EQUIPMENT VENTILATION AND AIR CONDITIONING

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USSR Report

INDUSTRIAL AFFAIRS

(FOUO 9/79)

INTERIOR SANITARY ENGINEERING EQUIPMENT

Ventilation and Air Conditioning

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Moscow VNUTRENIYE SANITARNO-TEKHNICHESKIYE USTROYSTVA V DVUKH CHASTYAKH CHAST' II VENTILYATSIYA I KONDITSIONIROVANAYE VOZDUKHA in Russian 1977 pp 6-9, 18, 39, 64, 76, 93, 105, 126, 128, 179, 215-216, 223-224, 229, 246, 282, 294, 316-317, 321, 330, 346, 364, 370

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ANNOTATION

[Excerpts] The basic standards materials and the requisite information for designing ventilation and air conditioning systems are given in the handbook. The requisite climate specifications for rooms, questions of the delivery of heat and moisture to rooms, as well as the intrusion of harmful gases and steps to combat them are treated. Equipment for cleaning dust out of air, information for the design of air conditioning and aeration systems for industrial buildings are presented, and recommendations are given for air baths, curtains and local vents. Questions of the design of air ducts, as well as pneumatic conveyance are treated. Measures are given for combating the noise of ventilation installations. Recommendations are given for heat insulation equipment and system automation. Fire safety requirements are presented. Data on basic ventilation equipment are given in the appendix.

The handbook is intended for engineering and technical workers in design and construction organizations.

Some 397 tables, 368 figures.

ORIGINAL TABLE OF CONTENTS

FOREWORD TO THE SECOND EDITION

Considerable attention is devoted in the resolutions of the 25th CTSU congress to the improvement of working conditions and maintaining the health of workers. Success in resolving this problem is determined by the efficient operation of air conditioning and ventilation systems being planned.

In the second edition, the main chapters of the handbook have undergone significant revision, taking into account the latest theoretical and experimental studies and achievements of scientific research and planning organizations. The requirements placed on the air and thermal condition of rooms and the specifications for the selection of the design conditions for project planning have been reviewed and brought into line with the new standards. Design data on the degree of atmospheric air polution by ventilation and industrial emissions have been systemized and presented, and formulas are given for the determination of the optimum height of the emissions of polluted air. Based on the new procedure for calculating the thermal mode of rooms, questions of the entry of solar radiation heat into them have been presented in a new manner. An attempt is made for the first time to set forth a method for determining the emissions of harmful substances into rooms on the basis of theoretical and experimental investigations. New information is provided concerning water-air systems for air conditioning, the optimal mode for heating and humififying air, as well as concerning specifications for protecting air heaters against freezing. The chapter on the distribution of convective air has been revised, with the data on convective streams and the correction factors for their calculation made more precise. New data are given for ceiling, wall and column air distributors, as well as for perforated panels and ceilings.

New data are given for acoustical design when combating the noise of air conditioning and ventilation installations, and including that for the calculation of the sound power of the air noise, the design of suppressors, sound insulating barriers, sound absorbing facings and vibrational isolation of equipment. Additionally included are data for the design of the thermal insulation of sanitary engineering systems which are inseparably tied to energy resource economy. Questions of the automatic control and monitoring of the operation of santiray engineering equipment are presented in a new manner. Detailed fire safety requirements are presented for heating, ventilation and air conditioning systems in accordance with the latest standards materials, coordinated with the USSR GUPO MVD [Main Administration of Fire Prevention of the Ministry of Internal Affairs] and the USSR Gosstroy.

Materials from the Lenpromstroyproyekt, Soyuzsantekhproyekt, TsNIITromzdaniy and other institutes were used in compiling the handbook.

Data on basic ventilation equipment being produced by industry as of 1 January, 1976 are given in the appendices: fans, air heaters, air conditioners, dust separators, filters and electric motors.

The individual chapters of the handbook were written by the following authors: the foreword by candidate of the engineering sciences I.G. Staroverov; Chapter 1 by candidate of the engineering sciences I.G. Staroverov (sections 1.1. and 1.7.), engineer V.I. Moshkin (sections 1.2., 1.4. and 1.6.), by doctor of the engineering sciences V.N. Bogoslovskiy (sections 1.3. and 1.5) and engineer Z.I. Konstantinova (section 1.8.); chapter 2 by engineer V.I. Moshkin (sections 2.1., 2.3., A-G and 2.5) and doctor of the engineering sciences V.N. Bogoslovskiy (sections 2.2., 2.3., G, H and 2.4.); chapter 3 by doctor of the engineering sciences V.M. El'terman; chapter 4 by doctor of the engineering sciences A.I. Pirumov; chapter 5 by doctor of the engineering sciences A.I. Shepelev and engineer Ye.O. Shil'krot; chapter 6 by engineer N.I. Berezina (section 6.1.) and candidate of the engineering sciences A.G. Yegiazarov (section 6.2.); chapter 7 by candidate of the engineering sciences B.V. Barkalov (sections 7.1. - 7.9.) and doctor of the engineering sciences V.N. Bogoslovskiy (section 7.10); chapter 8 by candidate of the engineering sciences B.V. Barkalov; chapter 9 by candidate of the engineering sciences I.G. Staroverov; chapter 10 by engineer L.F. Moor; chapter 11 by candidate of the engineering sciences T.A. Fialkovskaya; chapters 12 and 13 by engineer N.I. Berezina; chapter 14 by candidate of the engineering sciences I.G. Staroverov; chapter 15 by candidate of the engineering sciences B.V. Barkalov; chapter 16 by engineer I.N. Leykin; chapter 17 by candidate of the engineering sciences E.A. Leskov and engineer R.G. Kotlyar; chapter 18 by candidate of the engineering sciences I.G. Staroverov; chapter 19 by candidate of the engineering sciences V.M. Rubchinskiy; chapter 20 by candidate of engineering sciences B.V. Barkalov and engineer V.I. Moshkin.

Appendix I was written by engineer A.I. Ushomirskaya; appendices II, III and IV were written by candidate of the engineering sciences I.G. Staroverov; and appendix V was written by engineer M.M. Yastrebov.

FOREWORD TO THE THIRD EDITION

The importance of improving working conditions and labor safety, as well as its scientific organization is underscored in the new USSR constitution. Cons erable attention is likewise devoted to the protection of the air pool. The solution of the problems posed is impossible without the efficient operation of air condtioning and ventilation systems. The major questions in designing these systems are covered in the handbook.

The publishing of a third edition of the handbook is due to the urgent need for the material presented in it. Individual corrections and improvements have been made in the handbook in its re-editing.

CHAPTER 1. BASIC PRINCIPLES

1.2. Climatic Conditions in Rooms

The climatic conditions in a work area (at permanent work positions and outside of them) of production rooms and in the inhabited area of the rooms of public and residential buildings are established in accordance with the specifications of chapter II-33-75 of the SNiP [construction norms and specifications] "Heating, Ventilation and Air Conditioning". The work zone is considered to be the space with a height of up to 2 m from the floor level or the areas in which people are located or there are work positions. A work position is considered to be permanent if the worker spends the greatest part of his work time there (more than 50% or more than 2 hours continuously). If processes are managed at different points in the work area, then the permanent work position is considered to be the entire work area. The serviced zone in the rooms of public and residential buildings, and in auxiliary rooms and buildings of enterprises, is considered to be the space with a height up to 2 m from the floor level, and in rooms where there are people primarily in a sitting position (for example, theaters, restaurants, dining halls, the rooms of administrative buildings and the buildings of educational institutions), it is the space with a height up to 1.5 m from the floor level.

The permissible temperature, relative humidity and speed of air motion established by SNiT II-33-75 as a function of the characteristics of rooms (their function and the amounts of specific excess heat), the category of work and the season of the year are presented in Table 1.1. The explicit heat surpluses in Table 1.1. are understood to be the difference between the amount of heat entering a room following the implementation of all construction and technological steps to reduce it, and the amount of heat lost through the structural barriers of the room, referenced to 1 m^3 of internal room volume. The explicit heat liberated within the confines of a room and heating the air, and thereafter removed from it with the air of local vents or the overall exchange exhaust, is considered in the room characteristic as entering the room. Only that explicit heat which was produced within the confines of a room but was then removed from it without transfering the heat to the room air (for example, with gases through smokestacks or with the air of local vents from equipment) is not to be taken into account. Likewise, in determining the room characteristics for the explicit heat surpluses, the latent heat introduced into the room air with liberated moisture is not to be taken into account.

In those cases where the limits of the speed of air motion are given in Table 1.1., the greater speed is to be combined with the higher temperature of the internal air, while the lower speed is to be combined with the lower temperature.

The operating category is taken from the "Sanitary Standards for the Planning of Industrial Enterprises" based on the energy expenditure, which are established in accordance with the departmental standardizing documents by proceeding from the category of the work performed by 50% and more of the workers in a room. See GOST 12.1.005-76 for more precise specifications.

The temperatures and relative air humidities established by regulations in Table 1.1. in the cold period of the year should be observed for all outside air conditions within a range from the design parameters A or B for the cold period (depending on the function of the air conditioning and ventilation systems) up to a temperature of 10° C, and in the warm period of the year, for all outside air conditions within a range from a temperature of 10° C up to the A design parameters for the warm period. The characteristics of the state of the outside air for the case of the A and B design parameters are given in Chapter II-33-75 of the SNiP.

The permissible parameters for interior air for the warm period of the year, which are given in Table 1.1., should be adopted for all localities in which the design temperature of the outside air (the A design parameters) does not exceed 25° C (for the case of light or medium difficulty work) or 23° C (for the case of severe work). In those localities where the design temperature of the outside air (the A design parameters) exceeds the indicated limits, a higher air temperature (Table 1.2.) can be adopted for permanent work positions of industrial rooms. A corresponding increase of the temperature inside the rooms of public and residential buildings is also permitted.

It is permissible to plan lower air temperatures outside the permanent work positions during cold and transitional seasons as compared to those set by by standards: by as much as 12° C for the case of light work, up to 10° C for work of intermediate difficulty and up to 8° C for heavy work in heated production rooms, as well as in rooms with considerable heat excesses, where there is from 50 to 100 m^2 of useful area for each worker. In this case, the climatic conditions, governed by the regulations shown in Table 1.1., are to be maintained at permanent work positions.

The requisite air parameters are to be maintained only at permanent work positions in production rooms where the floor area per single worker exceeds 100 m^2, and it is impossible to maintain the values of the temperature, relative humidity and speed of air motion indicated in Tables 1.1. and 1.2. over the entire area of the work region because of technical reasons or it is not expedient to do so because of economic considerations.

In production rooms in which artificial air temperature or temperature and relative air humidity control is required based on technological conditions, it is permissible in the cold and transition seasons to adopt the climatic parameters indicated in Table 1.1. for the warm period of the year. However, in this case the air temperature should not differ by more than ± 2°C from the optimal temperature (see below) and should not exceed 25° C.

One can assume a relative air humidity in the work area of rooms which is 10% higher than that indicated in Table 1.1. in regions with an elevated outside air relative humidity (75% and more at a temperature corresponding to design parameters A) in the case of natural ventillation of buildings and facilities, for the calculation of the air changes during the warm season of the year (design parameters A).

TABLE 1.1.

The Permissible Standardized Climatic Conditions in the Work Area of Production Rooms and in a Serviced Area of Public and Residential Building Rooms, as well as in the Auxiliary Rooms and Buildings of Enterprises

Характеристика помещений / Room Characteristics	Категория работы / Work Category	(1) Температура воздуха, °C	(2) Относительная влажность, %, не более	(3) Скорость движения воздуха, м/с, не более	(4) Температура воздуха вне постоянных рабочих мест, °C	Air Temperature, °C. Температура воздуха, °C	(5) Относительная влажность воздуха, %, не более, при температуре воздуха, °C: 24	27	26	25	≤24	(6) Скорость движения воздуха, м/с	Air Temperature Outside Permanent Work Positions, °C. Температура воздуха вне постоянных рабочих мест, °C
		(7) на постоянных рабочих местах или в обслуживаемой зоне				At permanent work positions or / на постоянных рабочих местах или в обслуживаемой зоне / in a serviced area.							
		(8) для холодного и переходного периода года (температура наружного воздуха ниже 10° C)				(9) для теплого периода года (температура наружного воздуха 10° C и выше)							
(13) Производственные с незначительными избытками явного тепла [20 ккал/(ч·м³) и менее]	Легкая Light	17–22	75	0,3	15–22	(10) Не более чем на 3° C выше расчетной температуры наружного воздуха (расчетные параметры А), но не выше 28° C	55	60	65	70	75	0,3–0,5	Не более чем на 3° C выше расчетной температуры наружного воздуха (расчетные параметры А) (12)
	Moderate Средней тяжести	15–20	75	0,5	13–20		55	60	65	70	75	0,3–0,7	То же The Same
	Тяжелая Hard	13–18	75	0,5	12–18	То же, но не выше 26° C (11)	—	—	65	70	75	0,5–1	»
(14) Производственные со значительными избытками явного тепла [более 20 ккал/(ч·м³)]	Легкая Light	17–24	75	0,5	15–26	(15) Не более чем на 5° C выше расчетной температуры наружного воздуха (расчетные параметры А), но не выше 28° C	55	60	65	70	75	0,3–0,7	Не более чем на 5° C выше расчетной температуры наружного воздуха (расчетные параметры А) (16)
	Moderate Средней тяжести	16–22	75	0,5	15–24		55	60	65	70	75	0,5–1	То же
	Тяжелая Hard	13–17	75	0,5	12–19	То же, но не выше 26° C (11)	—	—	65	70	75	0,5–1	»
(17) Помещения общественных и жилых зданий, вспомогательные помещения производственных зданий и помещения вспомогательных зданий предприятий	—	18–22	65	0,3	—	Не более чем на 3° C выше расчетной температуры наружного воздуха (расчетные параметры А) (12)	≤65					≤0,5	—

[Key to Table 1.1.]:

1. Air temperature, °C;
2. Relative humidity, in percent, no more than;
3. Air velocity, m/sec, no more than;
4. Air temperature outside permanent work positions, °C;
5. Relative air humidity in percent, no more than, at an air temperature temperature of, °C;
6. Air velocity, m/sec;
7. At permanent work positions or in a serviced area;
8. For the cold and transition seasons of the year (outside air temperature below 10° C);
9. For the warm season of the year (outside temperature of 10°C and above);
10. No more than 3° C above the design temperature of the outside air (design parameters A), but not above 28° C;
11. The same, but not above 26° C;
12. No more than 3° C above the design temperature of the outside air (design parameters A);
13. Production [rooms] with minor excesses of explicit heat [20 Kcal/ /(h · m^3) and less];
14. Production [rooms] with considerable explicit heat surpluses [more than 20 Kcal/(h · m^3)];
15. No more than 5° C above the outside air design temperature (design parameters A), but no more than 28° C;
16. No more than 5° C above the outside air design temperature (design paremeters A);
17. The rooms of public and residential buildings, auxiliary rooms of production buildings and the rooms of auxiliary buildings of enterprises.

In rooms which are characterized by considerable emissions of moisture, an increase in the relative air humidity as compared to that indicated in Tables 1.1. and 1.2. is permitted at permanent work positions for the warm season of the year. Those moisture emissions are considered to be significant for which the heat-humidity ratio ε, i.e., the ratio of the total amount of explicit and latent heat to the amount of liberated moisture is less than 2,000 Kcal/kg. In the case of a heat-humidity ratio of less than 2,000 Kcal/kg, but more than 1,000 Kcal/kg, it is permissible to increase the relative air humidity by a maximum of 10%, and with a ratio ε less than 1,000 Kcal/kg, by a maximum of 20%, but in both cases, the relative humidity should be no higher than 75%. In this case, the air temperature in a room should not exceed 28° C in the case of light or moderate work and 26° C with hard work.

In localities with an outside air design temperature below 20° C (design parameters A in the warm season of the year), it is permissible when calculating air changes for production rooms with minor surpluses of explicit heat to assume an air temperature at permanent work positions 5° C above the outside air temperature, but no higher then the values of the lower limit of the optimum temperature for the inside air, given in Table 1.3. In this case, the relative humidity of the air should not exceed 75%.

TABLE 1.2.

The Permissible Standardized Climatic Conditions for the Warm Period of the Year in the Work Area at Permanent Work Positions in the Production Rooms of Buildings and Facilities Planned for Localities with a Design Outside Air Temperature (Design Parameters A) Above 25° C (for Light and Moderate Work) or Above 23° C (for Heavy Work)

(1) Характеристика производственных помещений	Temperature Температура, °C °C	(2) Относительная влажность, %, не более, при температуре воздуха, °C									
		33	32	31	30	29	28	27	26	25	≤24
(3) С незначительными избытками явного тепла [20 ккал/(ч·м³) и менее]	(4) Не более чем на 3° C выше расчетной температуры наружного воздуха (расчетные параметры А), но не выше 31° C	-	-	55	55	55	55	60	65	70	75
(5) Со значительными избытками явного тепла [более 20 ккал/(ч·м³)]	(6) Не более чем на 5° C выше расчетной температуры наружного воздуха (расчетные параметры А), но не выше 33° C	55	55	55	55	55	55	60	65	70	75
(7) По технологическим условиям требуется поддержание температуры и относительной влажности воздуха независимо от величины избытков явного тепла	(8) Не более чем на 2° C выше допустимой по табл. 1.1, но не выше 30° C	—	—	—	55	55	55	60	65	70	75

[Key to Table 1.2.]:

1. The characteristic of the production rooms;
2. Relative humidity in percent, no more than, at an air temperature of, ° C;
3. With minor explicit heat excesses [20 Kcal/(h • m^3) and less];
4. No more than 3° above the outside air design temperature (design parameters A), but no higher than 31° C;
5. With considerable excesses of explicit heat [more than 20 Kcal/ /(h • m^3)];
6. No more than 5° C above the outside air design temperature (design parameters A), but no higher than 33° C;
7. Based on technological conditions, it is necessary to maintain the temperature and relative humidity of the air indiependent of the amount of explicit surplus;
8. No more than 2° C above that permitted in Table 1.1., but no higher than 30° C.

The air parameters in a serviced area in public and residential buildings indicated in Table 1.1. for the warm season of the year apply to rooms for which it is necessary to determine the air changes on the basis of design calculations in accordance with the appropriate chapters of the SNiP (for example, theaters, restaurants, and auditoriums). The permissible parameters for the inside air in the production rooms of public buildings (for example, in kitchens, bakeries, laundries, etc.) are to taken from Tables 1.1. and 1.2. just as for the production rooms of industrial enterprises.

The optimal conditions given in Table 1.3. characterize the combinations of temperature, relative humidity and speed of air motion which are most favorable for the comfort of the majority of normally clothed people. The optimal air parameters are determined by the nature of the work, being performed by a person, and differs somewhat for the cold and warm seasons because of the fact that during these periods, people dress differently and experience different outside influences.

The conditions indicated in Table 1.3. are optimum ones when people are present in a room for no less than two hours, regardless of the outside air temperature. When people are present in a room for a short time (less than two hours), it is recommended that the optimal temperature during the warm season be chosen above that indicated in the Table by the amount of 0.4° C for each degree of the outside air design temperature above 30° C.

It is recommended that the optimal parameters of the air medium be maintained for the following rooms of public and residential buildings: 1) Operating rooms, delivery rooms, newborn wards, postoperative wards and wards for patients requiring special monitoring, in hospitals of categories one, two and three; 2) Auditoriums and foyers of theaters; 3) Auditoriums of movie theaters, clubs and houses of culture with 600 and more seats; 4) The dining rooms of category one restaurants and dining halls with 250 and more seats; 5) The sales areas of large stores with 75 and more work positions; 6) Part of the hotel rooms for hotels with 500 and more rooms.

In picture galleries, museums, book repositories and archives of unionwide significance, the optimal parameters are likewise to be chosen as the design conditions in the absence of special requirements based on the internal conditions to assure good preservation of cultural and artistic valuables.

It is also obligatory to maintain the optimum parameters for the air medium. which correspond to light work (see Table 1.3.), in rest period rooms for workers and within the confines of limited sections intended for taking a break close to the work position.

Besides the cases enumerated above, the use of optimal or close to optimal parameters for air is recommended with additional expenses are not incurred in maintaining them (for example, the use of air conditioning during the warm season of the year) or if the technical and economic expediency of additional capital outlays and operating expenses related to the maintenance of

TABLE 1.3.

The Optimal Standardized Climatic Conditions in the Work Area at Permanent Work Positions of Production Rooms and in a Serviced Area of Public and Residential Buidling Rooms, as Well as the Auxiliary Rooms and Buildings of Enterprises

Room Characteristics Характеристика помещений	Work Category Категория работы	(1) Темпера-тура воз-духа, °С	(2) Относитель-ная влаж-ность возду-ха, %	(3) Скорость движения воздуха, м/с	(1) Температура воздуха, °С	(2) Относитель-ная влаж-ность возду-ха, %	(3) Скорость движения воздуха, м/с
		(4) Для холодного и переходного периода года (температура наружного воздуха ниже 10° С)			(5) Для теплого периода года (температура наружного воздуха 10° С и выше)		
(6) Производственные независимо от величины избытков явного тепла	Легкая 8.	20—22	60—30	≤0,2	22—25	60—30	0,2—0,5
	Средней тяжести 9.	17—19	60—30	<0,3	20—23	60—30	0,2—0,5
	Тяжелая 10.	16—18	60—30	<0,3	18—21	60—30	0,3—0,7
(7) Помещения общественных и жилых зданий, вспомогательные помещения производственных зданий и помещения вспомогательных зданий предприятий	—	20—22	45—30	0,1—0,15	22—25	60—30	<0,25

Key:
1. Air temperature, ° C;
2. Relative air humidity, percent;
3. Air velocity, m/sec;
4. For cold and transition seasons of the year (outside air temperature below 10° C);
5. For the warm season of the year (outside air temperature of 10° and above);
6. Production [rooms] independent of the amount of explicit heat surplus;
7. The rooms of public and residential buildings, residential rooms of production buildings and the rooms of the auxiliary buildings of enterprises;
8. Light [work];
9. Moderate;
10. Hard.

such parameters in the rooms are justified by scientific research, accumulated experimental material and the appropriate calculations.

Regardless of the climatic conditions adopted in the designs, the content of harmful gases, vapors or dust in the air of the work area of rooms should not exceed the maximum permissible concentration given in SN 245-71 and supplements to the list of harmful agents, periodically published by the USSR Ministry of Health and the USSR Gosstroy.

1.3. The Assurance of the Thermal Internal Design Conditions

The thermal internal design conditions are determined by the combination of the inside air temperature, t_v, the room radiation temperature, t_r, the temperature of the individual heated and cooled surfaces (panels) in a room τ_p, the mobility v_v and the relative humidity ϕ_v of the inside air. Standardized values are given in Tables 1.1.-1.3. for t_v, v_v and ϕ_v in a work area of production rooms and in a serviced area of the rooms of public and residential buildings.

The first comfort condition. The environmental comfort temperature in rooms (during the warm season of the year) with large areas of heated (outside barriers) or cooledsurfaces (a radiative cooling system) is determined by the condition:

$$t_r = 1.5t_p - 0.5t_v \pm 1.5 \quad (1.18)$$

where t_p is the standardized room temperature taken as equal to t_v in Tables 1.1.-1.3.

The second comfort index condition. The permissible temperature of the inside heated surfaces of outside barriers (usually walls of a southern, eastern or western exposure, as well as roofs) is determined from the formula:

$$\tau_p^{per} \leq 28 + 2.7/\phi_{ch-p} \quad (1.19)$$

where ϕ_{ch-p} is the radiative coefficient (from the surface area element of a person onto a heated surface).

For the cooled surfaces of radiative cooling systems, the permissible temperature should be:

$$\tau_p^{per} \geq 23 - 5/\phi_{ch-p} \quad (1.20)$$

The specifications assurance factor for the interior design conditions. Depending on the function of rooms and the level of the requirements placed on the constancy of the interior conditions, deviations of these conditions from the design conditions are permitted with differing frequency and duration. The specifications assurance factors $k_{ob\ n}$ according to the number of cases of the absence of deviations, n) and $k_{ob\Delta z}$ (according to the duration of the absence of deviations Δz) are defined by formulas (2.8) and (2.9), as well as by Table 2.3. in part I of this handbook ("Heating, Water Piping, Ducting", Moscow, Stroyizdat Publishers, 1975).

Twenty-four hour days are used as the standard case in the determination of $k_{ob\ n}$ for the warm season of the year; the duration of the warm season is equated to the length of the calendar summer.

TABLE 1.4.
The Temperature Difference $t_v - \tau_p$

(1) Характеристика воздуха для вентиляции помещения	Средняя разность температур, °C, при продолжительности работы системы, ч/сут, около (2)		
	8	16	24
Необработанный (3)	1,5—1	1—0,6	0,6—0,3
Адиабатически увлажненный (4)	2,5—1,8	1,8—1	1—0,5
Искусственно охлажденный (5)	4,5—3	3—2	2—1,5

Key: 1. The characteristic of the air for room ventilation;
2. The average temperature difference, in ° C, where the duration of system operation is approximately the following in hours per day:;
3. Unprocessed;
4. Adiabatically humidified;
5. Artificially cooled.

The specific features of heat exchange in a room. The complex radiative and convective heat exchange at heated and cooled surfaces in a room are analyzed using the recommendations given in section II, part I of this handbook ("Heating, Water Piping, Ducting", Moscow ,Stroyizdat Publishers, 1975).

When determining the averaged value of the convective exchange α between the air t_v and the surfaces τ_n facing into the room, it is recommended that the average temperature difference $t_v - \tau_p$ be taken from Table 1.4.

CHAPTER 2. THE THERMAL MODE OF A BUILDING. THE ENTRY OF HEAT AND MOISTURE INTO A ROOM

2.1. General Principles

Materials are presented in this chapter for the calculation of the summer time thermal mode of buildings (the winter time thermal mode was treated in part I of the handbook). Included among the specific features of the summer time thermal mode are the simultaneous action of solar radiation and outside air on a building, as well as the daily periodicity of the entery of heat into a room, which is due to the non-steadystate nature of all of the heat ex change processes, which complicates the maintenance of the specified interior conditions in the room.

One of the tasks in planning microclimate conditioning systems consists in the design of the requisite thermal mode of the building for the case of various ways of maintaining it. Finding the most efficient and economic solution is accomplished in this sequence: 1) The design (permissible or optimal) interior thermal conditions and the extent of the provisions necessary for them are established; 2) The design parameters of the outside climate are defined; 3) Heat intrusions through outer barriers, household and industrial heat and moisture emissions are calculated and the heat balance sheet is drawn up for the room; 4) The possibility of assuring the requisite inside conditions by means of a natural mode with various structural and plan solutions for protection against overheating and ventilation is checked by design calculations; 5) Otherwise, the necessity of system equipment for controlled air conditioning is established; 6) The design capacity andcontrol mode of the conditioning system are defined, which assure the maintenance of optimal conditions in the room.

The following are taken into account when drawing up the thermal and humidity balance sheets for a room: a) Heat incoming from production equipment, electric motors, artificial lighting, heating devices, as well as the arrival (or removal) of heat from heated (or cooled materials or semifinished products, as well as from chemical reactions; b) The liberation of heat and moisture by people; c) The intrusion (or loss) of heat through exterior and interior bariers; d) The entry of solar radiation heat through light transparent barriers; e) The liberation or absorbtion of moisture, something which is accompanied in many cases by the absorption or liberation of heat.

As was indicated, the thermal and humidity balances in a room change with time. The first task of the design calculation consists in determining the maximum of the surplus of heat or heat and moisture in a room a the design parameters of the outside air for the warm period of the year, since this quantity serves as the basis for the selection of ventillation or air conditioning system capacity and the design calculations for the system networks. The second task of the design calculation consists in determining the least surpluses or the greatest surpluses of heat and the corresponding moisture surpluses at the design parameters at the outside air for the cold period of the year, which serve for the calculation of the air changes during this season, as well as for the calculation of the loads on air heaters and the heat mains.

In some cases, it is also necessary to compare the thermal and humidity balances of a room at outside air paramters which correspond to the conditions of the transition period of the year. Surpluses of heat, or heat and moisture, in such situations determine the air changes in a room in the transition period of the year; this air exchange is frequently held constant during the cold season.

Heat losses through outside barriers during the cold season of the year are computed on the assumption of a steady-state or nonsteady-state thermal mode (chapter 3 and II in part 1 of this handbook).

In conventional design practice, the entry of solar radiation heat is taken into account at outside air temperatures of 10° C and above.

In the majority of cases, the capacity of ventilation and air conditioning systems, and consequently, the outlays for their construction and operation, are determined by the surpluses of heat or heat and moisture in a room during the warm season of the year. To reduce industrial heat and moisture emissions, insulation and encapsulation of equipment and ducts which liberate heat is to be employed, through duct work beyond the bounds of the rooms being air conditioned are to be eliminated, jackets and shields cooled by water and air are to be set up for the equipment, closed air cooling is to be provided for electric motors, and other steps are to be taken in accordance with the local conditions.

CHAPTER 3. THE ENTRY OF HARMFUL SUBSTANCES INTO A ROOM

3.1. General Principles

Reductions in the concentrations of harmful substances in the air of a work area of a production room down to the maximally permissible levels indicated in sanitation standards SN 245-71 are primarily achieved by industrial measures to reduce the emissions of the harmful substances and local vents. Harmful substances which penetrate into a room are removed by the general exchange ventilation system. The maximum quantity of harmful substances, which can be permitted into the air of a production room are established by working from the technical capabilities of the overall air change ventillation.

With an increase in the air changes per hour, the solution of the air delivery problem becomes more complicated and the air mobility increases in the work area as well as the turbulent transfer of harmful substances. In the case of high rate of air changes per hour, uncomfortable climatic conditions can be created and the entry of harmful substances into the room air can increase due to the intensification of evaporation, the degredation of the effect of local vents and the stirring up of settled dust, and also, as a consequence, the quantity of harmful substances ejected into the atmosphere increases.

Based on practical experience, it is recommended that the maximum number of air changes per hour be considered as 20 hr^{-1}, while the most acceptable figure for a production room for the air change rate runs from 4 to 12 hr^{-1}. In line with this, the entry of any harmful substance which does not have a summation effect into the air of a production room should not exceed the following, in g/hr:

$$G_{max} = \frac{20}{1000} V_p (C_{pdc} - C_{pr}) \qquad (3.1)$$

where V_p is the volume of the production room, m^3; C_{pdc} is the maximum permissible concentration of the harmful substance in accordance with SN 245-71, mg/m^3; C_{pr} is the concentration of the harmful substance in the air inflow, mg/m^3; for preliminary calculations, one can assume that $C_{pr} = 0.3\ C_{pdc}$.

If in the sealing and local vent units, the entry of harmful substances into a room exceeds G_{max} and it is not possible to reduce it down to this level, then the industrial equipment must be enclosed in a housing with an offtake for controlling it in individual rooms (people are not inside the housing enclosures while the industrial process is underway).

The quantity of harmful substances emitted into the air of production rooms is taken from the data of process engineers and is indicated in the industrial process portion of the plan as maximum value at which the industrial process can be considered to be running normally.

In the industrial portion of the plan, provisions should be specified for effective means of preventing an increase in the emissions of harmful substances above the levels indicated for the ventilation design.

In individual cases, the quantity of harmful substances emitted in a production room can be determined by calculation (see section 3.2), based on the data of full-scale studies of similar enterprises (see section 3.3), on based on the data of health and sanitary engineering characteristics given in the data sheets for the industrial equipment. In this case, the amount of harmful substance determined by one of these methods should be confirmed by process engineers and specified in the industrial portion of the plan, where it is necessary to provide for measures which preclude this level being exceeded during the operation of the industrial equipment.

In the absence of data on the emissions of harmful substances, it is permissible to determine the quantity of ventilation air from the air changes per hour figure, specified in the standards documents approved and coordinated in the established procedure (see section 3.3).

The expediency of installing more expensive sealing equipment with a lower level of harmful substance emissions can be demonstrated by economic design calculations in which the referenced outlays for sealing and ventilation are compared.

As a rule, the supply air is fed to the work area, while the exhaust is taken from the area with the greatest concentrations of harmful substances (see section 3.4).

CHAPTER 4. CLEANING DUST OUT OF VENTILATION AIR

In the rooms of industrial, residential and public buildings, dust is combated by means of preventing its intrusion from without, and removing the dust formed in the rooms themselves. The outside and recirculated air delivered to rooms is cleaned in air filters, while the rooms themselves are isolated where necessary, by sealing cracks in window openings and creating aerodynamic locks in door entrances. An effort is to be made to reduce dust formation in production rooms by the appropriate choice or humidification of the raw materials, the materials being processed and transported or through the use of technological processes and equipment which are refined to the greatest extent in an environmental sanitation sense. The remaining sources of dust emission are localized by means of local vents which prevent its spreading.

Dusty air which is removed by local vents of aspiration systems is cleaned in dust traps to prevent polluting the atmosphere.

Vacuum cleaning the rooms, blowing out and dusting off special clothing are numbered among important dust removal measures.

CHAPTER 5. THE AERATION DESIGN OF INDUSTRIAL BUILDINGS

5.1. General Principles

Building aeration is the term for organized and controlled natural ventilation. Aeration is accomplished with aerostatic and wind pressures. Aeration is used in shops with considerable quantities of liberated heat if the concentration of dust and harmful gases in the supply air does not exceed 30% of the maximum in the work area. Aeration is not used if it is necessary to process the supply air beforehand or because of production technology conditions, or if the inflow of outside air produces fog or condensate.

Openings are made in the outer walls, positioning them at a height of 0.3 - - 1.8 m from the floor for the intake of outside air in the warm period of the year in single and double bay shops; the supply openings can be arranged in two levels or more in the longitudinal walls of the building which should be free of built-on additions. Gates, movable walls and openings into the floor of a room are also used as intake openings (with the passage of outside air through basements, ventilation floors or via special channels). Openings for the intake of outside air during the transition and cold seasons are made in outer walls, by positioning the openings in shops less than 6 m high at a height of no less than 3 m from the floor (in this case, the openings are equipped with deflectors or structural components which divert the supply air upward at an angle), and in shops more than 6 m high, at a height of no less 4 m from the floor.

For the supply of outside air in multiple bay shops, openings are made in the outer walls, as well as skylights in the "cold" bays, which should alternate with the "hot" ones, where the cold bays are separated from the hot ones by barriers lowered from above which clear the floor by 2 - 4 m.

Blowerless aeration (Figure 5.1) and light and aeration skylights or shafts are built in to remove air from an aerated room. It is permissible to use blowerless aeration openings in the upper portion of exterior walls to remove air. Wind protection panels cannot be made in П-shaped skylights (see Figure 5.1b) if the building being aerated is protected on the windward side by a higher building, where the spacing between the buildings does not exceed five times the height of the higher building, and if the flaps on the outside of the end skylight are closed, and the distance between the centers of the skylights which are identical to the end skylights does not exceed five times the skylight height.

The door flaps of aeration openings should be equipped with mechanisms for opening and closing them. The opening mechanisms are provided by the structural portion of the project plan, and data on them are given in the designer's handbook, "Metal Structural Designs of Industrial Buildings and Structures".

The methods of aeration design presented below take into account the temperature layering of the air with respect to height which occurs in aerated buildings. The air which is heated by heat liberating forces rises to the roof and part of it is eliminated through the skylight openings, while part accumulates in the upper region of the room, forming a "thermal cushion". The lower boundary of the thermal cushion, called the "temperature ceiling", conventionally splits the room into two zones: a lower one at a temperature equal to the air temperature in the work area, and an upper one at a temperature equal to the temperature of the air being removed.

Knowledge of the height at which the temperature ceiling temperature is located permits the calculation of the aeration taking into account temperature values for the air in each of the zones.

CHAPTER 6. The Specific Features of the Ventilation of Buildings for Various Purposes

6.1. Residential and Public Buildings, Auxiliary Buildings and the Rooms of Industrial Enterprises

A. General Principles

The choice of the ventilation scheme to produce an air medium in rooms which satisfies the established sanitation engineering standards and industrial requirements, depends on the function of the building, number of stories, and the kinds of harmful emissions. The air changes per hour for the determination of the ventilation air volumes of the majority of rooms are established by the chapters of the SNiP and are given below. If the air changes per hour for the room under consideration are not established by the SNiP, the ventilation volume is determined by calculations in accordance with the specifications of section 1.7, A.

To assure the requisite climatic conditions (temperature and humidity) during the cold and transition seasons, and the excess pressure in rooms of three and more story public buildings, which are located in the regions of the northern construction-climatic region, mechanically driven air supply systems are to be designed. The amount of air supply in this case should exceed the organized exhaust in the amount of no less than one air change in a room per hour.

Naturally driven ventil ation systems are designed taking into account gravitational pressure due to the difference in the specific weights of internal air at a temperature corresponding to that standardized for the cold period of the year and external air at a temperature of 5° C. The wind pressure is taken into account only when designing protection against blowing for ventillation openings and shafts.

The use of air recirculation in public buildings and in the aurxiliary buildings and rooms of industrial enterprises is regulated by the appropriate chapters of SNiP. It is permissible to provide air recirculation in residential buildings only within the confines of a single apartment or room.

For public and residential buildings, as well as for the auxiliary buildings of industrial enterprises, the feed of intake air is planned directly into those rooms for which the design calculations are made. It is permissible to provide for the feed of intake air into the corridors of residential and public buildings, as well as the auxiliary buildings of indust al enterprises, if the air changes per hour are established in the rooms by the standards documents only with respect to exhaust (with the exception of bathrooms) and does not exceed 1.5 hr^{-1}. In this case, grates and openings for the entry or overflow of air are not to be designed into the barrier structures between adjacent rooms or rooms and corridors.

When planning ventilation, the unorganized supply of outside air to production rooms to compensate for the exhaust during the cold season of the year is taken as a volume of no less than 1 hr^{-1}.

For the rooms of residential buildings, hospitals and administrative buildings, the velocity of the air exhaust from air distributors, as well as in the exhaust openings in the absence of local noise suppressors, is limited to 3 m/sec.

For residential and public buildings, as well as for the auxiliary buildings of industrial enterprises, air removal is planned from the upper zone, with the exception of those cases stipulated by the SNiP.

When planning ventillation with mecahnical drive, air conditioning and air heating in buildings of the indicated designation (with the exception of preventive medicine and medical facilities) where the number of floors is more than three, systems having a common vertical intake (or exhaust) main air duct (or collector) are to be provided. The collector can join vertical branches for the individual floors together for no more than 10 floors. When planning naturally driven exhaust systems, the collector can join together no more than 25 floors (see Figure 20.4).

The individual floor branches should be connected to the vertical collector beneath the ceiling of the stories above and below with respect to the floor being serviced.

It is likewise permissible to combine the floor by floor vertical intake (or exhaust) air ducts of two to five story buildings in one horizontal collector, while for multistory buildings, in several horizontal collectors. In the latter case, the air ducts for no more than five floors are connected to each horizontal collector.

For the rooms of notarial offices, information bureaus, kiosks, legal cons 1-tation offices, rooms for mothers and children, savings banks and cash receipt offices, built in to the first stories of residential buildings, it is permissible to connect the air ducts of exhaust ventilation systems which are naturally driven to the collectors of exhaust ventilation systems intended for sanitary engineering units and kitchens of the higher floors of the residential buildings.

It is not permissible to place the horizontal collectors which combine the air ducts from various floors in corridors, stairwells and other rooms serving as evacuation routes of people from the building.

In buildings 10 and more stories high, a system of self-closing check valves is to be provided in the inidvidual story exhaust air duct branches of the two top stories when they are connected directly to the horizontal collector above them.

CHAPTER 7. AIR CONDITIONING

7.1. General Principles

Air conditioning in rooms provides for the creation and maintenance in them of:

a) The permissible conditions for the air medium established by the standards, if they cannot be assured by simpler means;

b) Artificial climatic conditions in accordance with industrial requirements within rooms or a portion of them around the clock or during the warm or cold season of the year;

c) Optimal (or close to optimal) health conditions of the air medium in production rooms, if this is economcially justified by the increase in labor productivity;

d) Optimal conditions of the air medium in rooms of public and residential buildings, as well as in the auxiliary buildings of industrial enterprises.

Air conditioning (KV), which can be produced to create and maintain the permissible or optimal conditions of an air medium, is called comfort conditioning, while artificial climatic conditions in accordance with industrial requirements is called technological conditioning.

Air conditioning systems should provide for the standardized climatic parameters and air purity within rooms at B design parameters of the outside air for the warm and cold seasons in accordance with SNiP II-33-75. It is permissible to design KV systems using the V outside air parameters to satisfy industrial requirements or when technically and economically justified.

Air conditioning is accomplished by a complex of technical equipment, called an air conditioning system (SKV). Included the complement of an SKV are the equipment for preparing, transporting and distributing the air, preparing cold, as well as the equipment for heat and cold supply, automation, remote control and monitoring. The technical equipment for SKV's is completely or partially put together in units called air conditioners, as well as in assemblies which are called air heaters for local heating, humidifiers, mixers and finishers.

The design climatic conditions in the work area of production rooms, and in the serviced area of public and residential buildings, as well as the residential buildings of industrial enterprises, should be chosen subject to the data given in Table 1.1.

For many years, one of the criteria for assessing climatic conditions in public and production rooms, for people in close to a rest state or performing light work in a sitting position was the normal equaivalent effective temperature (EET). The EET did not take into account the radiation factor and were established on the basis of a comparison of the heat perception of people under selected conditions with their heat perception in a room with 100% humidity. The latter is not characteristic of actual conditions. The enumerated drawbacks of the EET let the fact that this criterion ceased to be considered, and in design practice, when determining the comfort conditions, the stipulations of SNiP II-33-75 or the data of special research and instructions are used.

Based on the data of the Institute of General Municipal Public Health imeni A.N. Sysin of the USSR Academy of Medical Sciences, the optimal parameters in service (or office) rooms as applied to the II climatic zone are as follows: in the cold season, a temperature of 21-22° C at a relative humidity of 30-45% and a rate of air motion of 0.1 m/sec, and in the warm season, a temperature of 22-25° C at a relative humidity of 30-55% and a rate of air motion of 0.15 m/sec.

According to the ASHRAE 55-56 standard (US), thermal comfort is defi d as the "state of a person satisfied by the ambient conditions at which he does not know whether he wants to change the environmental conditions, making them either warmer or colder." The parameters which satisfy 80% of healthy, normally clothed people, performing light work in a sitting position, based on the data of this standard, are as follows: a dry thermometer temperature t_s of 23-25° C, a mean radiation temperature t_i of 21-27° C, a relative humidity of 20-60%, air movement of 0.05-0.23 m/sec, when the following conditions are met: for the given room, the maximum dry thermometer temperature fluctuations are $\Delta t_c = \pm 1°$ C, the radiation temperature fluctuates by $\Delta t_i = \pm 0.8°$C, and for the humidity, $\Delta\phi = \pm 10\%$.

When people are present for a short time in rooms (cafes, restaurants, stores, etc.) during the warm season of the year, the comfort conditions depend on the outside temperature, since the great difference between the inside and outside temperature produced unpleasant sensations and can lead to catching a cold; in the case of outside temperatures above 30° C, it is recommended that the requisite air temperature in these rooms be determined from the following formulas:

for an exposure time of up to 2 hours:

$$t_{2h} = t_p + 0.4(t_n - 30); \tag{7.1}$$

for an exposure time of up to 1 hour:

$$t_{1h} = 1.04[t_p + 0.4(t_n - 30)], \tag{7.2}$$

where t_p is the optimum temperature where people are present in the room for a long time (see Table 1.1); $t_n > 30°$ C is the outside air temperature (during the warm season).

The air humidity in rooms where people are present for a short period of time should not exceed 60%.

Modern equipment for regulating SKV's provide for a specified air temperature at the point where the sensor is installed with extremely high precision (usually $\pm$ 0.3%), but at other points in the room, considerable deviations from this temperature are possible, where the degree of temperature equality depends primarily on the uniformity of the distribution of the heat sources, the method of system organization and the air change rate in the room.

Comfort conditions can be estimated from the ASHRAE 55-56 standard, and if this does not contradict SNiP II-33-75, one can work fro m the "effective draft temperature", defined by the formula:

$$\theta = t_x - t_c - 7.66(v - 0.1524), \tag{7.3}$$

where θ is the index of Nvis and Ward; t_x is the dry thermometer air temperature of the given point in a room, °C; t_c is the dry thermometer temperature in the room, °C; v is the rate of air motion at the given point, m/sec.

Based on the comfort conditions, the value of θ should fall within a range of:

$$-1.67 < \theta < 1.11 \quad (7.4)$$

for a velocity v from 0 to 0.36 m/sec.

For example, if it is given that $t_x = 24°C$, $t_c = 23°C$ and $v = 0.3$ m/sec, then $\theta = 24 - 23 - 7.66\ (0.3 - 0.1524) = 0.13$, which satisfies the comfort conditions.

It is recommended that the air temperature fall off going from the floor to the ceiling to maintain the comfort conditions in the serviced zone, however, it is also permissible to increase the temperature by no more than 2°C within the height range of person.

The floor temperature when walking should not exceed 25°C, and for people in a state of rest, 28°C. Radiation directed towards the head produces discomfort.

The industrial requirements as regards maintaining the temperature, humidity and rate of air motion are to be limited by the permissible climatic parameters in the work area of production rooms (see Table 1.1).

The optimum air parameters for several rooms are given in Table 7.1.

CHAPTER 8. AIR DISTRIBUTION IN A ROOM

8.1. The Calculation of Turbulent Supply Streams

The supply air for ventilation, heat and cooling rooms is distributed in them, as a rule, by turbulent streams having a temperature below or above the air temperature in these rooms, where the development of the streams is usually constrained by the room barriers. Such streams are called noniso-thermal and constrained. Isothermal streams having the same temperature as the air in the rooms are rarely used. Compact supply streams have parallel velocity vectors during outflow. Fan-shaped streams have velocity vectors during outflow which make a certain angle with each other. Twisted streams run in a spiral during outflow.

8.3. General Recommendations for Air Distribution

1. When selecting the scheme for the air feed into a room (see Figure 8.1) from those permitted by paragraphs 4.83 and 4.84 of SNiP II-33-75, their

characteristics are to be taken into account as expressed by the air change effectiveness factor $K_{ef} = \Delta t_u/\Delta t_{o \text{ or } r.z.}$ (here Δt_u and $\Delta t_{o \text{ or } r.z.}$ are the temperature difference of the air exiting the room or the air in the O or the RZ and the air coming into the room from the air distributor) (Table 8.26), and the capabilities of assuring uniformity of the parameters O or RZ with respect to the area are also to be taken into account: scheme I is characterized by the maximum K_{ef}, but by the greatest nonuniformity of the parameters with respect to the area; schemes II or III, in the case of air output close to the overlap by the streams which decay outside O or RZ ("concentrated feed"), is characterized by the lowest K_{ef} with relatively satisfactory uniformity of the parameters with respect to the area; scheme III, for the case of air output at a level of 3-4 m from the floor in horizontal or downward sloped streams (up to 30° with respect to the horizontal) is characterized by a high K_{ef} with good uniformity of the parameters with respect to area; schemes IV, V and VI are characterized by a high K_{ef}, which falls off in step with the increase in the distance from the floor to the air distributor, as well as by good uniformity of the parameters with respect to area.

2. Air distributors are to provide for an installation, as a rule, in a complete set with attachments which permit changing the direction of the air stream produced in the room (paragraph 4.136 of SNiP II-33-75), and when justified, also with accessories for regulating the amount of air produced (paragraph 4.137 of SNiP II-33-75), in which case the presence of devices for controlling the amount of air is obligatory for residential rooms, preventive medicine and medical rooms, children's institutions and other public buildings.

3. The air velocity in a channel supplying air to an air distributor mounted on its wall should be taken as less than the velocity in the live cross-section of the air distributor or provide for vanes which direct the air from the channel into the air distributor. Otherwise, only part of the air distributor will function as an air output, and through the remaining part, air will be sucked from the room.

4. To equalize the flow when it is delivered to an air distributor, it is necessary to provide for equalizing vanes. The length of these vanes should be equal to twice (but no less than one and a half times) the spacing between them. In the case of tangential air delivery to plafonds, one does not have to install equalizing vanes if the diameter of the plafond throat is equal to or less than 25% of the diameter or width of the air duct.

5. Valves which regulate air consumption are to be positioned at such a spacing from the air distributors that they do not disrupt the structure of the air flows delivered to the air distributors during the regulation process.

6. It is recommended that the air velocities in supply (or exhaust) recirculation branches or grates be chosen as a function of the level at which they

are positioned and the production noise in the rooms, being governed by the instructions in Chapter 17.

7. Air ducts and air distributors are to be designed, taking into account the possibility of the redistribution of the air with respect to that provided by the plan, when debugging the system.

8. The distribution of the air must be computed on the basis of the maximum loads and the permissible air velocities, corresponding to the warm season of the year, and by checking it for the cold season conditions.

9. Recirculation and exhaust openings are to be positioned so that the intake flares have no direct influence on closely located O or RZ sections, but where possible, amplify the air motion in stagnant zones and rooms, equalizing the temperature and humidity there.

10. When exhaust openings are located in the floor, it is necessary to provide for the capability of cleaning the channels beneath them of dust. Bottom removal of air is effective in those cases where the exhaust openings are located close to poorly heated heat sources. The correct organization of air removal can reduce the used capacity of the system by 15-30%.

CHAPTER 9. AIR BATHS

9.1. Air Bath Equipment

A. General Principles

Air bathing is the most effective measure in creating the requisite climatic conditions at permanent work positions (temperature, humidity and rate of air motion). The use of air baths is especially effective when workers are subject to thermal irradiation: at industrial furnaces, during operations with heated castings and blanks, with molten metal, etc.

Air bathing is employed in the following cases: a) When a worker is exposed to thermal irradiation of an intensity of 300 Kcal/(h • m^2) and more, as well as 150-300 Kca./(h • m^2) where the area of the irradiating surfaces within the confines of the work position is more than 0.2 m^2; b) In the case where the air in the work area is heated by convective heat up to a temperature above that established by the SNiP; c) In the case of open production processes with the emission of harmful gases or vapors, and where it is impossible to have local covers.

An air bath is set up at the long term position of a worker, as well as at locations for brief work breaks.

In the case of air baths, one can feed outside or inside air with its processing in permanent chambers (cleaning and cooling), or internal air by means of rotating (recirculation) aerators.

The cooling effect of an air bath depends on the difference between the temperature of the workers's body and the air flow, as well as on the velocity of the air flow around the body being cooled.

When streams exiting an opening are mixed with the ambient air, the velocity, the temperature difference and the concentration of impurities in the cross-section of a free stream all vary. The stream should be directed so that, where possible, it is prevented from picking up the hot or contaminated air with the gases. For example, when a permanent work position is located close to an open furnace opening, the air bath unit should not be placed near the opening with the stream directed towards the worker, since in this case, it is impossible to avoid sucking up hot gases, because of which, overheated air will get to the worker.

When air bathing is used, air bath devices are to be employed having a low coefficient of turbulence, since this has a substantial influence on the air consumption and the requisite extent of its cooling. Devices with cylindrical or conical nozzles have the least turbulence, however, the angle of stream expansion, and consequently, the work area they take in are small. Rotating aerators provide for relatively uniform velocities in the air flow and a broader service zone, however at temperatures above 28° C, their cooling effect falls off substantially.

CHAPTER 10. AIR CURTAINS*

10.1. General Principles

Air or air-heat curtains (air curtains with heated air) are planned in heated buildings and rooms in the following cases:

1) At gates which open more often than five times or are open for no less than 40 minutes per shift, as well as at the industiral entrances of buildings located in regions with an outside air design temperature for the cold season of the year of -15° C and below (design parameters B), if the possibility of installing vestibules or locks is precluded;

2) At gates and industrial entrances at any design temperatures and any duration of opening based on the following considerations:

3) In the lobbies and locks at the entrance doors of the vestibules of public buildings and the auxiliary buildings of industrial enterprises for

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* Based on the work of the Central Scientific Research Institute for Industrial Buildings, the All-Union Central Scientific Research Institute for Labor Safety and the Moscow Order of the Red Banner of Labor Civi Engineering Institute imeni V.V. Kuybyshev (Doctor of the Engineering Sciences V.M. El'terman and candidates of the engineering sciences A.N. Skanavi and G.T. Tatarchuk).

the case of a design outside air temperature (B parameters) from -15 to -25° C and where 400 and more persons pass through the lobby or lock in one hour, at a design temperature of from -26 to -45° C where 250 people pass through and more, and at a design temperature of below 45° C where 100 persons and more pass through;

4) In the lobbies and locks at the entrance doors of public and production buildings and rooms equipped with air conditioning systems;

5) In the lobbies and locks of the entrance doors of public and production buildings and rooms with significant moisture emissions or when permanent work positions are located close to the outside doors.

During the cold season (for the case of the B outside design parameters) when the gates, doors and industrial entrances are open, the curtains should provide for an air temperature in the rooms at the permanent work positions of no lower than 15° C for light physical work, 12° C for moderately hard work and 8° C for hard work.

In the absence of permanent work positions close to the gate, doors and industrial entrances, it is permissible to reduce the temperature in this area down to 5° C when they are open, if this does not violate the industrial requirements. In the vestibules of public buildings and the auxiliary buildings of industrial enterprises when the doors are open, it is permissible to reduce the air temperature down to 12° C. Thus, the temperature of the mixture of outside air and curtain air should be no lower than the indicated limits.

It is necessary to take the curtain air temperature no higher than 50° C for outside doors and 70° C for gates and industrial entrances, if the industrial requirements do not establish other values.

The air exit velocity from the air output devices of the curtains should be taken as no more than 5 m/sec for outside doors in public buildings and the auxiliary buildings of industrial enterprises, 8 m/sec for outside doors in industrial buildings and 25 m/sec for gates and industrial entrances, but no higher than the permissible values according to industrial requirements.

It is recommended that sliding vane type curtains be installed at transportation entrance and exit gates, as well as at industrial entrances (Figure 10.1). In this case, the air stream of the curtain, in reducing the amount of air passing through the opening, partially blocks the opening (the value of the air consumption coefficient through the opening when the curtain is operating becomes less). To reduce heat losses from that part of the curtain stream going outside, it is recommended that lobbies be set up (especially in the case of one-way curtains), which have side walls and a cover. The length of the lobby should be no less than the width of the gates, while the width should be one meter greater than the width of the gates. It is recommended in sliding vane type air curtains that the air be delivered through slot shaped nozzles at an angle of 30° to the plane of the opening directed towards the outside.

To assure a reliable direction of the air flow, the depth of the guiding slot shaped nozzle for the air output is taken as 2.5 times greater than the width of width of the slot, and to assure uniformity in the air velocity distribution at the start of the distribution box, no more than 70% of the exit velocity of the air from the slot is used as the design value. Distribution boxes are arranged on the inside of the opening at a spacing of no more than $0.1\sqrt{F_{pr}}$ (where F_{pr} is the area of the opened passage equipped with the curtain) from its plane, taking in the air for the curtain at the installation level of the unit. Air intake from the upper region of rooms is expedient if the temperature there is 5° C and more above that in the region where the unit is located. If the distribution boxes are separated by some distance from the wall, it is recommended that the gap between them and the opening by filled in.

It is recommended that lateral, two-way curtains of the sliding vane type be installed at motor vehicle and railroad gates, as well as at industrial entrances, but it is also permissible to install bottom or lateral one-way curtains*. Two-way side curtains, as compared to one-way ones, more reliably cover the opening during the movement or stoppage of the transportation. Curtains with a bottom air feed are recommended for use in the case of an opening which is significantly wider than it is high. They more reliably prevent the intrusion of cold air into the lower region of a room.

It is recommended that lateral, two-way mixing type curtains be set up at the entrance doors of public buildings and the auxiliary buildings of industrial enterprises, where these mix the outside air incoming through the entrance into the building with the curtain air. An air output is provided in the immediate vicinity of the doors being opened, however in such a manner that the air flows of the curtain are not interrupted by the leaves of the open doors. The structural design of the air output openings should provide for a horizontal direction of the air flow of the curtain. At the bottom, the air output openings are positioned at a height of 0.1 m from the floor, while at the top, at a height of 1.2 - 1. 6 m from the floor. The width of the openings is determined by design calculations. The air for the curtains

*The following standard blueprints have been developed by the Central Scientific Research Institute for Industrial Buildings and are dissemenated by the Central Institute of Standard Design and Planning: the PR-05-43/64 series,(Air and Air-Heat Curtains for Double-Door and Expendable Gates with dimensions of 3 x 3, 4 x 3, 4 x 4.2 and 4.7 x 5.6 m with centrifugal fans"; the 1.435-5 series, "Air and Air-Heat Curtains with Centrifugal Fans for the Gates of Buildings of Industrial Enterprises", and the 1.494-2 series, "Standardized Air-Heat Curtains in Industrial Buildings."

is, as a rule, taken in beneath the floor of the lobby. When an air-heat curtain is combined with convective ventilation, the air is taken in on the outside. When the air intake is derived from the room, it is recommended that it be fed into a hallway (an inside one - with triple doors), and when the air intake is from the outside, it is to be fed into a lobby.

The disengagement of the curtains is provided no earlier than the restoration of the standardized temperature. Heat consumption for air-heat curtains is determined, taking the fact that they can be turned on simultaneously into account.

CHAPTER 11. LOCAL VENTS

Local vents are set up to trap harmful production emissions at the places where they are produced. In preventing the spread of harmful emissions through a room, local vents remove them with the least consumption of ventilation air. The vent should be as close as possible to the source of the harmful emissions, and where possible, isolate it from the room. The removed air should not pass through the breathing zone of the worker. Exhaust hoods, outboard exhaust vents, fume cabinets, housing air receivers and aspirated covers are used in design practice as local vents.

The suction intake effect is characterized by suction spectra and is manifest at small distances from the intake openings. If the exhaust flows are not able to entrain and remove undirected harmful emissions, then the local vent is driven by intake flows, which in passing through the region of harmful emissions, direct them to a specified area. Such suction exhausts are called activated ones.

The suction spectrum is the name for the family of curves which represent the geometric points having identical air movement velocities at different distances from the opening (Figures 11.1 a and b). The numbers on the curves indicate the fraction of the velocities as a percentage of the mean velocity in the suction opening. The distances from the opening are expressed in fractions of its diameter. The lines perpendicular to the equal velocity curves show the direction of air motion.

Shown in Figure 11.1c is a generalized graph of the axial suction velocities, in which the relative distances x/A and x/d are plotted along the abscissa in fractions of the hydraulic radius A and the opening diameter d (here, x is the distance from the opening in m; $A = F/P$, where F is the area in m^2; P is the perimeter in m), and plotted along the ordinate are the relative velocities v_x/v_o, which are the ratio of the velocity at a given point v_x to the average velocity in the aperture v_o. For circular openings, $A = d/4$.

CHAPTER 12. THE DESIGN OF AIR DUCTS

12.1. General Principles

Air ducts and channels must be designed in accordance with the specifications of SNiP, taking into account the possibility of industrializing to the greatest extent the construction and installation work, and in this case, using prefab structures made of standard and typical components and parts, fabricated in plants or fabrication shops.

In the design of air ducts and channels for buildings and structures which are assigned a fire hazard rating in categories A, B, C or F, the requirements of the applicable standards documents are additionally to be taken into account.

CHAPTER 13. STRUCTURAL DESIGN SOLUTIONS FOR MECHANICAL VENTILATION AND AIR CONDITIONING SYSTEMS, AND SPECIFICATIONS FOR EQUIPMENT SELECTION

13.1. The Layout of Ventilation Systems and the Equipment for Chambers

A. The Arrangement of Supply and Exhaust Chambers

It is recommended that supply and exhaust chambers in single story production buildings be placed inside rooms, in mezzanines, in sets of shelves, in the spaces between girders and on roofs. Supply chambers should be layed out, taking into account the air intake from unpolluted areas and minimal referenced expenditures. Supply chambers and conditioners in public and administrative buildings, as well as in the auxiliary buildings of production enterprises, are to be designed into the lower portions of the building (predominately in the first stories), while the exhaust chambers are to be placed in the upper portions of the building (upper floors, attics). In multistory buildings with a large number of ventilation systems, it is recommended that engineering floors be built in.

The equipment sets of supply and exhaust ventilation systems are not to be placed in one room

The specifications for the placement and layout of chambers which service explosion hazardous rooms are provided in Chapter 20.

In production and public buildings, where ventilation equipment is installed for five and more systems, a room is to be provided for equipment repair, as well as for replenishing filter oil, if centralized repair shops or central installations for oil replenishment are lacking.

Where necessary, water intakes and drains should be provided in rooms for ventilation equipment and conditioners for washing the equipment and floors.

One is to be governed by the following considerations when laying out ventilation systems and arranging chambers:

1) The effective radius of the systems should be optimal both in terms of technical and economic, as well as structural design considerations (50 - - 60 m);

2) Ventilation systems should service rooms which are close in terms of the nature of the production and climatic conditions;

3) It is not permissible to combine exhaust devices which suck out dust and moist air, easily condensable vapors and dust, poisonous substances and other harmful emissions, the mixing of which creates a poisonous, flammable or explosive mechanical mixture, as well as combustible substances and gases (for example, exhausts from oil baths and thermal furnaces);

4) It is necessary to take into account the fire safety requirements specified in Chapter 20.

The following should be provided when planning chambers:

a) Stairs, floor areas as well as hatches and doors for access to equipment and pipes which require servicing;

b) Movable or permanent hoist and transport equipment (for example, block and tackle, monorails, and in individual cases for cumbersome equipment, cranes);

c) Electrical lighting for the rooms of chambers and sections, as well as rooms for the placement of ventilation system and conditioner equipment.

The height of a room intended for the placement of ventilation equipment should be taken as no less than 0.8 m greater than the height of the equipment, but no less than 1.9 m from the floor to the bottom of the protruding structures of the ceiling floors at points where service personnel pass through.

The width of a passage for servicing personnel between the protruding parts of equipment, as well as between the equipment and walls or columns should be no less than 0.7 m.

B. Air Ducts

The air ducts of ventilation systems are to planned so that in the case of their shortest length, the standardized climatic conditions are assured in all the work areas of a room.

The air ducts should be provided with a circular cross-section and be fabricated in a plant. Depending on the architectural, structural and other requirements, it is permissible to design air ducts with a rectangular or oval cross-section.

The cross-sectional dimensions of metal and asbestos-cement air ducts, as well as plastic air ducts, are given in Chapter 12.

CHAPTER 14. PNEUMATIC CONVEYANCE SYSTEMS FOR WOODWORKING WASTES

14.1. General Principles

The process of removing particles which are suspended in an air flow is called pneumatic conveyance. The wastes from the mechanical working of wood are trapped directly at the point they are produced and removed by pneumatic conveyance systems.

Wood wastes and the dust from the cutting heads of machine tools are trapped by the air flow using the motion of the particles communicated to them by the cutting tool,

Local vents (dust receivers) for the wastes are, as a rule, built into the structural designs of the woodworking machine tools, and in the majority of cases, they serve as a barrier for the moving parts of the machine tool.

For machine tools with moving working heads, the output pipe of the dust receiver is connected to a flexible metal sleeve, the length of which depends on the range of travel of the machine tool head.

The structural designs of some individual machine tools do not allow for dust receivers. In this case, floor mounted local vents which function either continually or periodically are planned for the location of these machine tools.

The aerodynamic resistance of local vents is characterized by the local resistance factor, which depends on the input coefficient ζ, which takes the form of the ratio of the area of the live cross-section of the dust receiver to the cross-sectional area of the suction pipe, i.e.:

$$\zeta = \phi(f_{in}/f_{pipe}), \qquad (14.1)$$

and is determined from the graph shown in Figure 14.1.

The basic data on local vents for the most widely disseminated woodworking machine tools is given in Table 14.1.

CHAPTER 15. THE REGULATION OF VENTILATION, AIR CONDITIONING AND AIR HEATING SYSTEMS

15.1. Valves in Pipelines

Valves which regulate the consumption of hot water should be installed in a return line if this is permissable based on the pressure conditions in the network.

15.2. Valves (Dampers) for the Regulation of Air Flows

Valves are broken down as follows:

a) Based on the manner of throttling the air flow - with sliding vane or rotating type flaps;

b) Based on purpose - into flow-through, mixing and distribution types;

c) Based on the nature of the action - into dual position (blocking) and control types;

d) Based on the structural design of the flaps - into noninsulated (cold) and insulated (thermal).

Valves with rotating leaves are the most widespread. Sliding vane type valves serve primarily for manual adjustment control.

CHAPTER 16. EJECTOR INSTALLATIONS

16.1. General Principles

Ejectors are primarily used to remove air which contains explosion hazardous or corrosive dust, vapors and gases. The flow of working (ejecting) air which exits from a nozzle at a high velocity into a mixing chambers entrains the air being ejected (or gas and air mixture), creating a region of reduced pressure in the receiving chamber.

Following the equalization of the velocities in the mixing chamber, the air is fed to a diffuser, where because of the reduction in the velocity, the dynamic pressure is converted to a static pressure.

Depending on the source of the working air, ejectors are divided into ventilator fan and compressor types (the latter using compressed air).

Ejector systems are broken down as follows based on the number of ejectors connected to a single source of working air:

a) Local ones, where each source of working air services an individual ejector;

b) Central ones, where a single source of working air services two or more ejector (Figure 16.1).

Central ejection systems make it possible for one fan to remove air from local vents located in different rooms in terms of harmfullness and the degree of danger.

The ejection feeders used in air conditioning systems are likewise an example of the use of a central ejection system.

Central ejector installations can be employed not only to remove air from local vents, but also for general exchange exhaust ventilation from a series of separate production rooms (located both on the same and on different floors), when due to safety requirements or sanitation and health considerations cannot be combined into a centralized exhaust installation in which the air being removed passes through the fan. For such conditions, ejector installations allow for a sharp reduction in the requisite area for ventilation chambers and the overall length of the air ducts.

It is expedient to use centralized ejection systems in large shops which require the installation of emergency ventilation, where hydrogen, acetylene and other gases can be released, which are not recommended for direct transportation by a fan. For these conditions, considering the short period of operation of the emergency ventilation and the low hydraulic resistance of the air removal channel, it is expedient to employ a higher ejection coefficient: $\beta = 3 - 4$.

The mixing factor or the ejection coefficient, β, is the term for the ratio of the amount of ejected air L_2 to the amount of ejecting air L_1.

Ejectors with a mixing factor of about 1 have the greatest efficiency; when $\beta > 1$, the ejector efficiency falls off slowly, something which makes it possible to adopt higher mixing factors in high pressure ejectors. Reducing β below 0.5 leads to a sharp drop in the installation efficiency.

To reduce the losses when mixing flows of ejected and working air it is necessary to correctly choose the most favorable velocity for the flow being suctioned at the start of the mixing chamber.

The ratio n of the velocity of the flow being suctioned, v_2, to the velocity of the mixed flow, v_3, is taken as the following in the subsequent calculations:

a) For low pressure ejectors with fan drive: 0.4;

b) For high pressure ejectors, operating on compressed air: 0.8.

The material used in the fabrication of the ejectors should be sufficiently resistant to the corrosive action of the ambient medium, as well as the transported chemically active media and substances used for periodic cleaning of the ejector.

When transporting air which contains the vapors of organic solvents or explosion hazardous substances, the condensates or dust of which are capable of igniting or exploding from a spark created by a static electricity charge, the ejectors must be made from an electrically conducting material..

The air duct for the ejected air is to be arranged coaxially with the ejector, since this increases the efficiency of the installation. A fan driven ejector should have a hatch which provides access to the nozzle and the capability of washing the interior surface of the ejector.

High pressure ejectors, in which it is difficult to locate a hatch for washing because of the small diameter of the housing, should be easily disconnected from the air ducts.

The interior surface of the ejector and exhaust air ducts should be smooth, and have no protruding parts or indentations.

In many cases, outside air can be used for ejection without preliminary heating of it in the winter, as well as air removed by the exhaust ventilation system. Such a solution significantly reduces the cost of construction and system operation.

CHAPTER 17. COMBATING THE NOISE OF VENTILATION AND AIR CONDITIONING SYSTEMS

17.1. General Principles

The noise level is an important criterion of ventilation and air conditioning system quality, something which must be considered when planning buildings for various purposes.

In selecting the permissible noise levels for ventilation systems, one must take into account the level of both the inherent noise in a room due to the normal work activity, as well as the noise in the room from municipal traffic.

It is considered economically unjustified for ventilation systems to use as the permissible noise level a figure more than 5 dB below the actual background noise level in a room.

CHAPTER 18. THERMAL INSULATION*

18.1. General Principles

Thermal insulation, as a rule, is applied to the following:

—The piping of heating systems - the main standpipes and feed lines, run in the immediate vicinity of work positions; all piping, expansion tanks and air receivers, located in unheated rooms (warehouses, passageways, galleries), in through, partially blocked and blocked channels, as well as at individual points where it is possible for the water pipe to either freeze or undergo excessive local cooling (in channels, at entrance doors, gates, in attics, etc.);

—Hot water and steam pipes run in a tificially cooled rooms, where the presence of excessively heated surfaces is not permitted by special requirements, as well as in rooms where the presence of heated surfaces can cause an explosion or fire;

—The piping of water sypply and conduit systems, run in unheated rooms, where it is possible for the water to freeze in the pipes during a temporary

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*Based on materials of the Alma Ata department Soyuzsantekhtroyekt [the All-Union Sanitary Engineering Project Planning Administration] (series A3-493).

interruption of the water supply, as well as drinking water supply piping, to prevent the heating of drinking water above 20° C;

--The piping of cold supply systems, with the exception of drain lines;

--The air ducts of ventilation systems, where it is necessary to maintain specified air parameters and to prevent moisture condensation on the exterior and internal surfaces of the air ducts.

CHAPTER 19. THE FUNDAMENTALS OF DESIGNING AUTOMATION FOR INTERIOR SANITARY ENGINEERING SYSTEMS

19.1. General Principles

The term "automation" is understood to mean the thermal engineering monitoring, automatic regulation, automatic protection of equipment and control of electric drives and interlocking.

Means of automation (monitoring, automatic regulation, equipment protection, interlocking, control and supervisory control) for heating, ventilation and air conditioning systems are to be designed for the following purposes: a) Assuring and maintaining the requisite conditions of the air medium in rooms, boosting the operational reliability of systems, as well as engaging and disengaging systems for special requirements (for example, in case of emergencies); b) Reducing the service personnel, saving heat, cold and electrical power.

The degree of automation depends on the function of the building and structure, the kinds of systems, the requisite running time of the equipment and economic expediency.

The automation of heating, ventilation and air conditioning systems should be planned on the basis of the simplest of the possible solutions and schemes, employing the minimum number of automation instruments and equipment.

Automatic monitor and control instruments, as a rule, should be of the same time, and when installed in the serviced rooms, should be of a chamber design, and when installed directly in the equipment, air ducts or piping, should be of an immersible design.

The type of design (for example, conventional, dust and spray proof, explosion proofed, anticorrosion) of the automation equipment and instruments depends on the medium in which they are installed and operate.

For automation, control and regulation instruments intended for installation in work rooms, it is recommended that cabinet type panels be used.

Automation project plans should be worked up taking into account the maximum industrialization of the installation, for which the following is to be done:

a) In planning structural designs, industrial processes, equipment and piping, the installation parts and components necessary for fastening and installing the instruments and automation equipment are to be provided;

b) Structure fabricated under plant conditions are to be employed, as well as the standard dimensions for automation panels and control boards;

c) Automation equipment and instruments are to be installed in accordance with standard specifications and standard drawings with maximum use of components fabricated in plants.

CHAPTER 20. FIRE SAFETY REQUIREMENTS

20.1. General Principles

Heating, cooling and air conditioning systems are to be planned while observing the fire safety requirements given in chapters II-A.5-70 of the SNiP, "Fire Safety Requirements. Basic Fundamentals of Planning"; II-M.2-72 of the SNiP, "The Production Buildings of Industrial Enterprises. Project Planning Standards"; II-33-75 of the SNiP, "Heating, Ventilation and Air Conditioning", as well as in the chapters of the SNiP which set standards for the project planning of various buildings. Also to be taken into account are the specification which differ from the fire safety requirements cited below and are contained in the departmental standards documents approved by USSR Gosstroy.

The fire safety requirements for the planning of heating, ventilation and air conditioning systems of production rooms and buildings depend on the explosion and fire hazard category of the production and the inflammability groups of the materials and structures employed. In chapter II-M.2-72 of the SNiP, six categories of explosion, fire-explosion and fire hazards are established: A, B, C, D, E and F. Construction materials and structures used in the construction of heating, ventilation and air conditioning systems, in accordance with II-A.5-70 of the SNiP, are broken down into three combustibility groups: noncombustible (nonflammable), difficultly combustible (difficultly flammable) and combustible (flammable).

The conditions for the use of electrical equipment are defined by the "Regulations for Electrical Installations" (PUE), according to which explosion hazardous rooms are subdivided into five classes: V-I, V-Ia, V-Ib, V-II and V-IIa; and fire hazardous ones, into three classes: P-I, P-II and P-IIa.

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