms should have a surface which can be whitewashed or painted. Walls should be proof against dampness, whether it originates in the ground, in weather conditions or in the presence of contiguous reservoirs.

IX

Flooring

Flooring or paving in covered-in working premises should be solid, watertight, even and not slippery. The material of which it is made should be easily cleansed.

In workrooms in which the processes carried on involve wet flooring, it should, in the absence of other protection for the worker, be such as to protect the workers' feet against damp and loss of heat.

X

Apertures, Windows, Doors

In new constructions glass partitions, windows and other external openings intended for the admission of light should be of such dimensions that their area amounts to at least one-sixth of the area of the floor of the workroom. In calculating this area, openings of sheds, roof lanterns, etc., but not glass panes or partitions in inside doors, should be taken into account.

Windows and other sources of admission of light should be so placed as to afford the most uniform distribution possible of daylight in all parts of the workroom. They should be easily cleaned. Some of them should be made to open readily.
XI

Measures should be taken to prevent direct radiation of sun on to the workers, or over-heating of the workrooms, and to prevent work being carried on in direct draughts.

XII

Where windows are the only means of natural lighting the space between these and the ground should not exceed 1 metre (3 ft. 3 in.). They should be so placed as to allow daylight to fall on the opposite wall of the workroom.

XIII

Doors should be well fitting and should open outwards.

XIV

Cleanliness and Maintenance

Walls and ceilings should always be maintained in a proper state of repair and of cleanliness.

The workroom should be cleaned as often as required by the nature of the work carried on, and cleaning should preferably be done during intervals between work and in a manner calculated to prevent the raising of dust.

Special precautions should be taken wherever, for technical reasons, cleaning must inevitably be done during working hours.

XV

Residues, Waste Water

Residual matter, residues and sweepings and in general waste material capable of harmful effects should be removed daily from the workroom.

Measures should be taken to ensure effective removal of waste water. This should be done in such a manner as to obviate production of effluvia. Consequently, sewers should be provided with hydraulic syphons or other effective devices constantly maintained in good working order and repair.

XVI

Ventilation

Workrooms should be thoroughly ventilated at least once daily outside working hours.
XVII

Lighting

It is advisable that all workrooms should receive adequate natural daylight.

At the level of the working place the amount of light should suffice for the accomplishment of the work without injury to the workers' sight.

XVIII

Windows and roof lighting and also transparent parts of artificial light sources should be kept sufficiently clean in order that they may normally fulfil their function.

XIX

Artificial light sources should not cause overheating or vitiation of the atmosphere; heat liberated by these should not be permitted to constitute a source of discomfort for the workers.

In all circumstances these light sources should afford lighting of practically constant intensity. Measures should be taken to prevent glare and the production of troublesome shadows.

XX

Temperature

A temperature suitable to the work engaged in should be maintained in the workroom. In summer, workrooms should be protected as far as possible against an excessive rise in temperature. During the cold season workrooms should be heated and a minimum temperature maintained. A thermometer in good working order and readily accessible should be fixed at the level of the workers' heads in the part of the workroom furthest removed from the heating.

The workers should be protected against excessive radiation from heating apparatus.

Heating apparatus should be so constructed as to prevent contamination of the air in the workrooms.

XXI

Drinking Water

Good drinking water, or in default of this wholesome beverages, should be provided for the workers. Distribution should be effected under conditions conforming to hygienic
principles. Water supply intended for drinking should be legibly marked “Drinking water.”

XXII

Cleanliness

Adequate cloakroom and sanitary installations should be provided and maintained in a good state of repair, enabling the workers:

(a) to keep their clothing, taken off during working hours, under satisfactory conditions as regards safety\(^1\) and health;
(b) to wash their faces and hands.

XXIII

Seats

Seats should be provided for all workers obliged to work in a standing position, in order that they may profit by any opportunities for rest which may occur during the course of their work.

XXIV

Spittoons

Notices explicitly forbidding spitting on the floor should be posted in all workrooms and adjacent premises. Where it is found necessary to provide spittoons they should be sufficient in number and so made and maintained as to satisfy hygienic requirements.

XXV

Privies, well constructed, separate for men and women, and in sufficient number, should be provided for the workers, their situation being clearly indicated.

Privies for men should comprise urinals.

Privies should not be in direct communication with the workrooms; they should be kept clean and thoroughly cleaned at least once daily. They should be adequately lighted and ventilated.

Construction and maintenance of the installations and emptying of cesspools, where such exist, should conform to hygienic requirements. The same applies to drains.

\(^1\) Against theft.
2.—WORKROOMS SITUATED BELOW THE LEVEL OF THE SURROUNDING GROUND

XXVI

**Semi-Underground Premises**

Where the competent authority deems it necessary to permit work being carried on in semi-underground premises all the foregoing provisions relative to notification, responsibility, posting of notices and work applicable to workrooms situated at or above ground level should likewise apply to workrooms the flooring of which is below the level of the outside ground.

The walls and flooring, after being thoroughly dried, should be covered with a damp-resisting material.

XXVII

In addition to the foregoing provisions, underground work should be subjected to special restrictions laid down by the competent authority.

3.—WORK UNDER SHELTERS, PENTHOUSES, ETC.

**Flooring, Lighting, Drinking-Water, Cleanliness, Spittoons, Privies**

XXVIII

The provisions in paragraphs IX, XIX, XXI, XXII, XXIII, XXIV and XXV, in so far as they are practicable, should apply to work under shelters, penthouses, etc.

XXIX

**Roofing**

Roofing, screening, etc., should be such as to guarantee effective protection for the workers against the heat of the sun and the inclemency of the weather.

4.—UNHEALTHY OR OFFENSIVE TRADES

XXX

**General Provisions**

All the provisions relative to work not involving special health risk should also apply to unhealthy or offensive trades.
XXXI

Special Provisions

In the absence of provisions included in special equivalent regulations, this work should be subject to the following provisions, in accordance with the nature of the risk involved.

XXXII

Dampness, Steam, Vapour

In workrooms in which the work carried on is the direct cause of abnormal humidification of the atmosphere:—

(a) the temperature should not be under 15° C. (59° F.), nor over 25° C. (77° F.) wet bulb, except, as regards the latter, where the outside temperature is still higher;
(b) measures should be taken to protect the workers from the effects of condensation of steam;
(c) hoods with ducts or other methods should be adopted for the suppression of steam.

XXXIII

Humidification

Where there is artificial and intentional humidification of the atmosphere of the workrooms, there should be provided in each workroom a special hygrometer, calibrated and situated close to the working places.

Readings of these should be noted daily at least one hour after beginning and at most one hour before the end of the working shift. These readings should be recorded and kept at the disposal of the competent authority.

XXXIV

Artificial humidification should be prohibited whenever:—

(a) the wet bulb thermometer registers 25° C. (77° F.);
(b) the difference between the two thermometers is under 1·5° C. (2·7° F.).

XXXV

Water used for humidification, pulverisation or spraying should be taken from a source known to be free from any risk as regards health.
XXXVI

Irritant Toxic or Asphyxiating Smoke, Fumes and Gases

Escape of irritant toxic or asphyxiating smoke, fumes or gas in workrooms or adjoining premises should be prohibited. Production and diffusion of smoke, fumes and gas of this nature should be prohibited as far as possible and their removal should be ensured by exhaust ventilation installed as near as possible to the point of production. Such smoke, fumes and gas should be rendered harmless prior to being passed into the outside air.

XXXVII

In workrooms in which, in spite of all precautions taken, asphyxiating toxic or irritant fumes and gas may escape, the air renewal should be such that the workers' health does not suffer.

XXXVIII

No worker should be allowed to enter without protective apparatus places likely to contain toxic asphyxiating, or inflammable fumes or gas, until it has been ascertained that there is no risk.

During work in closed apparatus and enclosed or partially enclosed spaces, where there is reason to apprehend the presence of dangerous gas or fume or an irrespirable atmosphere, approved masks or oxygen breathing apparatus should be provided and worn by the workers. Safety belts with ropes attached should also be provided and used, and wherever possible at least one person should supervise from the outside the worker or workers exposed to danger.

XXXIX

Dust

Escape of dust in workrooms or adjacent premises should be avoided. During manipulation of dust-producing material, or manual or mechanical work causing dust liable to injure the health, requisite measures should be taken to prevent dispersion of such dust in the air of the workroom.

XL

Mechanical processes accompanied by liberation of dust should as far as possible be carried on in closed apparatus, provided with exhaust devices.
In default of such methods, localised exhaust hoods should be provided to capture the dust as close to its point of origin as possible. Dust collected should be rendered inoffensive or destroyed.

**XLI**

In dusty trades, cloakrooms, washing accommodation, and eventually douche-baths, separate from the workrooms, should be provided for the workers. Conditions in regard thereto should be laid down by the competent authority.

**XLII**

*Large Furnaces*

In industries or trades where the nature of the work necessitates the use of glowing furnaces, measures should be taken to prevent workers in other departments of the establishment from being exposed to their action.

**XLIII**

Fireproof screens for protection from heat and, where necessary, fireproof suits or articles of clothing, and also glasses affording protection against harmful radiation, should be placed at the disposal of the workers directly exposed.

**XLIV**

Air renewal in workrooms should be such that high temperature does not injure the workers' health.

**XLV**

*Drying-Rooms, Stoves*

At no season should workers be made to enter drying-rooms and stoves when the interior temperature of these exceeds 50° C. (122° F.). Remaining in them continuously should be prohibited when the temperature exceeds 35° C. (95·0° F.).

**XLVI**

*Noise, Vibration, Shocks*

In noisy trades and in those in which the running of machinery causes noise, shocks and marked vibration, every effort should be made to reduce as far as possible the disagreeable effects.
Poisons

Any industrial or occupational operation involving manipulation, manufacture or use of, or causing production of, toxic substances should be subject to the following restrictions:

(a) apparatus to remove and render harmless gas, fumes or dust containing poisons should be installed with the greatest care and maintained in perfect working order;

(b) the competent authority should specify in each particular case the requisite technical measures of prevention to be taken, the number and arrangement of lavatories, douche-baths with their accessories, and the working clothes and articles of personal protection to be worn and maintained;

(c) the introduction, preparation and consumption of food in the workroom should be prohibited. Meals should be taken either in a canteen installed and maintained in a satisfactory condition for the workers, and heated in the cold season, or outside the factory;

(d) periodical medical examination of the workers should be organised, and the workers should be informed of the risk they incur, and of the precautions to be taken with a view to avoiding it.
EXPLANATORY NOTICE

1.—WORKING PREMISES SITUATED AT AND ABOVE GROUND LEVEL

I

Notification

By the term "working premises situated at and above ground level" is meant every type of industrial and commercial establishment without distinction, and apart from any question whatsoever of particularly unhealthy or offensive work. There is therefore no intention of defining here industrial or other work of this kind, nor of specifying the types of factories or industrial establishments covered. What is of importance is that it should be clearly understood that all provisions contained in the first part of this Standard Code are applicable to all work carried on in any working premises whatever.

It is a question of establishing minimum standards which require to be adopted with a view to issuing measures intended to serve as a basis for hygienic working conditions in new establishments, and it is with this in view that the paragraph relative to notification was drafted in the most general manner possible.

Renewal of the notification referred to in the text of the Standard Code is of importance with a view to preventing possible abuse when for instance an establishment hitherto destined for work free from risk becomes utilised for work involving dangerous processes without notice given to the competent authority regarding this change.

II

Responsibility

In the problem under consideration it is evident that the question is one of the responsibility of an employer or his representative. However, under certain circumstances and in certain countries, notably in Great Britain, there exist legal provisions in virtue of which the proprietor of a factory, whether or not he manages the latter, is responsible for the application of measures of hygiene concerned with the construction and plant. As an instance may be quoted the case of establishments in which motor power is distributed in the different parts of a building occupied by various persons, each of them carrying on a different occupation (tenement factories).
III

Posting of Notices

The objection has been made that posting up of notices would constitute a useless measure since the majority, if not all, of the workers do not read such notices. It is nevertheless true that the omission of such a measure prevents those who might have the intention of profiting by it from becoming acquainted with information relative to their rights and their duties.

The notices in question generally contain the texts of the hygiene regulations. They should be printed in legible characters and posted in a prominent place, for instance near the entrance through which all the workers are obliged to pass. It might be advisable, perhaps, to increase the attraction of such posters by providing them with illustrations. The number of notices posted up should, however, be reduced to a strict minimum, since where these are unduly numerous the effect achieved is exactly contrary to that intended.

In certain cases—besides hygiene regulations—special notices are posted indicating for each workshop: (a) the height, length and breadth of the room; (b) the cubic space; (c) the number of workers that may be employed. Further, where appropriate, it would be possible to inform the workers by means of such notices of the dates of medical examinations and of the precautions to be adopted against the dangers inherent in certain processes. Here it is naturally a question of the industries covered by the fourth part of the Standard Code, that is to say, those involving processes which are specially unhealthy and offensive (see below).

IV

Situation

Provisions concerned with the situation of industrial constructions are in general contained in public health regulations relative to buildings. In this case the principal consideration is that of measures calculated to safeguard health in the neighbourhood, and the question of industrial hygiene properly so-called is but a secondary consideration.

In the text of the Standard Code there is no allusion to the site or situation of the factory. This omission is justified by the fact that the measures in view are intended to apply to every type of establishment and in consequence even to premises situated, for instance, on damp and marshy soil. It is an under-
stood fact, of course, that once a previously constructed edifice is in question every measure should be taken to protect the latter against all conditions which may prejudice the workers' health, and which may be enumerated as follows: (1) dampness arising from the ground or from outside; (2) changing temperature, especially in winter, in buildings constructed of insufficiently solid material; (3) wind and rain. Finally, it is essential to consider the question of exposure to sunlight in order to assure provision of a sufficient quantity of daylight.

**Height**

In the majority of standard codes a fixed minimum limit of height is given with a view to preventing the construction of unduly low workrooms. It is, however, equally necessary to take into consideration the maximum limit compatible with the best working conditions. For this reason attempts have at times been made to regulate the height of a workroom in relation to its surface. The fact must not, however, be overlooked that in certain instances an attempt to do so is likely to encounter technical difficulties, as, for instance, in breweries or starch factories, where workrooms with a large surface would by no means necessitate a corresponding height. Such workrooms are very spacious, having at times 300 to 400 square metres (359 to 478 sq. yds.) of surface, though very few workers are employed therein. The essential point is to determine generally acceptable average heights, for, though it may be in contradiction with the principles of hygiene to accept standards of insufficient height in working premises, to insist, on the other hand, on unduly high dimensions involves demanding the immediate and final closing down of a great number of establishments which are nevertheless acceptable. For this reason there has been adopted a height of 3 metres (9 ft. 10 in.). It constitutes a dimension which satisfies the psychological needs of the worker; the welfare of the latter and his contentment during working hours are to a large extent dependent on the free space by which he is surrounded. The height of the workroom must, however, be that measured from the ground to the top of the walls and not to the top of the roof, which may be a sloping one and thus lead to a wrong estimate.

**Cubic Space**

The notion of cubic space is independent of the three dimensions which provide its definition. The section devoted thereto
in the text of the Code does not in consequence in any wise render superfluous the preceding one, for there may exist workrooms (underground, ground floor, attics) which give perfect satisfaction from the point of view of cubic space, but which nevertheless are inadequate as regards height (often 1·80 metres (5 ft. 11 in.) and even 1·50 metres (4 ft. 11 in.)).

The cubic space in itself constitutes only an estimation of the quantity of air available for each individual worker. It should in consequence be supplemented by the conception of air circulation with a view to providing a worker immobilised in a closed room with the greatest possible quantity of air. Regarded from this dynamic aspect, the rate which is considered to correspond to the physiological needs of the human body under ordinary conditions is about 30 cubic metres (40 cub. yds.) per worker and per hour.

Nevertheless, as in the Standard Code, certain hygiene experts currently employ a static definition, i.e. a fixed quantity of cubic space, and it is of interest to recall here that the German Association of Industrial Physicians has fixed the cubic space necessary for a worker at 15 cubic metres (20 cub. yds.). There was, perhaps, a certain element of opposition to the dynamic conception of the cubic space, in the opinion expressed by those hygiene experts who foresaw the possibility of a certain disadvantage to the workers' health in unduly intense air renewal, or rather who stressed the workers' own fears as regards draughts. It is evident that such counter-arguments do not, however, constitute fundamental and definite opposition but merely demand as occasion arises the adoption of adequate technical measures to prevent risks of this kind. In estimating the quantity of air required for each worker it is essential to take into consideration, in fixing the requisite cubic space, the character of the work engaged in (sedentary work, work involving movement, slow, rapid, etc.).

The great difficulty which arises in connection with the problem of cubic space is that of control of air renewal by inspectorates. One of the methods indicated is that of estimating the carbonic acid content of the air in the workrooms. The methods involved in such estimation, however, are cumbersome for inspectors, and the analyses required demand extremely delicate interpretation according to the spot at which the air sample has been taken.

1 Modern technique enables the same results to be obtained from the use of a single appliance for air conditioning (filtering, cleaning, renewing, humidifying, heating, etc.).
Another method consists in the use of the katathermometer, but the objection which has been raised against the practical efficiency of this instrument is that it indicates merely the air renewal and not the chemical composition of the air.

VI

Area

Like the height of the workroom, the surface also presents an aspect of particular importance. Thus, where workers are obliged to execute their work at working posts situated opposite each other, a certain separation ensures avoidance of the danger of transmission of contagious diseases, and especially tuberculosis. On the other hand, as in the case of height, the psychic factor enters into consideration and the impression of liberty of movement experienced by the worker when provided with sufficient space contributes to his contentment, especially where it is a case of work carried on under relatively trying conditions from other points of view (for instance, in underground or attic premises). The figure of 2 square metres (2.39 sq. yds.) per worker, as specified, for instance, by the Austrian and Italian regulations, may be considered as a satisfactory minimum.

VII

Roofing

As regards the construction of various kinds of roofs, the health of the workers may be prejudiced by failing to take into consideration the following factors: draughts and lowering of temperature due to permeable or defectively constructed roofing material, the accumulation of evaporation products and humidity in workrooms with a flat roof, penetration of rain or snow where the roof is not absolutely watertight, diminution of lighting where lighting apertures in the roof are inconveniently situated. It follows therefore that the attention of hygiene authorities should be directed to these various points when elaborating conditions to be fulfilled by factory roofing constructed in accordance with requirements. There are at the present time in existence different types of roofing adopted for industrial construction. The best known are: sheds, or saw-tooth roofing, span roofing, arch-shaped roofs and skylights.
Walls and Ceilings

In the case of enclosed workrooms the walls and ceilings should satisfy certain hygienic requirements. There should notably be taken into account the following considerations:

Humidity.—Since humidity generally arises from the ground, it is advisable to prevent it by means of insulation devices, in addition to taking measures for improving the ground; where it is a question of humidity necessarily resulting from the type of production, it is advisable that the walls should be covered with cement or similar material.

Dust.—In order that dust produced should be rendered readily visible, oil painting of the walls in a light colour is advisable. Oil painting is likewise advisable in order to facilitate ready cleansing of the walls. It may be replaced by whitewash or in certain particular cases by papering with washable paper.

Temperature.—The walls should be of sufficient thickness to ensure, where essential, satisfactory insulation against the influence of the external temperature.

Light.—The walls should preferably be light in colour with a view to augmenting, if need be, the lighting capacity of the windows.

Flooring

From the point of view of the workers' health, the flooring should be so constructed as to prevent: emanations and dampness from the ground, the accumulation of dust and other waste material in grooves or fissures of the flooring during work or cleaning.

The type of work engaged in must determine the choice of material for the construction of the flooring. Three general types of occupation may be distinguished according to the attitude of the worker: first, work during which the worker remains seated at a certain place; secondly, work during which he moves within a small radius around the working post, and, finally, work during which the worker is obliged to move about the workroom. In an establishment where workers remain seated, the flooring should be thick and warm, since special exposure to cold is involved in this case. The same holds good for the class of workers restricted
to movements within a small radius. As regards the third class of workers, the type of flooring demanded for the two previous classes becomes less important. On the other hand, in this last case, it is advisable to avoid slippery flooring, not only on account of accidents but also with a view to preventing fatigue caused by moving about under such conditions.

X, XI, XII and XIII

Apertures, Windows, Doors

The apertures which are of importance from the point of view of industrial hygiene are windows, since they assure provision of daylight.

In constructing the windows there must be taken into consideration requirements as regard daylight, prevention of draughts and undue cooling of the workroom. The dimension of the windows is of great importance from the point of view of adequate provision of daylight. It is recognised that to obtain adequate daylight their total surface should equal on an average at least one-sixth of the surface of the floor. The height of the window is more important than its breadth and the space between the top of the window and the ceiling should be as small as possible. This gives at the same time a larger angle of incidence for the light. These conditions constitute the basis of the Standard Code in so far as it relates to the construction of windows, and the figures quoted therein represent optimum conditions.

Finally, as regards the psychological aspect, it is desirable that even in workrooms where daylight is provided from above (sheds) windows should be provided in the walls to combat the feeling of isolation and imprisonment which is inspired by a walled building without windows.

XIV

Cleanliness and Maintenance

The question of effecting cleaning outside working hours is still engaging the attention of hygiene experts. The main consideration is to protect workers against inhalation of dust which may be raised during cleaning, especially where the latter is effected by primitive methods. Where possible it is advisable to utilise the period immediately following the cessation of
work and not that which precedes the commencement of work, or even short intervals during which interruptions of work occur. It is only under special circumstances, notably in continuous processes, that it becomes impossible to follow such methods, and in the latter case cleaning has to be effected during work. It is true that at the present time, with the technical methods available which permit of cleaning without raising dust in the workroom, the question of cleaning during or after working hours has become one of minor importance. However, these considerations at once assume importance again whenever precautions for preventing dust production (vacuum cleaners, etc.) are omitted.

A distinction must further be made between cleaning, that is to say, thorough cleaning, and simply dusting, or surface cleaning. It may be possible to admit of the latter being effected during working hours, but where it involves the raising of dust to a similar extent as in the case of thorough cleaning, the choice of time for effecting it must depend entirely on the means with which it is effected. On the other hand, effecting thorough cleaning during working hours, even where means are applied to prevent dust production, meets with considerable obstacles since it involves grave interference with the workers.

XV

Residues, Waste Waters

The removal of refuse, residues, sweepings and in general all waste matter is essential in virtue of the fundamental principles of hygiene. Even where the refuse in question is not likely to give rise to injury to health, as, for example, in the case of metal clippings in engineering workrooms, the presence of these becomes a serious inconvenience and favours accumulation of products likely to prejudice the health of the workers. Moreover, they constitute an encumbrance for the worker, already but too little concerned with considerations of order and cleanliness, and eventually create for him a sense of discomfort likely to be reflected by a diminution in his welfare and contentment and finally in his capacity for production.

As regards waste waters, their removal should be effected in such a manner that their dispersal in the workrooms or in the neighbourhood of the factory is prevented.
Ventilation

Natural airing of the workrooms is effected by means of doors and windows and in less degree through the interior walls. Circulation of air is determined by the difference between the temperature of the air of the workroom and that of the air in the adjoining atmosphere as well as by draughts (wind).

Under ordinary conditions, air renewal takes place in this manner once per hour or once in two hours, which means that airing is inadequate. It requires to be supplemented either by opening the windows or by the provision of artificial ventilation.

When windows are opened during working hours, efforts must be made to avoid the production of draughts arriving directly at the working posts. It is generally sufficient to open that part of the windows which is above the level of the workers' heads and assure protection by screening the sides of the angle formed by the windows which open from top to bottom. Very frequently this kind of ventilation is overlooked owing to the fear of draughts, or in the absence of suitable devices permitting of regulating the opening of windows without difficulty.

During interruptions of work wholesale ventilation should take place by opening doors and windows opposite each other. Under these conditions complete air renewal is effected in two to five minutes.

In numerous cases natural ventilation is inadequate, and in such circumstances it is essential to have recourse to various types of apparatus. Amongst ventilators without mechanical movement should be mentioned air-pipes constructed in the walls, which, by reason of the difference between the temperature of the interior and exterior atmosphere, give rise to atmospheric circulation. These pipes generally start from the foot of the wall, except where special conditions call for elimination of the upper layers of the atmosphere of the workrooms. In order to stimulate circulation, a current of air is injected or a flame is lit in these pipes. The latter practice is, however, being gradually abandoned. Air pipes may also be provided in the roof or near the chimneys.

Mechanical ventilating apparatus is generally operated by steam or by electricity. At the present time artificial ventilation by mechanical means is being more and more applied, and in the
majority of modern factories there exist various types of such apparatus for assuring air renewal.¹

XVII, XVIII and XIX

Lighting

Lighting may in general be considered adequate when the luminous intensity, that is to say, the quantity of light falling on a unit of surface (1 square metre), is sufficient for executing any kind of work. Apart from that, the lighting intensity should not be subject to considerable and repeated oscillations and particularly those occurring at fixed intervals. Finally, the eye should not be fatigued by an unduly intense glare from the lighting source nor by violent contrasts.

The luminous source used may be either natural or artificial.

Natural lighting.—Natural lighting is that provided by solar radiation, in other words, daylight. This type of lighting is extremely variable and is influenced chiefly by the season, the hour of the day, meteorological conditions, and the extent of sky visible from the building. The brightness of the sky varies greatly in accordance with meteorological conditions and it is greater when the sky is not blue.

At present new factory constructions receive a fairly well regulated amount of daylight distributed by large apertures in the roof (sheds, skylights) or in the case—the most usual—of buildings of more than one storey, by glass walls. For top lighting, the glass roof with a northern exposure has an angle of 40 to 45 degrees on both sides or one side of the dihedral angle which forms the roof. This top light is often used in combination with lateral lighting.

Where lateral lighting is in question the extent of sky which provides the light depends on the height of the window, provided that the situation of adjoining buildings does not interfere with the access of daylight.

In addition, account must be taken of the ratio existing between the height and the width of the workroom, since it is well known that lighting is inversely proportioned to the square of the distance which separates a given point from the wall in which the window is placed. According to Nussbaum, the

¹ See footnote, p. 20.
respective values for height and width of a room should be as follows:  

<table>
<thead>
<tr>
<th>Width (m)</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.50</td>
<td>3.00</td>
</tr>
<tr>
<td>5.00</td>
<td>3.30</td>
</tr>
<tr>
<td>5.50</td>
<td>3.60</td>
</tr>
<tr>
<td>6.00</td>
<td>3.90</td>
</tr>
<tr>
<td>6.50</td>
<td>4.20</td>
</tr>
<tr>
<td>7.00</td>
<td>4.50</td>
</tr>
</tbody>
</table>

As regards the working post, window panes, blinds, curtains, the colour of the walls and ceiling, the colour of the outer walls of the opposite building represent so many factors capable of improving or otherwise the local conditions of lighting. Apart from white more or less attenuated in shade, yellow is the colour which provides the best luminosity, especially with artificial lighting.

In order that natural lighting should be adequate, it must fulfil the following conditions:

- the light should arrive as far as possible at the opposite wall of the room;
- the light should arrive at the working post from the most effective direction;
- the distribution of the light on the working post should be as uniform as possible;
- the interior walls and furnishings of the workroom should be of a colour and have a surface such that they only absorb very little of the light falling on them;
- machines and accessory apparatus should be so placed as to avoid causing any inconvenient shadows.

**Artificial lighting.**—As regards artificial lighting, the conditions to be fulfilled may be summarised under the following four heads:

1. the light should be sufficiently intense;
2. the light should not be productive of disturbing contrasts; in consequence it should not form shadows capable of interfering with the vision and should not be subject to unequal distribution;
3. the lighting source should not be productive of glare;
4. the light should be economical.

---

1 2.70 m. = 8 ft. 10 in.
4.00 m. = 13 ft. 1 in.
7.00 m. = 22 ft. 11 in.
(1) There are given below the values, suggested by the Illuminating Engineering Society of America and adopted by the American Standards Association (September 1930), expressed approximately in lux.

Work where there is no necessity to discriminate detail ... 5 lux
(Manipulation of a coarse material; grinding clay products; rough sorting; coal and ash handling; foundry charging.)

Work where slight discrimination of detail is essential ... 10 lux
(Rough machining; rough assembling; rough bench work; rough forging; grain milling.)

Work where moderate discrimination of detail is essential ... 20 lux
(Machining; assembling; bench work; fine core making in foundries.)

Work where close discrimination of detail is essential... 40 lux
(Fine lathe work, pattern-making, tool-making; weaving or sewing of silk or woollen textiles of light colour; office work; accounting; typing.)

Work where discrimination of minute detail is essential ... 80 lux
(Drafting; weaving or sewing of dark coloured materials; very fine inspection or inspection of very dark goods.)

In the same industry the lighting intensity varies according to the process executed. There may be given as an instance of this details relative to certain occupations:

**Printing industries**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lighting Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matrixing and casting</td>
<td>120/80 lux</td>
</tr>
<tr>
<td>Proof reading, lithographing, etc.</td>
<td>150/100 lux</td>
</tr>
<tr>
<td>Engraving</td>
<td>1,000 to 250 lux</td>
</tr>
</tbody>
</table>

**Cotton industry**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Lighting Intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lapping, carding, dyeing, etc.</td>
<td>80/50 lux</td>
</tr>
<tr>
<td>Spooling, spinning, etc.</td>
<td>120/80 lux</td>
</tr>
<tr>
<td>Weaving, light goods</td>
<td>200/120 lux</td>
</tr>
<tr>
<td>Weaving, dark goods</td>
<td>150/100 lux</td>
</tr>
<tr>
<td>Knitting machines</td>
<td></td>
</tr>
</tbody>
</table>

(2) The contrasts or shadows caused by artificial lighting should not exceed a certain degree, constituting otherwise inconvenience. However, a complete absence of contrasts or tones in the lighting intensity is also harmful for the work, since estimation of distance is hampered by this fact; while unduly strong contrasts lead to faulty estimation as regards depth and salient points, complete absence of these renders all estimation impossible.

(3) It is indispensable to avoid direct glare produced by the light source.

Protection of the eye should be assured by a shade which completely covers the source of light and concentrates the light on the work at the point where it is most necessary. It is further essential to assure the best position of the source of light so that
the eye is not hampered by glare from the work or from brilliant surfaces on to which the light is reflected.

(4) In order to fulfil the requirements of (4), sources of light should be so distributed as to avoid waste.

XX

Temperature

In order to determine temperatures for the workroom, it is necessary first of all to take into account the type of work done by the workers engaged therein. The aim must be to attain an optimum temperature which, of course, would vary with the nature of the work in question. In Belgium the following average temperatures are generally permitted: 1

<table>
<thead>
<tr>
<th>Activity</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary work</td>
<td>15° C</td>
<td>18° C.</td>
</tr>
<tr>
<td>Light work</td>
<td>12° C</td>
<td>15° C.</td>
</tr>
<tr>
<td>Work involving more movement</td>
<td>10° C</td>
<td>12° C.</td>
</tr>
</tbody>
</table>

In France, Lebrasseur (1909) and Maniguet have furnished the following figures:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sedentary work not demanding violent effort (Lebrasseur)</td>
<td>15° C.</td>
<td>18° C.</td>
</tr>
<tr>
<td>Sedentary work demanding muscular effort (Lebrasseur)</td>
<td>13° C.</td>
<td>18° C.</td>
</tr>
<tr>
<td>Hard work (Lebrasseur)</td>
<td>10° C.</td>
<td>15° C. winter</td>
</tr>
<tr>
<td>Workrooms intended for workers moving about, according to occupation (Maniguet)</td>
<td>14° C.</td>
<td>19° C.</td>
</tr>
<tr>
<td>Workrooms for women at sedentary work</td>
<td>18° C.</td>
<td>—</td>
</tr>
<tr>
<td>Shops</td>
<td>16° C.</td>
<td>17° C.</td>
</tr>
<tr>
<td>Offices</td>
<td>17° C.</td>
<td>18° C.</td>
</tr>
</tbody>
</table>

In Great Britain, Haldane and Osborne are of opinion that the surrounding temperature should not fall below 60° F. (15·5° C.), especially in the case of light work executed by sedentary workers.

Whenever the type of work effected permits of it, the temperature of closed workrooms should be maintained within limits approaching those indicated above.

In summer the workrooms should be as far as possible protected against excessive elevation of the temperature. Amongst other means applied for this purpose, mention should be made of ventilation of the workroom, painting of window panes in light colours (bluish white), the playing of a water spray directing fresh water over the roof, etc. A thermometer should be fixed and maintained in good working order in each workshop. In

1 10° C. = 50° F.
20° C. = 68° F.
order to determine accurately a suitable temperature for the workers, it is necessary to take into account the influence exercised by the wet bulb and the air movement.

During the cold season, heating of the workrooms should be adequately provided for. Heating apparatus should be provided with devices ensuring regular elimination of combustion gases. The use of keys and regulating dampers liable to close completely piping for evacuation of these gases should be prohibited. Finally, stoves and piping belonging to the heating system should be so installed that the workers do not suffer from heat radiation or circulation of hot air.

Heating, air movement and ventilation of the workrooms should be so arranged as to correspond and combine satisfactorily.

There may be distinguished amongst various types of heating, local heating (fireplaces, braziers, stoves) and central heating. The latter tends increasingly to replace the former type. Amongst systems of central heating may be distinguished heating by hot air—the oldest system, which is falling more and more into disuse—and central heating by means of water or steam, the latter at high or low pressure. There is finally the system of heating by radiation, by means of heated panels (used chiefly in offices).

The heated air provided for the workrooms may be partly utilised again after undergoing purification (ozonisation, etc.).

XXI

Drinking Water

The existence of a good provision of drinking water is of special importance from the health point of view. Amongst devices for this purpose, two types may be distinguished: one by means of which the workers drink from a water jet, playing in an upward direction, whilst the other involves the use of cups. The former is obviously preferable, since it eliminates possibility of contagion due to the use by several people of the same cup.

XXII

Cleanliness

In the text of the Code, amongst the means necessary to the workers for fulfilling the requirements of bodily cleanliness, mention has been made of:

(a) cloakrooms;
(b) provision of lavatories.
(a) Cloakrooms.—In small factories and workshops a simple collection of pegs for hanging clothes is usually placed at the disposal of the workers. In this case it is essential that each worker should have a special place reserved for his own use and bearing his name or a number. The distance between the various pegs should not be less than 50 centimetres (19.7 in.), so as to avoid contact of wearing apparel belonging to different workers. Under these conditions "safety" (the term "safety" used in the text of the Code refers to safety against theft, not at all to safety against accidents) is not always assured and often the workers refuse to leave their town clothes in such a place. Control of access to cloakrooms where clothes are left, or other arrangements of a special character, may obviate this disadvantage. Such arrangements consist in: (1) suspension of the clothes at a height which is directly inaccessible but which may be regulated from below; (2) the provision of individual lockers. Such lockers have dimensions varying between $30 \times 30 \times 180$ centimetres ($11.8 \times 11.8 \times 70.1$ in.) and $40 \times 40 \times 200$ centimetres ($15.7 \times 15.7 \times 78.7$ in.). They are, as a rule, divided into two compartments, the upper for the hat and the lower for clothes, shoes, etc.

The cloakroom should be outside the workrooms and should be spacious and well ventilated. It should contain benches where it is necessary for workers to change their trousers or shoes in order that they may be comfortably seated while doing so.

In large undertakings special arrangements are provided permitting of the drying of working clothes or of town clothes after rain. In general, installations are provided with radiators placed below the hanging apparel or below individual lockers. Effective ventilation should in such cases be applied to assure withdrawal of the steam produced.

Rooms intended as cloakrooms should be maintained in a state of rigorous cleanliness. They should further be situated near the lavatories.

(b) Lavatories.—As regards the requisite means for the washing of hands and faces, the most important consideration is to have simple and easily cleaned installations constructed of resistant and hard-wearing material and provided in sufficient number to permit of all the workers using them with loss of the least possible time. A certain proportion between the number
of wash basins and the number of workers employed should be observed, the average figure being usually one wash basin for every five workers.

The lavatories should be provided with running hot and cold water and a system of waste pipes for the withdrawal of used water. When the lavatory is intended for several workers, the distance between the water pipes should be sufficient to prevent the workers getting in each other's way.

In any case, the pipes should be fixed at a convenient height (50-80 centimetres) (19.7-31.5 in.) above the individual or collective wash-basins, enabling the worker to wash his face and chest at the pipe. The type of basins which fulfil the requirement most satisfactorily are those made of enamelled cast metal.

The workers should besides be provided with all requisite toilet accessories.

With a view to preventing disappearance of toilet accessories, nail brushes should be attached by means of small chains or even screwed on to the basin in a position permitting their ready use. Liquid soap may be provided in distributors fixed to the wash basins or near them, and towels may be fixed on a locked support. It is preferable that each worker should have an individual towel which he can, if necessary, keep in his locker. Possible transmission of infectious diseases, skin infections, etc., is thereby avoided. Roller towels are nevertheless commonly used, though it is earnestly hoped that this practice will soon be abandoned.

The flooring of the lavatories should be impermeable and easily cleaned; likewise the walls up to a height of 1.20 to 1.50 metres (47 to 59 in.), unless the wash basins are situated in the middle of the room or at a sufficient distance from the walls. The best means of protecting the floor and the exposed part of the walls consists of tiling similar to that used for bathrooms.

**XXIII**

*Seats*

The question of seats is at present engaging the attention of the majority of industrial hygiene experts. In this connection it is interesting to note that the German Industrial Hygiene Association has published the following suggestions drawn up by the Committee for Health Organisation in Industry.

(1) Work executed standing usually demands greater effort than that effected in a sitting posture; in consequence, despite the fact that all
operations cannot be effected sitting, all those concerned should devote their attention to ascertaining whether a great number of operations effected by workers standing, in accordance with tradition, cannot be completely or partially effected by sedentary workers.

(2) Physiological research has proved that certain work—for instance, pulling of weights and, what is somewhat similar, traction by cranking—can be effected with much less effort seated than standing. For lifting weights or propulsion by cranking the standing position is, on the other hand, preferable.

(3) For work effected sitting it is very important that the lumbar region should have a good support. Research effected with the aid of the cinema on naked subjects has demonstrated that in the sitting position it is not only the thoracic region of the back which is bent forward but that the anterior convexity of the lumbar column tends to become deformed by transformation into a posterior convexity. The result is lasting tension of the long muscles of the dorsal region, and in the case of women distension of the ligaments of the uterus. These two effects explain the frequently occurring lumbar pains consequent on prolonged sitting without a support for the back.

(4) A good chair for industrial work should be provided in addition to a sufficiently wide seat with a support for the feet, having eventually a movable oblique latticed step, a lumbar support, and where possible a second support higher up. On account of the difference in height of the back, the backs of these chairs should be either adjustable or they should be provided in different sizes. A lumbar support which is upholstered and not too narrow may satisfy both requirements.

(5) The height of the working bench and of the position of the object to be manipulated should be adapted to the height of the worker when seated, and this is most easily done by adjusting the position of the seat and the support for the feet. The worker should be able to remain seated in an upright position during work and should have a slight support for his elbows. Every effort must be made to avoid as far as possible that the method of work should involve unsupported movements of the forearms. Work done in this way readily causes fatigue and is likely to lead to slight trembling of the arms, which interferes with precision.

By judicious adjustment of the material and tools it is no doubt possible to obtain solutions in the case of a great number of processes which will satisfy the above requirements.

XXIV

Spittoons

The use of spittoons raises objections in certain countries where it is considered a fundamental measure to prohibit spitting entirely. The absence of spittoons constitutes a tacit assumption of this prohibition. Workers may elsewhere, when necessary, use old boxes, etc., which are burned after use. Where, however, the provision of spittoons is found to be necessary, they must fulfill certain hygienic requirements. They should be fixed at a height of 1 metre above the ground and be supplied with a
device for rinsing them out with water, and must be so arranged as to exclude desiccation and dissemination of their contents in the air of the workrooms. The wall on which they are situated should be painted white with a view to rendering visible any soiling or contamination.

XXV

Privies

The ideal type is that provided with an automatic water supply. It is highly desirable that this type should be installed in all establishments situated in localities provided with sanitation. Where this is not possible, all technical means should be applied with a view to preventing stagnation in channels leading to septic trenches and liberation of odours or gas in the atmosphere of the privy or its neighbourhood. The use of peat moss in trenches has been advised on account of its disinfecting and deodorising properties.

When the privies are not situated in the factory building and do not communicate directly with it, sheltered passages should give protection to their access, more especially in the case of workers in establishments where they are exposed to heat and likely to perspire. As far as possible, adequate heating should be provided in privies, giving a temperature similar to that in the workrooms. At the same time, effective ventilation should be maintained and an ante-room leading to the latrines should be provided wherever the immediate proximity of workrooms renders this necessary.

Partitions between the individual compartments of privies should be constructed of wood, masonry or metal. They should at all events be coated with washable paint or cement. The use of wood is not advisable because of its lack of durability. Each individual compartment should be provided with a door the height of which should be at least 1·20 metres (4 ft.). The door should be furnished with an inside lock.

The floor of privies should be constructed in material which is easily cleaned and washed (concrete, asphalt, cement, tiles).

Wherever possible, privies should be situated near lavatories.

In conclusion, inspection of privies is necessary in establish­ments where large numbers of workers are employed.
2.—WORKROOMS SITUATED BELOW THE LEVEL OF THE SURROUNDING GROUND

XXVI and XXVII

Semi-Underground Premises

The workrooms referred to in the corresponding section of the text of the Standard Code are those in which two-thirds of the maximum height are below ground. They must in consequence have windows opening outside. In certain cases the formation of the adjacent ground permits of increasing the access of air and light in these workrooms; this may be done by constructing trenches 1·50 to 2 metres (59 to 79 in.) wide and 1·50 metres (59 in.) deep, and by providing galleries as a means of protection against the dampness of the surrounding soil, for facilitating air circulation, and enlarging the angle of incidence of the light.

3.—WORK UNDER SHELTERS, PENTHOUSES, ETC.

XXVIII and XXIX

The provisions given in the preceding sections in respect of working premises are also applicable to work under shelters, penthouses, etc., in so far as it is possible to adapt them to such conditions.

4.—UNHEALTHY OR OFFENSIVE TRades

XXX and XXXI

General and Special Provisions

It is of course understood that in the case of processes involving the adoption of hygienic measures of a special kind, all the foregoing provisions must be applied a fortiori. The following constitute complementary measures the object of which is to safeguard the health of the worker in industries with a particular inherent risk.
Dampness, Steam, Vapour

Experience has proved that working capacity attains its maximum when the surrounding atmosphere has a certain temperature combined with a certain humidity rate; thermic and hygrometrical values are interdependent and a variation in one involves a corresponding variation of the other in inverse proportion.

To express these variations, recourse is had to "air calories," which give the sum of the calories of the air and of the steam contained in 1 cubic metre. It corresponds to the quantity of heat required to raise the temperature of 1 cubic metre (1·31 cub. yd.) of dry air from 0° to 1° C. (32° F. to 33·8° F.), and which equals about 0·3 calories. On the other hand, the evaporation of 1 grm. of water requires 0·603 calories, that is to say, 1 grm. of steam equals about 2 "air calories." Under these conditions, according to research engaged in by Prött, the optimum conditions in question would correspond to about 17·5° C. (63·5° F.) and 10 grm. of water per cubic metre of air, which, expressed in "air calories," would correspond to about 37·5° C. (99·5° F.) temperature of the human body.

The figure of 37·5° C. expressed in "air calories" can be arrived at by a whole series of combinations (Prött): 1

<table>
<thead>
<tr>
<th>°C.</th>
<th>Grm.</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>13·9</td>
<td>12 of steam per cubic metre = 100 of &quot;relative saturation&quot;</td>
<td></td>
</tr>
<tr>
<td>17·8</td>
<td>10</td>
<td>83</td>
</tr>
<tr>
<td>19·8</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>25·7</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>31·6</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>37·5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The term "relative saturation" which, in the above table, replaces that usually employed, i.e. "relative humidity," means the relation between the quantity of humidity contained in 1 cubic metre of air and that which corresponds to complete saturation when the total caloric quantity of air humidity (and not the temperature of the air) remains constant.

By comparing these figures with the humidity rates relative to more or less corresponding temperatures, there may be found

---

1 13·9° C. = 57·0° F.
2 37·5° C. = 99·5° F.
3 0·0648 grm. = 1 grain.
the following percentages and divergences between the wet and dry bulb thermometers:

<table>
<thead>
<tr>
<th>°C</th>
<th>Grm.</th>
<th>Per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>12.1</td>
<td>of relative humidity with a divergence of 0° C.</td>
</tr>
<tr>
<td>18</td>
<td>10.2</td>
<td>= 66 of relative humidity with a divergence of 3.5° C.</td>
</tr>
<tr>
<td>20</td>
<td>8.9</td>
<td>= 50 of relative humidity with a divergence of 5.5° C.</td>
</tr>
<tr>
<td>25.5</td>
<td>6.3</td>
<td>= 26 of relative humidity with a divergence of 10.5° C.</td>
</tr>
</tbody>
</table>

On the other hand, the temperature suitable for ordinary work also oscillates between limits which practice has found to be situated between 15° and 25° C. (59° and 77° F.).

From the preceding it will be seen that the relative humidity rate calculated to avoid harm must lie in the neighbourhood of 66 per cent., that is to say, must vary so as to provide the value which can be expressed in "air calories" approximating that which corresponds to the temperature of the human body.

It is known that a certain humidity rate of atmosphere is often accompanied by the formation of mist and steam. Measures requisite to prevent this consist in injecting a current of hot air to supplement effective ventilation.

This method can only meet with success in well-constructed workrooms, the roof of which is guaranteed against undue heat loss and which does not favour condensation of steam clouds.

It is essential that the temperature of the current of hot air introduced should be maintained as near as possible to a figure the value of which in calories added to that of humidity calories does not exceed the optimum of 37·5° C. (99·5° F.), in accordance with the indications above referred to.

XXXIII, XXXIV and XXXV

**Humidification**

Humidification of workrooms may be effected in several ways. The very bad method of humidifying the air by jets of steam under pressure is merely mentioned with a view to recommending its entire suppression. There may be distinguished in general three methods which permit of producing the requisite evaporation necessary for supplementary humidification and ventilation to provide the required freshening of

---

114° C. = 57·2° F.  
25·5° C. = 77·9° F.  
0·0648 grm. = 1 grain.

3·5° C. = 6·3° F.  
5·5° C. = 9·9° F.  
10·5° C. = 18·9° F.
the atmosphere: these are saturation devices, atomisers and spray apparatus. The first consist in apparatus by means of which it is possible to humidify and freshen the atmosphere by the application of air previously prepared in piping or apparatus, such air only carrying the quantity of water corresponding to its saturation point; atomisers or super-saturation devices consist in apparatus in which preparation of damp air is made in two stages: in the first, preliminary preparation takes place analogous to that effected in the saturation devices, the air evaporating a quantity of water corresponding to its saturation point; in the second, completion of the preparation takes place in the workroom, since the air carries with it, in the form of mist, atoms of water ready for a second evaporation. Spray apparatus consists in devices which operate in the workrooms themselves, the preparation of the air not being effected in special chambers or apparatus.

Control of the humidity rate is effected by means of diverse methods, amongst which may be mentioned:

(1) *Psychrometric method.*—The psychrometer consists of an ordinary dry bulb thermometer and of another so-called “wet bulb thermometer,” since the bulb is surrounded by muslin which dips into a receptacle containing water and which maintains it in a damp state and causes constant evaporation at the surface. The heat from vaporisation of the water is borrowed from the reservoir of the thermometer, so that the wet bulb thermometer indicates, all other things being equal, a lower temperature than the dry bulb thermometer. The difference is so much the greater since evaporation is more rapid, as, for instance, when the air is dry, that is to say, further removed from its saturation point. It vanishes when the air is saturated.

For practical purposes, it is recognised that artificial humidification is not necessary from the point at which the wet bulb thermometer indicates at least 24° C. (75·2° F.). On the other hand, it is true that the humidity rate exceeds tolerable limits when the wet bulb thermometer rises above 26° C. (78·8° F.); under these conditions work should be suspended.

Apart from that, it is essential that there should be a divergence not exceeding certain limits between the temperature indicated by the dry bulb thermometer and that indicated by the wet bulb thermometer. In the cotton industry in England,
for instance, this divergence is indicated by the following table, expressed in Fahrenheit degrees:

<table>
<thead>
<tr>
<th>Dry bulb thermometer</th>
<th>Wet bulb thermometer</th>
<th>Dry bulb thermometer</th>
<th>Wet bulb thermometer</th>
<th>Dry bulb thermometer</th>
<th>Wet bulb thermometer</th>
</tr>
</thead>
<tbody>
<tr>
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<td>67</td>
<td>65</td>
<td>76</td>
<td>72.5</td>
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(2) Katathermometric method.—The katathermometer is a graduated alcohol thermometer from 100° F. (37.8° C.) to 95° F. (35° C.). This instrument is used for measuring what is called the cooling rate, that is to say, the time which alcohol requires to descend from 100° to 95° F. With this in view, the katathermometer is first of all heated by immersion in hot water to a temperature well above 100° F., the instrument being provided or not with a muslin cover according as to whether it is desired to utilise it as a dry bulb or wet bulb thermometer. It is thereafter suspended in the air to be tested, and the time taken in cooling is noted. The dry bulb instrument is cooled by radiation and convection, whilst the wet bulb apparatus is cooled by radiation, convection and evaporation, the latter depending on the humidity rate of the air and the air movement.

In practice there exist formulae which permit of estimating the humidity rate of the air and its rate of movement by means of readings furnished by measurements effected simultaneously when the dry bulb and wet bulb katathermometers are used.¹

The combination of the temperature, humidity rate and movement rate of the atmosphere in certain proportions gives, as the case may be, a more or less great sensation of comfort. A similar sensation of this kind may, on the other hand, be produced by different combinations, as is the case, for instance, in the circumstances indicated below, which exert a refreshing

¹ According to L. Hill, the cooling power needed to produce perspiration is as follows for certain kinds of work:

<table>
<thead>
<tr>
<th>Kind of Work</th>
<th>Coolant Power</th>
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<tbody>
<tr>
<td>sedentary</td>
<td>6 dry bulb k.-t.</td>
</tr>
<tr>
<td>light</td>
<td>9 &quot;</td>
</tr>
<tr>
<td>hard</td>
<td>18 &quot;</td>
</tr>
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</table>
effect on the human body when clothed (Pittsburg) (experiments effected by the United States Bureau of Mines).

<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>Rate of air movement per minute</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>0 m.</td>
</tr>
<tr>
<td>20</td>
<td>20.3°</td>
</tr>
<tr>
<td>50</td>
<td>19.2°</td>
</tr>
<tr>
<td>100</td>
<td>17.2°</td>
</tr>
</tbody>
</table>

Dry bulb thermometer temperature in °C.

XXXVI, XXXVII and XXXVIII

_Irritant Toxic or Asphyxiating Smoke, Fumes and Gases_

Wherever circumstances permit, industrial operations involving utilisation, liberation, or production of smoke or and irritating asphyxiating fumes or gases should be effected in hermetically closed apparatus. In cases, and these are numerous, where that is impossible, devices should be applied with a view to withdrawal of the dangerous products and should be arranged as close as possible to the source of production or escape of the products in question. Apparatus for application of localised ventilation are most commonly used and in general construction these do not differ much from those applied for withdrawal of dust (see below). It is, of course, clear that as regards details the various devices used require to be adapted to the special object for which they are intended and that requisite modifications in the model, construction, and site of the hoods, piping and certain parts of the apparatus require to be effected in consequence.

Removal of gas and fumes may be effected with a minimum draught where the products to be eliminated are not present in excessive quantities.

A good exhaust system for withdrawal of gas is usually combined with ventilation of the workroom, since the elimination of deleterious products and the stimulated circulation of air brought about by the working of the apparatus in question guarantees purification of the surrounding atmosphere. Every effort must be made to avoid the production of harmful draughts.

In workrooms where heating apparatus is provided, the latter
may be utilised for reheating air coming from the outside wherever circumstances require this.

The efficiency of exhaust apparatus depends not only on good construction but also on the manner in which it is maintained. Duly qualified persons should be entrusted with inspecting the state and regular working of apparatus of this kind.

According to the kind of smoke or gas to be withdrawn, it becomes necessary to utilise exhaust devices of the *per ascensum* or *per descensum* type, the former being applied in the case of light emanations while the latter is used rather for elimination of heavy gases and fumes. In the case of smoke, its dispersion in the atmosphere is further prevented by causing it to pass through chimneys known as "smoke-consumption chimneys." All gaseous, irritant, toxic or harmful products collected in the factory should be subjected to effective processes of condensation (in water or other suitable liquids), chemical neutralisation, saturation, or pyrogenous transformation (directed under the hearth of the furnace or into a special furnace) or to equivalent processes corresponding to the particular character of the gaseous products in question. Where it is a question of complex gaseous products, partly condensable and partly susceptible of pyrogenous transformation, recourse is had to two or more of the above-mentioned processes.

A modern improvement made in the technique for the purifying of gas and smoke consists in the Cottrell method, the principle of which is based on the flocculation of aerosols, brought about by causing a variation in the electric charge protecting these particles. It is known that mixing with an electrified aerosol another dispersed substance charged with electricity of the opposite sign produces an effect similar to that present when the original aerosol is formed of neutral particles; the latter become charged by induction by elements electrified by a sign contrary to that of their attraction. The Cottrell unit used in industrial technique is formed essentially of a vertical metallic wire carried to very high tension and enclosed in a vertical metallic tube of which it forms the axis. The tube is earthed. The intensity of the field thus created between the wire and the tube sets up intense ionisation of the current of gas, steam, or dust-laden air passing through the tube. The result is that all the solid particles in suspension become discharged and form agglomerations which finally collect in a collecting receptacle situated in the lower part of the apparatus.
Premises likely to contain fumes or gases of an injurious or inflammable nature should be abundantly ventilated before workers are allowed to enter them; when these premises contain several apertures on opposite sides of the room, the latter should be left open for several hours, prior to the commencement of work, and when this is not feasible or where it is not possible to provide a strong draught recourse must be had, prior to or during the work, to injecting continuously a supply of air with a view to renewing the atmosphere in the workroom.

XXXIX, XL and XLI

**Dust**

The best protection against dust is furnished by the utilisation of closed apparatus for all operations involving liberation of dust. This method is, however, not always capable of realisation, and in the numerous instances in which its application encounters grave obstacles, it is necessary to provide suitable apparatus ensuring exhaust draught, as near as possible to the source of production of the dust in question.

In every system adopted there must be taken into consideration the volume of the particles of dust and their specific weight with a view to determining the amount of force necessary for their withdrawal. Further, for technical reasons it is important to ascertain whether there is continuous production of the dust in question or not, and also to recognise its possible value with a view to eventual recuperation.

The collection of dust at its point of origin is not always easy. The apparatus and processes applied for this purpose are so varied that it is not possible to adjust the dust collector at any special point except by provision of a special technical device. For ordinary dusty processes exhaust hoods in wood or metal are constructed or at times a sleeve-shaped cloth collector is used; the dust is removed as near as possible to its point of origin and withdrawal is effected by means of exhaust through a system of piping by means of mechanically operated ventilators.

At the present time there are on the market numerous constructions neither too costly nor too cumbersome and which satisfy the essential conditions required from plant of this kind, that is to say, are capable of adjustment close to the dust-

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1 The observations apply to cases where humidification to precipitate the dust is impossible for technical or financial reasons.
producing apparatus and of being brought into close contact with all points at which dust may be produced.

In other cases, the mouth of the exhaust apparatus is situated below the working post eliminating the dust *per descensum*: whether it is a case of sieves or perforated tables, there always comes into play the same principle, by virtue of which the materials under manipulation yield their dust to the aperture which absorbs them, thus preventing their dispersion in the air.

At times the action of this exhaust device—hood or other apparatus—is reinforced by a draught blowing in the direction of the withdrawal, that is to say, in the direction from the worker towards the ventilating apparatus.

The large pipe intended to direct the dust towards a special collector or outside the factory should possess a diameter increasing with the flow of the current, in order to avoid interference with the free circulation of the dust-laden air. Similarly, its length should not be excessive, thus constituting a source of resistance to evacuation. Further, elbow bends and angles should be accurately calculated so as to facilitate the dust withdrawal. The interior surface of the piping should be smooth and in no wise adhesive. Traps for deposit of heavy dusts and small apertures permitting of cleansing should be arranged here and there throughout the length of the piping.

Branch pipes should never form a right angle with the principal piping and two branch pipes should never be placed opposite one another. Similarly, it is essential to avoid pipes having a Y formation, since two conflicting draughts retard circulation and may at times choke the apparatus. The cross-section of the central piping must at one point be equal to the sum of the cross-sections of the branch piping which has entered it up to that point.

When a series of exhaust pipes are connected up with the same ventilator, it is essential that the intensity and rapidity of the air withdrawal should be equal in all the pipes in question. Where this is not so, there is a risk of the circulation becoming arrested in those pipes in which it is less rapid.

The type of ventilator used for aspiration of dust varies in accordance with the nature of the industrial operations. The propulsion type is only applied in relatively small workrooms possessing piping with a large diameter and not requiring withdrawal of large quantities of dust. In all other cases it is preferable to use centrifugal ventilators, the working capacity
of which (size, number of revolutions) should be suitably adapted
to the work in course of execution.

It is sometimes necessary to have a mobile exhaust apparatus,
notably for cleaning dusty workrooms. In this way the use of
dusters or blowers is avoided.

Wherever a powerful dust exhaust apparatus is used, measures
must be taken with a view to ensuring renewal of the air removed
by ventilator. Without this precaution the working of the
exhaust apparatus would be rendered difficult, especially when
the doors and windows of the workroom are kept closed. It
is further necessary to entrust competent persons with the
inspection and supervision of dust-exhaust apparatus. Dust
withdrawn from the workrooms is directed into collectors, dust
chambers, cyclone separators, water separators, either floating
or with injection of water or felt filters. As in the case of gas,
fumes and smoke, precipitation by the electrostatic method is
also used for dealing with dust. This method even permits of
fractionated precipitations of dusts, formed of several dispersed
constituents possessing varying volatility. With a view to this,
Cottrell unities are grouped, or use is made of vertical wires
at high tension arranged in parallel layers and separated by
metallic sheets similarly vertical and parallel, and earthed, the
wires being enclosed in chambers of masonry. Electric precipita-
tion thus enables recovery of dusts which are of special marketable
value.

Individual protection.—A supplementary measure of equal
importance in workshops where smoke, gas, fumes and dust
are freely given off consists in the provision of working
clothes. In all such places employers should be obliged to
place at the disposal of their workers working clothes or overalls,
whilst cloakrooms enabling the workers to change their clothes
and hang up their town clothes should likewise be provided.

Working clothes are generally made of a smooth and close
material, often impregnated with a substance preventing the
adhesion of dust or other products handled during work. They
should cover the body entirely and prevent irritating substances
from penetrating at the neck and wrists. Head gear should be
provided for protecting the head, and where irritating products
are handled the workers require to be furnished with gloves, and
at times also with masks. Various types of these are in use,
chief amongst which are respirators, anti-gas masks, respiratory
apparatus with provision of oxygen, masks with flexible piping connected with an exterior source of fresh air, and finally liquid oxygen apparatus. Respiratory apparatus must be of strong and simple construction and easy manipulation and made of lasting material. They should be of simple and sure usage, even when in the hands of inexperienced workers liable to the effects of emotion. They must be perfectly airtight at all points and no part thereof should be subject to constant negative pressure which is likely to favour entry of dust should they not remain absolutely airtight. They should be easy to wear and should not give rise to any interference with movement nor any irritation of the skin at the points of contact or of application.

The respiratory apparatus however ought to be closely applied to the face, and with a view to this it is essential that each worker possesses an apparatus which fits him. What is known as the "deadspace" should be as small as possible. They should, as far as possible, leave the chest and arms free and should not present a striking or ridiculous appearance. Further, they should permit of the execution of normal work without causing respiratory inconvenience or discomfort, and should be provided with a device permitting of elimination of the necessary portion of CO₂ from the expired air.

Finally, they should lend themselves readily to inspection and disinfection, and where they are provided with a mouthpiece they should possess a saliva trap and a nose clip.

Mention should also be made here of goggles for protecting the eyes against dust, gas, fumes, etc.

Where necessary, lavatories or douche baths should be placed at the disposal of workers on leaving work.

As regards douche baths, these should be arranged in separate compartments with a view to avoiding promiscuous use. These compartments should have dimensions not inferior to 1·50 metres (5 ft.) in width by 1·50 to 3 metres (5 to 10 ft.) in length, according as to whether it is a question simply of douches or of baths. The latter are usually preferred by women workers, while men ordinarily use the douches. In providing douche baths for women it is preferable to install those with a ring spray rather than a head spray to avoid wetting the hair. In the bathing cabins a free space should be provided between the ground and the bath in order to allow the water to run off.
Construction material should be so chosen as to permit of rapid cleansing. All requisite toilet accessories (soap, towels, lockers) should be provided.

XLII, XLIII and XLIV

_Large Furnaces_

Heat-radiating furnaces should be installed in a room or compartment specially destined for this purpose wherever lack of space renders impossible protection of those workers not directly occupied at the furnaces.

The workers who attend the furnaces should be specially protected against the harmful action of heat radiation. In certain instances it is advisable to circulate a current of fresh air drawn from outside (previously slightly heated in winter) between the glowing furnaces and the worker tending it. Precautions must in such a case be taken to avoid workers catching chills likely to lead to neuralgic or rheumatic affections.

A system of rotation of shifts is generally in force with a view to reducing to a relatively short period the time spent in front of the furnace. With this in view, the number of workers should exceed (usually at least twice) the working posts, permitting one shift to recover whilst the other is in action. Special rest rooms must in such a case be placed at the disposal of the workers.

Certain furnaces are provided with doors, sometimes double, with an intervening space in which cold water may be circulated.\(^1\) In this manner the worker is protected against heat stroke. The openings arranged in the doors for the introduction of tools and supervision of the process are mostly provided with sliding plates, the closing or opening of which enables the emergence of heat radiation to be checked as required. Finally, cast-iron screens, sackcloth or fireproof screens (asbestos) are currently employed for protecting workers particularly exposed. Where necessary, fireproof clothing or certain fireproof garments should be worn by these workers.

The eyes should be protected against the action of heat radiation by means of protective glasses. The conditions which such glasses should fulfil may be summarised as follows: they should be as light as possible, easy and comfortable to wear, and

\(^1\) The worker can also be isolated by means of "curtains" of water or fresh air.
should not give rise to friction or irritation. They should have solid and durable frames constructed of material capable of resisting possible harmful influences connected with working conditions. Further, the glasses should in no wise interfere with vision and should be replaceable. The visual field should be as large as possible and the glasses should be so mounted as to permit of the free access of air, to prevent heating of the eyes and the formation of steam. The form and colour of the glasses should constitute an effective means of protection against the harmful agent. Periodical control of the filtering power of glasses should be instituted. Finally, such glasses should not prevent the worker requiring these from wearing at the same time ordinary glasses for correcting visual defects.

In certain cases fireproof helmets covering the whole head and provided with transparent glasses are provided.

In further instances, as for example in glass works, special apparatus exists allowing of automatic dropping of a protecting screen between the source of radiation and the worker whenever the latter is obliged to proceed to the opening of an incandescent furnace.

Finally, it is advisable to provide special shoes for workers tending furnaces with a view to preventing burns, to which they are exposed.

XLV

Drying-Rooms, Stoves

Apart from the precautions to be taken enumerated in the text of section XLV of the Code, attention must be paid to the quality of the atmosphere in constructions serving as stoves and drying-rooms at the moment when workers are obliged to enter these. The accumulation of gas or other volatile products given off by the substances to be dried or by combustion become so much the more dangerous in such cases, since ventilation apertures are often closed down in constructions of this kind with a view to raising the temperature.

XLVI

Noise, Vibration, Shocks

Protection of workers against noise involves the adoption of several measures, certain of which are applicable to the worker and certain others to the work.

Amongst the former may be enumerated the use of cotton wool ear-plugs or other obturating devices, or of protective
helmets. The latter, it must be confessed, are generally uncomfortable and the workers are disinclined to use them. Medical examination on commencing work is advisable with a view to eliminating workers predisposed to ear trouble or suffering from diseases of the ear. Similarly, medical inspection (periodical examination) should be effected with a view to detection and timely treatment of derangements of hearing. A final measure consists in organising alternating shifts of workers in order to provide the most frequent interruptions possible of the work.

Measures applicable to the work itself are more rational since they aim at suppressing the cause of noise and not its effect, as in the case mentioned above. It is here a question of technical measures tending to insulate and deafen noise. In their entirety, these measures may be classed with those generally adopted for protection against shocks and vibration. They cannot be determined except after detailed examination of the surrounding conditions and they vary in accordance with these. Generally speaking, covering of walls, ceiling and especially of floors with material intended for deadening noise reduces the production of vibrations by way of the floor (felt, rubber, linoleum, "acoustic," "celtothex," "akoustolith," various special plasters, etc.). Vibration from machinery may be deadened by special arrangement of the machines on supports made of special substances or by placing them on special bases which are constructed independently from the flooring used by the workers. They may further be isolated in special closed chambers having thick iron doors.

XLVII

Poisons\(^1\)

Since measures of protection against the various poisons do not differ essentially from those against gas, fumes, smoke and dust, the reader is referred to the parts of the Explanatory Notice where these causes of injury are dealt with.

\(^1\) For further information under this head, see *Occupation and Health, Encyclopaedia of Industrial Hygiene*, 2 vols. Geneva, International Labour Office, 1930–1934.