Australian Institute of Refrigeration Air Conditioning and Heating

AIRAH

achieving recognition

www.airah.org.au

DA09

application manual

WHO IS AIRAH?

Founded in 1920, the Australian Institute of Refrigeration, Air Conditioning and Heating Inc. (AIRAH) promotes the science and practice of refrigeration, air conditioning, heating, ventilation and associated building services for the advancement of industry and subsequent benefit of the community.

AIRAH undertakes a variety of activities within the industry, focusing on professional development of industry personnel and dissemination of technical information. Services provided to industry include training and accreditation programs, seminars, specialist conferences, a monthly industry magazine (EcoLibrium™) and a suite of reference manuals and handbooks.

AIRAH embraces the values of ethical behaviour, performance excellence, equality of opportunity and peer support in industry. To this end, the Institute has developed a number of voluntary best practice guidelines and accreditation initiatives with a view to both increasing the level of professionalism in industry and reducing its impact on the environment.

AIRAH believes that if industry is well informed and well trained, the community will benefit from higher quality indoor environments, reduced greenhouse gas emissions, lower peak electrical demand and a more secure and reliable food chain.

PREFACE TO FIRST EDITION

This manual is based substantially on the principles set out by Carrier International Corporation in Handbook of Air Conditioning System Design (McGraw-Hill Book Company, 1972), material from which publication has been reproduced by kind permission of the publisher. The text on stack effect (Chapter 6) is taken from Section A-4 of the IHVE Guide Book A (1970) with grateful acknowledgement to the Institution of Heating and Ventilating Engineers, London.

A considerable amount of new material has been added with special reference to Australian conditions, and the whole is now presented in SI units and terminology. Mr E. G.A. Weiss M.B.E. Consulting Engineers Mr. B. W. Thompson, and other staff the Australian Department of Housing and Construction carried out the conversion and preparation of new work.

PREFACE TO SECOND EDITION

This document is one of a series Application manuals being prepared to provide practical assistance to designers with their day to day tasks in the design of mechanical building services. it seeks to set down knowledge of the art and current practice in the particular area of air conditioning systems design. It is based on a document with the same title produced by the Australian government department of Transport and Construction and published by AGPS in 1973. This new document incorporate much of the original material but also includes extensions to the weather data to include a number of locations in new Zealand, an index and a number of corrections and minor amendments.

This Application Manual was reviewed by the industry and edited by a review panel prior to publication.

Acknowledgment is made to Mr. D. Williamsz, Mr. P Beddingfield (New Zealand), Mr. B.W. Thompson and the staff of the ACADS Mechanical Building Services Group for their contribution to the revision of this document.

PREFACE TO THIRD EDITION

This third edition includes updated design conditions for those locations in Australia and Papua New Guinea listed in the previous edition as well as some 500 additional locations. Much of this data was published as "Air Conditioning Systems - Design Temperature Data" DA9a and this document has now been incorporated in *Chapter 2* and *Appendix 1 Table 1A*. Data has also been included for a number of locations in South East Asia.

Monthly design temperatures have also been included for these locations as *Appendix 1 Table 1B*. The derivation and details of this monthly data has been included in the revised *Chapter 2*.

Note:
The various references in this document to:-

- The Department
- The Department of Works
- The Australian Department of Housing and Construction
- The Australian Government Department of Transport and Construction

all refer to the Australian Federal Government's Construction Authority at that time.

The Australian Institute of Refrigeration, Air Conditioning and Heating (Inc)
Level 7/1 Elizabeth St Melbourne VIC Australia Tel 61 3 9614 8868 Fax 61 3 9614 8949

The Institute of Refrigeration Heating Air Conditioning Engineers Inc.
PO Box 11 130 Ellerslie Auckland New Zealand Tel 64 9 262 1405

Review and Revision

This Application Manual was reviewed by an industry review panel prior to publication.

In order to assist the preparation of new Application Manuals, and particularly to assist the periodic review and revision of Application Manuals already issued, users are encouraged to make known their experience in using the Application Manuals and to notify any additional information which they can provide or to which reference can be made. This information should be forwarded to the Federal Office of AIRAH.

Acknowledgements

The development of this and other documents in this series was only made possible by a co-operative decision made in 1972 between the Australian Federal Government through the then Department of Works and AIRAH. The authors and AIRAH wish to acknowledge the significance of this pioneering arrangement in the industry, and the considerable assistance provided over the years by the department.

First edition published for the Australian Department of Housing and Construction, 1973.

Second edition published as part of the series 'Mechanical Engineering Services Design Aids', 1982

Reprinted April 1988
Reprinted April 1994

Third edition published May 1994
Reprinted with amendments July 1997
Reprinted November 1998

ISSN 0725-1998
ISBN 0 644 00470 3

Editor-in-Chief
Frank Wickham A.M.
F.I.E.Aust.,CPEng,M.AIRAH

Disclaimer

The information or advice contained in this document is intended for use only by persons who have had adequate technical training in the field to which the Application Manual relates. The document has been compiled as an aid only and the information or advice should be verified before it is put to use by any person. The user should also establish the applicability of the information or advice in relation to any specific circumstances. While the information or advice is believed to be correct the Australian Institute of Refrigeration Air Conditioning and Heating Inc., its officers, employees and agents, the Institute of Refrigeration Heating and Air Conditioning Engineers of New Zealand, its officers, employees and agents, disclaim responsibility for any inaccuracies contained within the document including those due to any negligence in the preparation and publication of the said document.

CONTENTS

CHAPTER 1. BUILDING SURVEY AND LOAD ESTIMATE

The primary function of air conditioning is to maintain conditions that are (1) conducive to human comfort and/or efficiency, or (2) required by a product, or process within a space. To perform this function, equipment of the proper capacity must be installed and controlled throughout the year. The equipment capacity is determined by the *actual* instantaneous peak load requirements: type of control is determined by the conditions to be maintained during peak and partial load. Generally, it is impossible to measure either the actual peak or the partial load in any given space; these loads must be estimated. It is for this purpose that the data contained in this manual has been compiled.

Before the load can be estimated, it is important that a comprehensive survey be made to assure accurate evaluation of the load components. If the building facilities and the actual instantaneous load within a given mass of the building are carefully studied, an economical equipment selection and system design can result, and smooth, trouble free performance is then possible.

The heat gain or loss is the amount of heat instantaneously coming into or going out of the space. *The actual load is defined as that amount of heat which is instantaneously added or removed by the equipment.* The instantaneous heat gain and the actual load on the equipment will rarely be equal, because of the thermal inertia or storage effect of the building structures surrounding a conditioned space.

Chapters 2, 4, 5, 6, and *7* contain the data from which the instantaneous heat gain or loss is estimated. *Chapter 3* provides the data and procedure for applying storage factors to the appropriate heat gains to result in the actual load. *Chapter 8* provides the bridge between the load estimate and the equipment selection. It furnishes the procedure for establishing the criteria to fulfill the conditions required by a given project.

The basis of the data and its use, with examples, are included in each chapter with the tables and charts; also an explanation of how each of the heat gains and the loads manifest themselves.

BUILDING SURVEY

SPACE CHARACTERISTICS AND HEAT LOAD SOURCES

An accurate survey of the load components of the space to be air conditioned is a basic requirement for a realistic estimate of cooling and heating loads. *The completeness and accuracy of this survey is the very foundation of the estimate, and its importance can not be overemphasized.* Mechanical and architectural drawings, complete field sketches and, in some cases, photographs of important aspects are part of a good survey. The following physical aspects must be considered:

1. *Orientation of building*—Location of the space to be air conditioned with respect to:
   (*a*) Compass points—sun and wind effects.
   (*b*) Nearby permanent structures—shading effects.
   (*c*) Reflective surfaces—water, sand, parking areas, etc.
2. *Use of space(s)*—Office, hospital, department store, laboratory, machine shop, factory, assembly plant, etc.
3. *Physical dimensions of space(s)*—Length, width, and height.
4. *Ceiling height*—Floor to floor height, floor to ceiling, clearance between suspended ceiling and beams.
5. *Columns and beams*—Size, depth, also knee braces.
6. *Construction materials*—Materials and thickness of walls, roof, ceiling, floors and partitions, and their relative position in the structure.
7. *Surrounding conditions*—Exterior colour of walls and roof, shaded by adjacent buildings or sunlit. Attic spaces—unvented or vented, gravity or forced ventilation. Surrounding spaces conditioned or unconditioned—temperature of non-conditioned adjacent spaces, such as furnace or boiler room, and kitchens. Floor on ground, crawl space, basement.
8. *Windows*—Size and location, wood or metal sash, single or double glazing, gasketed or not. Type of glass and type of shading device. Dimensions of reveals and overhangs.
9. *Doors*—Location, type, size, and frequency of use.
10. *Stairways, lifts and escalators*—Location, temperature of space if open to unconditioned area. Power of machinery, ventilated or not.
11. *People*—Number, duration of occupancy, nature of activity, any special concentration. At times, it is required to estimate the number of people

on the basis of square metre per person, or on average traffic.

12. *Lighting*—Wattage at peak. Type—incandescent, fluorescent, recessed, exposed. If the lights are recessed, the type of air flow over the lights, exhaust, return or supply, should be anticipated. At times, it is required to estimate the wattage on a basis of watts per square metre due to lack of exact information.

13. *Motors*—Location, rated output, and usage. The latter is of great significance and should be carefully evaluated.

    The power input to electric motors is not necessarily equal to the rated output divided by the motor efficiency. These motors may be operating under a continuous overload, or may be operating at less than rated capacity. It is always advisable to measure the power input wherever possible. This is especially important in estimates for industrial installations where the motor machine load is normally a major portion of the cooling load.

14. *Appliances, business machines, electronic equipment*—Location, rated wattage, steam or gas consumption, hooded or unhooded, exhaust air quantity installed or required, and usage.

    Greater accuracy may be obtained by measuring the power or gas input during times of peak loading. The regular service meters may often be used for this purpose, provided power or gas consumption not contributing to the room heat gain can be segregated.

    Avoid pyramiding the heat gains from various appliances and business machines. For example, a toaster may not be used during the evening, or the hot-press may not be used during morning, or not all business machines in a given space may be used at the same time.

    Electronic equipment often requires individual air conditioning. The manufacturer's recommendation for temperature and humidity variation must be followed, and these requirements are often quite stringent.

15. *Ventilation*—Criteria for ventilation requirements, i.e. dilution of odours or of toxic or explosive mixtures, offsetting air infiltration, limitation of equipment, and economic factors, see *Chapter 6*.

16. *Thermal storage*—Includes system operating schedule (12, 16 or 24 hours per day) specifically during peak outdoor conditions permissible temperature swing in space during a design day, rugs on floor, nature of surface materials enclosing the space (see *Chapter 3*).

17. *Continuous or intermittent operation*—Whether system be required to operate every business day during cooling season, or only occasionally, such as churches and ballrooms. If intermittent operation, determine duration of time available for precooling or pulldown.

LOCATION OF EQUIPMENT AND SERVICES

The building survey should also include information which enables the engineer to select equipment location, and plan the air and water distribution systems. The following is a guide to obtaining this information:

1. *Available spaces*—Location of all stairwells, lift shafts, abandoned smokestacks, pipe shafts, dumbwaiter shafts, etc., and spaces for air handling apparatus, refrigeration machines, cooling towers, pumps, and services (also see *Item 5*).

2. *Possible obstructions*—Locations of all electrical conduits, pipe lines, and other obstructions or interferences that may be in the way of the duct system.

3. *Location of all fire walls and partitions*—Requiring fire dampers.

4. *Location of outdoor air intakes*—In reference to street, other buildings, wind direction, dirt, and short-circuiting of unwanted contaminants.

5. *Power service*—Location, capacity, current limitations, voltage, phases and cycle; how additional power (if required) may be brought in and where.

6. *Water service*—Location, size of lines, capacity, pressure, maximum temperature.

7. *Steam or high pressure hot water service*—Location, size, capacity, temperature, pressure, type of return system.

8. *Refrigeration, brine or chilled water* (if furnished by client)—Type of system, capacity, temperature, pressure.

9. *Architectural characteristics of space*—For selection of shading devices (blinds, drapes) and of air outlets that will blend into the space design.

10. *Existing air conveying equipment and ducts*—For possible reuse.

11. *Drains*—Location and capacity, sewage disposal.

12. *Control facilities*—Compressed air source and pressure, electrical.

13. *Foundation and support*—Requirements and facilities, strength of building.

14. *Sound and vibration control requirements*—Relation of refrigeration and air handling apparatus location to critical areas.

15. *Accessibility for moving equipment to the final location and for regular maintenance*—Lifts, stairways, doors, accessibility from street.

AIR CONDITIONING LOAD ESTIMATE

The air conditioning load is estimated to provide the basis for selecting the conditioning equipment. It must take into account the heat coming into the space from outdoors on a design day, as well as the heat being generated within the space. A design day is defined as a day of outside and inside design conditions (*Chapter 2*), when there is little or no haze in the air to reduce the solar heat (*Chapter 4*) and when all of the internal loads are normal (*Chapter 7*).

The time of peak load can usually be established by inspection, although, in some cases, estimates must be made for several different times of the day.

Actually, the situation of having all of the loads peaking at the same time will very rarely occur. To be realistic, various diversity factors must be applied to some of the load components; refer to *Chapter 3*, '*Heat Storage, Diversity, and Stratification*'.

The infiltration and ventilation air quantities are estimated as described in *Chapter 6*.

Fig. 1 illustrates an air conditioning load estimate form and is designed to permit systematic load evaluation. This form contains the references identified to the particular chapters of data and tables required to estimate the various load components.

OUTDOOR LOADS

The loads from outdoors consist of:

1. *The sun rays entering windows*—*Tables 14* to *18* provide data from which the solar heat gain through glass and shading devices is estimated. In addition to this reduction, all or part of the window may be shaded by reveals, overhangs, and by adjacent buildings. *Chart 1* and *Table 20* provide an easy means of determining how much the window is shaded at a given time.

   A large portion of the solar heat gain is radiant and will be partially stored as described in *Chapter 3*. *Tables 6* to *10* provide the storage factors to be applied to solar heat gains in order to arrive at the actual cooling load imposed on the air conditioning equipment. These storage factors are applied to *peak solar heat gains* obtained from *Table 5*, with overall factors from *Tables 15* to *18*.

2. *The sun rays striking the walls and roof*—These, in conjunction with the high outdoor air temperature, cause heat to flow into the space. *Tables 21* and *22* provide equivalent temperature differences for sunlit and shaded walls and roofs. *Tables 24, 25, 30, 31,* and *32* provide the transmission coefficients or rates of heat flow for a variety of roof and wall constructions.

3. *The air temperature outside the conditioned space*—A higher ambient temperature causes heat to flow through the windows, partitions, and floors. *Tables 26* to *29* and *Tables 33, 34,* and *36* provide the transmission coefficients. The temperature differences used to estimate the heat flow through these structures are contained in the notes after each table.

4. *The air vapour pressure*—A higher vapour pressure surrounding conditioned space causes water vapour to flow through the building materials. This load is significant only in low dewpoint applications. The data required to estimate this load is contained in *Table 43*. In comfort applications, this load is neglected.

5. *The wind blowing against a side of the building*—Wind causes the outdoor air that in summer is higher in temperature and moisture content to infiltrate through the cracks around the doors and windows, resulting in localized sensible and latent heat gains. All or part of this infiltration may be offset by air being introduced through the apparatus for ventilation purposes. In winter infiltration causes localised heat losses; stack effect must be taken into consideration in tall buildings with unrestricted access from floors to stair wells. *Chapter 6* and *Table 44* contain the estimating data.

6. *Outdoor air usually required for ventilation purposes*—Outdoor air is usually necessary to flush out the space and keep the odour level down. This ventilation air imposes a cooling and dehumidifying load on the apparatus because the heat and/or moisture must be removed. Most air conditioning equipment permits some outdoor air to bypass the cooling surface (see *Chapter 8*). This bypassed outdoor air becomes a load within the conditioned space, similar to infilltration; instead of coming through a crack around the window, it enters the room through the supply air duct. The amount of bypassed outdoor air depends on the type of equipment used as outlined in *Chapter 8*. *Chapter 6* provides the data from which the ventilation requirements for most comfort applications can be estimated.

The foregoing is that portion of the load on the air conditioning equipment that originates outside the space and is common to all applications.

INTERNAL LOADS

Chapter 7 contains the data required to estimate the heat gain from most items that generate heat within the conditioned space. The internal load, or heat generated within the space, depends on the character of the application. Proper diversity and usage factor should be applied to all internal loads. As with the solar heat gain, some of the internal gains consist of radiant heat which is partially stored

CHAP REF	TABLE REFERENCES			
	ITEM	AREA OR QUANTITY	SUN GAIN OR TEMP. DIFF.	FACTORS
3 & 4	**SOLAR GAIN – GLASS**			
	GLASS	m^2 ×	[Tables 5 to 10 & 14] ×	[Corrections from Table 5 or 14; Tables 15 to 19]
	GLASS	m^2 ×	×	
	GLASS	m^2 ×	×	
	GLASS	m^2 ×	×	
	SKYLIGHT	m^2 ×	×	× ×
5	**SOLAR AND TRANSMISSION GAIN – WALLS AND ROOF**			
	WALL	m^2 ×	[Table 21] ×	[Tables 24 & 25]
	WALL	m^2 ×	×	
	WALL	m^2 ×	×	
	WALL	m^2 ×	×	
	ROOF – SUN	m^2 ×	[Table 22] ×	[Tables 30 & 32]
	ROOF – SHADED	m^2 ×	×	
	TRANSMISSION GAIN EXCEPT WALLS AND ROOF			
	ALL GLASS	m^2 × [Note 2]		× [Table 36]
	PARTITION	m^2 ×	[Equations from Tables 26	× [Table 26]
	CEILING	m^2 ×	33	× [Table 33]
	FLOOR	m^2 ×	27 & 33]	× [Tables 27 & 33]
6	INFILTRATION	ℓ/s × [Note 2]		× 1.20
3 & 7	**INTERNAL HEAT**			
	PEOPLE		PEOPLE	× [Tables 13 & 45]
	POWER		[Table 48] W	× [Footnote to Table 48]
	LIGHTS		W	× [Tables 11 & 13]
	APPLIANCES ETC.	[Tables 46 & 47] [Tables 49 to 52]	W	× [Corrections: Tables 46 & 47]
2 & 3	STORAGE FROM SWING(DEDUCT)			m^2 × [Temp swing] × [Table 12]
7	SAFETY FACTOR [End of Chapter 7]		%	
				ROOM SENSIBLE HEAT ■
	SUPPLY DUCT HEAT GAIN [Chart 3] %+ SUPPLY DUCT LEAK LOSS [Text after Chart 3] %+ FAN kW [Table 53] %			
8	OUTDOOR AIR		ℓ/s × [Note 2] °C × [Tables 55 & 56] BF × 1.20	
				EFFECTIVE ROOM SENSIBLE HEAT ■
6	**LATENT HEAT**			
	INFILTRATION	ℓ/s × [Note 3]	g/kg × 3.0	
3 & 7	PEOPLE	PEOPLE × [Table 13]		× [Table 45]
	STEAM	g/s × 2500		
	APPLIANCES ETC. [Tables 46 & 47] [Tables 49 to 52]	W	× [Corrections: Tables 46 & 47]	
5	VAPOUR TRANS.	m^2 × 0.001 × [Note 3] g/kg		× [Table 43]
7	SAFETY FACTOR [End of Chapter 7]	%		
				LATENT ROOM HEAT ■
	SUPPLY DUCT LEAKAGE LOSS [Text after Chart 3]		%	
8	OUTDOOR AIR	ℓ/s × [Note 3] g/kg	× [Tables 55 & 56] BF × 3.0	
				EFFECTIVE ROOM LATENT HEAT
				EFFECTIVE ROOM TOTAL HEAT ■
	OUTDOOR AIR HEAT			
	SENSIBLE:	ℓ/s × [Note 2]	°C × (1 – [Tables 55 & 56] BF × 1.20	
	LATENT:	ℓ/s ×	g/kg × (1 – [Tables 55 & 56] BF × 3.0	
7	RETURN DUCT HEAT GAIN [Chart 3] %+ RETURN DUCT LEAK GAIN [Text after Chart 3] %+ PUMP [Table 54] %+ DEHUM & PIPE LOSS [End of Chapt 7] %			
				GRAND TOTAL HEAT ■

CHAP REF	TABLE REFERENCES					
	HOURS OF OPERATION					
2	**DESIGN CONDITIONS**	DRY BULB °C	WET BULB °C	% RH	DEW POINT °C	g/kg
	OUTDOOR AIR (OA)	[Tables 1 to 3]				
	ROOM AIR (RM)	[Note 1. Text of Chapter 2, Table 4]				
	DIFFERENCE					

CHAP REF 6

OUTDOOR AIR
(a) EXHAUST AIR = ... ℓ/s
(b) ½ CHANGE PER HOUR = ... ℓ/s
(c) MINIMUM VENTILATION AIR = (a) + (b) = ... ℓ/s
(d) CHECK ON ODOUR DILUTION: .... PEOPLE × .... ℓ/s PERSON = ... ℓ/s
(e) CHECK ON OUTDOOR AIR PERCENTAGE: .... ℓ/s_{OA} ÷ .... ℓ/s_{SA} × 100 = %
Allow not less than 10 % .... [Note 4] ℓ/s
(f) VENTILATION AIR = OUTDOOR AIR THROUGH APPARATUS = HIGHEST VALUE OF (c), (d) OR (e) = ... ℓ/s = [Note 5] Ch/h

INFILTRATION
(a) ΣCHANGES PER HOUR (FROM TABLE 44 CHAPTER 6) = ... ℓ/s
(b) VENTILATION AIR: (f) ABOVE = ... ℓ/s
(c) ½ CHANGE PER HOUR = ... ℓ/s
(d) = (b) – (c) = ... ℓ/s
= .... ℓ/s
(e) INFILTRATION = (a) – (d) [Note 6] = ... ℓ/s

CHAP REF 8

APPARATUS DEWPOINT
EFFECTIVE SENSIBLE HEAT FACTOR [Table 59 or Psych Chart Fig 36] = EFFECTIVE ROOM SENSIBLE HEAT / EFFECTIVE ROOM TOTAL HEAT = ...
INDICATED ADP = ... °C SELECTED ADP = ... °C

DEHUMIDIFIED AIR QUANTITY
TEMPERATURE RISE = (1 – [Tables 55 & 56] BF) × (............ $°C_{RM}$ – .... $°C_{ADP}$) = ... °C
DEHUMIDIFIED AIR ℓ/s = EFFECTIVE ROOM SENSIBLE HEAT / (1.20 × °C TEMPERATURE RISE) = ... ℓ/s DA
OUTLET TEMP. DIFF. = ROOM SENSIBLE HEAT / (1.20 × ℓ/s DA) = ... °C (RM – OUTLET AIR)*

SUPPLY AIR QUANTITY
SUPPLY FLOW RATE = ROOM SENSIBLE HEAT / (1.20 × °C DESIRED DIFFERENTIAL) = ... ℓ/s SA
BY PASS FLOW RATE .... ℓ/s SA – .... ℓ/s DA = ... ℓ/s BA

RESULTING ENTERING AND LEAVING CONDITIONS AT APPARATUS
ENTERING DRY BULB TEMP. = ... $°C_{RM}$ + [Fig 47] ℓ/s OA / ℓ/s ‡ × (............ $°C_{OA}$ – .... $°C_{RM}$) = ... $°C_{EDB}$
LEAVING DRY BULB TEMP. = ... $°C_{ADP}$ + [Tables 55 & 56] BF × (............ $°C_{EDB}$ – .... $°C_{ADP}$) = ... $°C_{LDB}$
FROM PSYCHROMETRIC CHART .... $°C_{EWB}$, ... $°C_{LWB}$

CHECK FIGURES
ℓ/s_{SA} PER kW ERTH .... ℓ/s_{SA} PER kW GTH ....
ℓ/s_{SA} PER m^2 FLOOR AREA [Ceiling Outlets] .... ℓ/s_{SA} PER m^2 WALL AREA [Wall Outlets] ....
GTH (kW) PER m^2 FLOOR AREA .... TOTAL CHANGES PER HOUR ....

NOTES
1. Use revised room dry-bulb temperature for rooms with radiating surfaces.
2. Use dry-bulb temperature differences from top of estimate form, utilising revised room design dry-bulb temperatures for rooms with radiant surfaces.
3. Use moisture content difference (g/kg) from top of estimate form.
4. At this stage this involves assuming a figure for the supply air quantity. It can be estimated by reference to the psychrometric chart.
5. If the ventilation air exceeds 2¾ changes per hour, do not calculate infiltration which may be considered zero.
6. If the value is negative, consider infiltration to be zero.

* IF THIS ΔT IS TOO HIGH, DETERMINE SUPPLY ℓ/s FOR DESIRED TEMPERATURE DIFFERENCE BY SUPPLY AIR QUANTITY FORMULA.
‡ WHEN BY PASSING A MIXTURE OF OUTDOOR AND RETURN AIR, USE SUPPLY ℓ/s. WHEN BY PASSING RETURN AIR ONLY, USE DEHUMIDIFIED ℓ/s.

Fig. 1 Air conditioning load estimate

(as described in *Chapter 3*), thus reducing the load to be impressed on the air conditioning equipment.

Generally, *internal heat gains* consist of some or all of the following items:

1. *People*—The human body through metabolism generates heat within itself and releases it by radiation, convection, and evaporation from the surface, and by convection and evaporation in the respiratory tract. The amount of heat generated and released depends on surrounding temperature and on the activity level of the person, as listed in *Table 45*.

2. *Lights*—Luminairs convert electrical power into light and heat (refer to *Chapter 7*). Some of the heat is radiant and is partially stored (see *Chapter 3*).

3. *Appliances*—Pantries or tearooms, hospitals and laboratories have electrical, gas, or steam appliances which release heat into the space. *Tables 46* and *47* list the recommended heat gain values for most appliances when not hooded. If a positive exhaust hood is used with the appliances, the heat gain is reduced.

4. *Electric calculating machines*—Refer to manufacturer's data to evaluate the heat gain from electric calculating machines. Normally, not all of the machines would be in use simultaneously, and, therefore, a usage or diversity factor should be applied to the full load heat gain. The machines may also be hooded, or partially cooled internally, to reduce the load on the air conditioning system.

5. *Electric motors*—Electric motors are a significant load in industrial applications and should be thoroughly analyzed with respect to operating time and capacity before estimating the load (see *Item 13* under '*Space Characteristics and Heat Load Sources*'). It is frequently possible to actually measure this load in existing applications, and this should be done where possible. *Table 48* provides data for estimating the heat gain from electric motors.

6. *Hot pipes and tanks*—Steam or hot water pipes running through the air conditioned space, or hot water tanks in the space, add heat. In many industrial applications, tanks are open to the air, causing water to evaporate into the space. *Tables 49* to *52* provide data for estimating the heat gain from these sources.

7. *Miscellaneous sources*—There may be other sources of heat and moisture gain within a space, such as escaping steam (industrial cleaning devices, pressing machines, etc.), absorption of water by hygroscopic materials (paper, textiles, etc.); see *Chapter 7*.

In addition to the heat gains from the indoor and outdoor sources, the air conditioning equipment and duct system gain or lose heat. The fans and pumps required to distribute the air or water through the system add heat; heat is also added to supply and return air ducts running through warmer or hot spaces; cold air may leak out of the supply duct and hot air may leak into the return duct. The procedure for estimating the heat gains from these sources in percentage of room sensible load, room latent load, and grand total heat load is contained in *Chart 3* and *Tables 53* and *54*.

HEATING LOAD ESTIMATE (Warm air heating only)

The heating load evaluation is the foundation for selecting air heating equipment. Normally, the heating load is estimated for the winter design temperatures (*Chapter 2*) usually occurring in the morning just before occupancy; therefore, no credit is taken for the heat given off by internal sources (people, lights, etc.). This estimate must take into account the heat loss through the building structure surrounding the spaces and the heat required to offset the outdoor air which may infiltrate and/or may be required for ventilation. *Chapter 5* contains the transmission coefficients and procedures for determining heat loss. *Chapter 6* contains the data for estimating the infiltration and ventilation air quantities. *Fig. 2* illustrates a heating estimate form for calculating the heat loss in a building structure.

For continuously heated premises it is theoretically possible to provide plant capacity lower than the design heating load if the temperature within the space is allowed to drop a few degrees during periods of design load. *Chapter 2* gives the recommended inside conditions and *Table 12* contains the data for estimating capacity reduction for temperature swing. However, as the heating-up periods after a forced shut-down may become unduly long (see below), it is recommended that no reduction in design load be allowed even for continuously heated premises where temperature swing is permissible.

For premises with intermittently operated heating plants or with dual temperature operation (e.g. 21°C during the day and 10°C at night) capacity reduction is not feasible. Rather, additional capacity must be provided if unduly long heating up periods are to be avoided.

In the absence of experience other than with Canberra heating installations it is recommended that boiler plant capacities in excess of design heating loads be provided as indicated hereunder (the capacity of the hot water heating coil in the air handling plant does not require to be increased).

Difference between inside and outside design temperatures (°C)	10.0	12.5	15.0	17.5	20.0
Excess boiler plant capacity (%)	10	10	15	20	25

It is estimated that these excess capacities will enable multistorey buildings of curtain wall construction to reach close to design inside temperatures (during design outside conditions) approximately 2–2½ hours after commencement of plant operation, on the assumption that the plant will operate approximately 11 out of 24 hours. For buildings of heavier construction or plant operating over shorter periods (less than 11 out of 24 hours) the heating up periods would be longer and for buildings of light weight construction (e.g. insulated panels) and/or longer periods of plant operation the heating up periods would be shorter.

It is stressed that this section (heating) applies to warm air heating only.

HIGH ALTITUDE LOAD CALCULATIONS

Since air conditioning load calculations are based on the mass of air necessary to handle a load, a decrease in density means an increase in the flow rate required to satisfy the given sensible load. The amount of air required to meet the latent load is decreased because of the higher latent load capacity of the air at higher altitudes (greater g/kg per degree difference in dew-point temperature). For the same dry-bulb and percent relative humidity, the wet-bulb temperature decreases (except at saturation) as the elevation above sea level increases.

The following adjustments are required for high altitude load calculations (see *Chapter 8, Table 60*).

1. Design room air moisture content must be adjusted to the required elevation.
2. Standard load estimating methods and forms are used for load calculations, except that the factors affecting the calculations of volume and sensible and latent heat of air must be multiplied by the relative density at the particular elevation.
3. Because of the increased moisture content of the air, the effective sensible heat factor must be corrected.

EQUIPMENT SELECTION

After the load has been evaluated, the equipmens must be selected with capacity sufficient to offset thit load. The air supplied to the space must be of the proper conditions to satisfy both the sensible and latent loads estimated. *Chapter 8, 'Applied Psychrometrics'*, provides procedures and examples for determining the criteria from which the air conditioning equipment is selected (air quantity, apparatus dewpoint, etc.).

WINTER DESIGN CONDITIONS

ROOM .... °C DB .... % RH .... g/kg
[Chapter 2]
OUTSIDE .... °C DB .... % RH .... g/kg

DIFFERENCE .... °C DB .... g/kg

HOURS OF OPERATION .... HOURS OUT OF 24 HOURS

HUMIDIFICATION

HEAT INPUT INTO HUMIDIFIER =

.... ℓ/s × .... g/kg DIFF. × 3.0 = ... WATTS

REQUIRED EVAPORATION

.... WATTS /2500 = ... g/s (WATER)

VENTILATION AIR

FROM AIR CONDITIONING LOAD ESTIMATE

VENTILATION = [From Fig 1] .... ℓ/s

INFILTRATION

FROM AIR CONDITIONING LOAD ESTIMATE

INFILTRATION = [From Fig 1] .... ℓ/s

OUTDOOR AIR

VENTILATION AIR .... ℓ/s

INFILTRATION .... ℓ/s

TOTAL .... ℓ/s OA

TRANSMISSION LOSSES

ITEM	AREA m²	TEMP. DIFF. °C	U - VALUE W/m².°C	HEAT LOSS W	SUB - TOTALS W
GLASS	×	[From above Winter Design Conditions]	× [Table 36]		
GLASS	×		×		
GLASS	×		×		
GLASS	×		×		
SKYLIGHT	×		×		
WALL	×	[From above Winter Design Conditions]	× [Tables 24 & 25]		
WALL	×		×		
WALL	×		×		
WALL	×		×		
WALL *	×	[See Notes]	× [Tables 38 to 40]		
PARTITION	×	[Equation at foot of Table 26]	× [Table 26]		
PARTITION	×		×		
CEILING - FLOOR	×	[Equation at foot of Table 34]	× [Table 34]		
CEILING - ROOF	×	[Equation at foot of Tables 29 & 31]	× [Tables 29 & 31]		
FLOOR *	×	[See Notes]	× [Table 28 Tables 38 to 40]		

(a) TOTAL TRANSMISSION .... WATTS

OUTDOOR AIR (VENTILATION + INFILTRATION)

(b) .... ℓ/s OA × .... TEMP. DIFF. × 1.2 = ... WATTS

(c) = (a) + (b) CAPACITY OF HOT WATER AIR HEATING COIL ‡ = ... WATTS

(d) EXCESS BOILER PLANT CAPACITY [Chapter 1] .... % = ... WATTS

(e) = (c) + (d) = BOILER PLANT CAPACITY = ... WATTS

NOTES: * FOR INTERMITTENT HEATING CALCULATE HEAT LOSSES FOR BASEMENT WALLS AND FLOORS ON THE BASIS OF AIR TEMPERATURE DIFFERENCE BETWEEN ROOM AND OUTSIDE. FOR CONTINUOUS HEATING CALCULATE BASEMENT FLOOR AND WALL LOSSES IN ACCORDANCE WITH CHAPTER 5, TABLES 38 TO 40.

‡ FOR DIRECT HEATING i.e. ELECTRIC ELEMENTS IN AIR STREAM, GAS FIRING OR A STEAM AIR HEATING COIL ADD EXCESS PLANT CAPACITY TO AIR HEATING ELEMENT WHICH WILL THEN HAVE THE SAME CAPACITY AS THE BOILER PLANT.

Fig. 2—Heating load estimate (for warm air heating only)

CHAPTER 2. DESIGN CONDITIONS

This chapter presents the data from which the outdoor design conditions are established for various localities and inside design conditions for various applications. The design conditions established determine the heat content of the air, both outdoor and inside. They directly affect the load on the air conditioning equipment by influencing the transmission of heat across the exterior structure and the difference in heat content between the outdoor and the inside air. For further details, refer to *Chapters 5 and 6.*

OUTDOOR DESIGN CONDITIONS-SUMMER AND WINTER

Outdoor design conditions are listed in *Table 1* for Australia's and Papua New Guinea's major centres of population and New Zealand. In addition *Appendix 1 Table 1A* contains a complete list of design conditions for Australia, Papua New Guinea, some Pacific islands and a number of locations in Asia. Major locations listed in *Table 1* are shown on the maps of Australia, Papua New Guinea and New Zealand *(Figs. 3 and 4a & 4b).* Maps of the Australian States and Papua New Guinea are included in *Appendix 1* showing all those locations listed in the Appendix.

The design data consists of summer design dry-bulb and wet-bulb and winter dry-bulb for comfort conditions and where available for critical conditions. Presented also in *Table 1 and Table 1A* are the average daily range and yearly range, the elevation above sea level and the latitude and longitude for each location.

AUSTRALIA, PAPUA NEW GUINEA, SOLOMON ISLANDS AND VANUATU

The data were supplied from the archives of the Commonwealth of Australia, Bureau of Meteorology. The calculations were undertaken by the Bureau's Consulting Services section and the CSIRO division of Building Construction and Engineering (1). PNG data are published with the permission of the Director, National Weather Services, Papua New Guinea. Acknowledgment is also made of the assistance from Australian Construction Services and financial support provided by the National Energy Research, Development and Demonstration Program.

For all locations the occurrences of 3.00 p.m. dry-bulb and wet-bulb temperatures and 8.00 a.m. dry-bulb in each month of the year are available on diskette from ACADS. Full hourly data (dry-bulb temperature; absolute moisture content; atmospheric pressure; wind speed and direction; cloud cover; global, direct - normal and diffuse solar radiation, solar altitude and azimuth) are also available from ACADS, but only for those locations are where critical-process design temperatures are listed.

The wet-bulb temperatures in the tables are 'sling' values, which correspond closely to the thermodynamic wet-bulb on which psychrometric charts and cooling load calculations are based. They have been calculated from the Bureau measurements (taken in a Stevenson screen) using the formulae in section C1 (Properties of Humid Air) of the CIBS Guide (2).

An asterisk denotes locations where the 8.00 a.m. and 3 p.m. data contain a significant proportion of missing records.

This data in this Application Manual does not replace AIRAH Publication R3 'Design Temperature Data for Australia'.

Summer Outdoor Design Conditions

The comfort design temperatures are shown in bold typeface and are the 3.00 p.m. dry-bulb and wet-bulb temperatures which are individually exceeded on 10 days per year (inclusive of one standard deviation).

For critical processes the design temperatures are the dry-bulb and wet-bulb temperatures which are individually exceeded on 0.25% of the plant operating hours. Two sets of values (for 24 hours operation and 0800-1800 hour inclusive operation) are shown. Critical process design outdoor temperatures should be discussed with and agreed to by the client.

An alternative proceedure for determining critical design conditions has been proposed by Mason (3). This alternative method is based on the January (July in the Northern Hemisphere) 3.00 p.m. dry-bulb and wet-bulb temperatures which are individually exceeded on an average of one day in two years. The advantage of this method is that these design temperatures can be established for locations where only 3.00 p.m. temperatures are recorded. These temperatures for Australia, New Zealand, Papua New Guinea, Solomon Islands and Vanuatu as well as some locations in Asiaare listed in *Appendix 1 Table 1B.*

Coincident Temperatures

On either side of the 3.00 p.m. comfort design temperatures are shown the mean coincident wet bulb or CWB (associated with the design dry-bulb) and the mean coincident dry-bulb or CDB (associated with the design wet-bulb).

These coincident temperatures may be used for additional or alternative cooling load calculations where a particular design requires a large component of fresh air (more sensitive to wet-bulb) or has a large building surface (more sensitive to dry-bulb).

---

1. Delsante, A.E. and Mason M. An Expanded Climatic Data Base for Australia. AIRAH Annual Confrence, Paper 13 (1990).
2. CIBS Guide, C1, articles C1.7 - 1.9 (1975)
3. Mason M.D. Extension of availible critical design conditions for AC load estimation. AIRAH Journal Vol 47 No. 2, Feb 1993.

Thus three possible pairs of temperatures may be used to estimate the 3.00 p.m. cooling load, viz:

Design Values:	DB, WB (recommended)
Option 1:	DB, CWB (dry-bulb sensitive)
Option 2:	CDB, WB (wet-bulb sensitive)

Comparative load calculations using program 'CAMEL' have been performed for a hypothetical office in Melbourne, Darwin and Alice Springs (1). The results generally indicated lower loads and higher air quantities using Option 1, and similar loads but lower air quantities using Option 2.

AIRAH recommends that the 'design conditions' should be used for calculation purposes on all normal comfort air conditioning systems. The use of Option 1 and Option 2 in isolation is not recommended, but experienced designers may wish to use them in conjunction with the design conditions for inland or tropical installations or for analysing performance of components such as cooling towers or evaporative condensers.

Winter Outdoor Design Conditions

The comfort design temperature is shown in bold typeface and is the 8.00 a.m. dry-bulb which is not exceeded on 10 days per year (inclusive of one standard deviation). The design outdoor relative humidity should be taken as 80%.

For Critical processes the design temperature is the dry-bulb temperature which is not exceeded on 0.25% of the plant operating hours. Two values (for 24 hours operation and 0800-1800 hour inclusive operation) are shown. Critical-process design outdoor temperatures should be discussed with and agreed to by the client.

The comfort design temperatures were calculated from the Bureau's estimated 8.00 a.m. temperatures, the estimate being based on the minimum temperature (assumed to occur at dawn) and the measured 9.00 a.m. temperature. The critical-process design temperatures were calculated from linearly interpolated three-hourly measured temperatures (at 6.00 a.m., 9.00 a.m. etc.), which may over estimate the 8.00 a.m. temperature if the minimum occurs after 6.00 a.m. Consequently, the critical-process temperature for the 0800-1800 operation was sometimes found to be slightly higher than the comfort temperature. Where this occurred, the critical-process temperature has been set to the comfort temperature.

If humidity control is important the winter outdoor design wet-bulb temperature should be determined on the same basis as the dry-bulb temperature.

Outdoor winter design conditions for critical process installations should be discussed with and agreed to by the client.

NEW ZEALAND

Data on New Zealand locations equivalent to that given for Australia and Papua New Guinea is only available for the four locations which are listed in *Appendix 1 Table 1A & 1B*. The outdoor conditions for cities and towns in New Zealand *(Table 1)* are:

Summer Outdoor Design Conditions

Dry bulb and concurrent wet bulb temperatures not exceeded more than 1%, 2½%, and 5% of the time between 8.00 a.m. and 6.00 p.m. from November 1 to April 30.

Winter Outdoor Design Conditions

Dry bulb below which temperature does not fall 1%, 2½%, and 5% of the time both for 8.00 a.m. to 6.00 p.m. and 24 hour operation from MAY 1 to October 31.

OTHER COUNTRIES

Generally the data presented for other countries has been processed according to the criteria used for the Australian data wherever possible. Any variation from these criteria are detailed in the Table footnotes.

The Meteorological data was supplied by the respective National Meteorological Bureau to whom acknowledgement is given.

DESIGN TEMPERATURES FOR OTHER MONTHS

The outdoor design conditions for summer, listed in *Table 1* or *Table 1A in Appendix 1* are for the month of January (July in the Northern Hemisphere). When determining peak air conditioning loads the design conditions for other months are required. In the absence of specific local data the corrections based on yearly range listed in *Table 3* may be applied as detailed in the next section of this chapter.

Alternatively, for those locations listed in *Appendix 1 Table 1B*, local data has been analysed to produce monthly design temperatures and these should be used in preference to the standard corrections listed in *Table 3*.

The monthly 3.00 p.m. dry-bulb and wet-bulb temperatures in *Appendix 1 Table 1B* are those which are individually exceeded on an average of one day in two years. For comfort or non critical design conditions where this monthly value exceeds the design temperatures based on the 10 days criteria, then this later value is used in preference.

For critical process conditions the one day in two year monthly temperatures are used for every month.

The data for the locations listed in *Appendix 1 Table 1B* has been determined using the method suggested by Mason and Kingston (4). The advantage of this one day in two years data is that it is location specific and therefore takes into account any local weather variations e.g. monsoon season.

---

4. Mason M. and Kingston T. Weather Data for A.C. Load Estimation. AIRAH Annual Confrence 1988 Paper A15.

TABLE 1 - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (FOR ADDITIONAL LOCATIONS SEE APPENDIX 1)

LOCATION	SUMMER								WINTER								
	Comfort or non-critical process				Critical process				Comfort or non-critical	Critical process		Elev. above sea level (m)	Latitude South	Longitude East	Average daily range (K)	early range (K)	Data years
	Design				24-hour		0800-1800			24-hour	08-1800						
	CWB	DB	WB	CDB	DB	WB	DB	WB	DB	DB	DB						
AUSTRALIAN CAPITAL TERRITORY																	
CANBERRA AMO	17.8	34.1	19.2	30.2	35.0	20.0	36.0	20.5	-3.1	-5.0	-3.1	571	35° 19'	149° 12'	15.6	37.2	79-88
CANBERRA CITY	18.1	34.3	19.6	31.3	35.0	20.0	36.0	20.5	-2.2	-4.0	-2.2	564	35° 16'	149° 07'	15.4	36.5	79-88
NEW SOUTH WALES																	
BANKSTOWN AMO	21.1	33.8	22.8	31.5	-	-	-	-	3.3	-	-	9	33° 56'	150° 59'	9.9	30.5	70-78
CAMPBELLTOWN *	20.9	34.1	22.6	31.0	-	-	-	-	3.1	-	-	75	34° 05'	150° 49'	10.9	30.4	69-78
LIVERPOOL COUNCIL	21.5	35.1	23.4	31.2	-	-	-	-	3.3	-	-	21	33° 55'	150° 55'	10.8	31.8	77-86
LUCAS HEIGHTS (AAEC)	20.3	33.1	22.5	28.6	-	-	-	-	6.2	-	-	140	34° 03'	150° 59'	8.6	26.9	73-82
MARSFIELD (MACQUARIE UNIV)	20.8	33.5	23.3	28.8	-	-	-	-	5.1	-	-	55	33° 46'	151° 07'	9.9	28.4	73-82
NEWCASTLE (NOBBYS)	20.2	30.4	22.6	25.6	-	-	-	-	6.6	-	-	33	32° 55'	151° 48'	5.8	23.8	77-86
ORCHARD HILLS (BRINGELLY)	22.2	34.5	23.8	32.1	-	-	-	-	4.3	-	-	93	33° 48'	150° 43'	11.3	30.2	74-82
PARRAMATTA NORTH	22.2	34.6	23.9	32.4	-	-	-	-	5.8	-	-	60	33° 48'	151° 01'	10.6	28.8	76-85
PORT KEMBLA	20.4	26.5	22.8	24.6	-	-	-	-	9.1	-	-	11	34° 29'	150° 55'	5.4	17.4	66-75
SYDNEY AIRPORT MO	20.2	32.8	22.6	29.4	34.5	23.5	36.5	23.5	6.3	4.0	6.0	6	33° 56'	151° 10'	7.9	26.5	79-88
SYDNEY RO	19.8	31.1	22.7	29.5	33.0	23.5	35.5	24.0	7.2	6.0	7.0	42	33° 52'	151° 12'	7.0	23.9	79-88
WOLLONGONG (UNIV)	19.7	29.6	22.6	26.2	-	-	-	-	8.0	-	-	30	34° 24'	150° 53'	7.8	21.6	77-86
NORTHERN TERRITORY																	
ALICE SPRINGS AMO	18.8	40.1	22.8	34.2	40.5	23.5	41.0	24.0	1.1	-1.0	1.1	545	23° 49'	133° 54'	15.5	39.0	79-88
DARWIN AIRPORT	23.6	34.4	27.7	32.1	34.5	27.5	34.5	28.0	18.1	16.5	18.1	31	12° 25'	130° 52'	6.9	16.3	79-88
QUEENSLAND																	
ARCHERFIELD AIRPORT *	22.7	33.1	24.8	31.1	-	-	-	-	7.5	-	-	23	27° 34'	153° 00'	10.5	25.6	85-88
BRISBANE AMO	22.8	30.8	24.9	29.7	32.0	25.5	33.5	26.0	9.2	6.0	9.2	4	27° 23'	153° 07'	8.2	21.6	79-88
BRISBANE RO	23.4	31.9	24.9	30.6	-	-	-	-	9.3	-	-	38	27° 29'	153° 02'	7.9	22.6	76-85
BUNDABERG PO	23.8	31.4	25.3	29.8	-	-	-	-	10.5	-	-	14	24° 52'	152° 21'	8.7	20.9	78-87
CAIRNS AMO	25.3	32.8	26.8	31.5	33.0	27.0	33.5	27.5	15.1	12.5	15.1	3	16° 53'	145° 45'	7.6	17.7	79-88
CALOUNDRA (SIGNAL STATION)	24.2	28.4	25.1	27.9	-	-	-	-	10.1	-	-	46	26° 48'	153° 09'	6.4	18.3	75-84
COOLANGATTA COMPOSITE	23.9	28.9	25.3	28.2	-	-	-	-	11.0	-	-	6	28° 11'	153° 32'	6.2	17.9	73-80
MOUNT ISA PO	21.4	40.7	24.9	36.6	-	-	-	-	7.8	-	-	356	20° 44'	139° 29'	13.0	32.9	59-66

TABLE 1 - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued) (FOR ADDITIONAL LOCATIONS SEE APPENDIX 1)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Latitude South	Longitude East	Average daily range (K)	early range (K)	Data years
	Comfort or non-critical process				Critical process				Comfort or non-critical	Critical process							
		Design			24-hour		0800-1800			24-hour	08-1800						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
SOUTHPORT	23.8	**30.1**	**25.0**	29.7	-	-	-	-	**9.1**	-	-	20	27° 57'	153° 24'	8.2	21.0	79-88
TOWNSVILLE AMO	24.7	**32.8**	**26.7**	31.0	33.5	27.0	34.5	27.5	**13.1**	8.0	13.1	4	19° 15'	146° 46'	6.7	19.7	79-88
SOUTH AUSTRALIA																	
ADELAIDE (WEST TCE)	19.4	**34.8**	**21.3**	31.3	36.5	22.0	38.0	22.5	**6.4**	5.0	6.4	40	34° 56'	138° 35'	10.5	28.4	67-76
ADELAIDE AIRPORT	18.1	**36.0**	**20.8**	31.4	37.5	21.5	39.0	22.5	**4.5**	2.5	4.5	4	34° 57'	138° 32'	12.2	31.5	79-88
ADELAIDE RO (KENTOWN)	20.1	**37.0**	**21.4**	35.1	38.5	22.5	40.0	23.0	**4.9**	3.0	4.9	47	34° 55'	138° 37'	12.3	32.1	79-88
PENFIELD (WEAPONS RESEARCH)*	20.7	**36.3**	**21.6**	34.0	-	-	-	-	**4.8**	-	-	24	34° 44'	138° 39'	13.6	31.5	69-78
WHYALLA	19.1	**38.7**	**22.3**	34.5	-	-	-	-	**6.0**	-	-	13	33° 02'	137° 32'	10.0	32.7	76-85
TASMANIA																	
HOBART AIRPORT AMO	16.8	**27.1**	**18.5**	25.3	29.0	19.0	31.0	19.5	**1.5**	0.5	1.5	4	42° 50'	147° 30'	10.4	25.6	79-88
HOBART RO	17.1	**27.0**	**18.0**	25.8	29.0	19.0	31.0	19.5	**1.9**	1.0	1.5	55	42°53'	147° 20'	9.4	25.1	79-88
LAUNCESTON (ELPHIN)	19.3	**28.1**	**20.1**	27.1	-	-	-	-	**-2.5**	-	-	8	41° 27'	147° 10'	12.9	30.6	72-78
LAUNCESTON AIRPORT	17.6	**27.2**	**18.4**	25.3	28.0	18.5	30.0	19.0	**-1.2**	-2.5	-1.2	171	41° 33'	147° 13'	13.2	28.4	79-88
VICTORIA																	
ESSENDON AIRPORT	17.8	**33.9**	**20.3**	29.8	35.5	20.5	37.0	21.0	**2.1**	1.0	2.1	86	37° 44'	144° 54'	13.1	31.8	57-66
GEELONG (NORLANE)	19.1	**33.8**	**21.3**	30.1	-	-	-	-	**1.9**	-	-	55	38° 05'	144° 20'	12.0	31.9	76-84
GEELONG SEC	17.6	**32.8**	**20.7**	29.7	-	-	-	-	**2.4**	-	-	17	38° 07'	144° 22'	11.5	30.4	64-69
LAVERTON AERO AMO	19.1	**34.6**	**20.6**	32.3	36.5	21.5	38.5	21.5	**1.1**	0.0	1.1	16	37° 52'	144° 45'	11.9	33.5	75-84
MELBOURNE AIRPORT	19.3	**34.6**	**20.4**	32.9	36.0	21.0	38.0	21.5	**2.4**	1.0	2.4	132	37° 41'	144° 51'	12.9	32.2	75-84
MELBOURNE RO	19.4	**34.3**	**20.5**	32.3	36.0	21.0	37.5	21.5	**3.5**	2.5	3.5	112	37° 49'	144° 58'	10.5	30.8	75-84
WESTERN AUSTRALIA																	
GERALDTON AMO	20.2	**38.4**	**22.7**	33.6	40.0	23.5	41.0	24.0	**7.4**	5.0	7.4	38	28° 48'	114° 42'	14.2	31.0	79-88
PERTH AIRPORT MO (BELMONT)	19.4	**37.4**	**21.9**	33.6	38.5	22.5	40.0	23.0	**5.9**	3.5	5.9	20	31° 56'	115° 58'	15.0	31.5	79-88
PERTH RO	20.1	**36.6**	**22.4**	31.8	38.5	22.5	40.0	23.0	**7.4**	3.5	6.5	19	31° 57'	115° 52'	11.4	29.2	79-88
PAPUA NEW GUINEA																	
PORT MORESBY (JACKSON A/F)	25.4	**32.9**	**27.3**	31.7	33.0	27.0	33.5	27.0	**21.2**	18.0	21.2	35	9° 27'	147° 12'	8.7	11.7	64-73
LAE A/F	25.7	**31.9**	**26.9**	30.8	32.5	26.5	33.0	27.0	**21.8**	21.0	21.8	7	6° 44'	147° 00'	6.9	10.1	64-73

TABLE 1—OUTSIDE DESIGN CONDITIONS—SUMMER AND WINTER (Continued)

NEW ZEALAND

Location City or Town and Meteorological Station Locality	**Summer** Temp. not exceeded more than stated % of time, 0800-1800 NZCT. November 1 – April 30						**Winter** Dry bulb below which temp. does not fall for stated % of time May 1 – October 31						Elev. above sea level m	Longitude Degrees East	Latitude Degrees South	Average Daily Range °CDB	Yearly Range °CDB
							0800–1800 NZCT			Full 24 hrs.							
	1%		2½%		5%		1%	2½%	5%	1%	2½%	5%					
	°CDB	°CWB	°CDB	°CWB	°CDB	°CWB	°CDB	°CDB	°CDB	°CDB	°CDB	°CDB					
Auckland																	
(Albert Park)	25.5	21.0	24.5	20.5	24.0	20.0	6.0	8.5	9.0	5.0	6.0	7.5	49	174°46′	36°51′	7.3	16.0
‡ (Whenuapai)	26.0	21.0	25.5	20.5	24.5	20.0	3.5	6.0	8.0	1.0	2.0	4.5	26	174°38′	36°47′	9.8	19.5
‡ Alexandra	28.5	19.5	27.0	18.5	25.0	18.0	-4.5	-3.0	-1.0	-4.5	-3.5	-3.0	141	169°23′	45°16′	12.4	30.0
‡ Christchurch	28.0	19.5	26.0	18.5	24.5	18.0	-0.5	1.0	3.0	-2.5	-1.0	0.0	7	172°37′	43°32′	9.8	25.0
‡ Dunedin (Musselberg)	24.5	18.5	23.0	18.0	21.0	17.0	1.0	2.0	3.5	0.0	1.0	1.5	2	170°31′	45°54′	8.0	21.0
‡ Gisborne (Airport)	28.5	20.5	27.0	20.0	26.0	19.5	3.5	5.0	6.0	2.0	4.0	5.0	4	177°59′	38°40′	11.6	22.0
‡ Hamilton (Raukura)	26.5	25.5	24.5	21.0	20.5	20.0	0.5	3.5	5.0	-1.5	0.0	1.0	40	175°19′	37°47′	12.0	22.0
‡ Hastings	29.0	20.5	27.0	20.0	26.0	19.5	1.0	3.0	4.0	-1.0	0.0	1.0	14	176°51′	39°39′	13.0	24.0
‡ Hokitika	21.5	19.5	20.5	19.0	19.5	18.5	0.5	2.0	4.0	0.0	1.0	2.0	4	170°57′	42°43′	7.5	18.5
‡ Invercargill (Airport)	24.0	19.0	22.0	18.0	20.5	17.0	-2.0	0.0	1.5	-3.0	-1.0	0.0	0	168°20′	46°25′	9.5	22.0
‡ Lower Hutt	24.5	19.5	23.5	19.0	22.0	18.5	1.5	3.5	4.5	0.0	1.5	3.0	65	174°58′	41°11′	8.2	20.0
‡ Napier	28.5	20.5	26.5	20.0	25.5	19.5	3.0	4.5	5.5	1.0	2.5	3.5	2	176°55′	39°30′	9.4	22.0
‡ Nelson (Airport)	25.0	19.5	24.0	19.0	23.0	18.5	-1.0	0.5	3.0	-2.0	-0.5	0.5	2	173°14′	41°17′	9.4	23.5
New Plymouth	24.0	20.0	23.0	19.5	22.0	19.0	5.0	7.0	8.0	2.0	3.5	4.5	49	174°04′	39°04′	7.6	16.0
‡ Palmerston North	25.5	20.0	24.5	19.5	23.5	18.5	3.0	4.5	6.0	0.0	1.0	2.0	34	175°37′	40°23′	9.2	20.0
Rotorua	26.5	20.5	25.5	20.0	24.5	19.5	0.5	2.0	4.5	-1.5	0.0	1.0	287	176°19′	38°07′	11.7	25.5
‡ Tauranga (Airport)	26.5	21.0	25.5	20.5	24.5	20.5	3.5	5.0	7.0	1.0	2.0	3.5	4	176°12′	37°40′	10.0	20.5
‡ Timaru	26.5	19.5	25.0	18.5	23.5	18.0	-1.0	0.5	1.5	-2.0	-0.5	0.0	17	171°15′	44°25′	10.5	24.5
‡ Wanganui	24.0	20.0	23.0	19.5	22.0	18.5	3.5	5.0	7.0	1.5	3.0	4.0	22	175°03′	39°56′	8.2	18.0
Whangarei (Airport)	26.5	25.5	24.5	21.5	21.0	20.5	6.0	9.0	10.5	4.0	5.5	7.5	107	174°21′	35°39′	11.1	16.5
Wellington (Kelburn)	23.5	19.0	22.0	18.5	21.0	18.0	4.5	5.0	6.0	3.5	4.5	5.0	126	174°46′	41°17′	7.2	17.0

Average Daily Range is taken as the difference between the mean daily maximum and the mean daily minimum in January.

Yearly Range is taken as the difference between the SUMMER 2½% °CDB and the WINTER 2½% °CDB.

The above data were extracted from "Summaries of Climatalogical Observations to 1970", published by the New Zealand Meteorological Service, Mis. Pub, 143 Government Printer, Wellington, New Zealand 1973.

* Locations where design conditions were evaluated from comprehensive meteorological data.

‡ Locations that either annually or occasionally experience freezing conditions which may cause damage due to ice formation on cooling coils handling outside air, solar hot water panels and piping and other systems using water. With such systems special consideration should be given to techniques which prevent this damage.

o Locations where insufficient data available to assess the likelihood of damage due to freezing conditions.

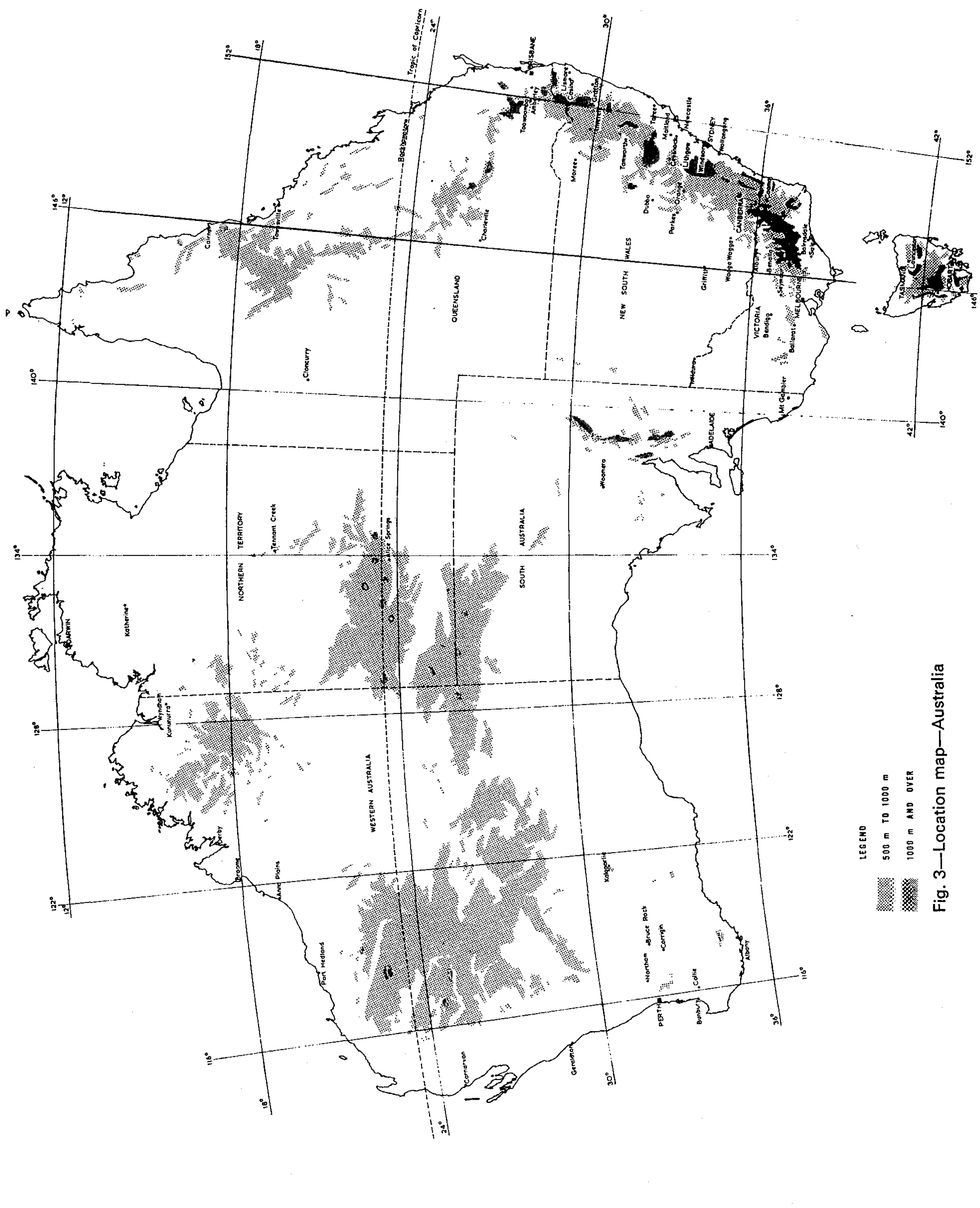


Fig. 3—Location map—Australia

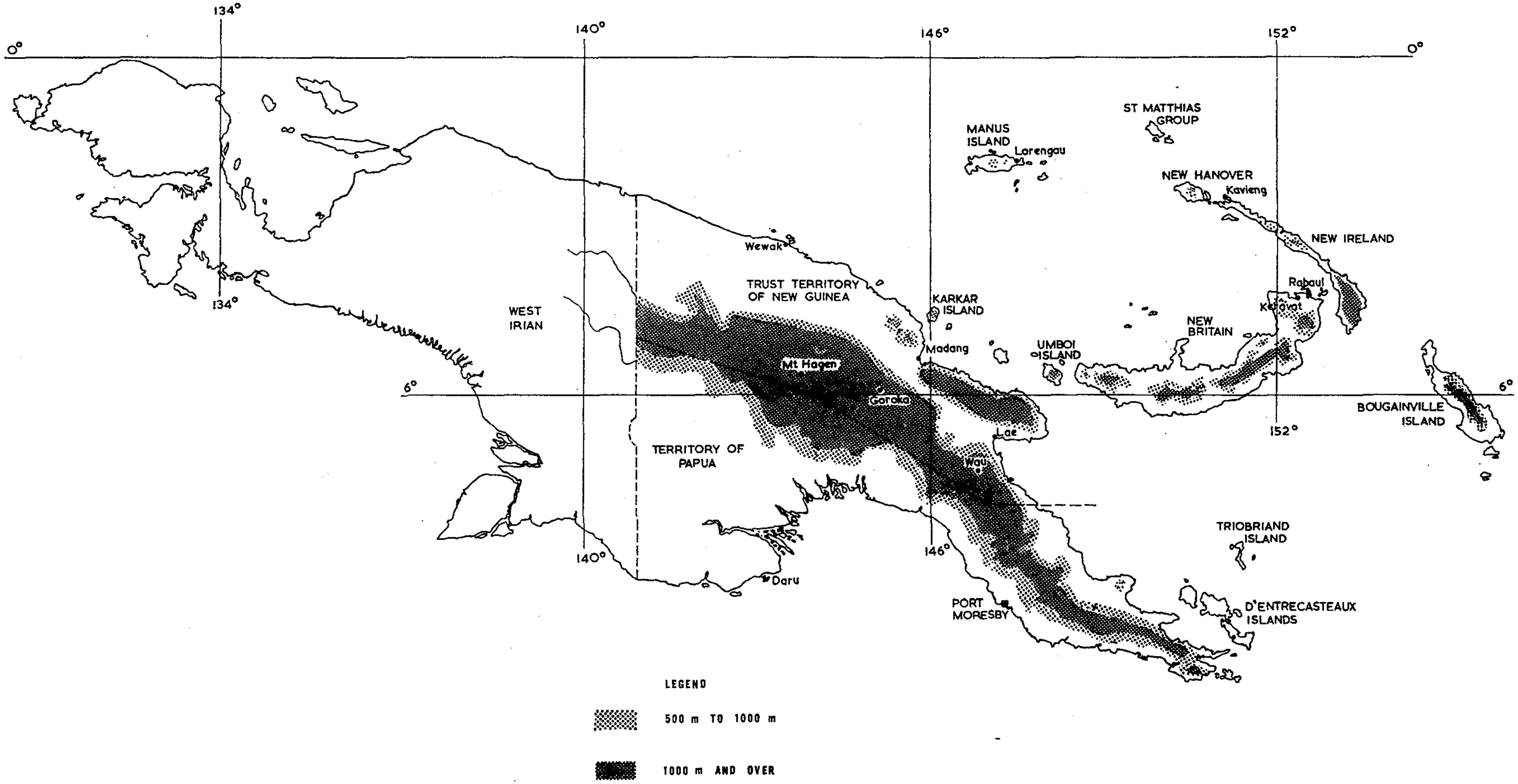


Fig. 4—Location map—Papua New Guinea

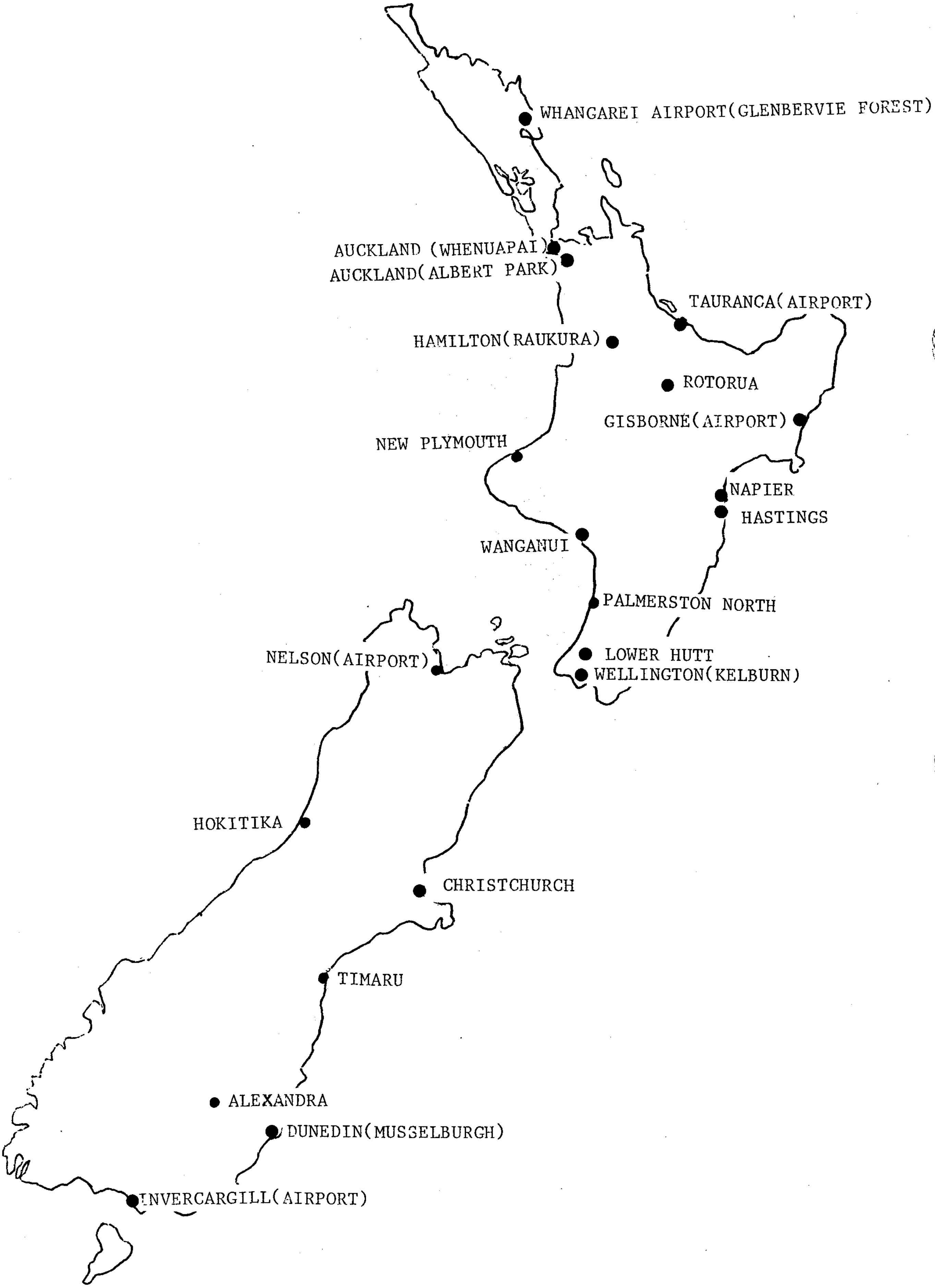


Fig. 4b – Location Map – New Zealand

CORRECTIONS TO OUTDOOR DESIGN CONDITIONS FOR TIME OF DAY AND TIME OF YEAR

The outdoor design conditions for summer, listed in *Table 1* for comfort or non-critical process installations are applicable to the month of January at about 3.00 p.m. Frequently, the design conditions at other times of the day and other months of the year must be known.

Table 2 lists the approximate corrections on the dry-bulb and wet-bulb temperatures from 8 a.m. to 12 p.m. based on the average daily range. The dry-bulb corrections are based on analysis of weather data, and the wet-bulb corrections assume a relatively constant dewpoint throughout the 24 hour period.

Table 3 lists the approximate corrections of the dry-bulb and wet-bulb temperatures from September to May, based on the yearly range in dry-bulb temperature (the difference between the 3 p.m. dry-bulb temperature exceeded on 10 days in the year and the 8 a.m. dry-bulb temperature not exceeded 10 days in the year). These corrections are based on analysis of weather data and are applicable only to the cooling load estimate.

Example 1—Corrections to Design Conditions

Given:

A comfort application in Sydney, N.S.W.

Find:

The approximate dry-bulb and wet-bulb temperatures at 12:00 noon in April.

Solution:

Outdoor design conditions for comfort installations for Sydney in January at 3.00 p.m. are 30.6°C DB, 23.0°C WB (*Table 1*)

Daily range in Sydney is 7.5°C DB

Yearly range in Sydney = 30.5 − 7.0 = 23.5°C DB

Correction for time of day (12 noon) from *Table 2*:

Dry-bulb = −3°C

Wet-bulb = −1°C

Correction for time of year (April) from *Table 3*:

Dry-bulb = −2°C

Wet-bulb = −1°C

Design conditions at 12 noon in April:

Dry-bulb = 30.5 − 5 = 25.5°C

Wet-bulb = 23 − 2 = 21°C

INSIDE COMFORT DESIGN CONDITIONS

Inside comfort design conditions are to be taken as 24°C DB, 50% RH for summer, and 21°C DB, 30% RH for winter. This does not necessarily mean that the thermostat has to be set at the quoted dry-bulb temperatures, nor that the relative humidity is to be maintained at the levels quoted. The design conditions are to be used for determining capacities of air handling, cooling, heating and humidification plant.

Hot radiating surfaces such as sunlit dark Holland blinds, venetian blinds of any colour, whether between two sheets of glass or exposed in the conditioned space, heat absorbing glass facing the room, etc., have a marked influence on the comfort (or discomfort) of people located close to these surfaces. It should be

TABLE 2—CORRECTIONS IN OUTDOOR DESIGN TEMPERATURES FOR TIME OF DAY
(For Cooling Load Estimates)

Sun Time

Daily Range of Temperature °C*	Dry- or Wet-Bulb	AM			PM						
		8	10	12	2	3	4	6	8	10	12
5	Dry-Bulb	−5	−4	−3	−1	0	−1	−1	−3	−4	−5
	Wet-Bulb	−1	−1	−1	0	0	0	−1	−1	−1	−1
10	Dry-Bulb	−7	−5	−3	−1	0	−1	−2	−4	−6	−8
	Wet-Bulb	−2	−2	−1	0	0	0	−1	−1	−2	−3
15	Dry-Bulb	−9	−6	−4	−1	0	−1	−3	−6	−9	−11
	Wet-Bulb	−2	−2	−1	0	0	0	−1	−1	−3	−6
20	Dry-Bulb	−12	−8	−4	−1	0	−1	−4	−7	−11	−14
	Wet-Bulb	−3	−2	−1	0	0	0	−1	−2	−4	−8
25	Dry-Bulb	−14	−9	−4	−1	0	−1	−4	−9	−13	−17
	Wet-Bulb	−4	−3	−1	0	0	−1	−1	−2	−4	−11
30	Dry-Bulb	−17	−11	−5	−1	0	−1	−5	−10	−16	−20
	Wet-Bulb	−5	−3	−1	0	0	−1	−1	−3	−5	−13

*The daily range of dry-bulb temperature is the difference between the average daily maximum and the average daily minimum dry-bulb temperature in January. (See *Table 1* for values of daily range for a particular location.)

Equation: Outdoor design temperature at any time = Outdoor design temperature from *Table 1* + Correction from above table.

TABLE 3—CORRECTIONS IN OUTDOOR DESIGN CONDITIONS FOR TIME OF YEAR
(For Cooling Load Estimates)

Yearly Range of Temperature °C*	Dry- or Wet-bulb	Time of Year								
		Jan	Feb	March	April	May	Sept	Oct	Nov	Dec
68	Dry-Bulb	0	0	−5	−13	−24	−23	−13	−6	−2
	Wet-Bulb	0	0	−2	−8	−17	−14	−7	−3	−1
66	Dry-Bulb	0	0	−5	−12	−22	−21	−12	−6	−2
	Wet-Bulb	0	0	−2	−7	−14	−12	−6	−3	−1
64	Dry-Bulb	0	0	−4	−11	−20	−18	−12	−6	−2
	Wet-Bulb	0	0	−2	−6	−12	−10	−6	−3	−1
62	Dry-Bulb	0	0	−4	−10	−18	−17	−12	−6	−2
	Wet-Bulb	0	0	−2	−5	−10	−9	−6	−3	−1
60	Dry-Bulb	0	0	−3	−10	−17	−17	−11	−6	−2
	Wet-Bulb	0	0	−2	−4	−9	−8	−6	−3	−1
58	Dry-Bulb	0	0	−3	−9	−16	−16	−11	−6	−2
	Wet-Bulb	0	0	−2	−4	−8	−8	−6	−3	−1
56	Dry-Bulb	0	0	−3	−9	−15	−16	−11	−6	−2
	Wet-Bulb	0	0	−2	−4	−8	−8	−6	−3	−1
54	Dry-Bulb	0	0	−3	−9	−15	−16	−11	−6	−2
	Wet-Bulb	0	0	−2	−4	−8	−8	−6	−3	−1
52	Dry-Bulb	0	0	−3	−9	−15	−16	−11	−5	−2
	Wet-Bulb	0	0	−2	−4	−8	−8	−6	−3	−1
50	Dry-Bulb	0	0	−3	−9	−15	−16	−10	−5	−2
	Wet-Bulb	0	0	−2	−4	−8	−8	−6	−3	−1
48	Dry-Bulb	0	0	−3	−9	−14	−16	−10	−5	−2
	Wet-Bulb	0	0	−1	−4	−8	−6	−6	−3	−1
46	Dry-Bulb	0	0	−3	−8	−13	−15	−10	−5	−1
	Wet-Bulb	0	0	−1	−4	−7	−7	−5	−2	−1
44	Dry-Bulb	0	0	−2	−7	−11	−12	−8	−4	−1
	Wet-Bulb	0	0	−1	−3	−6	−7	−5	−2	−1
42	Dry-Bulb	0	0	−2	−5	−9	−8	−6	−3	−1
	Wet-Bulb	0	0	−1	−3	−5	−4	−3	−1	0
40	Dry-Bulb	0	0	−1	−4	−9	−7	−5	−2	−1
	Wet-Bulb	0	0	−1	−2	−4	−4	−3	−1	0
38	Dry-Bulb	0	0	−1	−4	−8	−7	−5	−2	−1
	Wet-Bulb	0	0	−1	−2	−3	−3	−2	−1	0
36	Dry-Bulb	0	0	−1	−4	−8	−6	−5	−2	0
	Wet-Bulb	0	0	−1	−2	−3	−3	−2	−1	0
34	Dry-Bulb	0	0	−1	−3	−7	−5	−5	−2	0
	Wet-Bulb	0	0	0	−2	−3	−3	−2	0	0
32	Dry-Bulb	0	0	−1	−3	−6	−4	−4	−2	0
	Wet-Bulb	0	0	0	−1	−2	−2	−2	0	0
30	Dry-Bulb	0	0	−1	−3	−5	−3	−3	−2	0
	Wet-Bulb	0	0	0	−1	−2	−2	−1	0	0
28	Dry-Bulb	0	0	−1	−2	−5	−3	−2	−2	0
	Wet-Bulb	0	0	0	−1	−2	−2	−1	0	0
26	Dry-Bulb	0	0	−1	−2	−4	−2	−2	−1	0
	Wet-Bulb	0	0	0	−1	−2	−1	−1	0	0
24	Dry-Bulb	0	0	0	−2	−3	−1	−2	−1	0
	Wet-Bulb	0	0	0	−1	−1	−1	−1	0	0

TABLE 3—CORRECTIONS IN OUTDOOR DESIGN CONDITIONS FOR TIME OF YEAR (continued)

Yearly Range of Temperature °C*	Dry- or Wet-Bulb	Time of Year								
		Jan	Feb	March	April	May	Sept	Oct	Nov	Dec
22	Dry-Bulb	0	0	0	−2	−2	−1	−1	−1	0
	Wet-Bulb	0	0	0	0	−1	−1	−1	0	0
20	Dry-Bulb	0	0	0	−1	−1	−1	−1	−1	0
	Wet-Bulb	0	0	0	0	−1	−1	0	0	0
18	Dry-Bulb	0	0	0	−1	−1	−1	−1	0	0
	Wet-Bulb	0	0	0	0	−1	0	0	0	0
16	Dry-Bulb	0	0	0	−1	−1	−1	−1	0	0
	Wet-Bulb	0	0	0	0	0	0	0	0	0
14	Dry-Bulb	0	0	0	0	−1	0	0	0	0
	Wet-Bulb	0	0	0	0	0	0	0	0	0
12	Dry-Bulb	0	0	0	0	0	0	0	0	0
	Wet-Bulb	0	0	0	0	0	0	0	0	0

*Yearly range of temperature is the difference between the 3 p.m. dry-bulb temperature exceeded on 10 days in the year and the 8 a.m. dry-bulb temperature not exceeded 10 days in the year (*Table 1*).
Equation: Outdoor design temperature = Outdoor design temperature from Table 1 + Corrections from above table.

noted that certain white Holland blinds have such good reflecting qualities that they do not represent hot radiating surfaces. (See *Table 16*, *Chapter 4*.) Because of the relatively mild winter in Australia, cold surfaces in the form of window glass are in general not a problem.

There are many temperature indices which take into account the effects of radiation, the most common one being 'operative' or 'environmental' temperature. This is defined as the uniform temperature of an imaginary enclosure with which man will exchange the same dry heat by radiation and convection as in the actual environment, i.e.

$$r+c = q(t_o-t_{sur}) = q(t_o-t_{sk})E_{cl},$$

where $r+c$ = dry heat exchange with the environment (by radiation and convection), W/m²
q = combined heat transfer coefficient, W/m².°C
t_o = operative temperature, °C
t_{sur} = surface temperature, °C
t_{sk} = skin temperature, °C
E_{cl} = Non-dimensional factor (function of clothing insulation)

Operative temperature can also be defined as an average of mean radiant and ambient temperatures, weighted by their respective transfer coefficients, i.e.

$$t_o = (q_r t_r + q_c t_a)/(q_r + q_c),$$

where q_r = coefficient of linear radiation, W/m².°C
q_c = coefficient of convective heat transfer, W/m².°C
t_r = mean radiant temperature, °C
t_a = ambient temperature, °C

q_r varies with posture and q_c with air movement.

In the absence of more precise information q_r may be assumed as 5.1 W/m².°C and q_c for low air movement at 2.9 W/m².°C.

($q = q_r + q_c = 5.1 + 2.9 = 8.0$ W/m².°C) Although strictly speaking only correct for a cubical room with equal convective coefficients for all surfaces, the following relationship is usually accurate enough for the air conditioning designer: $t_o = \frac{2}{3}t_r + \frac{1}{3}t_a$. (There are some authorities who attribute greater influence to the ambient than to the mean radiant temperature.)

In order to offset the reduced comfort caused by hot radiating surfaces (e.g. sunlit heat absorbing glass exposed to the room) it is necessary to lower the room design dry-bulb temperature. The recommended amount is that by which the calculated operative temperature exceeds the design dry-bulb temperature. The term adopted for the lower temperature is 'revised' room design dry-bulb temperature. (The 'revised' temperature is higher than recommended in ASHRAE Comfort Standard 55–66.)

Based on the fact that radiant surfaces between 6°C and 12°C higher than room dry-bulb temperatures have been measured and based on simplified calculations it is recommended that cooling loads be determined on the basis of the following 'revised' design room dry-bulb temperatures for any rooms with hot radiant surfaces:

Window area less than 1/3 wall area	23°C DB
Window area equal to 1/3 or less than 2/3 wall area	22°C DB*
Window area in excess of 2/3 wall area	21.5°C DB*

*Air distribution is to be arranged so that the radiating surfaces (glass, blinds, etc.) are "washed" by the air stream.

As in the case of the design room dry-bulb temperature, it does not necessarily mean that the thermostat has to be set to the level of the 'revised' design room dry-bulb temperature.

INSIDE DESIGN CONDITIONS FOR INDUSTRIAL INSTALLATIONS

Table 4 lists internal design conditions and required accuracies of the automatic control systems for typical industrial applications. Design conditions and control accuracies should be discussed with and agreed to by the client.

The internal dry-bulb temperatures and relative humidities as listed are to be used for heating and cooling load calculations whether or not temperature swing is permissible, and, except for installations with permissible swing, are to be maintained throughout the year, within the limits of tolerance quoted in the table.

Where a temperature swing is permissible, e.g. in cross-bar telephone exchanges, heat (or cold) will be stored in the building and equipment mass. Refer to *Chapter 3, 'Heat Storage, Diversity and Stratification'*, for a more complete discussion of heat storage. Although the temperature will be maintained most of the time at the design level (24.0°C for cross-bar exchanges) with the stipulated control accuracy (±1.0°C for cross-bar), when the cooling or heating load rises to peak conditions the temperature will rise or fall to the level permitted by the swing (24.0+5.0= 29.0°C or 24.0−5.0 = 19.0°C for cross-bar).

In some cases maintaining design conditions is essential for the proper execution of work in the conditioned space (precision machining or measuring, paper conditioning, the manufacture of textiles, etc.), in other cases it is essential for the proper and maintenance-free functioning of equipment in the controlled spaces (computers, telephone equipment, radar control rooms, etc.), yet in others the conditions will only affect product or process by increasing the efficiency of the employee: improved workmanship and uniformity, reduction of rejects and of production costs.

Generally, specific design conditions are applied for one or more of the following reasons:

1. The machining of precision components requires a constant temperature. Stability of temperature is of importance in this case, more so than the actual temperature level itself. To prevent corrosion of highly polished surfaces, the relative humidity should be maintained below approximately 55%
2. In precision measuring laboratories, such as National Standards Laboratories and Defence Standards Laboratories, where highly polished metal surfaces are used and stored, relative humidity should be maintained below approximately 55%. Close temperature control (usually ±0.5°C) is necessary.
3. Non-hygroscopic materials such as metal, glass, and plastic have the ability to capture water molecules in microscopic surface crevices. The density of this film increases with relative humidity and this film must be controlled to prevent the corrosion of metal surfaces and deterioration of the electrical resistance of insulating material.
4. In order that the strength, pliability and regain of hygroscopic materials such as paper and textiles may be maintained, close control of humidity is essential. Other processes require humidity control to allay the sometimes deleterious manifestations of static electricity. If the relative humidity is maintained above 55%, the ability of static electricity to develop is considerably reduced.

TABLE 4 – TYPICAL INDUSTRIAL DESIGN CONDITIONS

Type of Application	Internal design		Control accuracy	
	Dry-bulb °C	% RH	Temp. °C	% RH
Computer Rooms	24.0	50	±1.0	±5.0
Electronic Telephone Exchanges – Switching	24.0	55	±1.0	+10.0
Electronic Telephone Exchanges – Central Processing	24.0	55	±1.0	±10.0
Electronic Telephone Exchanges – CUDN	22.0	50	±0.5	±5.0
Cross bar telephone exchanges	24.0	55	±1.0*	±15.0
Precision Measuring Laboratories	20.0	40	±0.5	±5.0
Radar and Radio Control Rooms	24.0	40	±1.0	±5.0
Paper Conditioning for testing	20.0	65	±1.0	±5.0
Paper Conditioning for printing	24.0	55	±1.0	±5.0
Textile fibre testing†	20.0	65	±1.0	±5.0
Operating Theatres	24.0	60	±2.0	+10.0 / −5.0

*For the cross bar telephone exchange installation a temperature swing of ±5.0°C is permissible.
†CSIRO laboratory conditions for testing of natural and synthetic fibres.

CHAPTER 3. HEAT STORAGE, DIVERSITY AND STRATIFICATION

The normal load estimating procedure has been to evaluate the instantaneous heat gain to a space and to assume that the equipment will remove the heat at this rate. Generally, it was found that the equipment selected on this basis was oversized and therefore capable of maintaining much lower room conditions than the original design. Extensive analysis, research and testing have shown that the reasons for this are:

1. Storage of heat in the building structure.
2. Non-simultaneous occurrence of the peak of the individual loads (diversity).
3. Stratification of heat, in some cases.

This chapter contains the data and procedures for determining the load the equipment is actually picking up at any one time (actual cooling load), taking into account the above factors. Application of these data to the appropriate individual heat gains results in the actual cooling load.

The actual cooling load is generally considerably below the peak total instantaneous heat gain, thus requiring smaller equipment to perform a specific job. In addition, the air quantities and/or water quantities are reduced, resulting in a smaller overall system. Also, as brought out in the tables, if the equipment is operated somewhat longer during the peak load periods, and/or the temperature in the space is allowed to rise a few degrees at the peak periods during cooling operation, a further reduction in required capacity results. The smaller system operating for longer periods at times of peak load will produce a lower first cost to the customer with commensurate lower demand charges and lower operating costs. It is a well-known fact that equipment sized to more nearly meet the requirements results in a more efficient, better operating system. Also, if a smaller system is selected, and is based on extended periods of operation at the peak load, it results in a more economical and efficient system at a partially loaded condition.

Since, in most cases, the equipment installed to perform a specific function is smaller, there is less margin for error. This requires more exacting engineering including air distribution design and system balancing.

With multi-storey, multi-room application, it is usually desirable to provide some flexibility in the air side or room load to allow for individual room control, load pickup, etc. Generally, it is recommended that the full reduction from storage and diversity be taken on the overall refrigeration or building load, with some degree of conservatism on the air side or room loads. This degree should be determined by the engineer from project requirements and client desires. A system so designed, full reduction on refrigeration load and less than full reduction on air side or room load, meets all of the flexibility requirements, except at time of peak load. In addition, such a system has a low owning and operating cost.

STORAGE OF HEAT IN BUILDING STRUCTURES

The instantaneous heat gain in a typical comfort application consists of sun, lights, people, transmission through walls, roof and glass, infiltration and ventilation air and, in some cases, machinery, appliances, electric calculating machines, etc. A large portion of this instantaneous heat gain is radiant heat which does not become an instantaneous load on the equipment, because it must strike a solid surface and be absorbed by this surface before becoming a load on the equipment. The breakdown on the various instantaneous heat gains into radiant heat and convected heat is approximately as follows:

Heat Gain Source	Radiant Heat	Convective Heat
Solar, without inside blinds	100%	—
Solar, with inside blinds	58%	42%
Fluorescent Lights	50%	50%
Incandescent Lights	80%	20%
People*†	40%	20%
Transmission†	60%	40%
Infiltration and Ventilation	—	100%
Machinery or Appliances‡	20–80%	80–20%

*The remaining 40% is dissipated as latent load.

†Although people and transmission gains contain radiant components as indicated in the table it is customary in heat load calculations to regard them as 100% convective loads.

‡The load from machinery or appliances varies, depending upon the temperature of the surface. The higher the surface temperature, the greater the radiant heat load.

CONSTANT SPACE TEMPERATURE AND EQUIPMENT OPERATING PERIODS

As the radiant heat from sources shown in the above table strikes a solid surface (walls, floor, ceiling, etc.), it is absorbed, raising the temperature at the surface of the material above that inside the material and the air adjacent to the surface. This temperature difference causes heat flow into the material by conduction and into the air by convection. The heat conducted away from the surface is stored, and the heat convected from the surface becomes an instantaneous cooling load. The portion of radiant heat being stored depends on the ratio of the resistance to heat flow into the material and the resistance to heat flow into the air film. With most construction materials, the resistance to heat flow into the material is much lower than the air resistance; therefore, most of the radiant heat will be stored. However, as this process of absorbing radiant heat continues, the material becomes warmer and less capable of storing more heat.

The highly varying and relatively sharp peak of the instantaneous solar heat gain results in a large part of it being stored at the time of peak solar heat gain, as illustrated in *Fig. 5*.

The upper curve in *Fig. 5* is typical of the *solar heat gain* for a west exposure, and the lower curve is the actual cooling load that results in an average construction application with the space temperature held constant. The reduction in the peak heat gain is approximately 40% and the peak load lags the peak heat gain by approximately 1 hour. The cross-hatched areas (*Fig. 5*) represent the Heat Stored and the Stored Heat Removed from the construction. Since all of the heat coming into a space must be removed, these two areas are equal.

The relatively constant light load results in a large portion being stored just after the lights are turned on, with a decreasing amount being stored the longer the lights are on, as illustrated in *Fig. 6*.

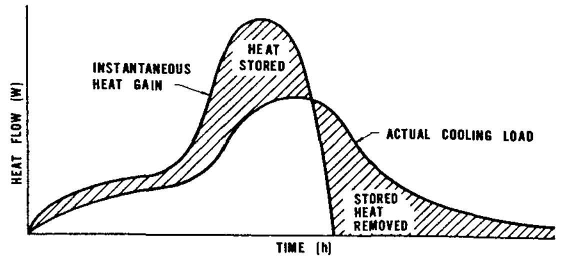


Fig. 5—Actual cooling load, solar heat gain, west exposure, average construction

The upper and lower curves represent the instantaneous heat gain and actual cooling load from *fluorescent lights* with a constant space temperature. The cross-hatched areas are the Heat Stored and the Stored Heat Removed from the construction. The dotted line indicates the actual cooling load for the first day if the lights are on longer than the period shown.

Figs. 5 and *6* illustrate the relationship between the instantaneous heat gain and the actual cooling load in average construction spaces. With light construction, less heat is stored at the peak (less storage capacity available), and with heavy construction, more heat is stored at the peak (more storage capacity available), as shown in *Fig. 7*. This aspect affects the extent of zoning required in the design of a system for a given building; the lighter the building construction, the more attention should be given to zoning.

The upper curve of *Fig. 7* is the instantaneous solar heat gain while the three lower curves are the actual cooling load for *light, medium and heavy construction* respectively, with a constant temperature in the space.

One more item that significantly affects the storage of heat is the operating period of the air conditioning equipment. All of the curves shown in *Figs. 5, 6* and *7* illustrate the actual cooling load for 24-hour operation. If the equipment is shut down after 16 hours of operation, some of the stored heat remains in the building construction. This heat must be removed (heat in must equal heat out) and will appear as a pulldown load when the equipment is turned on the next day, as illustrated in *Fig. 8*.

Adding the pulldown load to the cooling load for that day results in the actual cooling load for *16-hour operation*, as illustrated in *Fig. 9*.

The upper curve represents the instantaneous heat gain and the lower curve the *actual cooling load* for that day with a constant temperature maintained within the space during the operating period of the equipment. The dotted line represents the additional cooling load from the heat left in the building construction. The temperature in the space rises during the shutdown period from the night-time transmission load and the stored heat, and is brought back to the control point during the pulldown period.

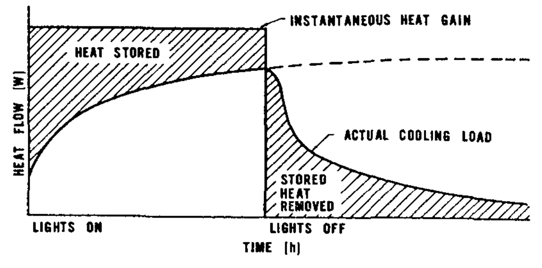


Fig. 6—Actual cooling load from fluorescent lights, average construction

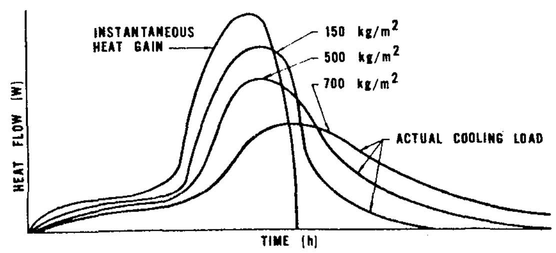


Fig. 7—Actual cooling load, solar heat gain, light, medium and heavy construction

Shorter periods of operation increase the pulldown load because more stored heat is left in the building construction when the equipment is shut off. *Fig. 10* illustrates the *pulldown load for 12-hour operation.*

Adding this pulldown load to the cooling load for that day results in the actual cooling load for *12-hour operation*, as illustrated in *Fig. 11.*

The upper and lower solid curves are the instantaneous heat gain and the actual cooling load in average construction space with a constant temperature maintained during the operating period. The cross-hatched areas again represent the Heat Stored and the Stored Heat Removed from the construction.

The *light load (fluorescent)* is shown in *Fig. 12* for *12- and 16-hour operation* with a constant space temperature (assuming 10-hour operation of lights).

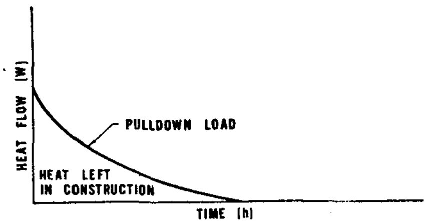


Fig. 8—Pulldown load, solar heat gain, west exposure, 16-hour operation

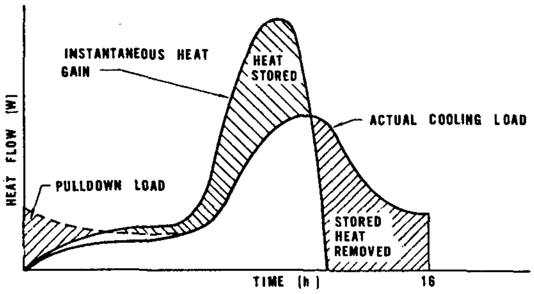


Fig. 9—Actual cooling load, solar heat gain, west exposure, 16-hour operation

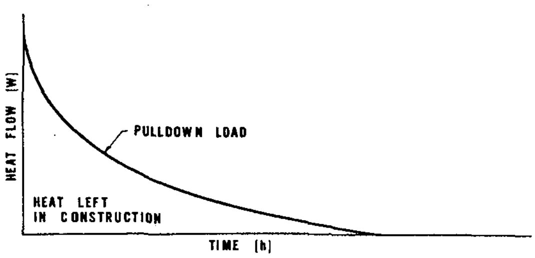


Fig. 10—Pulldown load, solar heat gain, west exposure, 12-hour operation

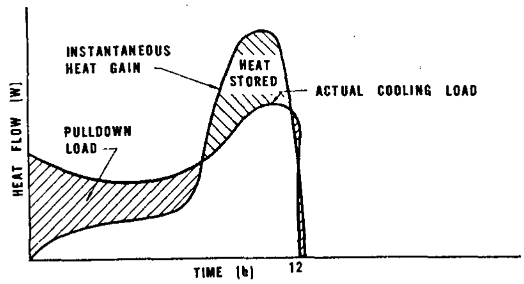


Fig. 11—Actual cooling load, solar heat gain, west exposure, 12-hour operation

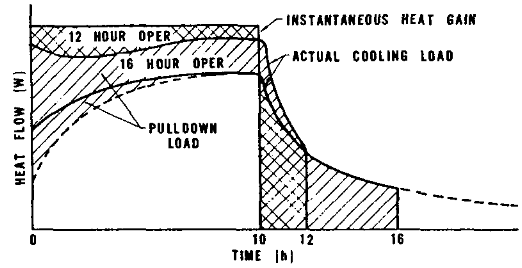


Fig. 12—Actual cooling load from fluorescent lights, 12- and 16-hour operation

Basis of Tables 6 to 11
Storage Load Factors
Solar and Light Heat Gain
12-, 16-, and 24-hour Operation,
Constant Space Temperature

These tables are calculated, using a procedure developed from a series of tests in actual buildings. These tests were conducted in office buildings, supermarkets, and residences throughout the U.S.A.

The magnitude of the storage effect is determined largely by the thermal capacity or heat holding capacity of the materials surrounding the space. The thermal capacity of a material is the mass times the specific heat of the material. Since the specific heat of most construction material is approximately 0.84 kJ/kg.°C, the thermal capacity is directly proportional to the mass of the material. Therefore, the data in the tables is based on mass of the materials surrounding the space, per square metre of floor area.

Use of Tables 6 to 11
Storage Load Factors,
Solar and Light Heat Gain
12-, 16-, and 24-hour Operation,
Constant Space Temperature

Tables 6 to *10* are used to determine the actual cooling load from the solar heat gain with a constant temperature maintained within the space for different types of construction and periods of operation. With both the 12- and 16-hour factors, the starting time is assumed to be 6 a.m. suntime (7 a.m. Daylight Saving Time). The mass per square metre of types of construction are listed in *Table 24* to *36*.

The actual cooling load is determined by multiplying the storage load factor from these tables for any or all times by the peak solar heat gain for the particular exposure, month and latitude desired. *Table 5* is a compilation of the peak solar heat gains for each exposure, month and latitude. These values are extracted from *Table 14*. The peak solar heat gain is also to be multiplied by either or both the applicable over-all factor for shading devices (*Tables 15* to *18*) and the corrections listed under *Table 5*. Reduction in solar heat gain from the shading of the window by reveals and/or overhang should also be utilized.

Example 1—Actual Cooling Load, Solar Heat Gain through Window

Given:

A 6.0 m × 6.0 m × 2.6 m outside office with 150 mm concrete floor, 25 mm topping and vinyl tile finish, 100 mm terracotta brick partition with 15 mm gypsum plaster finish, no suspended ceiling, and 2 × 110 mm outside brick wall with 50 mm air gap, 15 mm gypsum plaster finish inside. A steel sash window 4.5 m × 1.5 m is in the outside wall, with an internal "Brella" white Holland blind. The wall faces west.

Find:

1. The actual cooling load from solar heat gain through the window in January at 4 p.m., 40° South latitude, with the air conditioning equipment operating 24 hours during the peak load periods and a constant temperature maintained within the room.
2. The cooling load at 8 p.m. for the same condition.

Solution:

The mass per square metre of floor area of this room (values obtained from *Chapter 5*) is:

Outside wall;
(6.0 × 2.6 − 4.5 × 1.5) × 444 kg/m² (Table 24) × 1/(6.0 × 6.0) = 109 kg/m²

Partitions;
0.5 (6.0 × 2.6 × 3.0) × 122 kg/m² (Table 26) × 1/(6.0 × 6.0) = 79 kg/m²

Floor;
0.5 (6.0 × 6.0) × 412 kg/m² (Table 27) × 1/(6.0 × 6.0) = 206 kg/m²

Ceiling;
Same as floor, = 206 kg/m²

Note:

One half of the partition, floor and ceiling thickness is used, assuming that the spaces above and below are conditioned and are utilizing the other halves for storage of heat.

Total mass per square metre of floor area = 109 + 79 + 206 + 206 = 600 kg/m²

The overall solar factor for the window with the white "Brella" Holland blind is 0.33 (*Table 16*) and the correction for steel sash is 1/0.85.

1. Storage factor, 4 p.m. = 0.655 (*Table 6*)
   The peak solar heat gain for a west exposure in January at 40° South latitude is 550 W/m² (*Table 5*)
   Actual cooling load = (4.5 × 1.5 × 550 × 0.33 × 1/0.85) × 0.655 = 945 W.
2. Storage factor, 8 p.m. = 0.195 (Table 6)
   Actual cooling load = (4.5 × 1.5 × 550 × 0.33 × 1/0.85) × 0.195 = 282 W.

Table 11 is used to determine the actual cooling load from the heat gain from lights. These data may also be used to determine the actual cooling load from some appliances and machines that operate periodically, with hot exterior surfaces such as ovens, dryers, hot tanks, etc. In such cases, use values listed for fluorescent exposed lights.

Example 2—Actual Cooling Load and Lights

Given:

The same room as in *Example 1* with a light heat gain from exposed fluorescent lights of 30 W/m² of floor area not including ballast located in the conditioned space. (See *Chapter 7*, *Fig. 34*).

Find:

The actual cooling load at 4 p.m. (with the lights turned on at 8 a.m.).

Solution:

The time elapsed after the lights are turned on is 8 hours (8 a.m. to 4 p.m.).

Storage load factor = 0.855 (*Table 11*).

Actual cooling load
= (30 × 1.25 × 6.0 × 6.0) × 0.855
= 1155 W

TABLE 5—PEAK SOLAR HEAT GAIN THROUGH REFERENCE GLASS*

Watts per square metre (W/m²)

South Latitude	Month	Exposure N	NE	E	SE	S†	SW	W	NW	Horiz.
0°	Jan.	47	175	510	520	160	520	510	175	790
	Feb. & Oct.	45	250	510	440	80	440	510	250	770
	Mar. & Sept.	45	370	530	370	32	370	530	370	790
	Apr. & Aug.	105	440	510	250	32	250	510	440	770
	May & July	210	480	480	160	32	160	480	480	740
	June	260	490	460	130	32	130	460	490	710
	Nov.	45	160	480	480	150	480	480	160	740
	Dec.	47	140	500	530	190	530	500	140	760
10°	Jan.	47	220	530	500	95	500	530	220	830
	Feb. & Oct.	45	300	510	410	40	410	510	300	790
	Mar. & Sept.	90	400	520	320	32	320	520	400	780
	Apr. & Aug.	230	470	490	210	32	210	490	470	730
	May & July	330	510	450	115	28	115	450	510	660
	June	380	510	430	90	28	90	430	510	640
	Nov.	45	210	500	470	95	470	500	210	780
	Dec.	47	190	520	520	135	520	520	190	820
20°	Jan.	47	290	550	470	65	470	550	290	850
	Feb. & Oct.	80	360	520	370	35	370	520	360	780
	Mar. & Sept.	210	440	510	270	32	270	510	440	740
	Apr. & Aug.	350	500	460	160	28	160	460	500	660
	May & July	440	520	400	80	25	80	400	520	570
	June	470	530	380	57	25	57	380	500	540
	Nov.	45	270	510	440	60	440	510	270	790
	Dec.	47	250	540	520	88	520	540	250	840
30°	Jan.	100	340	550	440	55	440	550	340	830
	Feb. & Oct.	200	410	520	340	35	340	520	410	740
	Mar. & Sept.	330	480	500	280	28	280	500	480	670
	Apr. & Aug.	460	510	430	120	25	120	430	510	560
	May & July	500	510	370	50	22	50	370	510	460
	June	510	510	330	32	19	32	330	510	410
	Nov.	95	320	520	410	50	410	520	320	780
	Dec.	70	300	540	470	68	470	540	300	840
40°	Jan.	230	420	550	430	50	430	550	420	790
	Feb. & Oct.	320	460	510	320	35	320	510	460	680
	Mar. & Sept.	440	510	470	180	28	180	470	510	580
	Apr. & Aug.	510	510	380	110	22	110	380	510	410
	May & July	520	490	320	38	16	38	320	490	320
	June	520	470	270	32	16	32	270	470	270
	Nov.	220	390	520	400	47	400	520	390	740
	Dec.	180	370	550	450	57	450	550	370	800
50°	Jan.	360	480	550	390	47	390	550	480	710
	Feb. & Oct.	440	500	500	300	35	300	500	500	580
	Mar. & Sept.	500	510	440	180	25	180	440	510	470
	Apr. & Aug.	530	500	330	90	16	90	330	500	300
	May & July	480	400	200	28	13	28	200	400	170
	June	440	370	150	22	9	22	150	370	125
	Nov.	330	450	510	370	45	370	510	450	670
	Dec.	310	460	550	430	55	430	550	460	740

Solar Gain Correction	Steel sash or no sash ×1/0.85 or 1.17	Haze −15% (Max)	Altitude +2.3% per 1000 m	Dewpoint: Decrease from 20°C+13% per 10°C	Dewpoint: Increase from 20°C−13% per 10°C

*Abstracted from *Table 14*, except for south exposure (see below).

†Solar heat gain on south exposure consists primarily of diffused radiation which is essentially constant throughout the day. The solar heat gain values for this exposure are the average for the 12-hour period (6 a.m. to 6 p.m.). The storage factors in *Tables 6* to *10* assume that the solar heat gain on the south exposure is constant.

TABLE 6—STORAGE LOAD FACTORS, SOLAR HEAT GAIN THROUGH GLASS
WITH INTERNAL SHADE*
24 Hour Operation, Constant Space Temperature†

Exposure	Mass per unit area of floor kg/m² ‡	SUN TIME																							
		AM							PM													AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
North	700 & Over	0.06	0.06	0.23	0.38	0.51	0.60	0.66	0.67	0.64	0.59	0.42	0.24	0.22	0.19	0.17	0.15	0.13	0.12	0.11	0.10	0.09	0.08	0.07	0.07
	500	0.04	0.04	0.22	0.38	0.52	0.63	0.70	0.71	0.69	0.59	0.45	0.26	0.22	0.18	0.16	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05
	150	0.10	0.21	0.43	0.63	0.77	0.86	0.88	0.82	0.56	0.50	0.24	0.16	0.11	0.08	0.05	0.04	0.02	0.02	0.01	0.01	0	0	0	0
Northeast	700 & Over	0.04	0.28	0.47	0.59	0.64	0.62	0.53	0.41	0.27	0.24	0.21	0.19	0.16	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.06	0.06	0.05	0.05
	500	0.03	0.28	0.47	0.61	0.67	0.65	0.57	0.44	0.29	0.24	0.21	0.18	0.15	0.12	0.10	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03
	150	0	0.30	0.57	0.75	0.84	0.81	0.69	0.50	0.30	0.20	0.17	0.13	0.09	0.05	0.04	0.03	0.02	0.01	0	0	0	0	0	0
East	700 & Over	0.39	0.56	0.62	0.59	0.49	0.33	0.23	0.21	0.20	0.18	0.17	0.15	0.12	0.10	0.09	0.08	0.08	0.07	0.06	0.05	0.05	0.05	0.04	0.04
	500	0.40	0.58	0.65	0.63	0.52	0.35	0.24	0.22	0.20	0.18	0.16	0.14	0.12	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02
	150	0.46	0.70	0.80	0.79	0.64	0.42	0.25	0.19	0.16	0.14	0.11	0.09	0.07	0.04	0.02	0.02	0.01	0.01	0	0	0	0	0	0
Southeast	700 & Over	0.47	0.58	0.54	0.42	0.27	0.21	0.20	0.19	0.18	0.17	0.16	0.14	0.12	0.09	0.08	0.07	0.06	0.06	0.05	0.05	0.04	0.04	0.04	0.03
	500	0.48	0.60	0.57	0.46	0.30	0.24	0.20	0.19	0.17	0.16	0.15	0.13	0.11	0.08	0.07	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02
	150	0.55	0.76	0.73	0.58	0.36	0.24	0.19	0.17	0.15	0.13	0.12	0.11	0.07	0.04	0.02	0.02	0.01	0.01	0	0	0	0	0	0
Southwest	700 & Over	0.08	0.09	0.10	.010	0.10	0.10	0.10	0.10	0.16	0.33	0.49	0.61	0.60	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.06
	500	0.07	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.16	0.34	0.52	0.65	0.64	0.23	0.18	0.15	0.12	0.11	0.09	0.08	0.07	0.06	0.06	0.05
	150	0.03	0.05	0.07	0.08	0.09	0.09	0.10	0.10	0.17	0.39	0.63	0.80	0.79	0.28	0.18	0.12	0.09	0.06	0.04	0.03	0.02	0.02	0.01	0
West	700 & Over	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.18	0.36	0.52	0.63	0.65	0.55	0.22	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.07
	500	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.18	0.36	0.54	0.66	0.68	0.60	0.25	0.20	0.17	0.15	0.13	0.11	0.10	0.08	0.07	0.06	0.05
	150	0.03	0.04	0.06	0.07	0.08	0.08	0.08	0.19	0.42	0.65	0.81	0.85	0.74	0.30	0.19	0.13	0.09	0.06	0.05	0.03	0.02	0.02	0.01	0
Northwest	700 & Over	0.08	0.08	0.09	0.10	0.11	0.24	0.39	0.53	0.63	0.66	0.61	0.47	0.23	0.19	0.18	0.16	0.14	0.13	0.11	0.10	0.09	0.08	0.08	0.07
	500	0.07	0.08	0.08	0.08	0.10	0.24	0.40	0.55	0.66	0.70	0.64	0.50	0.26	0.20	0.17	0.15	0.13	0.11	0.10	0.09	0.08	0.07	0.06	0.05
	150	0.03	0.04	0.06	0.07	0.09	0.23	0.47	0.67	0.81	0.86	0.79	0.60	0.26	0.17	0.12	0.08	0.05	0.04	0.03	0.02	0.01	0.01	0	0
South and Shade	700 & Over	0.08	0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.88	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10
	500	0.06	0.31	0.67	0.72	0.76	0.79	0.81	0.83	0.85	0.87	0.88	0.90	0.91	0.30	0.26	0.22	0.19	0.16	0.15	0.13	0.12	0.10	0.09	0.08
	150	0	0.25	0.74	0.83	0.88	0.91	0.94	0.96	0.96	0.98	0.98	0.99	0.99	0.26	0.17	0.12	0.08	0.05	0.04	0.03	0.02	0.01	0.01	0.01

Equation: Cooling Load, W = [Peak solar heat gain, W/m². (*Table 5*)]
× [Window area, m²]
× [Overall solar factor, Haze factor, etc. (*Chapter 4*)]
× [Storage factor, (above Table at desired time)]

*Internal shading device is any type of shade located on the inside of the glass.

†These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors.

‡Mass per unit area of floor—

$$\text{Room on Building Exterior (one or more outside walls)} = \frac{\text{(Mass of outside walls, kg)} + 0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Room in Building Interior (no outside walls)} = \frac{0.5\ \text{(Mass of Partitions, Floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Basement Room (floor on ground)} = \frac{\text{(Mass of outside walls, kg)} + \text{(Mass of floor, kg)} + 0.5\text{(Mass of partitions and ceilings, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Entire Building or Zone} = \frac{\text{(Mass of outside wall, partitions, floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area m}^2}$$

With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.
Mass per unit area of common types of construction are contained in *Tables 24* to *36*.

TABLE 7—STORAGE LOAD FACTORS, SOLAR HEAT GAIN THROUGH GLASS

WITH BARE GLASS OR WITH EXTERNAL SHADE*

24 Hour Operation, Constant Space Temperature†

Exposure	Mass per unit area of floor kg/m² ‡	SUN TIME																							
		AM							PM												AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
North	700 & Over	0.10	0.09	0.13	0.20	0.28	0.35	0.43	0.49	0.52	0.52	0.49	0.42	0.37	0.33	0.29	0.26	0.23	0.21	0.19	0.17	0.15	0.14	0.13	0.11
	500	0.07	0.06	0.12	0.20	0.30	0.39	0.48	0.54	0.58	0.57	0.53	0.45	0.37	0.31	0.27	0.23	0.20	0.18	0.16	0.14	0.12	0.11	0.10	0.08
	150	0	0	0.12	0.29	0.48	0.64	0.75	0.82	0.81	0.75	0.61	0.42	0.28	0.19	0.13	0.09	0.06	0.04	0.03	0.02	0.01	0.01	0	0
Northeast	700 & Over	0.08	0.14	0.22	0.32	0.39	0.44	0.45	0.44	0.39	0.35	0.32	0.29	0.26	0.23	0.21	0.19	0.16	0.15	0.13	0.12	0.11	0.10	0.09	0.08
	500	0.05	0.12	0.23	0.35	0.44	0.49	0.51	0.47	0.41	0.36	0.31	0.27	0.24	0.21	0.18	0.16	0.14	0.12	0.10	0.09	0.08	0.08	0.06	0.06
	150	0	0.18	0.40	0.59	0.72	0.77	0.72	0.60	0.44	0.32	0.23	0.18	0.14	0.09	0.07	0.05	0.03	0.02	0.01	0.01	0.01	0	0	0
East	700 & Over	0.16	0.26	0.34	0.40	0.41	0.39	0.34	0.30	0.28	0.26	0.23	0.22	0.20	0.18	0.16	0.14	0.13	0.12	0.10	0.09	0.08	0.08	0.07	0.06
	500	0.16	0.29	0.40	0.46	0.46	0.42	0.36	0.31	0.28	0.25	0.23	0.20	0.18	0.15	0.14	0.12	0.11	0.09	0.08	0.08	0.06	0.06	0.05	0.04
	150	0.27	0.50	0.67	0.73	0.68	0.53	0.38	0.27	0.22	0.18	0.15	0.12	0.09	0.06	0.04	0.03	0.02	0.01	0.01	0.01	0.01	0	0	0.01
Southeast	700 & Over	0.17	0.28	0.34	0.34	0.32	0.30	0.27	0.25	0.23	0.22	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.07	0.06	0.06
	500	0.19	0.31	0.38	0.39	0.36	0.34	0.27	0.24	0.22	0.21	0.19	0.17	0.16	0.14	0.12	0.10	0.07	0.08	0.07	0.06	0.05	0.05	0.04	0.03
	150	0.31	0.56	0.65	0.61	0.46	0.33	0.26	0.21	0.18	0.16	0.14	0.12	0.09	0.06	0.04	0.03	0.02	0.01	0.01	0.01	0	0	0	0
Southwest	700 & Over	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.17	0.25	0.35	0.40	0.35	0.29	0.26	0.23	0.20	0.18	0.16	0.14	0.13	0.12	0.10
	500	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.11	0.19	0.29	0.40	0.46	0.40	0.32	0.26	0.22	0.19	0.16	0.14	0.13	0.11	0.10	0.08
	150	0.02	0.04	0.05	0.07	0.08	0.09	0.10	0.10	0.13	0.27	0.48	0.65	0.73	0.49	0.31	0.21	0.16	0.10	0.07	0.05	0.04	0.03	0.02	0.01
West	700 & Over	0.12	0.11	0.11	0.10	0.10	0.10	0.10	0.13	0.19	0.27	0.36	0.43	0.45	0.38	0.33	0.29	0.26	0.23	0.21	0.18	0.16	0.15	0.13	0.12
	500	0.09	0.09	0.09	0.09	0.09	0.09	0.10	0.12	0.19	0.30	0.40	0.48	0.51	0.42	0.35	0.30	0.25	0.22	0.19	0.16	0.14	0.13	0.11	0.09
	150	0.02	0.03	0.05	0.06	0.07	0.07	0.08	0.14	0.29	0.49	0.67	0.76	0.75	0.53	0.33	0.22	0.15	0.11	0.08	0.05	0.04	0.03	0.02	0.01
Northwest	700 & Over	0.11	0.10	0.10	0.10	0.10	0.14	0.21	0.29	0.36	0.44	0.48	0.47	0.41	0.34	0.30	0.27	0.24	0.22	0.20	0.18	0.16	0.14	0.13	0.12
	500	0.09	0.09	0.08	0.09	0.09	0.14	0.22	0.31	0.42	0.50	0.53	0.51	0.44	0.35	0.29	0.26	0.22	0.19	0.17	0.15	0.13	0.12	0.11	0.09
	150	0.02	0.03	0.05	0.06	0.08	0.12	0.34	0.53	0.68	0.78	0.78	0.68	0.46	0.29	0.20	0.14	0.09	0.07	0.05	0.03	0.02	0.02	0.01	0.01
South and Shade	700 & Over	0.15	0.24	0.34	0.42	0.48	0.53	0.58	0.62	0.67	0.70	0.73	0.75	0.59	0.52	0.46	0.41	0.37	0.34	0.31	0.27	0.25	0.23	0.21	0.17
	500	0.11	0.33	0.44	0.51	0.57	0.62	0.66	0.70	0.74	0.76	0.79	0.80	0.60	0.51	0.44	0.37	0.32	0.29	0.27	0.23	0.21	0.18	0.16	0.13
	150	0	0.48	0.66	0.76	0.82	0.87	0.91	0.93	0.95	0.97	0.98	0.98	0.52	0.34	0.24	0.16	0.11	0.07	0.05	0.04	0.02	0.02	0.01	0.01

Equation: Cooling Load, W = [Peak solar heat gain, W m² (*Table 5*)]
× [Window area, m²]
× [Glass or overall solar factor, haze factor, etc., (*Chapter 4*)]
× [Storage factor, (above Table at desired time)]

*Bare glass—Any window with no inside shading device. Windows with shading devices on the outside or shaded by external projections are considered bare glass.

†These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors.

‡Mass per unit area of floor—

$$\text{Room on Building Exterior (one or more outside walls)} = \frac{\text{(Mass of outside walls, kg)} + 0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Room in Building Interior (no outside walls)} = \frac{0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Basement Room (floor on ground)} = \frac{\text{(Mass of outside walls, kg)} + \text{(Mass of floor, kg)} + 0.5\ \text{(Mass of partitions and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Entire building or zone} = \frac{\text{(Mass of outside wall, partitions floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area, m}^2}$$

With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.

Mass per unit area of common types of construction are contained in *Table 24* to *36*.

TABLE 8—STORAGE LOAD FACTORS, SOLAR HEAT GAIN THROUGH GLASS

WITH INTERNAL SHADING DEVICE*

16 Hour Operation, Constant Space Temperature†

Exposure	Mass per unit area of floor kg/m² ‡	SUN TIME															
		AM							PM								
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
North	700 & Over	0.19	0.18	0.34	0.48	0.60	0.68	0.73	0.72	0.66	0.59	0.42	0.24	0.22	0.19	0.17	0.15
	500	0.16	0.14	0.31	0.46	0.59	0.69	0.76	0.70	0.69	0.59	0.45	0.26	0.22	0.18	0.16	0.13
	150	0.12	0.23	0.44	0.64	0.77	0.86	0.88	0.82	0.56	0.50	0.24	0.16	0.11	0.08	0.05	0.04
Northeast	700 & Over	0.14	0.37	0.55	0.66	0.70	0.68	0.58	0.46	0.27	0.24	0.21	0.19	0.16	0.14	0.12	0.11
	500	0.11	0.35	0.53	0.66	0.72	0.69	0.61	0.47	0.29	0.24	0.21	0.18	0.15	0.12	0.10	0.09
	150	0.02	0.31	0.57	0.75	0.84	0.81	0.69	0.50	0.30	0.20	0.17	0.13	0.09	0.05	0.04	0.03
East	700 & Over	0.47	0.63	0.68	0.64	0.54	0.38	0.27	0.25	0.20	0.18	0.17	0.15	0.12	0.10	0.09	0.08
	500	0.46	0.63	0.70	0.67	0.56	0.38	0.27	0.24	0.20	0.18	0.16	0.14	0.12	0.09	0.08	0.07
	150	0.47	0.71	0.80	0.79	0.64	0.42	0.25	0.19	0.16	0.14	0.11	0.09	0.07	0.04	0.02	0.02
Southeast	700 & Over	0.53	0.64	0.59	0.47	0.31	0.25	0.24	0.22	0.18	0.17	0.16	0.14	0.12	0.09	0.08	0.07
	500	0.53	0.65	0.61	0.50	0.33	0.27	0.22	0.21	0.17	0.16	0.15	0.13	0.11	0.08	0.07	0.06
	150	0.56	0.77	0.73	0.58	0.36	0.24	0.19	0.17	0.15	0.13	0.12	0.11	0.07	0.04	0.02	0.02
Southwest	700 & Over	0.21	0.21	0.20	0.19	0.18	0.18	0.17	0.16	0.16	0.33	0.49	0.61	0.53	0.19	0.17	0.15
	500	0.19	0.19	0.18	0.17	0.17	0.16	0.16	0.15	0.16	0.34	0.52	0.65	0.23	0.18	0.15	0.12
	150	0.12	0.11	0.11	0.11	0.11	0.11	0.11	0.10	0.17	0.39	0.63	0.80	0.78	0.28	0.18	0.12
West	700 & Over	0.23	0.23	0.21	0.21	0.20	0.19	0.18	0.25	0.36	0.52	0.63	0.65	0.56	0.22	0.19	0.17
	500	0.22	0.21	0.19	0.19	0.17	0.16	0.15	0.23	0.36	0.54	0.66	0.68	0.60	0.25	0.20	0.17
	150	0.12	0.10	0.10	0.10	0.10	0.10	0.09	0.19	0.42	0.65	0.81	0.85	0.74	0.30	0.19	0.13
Northwest	700 & Over	0.22	0.21	0.20	0.20	0.20	0.32	0.47	0.60	0.63	0.66	0.61	0.47	0.23	0.19	0.18	0.16
	500	0.20	0.19	0.18	0.17	0.18	0.31	0.46	0.60	0.66	0.70	0.64	0.50	0.26	0.20	0.17	0.15
	150	0.08	0.08	0.09	0.09	0.10	0.24	0.47	0.67	0.81	0.86	0.79	0.60	0.26	0.17	0.12	0.08
South and Shade	700 & Over	0.23	0.56	0.75	0.79	0.80	0.80	0.81	0.82	0.83	0.84	0.86	0.87	0.88	0.39	0.35	0.31
	500	0.25	0.46	0.73	0.78	0.82	0.82	0.83	0.84	0.85	0.87	0.88	0.89	0.90	0.40	0.34	0.29
	150	0.07	0.22	0.69	0.80	0.86	0.93	0.94	0.95	0.97	0.98	0.98	0.99	0.99	0.35	0.23	0.16

Equation: Cooling Load, W = [Peak solar heat gain, W/m² (*Table 5*)]
× [Window area, m²]
× [Overall solar factor, haze factor, etc. (*Chapter 4*)]
× [Storage factor (*above Table at desired time*)]

*Internal shading device is any type of shade located on the inside of the glass.

†These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors.

‡Mass per unit area of floor—

Room on Building Exterior (one or more outside walls) $= \dfrac{\text{(Mass of outside walls, kg)} + 0.5\ \text{(Mass of partitions, floor and ceiling kg)}}{\text{Floor area in room, m}^2}$

Room in Building Interior (no outside walls) $= \dfrac{0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$

Basement Room (floor on ground) $= \dfrac{\text{(Mass of outside walls, kg)} + \text{(Mass of floors, kg)} \times (0.5\ \text{(Mass of partitions and ceiling, kg)}}{\text{Floor area in room, m}^2}$

Entire Building or Zone $= \dfrac{\text{(Mass of outside wall, partitions, floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area, m}^2}$

With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.

Mass per unit area of common types of construction are contained in *Tables 24* to *36*.

TABLE 9—STORAGE LOAD FACTORS, SOLAR HEAT GAIN THROUGH GLASS

WITH BARE GLASS OR WITH EXTERNAL SHADE*

16 Hour Operation, Constant Space Temperature†

Exposure	Mass per unit area of floor kg/m² ‡	SUN TIME															
		AM							PM								
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9
North	700 & Over	0.32	0.30	0.32	0.37	0.43	0.49	0.55	0.60	0.57	0.52	0.49	0.42	0.37	0.33	0.29	0.26
	500	0.27	0.24	0.28	0.34	0.42	0.50	0.58	0.60	0.60	0.57	0.53	0.45	0.37	0.31	0.27	0.23
	150	0.06	0.04	0.15	0.31	0.49	0.65	0.75	0.82	0.81	0.75	0.61	0.42	0.28	0.19	0.13	0.09
Northeast	700 & Over	0.24	0.28	0.35	0.43	0.49	0.53	0.53	0.51	0.39	0.35	0.32	0.29	0.26	0.23	0.21	0.19
	500	0.19	0.24	0.33	0.44	0.52	0.57	0.57	0.53	0.41	0.36	0.31	0.27	0.24	0.21	0.18	0.16
	150	0.03	0.20	0.41	0.60	0.73	0.77	0.72	0.60	0.44	0.32	0.23	0.18	0.14	0.09	0.07	0.05
East	700 & Over	0.29	0.38	0.44	0.49	0.49	0.46	0.41	0.36	0.28	0.26	0.23	0.22	0.20	0.18	0.16	0.14
	500	0.27	0.38	0.48	0.54	0.52	0.48	0.41	0.35	0.28	0.25	0.23	0.20	0.18	0.15	0.14	0.12
	150	0.29	0.51	0.68	0.74	0.69	0.53	0.38	0.27	0.22	0.18	0.15	0.12	0.09	0.06	0.04	0.03
Southeast	700 & Over	0.28	0.37	0.42	0.41	0.38	0.36	0.33	0.31	0.23	0.22	0.20	0.19	0.17	0.15	0.14	0.12
	500	0.28	0.39	0.45	0.45	0.41	0.39	0.31	0.27	0.22	0.21	0.19	0.17	0.16	0.14	0.12	0.10
	150	0.33	0.57	0.66	0.62	0.46	0.33	0.26	0.21	0.18	0.16	0.14	0.12	0.09	0.06	0.04	0.03
Southwest	700 & Over	0.33	0.30	0.28	0.26	0.24	0.23	0.22	0.20	0.18	0.17	0.25	0.35	0.40	0.35	0.29	0.26
	500	0.30	0.28	0.25	0.23	0.22	0.20	0.19	0.17	0.17	0.19	0.29	0.40	0.46	0.40	0.32	0.26
	150	0.18	0.14	0.12	0.12	0.12	0.12	0.12	0.11	0.13	0.27	0.48	0.65	0.73	0.49	0.31	0.21
West	700 & Over	0.38	0.34	0.32	0.28	0.26	0.25	0.23	0.25	0.26	0.27	0.36	0.43	0.45	0.39	0.33	0.29
	500	0.34	0.31	0.28	0.25	0.23	0.22	0.21	0.21	0.23	0.30	0.40	0.48	0.51	0.43	0.35	0.30
	150	0.17	0.14	0.13	0.11	0.11	0.10	0.10	0.15	0.29	0.49	0.67	0.76	0.75	0.53	0.33	0.22
Northwest	700 & Over	0.35	0.32	0.29	0.28	0.26	0.28	0.30	0.37	0.43	0.47	0.47	0.41	0.36	0.31	0.27	0.24
	500	0.31	0.28	0.25	0.24	0.22	0.26	0.33	0.40	0.46	0.50	0.53	0.51	0.44	0.35	0.29	0.26
	150	0.11	0.10	0.10	0.09	0.10	0.14	0.35	0.54	0.68	0.78	0.78	0.68	0.46	0.29	0.20	0.14
South and Shade	700 & Over	0.31	0.55	0.63	0.68	0.72	0.73	0.73	0.74	0.75	0.76	0.77	0.78	0.79	0.59	0.52	0.46
	500	0.30	0.47	0.60	0.67	0.72	0.74	0.77	0.78	0.79	0.80	0.81	0.82	0.83	0.60	0.51	0.44
	150	0.04	0.07	0.53	0.70	0.78	0.84	0.88	0.91	0.93	0.95	0.97	0.98	0.99	0.62	0.34	0.24

Equation: Cooling Load, W = [Peak solar heat gain, W/m², (*Table 5*)]
× [Window area, m²]
× [Glass or overall solar factor, haze factor, etc. (*Chapter 4*)]
× [Storage factor (above Table at desired time)]

*Bare glass—Any window with no inside shading device. Windows with shading devices on the outside or shaded by external projections are considered bare glass.

†These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors.

‡Mass per unit area of floor—

$$\text{Room on Building Exterior (one or more outside walls)} = \frac{\text{(Mass of outside walls, kg)} + 0.5 \text{ (Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Room in Building Interior (no outside walls)} = \frac{0.5 \text{ (Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Basement Room (floor on ground)} = \frac{\text{(Mass of outside walls, kg)} + \text{(Mass of floor, kg)} + 0.5 \text{ (Mass of partitions and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Entire Building or Zone} = \frac{\text{(Mass of outside wall, partitions, floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area, m}^2}$$

With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.
Mass per unit area of common types of construction are contained in *Tables 24* to *36*.

TABLE 10—STORAGE LOAD FACTORS, SOLAR HEAT GAIN THROUGH GLASS

12 Hour Operation, Constant Space Temperature†

Exposure	Mass per unit area of floor kg/m² §	INTERNAL SHADE*											
		SUN TIME											
		AM						PM					
		6	7	8	9	10	11	12	1	2	3	4	5
North	700 & Over	0.28	0.25	0.40	0.53	0.64	0.72	0.77	0.77	0.74	0.67	0.49	0.31
	500	0.26	0.22	0.38	0.51	0.64	0.73	0.79	0.79	0.77	0.65	0.51	0.31
	150	0.21	0.29	0.48	0.67	0.79	0.88	0.89	0.83	0.56	0.50	0.24	0.16
Northeast	700 & Over	0.20	0.42	0.59	0.70	0.74	0.71	0.61	0.48	0.33	0.30	0.26	0.24
	500	0.18	0.40	0.57	0.70	0.75	0.72	0.63	0.49	0.34	0.28	0.25	0.21
	150	0.09	0.35	0.61	0.78	0.86	0.82	0.69	0.50	0.30	0.20	0.17	0.13
East	700 & Over	0.51	0.66	0.71	0.67	0.57	0.40	0.29	0.26	0.25	0.23	0.21	0.19
	500	0.52	0.67	0.73	0.70	0.58	0.40	0.29	0.26	0.24	0.21	0.19	0.16
	150	0.53	0.74	0.82	0.81	0.65	0.43	0.25	0.19	0.16	0.14	0.11	0.09
Southeast	700 & Over	0.59	0.67	0.62	0.49	0.33	0.27	0.25	0.24	0.22	0.21	0.20	0.17
	500	0.59	0.68	0.64	0.52	0.35	0.29	0.24	0.23	0.20	0.19	0.17	0.15
	150	0.62	0.80	0.75	0.60	0.37	0.25	0.19	0.17	0.15	0.13	0.12	0.11
Southwest	700 & Over	0.68	0.28	0.27	0.25	0.23	0.22	0.20	0.19	0.24	0.41	0.56	0.67
	500	0.71	0.31	0.27	0.24	0.22	0.21	0.19	0.18	0.23	0.40	0.58	0.70
	150	0.82	0.33	0.25	0.20	0.18	0.15	0.14	0.13	0.19	0.41	0.64	0.80
West	700 & Over	0.63	0.31	0.28	0.27	0.25	0.24	0.22	0.29	0.46	0.61	0.71	0.72
	500	0.67	0.33	0.28	0.26	0.24	0.22	0.20	0.28	0.44	0.61	0.72	0.73
	150	0.77	0.34	0.25	0.20	0.17	0.14	0.13	0.22	0.44	0.67	0.82	0.85
Northwest	700 & Over	0.31	0.27	0.27	0.26	0.25	0.24	0.50	0.63	0.72	0.74	0.69	0.54
	500	0.33	0.28	0.25	0.23	0.23	0.35	0.50	0.64	0.74	0.77	0.70	0.55
	150	0.29	0.21	0.18	0.15	0.14	0.27	0.50	0.69	0.82	0.87	0.79	0.60
South and Shade	700 & Over	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
	500	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
	150	← 1.00 →											

Exposure	Mass per unit area of floor kg/m² §	BARE GLASS OR EXTERNAL SHADE‡											
		SUN TIME											
		AM						PM					
		6	7	8	9	10	11	12	1	2	3	4	5
North	700 & Over	0.47	0.47	0.42	0.46	0.51	0.56	0.61	0.65	0.66	0.65	0.61	0.54
	500	0.44	0.37	0.39	0.43	0.50	0.57	0.64	0.68	0.70	0.68	0.63	0.53
	150	0.28	0.19	0.25	0.38	0.54	0.68	0.78	0.84	0.82	0.76	0.61	0.42
Northeast	700 & Over	0.33	0.37	0.43	0.50	0.54	0.58	0.57	0.55	0.50	0.45	0.41	0.37
	500	0.29	0.33	0.41	0.51	0.58	0.61	0.61	0.56	0.49	0.44	0.37	0.33
	150	0.14	0.27	0.47	0.64	0.75	0.79	0.73	0.61	0.45	0.32	0.23	0.18
East	700 & Over	0.36	0.44	0.50	0.54	0.53	0.50	0.44	0.39	0.36	0.34	0.30	0.28
	500	0.34	0.44	0.54	0.58	0.57	0.51	0.44	0.39	0.34	0.31	0.28	0.24
	150	0.36	0.56	0.71	0.76	0.70	0.54	0.39	0.28	0.23	0.18	0.15	0.12
Southeast	700 & Over	0.34	0.42	0.47	0.45	0.42	0.39	0.36	0.33	0.30	0.29	0.26	0.25
	500	0.35	0.45	0.50	0.49	0.45	0.42	0.34	0.30	0.27	0.26	0.23	0.20
	150	0.40	0.62	0.69	0.64	0.48	0.34	0.27	0.22	0.18	0.16	0.14	0.12
Southwest	700 & Over	0.49	0.45	0.39	0.36	0.33	0.30	0.28	0.26	0.26	0.30	0.37	0.44
	500	0.54	0.49	0.41	0.35	0.31	0.28	0.25	0.23	0.24	0.30	0.39	0.48
	150	0.75	0.53	0.36	0.28	0.24	0.19	0.17	0.15	0.17	0.30	0.50	0.66
West	700 & Over	0.56	0.49	0.44	0.39	0.36	0.33	0.31	0.31	0.35	0.42	0.49	0.54
	500	0.60	0.52	0.44	0.39	0.34	0.31	0.29	0.28	0.33	0.43	0.51	0.57
	150	0.77	0.56	0.38	0.28	0.22	0.18	0.16	0.19	0.33	0.52	0.69	0.77
Northwest	700 & Over	0.51	0.44	0.40	0.37	0.34	0.36	0.41	0.47	0.54	0.57	0.60	0.58
	500	0.53	0.44	0.37	0.35	0.31	0.33	0.39	0.46	0.55	0.62	0.64	0.60
	150	0.48	0.32	0.25	0.20	0.17	0.19	0.39	0.56	0.70	0.80	0.79	0.69
South and Shade	700 & Over	0.75	0.75	0.79	0.83	0.84	0.86	0.88	0.88	0.91	0.92	0.93	0.93
	500	0.81	0.84	0.86	0.89	0.91	0.93	0.93	0.94	0.94	0.95	0.95	0.95
	150	← 1.00 →											

Equation: Cooling Load, W = [Peak solar heat gain, W/m² (*Table 5*)]
× [Window area, m²]
× [Glass or overall solar factor. haze factor, etc. (*Chapter 4*)]
× [Storage factor (above Table at desired time)]

*Internal shading device is any type of shade located on the inside of the glass.

†These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors.

‡Bare glass—Any window with no inside shading device. Windows with shading devices on the outside or shaded by external projections are considered bare glass.

§Mass per unit area of floor—

$$\text{Room on Building Exterior (one or more outside walls)} = \frac{\text{(Mass of outside walls, kg)} + 0.5\ \text{(Mass of partitions, floors and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Room in Building Interior (no outside walls)} = \frac{0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Basement Room (floor on ground)} = \frac{\text{(Mass of outside walls, kg)} + \text{(Mass of floor, kg)} + 0.5\ \text{(Mass of partitions and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Entire Building or Zone} = \frac{\text{(Mass of Outside wall, partitions, floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area, m}^2}$$

With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.
Mass per unit area of common types of construction are contained in *Tables 24* to *36*.

TABLE 11—STORAGE LOAD FACTORS, HEAT GAIN, LIGHTS*

Lights on 10 Hours† with Equipment Operating 12, 16 and 24 Hours, Constant Space Temperature

	Equipment Operation Hours	Mass per‡ unit area of floor kg/m²	Number of hours after lights are turned on																						
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Fluorescent Lights Exposed	24	700 & over	0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08
		500	0.31	0.67	0.72	0.76	0.79	0.81	0.83	0.85	0.87	0.88	0.90	0.30	0.26	0.22	0.19	0.16	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06
		150	0.25	0.74	0.83	0.88	0.91	0.94	0.96	0.96	0.98	0.98	0.99	0.26	0.17	0.12	0.08	0.05	0.04	0.03	0.02	0.01	0.01	0.01	0	0
	16	700 & over	0.58	0.82	0.83	0.84	0.84	0.85	0.85	0.85	0.86	0.88	0.90	0.32	0.28	0.25	0.23	0.19								
		500	0.46	0.79	0.84	0.86	0.87	0.88	0.88	0.89	0.89	0.90	0.90	0.30	0.26	0.22	0.19	0.16								
		150	0.29	0.77	0.85	0.89	0.92	0.95	0.96	0.96	0.98	0.98	0.99	0.26	0.17	0.12	0.08	0.05								
	12	700 & over	0.63	0.90	0.91	0.93	0.93	0.94	0.95	0.95	0.95	0.96	0.96	0.37												
		500	0.57	0.89	0.91	0.92	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.36												
		150	0.42	0.86	0.91	0.93	0.95	0.97	0.98	0.98	0.99	0.99	0.99	0.26												
Fluorescent Lights Recessed in Suspended Ceiling or Exposed Incandescent Lights	24	700 & over	0.32	0.55	0.61	0.65	0.68	0.71	0.74	0.77	0.79	0.81	0.83	0.39	0.35	0.31	0.28	0.25	0.23	0.20	0.18	0.16	0.15	0.13	0.12	0.11
		500	0.24	0.56	0.63	0.68	0.72	0.75	0.78	0.80	0.82	0.84	0.86	0.40	0.34	0.29	0.25	0.20	0.18	0.17	0.15	0.14	0.12	0.10	0.09	0.08
		150	0.17	0.65	0.77	0.84	0.88	0.92	0.94	0.95	0.97	0.98	0.98	0.35	0.23	0.16	0.11	0.07	0.05	0.04	0.03	0.02	0.01	0.01	0	0
	16	700 & over	0.57	0.75	0.79	0.80	0.80	0.81	0.82	0.83	0.84	0.86	0.87	0.39	0.35	0.31	0.28	0.25								
		500	0.46	0.73	0.78	0.82	0.82	0.82	0.83	0.84	0.85	0.87	0.88	0.40	0.34	0.29	0.25	0.20								
		150	0.22	0.69	0.80	0.86	0.89	0.93	0.94	0.95	0.97	0.98	0.98	0.35	0.23	0.16	0.11	0.07								
	12	700 & over	0.67	0.86	0.89	0.90	0.91	0.91	0.92	0.93	0.94	0.95	0.95	0.50												
		500	0.58	0.85	0.88	0.88	0.90	0.92	0.93	0.94	0.94	0.94	0.95	0.48												
		150	0.40	0.81	0.88	0.91	0.93	0.96	0.97	0.97	0.98	0.99	0.99	0.35												
Fluorescent or Incandescent Lights Recessed in Suspended Ceiling and Ceiling Plenum Return System	24	700 & over	0.22	0.33	0.41	0.47	0.52	0.57	0.61	0.66	0.70	0.73	0.74	0.59	0.52	0.46	0.42	0.37	0.34	0.31	0.27	0.25	0.23	0.21	0.18	0.16
		500	0.17	0.33	0.44	0.52	0.56	0.61	0.66	0.69	0.74	0.77	0.79	0.60	0.51	0.44	0.37	0.32	0.30	0.27	0.23	0.20	0.18	0.16	0.14	0.12
		150	0	0.48	0.66	0.76	0.82	0.87	0.91	0.93	0.95	0.97	0.98	0.52	0.34	0.24	0.16	0.11	0.07	0.05	0.04	0.02	0.02	0.01	0	0
	16	700 & over	0.56	0.64	0.68	0.72	0.73	0.73	0.75	0.75	0.76	0.76	0.78	0.59	0.52	0.46	0.42	0.37								
		500	0.47	0.60	0.67	0.72	0.74	0.77	0.78	0.79	0.80	0.81	0.82	0.60	0.51	0.44	0.37	0.32								
		150	0.07	0.53	0.70	0.78	0.84	0.88	0.91	0.93	0.95	0.97	0.98	0.52	0.34	0.24	0.16	0.11								
	12	700 & over	0.75	0.79	0.83	0.84	0.86	0.88	0.89	0.91	0.91	0.93	0.93	0.75												
		500	0.68	0.77	0.81	0.84	0.86	0.88	0.89	0.89	0.92	0.93	0.93	0.72												
		150	0.34	0.72	0.82	0.87	0.89	0.92	0.95	0.95	0.97	0.98	0.98	0.52												

*These factors apply when maintaining a CONSTANT TEMPERATURE in the space during the operating period. Where the temperature is allowed to swing, additional storage will result during peak load periods. Refer to *Table 12* for applicable storage factors. With lights operating the same number of hours as the time of equipment operation, use a load factor of 1.00.

†Lights on for Shorter or Longer Periods than 10 Hours

Occasionally adjustments may be required to take account of lights operating less or more than the 10 hours on which the table is based. The following is the procedure to adjust the load factors:

A—WITH LIGHTS IN OPERATION FOR SHORTER PERIOD THAN 10 HOURS and the equipment operating 12, 16 or 24 hours at the time of the overall peak load, extrapolate load factors as follows:

1. Equipment operating for 24 hours:
   (a) Use the storage load factors as listed up to the time the lights are turned off.
   (b) Shift the load factors beyond the 10th hour (on the right of heavy line) to the left to the hour the lights are turned off. This leaves last few hours of equipment operation without designated load factors.
   (c) Extrapolate the last few hours at the same rate of reduction as the end hours in the table.

2. Equipment operating for 16 hours:
   (a) Follow the procedure in Step 1, using the storage load factor values in 24-hour equipment operation table.
   (b) Now construct a new set of load factors by adding the new values for the 16th hour to that denoted 0, 17th hour to the 1st hour, etc.
   (c) The load factors for the hours succeeding the switching-off the lights are as in Steps 1*(b)* and 1*(c)*.

3. Equipment operating for 12 hours:
   Follow procedure in Step 2, except in Step 2*(b)* add values of 12th hour to that designated 0, 13th hour to the 1st hour, etc.

B—WITH LIGHTS IN OPERATION FOR LONGER PERIOD THAN 10 HOURS and the equipment operating 12, 16 or 24 hours at the time of the overall peak load, extrapolate load factors as follows:

1. Equipment operating for 24 hours:
   (a) Use the load factors as listed through 10th hour and extrapolate beyond the 10th hour at the rate of the last 4 hours.
   (b) Follow the same procedure as in Step 1*(b)* of 'A' except shift load factors beyond 10th hour now to the right, dropping off the last few hours.
2. Equipment operating for 16 hours or 12 hours:
   (a) Use the load factors in 24-hour equipment operation table as listed through 10th hour and extrapolate beyond the 10th hour at the rate of the last 4 hours.
   (b) Follow the procedure in Step 1*(b)* of 'A' except shift the load factors beyond the 10th hour to now the right.
   (c) For 16-hour equipment operation, follow the procedure in Steps 2*(b)* and 2*(c)* of 'A'.
   (d) For 12-hour equipment operation follow the procedure in Step 3 of 'A'.

Example

Adjust values for 24-hour equipment operation and derive new values for 16-hour equipment operation for fluorescent lights in operation 8 and 13 hours, and an enclosure of 700 kg/m².

Equipment Operation Hours	Mass per unit area of floor kg/m²‡	NUMBER OF HOURS AFTER LIGHTS ARE TURNED ON																								Lights On Hours
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
24	700	0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.89	0.90	0.92	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	13
		0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08	0.07	0.06	8
		0.36	0.67	0.71	0.74	0.76	0.79	0.81	0.83	0.84	0.86	0.87	0.29	0.26	0.23	0.20	0.19	0.17	0.15	0.14	0.12	0.11	0.10	0.09	0.08	10
16	700	0.59	0.87	0.90	0.91	0.91	0.93	0.93	0.94	0.94	0.95	0.95	0.96	0.96	0.97	0.29	0.26									13
		0.50	0.79	0.82	0.84	0.85	0.87	0.88	0.89	0.90	0.29	0.26	0.23	0.20	0.19	0.17	0.15									8
		0.58	0.82	0.83	0.84	0.84	0.85	0.85	0.85	0.86	0.88	0.90	0.32	0.28	0.25	0.23	0.19									10

‡Mass per unit area of floor—

$$\text{Room on Building Exterior (one or more outside walls)} = \frac{\text{(Mass of outside walls, kg)} + 0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Room in Building Interior (no outside walls)} = \frac{0.5\ \text{(Mass of partitions, floor and ceiling, kg)}}{\text{Floor area in room m}^2}$$

$$\text{Basement Room (floor on ground)} = \frac{\text{(Mass of outside walls, kg)} + \text{(Mass of floor, kg)} + 0.5\ \text{(Mass of partitions and ceiling, kg)}}{\text{Floor area in room, m}^2}$$

$$\text{Entire Building or Zone} = \frac{\text{(Mass of outside wall, partitions, floors, ceilings, structural members and supports, kg)}}{\text{Air conditioned floor area, m}^2}$$

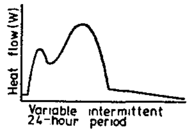
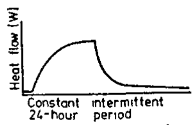
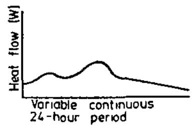
With rug on floor—Mass of floor should be multiplied by 0.50 to compensate for insulating effect of rug.

Mass per unit area of common types of construction are contained in *Tables 24* to *36*.

TABLE 12—STORAGE FACTORS, SPACE TEMPERATURE SWING

Watts per square metre of floor area degree Celsius (W/m^2.°C)

NOTE: This reduction is to be taken at the time of peak load only

TYPE APPLICATION / Load Pattern	Building Type	Mass per unit area of floor kg/m^2 *	Glass Ratio‡ %	HOURS OF OPERATION 24 — Temperature Swing °C 1	24 — 2	24 — 3	16 — 1	16 — 2	16 — 3	12 — 1	12 — 2	12 — 3
	Office Building Periphery Except South Side	700 & over	75	10.8	10.2	9.4	10.2	9.7	8.8	9.1	8.5	7.9
			50	9.7	9.1	8.2	9.1	8.5	7.7	8.5	7.7	7.1
			25	8.5	7.9	—	7.9	7.4	—	7.4	6.8	—
		500	75	9.7	9.1	8.2	8.5	8.2	7.7	7.9	7.7	7.4
			50	8.5	7.9	7.4	7.7	7.4	6.8	7.4	7.1	6.2
			25	7.7	7.1	6.8	7.1	5.7	5.1	6.8	5.4	4.0
		150	75	7.9	7.1	5.7	6.8	6.2	5.4	5.7	5.4	5.0
			50	6.8	5.4	4.5	6.2	5.1	4.5	5.1	4.8	4.5
Variable Intermittent 24-hour period			25	5.1	4.5	4.0	4.8	4.3	3.4	4.5	4.0	3.1
	Interior Zones†	700 & over	—	9.1	8.8	8.5	8.5	8.2	—	7.7	—	—
	Department Stores,	500	—	7.9	7.8	7.7	7.4	7.3	7.1	7.1	6.8	—
Constant Intermittent 24-hour period	Factories	150	—	5.4	5.2	5.1	5.1	5.0	4.8	4.8	4.5	—
	Flats, Hotels, Hospitals and Residences	700 & over	75	10.5	9.9	7.9	—	—	—	—	—	—
			50	9.4	8.5	—	—	—	—	—	—	—
			25	8.2	—	—	—	—	—	—	—	—
		500	75	8.8	8.2	7.9	—	—	—	—	—	—
			50	7.9	7.7	—	—	—	—	—	—	—
			25	7.4	—	—	—	—	—	—	—	—
		150	75	6.8	6.2	5.4	—	—	—	—	—	—
			50	6.2	5.1	4.5	—	—	—	—	—	—
Variable continuous 24-hour period			25	4.8	4.0	—	—	—	—	—	—	—

Equation: Reduction in Peak Cooling Load, W = (Floor area, m^2) × (Desired Temp. Swing) × (Storage Factor, above table)

*Mass per unit area of floor may be obtained from the equation in the footnotes to *Table 6*.

†For 12-hour operation, use a 1 °C maximum temperature swing.

‡Glass ratio is the percent of glass area to the total wall area.

SPACE TEMPERATURE SWING

In addition to the storage of radiant heat with a constant room temperature, heat is stored in the building structure when the space temperature is forced to swing. If the cooling capacity supplied to the space matches the cooling load, the temperature in the space remains constant throughout the operating period. On the other hand, if the cooling capacity supplied to the space is lower than the actual cooling load at any point, the temperature in the space will rise. As the space temperature increases, less heat is convected from the surface and more radiant heat is stored in the structure. This process of storing additional heat is illustrated in *Fig. 13.*

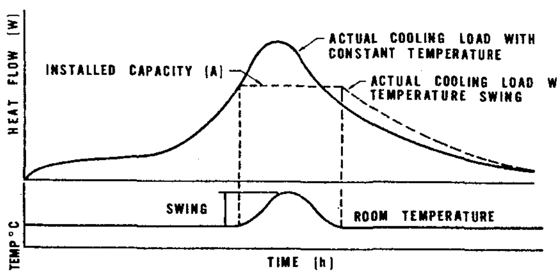


Fig. 13—Actual cooling load with varying room temperature

The solid curve is the actual cooling load from the solar heat gain on a west exposure with a constant space temperature, 24-hour operation. Assume that the maximum cooling capacity available is represented by *A*, and that the capacity is controlled to maintain a constant temperature at partial load. When the actual cooling load exceeds the available cooling capacity, the temperature will swing as shown in the lower curve. The actual cooling load with temperature swing is shown by the dotted line. This operates in a similar manner with different periods of operation and with different types of construction.

Note:

When a system is designed for a temperature swing, the maximum swing occurs only at the peak on design days, which are defined as those days when all loads simultaneously peak. Under normal operating conditions, the temperature remains constant or close to constant.

Basis of Table 12 —Storage Factors, Space Temperature Swing

The storage factors in *Table 12* were computed using essentially the same procedure as *Tables 6* to *11* with the exception that the equipment capacity available was limited and the swing in room temperature computed.

The magnitude of the storage effect is determined largely by the thermal capacity or heat holding capacity of the materials surrounding the space. It is limited by the amount of heat available for storage. Load patterns for different applications vary approximately as shown in the first column of *Table 12.* For instance, an office building has a rather large varying load with a high peak that occurs intermittently. An interior zone has an intermittent peak but the load pattern is relatively constant. A hospital, on the other hand, has a constant base load which is present for 24 hours with an additional intermittent load occurring during daylight hours.

The thermal capacity of a material is the mass times the specific heat of the material. Since the specific heat of most construction material is approximately 0.84 kJ/kg.°C, the thermal capacity is directly proportional to the mass of the material. Therefore, the data in the tables is based on the mass of the materials surrounding the space, per square metre of floor area.

Use of Table 12 —Storage Factors, Space Temperature Swing

Table 12 is used to determine the reduction in cooling load when the space temperature is forced to swing by reducing the equipment capacity below that required to maintain the temperature constant. This reduction is to be subtracted from the room sensible heat.

Note:

This reduction is only taken at the time of *peak cooling load.*

Example 3—Space Temperature Swing

Given:

The same room as in *Example 1.*

Find:

The actual cooling load at 4 p.m. from sun through window and with 2°C temperature swing in the space.

Solution:

The peak sensible cooling load in this room from the sun, through the window and lights, (neglecting people, transmission infiltration, ventilation and other internal heat gain) is

$945 + 1155 = 2100$ W (*Examples 1 and 2.*)

Note:

The peak cooling load in this room occurs at approximately 4 p.m. The solar and light loads are almost at their peak at 4 p.m. Although the transmission across the large glass window peaks at about 3 p.m., the peak infiltration and ventilation load also occurs at 3 p.m. and the relatively small transmission load across the wall peaks much later at about 12 midnight. The sum of these loads results in the peak cooling load occurring at about 4 p.m. in the spaces with this exposure.

The mass of the materials surrounding the room in *Example 1* is 600 kg/m² of floor area.

Reduction in cooling load for a 2°C swing (*Table 12*)

$= 6.0 \times 6.0 \times 8.5 \times 2.0 = 610$ W

Cooling load = 2100 − 610 = 1490 W

(For comparison purposes, the instantaneous heat gain from sun and lights in this particular room is 2790 W.)

Since the normal thermostat setting is about 24°C the design temperature (26°C = 24°C thermostat setting +2°C swing) occurs only on design peak days at the time of peak load. Under partial load operation, the room temperature is between 24°C DB and 26°C DB, depending on the load.

PRECOOLING AS A MEANS OF INCREASING STORAGE

Precooling a space below the temperature normally desired *increases the storage of heat* at the time of peak load, only when the precooling temperature is maintained as the control point. This is because the potential temperature swing is increased, thus adding to the amount of heat stored at the time of peak load. Where the space is precooled to a lower temperature and the control point is reset upward to a comfortable condition when the occupants arrive, no additional storage occurs. In this situation, the cooling unit shuts off and there is no cooling during the period of warming up. When the cooling unit begins to supply cooling again, the cooling load is approximately up to the point it would have been without any precooling.

Precooling is very useful in reducing the cooling load in applications such as churches, supermarkets, theatres, etc., where the precooled temperature can be maintained as the control point and the temperature swing increased to 4°C or 5°C.

DIVERSITY OF COOLING LOADS

Diversity of cooling load results from the probable non-occurrence of part of the cooling load on a design day. Diversity factors are applied to the refrigeration capacity in large air conditioning systems. These factors vary with location, type and size of the application, and are based entirely on the judgment of the engineer.

Generally, diversity factors can be applied to people and light loads in large multi-storey office, hotel or apartment buildings. The possibility of having all of the people present in the building and all of the lights operating at the time of peak load are slight. Normally, in large office buildings, some people will be away from the office on other business. Also, the lighting arrangement will frequently be such that the lights in the vacant offices will not be on. In addition to lights being off because the people are not present, the normal maintenance procedure in large office buildings usually results in some lights being inoperative. Therefore, a diversity factor on the people and light loads should be applied for selecting the proper size refrigeration equipment.

The size of the diversity factor depends on the size of the building and the engineer's judgment of the circumstances involved. For example, the diversity factor on a single small office with 1 or 2 people is 1.0 or no reduction. Expanding this to one floor of a building with 50 to 100 people, 5% to 10% may be absent at the time of peak load, and expanding to a 20-, 30- or 40-storey building, 10% to 20% may be absent during the peak. A building with predominantly sales offices would have many people out in the normal course of business.

This same concept applies to apartments and hotels. Normally, very few people are present at the time the solar and transmission loads are peaking, and the lights are normally turned on only after sundown. Therefore, in apartments and hotels, the diversity factor can be much greater than with office buildings.

These reductions in cooling load are real and should be made where applicable. *Table 13* lists some typical diversity factors, based on judgment and experience.

TABLE 13—TYPICAL DIVERSITY FACTORS FOR LARGE BUILDINGS
(Apply to Refrigeration Capacity)

TYPE OF APPLICATION	DIVERSITY FACTOR	
	People	Lights
Office	0.75 to 0.90	0.70 to 0.85
Apartment, Hotel	0.40 to 0.60	0.30 to 0.50
Department Store	0.80 to 0.90	0.90 to 1.00
Industrial*	0.85 to 0.95	0.80 to 0.90

Equation:

Cooling Load (for people and lights), W
= (Heat Gain, *W, Chapter 7*)
× (Storage Factor, *Table 11*) × (Diversity Factor, above table)

*A diversity factor should also be applied to the machinery load. Refer to *Chapter 7.*

Use of Table 13 —Typical Diversity Factors for Large Buildings

The diversity factors listed in *Table 13* are to be used as a guide in determining a diversity factor for any particular application. The final factor must necessarily be based on judgment of the effect of the many variables involved.

STRATIFICATION OF HEAT

There are generally two situations where heat is stratified and will reduce the cooling load on the air conditioning equipment:

1. Heat may be stratified in rooms with high ceilings where air is exhausted through the roof or ceiling.
2. Heat may be contained above suspended ceilings with recessed lighting and/or ceiling plenum return systems.

The first situation generally applies to industrial applications, churches, auditoriums, and the like. The second situation applies to applications such as office buildings, hotels, and apartments. In both cases, the basic fact that hot air tends to rise makes it possible to stratify loads such as convection from the roof, convection from lights, and convection from the upper part of the walls. The convective portion of the roof load is about 25% (the rest is radiation); the light load is about 50% with fluorescent (20% with incandescent), and the wall transmission load about 40%.

In any room with a high ceiling, a large part of the convenction load being released above the supply air stream will stratify at the ceiling or roof level. Some will be induced into the supply air stream. Normally, about 80% is stratified and 20% induced in the supply air. If air is exhausted through the ceiling or roof, this convection load released above the supply air may be subtracted from the air conditioning load. This results in a large reduction in load if the air is to be exhausted. It is not normally practical to exhaust more air than necessary, as it must be made up by bringing outdoor air through the apparatus. This usually results in a larger increase in load than the reduction realized by exhausting air.

Nominally, about a 5°C to 10°C rise in exhaust air temperature may be figured as load reduction if there is enough heat released by convection above the supply air stream.

Hot air stratifies at the ceiling even with no exhaust but rapidly builds up in temperature, and no reduction in load should be taken where air is not exhausted through the ceiling or roof.

With suspended ceilings, some of the convective heat from recessed lights flows into the plenum space. Also, the radiant heat within the room (sun, lights, people, etc.) striking the ceiling warms it up and causes heat to flow into the plenum space. These sources of heat increase the temperature of air in the plenum space which causes heat to flow into the underside of the floor structure above. When the ceiling plenum is used as a return air system, some of the return air flows through and over the light fixture, carrying more of the convective heat into the plenum space.

Containing heat within the ceiling plenum space tends to 'flatten' both the room and equipment load. The storage factors for estimating the load with the above conditions are contained in *Table 11.*

CHAPTER 4. SOLAR HEAT GAIN THROUGH GLASS

GENERAL CONSIDERATIONS—SELECTION OF GLAZING AND SHADING DEVICES

There are many points to be taken into consideration when selecting glazing and shading devices. Factors to be considered are strength, heat transmission, radiation from inner surfaces, natural and artificial light, noise reduction and costs in relation to total annual charges of the air conditioning plant. These charges may be materially influenced by the selection of size and type of glazing as well as of shading devices. The selection must take into consideration aesthetics and serviceability.Consultation between the engineer and architect is essential.

The following sections of this chapter are concerned solely with the aspect of solar heat transmission.

SOLAR HEAT—DIRECT AND DIFFUSE

The solar heat on the outer edge of the earth's atmosphere is about 1400 W/m² on December 21 when the sun is closest to the earth, and about 1300 W/m² on June 21 when it is farthest away. The amount of solar heat outside the earth's atmosphere varies between these limits throughout the year.

The solar heat reaching the earth's surface is reduced considerably below these figures because a large part of it is scattered, reflected back out into space, and absorbed by the atmosphere. The scattered radiation is termed *diffuse* or *sky radiation*, and is more or less evenly distributed over the earth's surface because it is nothing more than a reflection from dust particles, water vapour and ozone in the atmosphere. The solar heat that comes directly through the atmosphere is termed *direct radiation.* The relationship between the total and the direct and diffuse radiation at any point on earth is dependent on the following two factors:

1. The distance travelled through the atmosphere to reach the point on the earth.

2. The amount of haze in the air.

As the distance travelled or the amount of haze increases, the diffuse radiation component increases but the direct component decreases. As either or both of these factors increase, the overall effect is to reduce the total quantity of heat reaching the earth's surface.

ORDINARY GLASS

Ordinary or clear glass comes in various thicknesses and slightly varying solar characteristics. The solar heat gain through ordinary glass depends on its location on the earth's surface (latitude), time of day, time of year, facing direction of the window and on the outdoor and indoor film coefficients. The direct radiation component results in a heat gain to the conditioned space only when the window is in the direct rays of the sun, whereas the diffuse radiation component results in a heat gain, even when the window is not facing the sun (provided the window can 'see' the sky).

Ordinary glass absorbs a small portion of the solar heat (5% to 8%) and reflects or transmits the rest. The amount reflected or transmitted depends on the angle of incidence. (The angle of incidence is the angle between the perpendicular to the window surface and the sun's rays, *Fig. 21*).

At low angles of incidence, about 86% or 87% is transmitted and 8% or 9% is reflected, as shown in *Fig. 14*. As the angle of incidence increases, more solar heat is reflected and less is transmitted, as shown in *Fig. 15.* The total solar heat gain to the conditioned space consists of the transmitted heat plus a portion of the heat that is absorbed in the glass.

REFERENCE GLASS AND REFERENCE CONDITIONS

Reference glass is defined here as a clear glass of 3 mm thickness with absorptivity of 6% and reflectivity of 8%. Reference conditions are a sun angle

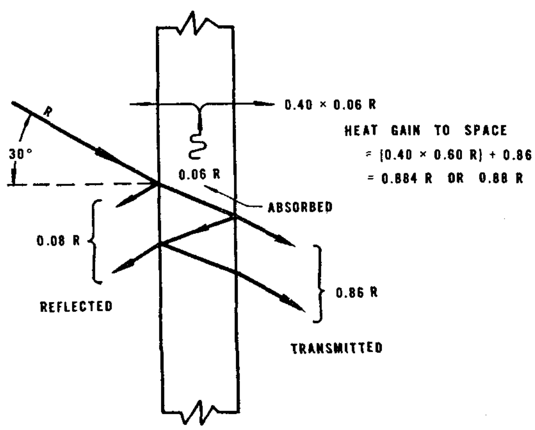


Fig. 14—Reaction on solar heat (R), Reference glass, 30° angle of incidence

of incidence of 30°, a wind velocity outside of 2.5 m/s and an internal air velocity against the glass of approximately 1.0 m/s.

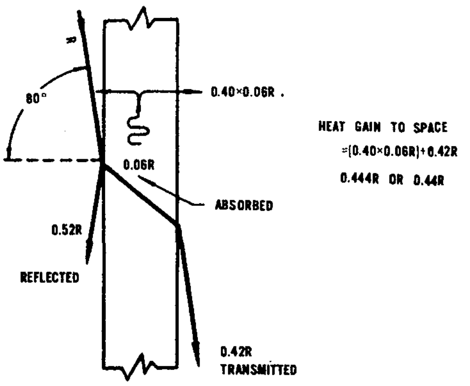


Fig. 15—Reaction on solar heat (R), reference glass, 80° angle of incidence

According to ASHRAE and Carrier the air film coefficients for glass for various wind speeds are as follows:

Wind speed m/s	Film coefficient W/m². °C
0	8.4
1.0	10.5
2.0	15.0
2.5	16.7
3.0	18.2
4.0	21.2
5.0	24.1
6.0	26.5
7.0	28.9

Under 'reference conditions' therefore, the portion of absorbed heat which finds its way into the room is $10.5/(10.5+16.7)\times 100 = 38.6$, say 40%. Although sweeping the inside of the windows with an air stream (approximately 1.0 m/s) is not always done, it has been decided to standardise on this air film coefficient of 10.5 rather than 8.4 W/m².°C which would be applicable to still air conditions.

INFLUENCE OF FILM COEFFICIENTS ON HEAT TRANSMISSION

There is a great deal of variation in commercial practice regarding the assumption of wind speed which varies from 2 m/s to 7 m/s and most manufacturers budget for still air inside. With a 7 m/s wind outside and still air inside $8.4/(8.4+28.9)\times 100 =$ 22.5% say 23% of the heat absorbed in the glass would find its way into the room, against 40% for reference conditions. The variation in film coefficients becomes more important for heat absorbing glasses, as will be seen from the following:

For reference glass (*Fig. 14*) the heat gain to space is $0.86R+(0.40\times 0.06R) = 0.884R$ whilst it would be $0.86R+(0.23\times 0.06R) = 0.874R$ for 7 m/s outside and still air inside, a difference of approximately 1.1%.

For heat absorbing glass with say 74% absorptivity and 5% reflectivity the heat gain to space would be:

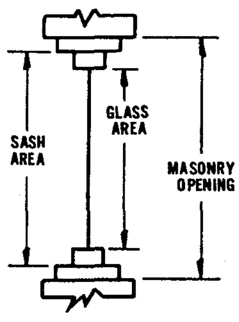
$(0.4\times 0.74R)+0.21R = 0.506$ under reference conditions, and $(0.23\times 0.74R)+0.21R = 0.380$ with 7 m/s wind outside and still air inside, a difference of approximately 25%.

Basis of Table 14 —Solar Heat Gain through Reference Glass

Table 14 provides data for 0°, 10°, 20°, 30°, 40°, and 50° latitudes, for each month of the year and for each hour of the day. This table includes the direct and diffuse radiation and that portion of the heat absorbed in the glass which gets into the space. It *does not* include the transmission of heat across the glass caused by a temperature difference between the outdoor and inside air. (See *Chapter 5* for U values.)

The data in *Table 14* is based on the following conditions:

1. A glass area equal to 85% of the sash area. This is typical for wood sash windows. For metal sash windows, the glass area is assumed equal to 100% of the sash area because the conductivity of the metal sash is very high and the solar heat absorbed in the sash is transmitted almost instantaneously.



Note:
The sash area equals approximately 85% of the masonry opening (or frame opening with frame walls) with wood sash windows, 90% of masonry opening with double hung metal sash windows, and 100% of masonry opening with casement windows.

Fig. 16
Window areas

2. No haze in the air.
3. Sea level elevation.
4. A sea level dewpoint temperature of 20°C (35°C DB, 24°C WB) which approximately corresponds to 40 mm of precipitable water vapour. Precipitable water vapour is all of the water vapour in a column of air from sea level to the outer edge of the atmosphere.

If these conditions do not apply, use the correction factors at the bottom of each page of *Table 14.*

Use of Table 14
—Solar Heat Gain through Reference Glass

In Table 14 the values in italic face type indicate the maximum solar heat gain for the month for each exposure. The values in bold face type indicate the yearly maximums for each exposure.

Table 14 is used to determine the solar heat gain through ordinary glass at any time, in any space, zone, or building.

To determine the actual cooling load *due to the solar heat gain*, refer to *Chapter 3*, *'Heat Storage, Diversity and Stratification'*.

CAUTION—Where Estimating Multi-Exposure Rooms or Buildings

If a haze factor is used on one exposure to determine the peak room or building load, the diffuse component listed for the other exposures must be divided by the haze factor to result in the actual room or building peak load. This is because the diffuse component increases with increasing haze, as explained earlier, under the heading 'Solar heat—direct and diffuse'.

Example 1—Peak Solar Heat Gain (2 Exposures)

Since the time at which the peak solar load occurs in a space with 2 exposures is not always apparent, the solar heat gain is generally calculated at more than one time to determine its peak.

Given:

A room with equal glass areas on the West and North at 40° South latitude.

Find:

Peak solar heat gain.

Solution:

From *Table 14*

Solar heat gain—				
March 22	1:00	2:00	3:00	4:00 p.m.
West	140	310	440	470
North	380	350	260	140
Total	520	660	700	610

Solar heat gain—				
April 20	1:00	2:00	3:00	4:00 p.m.
West	120	280	380	370
North	490	430	330	190
Total	610	710	710	560

Solar heat gain—				
May 21	1:00	2:00	3:00	4:00 p.m.
West	105	230	320	290
North	500	440	330	190
Total	605	670	650	480

The peak solar heat gain to this room occurs between 2:00 p.m. and 3:00 p.m. on April 20. The peak room cooling load does not necessarily occur at the same time as the peak solar heat gain, because the peak transmission load, people load, etc., may occur at some other time.

Example 2—Solar Gain Correction Factors (Bottom Table 14)

The conditions on which *Table 14* is based do not apply to all locations, since many cities are above sea level, and many have different design dew points and some haze in their atmosphere.

Given:

A west exposure with steel casement windows
Altitude—250 m
Design dewpoint—22°C
40° South latitude
Somewhat hazy condition

Find:

Peak solar heat gain

Solution:

By inspection of *Table 14* the boxed values for peak solar heat gain, occurring at 4:00 p.m. on January 21 $= 500\ \text{W/m}^2$

Altitude correction $= 1.00575$ (bottom *Table 14*)
Dewpoint difference $= 22 - 20 = 2$°C
Dewpoint correction $= 1 - (2/10 \times 0.13) = 0.974$ (bottom *Table 14*)
Haze correction $= 1 - 0.10 = 0.90$ (bottom *Table 14*)
Steel sash correction $= 1/0.85$ (bottom *Table 14*)
Solar heat gain at 4:00 p.m., January 21
$= 500 \times 1.00575 \times 974 \times 0.90 \times 1/0.85$
$= 515\ \text{W/m}^2$

GLASS TYPES AND GLASS FACTORS

Glass other than reference glass (3 mm thick, absorptivity 6%, reflectivity 8%) transmits less heat into the space because it may be thicker or specially treated to absorb and/or reflect more energy. In all cases the solar heat transmitted into space can be calculated under reference conditions as follows:

$$Q' = R(\tau + 0.4\alpha)$$

where Q' = solar heat gain into space (W/m^2 sash area)
R = incident solar energy (W/m^2 sash area) (from *Table 14*, divided by 0.88)
τ = solar transmissibility
α = solar absorptivity
0.88 = portion of R penetrating into space through reference glass

Glass factor is defined here as the ratio of solar heat transmitted into space through a particular glass when compared with that through a reference glass, both under reference conditions (0.88R; see *Fig. 14*). The glass factor for reference glass is therefore unity.

Fig. 17 shows the reaction on solar heat for a 52% heat absorbing glass with a reflectance of 5% under reference conditions: the heat gain to space is 64% of the incident solar energy, and the glass factor is 73%.

Absorptivity, reflectivity, transmissibility and glass factors for various glasses are shown in the following table (*15*). Glass factors are for use with *Table 14*.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS

Watts per square metre sash area (W/m^2)

0° South Latitude		AM					Sun Time					PM		
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	0	20	37	44	47	47	47	47	47	44	37	20	0
	Northeast	0	155	*175*	120	60	47	47	47	47	44	37	20	0
	East	0	410	*510*	470	320	145	47	47	47	44	37	20	0
	Southeast	0	400	*520*	510	420	290	145	55	47	44	37	20	0
	South	0	125	180	210	220	220	230	220	220	210	180	125	0
	Southwest	0	20	37	44	47	55	145	290	420	510	*520*	400	0
	West	0	20	37	44	47	47	47	145	320	470	*510*	410	0
	Northwest	0	20	37	44	47	47	47	47	60	120	*175*	155	0
	Horizontal	0	100	310	510	660	750	*790*	750	660	510	310	100	0
Feb 20 & Oct 23	North	0	19	38	40	45	45	*45*	45	45	40	38	19	0
	Northeast	0	210	*250*	210	110	47	45	45	45	40	38	19	0
	East	0	410	*510*	470	320	145	45	45	45	40	38	19	0
	Southeast	0	350	*440*	420	320	190	75	45	45	40	38	19	0
	South	0	54	90	100	105	105	*105*	105	105	100	90	54	0
	Southwest	0	19	38	40	45	45	75	190	320	420	*440*	350	0
	West	0	19	38	40	45	45	45	145	320	470	*510*	410	0
	Northwest	0	19	38	40	45	45	45	47	110	210	*250*	210	0
	Horizontal	0	100	310	470	650	740	*770*	740	650	470	310	100	0
Mar 22 & Sept 22	North	0	19	38	40	45	45	*45*	45	45	40	38	19	0
	Northeast	0	300	*370*	320	210	100	45	45	45	40	38	19	0
	East	0	420	**530**	480	340	150	45	45	45	40	38	19	0
	Southeast	0	300	*370*	320	210	100	45	45	45	40	38	19	0
	South	0	19	38	40	45	45	*45*	45	45	40	38	19	0
	Southwest	0	19	38	40	45	45	45	100	210	320	*370*	300	0
	'	0	19	38	40	45	45	45	150	340	480	**530**	420	0
	Nortnwest	0	19	38	40	45	45	45	100	210	320	*370*	300	0
	Horizontal	0	100	320	510	660	760	**790**	760	660	510	320	100	0
Apr 20 & Aug 24	North	0	54	90	100	105	105	*105*	105	105	100	90	54	0
	Northeast	0	350	*440*	420	320	190	75	45	45	40	38	19	0
	East	0	410	*510*	470	320	145	45	45	45	40	38	19	0
	Southeast	0	210	*250*	210	110	47	45	45	45	40	38	19	0
	South	0	19	38	40	45	45	*45*	45	45	40	38	19	0
	Southwest	0	19	38	40	45	45	45	47	110	210	*250*	210	0
	West	0	19	38	40	45	45	45	145	320	470	*510*	410	0
	Northwest	0	19	38	40	45	45	75	190	320	420	*440*	350	0
	Horizontal	0	100	310	470	650	740	770	740	650	470	310	100	0
May 21 & July 23	North	0	115	170	190	210	210	*210*	210	210	190	170	115	0
	Northeast	0	370	*480*	470	390	270	135	50	45	40	35	19	0
	East	0	380	*480*	440	300	135	45	45	45	40	35	19	0
	Southeast	0	145	*160*	115	57	45	45	45	45	40	35	19	0
	South	0	19	35	40	45	45	*45*	45	45	40	35	19	0
	Southwest	0	19	35	40	45	45	45	45	57	115	*160*	145	0
	West	0	19	35	40	45	45	45	135	300	440	*480*	380	0
	Northwest	0	19	35	40	45	50	135	270	390	470	*480*	370	0
	Horizontal	0	90	290	480	620	700	*740*	700	620	480	290	90	0
June 21	North	0	140	210	230	250	250	**260**	250	250	230	210	140	0
	Northeast	0	380	**490**	490	420	300	170	63	45	40	35	19	0
	East	0	370	*460*	430	290	135	45	45	45	40	35	19	0
	Southeast	0	115	*130*	85	47	45	45	45	45	40	35	19	0
	South	0	19	35	40	45	45	*45*	45	45	40	35	19	0
	Southwest	0	19	35	40	45	45	45	45	47	85	*130*	115	0
	West	0	19	35	40	45	45	45	135	290	430	*460*	370	0
	Northwest	0	19	35	40	45	63	170	300	420	490	**490**	380	0
	Horizontal	0	90	270	460	600	680	*710*	680	600	460	270	90	0
Nov 21	North	0	19	35	40	45	45	*45*	45	45	40	35	19	0
	Northeast	0	145	*160*	115	57	45	45	45	45	40	35	19	0
	East	0	380	*480*	440	300	135	45	45	45	40	35	19	0
	Southeast	0	370	*480*	470	390	270	135	50	45	40	35	19	0
	South	0	115	170	190	210	210	*210*	210	210	190	170	115	0
	Southwest	0	19	35	40	45	50	135	270	390	470	*480*	370	0
	West	0	19	35	40	45	45	45	135	300	440	*480*	380	0
	Northwest	0	19	35	40	45	45	45	45	57	115	*160*	145	0
	Horizontal	0	90	290	480	620	700	*740*	700	620	480	290	90	0
Dec 22	North	0	20	37	44	47	47	47	47	47	44	37	20	0
	Northeast	0	125	*140*	90	50	47	47	47	47	44	37	20	0
	East	0	390	*500*	460	310	145	47	47	47	44	37	20	0
	Southeast	0	400	**530**	520	450	320	180	68	47	44	37	20	0
	South	0	150	220	250	260	270	**280**	270	260	250	220	150	0
	Southwest	0	20	37	44	47	68	180	320	450	520	**530**	400	0
	West	0	20	37	44	47	47	47	145	310	460	500	390	0
	Northwest	0	20	37	44	47	47	47	47	50	90	*140*	125	0
	Horizontal	0	95	290	500	640	730	*760*	730	640	500	290	95	0

Solar Gain Correction	Steel Sash, or No Sash × 1/0·85 or 1.17	Haze —15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C−13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS (Continued)

Watts per square metre sash area (W/m^2)

10° South Latitude		AM						Sun Time					PM	
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	3	24	37	44	47	47	47	47	47	44	37	24	3
	Northeast	88	190	*220*	190	110	47	47	47	47	44	37	24	3
	East	170	460	**530**	480	330	145	47	47	47	44	37	24	3
	Southeast	140	430	*500*	450	370	190	75	47	47	44	37	24	3
	South	17	115	*130*	120	110	105	100	105	110	120	*130*	115	17
	Southwest	3	24	37	44	47	47	75	190	370	450	*500*	430	140
	West	3	24	37	44	47	47	47	145	330	480	**530**	460	170
	Northwest	3	24	37	44	47	47	47	47	110	190	*220*	190	88
	Horizontal	10	140	360	560	710	800	**830**	800	710	560	360	140	10
Feb 20 & Oct 23	North	3	22	35	40	45	45	*45*	45	45	40	35	22	3
	Northeast	57	250	*300*	270	190	85	45	45	45	40	35	22	3
	East	80	440	*510*	470	330	145	45	45	45	40	35	22	3
	Southeast	54	360	*410*	350	250	105	45	45	45	40	35	22	3
	South	3	47	*50*	47	47	45	45	45	47	47	*50*	47	3
	Southwest	3	22	35	40	45	45	45	105	47	350	*410*	360	54
	West	3	22	35	40	45	45	45	145	250	470	*510*	440	80
	Northwest	3	22	35	40	45	45	45	85	190	270	*300*	250	57
	Horizontal	6	120	330	530	670	760	*790*	760	670	530	330	120	6
Mar 22 & Sept 22	North	3	19	40	60	75	85	*90*	85	75	60	40	19	3
	Northeast	3	310	*400*	380	300	180	65	45	45	40	35	19	3
	East	3	410	*520*	480	330	150	45	45	45	40	35	19	3
	Southeast	3	280	*320*	250	140	54	45	45	45	40	35	19	3
	South	3	19	35	40	45	45	*45*	45	45	40	35	19	3
	Southwest	3	19	35	40	45	45	45	54	140	250	*320*	280	3
	West	3	19	35	40	45	45	45	150	330	480	*520*	410	3
	Northwest	3	19	35	40	45	45	65	180	300	380	*400*	310	3
	Horizontal	3	100	310	500	650	740	*780*	740	650	500	310	100	3
Apr 20 & Aug 24	North	0	57	125	170	210	220	*230*	220	210	170	125	57	0
	Northeast	0	320	460	*470*	390	260	145	57	45	40	32	16	0
	East	0	370	*490*	460	320	125	45	45	45	40	32	16	0
	Southeast	0	180	*210*	140	90	45	45	45	45	40	32	16	0
	South	0	16	32	40	45	45	*45*	45	45	40	32	16	0
	Southwest	0	16	32	40	45	45	45	45	90	140	*210*	180	0
	West	0	16	32	40	45	45	45	125	320	460	*490*	370	0
	Northwest	0	16	32	40	45	57	145	260	390	*470*	460	320	0
	Horizontal	0	70	270	440	610	690	*730*	690	610	440	270	70	0
May 21 & July 23	North	0	110	210	290	300	330	*330*	330	300	290	210	110	0
	Northeast	0	310	480	*510*	460	340	220	100	54	38	28	13	0
	East	0	310	*450*	420	290	120	45	45	40	38	28	13	0
	Southeast	0	85	*115*	54	40	45	45	45	40	38	28	13	0
	South	0	13	28	38	40	45	*45*	45	40	38	28	13	0
	Southwest	0	13	28	38	40	45	45	45	40	54	*115*	85	0
	West	0	13	28	38	40	45	45	120	290	420	*450*	310	0
	Northwest	0	13	28	38	54	100	220	340	460	*510*	480	310	0
	Horizontal	0	54	200	410	550	640	*660*	640	550	410	200	54	0
June 21	North	0	160	230	300	340	370	**380**	370	340	300	230	160	0
	Northeast	0	310	490	**510**	470	380	250	115	73	38	28	13	0
	East	0	270	*430*	410	290	130	45	45	40	38	28	13	0
	Southeast	0	47	*90*	54	40	45	45	45	40	38	28	13	0
	South	0	13	28	38	40	45	*45*	45	40	38	28	13	0
	Southwest	0	13	28	38	40	45	45	45	40	54	*90*	47	0
	West	0	13	28	38	40	45	45	130	290	410	*430*	270	0
	Northwest	0	13	28	38	73	115	250	380	470	**510**	490	310	0
	Horizontal	0	45	210	380	530	610	*640*	610	530	380	210	45	0
Nov 21	North	3	22	35	40	45	45	*45*	45	45	40	35	22	3
	Northeast	80	180	*210*	180	100	45	45	45	45	40	35	22	3
	East	160	430	*500*	450	310	135	45	45	45	40	35	22	3
	Southeast	130	400	*470*	420	340	180	70	45	45	40	35	22	3
	South	16	105	*120*	110	105	100	95	100	105	110	*120*	105	16
	Southwest	3	22	35	40	45	45	70	180	340	420	*470*	400	130
	West	3	22	35	40	45	45	45	135	310	450	*500*	430	160
	Northwest	3	22	35	40	45	45	45	45	100	180	*210*	180	80
	Horizontal	9	130	340	520	660	740	*780*	740	660	520	340	130	9
Dec 22	North	7	27	37	44	47	47	47	47	47	44	37	27	7
	Northeast	60	165	*190*	145	85	47	47	47	47	44	37	27	7
	East	180	450	*520*	470	330	140	47	47	47	44	37	27	7
	Southeast	190	440	**520**	470	360	220	95	47	47	44	37	27	7
	South	65	150	*170*	150	150	145	140	145	150	150	**170**	150	7
	Southwest	7	27	27	44	47	60	95	220	360	470	**520**	440	190
	West	7	27	27	44	47	47	47	140	330	470	*520*	450	180
	Northwest	7	27	27	44	47	47	47	47	85	145	*190*	165	60
	Horizontal	14	150	360	560	690	790	*820*	790	690	560	360	150	14

Solar Gain Correction	Steel Sash, or No Sash ×1/0·85 or 1·17	Haze −15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C −13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS (Continued)

Watts per square metre sash area (W/m²)

20° South Latitude		AM						Sun Time				PM		
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	10	27	40	44	47	47	47	47	47	44	40	27	10
	Northeast	105	240	*290*	270	190	100	47	47	47	44	40	27	10
	East	250	500	**550**	490	330	155	47	47	47	44	40	27	10
	Southeast	240	450	*470*	370	250	105	47	47	47	44	40	27	10
	South	68	*95*	78	57	50	47	47	47	50	57	78	*95*	68
	Southwest	10	27	40	44	47	47	47	105	250	370	*470*	450	240
	West	10	27	40	44	47	47	47	155	330	490	**550**	500	250
	Northwest	10	27	40	44	47	47	47	100	190	270	*290*	240	105
	Horizontal	27	190	400	590	730	810	**850**	810	730	590	400	190	27
Feb 20 & Oct 23	North	6	22	35	45	63	75	*80*	75	63	45	35	22	6
	Northeast	90	280	*360*	340	310	170	63	45	45	40	35	22	6
	East	170	450	*520*	470	330	160	45	45	45	40	35	22	6
	Southeast	140	350	*370*	280	160	57	45	45	45	40	35	22	6
	South	19	32	35	40	45	45	*45*	45	45	40	35	32	19
	Southwest	6	22	35	40	45	45	45	57	160	280	*370*	350	140
	West	6	22	35	40	45	45	45	160	330	470	*520*	450	170
	Northwest	6	22	35	40	45	45	63	170	310	340	*360*	280	90
	Horizontal	16	150	340	530	660	740	*780*	740	660	530	340	150	16
Mar 22 & Sept 22	North	0	25	70	120	160	200	*210*	200	160	120	70	25	0
	Northeast	0	310	430	*440*	380	270	130	47	45	40	35	19	0
	East	0	410	*510*	470	330	140	45	45	45	40	35	19	0
	Southeast	0	260	*270*	190	70	45	45	45	45	40	35	19	0
	South	0	19	35	40	45	45	*45*	45	45	40	35	19	0
	Southwest	0	19	35	40	45	45	45	45	70	190	*270*	260	0
	West	0	19	35	40	45	45	45	140	330	470	*510*	410	0
	Northwest	0	19	35	40	45	47	130	270	380	*440*	430	310	0
	Horizontal	0	95	290	480	620	710	*740*	710	620	480	290	95	0
Apr 20 & Aug 24	North	0	65	160	240	290	330	*350*	330	290	240	160	65	0
	Northeast	0	290	460	*500*	470	380	230	85	40	38	28	13	0
	East	0	310	*460*	440	320	155	45	45	40	38	28	13	0
	Southeast	0	140	*160*	90	40	45	45	45	40	38	28	13	0
	South	0	13	28	38	40	45	*45*	45	40	38	28	13	0
	Southwest	0	13	28	38	40	45	45	45	40	90	*160*	140	0
	West	0	13	28	38	40	45	45	155	320	440	*460*	310	0
	Northwest	0	13	28	38	40	85	230	380	470	*500*	460	290	0
	Horizontal	0	57	210	400	540	620	660	620	540	400	210	57	0
May 21 & July 23	North	0	90	220	320	390	430	*440*	430	390	320	220	90	0
	Northeast	0	230	450	*520*	500	430	290	145	50	35	25	9	0
	East	0	220	*400*	400	290	135	40	40	40	35	25	9	0
	Southeast	0	75	*80*	45	40	40	40	40	40	35	25	9	0
	South	0	9	25	35	40	40	*40*	40	40	35	25	9	0
	Southwest	0	9	25	35	38	40	40	40	40	45	*80*	75	0
	West	0	9	25	35	38	40	40	135	290	400	*400*	220	0
	Northwest	0	9	25	35	50	145	290	430	500	*520*	450	230	0
	Horizontal	0	16	150	320	460	540	*570*	540	460	320	150	16	0
June 21	North	0	80	230	350	420	460	**470**	460	420	350	230	80	0
	Northeast	0	190	440	**530**	500	420	310	190	63	35	22	6	0
	East	0	180	370	*380*	270	105	40	40	38	35	22	6	0
	Southeast	0	45	*57*	38	38	40	40	40	38	35	22	6	0
	South	0	6	22	35	38	40	*40*	40	38	35	22	6	0
	Southwest	0	6	22	35	38	40	40	40	38	38	*57*	45	0
	West	0	6	22	35	38	40	40	105	270	*380*	370	180	0
	Northwest	0	6	22	35	63	190	310	420	**500**	530	440	190	0
	Horizontal	0	13	115	290	430	510	*540*	510	430	290	115	13	0
Nov 21	North	9	25	38	40	45	45	*45*	45	45	40	38	25	9
	Northeast	100	220	*270*	250	180	90	45	45	45	40	38	25	9
	East	240	470	*510*	460	310	145	45	45	45	40	38	25	9
	Southeast	220	420	*440*	350	230	100	45	45	45	40	38	25	9
	South	63	*90*	73	54	47	45	45	45	47	54	73	*90*	63
	Southwest	9	25	38	40	45	45	45	100	230	350	*440*	420	220
	West	9	25	38	40	45	45	45	145	310	460	*510*	470	240
	Northwest	9	25	38	40	45	45	45	90	180	250	*270*	220	100
	Horizontal	25	170	370	550	680	760	*790*	760	680	550	370	170	25
Dec 22	North	10	30	40	47	47	47	*47*	47	47	47	40	30	10
	Northeast	95	210	*250*	220	150	70	47	47	47	47	40	30	10
	East	270	500	*540*	480	320	140	47	47	47	47	40	30	10
	Southeast	270	**520**	490	410	280	130	50	47	47	47	40	30	10
	South	95	*140*	110	85	65	57	50	57	65	85	110	**140**	95
	Southwest	10	30	40	47	47	47	50	130	280	410	490	**520**	270
	West	10	30	40	47	47	47	47	140	320	480	540	500	270
	Northwest	10	30	40	47	47	47	47	70	150	220	250	210	95
	Horizontal	37	200	410	590	730	780	*840*	780	730	590	410	200	37

Solar Gain Correction	Steel Sash, or No Sash ×1/0·85 or 1·17	Haze —15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C—13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS (Continued)

Watts per square metre sash area (W/m²)

30° South Latitude		AM					Sun Time					PM		
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	14	30	40	47	68	90	*100*	90	68	47	40	30	14
	Northeast	140	280	*340*	*340*	280	180	75	47	47	44	40	30	14
	East	340	520	**550**	490	330	150	47	47	47	44	40	30	14
	Southeast	310	*440*	420	300	155	55	47	47	47	44	40	30	14
	South	*75*	68	47	44	47	47	47	47	47	44	47	68	*75*
	Southwest	14	30	40	44	47	47	47	55	155	300	420	*440*	310
	West	14	30	40	44	47	47	47	150	330	490	**550**	520	340
	Northwest	14	30	40	44	47	47	47	180	280	*340*	*340*	280	140
	Horizontal	50	220	420	590	720	800	*830*	800	720	590	420	220	50
Feb 20 & Oct 23	North	6	25	40	85	150	180	*200*	180	150	85	40	25	6
	Northeast	115	310	400	*410*	350	260	120	47	40	40	35	25	6
	East	210	460	*520*	470	320	145	45	45	40	40	35	25	6
	Southeast	170	*340*	320	210	85	45	45	45	40	40	35	25	6
	South	19	25	35	40	40	45	*45*	45	40	40	35	25	19
	Southwest	6	25	35	40	40	45	45	45	85	210	320	*340*	170
	West	6	25	35	40	40	45	45	145	320	470	*520*	460	210
	Northwest	6	25	35	40	40	47	120	260	350	*410*	400	310	115
	Horizontal	19	150	340	510	630	710	*740*	710	630	510	340	150	19
Mar 22 & Sept 22	North	0	28	57	190	260	310	*330*	310	260	190	57	28	0
	Northeast	0	310	410	*480*	440	360	210	80	40	38	32	16	0
	East	0	390	*500*	450	320	150	45	45	40	38	32	16	0
	Southeast	0	230	*280*	125	47	45	45	45	40	38	32	16	0
	South	0	16	32	38	40	45	*45*	45	40	38	32	16	0
	Southwest	0	16	32	38	40	45	45	45	47	125	*280*	230	0
	West	0	16	32	38	40	45	45	150	320	450	*500*	390	0
	Northwest	0	16	32	38	40	80	210	360	440	*480*	410	310	0
	Horizontal	0	80	260	430	560	640	*670*	640	560	430	260	80	0
Apr 20 & Aug 24	North	0	57	180	290	380	440	*460*	440	380	290	180	57	0
	Northeast	0	230	450	**510**	500	430	290	150	47	35	25	9	0
	East	0	250	*430*	420	300	135	45	40	38	35	25	9	0
	Southeast	0	105	*120*	57	38	40	45	40	38	35	25	9	0
	South	0	9	25	35	38	40	*45*	40	38	35	25	9	0
	Southwest	0	9	25	35	38	40	45	40	38	57	*120*	105	0
	West	0	9	25	35	38	40	45	135	300	420	*430*	250	0
	Northwest	0	9	25	35	47	150	290	430	500	**510**	450	230	0
	Horizontal	0	19	155	320	450	540	*560*	540	450	320	155	19	0
May 21 & July 23	North	0	32	210	340	430	490	*500*	490	430	340	210	32	0
	Northeast	0	90	400	510	*510*	450	330	200	73	28	19	3	0
	East	0	85	340	*370*	260	110	38	38	35	28	19	3	0
	Southeast	0	25	*50*	28	35	38	38	38	35	28	19	3	0
	South	0	3	19	28	35	38	*38*	38	35	28	19	3	0
	Southwest	0	3	19	28	35	38	38	38	35	28	*50*	25	0
	West	0	3	19	28	35	38	38	110	260	*370*	340	85	0
	Northwest	0	3	19	28	73	200	330	450	*510*	510	400	90	0
	Horizontal	0	6	85	220	340	430	*460*	430	340	220	85	6	0
June 21	North	0	0	200	360	450	500	**510**	500	450	360	200	0	0
	Northeast	0	0	360	500	*510*	450	340	230	90	28	13	0	0
	East	0	0	290	*330*	250	100	38	38	35	28	13	0	0
	Southeast	0	0	*32*	28	35	38	38	38	35	28	13	0	0
	South	0	0	13	28	35	38	*38*	38	35	28	13	0	0
	Southwest	0	0	13	28	35	38	38	38	35	28	*32*	0	0
	West	0	0	13	28	35	38	38	100	250	*330*	290	0	0
	Northwest	0	0	13	28	90	230	340	450	*510*	500	360	0	0
	Horizontal	0	0	60	190	310	380	*410*	380	310	190	60	0	0
Nov 21	North	13	28	38	45	63	85	*95*	85	63	45	38	28	13
	Northeast	130	260	*320*	*320*	260	170	70	45	45	40	38	28	13
	East	320	490	*520*	460	310	140	45	45	45	40	38	28	13
	Southeast	290	*410*	390	280	145	50	45	45	45	40	38	28	13
	South	*70*	63	45	40	45	45	45	45	45	40	45	63	*70*
	Southwest	13	28	38	40	45	45	45	50	145	280	390	*410*	290
	West	13	28	38	40	45	45	45	140	310	460	*520*	490	320
	Northwest	13	28	38	40	45	45	45	170	260	*320*	*320*	260	130
	Horizontal	47	210	390	560	680	740	*780*	740	680	560	390	210	47
Dec 22	North	17	34	40	47	50	65	*70*	65	50	47	40	34	17
	Northeast	140	250	*300*	*300*	250	150	57	47	47	47	40	34	17
	East	360	530	*540*	480	330	150	47	47	47	47	40	34	17
	Southeast	350	**470**	440	330	190	65	47	47	47	47	40	34	17
	South	**110**	100	60	47	47	47	47	47	47	47	60	100	*110*
	Southwest	17	34	40	47	47	47	47	65	190	330	440	**470**	350
	West	17	34	40	47	47	47	47	150	330	480	*540*	530	360
	Northwest	17	34	40	47	47	47	57	150	250	*300*	*300*	250	140
	Horizontal	65	210	440	610	730	810	**840**	810	730	610	440	210	65

Solar Gain Correction	Steel Sash, or No Sash × 1/0·85 or 1·17	Haze −15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C −13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS (Continued)

Watts per square metre sash area (W/m^2)

40° South Latitude		AM					Sun Time					PM		
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	17	34	44	88	150	210	*230*	210	150	88	44	34	17
	Northeast	180	320	400	*420*	370	280	140	50	47	44	40	34	17
	East	400	540	**550**	490	330	145	47	47	47	44	40	34	17
	Southeast	360	*430*	350	220	88	47	47	47	47	44	40	34	17
	South	*80*	47	40	44	47	47	47	47	47	44	40	47	*80*
	Southwest	17	34	40	44	47	47	47	47	88	220	350	*430*	360
	West	17	34	40	44	47	47	47	145	330	490	**550**	540	400
	Northwest	17	34	40	44	47	50	140	280	370	*420*	400	320	180
	Horizontal	80	250	430	580	690	760	*790*	760	690	580	430	250	80
Feb 20 & Oct 23	North	9	25	75	160	280	310	*320*	310	280	160	75	25	9
	Northeast	150	330	440	*460*	440	340	210	80	45	40	35	25	9
	East	270	460	*510*	460	320	140	45	45	45	40	35	25	9
	Southeast	210	*320*	260	145	50	45	45	45	45	40	35	25	9
	South	22	25	35	40	45	45	*45*	45	45	40	35	25	22
	Southwest	9	25	35	40	45	45	45	45	50	145	260	*320*	210
	West	9	25	35	40	45	45	45	140	320	460	*510*	460	270
	Northwest	9	25	35	40	45	80	210	340	440	*460*	440	330	150
	Horizontal	28	150	320	470	580	650	*680*	650	580	470	320	150	28
Mar 22 & Sept 22	North	0	38	140	260	350	380	*440*	380	350	260	140	38	0
	Northeast	0	300	450	**510**	500	420	280	130	45	38	28	16	0
	East	0	370	*470*	440	310	140	45	40	40	38	28	16	0
	Southeast	0	160	*180*	80	40	40	45	40	40	38	28	16	0
	South	0	16	28	38	40	40	*45*	40	40	38	28	16	0
	Southwest	0	16	28	38	40	40	45	40	40	80	*180*	160	0
	West	0	16	28	38	40	40	45	140	310	440	*470*	370	0
	Northwest	0	16	28	38	45	130	280	420	500	*510*	450	300	0
	Horizontal	0	65	210	390	480	560	*580*	560	480	390	210	65	0
Apr 20 & Aug 24	North	0	65	190	330	430	490	*510*	490	430	330	190	65	0
	Northeast	0	260	420	510	*510*	450	340	200	63	32	19	6	0
	East	0	270	370	*380*	280	120	38	38	35	32	19	6	0
	Southeast	0	*110*	105	38	35	38	38	38	35	32	19	6	0
	South	0	6	19	32	35	38	*38*	38	35	32	19	6	0
	Southwest	0	6	19	32	35	38	38	38	35	38	105	*110*	0
	West	0	6	19	32	35	38	38	120	280	*380*	370	270	0
	Northwest	0	6	19	32	63	200	340	450	**510**	510	420	260	0
	Horizontal	0	25	90	200	320	390	*410*	390	320	200	90	25	0
May 21 & July 23	North	0	0	190	330	440	500	**520**	500	440	330	190	0	0
	Northeast	0	0	340	450	*490*	450	370	220	85	22	9	0	0
	East	0	0	290	*320*	230	105	35	32	28	22	9	0	0
	Southeast	0	0	*38*	22	28	32	35	32	28	22	9	0	0
	South	0	0	9	22	28	32	*35*	32	28	22	9	0	0
	Southwest	0	0	9	22	28	32	35	32	28	22	*38*	0	0
	West	0	0	9	22	28	32	35	105	230	*320*	290	0	0
	Northwest	0	0	9	22	85	220	370	450	*490*	450	340	0	0
	Horizontal	0	0	50	135	230	290	*320*	290	230	135	50	0	0
June 21	North	0	0	160	310	420	500	*520*	500	420	310	160	0	0
	Northeast	0	0	280	420	*470*	450	360	230	95	22	6	0	0
	East	0	0	230	*270*	210	100	32	32	28	19	6	0	0
	Southeast	0	0	22	19	28	32	32	32	28	19	6	0	0
	South	0	0	6	19	28	32	32	32	28	19	6	0	0
	Southwest	0	0	6	19	28	32	32	32	28	19	22	0	0
	West	0	0	6	19	28	32	32	100	210	*270*	230	0	0
	Northwest	0	0	6	22	95	230	360	450	*470*	420	280	0	0
	Horizontal	0	0	25	100	170	240	*270*	240	170	100	25	0	0
Nov 21	North	16	32	40	80	140	200	*220*	200	140	80	40	32	16
	Northeast	170	300	380	*390*	350	260	130	47	45	40	38	32	16
	East	370	510	520	450	310	135	45	45	45	40	38	32	16
	Southeast	330	*400*	330	210	80	45	45	45	45	40	38	32	16
	South	*75*	45	38	40	45	45	45	45	45	40	38	45	*75*
	Southwest	16	32	38	40	45	45	45	45	80	210	330	*400*	330
	West	16	32	38	40	45	45	45	135	310	450	*520*	510	370
	Northwest	16	32	38	40	45	47	130	260	350	*390*	380	300	170
	Horizontal	75	230	400	540	640	710	*740*	710	640	540	400	230	75
Dec 22	North	20	34	40	65	120	150	*180*	150	120	65	40	34	20
	Northeast	170	300	370	*370*	330	240	115	47	47	44	40	34	20
	East	430	540	*550*	480	320	150	47	47	47	44	40	34	20
	Southeast	400	**450**	380	250	100	47	47	47	47	44	40	34	20
	South	**110**	68	40	44	47	47	47	47	47	44	40	68	*110*
	Southwest	20	34	40	44	47	47	47	47	100	250	380	**450**	400
	West	20	34	40	44	47	47	47	150	320	480	*550*	540	430
	Northwest	20	34	40	44	47	47	115	240	330	*370*	370	300	170
	Horizontal	105	280	450	600	710	780	**800**	780	710	600	450	280	105

Solar Gain Correction	Steel Sash, or No Sash ×1/0·85 or 1·17	Haze −15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C −13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 14—SOLAR HEAT GAIN THROUGH REFERENCE GLASS (Continued)

Watts per square metre sash area (W/m²)

50° South Latitude		AM					Sun Time						PM	
Time of Year	Exposure	6	7	8	9	10	11	Noon	1	2	3	4	5	6
Jan 21	North	20	34	70	170	270	330	*360*	330	270	170	70	34	20
	Northeast	220	360	450	*480*	460	370	240	88	47	44	40	34	20
	East	440	540	*550*	480	320	145	47	47	47	44	40	34	20
	Southeast	380	*390*	290	150	50	47	47	47	47	44	40	34	20
	South	*70*	37	40	44	47	47	47	47	47	44	40	37	*70*
	Southwest	20	34	40	44	47	47	47	47	50	150	290	*390*	380
	West	20	34	40	44	47	47	47	145	320	480	*550*	540	440
	Northwest	20	34	40	44	47	88	240	370	460	*480*	450	360	220
	Horizontal	110	250	400	540	630	690	*710*	690	630	540	400	250	110
Feb 20 & Oct 23	North	13	28	115	230	330	410	*440*	410	330	230	115	28	13
	Northeast	170	350	450	*500*	480	420	280	125	40	38	32	25	13
	East	300	460	*500*	440	310	140	45	45	40	38	32	25	13
	Southeast	240	*300*	220	100	40	45	45	45	40	38	32	25	13
	South	25	25	32	38	40	45	*45*	45	40	38	32	25	25
	Southwest	13	25	32	38	40	45	45	45	40	100	220	*300*	240
	West	13	25	32	38	40	45	45	140	310	440	*500*	460	300
	Northwest	13	25	32	38	40	125	280	420	480	*500*	450	350	170
	Horizontal	40	145	280	410	500	560	*580*	560	500	410	280	145	40
Mar 22 & Sept 22	North	0	35	160	290	410	470	*500*	470	410	290	160	35	0
	Northeast	0	270	440	510	**510**	460	330	180	54	32	25	13	0
	East	0	320	*440*	410	290	135	38	38	38	32	25	13	0
	Southeast	0	*180*	145	50	38	38	38	38	38	32	25	13	0
	South	0	13	25	32	38	38	*38*	38	38	32	25	13	0
	Southwest	0	13	25	32	38	38	38	38	38	50	145	*180*	0
	West	0	13	25	32	38	38	38	135	290	410	*440*	320	0
	Northwest	0	13	25	32	54	180	330	460	510	**510**	440	270	0
	Horizontal	0	47	155	280	370	440	*470*	440	370	280	155	47	0
Apr 20 & Aug 24	North	0	54	170	310	430	500	**530**	500	430	310	170	54	0
	Northeast	0	220	350	460	*500*	450	360	220	75	22	13	0	0
	East	0	230	310	*330*	250	110	35	32	28	22	13	0	0
	Southeast	0	*90*	63	22	28	32	35	32	28	22	13	0	0
	South	0	0	13	22	28	32	*35*	32	28	22	13	0	0
	Southwest	0	0	13	22	28	32	35	32	28	22	63	*90*	0
	West	0	0	13	22	28	32	35	110	250	*330*	310	230	0
	Northwest	0	0	13	22	75	220	360	450	*500*	460	350	220	0
	Horizontal	0	6	60	140	230	270	*300*	270	230	140	60	6	0
May 21 & July 23	North	0	0	105	220	370	450	*480*	450	370	220	105	0	0
	Northeast	0	0	200	300	*400*	*400*	340	210	65	13	3	0	0
	East	0	0	160	*200*	180	90	28	25	19	13	3	0	0
	Southeast	0	0	16	13	19	25	*28*	25	19	13	3	0	0
	South	0	0	3	13	19	25	*28*	25	19	13	3	0	0
	Southwest	0	0	3	13	19	25	*28*	25	19	13	16	0	0
	West	0	0	3	13	19	25	28	90	180	*200*	160	0	0
	Northwest	0	0	3	13	65	210	340	*400*	*400*	300	200	0	0
	Horizontal	0	0	13	40	95	150	*170*	150	95	40	13	0	0
June 21	North	0	0	0	100	310	410	*440*	410	310	100	0	0	0
	Northeast	0	0	0	130	340	*370*	320	200	80	9	0	0	0
	East	0	0	0	85	*150*	73	22	19	16	9	0	0	0
	Southeast	0	0	0	9	16	19	22	19	16	9	0	0	0
	South	0	0	0	9	16	19	22	19	16	9	0	0	0
	Southwest	0	0	0	9	16	19	22	19	16	9	0	0	0
	West	0	0	0	9	16	19	22	73	*150*	85	0	0	0
	Northwest	0	0	0	9	80	200	320	*370*	340	130	0	0	0
	Horizontal	0	0	0	16	60	105	*125*	105	60	16	0	0	0
Nov 21	North	19	32	65	160	250	310	*330*	310	250	160	65	32	19
	Northeast	210	340	420	*450*	430	340	220	80	45	40	38	32	19
	East	410	510	*510*	440	300	135	45	45	45	40	38	32	19
	Southeast	360	*370*	270	140	47	45	45	45	45	40	38	32	19
	South	*65*	35	38	40	45	45	45	45	45	40	38	35	*65*
	Southwest	19	32	38	40	45	45	45	45	47	140	270	*370*	360
	West	19	32	38	40	45	45	45	135	300	440	*510*	510	410
	Northwest	19	32	38	40	45	80	220	340	430	*450*	420	340	210
	Horizontal	105	240	380	500	590	650	*670*	650	590	500	380	240	105
Dec 22	North	27	34	55	130	230	290	*310*	290	230	130	55	34	27
	Northeast	220	340	430	*460*	420	330	210	78	47	44	40	34	27
	East	470	**550**	550	460	320	140	47	47	47	44	40	34	27
	Southeast	**430**	420	320	170	55	47	47	47	47	44	40	34	27
	South	**100**	40	40	44	47	47	47	47	47	44	40	40	*100*
	Southwest	27	34	40	44	47	47	47	47	55	170	320	420	**430**
	West	27	34	40	44	47	47	47	140	320	460	550	**550**	470
	Northwest	27	34	40	44	47	78	210	330	420	*460*	430	340	220
	Horizontal	150	290	450	580	670	720	**740**	720	670	580	450	290	150

Solar Gain Correction	Steel Sash, or No Sash × 1/0·85 or 1·17	Haze —15% (Max.)	Altitude +2·3% per 1000 m	Dewpoint Decrease from 20°C+13% per 10°C	Dewpoint Increase from 20°C —13% per 10°C

Italic values: monthly maxima. **Bold** values: yearly maxima.

TABLE 15—SOLAR CHARACTERISTICS AND GLASS FACTORS FOR VARIOUS GLASSES

	Type of Glass	Absorptivity (α)	Reflectivity (ρ)	Transmissibility (τ)	Glass Factor
Carrier	Reference (3 mm clear)	0.06	0.08	0.86	1.00
	Plate clear (6 mm)	0.15	0.08	0.77	0.94
Pilkington	"Spectrafloat" 50/67 Bronze (6 mm)	0.34	0.10	0.56	0.80
	"Antisun" float 41/62 Grey (6 mm)	0.51	0.05	0.44	0.73
	"Antisun" float 29/46 Bronze (12 mm)	0.74	0.05	0.21	0.58
	"Calorex" 48/45, Blue/Green (6 mm)	0.75	0.05	0.20	0.57
CSIRO	Laminated "Stopray" Gold (6 mm)	0.36	0.39	0.25	0.44
	"Reflectoshield" control film R.S. 20 on clear glass (6 mm)	0.44	0.44	0.12	0.34
	"Scotchtint" control film A 18 on clear glass (4 mm)	0.30	0.53	0.17	0.33

Note: Absorptivity, reflectivity and transmissibility values have been taken from Carrier, the manufacturer or CSIRO tests as indicated in the first column. Glass factors have been determined from these values.

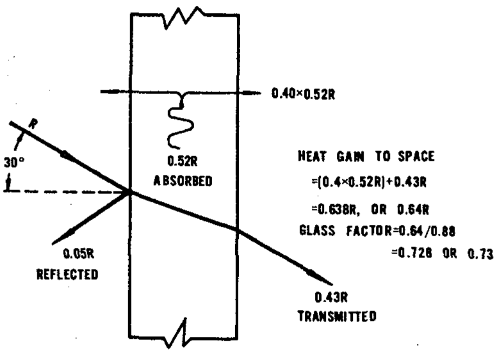


Fig. 17—Reaction on solar heat (R), 52% heat absorbing glass and reference conditions

Example 3—Peak Solar Heat Gain through "Stopray" Glass

Given:

West exposure, 30° South latitude
6 mm laminated "Stopray" (Gold), in steel sash.

Find:

Peak solar heat gain.

Solution:

By inspection of *Table 14* the boldface value for peak solar heat gain, occurring at 4:00 p.m. on January 21 = 550 W/m²

Steel sash window correction = 1/0.85 (bottom *Table 14*).

From *Table 15*, the factor = 0.44

$$\text{Solar heat gain} = \frac{550 \times 0.44}{0.85} = 285\ \text{W/m}^2$$

SHADING DEVICES

The effectiveness of a *shading device* depends on its ability to keep solar heat from the conditioned space.

All shading devices reflect and absorb a major portion of the solar gain, leaving a small portion to be transmitted. The outdoor shading devices are much more effective than the inside devices because all of the reflected solar heat is kept out and the absorbed heat is dissipated to the outdoor air. Inside devices necessarily dissipate their absorbed heat within the conditioned space and must also reflect the solar heat back through the glass (*Fig. 18*) wherein some of it is absorbed.

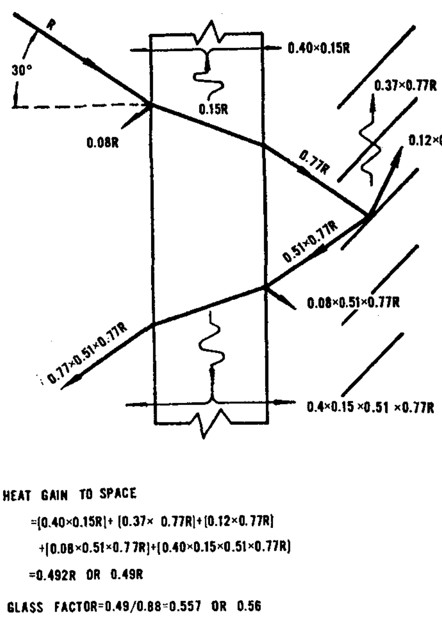


Fig. 18—Reaction on solar heat (R), 6 mm clear plate glass, white venetian blind and reference conditions

The solar heat gain through glass with an inside shading device may be expressed as follows:

$Q' = [0.4\,\alpha_g + \tau_g\,(\alpha_{sd} + \tau_{sd} + \rho_g\,\rho_{sd} + 0.4\,\alpha_g\,\rho_{sd})]\,R$

where:

Q' = solar heat gain to space, W/m^2
R = incident energy, (W/m^2) (from *Table 14*, divided by (0.88 × 0.85))
α = solar absorptivity
τ = solar transmissibility
ρ = solar reflectivity
g = glass
sd = shading device
0.88 = portion of R penetrating into the conditioned space through reference glass
0.85 = correction factor for no sash

TABLE 16—INTERNAL SHADING DEVICES BEHIND REFERENCE GLASS

Type of shading device	Absorptivity (α)	Reflectivity (ρ)	Transmissibility (τ)	Solar Factor
Venetian blind, light colour	0.37	0.51	0.12	0.56
medium colour	0.58	0.39	0.03	0.65
dark colour	0.72	0.27	0.01	0.75
'Metalon' blind 310/2	0.29	0.48	0.23	0.58
'Brella' Holland blind, white	0.09	0.77	0.14	0.33

Note:
Actually the reaction on the solar heat reflected back through the glass from the blind is not always identical to the first pass as assumed in Fig. 18 and the formula for Q'. The first pass through the glass filters out most of solar radiation that is to be absorbed in the glass, and the second pass absorbs somewhat less. For simplicity the reaction is assumed identical, since the quantities are normaly small on the second pass.

Absorptivity, reflectivity, transmissibility and overall solar factors for various internal shading devices in combination with reference glass are shown in the following table (*16*).

Overall Solar Factor is defined as the ratio of solar heat transmitted into the space through a particular glass in combination with a shading device, both under reference conditions. The overall solar factors are for use with *Table 14*.

The table above shows *inter alia* that a white 'Brella' Holland blind behind clear (reference) glass lets through approximately one third the solar heat that would come through the clear glass without the blind. The provision of blinds in combination with heat absorbing glass is less effective. For instance, for a highly heat absorbing glass with 74% absorptivity and 5% reflectivity the heat released into the space under reference conditions is 0.506, say 0.51 of the incident solar energy and the glass factor is therefore 0.51/0.88 = 0.58. If a 'Brella' white Holland blind is placed behind that glass the Solar Factor is calculated to be 0.57. The presence of the Holland blind has therefore hardly any effect and its use in combination with this highly heat absorbing glass lets ((0.57−0.33)/0.33) × 100 = 72.5% more solar heat into the conditioned space than the same blind behind a sheet of clear (reference) glass.

Example 4—Partially Drawn Shades

Occasionally it is necessary to estimate the cooling load in a building where the blinds are not to be fully drawn. The procedure is illustrated in the following example:

Given:
West exposure, 30° South latitude
Steel sash window with reference glass (3 mm, clear) and white 'Brella' Holland blind on inside, ¾ drawn.

Find:
Peak solar heat gain.

Solution:
By inspection of *Table 14*, the bold values for peak solar heat gain, occurring at 4:00 p.m. on January 21 = 550 W/m^2
Correction for steel sash = 1/0.85 (bottom *Table 14*)
In this example, ¾ of the window is covered with the venetian blind and ¼ is not; therefore, the solar heat gain factor equals ¾ of the overall factor + ¼ of the glass factor.

Factor for ¾ drawn $= (\tfrac{3}{4} \times 0.33) + (\tfrac{1}{4} \times 1.0)$ (*Table 15 & 16*)
$= 0.50$

Solar heat gain $= 550 \times \dfrac{0.50}{0.85}$
$= 324$ W/m^2

DRAPES

Drapes behind glazing are sometimes provided for other than thermal reasons. Their effect as shading devices is shown in the following table (*17*) adapted from ASHRAE research

TABLE 17
Overall solar factors for 6 mm glazing with drapes of 100% fullness

Clear glass/Tinted glass
(absorptivity 0.42, reflectivity 0.05)

Weave	Colour		
	Dark	Medium	Light
Open	0.73/0.57	0.67/0.53	0.65/0.52
Semi-open	0.68/0.53	**0.61/0.49**	0.56/0.47
Close	0.64/0.51	0.54/0.45	0.44/0.39

Factors are for use with Table 14.

Notes:

(a) *Weave:* The following applies to flat fabric; not 100% fullness which signifies material width twice the width of the window.
Open: (Openness factor over 25%)—details can be seen through material and general view is relatively clear with no confusion of vision.
Semi-open: (Openness factor 7% to 25%)—details cannot be seen but large objects are clearly defined.
Close: (Openness factor 0 to 7%)—no objects visible through material large light and dark areas may perhaps show.

(b) *Colour* is the colour or shade of the yarn. Corresponding reflectances for dark, medium and light are 0–25%, 25–50% and over 50%.

(c) *General suitability:* When considering *all* factors such as protection from solar radiation, glare control, the effectiveness in allowing outward vision and preventing inward viewing, the medium colour drape with semi-open weave is the optimum. (Overall solar factors 0.61 for clear and 0.49 for tinted glass; **bold** figures in Table 17.)

Example 5—Peak solar heat gain through clear plate glass with drapes behind

Given:
West exposure, 30° South latitude
6 mm clear plate glass in wooden sash
100% full drapes, orange colour, close weave

Find:
Peak solar gain.

Solution:
From bold values of *Table 14*, solar peak occurs at 4.00 p.m. on January 21 = 550 W/m²
From *Table 17* the overall solar factor is 0.54
Solar heat gain 550 × 0.54 = 300 W/m²

VENETIAN BLIND BETWEEN GLASS

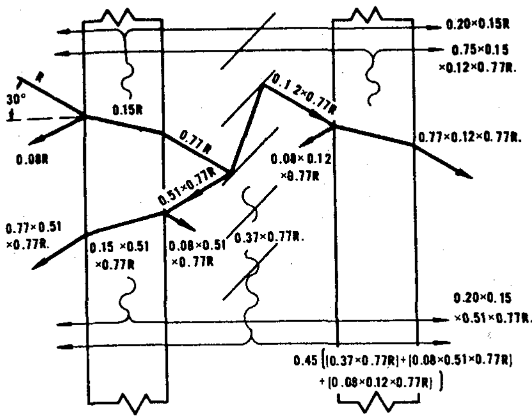
Solar heat transmission and overall solar factors can be calculated from information on absorptivity, reflectivity and transmissibility given in *Tables 15* and *16* and on the assumption that heat absorbed between the glass panes (dead air space) is divided 45% and 55% between the in and out flow respectively, and that heat absorbed within the glass panes is divided 20% in and 80% out for the outer pane, and 75% in and 25% out for the inner pane. These divisions are based on reference conditions and the overall thermal conductance of the air space of 7.8 W/m².°C. The overall solar coefficients for Venetian blinds between clear glass and between heat absorbing and clear glass are calculated in *Examples* 6 and 7.

Example 6—Overall solar factor for venetian blind between clear plate glass

Given:
6 mm clear plate glass inside and outside
White venetian blind in dead air space
Reference conditions

Find:
Overall solar factor

Solution:
From *Table 15* for 6 mm clear plate: absorptivity 0.15, reflectivity 0.08, transmissibility 0.77
From *Table 16* for white venetian blind: absorptivity 0.37, reflectivity 0.51, transmissibility 0.12



HEAT GAIN TO SPACE
= (0.75×0.15×0.12×0.77R)+(0.77×0.12×0.77R)
+ 0.45{(0.37×0.77R)+(0.08×0.51×0.77R)
+(0.08×0.12×0.77R) }
+0.20{(0.15R)+(0.15×0.51×0.77R) }
= 0.2684R OR 0.27R

OVERALL SOLAR FACTOR
=0.27R/0.88R=0.31

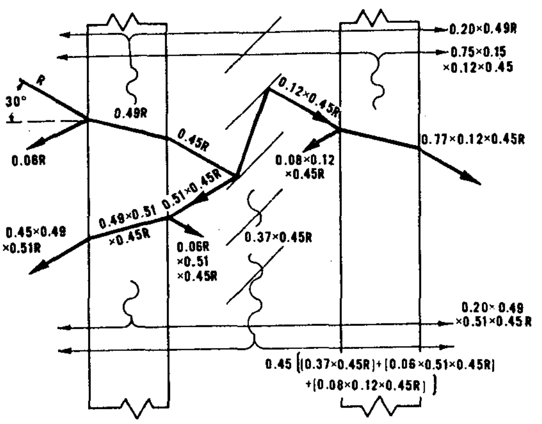
Fig. 19—Reaction on solar heat (R), 6 mm clear plate glass, white venetian blind, 6 mm clear plate glass and reference conditions

Example 7—Overall solar factor for venetian blind between heat absorbing glass outside and clear glass inside

Given:
6 mm 'Antisun' Float 74/61 green outside
6 mm clear plate inside
White venetian blind in dead space

Find:
Overall solar factor

Solution:
For heat absorbing glass from maker (Pilkington): absorptivity 0.49, reflectivity 0.06, transmissibility 0.45
For clear glass, from Table 15: absorptivity 0.15, reflectivity 0.08, transmissibility 0.77
For venetian blind, from Table 16: absorptivity 0.37, reflectivity 0.51, transmissibility 0.12



HEAT GAIN INTO SPACE

(0.75×0.15×0.12×0.45R) + (0.77×0.12×0.45R)
+0.45 [(0.37×0.45R) + (0.06×0.51×0.45R)
+ (0.08×0.12×0.45R)]
+0.20 [(0.49R) + (0.49× 0.51×0.45R)]
= 0.2511 OR 0.25R.

OVERALL SOLAR FACTOR

= 0.25R/0.88R = 0.284.

Fig. 20—Reaction on solar heat (R), 6 mm heat absorbing glass, white venetian blind, 6 mm clear plate glass and reference conditions

APPROXIMATE OVERALL SOLAR FACTORS

When solar characteristics of glass and/or shading devices (absorptivity, reflectivity and transmissibility) are not known, the following table (*18*) may be used. Factors are for use with *Table 14.*

Example 8—Solar heat gain through double glazed window with and without outside shade screen

Given:

An air conditioned office building 30° South latitude at sea level on a very hazy day.
Windows facing east, factory sealed, double glazed, with heat absorbing glass on the outside and clear glass on the inside.

Find:

The solar load through the windows at 6 a.m.
(a) without shading devices
(b) with medium colour outside shade screens

TABLE 18—APPROXIMATE OVER-ALL FACTORS FOR SOLAR HEAT GAIN THROUGH GLASS

With and Without Shading Devices*

Type of Glass	Glass Factor No Shade	Inside Venetian Blind* 45° horiz. or vertical or Roller Shade			Outside Venetian Blind 45° horiz. slats		Outside Shading Screen† 17° horiz. slats		Outside Awning‡ vent. sides & top	
		Light Colour	Medium Colour	Dark Colour	Light Colour	Light on Outside Dark on Inside	Medium‖ Colour	Dark§ Colour	Light Colour	Med. or Dark Colour
Reference glass (3 mm, clear)	1.00	0.56	0.65	0.75	0.15	0.13	0.22	0.15	0.20	0.25
Plate glass (6 mm, clear)	0.94	0.56	0.65	0.74	0.14	0.12	0.21	0.14	0.19	0.24
Heat Absorbing Glass ¶										
40 to 48% Absorbing	0.80	0.56	0.62	0.72	0.12	0.11	0.18	0.12	0.16	0.20
48 to 56% Absorbing	0.73	0.53	0.59	0.62	0.11	0.10	0.16	0.11	0.15	0.18
56 to 70% Absorbing	0.62	0.51	0.54	0.56	0.10	0.10	0.14	0.10	0.12	0.16
Double Glazing										
Reference Glass (3 mm, clear)	0.90	0.54	0.61	0.67	0.14	0.12	0.20	0.14	0.18	0.22
Plate Glass (6 mm, clear)	0.80	0.52	0.59	0.65	0.12	0.11	0.18	0.12	0.16	0.20
48 to 56% Absorbing outside; Reference Glass inside	0.52	0.36	0.39	0.43	0.10	0.10	0.11	0.10	0.10	0.13
48 to 56% Absorbing outside; Plate inside	0.50	0.36	0.39	0.43	0.10	0.10	0.11	0.10	0.10	0.12

*Shading devices fully drawn except roller shades. For fully drawn roller shades, multiply light colours by 0.73, medium colours by 0.95, and dark colours by 1.08.

† Factors for solar altitude angles of 40° or greater. At solar altitudes below 40°, some direct solar rays pass through the slats. Use following multipliers:

‡With outside canvas awning tight against building on sides and top, multiply over-all factor by 1.4.

§Commercial shade bronze. Metal slats 1.2 mm wide, 7 per 10 mm.

‖Commercial shade, aluminium. Metal slats 1.5 mm wide, 7 per 10 mm.

¶Most heat absorbing glass used in comfort air conditioning is in the 40% to 56% range; industrial applications normally use 56% to 70%.

MULTIPLIERS FOR SOLAR ALTITUDES BELOW 40°

Approximate Sun Time, January 21			Solar Altitude Angle (deg)	Multiplier	
30° Lat.	40° Lat.	50° Lat.		Med. Colour	Dark Colour
6.00 a.m. 6.00 p.m.	5.45 a.m. 6.15 p.m.	5.30 a.m. 6.30 p.m.	10	2.09	3.46
6.45 a.m. 5.15 p.m.	6.40 a.m. 5.20 p.m.	6.30 a.m. 5.30 p.m.	20	1.59	2.66
7.30 a.m. 4.30 p.m.	7.30 a.m. 4.30 p.m.	7.30 a.m. 4.30 p.m.	30	1.09	1.67

Solution:
From *Table 18*:
(a) Glass factor: 0.50
(b) Overall solar factor: 0.11
Correction for (b): 2.09
From *Table 14*: Heat gain = 340 W/m²
Correction for steel frame: 1/0.85
Correction for haze: 0.85

Solar heat gain through the window
(a) $340 \times 0.85/0.85 \times 0.5 = 170\ \text{W/m}^2$
(b) $340 \times 0.85/0.85 \times 2.09 \times 0.11 = 78\ \text{W/m}^2$

GLASS BLOCK

Glass block differs from sheet glass in that there is an appreciable absorption of solar heat and a fairly long time lag before the heat reaches the inside (about 3 hours). This is primarily caused by the thermal storage capacity of the glass block itself. The high absorption of heat increases the inside surface temperature of the sunlit glass block which may require lower room temperatures to maintain comfort conditions as explained in *Chapter 2*.

Shading devices on the outdoor side of glass block are almost as effective as with any other kind of glass since they keep the heat away from the glass. Shading devices on the inside are not effective in reducing the heat gain because most of the heat reflected is absorbed in the glass block.

Basis of Table 19 —Solar Heat Gain Factors for Glass Block, With and Without Shading Devices

The factors in *Table 19* are the average of tests conducted by the ASHRAE on several types of glass block.

Since glass block windows have no sash, the factors in *Table 19* have been increased to include the 1/0.85 multiplier in *Table 14*.

Use of Table 19 —Solar Heat Gain Factors for Glass Block, With and Without Shading Devices

The factors in *Table 19* are used to determine the solar heat gain through all types of glass block.

The transmission of heat caused by a difference between the inside and outdoor temperatures must also be figured, using the appropriate *U* value, *Chapter 5*.

Example 9—Peak Solar Heat Gain, Glass Block

Given:
West exposure, 40° South latitude
Glass block window

Find:
Peak solar heat gain

Solution:
By inspection of *Table 14*, the peak solar heat gain occurs on January 21.
Solar heat gain

At 4.00 p.m. $= (0.39 \times 550) + (0.21 \times 145) = 245\ \text{W/m}^2$
At 5.00 p.m. $= (0.39 \times 540) + (0.21 \times 330) = 280\ \text{W/m}^2$
At 6.00 p.m. $= (0.39 \times 400) + (0.21 \times 490) = 259\ \text{W/m}^2$

Peak solar heat gain occurs at 5.00 p.m. on January 21.

TABLE 19
Solar Heat gain Factors for Glass Block
WITH AND WITHOUT SHADING DEVICES*
Apply Factors to Table 14

EXPOSURE IN SOUTH LATITUDE	Multiplying Factors for Glass Block		
	Instantaneous Transmission Factors (B_i)	Absorption Transmission	
		Factor (B_a)	Time Lag Hours
North			
Summer†	0.27	0.24	3.0
Winter†	0.39	0.22	3.0
Northeast	0.35	0.22	3.0
East	0.39	0.21	3.0
Southeast	0.27	0.24	3.0
Southwest	0.27	0.24	3.0
West	0.39	0.21	3.0
Northwest	0.35	0.22	3.0

*Factors include correction for no sash with glass block windows.
†Use the summer factors for all latitudes, South or North. Use the winter factors for intermediate seasons, 30° to 50° South or North latitude.

Equations:
Solar heat gain *without shading devices*
$= (B_i \times I_i) + (B_a \times I_a)$
Solar heat gain *with outdoor shading devices*
$= (B_i \times I_i + B_a \times B_a) \times 0.25$
Solar heat gain *with inside shading devices*
$= (B_i \times I_i + B_a \times I_a) \times 0.90$

Where:
B_i = Instantaneous transmission factor from *Table 19*.
B_a = Absorption transmission factor from *Table 19*.
I_i = Solar heat gain value from *Table 14* for the desired time and wall facing.
I_a = Solar heat gain value from *Table 14* for 3 hours earlier than I_i and same wall facing.

SHADING FROM REVEALS, OVERHANGS, FINS AND ADJACENT BUILDINGS

Each window is shaded to a greater or lesser degree by the projections close to it and by buildings around it. This shading reduces the solar heat gain through these windows by keeping the direct rays of the sun off part or all of the window. The shaded portion has only the diffuse component striking it. Shading of windows is significant in monumental type buildings where the reveal may be large, even at the time of peak solar heat gain. *Chart 1*, this chapter, is presented to simplify the determination of the shading of windows by these projections.

Basis of Chart 1
—Shading from Reveals, Overhangs, Fins and Adjacent Buildings

The location of the sun is defined by the solar azimuth angle and the solar altitude angle as shown in *Fig. 21*. The solar azimuth angle is the angle in a horizontal plane between North and the vertical plane passing through the sun and the point on earth. The solar altitude angle is the angle in a vertical plane between the sun and a horizontal plane through a point on earth. The location of the sun with respect to the particular wall facing is defined by the wall solar azimuth angle and the solar altitude angle. The wall solar azimuth angle is the angle in the horizontal plane between the perpendicular to the wall and the vertical plane passing through the sun and point on earth.

The shading of a window by a vertical projection alongside the window (see *Fig. 22*) is the tangent of the wall solar azimuth angle (B), times depth of the projection. The shading of a window by a horizontal projection above the window is the tangent of angle (X), a resultant of the combined effects of the altitude angle (A) and the wall solar azimuth angle (B), times the depth of the projection.

$$\text{Tan X} = \frac{\text{Tan A, solar altitude angle}}{\text{Cos B, wall solar azimuth angle}}$$

The upper part of *Chart 1* determines the tangent of the wall solar azimuth angle and the bottom part determines tan X.

Use of Chart 1
—Shading from Reveals, Overhangs, Fins and Adjacent Buildings

The procedure to determine the top and side shading from *Chart 1* is.

1. Determine the solar azimuth and altitude angles from *Table 20.*
2. Locate the solar azimuth angle on the scale in upper part of *Chart 1.*
3. Proceed horizontally to the exposure desired.
4. Drop vertically to 'Shading from Side' scale.
5. Multiply the depth of the projection (plan view) by the 'Shading from Side'.
6. Locate the solar altitude angle on the scale in lower part of *Chart 1.*
7. Move horizontally until the 'Shading from Side' value (45° lines) determined in Step 4 is intersected.
8. Drop vertically to 'Shading from Top' from intersection.
9. Multiply the depth of the projection (elevation view) by the 'Shading from Top'.

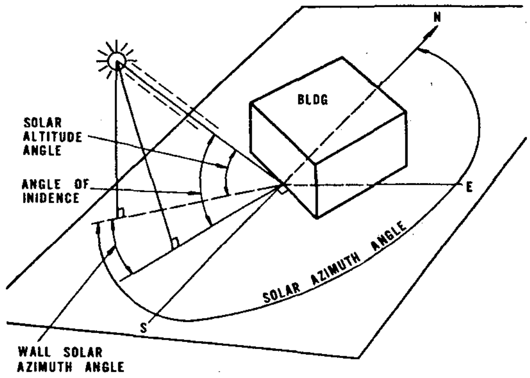


Fig. 21—Solar angles

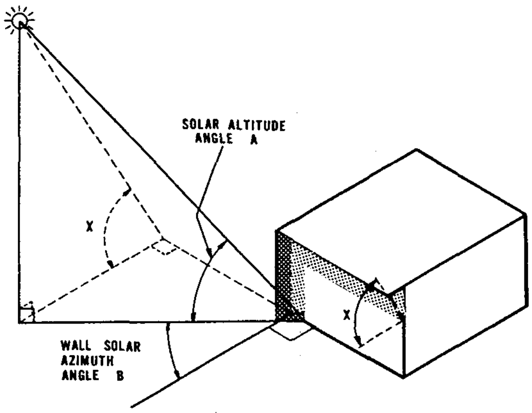


Fig. 22—Shading by wall projections

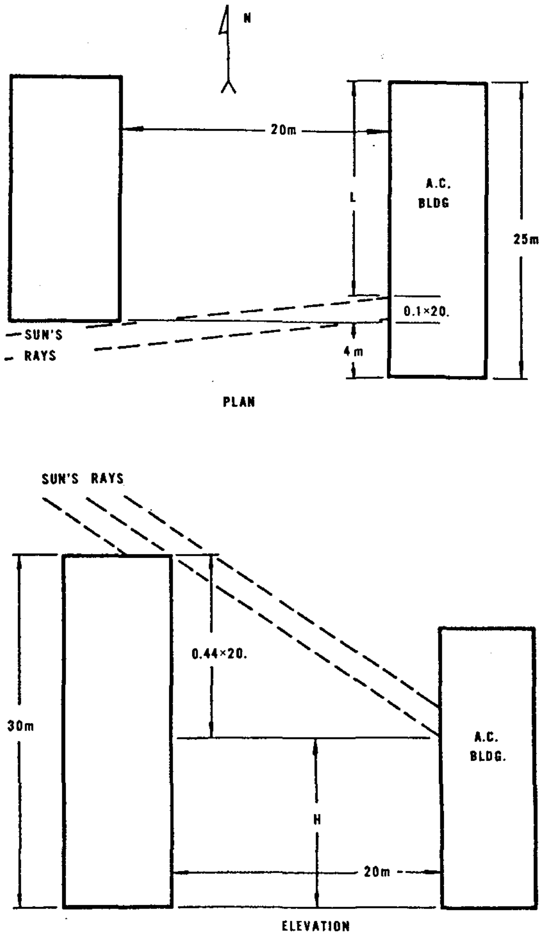


Fig. 23—Shading of building by adjacent building

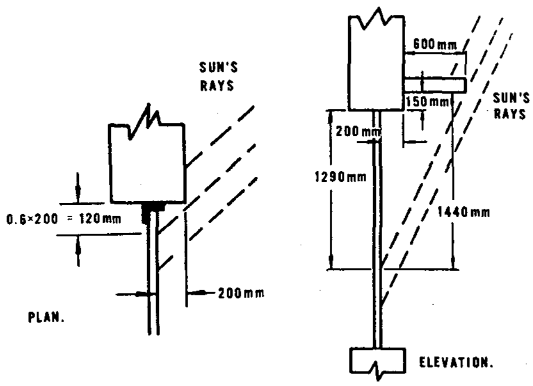


Fig. 24—Shading of reveal and overhang

Example 9—Shading of Building by Adjacent Building

Given:

Buildings located as shown in *Fig. 23,* 40° South latitude

Find:

Shading at 5 p.m. January 21, of building to be air conditioned.

Solution:

It is recommended that the building plans and elevations be sketched to scale with approximate location of the sun, to enable the engineer to visualize the shading conditions.

From *Table 20,* solar azimuth angle = 263°
solar altitude angle = 24°

From *Chart 1,* shading from side = 0.1 mm/mm
shading from top = 0.44 mm/mm

Length of building in shade, L
$= 25 - 4 - (0.1 \times 20) = 19$ m

Height of building in shade, $H = 30 - (0.44 \times 20)$
$= 21.2$ m

The air conditioned building is shaded to a height of 21.2 m and 19 m along the face at 5.00 p.m. on January 21.

Example 10—Shading of Window by Reveals

Given:

A steel casement window on the east side with a 200 mm reveal.

Find:

Shading by the reveal at 10.00 a.m. on January 21, 40° South latitude.

Solution:

From *Table 20,* solar azimuth angle = 61°
solar altitude angle = 58°

From *Chart 1,* shading from side reveal $= 0.6 \times 200$
$= 120$ mm
shading from top reveal $= 1.8 \times 200$
$= 360$ mm.

Example 11—Shading of Window by Overhang and Reveal

Given:

The same window as in *Example 10* with a 600 mm overhang 150 mm above the window.

Find:

Shading by reveal and overhang at 10.00 a.m. on January 21, 40° South latitude.

Solution:

Refer to *Fig. 24*
Shading from side reveal (same as *Example 10*) = 120 mm.
Shading from overhang $= 1.8 \times (600 + 200) =$ 1440 mm.
Since the overhang is 150 mm above the window, the portion of window shaded $= 1440 - 150 = 1290$ mm.

Chart 1—Shading from reveals, overhangs, fins and adjacent buildings

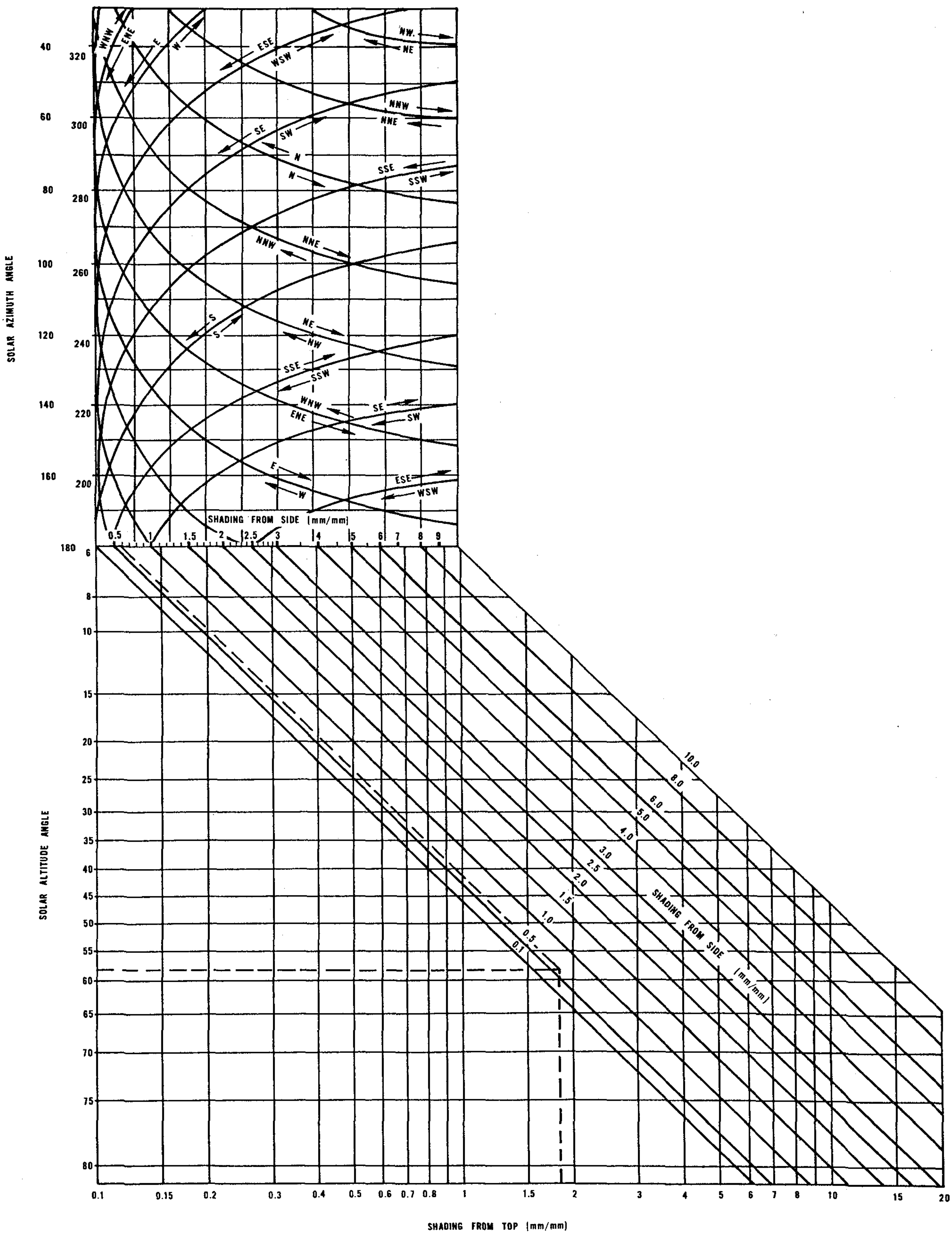


TABLE 20—SOLAR ALTITUDE AND AZIMUTH ANGLES

SOUTH LATITUDE	SUN TIME	Jan. 21		Feb. 20		Mar. 22		Apr. 20		May 21		June 21		July 23		Aug. 24		Sept. 22		Oct. 23		Nov. 21		Dec. 22		SUN TIME
		Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	
LAT 0°	6 AM	0	110	0	101	0	90	0	79	0	70	0	67	0	70	0	79	0	90	0	101	0	110	0	113	6 AM
	7	14	111	15	102	15	90	15	78	14	69	14	66	14	69	15	78	15	90	15	102	14	110	14	114	7
	8	28	113	29	103	30	90	29	77	28	67	27	63	28	67	29	77	30	90	29	103	28	113	27	117	8
	9	42	117	44	106	45	90	44	74	42	63	40	58	42	62	44	74	45	89	44	106	42	117	40	121	9
	10	54	126	58	112	60	90	58	68	54	54	53	49	54	54	58	68	60	89	58	111	55	126	53	131	10
	11	65	145	71	127	75	89	71	52	65	35	62	31	65	35	71	52	75	88	71	127	65	144	62	149	11
	12 N	70	180	79	180	90	0	79	0	70	0	67	0	70	0	79	0	89	0	79	180	70	180	67	180	12 N
	1 PM	65	215	71	233	75	271	71	308	65	325	62	329	65	325	71	308	75	272	71	233	65	216	62	211	1 PM
	2	54	234	58	248	60	270	58	292	54	306	53	311	54	306	58	292	60	271	58	249	55	234	53	229	2
	3	42	243	44	254	45	270	44	286	42	297	40	302	42	298	44	286	45	271	44	254	42	243	40	239	3
	4	28	247	29	257	30	270	29	283	28	293	27	297	28	293	29	283	30	270	29	257	28	247	27	243	4
	5	14	249	15	258	15	270	15	282	14	291	14	294	14	291	15	282	15	270	15	258	14	250	14	246	5
	6	0	250	0	259	0	270	0	281	0	290	0	293	0	290	0	281	0	270	0	259	0	250	0	247	6
LAT 10°	6 AM	3	110	2	101															2	101	3	109	4	113	6 AM
	7	17	108	16	99	15	87	12	76	10	67	9	64	10	67	12	76	15	87	16	99	17	108	18	112	7
	8	31	108	31	97	29	84	27	72	24	63	22	59	24	63	27	72	29	84	31	97	31	107	31	111	8
	9	46	109	46	96	44	80	40	66	37	56	35	52	36	55	40	66	44	79	46	96	46	108	45	113	9
	10	59	113	60	95	58	73	53	55	48	44	46	41	48	44	53	55	58	72	60	95	59	112	58	119	10
	11	72	127	75	96	72	56	64	35	57	26	53	24	56	26	64	35	72	55	75	96	73	126	70	135	11
	12 N	80	180	89	180	80	0	69	0	60	0	57	0	60	0	69	0	79	0	89	180	80	180	77	180	12 N
	1 PM	72	233	75	264	72	304	64	325	57	334	53	336	56	334	64	325	72	305	75	264	73	234	70	225	1 PM
	2	59	247	60	265	58	287	53	305	48	316	46	319	48	316	53	305	58	288	60	265	59	248	58	241	2
	3	46	251	46	264	44	280	40	294	37	304	35	308	36	305	40	294	44	281	46	264	46	252	45	247	3
	4	31	252	31	263	29	276	27	288	24	297	22	301	24	297	27	288	29	276	31	263	31	253	31	249	4
	5	17	252	16	261	15	273	12	284	10	293	9	296	10	293	12	284	15	273	16	261	17	252	18	248	5
	6	3	250	2	259															2	259	3	251	4	247	6
LAT 20°	6 AM	7	109	4	101															4	100	7	109	8	112	6 AM
	7	20	105	18	96	14	84	10	74	6	66	5	63	6	66	10	74	14	84	18	96	20	104	21	108	7
	8	34	101	32	91	28	78	23	68	19	59	17	56	19	59	23	67	28	78	32	91	34	101	35	105	8
	9	48	98	46	85	41	71	36	59	30	50	28	47	30	50	36	59	41	70	46	85	48	98	48	103	9
	10	62	95	60	78	54	59	47	46	40	38	38	35	40	38	47	46	54	58	60	77	62	95	62	103	10
	11	76	93	73	61	65	38	55	27	47	21	44	19	47	21	55	26	65	37	73	61	76	92	76	107	11
	12 N	90	180	81	0	70	0	59	0	50	0	47	0	50	0	59	0	69	0	81	0	90	0	87	180	12 N
	1 PM	76	267	73	299	65	322	55	333	47	339	44	341	47	339	55	334	65	323	73	299	76	268	76	253	1 PM
	2	62	265	60	282	54	301	47	314	40	322	38	325	40	322	47	314	54	302	60	283	62	265	62	257	2
	3	48	262	46	275	41	289	36	301	30	310	28	313	30	310	36	301	41	290	46	275	48	262	48	257	3
	4	34	259	32	269	28	282	23	292	19	301	17	304	19	301	23	293	28	282	32	269	34	259	35	255	4
	5	20	255	18	264	14	276	10	286	6	294	5	297	6	294	10	286	14	276	18	264	20	256	21	252	5
	6	7	251	4	259															4	260	7	251	8	248	6

TABLE 20—SOLAR ALTITUDE AND AZIMUTH ANGLES (Continued)

SOUTH LATITUDE	SUN TIME	Jan. 21		Feb. 20		Mar. 22		Apr. 20		May 21		June 21		July 23		Aug. 24		Sept. 22		Oct. 23		Nov. 21		Dec. 22		SUN TIME
		Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	Alt	Az	
LAT 30°	6 AM	10	108	6	100															6	100	10	107	11	111	6 AM
	7	22	101	18	92	13	82	7	73	2	65	0	62	2	65	7	73	13	82	18	92	22	101	24	104	7
	8	35	94	31	85	25	74	19	64	14	57	11	54	13	57	19	64	25	73	31	85	35	94	37	98	8
	9	48	87	44	76	38	63	30	53	24	47	21	44	24	46	30	53	37	63	44	75	48	87	50	92	9
	10	61	77	56	62	48	49	40	40	32	34	29	32	32	34	40	39	48	48	56	62	61	76	62	83	10
	11	73	57	67	40	56	28	46	22	38	18	35	17	38	18	46	21	56	28	67	40	73	56	75	67	11
	12 N	80	0	71	0	60	0	49	0	40	0	37	0	40	0	49	0	59	0	71	0	80	0	83	0	12 N
	1 PM	73	303	67	320	56	332	46	338	38	342	35	343	38	342	46	339	56	332	67	320	73	304	75	293	1 PM
	2	61	283	56	298	48	311	40	320	32	326	29	328	32	326	40	321	48	312	56	298	61	284	62	277	2
	3	48	273	44	284	38	297	30	307	24	313	21	316	24	314	30	307	37	297	44	285	48	273	50	268	3
	4	35	266	31	275	25	286	19	296	14	303	11	306	13	303	19	296	25	287	31	275	35	266	37	262	4
	5	22	259	18	268	13	278	7	287	2	295	0	298	2	295	7	287	13	278	18	268	22	259	24	256	5
	6	10	252	6	260															6	260	10	253	11	249	6
LAT 40°	6 AM	13	106	7	99															7	99	13	105	15	108	6 AM
	7	24	97	19	89	11	80	4	72							4	72	11	80	19	89	24	96	26	100	7
	8	35	87	30	79	22	69	14	61	8	55	5	53	8	55	14	61	22	69	30	79	35	87	37	90	8
	9	47	76	41	67	33	57	24	49	17	44	14	42	17	44	24	49	32	57	41	67	47	76	49	80	9
	10	58	61	51	51	41	42	32	35	24	31	21	29	24	31	32	35	41	41	51	51	57	61	60	66	10
	11	66	37	58	29	47	22	37	19	28	16	25	15	28	16	37	18	47	22	58	29	66	37	69	42	11
	12 N	70	0	61	0	50	0	39	0	30	0	27	0	30	0	39	0	49	0	61	0	70	0	73	0	12 N
	1 PM	66	323	58	331	47	338	37	341	28	344	25	345	28	344	37	342	47	338	58	331	66	323	69	318	1 PM
	2	58	299	51	309	41	318	32	325	24	329	21	331	24	329	32	325	41	319	51	309	57	299	60	294	2
	3	47	284	41	293	33	303	24	311	17	316	14	318	17	316	24	311	32	303	41	293	47	284	49	280	3
	4	35	273	30	281	22	291	14	299	8	305	5	307	8	305	14	299	22	291	30	281	35	273	37	270	4
	5	24	263	19	271	11	280	4	288							4	288	11	280	19	271	24	264	26	260	5
	6	13	254	7	261															7	261	13	255	15	252	6
LAT 50°	6 AM	15	103	9	97															9	97	15	103	18	106	6 AM
	7	25	92	18	86	9	78	1	71							1	71	9	78	18	86	25	92	27	95	7
	8	34	80	28	74	18	66	10	59	2	55			2	54	9	59	18	66	28	73	34	80	37	83	8
	9	44	67	36	60	27	52	17	47	9	42	6	41	9	42	17	47	26	52	36	60	43	66	46	70	9
	10	52	49	44	43	34	37	23	32	15	29	12	28	15	29	23	32	33	37	44	43	52	49	55	52	10
	11	58	27	49	23	38	19	27	17	19	15	15	14	19	15	27	17	38	19	49	23	57	27	61	29	11
	12 N	60	0	51	0	40	0	29	0	20	0	17	0	20	0	29	0	39	0	51	0	60	0	63	0	12 N
	1 PM	58	333	49	337	38	341	27	343	19	345	15	346	19	345	27	343	38	341	49	337	57	333	61	331	1 PM
	2	52	311	44	317	34	323	23	328	15	331	12	332	15	331	23	328	33	323	44	317	52	311	55	308	2
	3	44	293	36	300	27	308	17	313	9	318	6	319	9	318	17	313	26	308	36	300	43	294	46	290	3
	4	34	280	28	286	18	294	10	301	2	305			2	306	9	301	18	294	28	287	34	280	37	277	4
	5	25	268	18	274	9	282	1	289							1	289	9	282	18	274	25	268	27	265	5
	6	15	257	9	263															9	263	15	257	18	254	6

CHAPTER 5. HEAT AND WATER VAPOUR FLOW THROUGH STRUCTURES

This chapter presents the methods and data for determining the sensible and latent heat gain or loss through the outdoor structures of a building or through a structure surrounding a space within the building. It also presents data for determining and preventing water vapour condensation on the enclosure surfaces or within the structure materials.

Heat flows from one point to another whenever a temperature difference exists between the two points; the direction of flow is always towards the lower temperature. Water vapour also flows from one point to another whenever a difference in vapour pressure exists between the two points; the direction of flow is towards the point of low vapour pressure. The rate at which the heat or water vapour will flow varies with the resistance to flow between the two points in the material. If the temperature and vapour pressure of the water vapour correspond to saturation conditions at any point, condensation occurs.

HEAT FLOW THROUGH BUILDING STRUCTURES

Heat gain through the exterior construction (walls and roof) is normally calculated at the time of greatest heat flow. It is caused by solar heat being absorbed at the exterior surface and by the temperature difference between the outdoor and indoor air. Both heat sources are highly variable throughout any one day and, therefore, result in unsteady state heat flow through the exterior construction. This unsteady state flow is difficult to evaluate for each individual situation; however, it can be handled best by means of an equivalent temperature difference across the structure.

The equivalent temperature difference is that temperature difference which results in the total heat flow through the structure as caused by the variable solar radiation and outdoor temperature. The equivalent temperature difference across the structure must take into account the different types of construction and exposures, time of day, location of the building (latitude), and design conditions. The heat flow through the structure may then be calculated, using the steady state heat flow equation with the equivalent temperature difference.

$$Q = Ua\Delta t_e$$

where Q = heat flow, W
U = transmission coefficient, W/m².°C
a = area of surface, m²
Δt_e = equivalent temperature difference °C

Heat loss through the exterior construction (walls and roof) is normally calculated at the time of greatest heat flow. This occurs early in the morning after a few hours of very low outdoor temperatures. This approaches steady state heat flow conditions, and for all practical purposes may be assumed as such.

Heat flow through the interior construction (floors, ceilings and partitions) is caused by a difference in temperature of the air on both sides of the structure. This temperature difference is essentially constant throughout the day and, therefore, the heat flow can be determined from the steady state heat flow equation, using the actual temperatures on either side.

EQUIVALENT TEMPERATURE DIFFERENCE—SUNLIT AND SHADED WALLS AND ROOFS

The process of transferring heat through a wall under indicated unsteady state conditions may be visualized by picturing a 290 mm brick wall sliced into ten 29 mm sections. *Assume that temperatures in each slice are all equal at the beginning, and that the indoor and outdoor temperatures remain constant.*

When the sun shines on this wall, most of the solar heat is absorbed in the first slice, *Fig. 25.* This raises the temperature of the first slice above that of the outdoor air and the second slice, causing heat to flow to the outdoor air and also to the second slice, *Fig. 26.* The amount of heat flowing in either direction depends on the resistance to heat flow within the wall and through the outdoor air film. The heat flow into the second slice, in turn, raises its temperature, causing heat to flow into the third slice, *Fig. 27.* This process of absorbing heat and passing some on to the next slice continues through the wall to the last or tenth slice where the remaining heat is transferred to the inside by convection and radiation. For this

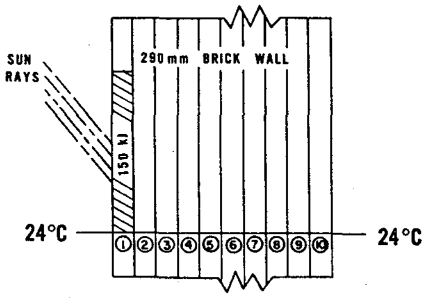


Fig. 25—Solar heat absorbed in first slice

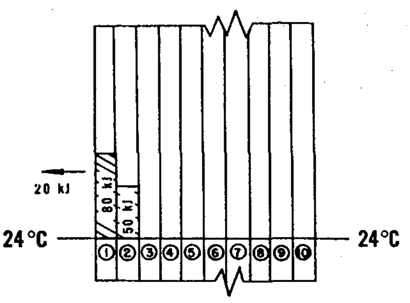


Fig. 26—Behaviour of absorbed solar heat during second time interval

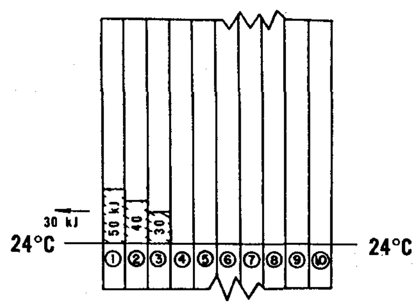


Fig. 27—Behaviour of absorbed solar heat during third time interval

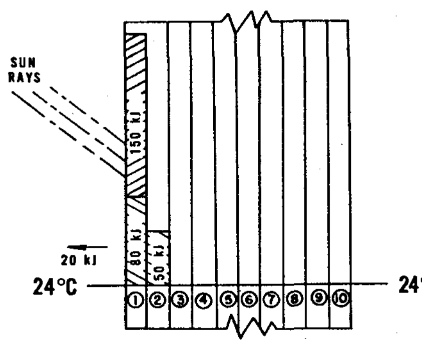


Fig. 28—Behavoir of absorbed solar heat during second time interval plus additional solar heat absorbed during this interval

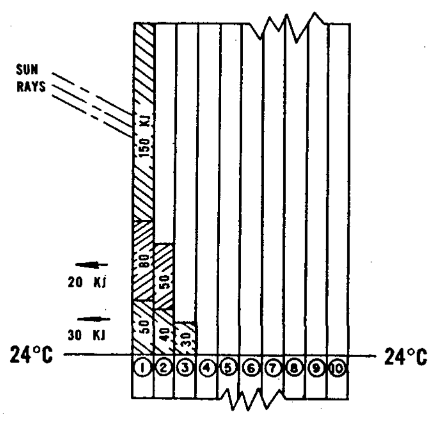


Fig. 29—Behavoir of absorbed solar heat during third time interval plus additional solar heat absorbed during this interval

particular wall, it takes approximately 7 hours for solar heat to pass through the wall into the room. Because each slice must absorb some heat before passing it on, the magnitude of heat released to inside space would be reduced to about 10% of that absorbed in the slice exposed to the sun.

These diagrams do not account for possible changes in solar intensity or outdoor temperature.

The solar heat absorbed at each time interval by the outdoor surface of the wall throughout the day goes through this same process. *Figs. 28* and *29* show the total solar heat flow during the second and third time intervals.

A rise in outdoor temperature reduces the amount of absorbed heat going to the outdoors and more flows through the wall.

This same process occurs with any type of wall construction to a greater or lesser degree, depending on the resistance to heat flow through the wall and the thermal capacity of the wall.

Note:

The thermal capacity of a wall or roof is the density of the material in the wall or roof, times the specific heat of the material, times the volume.

This progression of heat gain to the interior may occur over the full 24-hour period, and may result in a heat gain to the space during the night. If the equipment is operated less than 24 hours, i.e. either skipping the peak load requirement or as a routine procedure, the nighttime radiation to the sky and the lowering of the outdoor temperature may decrease the transmission gain and often may reverse it. Therefore, the heat gain estimate (sun and transmission through the roof and outdoor walls), even with equipment operating less than 24 hours, may be evaluated by the use of the equivalent temperature data presented in *Tables 21* and *22*.

Basis of Tables 21 and 22 —Equivalent Temperature Difference for Sunlit and Shaded Walls and Roofs

Tables 21 and *22* are analogue computer calculations using Schmidt's method based on the following conditions:

1. Solar heat in January at 40° South latitude.
2. Outdoor daily range of dry-bulb temperatures, 10°C.
3. Maximum outdoor temperature of 35°C DB and a design indoor temperature of 25°C DB, i.e. a design difference of 10°C.
4. Dark colour walls and roofs with absorptivity of 0.90. For light colour, absorptivity is 0.50; for medium colour, 0.70.
5. Sun time.

The specific heat of most construction materials is approximately 0.836 kJ/kg°C the thermal capacity of typical walls or roofs is proportional to the mass per unit area; this permits easy interpolation.

Uses of Tables 21 and 22 —Equivalent Temperature Difference for Sunlit and Shaded Walls and Roofs

The equivalent temperature differences in *Tables 21* and *22* are multiplied by the transmission coefficients listed in *Tables 24, 25, 30* and *32* to determine the heat gain through walls and roofs per unit area during the summer. The total mass per unit area of walls and roofs is obtained by adding the mass per unit area of each component of a given structure. Figures for mass per unit area are shown in brackets in *Tables 24, 25, 30* and *32.* Where the total mass per unit area exceeds that shown in *Tables 21* and *22,* determine the equivalent temperature difference on the basis of the highest mass per unit area shown in these tables.

Example 1—Equivalent Temperature Difference, Roof

Given:

A bituminous roof exposed to the sun, with 150 mm concrete and 25 mm sand and cement topping. The suspended ceiling is 12 mm hardwood with 50 mm mineral fibre insulation.
Room design temperature = 25°C DB
Outdoor design temperature = 35°C DB
Daily range = 10°C

Find:

Equivalent temperature difference at 4 p.m. January, 40° South latitude.

Solution:

Mass per unit area = 437 + 11 + 3 = 451 kg/m² (*Table 30*)
Equivalent temperature difference
= 20°C (*Table 22*)

Example 2—Daily Range and Design Temperature Difference Correction

At times the daily range may be more or less than 10°C the difference between outdoor and room design temperatures may be more or less than 10°C. The corrections to be applied to the equivalent temperature difference for combinations of these two variables are listed in the notes following *Table 23.*

Given:

The same roof as in *Example 1*
Room design temperature = 21°C DB*
Outdoor design temperature = 36°C DB
Daily range = 16°C

Find:

Equivalent temperature difference under changed conditions

Solution:

Design temperature difference = 15°C
Daily range = 16°C

*If radiant surfaces are present, the 'revised' room design temperature is to be used. (See *Chapter 2*)

Correction to equivalent temperature difference
= 2°C (*Table 23*)
Equivalent temperature difference = 20 + 2 = 22°C

Example 3—Other Months and Latitudes

Occasionally the heat gain through a wall or roof must be known for months and latitudes other than those listed in *Note 3* following *Table 23.* This equivalent temperature difference is determined from the equation in *Note 3.* This equation adjusts the equivalent temperature difference for solar radiation only. Additional correction may have to be made for differences between outdoor and indoor design temperatures other than 10°C. Refer to *Tables 21 and 22,* and to the correction *Table 23.* Corrections for these differences must be made first; then the corrected equivalent temperature differences for both sun and shade must be applied in corrections for latitude.

Given:

2 × 90 mm dark red clay brick wall facing west, with 60 mm air gap and 15 mm gypsum plaster finish, located in Canberra (35° South latitude).

Find:

Equivalent temperature difference in May at 12 noon.

Solution:

The correction for design temperature is as follows:
Summer outside design dry-bulb in Canberra (comfort installations) = 34.0°C DB (*Table 1*).
Winter outside design dry-bulb in Canberra (comfort installations) = 0.5°C DB (*Table 1*).
Yearly range: 34.0 − 0.5 = 33.5°C.
Correction in outdoor design temperature for May and a yearly range of 33.5°C = 6.7°C approx. (*Table 3* interpolated).
Outdoor design temperature in May at 3 p.m.
= 34.0 − 6.7 = 27.3°C.
With a 21°C DB room design, the outdoor to indoor difference is 27.3 − 21.0 = 6.3°C.
Average daily range in Canberra = 15°C (*Table 1*).
The difference between outdoor design for May at 3 p.m. and room temperature of 6.3°C and the daily range of 15°C results in a −6.2°C addition to the equivalent temperature difference, by interpolation in *Table 23.*
Equivalent temperature differences for 2 × 90 mm dark red clay brick wall facing west with 60 mm air gap and 15 mm gypsum plaster finish (367 kg/m²; *Table 24*) for 12 noon May at 40° South latitude:

(*a*) Δt_{em} for west wall in sun = 4.8 (*Table 21* interpolated) −6.2 = −1.4°C
(*b*) Δt_{es} for west wall in shade = 2.2 (*Table 21* interpolated) −6.2 = −4.0°C

The correction for different solar intensity is

$$\Delta t_e = \Delta t_{es} + \frac{\sigma_s}{\sigma_m}(\Delta t_{em} - \Delta t_{es})$$

$= -4.0$°C as corrected (*Tables 21* and *23*)
$= -1.4$°C as corrected (*Tables 21* and *23*)
σ_s = (370 + 320)/2 = 345 W/m² sash area. (*Table 14* for 35° South from *Tables* for 30° and 40° South, May, west wall).
σ_m = 550 W/m² sash area (*Table 14*, 40° South, January, west wall)

$$= -4.0 + \frac{345}{550}[-1.4 - (-4.0)]$$

$= -2.4$°C (Canberra, 12 noon, west wall).

TABLE 21—EQUIVALENT TEMPERATURE DIFFERENCE (°C)

FOR DARK COLOURED†, SUNLIT AND SHADED WALLS*

Based on Dark Coloured Walls, 35°C DB Outdoor Design Temp.; Constant 25°C DB Room Temp.; 10°C, Daily Range; 24-Hour Operation; January and 40° South Latitude†

Exposure	Mass of wall per unit area ‡ kg/m²	SUN TIME																							
		AM							PM												AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
North	100	1.7	1.1	0.0	2.8	4.4	10.0	14.4	17.2	18.9	17.8	16.7	13.3	11.1	8.9	7.8	6.1	5.6	3.9	3.3	2.8	2.8	2.2	2.2	1.7
	300	1.7	0.6	0.0	0.6	1.1	6.1	8.9	13.3	15.6	16.1	16.7	15.0	13.3	10.6	8.9	7.8	6.7	5.6	4.4	3.3	2.8	2.8	2.2	1.7
	500	4.4	4.4	3.3	3.3	3.3	3.9	4.4	6.7	8.9	10.6	11.1	12.2	12.2	10.6	10.0	8.3	7.8	7.2	6.7	6.7	6.1	5.6	5.6	5.0
	700	6.1	5.6	5.6	5.0	4.4	4.4	4.4	4.4	4.4	6.1	7.8	9.4	10.0	10.6	11.1	11.1	10.0	8.9	7.8	7.8	7.2	7.2	6.7	6.1
Northeast	100	7.8	5.6	9.4	12.8	16.7	17.2	17.8	16.7	15.6	12.8	11.1	10.6	10.0	8.9	7.8	6.7	5.6	4.4	3.3	2.2	1.7	1.7	1.1	1.1
	300	2.8	2.8	2.2	9.4	13.3	15.6	17.8	16.7	16.1	13.9	12.2	10.6	10.0	9.4	8.9	8.3	7.8	6.7	5.6	5.0	4.4	3.9	3.9	3.3
	500	6.1	6.1	5.6	5.6	5.6	8.3	11.1	11.7	12.2	12.8	12.2	11.1	10.0	9.4	8.9	8.3	7.8	7.8	7.8	7.2	7.2	6.7	6.7	6.1
	700	7.2	6.7	6.7	6.7	6.7	6.1	5.6	8.3	10.0	10.6	11.1	12.2	11.1	10.6	10.0	9.4	8.9	8.9	8.9	8.3	8.3	7.8	7.8	7.2
East	100	2.8	11.7	18.9	20.6	22.2	21.7	20.0	13.3	8.9	9.4	10.0	10.0	10.0	8.9	7.8	6.7	5.6	4.4	3.3	2.2	1.7	1.1	0.6	0.6
	300	1.7	1.7	2.2	13.9	18.9	19.4	19.4	12.8	10.0	9.4	8.9	9.4	10.0	9.4	8.9	8.3	7.8	6.7	5.0	4.4	3.9	2.8	2.8	2.2
	500	5.0	5.0	5.6	6.7	10.0	13.3	15.6	16.1	15.6	13.3	12.2	11.1	10.0	10.0	10.0	9.4	8.9	8.3	7.8	7.2	6.7	6.1	6.1	5.6
	700	8.3	7.8	7.8	7.2	6.7	7.2	7.8	10.6	12.2	12.8	12.2	11.7	11.1	10.0	8.9	9.4	10.0	10.0	10.0	9.4	9.4	8.9	8.9	8.9
Southeast	100	5.0	10.6	14.4	15.0	15.6	12.8	10.0	9.4	8.9	9.4	10.0	10.0	10.0	8.9	7.8	6.7	5.6	4.4	3.3	2.2	1.1	0.6	0.0	1.1
	300	1.7	1.1	1.1	5.0	15.6	14.4	13.3	10.6	7.8	8.3	8.9	9.4	10.0	9.4	8.9	8.3	7.8	6.7	5.6	4.4	3.3	2.8	2.2	1.7
	500	4.4	3.9	4.4	4.4	4.4	7.8	11.1	10.6	10.0	8.9	7.8	8.3	8.9	8.9	8.9	8.3	7.8	7.2	6.7	6.1	5.6	5.6	5.0	5.0
	700	5.0	5.0	5.6	5.6	5.6	5.6	5.6	7.8	10.0	11.1	10.0	8.9	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.2	7.2	6.7	6.1	6.1
Southwest	100	0.6	0.0	0.0	1.1	2.2	3.9	5.6	7.8	8.9	12.8	15.6	20.6	24.4	22.8	21.1	12.2	5.6	4.4	3.3	2.2	1.7	1.7	1.1	1.1
	300	1.1	0.6	0.0	0.6	1.1	2.2	3.3	5.6	6.7	7.8	8.9	13.9	18.9	19.4	20.0	13.9	8.9	6.7	5.6	4.4	3.9	2.8	2.2	1.7
	500	5.0	4.4	4.4	4.4	4.4	4.4	4.4	4.4	4.4	5.0	5.6	7.2	8.9	11.7	13.3	13.9	14.4	10.0	6.7	6.1	6.1	5.6	5.6	5.0
	700	6.7	6.1	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	6.1	6.7	7.2	7.8	10.0	12.2	12.8	13.3	11.1	9.4	8.3	7.8	7.2
West	100	1.1	0.6	0.0	1.1	2.2	3.9	5.6	10.0	13.3	20.0	24.4	27.2	28.9	21.1	14.4	10.0	6.7	5.0	3.3	2.8	2.2	2.2	1.7	1.7
	300	3.3	2.8	2.2	2.2	2.2	3.3	4.4	6.1	7.8	12.8	16.7	21.1	24.4	25.0	22.2	17.8	11.1	7.8	5.6	5.0	4.4	3.9	3.9	3.3
	500	6.1	6.1	5.6	5.6	5.6	5.6	5.6	6.1	6.7	7.8	8.9	11.7	13.3	16.1	17.8	17.2	16.7	12.8	10.0	8.9	8.3	7.8	7.2	6.7
	700	8.9	8.3	7.8	7.2	6.7	6.7	6.7	7.2	7.8	7.8	7.8	8.3	8.9	10.0	11.1	13.9	14.4	15.0	14.4	13.3	12.2	11.1	10.6	9.4
Northwest	100	1.1	0.0	0.0	1.1	2.2	4.4	5.6	12.8	16.7	21.1	24.4	25.0	25.6	18.9	15.6	8.9	5.6	4.4	3.3	2.8	2.8	2.2	1.7	1.7
	300	3.3	2.8	2.2	2.2	2.2	2.8	3.3	6.7	8.9	15.6	20.0	21.7	22.2	21.7	21.1	13.3	7.8	6.1	5.6	5.0	4.4	4.4	3.9	3.9
	500	6.1	5.0	5.6	5.0	4.4	5.0	5.6	6.1	6.7	8.9	10.0	12.8	14.4	15.0	15.6	15.0	14.4	10.6	7.8	7.8	7.2	7.2	6.7	6.1
	700	6.7	6.7	6.7	6.7	6.7	6.1	5.6	5.6	5.6	6.1	6.7	7.2	7.8	10.6	12.2	12.8	13.3	9.4	6.7	6.7	6.7	6.7	6.7	6.7
South (Shade)	100	0.6	0.6	0.0	0.6	1.1	2.8	4.4	6.7	7.8	8.9	10.0	9.4	8.9	7.8	6.7	5.6	4.4	3.3	2.2	2.2	1.7	1.7	1.1	1.1
	300	0.6	0.6	0.0	0.6	1.1	1.7	2.2	3.9	5.6	6.7	7.8	8.3	8.9	8.9	8.9	7.8	6.7	5.6	4.4	3.3	2.8	2.2	1.7	1.1
	500	2.8	2.8	2.2	2.2	2.2	2.2	2.2	2.8	3.3	3.9	4.4	5.0	5.0	5.0	6.7	6.1	5.6	5.0	4.4	3.9	3.9	3.3	3.3	2.8
	700	2.8	2.8	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.8	3.3	3.9	4.4	5.0	5.6	6.1	6.7	6.1	5.6	4.4	3.9	3.3	3.3	2.8

Equation: Heat Gain through Walls, $W =$ (Area, m²) × (Equivalent temperature difference) × (Transmission coefficient U, *Tables 24* and *25*).

*All values are for both insulated and uninsulated walls.

†For other conditions refer to corrections listed after *Table 23*.

‡'Mass per unit area' values for common types of construction are listed in *Tables 24* and *25*.
For wall constructions less than 100 kg/m², use listed values of 100 kg/m², for wall constructions more than 700 kg/m², use listed values of 700 kg/m².

TABLE 22—EQUIVALENT TEMPERATURE DIFFERENCE (°C)

FOR DARK COLOURED†, SUNLIT AND SHADED ROOFS*

Based on 35°C DB Outdoor Design Temp.; Constant 25°C DB Room Temp.; 10°C Daily Range; 24-Hour Operation; January and 40° South Latitude†

Condition	Mass of roof per unit area kg/m² ‡	SUN TIME																							
		AM							PM													AM				
		6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Exposed to Sun	50	0.0	−1.1	−1.7	−0.6	1.7	6.1	10.6	15.6	20.0	23.3	26.1	27.8	27.2	25.0	21.7	17.8	14.4	11.1	7.8	6.1	3.9	2.8	1.7	0.6
	100	2.2	1.7	1.1	1.7	3.3	7.2	11.1	15.0	18.9	22.2	25.0	26.1	26.1	24.4	21.7	18.9	16.1	13.3	10.6	8.9	6.7	5.6	4.4	3.3
	200	4.4	3.9	3.3	3.9	5.6	7.8	11.1	15.0	17.8	20.6	23.3	24.4	25.0	23.9	21.7	20.0	17.8	15.6	13.3	11.7	9.4	8.3	7.2	5.6
	300	7.2	6.7	5.6	6.1	6.7	8.3	11.1	14.4	17.2	19.4	21.7	23.3	23.9	23.3	22.2	21.1	19.4	17.8	16.1	14.4	12.2	11.1	9.4	8.3
	400	9.4	8.9	8.3	8.3	8.9	9.4	11.1	14.4	16.7	17.8	20.0	21.7	22.8	22.8	21.7	21.1	21.1	20.0	18.9	17.2	15.0	13.3	12.2	10.0
Covered with Water	100	−0.6	1.1	2.2	3.3	4.4	7.8	11.1	12.8	14.4	13.3	12.2	11.1	10.0	8.9	7.8	5.6	3.3	2.8	2.8	1.7	1.1	0.6	0.0	−0.6
	200	0.6	1.1	1.7	1.7	2.2	5.0	7.8	9.4	10.6	10.6	11.1	10.6	10.6	10.0	8.9	7.8	6.1	5.0	3.9	2.8	1.7	1.1	0.6	0.6
	300	1.7	1.1	1.1	1.1	1.1	3.3	5.0	6.1	7.8	8.9	10.0	10.6	11.1	10.6	10.0	8.9	7.8	6.7	5.6	4.4	3.9	3.3	2.8	2.2
Sprayed	100	0.0	1.1	2.2	3.3	4.4	6.7	8.9	10.6	12.2	11.7	11.1	10.6	10.0	8.9	7.8	5.6	3.3	2.8	2.2	1.7	1.1	1.1	0.6	0.6
	200	1.1	1.1	1.7	1.7	2.2	3.3	5.0	7.2	9.4	10.0	10.0	10.0	10.0	9.4	8.9	7.2	6.1	5.0	3.9	2.8	2.2	2.2	1.7	1.7
	300	1.7	1.1	1.1	1.1	1.1	2.2	3.3	5.0	6.7	7.8	8.9	9.4	10.0	9.4	8.9	8.3	7.8	6.7	5.6	4.4	3.3	2.8	2.2	1.7
Shaded	100	−0.6	−0.6	0.0	1.1	2.2	3.3	5.6	7.2	8.9	9.4	10.0	9.4	8.9	7.8	6.7	5.0	3.3	2.8	2.2	1.7	0.6	0.0	−0.6	−0.6
	200	−0.6	−0.6	0.0	0.6	1.1	2.2	3.3	5.0	6.7	7.8	8.9	9.4	8.9	8.3	7.8	6.7	5.6	4.4	3.3	2.2	1.7	0.6	0.0	−0.6
	300	0.6	0.6	1.1	1.1	1.1	1.7	2.2	3.3	4.4	5.6	6.7	7.2	7.8	7.8	7.8	7.2	6.7	5.6	4.4	3.3	2.8	2.2	1.7	1.1

Equation: Heat Gain through Walls, $W =$ (Area, m²) × (Equivalent temperature difference) × (Transmission coefficient U, *Tables 30* and *32*).
*With attic ventilated and ceiling insulated roofs, reduce equivalent temperature difference 25%.
For peaked roofs, use the roof area projected on a horizontal plane.
†For other conditions, refer to corrections listed immediately following *Table 23*.
‡*'Mass per unit area' values for common types of construction are listed in Tables 30* and *32*.

TABLE 23—CORRECTIONS TO EQUIVALENT TEMPERATURES (°C)

Outdoor Design For Month at 3 PM Minus Room Temp. (°C)	Daily Range (°C)									
	2	4	6	8	10	12	14	16	18	20
−15	−21	−22	−23	−24	−25	−26	−27	−28	−29	−30
−10	−16	−17	−18	−19	−20	−21	−22	−23	−24	−25
−5	−11	−12	−13	−14	−15	−16	−17	−18	−19	−20
0	−6	−7	−8	−9	−10	−11	−12	−13	−14	−15
5	−1	−2	−3	−4	−5	−6	−7	−8	−9	−10
10	4	3	2	1	0	−1	−2	−3	−4	−5
15	9	8	7	6	5	4	3	2	1	0
20	14	13	12	11	10	9	8	7	6	5
25	19	18	17	16	15	14	13	12	11	10

Corrections to Equivalent Temperature Differences in Tables 21 and 22 for Conditions Other Than Basis of Table

1. Outdoor Design Temperature Minus Room Temperature (or 'revised' room temperature if radiant surfaces are present; see *Chapter 2*) *Greater or Less* Than 10°C DB, and/or Daily Range *Greater or Less* Than 10°C DB.
   Add the corrections listed in *Table 23;* where the outdoor design temperature (*Table 1*), minus the room or indoor design temperature (*Chapter 2*) is different from 10°C DB or the daily range is different from the 10°C DB on which *Tables 21* and *22* are based.
   This correction is to be applied to both equivalent temperature difference values, exposed to sun and shaded walls or roof.

2. Shaded walls
   For shaded walls on any exposure, use the values of equivalent temperature difference listed for south (shade), corrected if necessary as shown in Correction 1.

3. Latitudes other than 40° South and for other months with different solar intensities. *Tables 21* and *22* values are approximately correct for the east or west wall in any latitude during the hottest weather. In lower latitudes when the maximum solar altitude is 80° to 90° (the maximum occurs at noon), the temperature difference for either south or north wall is approximately the same as a south or shade wall. See *Table 20* for solar altitude angles.
   The temperature differential Δt_e for any wall facing or roof and for any latitude for any month is approximated as follows:

$$\Delta t_e = \Delta t_{es} + \frac{\sigma_s}{\sigma_m}(\Delta t_{em} - \Delta t_{es}) = \frac{\sigma_s}{\sigma_m}\Delta t_{em} + (1 - \frac{\sigma_s}{\sigma_m})\Delta t_{es}$$

where

Δt_e = equivalent temperature difference for latitude, month and time of day desired.

Δt_{es} = equivalent temperature difference for same wall or roof in shade at 40° South and at desired time of day, corrected if necessary for design conditions.

Δt_{em} = equivalent temperature difference for wall or roof exposed to the sun at 40° South and for desired time of day, corrected if necessary for design conditions.

σ_s = maximum solar heat gain in W/m² through glass for wall facing or horizontal for roofs, for month and latitude desired, *Table 14*, or *Table 5.*

σ_m = maximum solar heat gain in W/m² through glass for wall facing or horizontal for roofs, for January at 40° South latitude, *Table 14*, or *Table 5.*

Example 3 illustrates the procedure.

4. Light or medium colour wall or roof
   Light colour wall or roof:

$$\Delta t_e = \Delta t_{es} + \frac{0.50}{0.90}(\Delta t_{em} - \Delta t_{es}) = 0.55\ \Delta t_{em} + 0.45\ \Delta t_{es}$$

Medium colour wall or roof:

$$\Delta t_e = \Delta t_{es} + \frac{0.70}{0.90}(\Delta t_{em} - \Delta t_{es}) = 0.78\ \Delta t_{em} + 0.22\ \Delta t_{es}$$

where:

Δt_e = equivalent temperature difference for colour of wall or roof desired.

Δt_{es} = equivalent temperature difference for same wall or roof in shade at desired time of day, corrected if necessary for design conditions.

Δt_{em} = equivalent temperature difference for wall or roof exposed to the sun for the desired time of day, corrected if necessary for design conditions.

Note:
Light colour = white, cream, etc.
Medium colour = light green, light blue, grey, etc.
Dark colour = dark blue, dark red, dark brown, etc.

5. Other latitude, other month, light or medium colour walls or roof.
   The combined formulae are:
   Light colour walls or roof

$$\Delta t_e = 0.55\frac{\sigma_s}{\sigma_m}\Delta t_{em} + (1 - 0.55\frac{\sigma_s}{\sigma_m})\Delta t_{es}$$

Medium colour walls or roof.

$$\Delta t_e = 0.78\frac{\sigma_s}{\sigma_m}\Delta t_{em} + (1 - 0.78\frac{\sigma_s}{\sigma_m})\Delta t_{es}$$

TRANSMISSION COEFFICIENT *U*

Transmission coefficient or *U* value is the rate at which heat is transferred through a building structure in watts per square metre degrees Celsius temperature difference. The rate times the temperature difference is the heat flow through the structure. The reciprocal of the *U* value for any wall is the total resistance of this wall to the flow of heat. The total resistance of any wall to heat flow is the summation of the resistance in each component of the structure and the resistances of the outdoor and inside surface films. The transmission coefficients listed in *Tables 24* to *36* have been calculated for the most common types of construction.

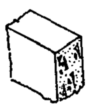
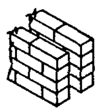
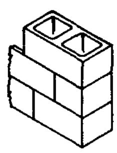
Basis of Tables 24 to 36 —Transmission Coefficients *U* for Walls, Roofs, Partitions, Ceilings, Floors, Doors, and Windows

Tables 24 to *36* contain calculated *U* values based on the resistance listed in *Table 37*. The resistance of the outdoor surface film coefficient for summer and winter conditions and the inside surface film is also listed in *Table 37*.

Use of Tables 24 to 36 —Transmission Coefficients *U* for Walls, Roofs, Partitions, Ceilings, Floors, Doors, and Windows

The transmission coefficients may be used for calculating the heat flow for both summer and winter conditions.

TABLE 24—TRANSMISSION COEFFICIENT U-MASONRY WALLS
Watts per square metre degree Celsius

CONSTRUCTION				INTERIOR FINISH	
Description		Thickness mm‡	Mass per Unit Area kg/m²‡	None	15 mm Gypsum Plaster (21)
 Concrete: Crushed Rock Aggregate	W*	100	240	4.59	4.15
1 part cement	S†	100	240	4.29	3.91
2 parts fine	W	150	360	3.95	3.61
4 parts coarse	S	150	360	3.73	3.42
Density = 2400 kg/m³	W	300	720	2.80	2.63
	S	300	720	2.69	2.53
Clinker Aggregate	W	100	152	2.22	2.12
1 part cement	S	100	152	2.16	2.05
2½ parts fine	W	150	228	1.67	1.61
7 parts coarse	S	150	228	1.63	1.57
	W	300	457	0.953	0.933
Density = 1522 kg/m³	S	300	457	0.940	0.920
Claybrick 2 × 90 mm brick 60 mm air gap	W	240	346	2.12	2.02
	S	240	346	2.11	2.01
 Claybrick: 2 × 110 mm brick 50 mm air gap	W	270	423	1.97	1.88
	S	270	423	1.96	1.88
 Concrete Block: Lightweight Aggregate: (clay, slate or slag, pumice)	W	90	100	2.55	2.41
	S	90	100	2.46	2.33
	W	140	123	2.20	2.09
	S	140	123	2.12	2.03
	W	190	150	2.03	1.93
	S	190	150	1.96	1.88
Sand and gravel aggregate	W	90	153	3.82	3.51
	S	90	153	3.61	3.33
	W	140	189	3.31	3.08
	S	140	189	3.15	2.94
	W	190	230	2.98	2.78
	S	190	230	2.85	2.67

*Assumed still air inside, and wind speed of 7 m/s outside during winter.
†Assumed still air inside, and wind speed of 3.5 m/s outside during summer.
‡Values quoted are for the basic construction, and do not take into account variations due to the different finishes. The contribution of the finishes is given at the top of the appropriate column. The mass per unit area is in brackets.
Equations: Heat gain W = (Area m²) × (*U*-Value) × (Equivalent temperature difference, *Table* 21)
Heat loss W = (Area m²) × (*U*-Value) × (Indoor temperature − outdoor temperature)

Example 4—Transmission Coefficients

Given:

Brick veneer wall (110 mm brick, 150 mm air) with 9 mm fibrous plaster finish.

Find:

Transmission coefficient, summer and winter.

Solution:

Transmission coefficient U

$= 2.12\ W/m^2.°C \ldots$ summer } *Table 25*
$ 2.19\ W/m^2.°C \ldots$ winter }

Example 5—Transmission Coefficient, Addition of Insulation

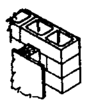
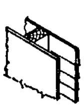
Where fibrous insulation or reflective insulation is not included in the transmission coefficients listed in *Tables 24* to *34*, the transmission coefficient for the typical constructions listed in these tables, with insulation, may be determined from *Table 35.*

Given:

Brick veneer wall (110 mm brick, 150 mm air) with 75 mm fibrous insulation in the air space. Internal finish is 9 mm fibrous plaster.

TABLE 25—TRANSMISSION COEFFICIENT U-VENEER WALLS

Watts per square metre degree Celsius

CONSTRUCTION				INTERIOR FINISH			
Description		Thickness mm‡	Mass per Unit Area kg/m²‡	Fibrous Plaster 9 mm (9.9)	Plaster-board 12 mm (11)	Hard-board 6 mm (16)	Vinyl Clad Steel (4.7)
 Brick Veneer 90 mm brick, with 150 mm air gap	W* S†	240 240	184 184	2.28 2.20	2.09 2.03	1.90 1.84	— —
110 mm brick with 150 mm air gap	W S	260 260	222 222	2.19 2.12	2.02 1.96	1.82 1.77	— —
 Lightweight Concrete Block Veneer 90 mm block, with 150 mm air gap	W S	240 240	111 111	1.66 1.62	1.56 1.52	1.45 1.41	— —
140 mm block, with 150 mm air gap	W S	290 290	134 134	1.50 1.47	1.42 1.39	1.33 1.30	— —
Sand & Gravel Aggregate Concrete Block Veneer 90 mm block, with 150 mm air gap	W S	240 240	164 164	2.11 2.04	1.95 1.90	1.78 1.73	— —
140 mm block, with 150 mm air gap	W S	290 290	200 200	1.95 1.89	1.81 1.76	1.66 1.62	— —
 Weatherboard outside, with timber framing, 100 mm air gap	W S	125 125	35 35	2.13 2.06	1.97 1.90	1.75 1.72	2.30 2.22
As above with 75 mm of mineral fibre & 25 mm air gap	W S	125 125	40 40	0.523 0.520	0.514 0.510	0.502 0.490	0.535 0.532
 Metal clad outside with timber framing 100 mm air gap	W S	124 124	9.4 9.4	2.60 2.48	2.36 2.30	2.09 2.02	2.86 2.74
As above with 75 mm of mineral fibre and 25 mm air gap	W S	124 124	14 14	0.549 0.546	0.540 0.536	0.520 0.518	0.558 0.553

*Assumed still air inside, and wind speed of 7 m/s outside during winter.

†Assumed still air inside, and wind speed of 3.5 m/s outside during summer.

‡Values quoted are for the basic construction, and do not take into account variations due to the different interior finishes. The contribution of the interior finishes is given at the top of the appropriate column. The mass per unit area is in brackets.

Equations: Heat gain W = (Area m²) × (U-Value) × (Equivalent temperature difference, *Table 21*)
Heat loss W = (Area m²) × (U-Value) × (Indoor Temperature—outdoor temperature)

Find:
Transmission coefficient, for winter.

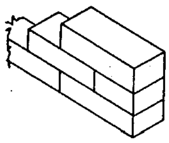
Solution:
Refer to *Tables 25* and *35*

U value for wall without insulation
$= 2.19$ W/m².°C

U value for wall with insulation
$= 0.43$ W/m².°C

TABLE 26—TRANSMISSION COEFFICIENT U—PARTITION SYSTEMS

Watts per square metre degree Celsius. Still air assumed on both sides of the partitions

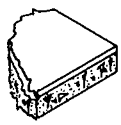
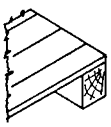
CONSTRUCTION			INTERIOR FINISH				
Description	Thickness mm*	Mass per Unit Area* kg/m²	None	15 mm Gypsum Plaster (21)	12 mm Plaster Board (11)	6 mm Hard-Board (16)	12 mm Hard-Wood (11)
 100 mm air	100	11			1.78	1.51	1.70
50 mm air, 50 mm glass wool	100	14			0.560	0.530	0.550
100 mm glass wool	100	18			0.347	0.336	0.344
Aluminium Foil on one inner surface, and 100 mm of air	100	11			1.27	1.12	1.22
Terracotta Brick 	100	101	2.27	2.06			

*Values quoted are for the studs and for the terracotta bricks. The contribution of the finishes is given at the top of the appropriate column. The mass per unit area is in brackets.
Equations: Heat gain W = (Area m²) × (U-Value) × 0.5 (Outdoor temperature—indoor temperature)‡
Heat loss W = (Area m²) × (U-Value) × 0.5 (Indoor temperature—outdoor temperature)‡
‡It is assumed that the temperature of the unconditioned space adjacent to the partition is midway between the outside temperature and the temperature inside the conditioned space.

TABLE 27—TRANSMISSION COEFFICIENT U—SUSPENDED FLOORS

HEAT FLOW UP

Watts per square metre degree Celsius. Still air is assumed on both sides

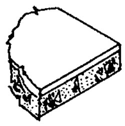
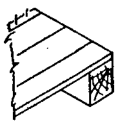
CONSTRUCTION			INTERIOR FINISH		
Description	Thickness mm*	Mass per Unit Area kg/m²*	None	Vinyl Tiles 3 mm (5)	Carpet and Underlay (11)
 Concrete: 100 mm + 25 mm sand and cement topping	125	287	3.14	3.07	1.38
150 mm + 25 mm topping	175	407	2.84	2.78	1.32
300 mm + 25 mm topping	325	767	2.18	2.15	1.16
 22 mm Timber floor†	122	32	2.65	2.60	1.28
25 mm Chipboard	125	28	2.54	2.49	1.25
22 mm Timber floor plus Alfoil with 100 mm air gap	122	32	1.42	1.40	0.900
25 mm Chipboard plus Alfoil with 100 mm air gap	125	28	1.38	1.37	0.887

*Values quoted are for the basic construction and do not take into account variations due to the different finishes. The contribution of the finishes is given at the top of the appropriate column. The mass per unit area is in brackets.
†1120 kg/m³ has been assumed for timber bearers; 950 kg/m³ has been assumed for floor boards.
Equation: Heat gain W = (Area m²) × (U-Value) × 0.5 (Outdoor temperature—indoor temperature)‡
‡It is assumed that the temperature of the unconditioned space on the underside of the floor is midway between the outside temperature and the temperature inside the conditioned space.

TABLE 28—TRANSMISSION COEFFICIENT U—SUSPENDED FLOORS

HEAT FLOW DOWN

Watts per square metre degree Celsius. Still air assumed on both sides

CONSTRUCTION			INTERIOR FINISH		
Description	Thickness mm*	Mass per Unit Area kg/m² *	None	Vinyl Tiles 3 mm (5)	Carpet and Underlay (11)
 Concrete:					
100 mm + 25 mm sand and cement topping	125	287	2.40	2.35	1.22
150 mm + 25 mm topping	175	407	2.21	2.17	1.17
300 mm + 25 mm topping	325	767	1.80	1.77	1.04
 22 mm Timber floor†	122	32	2.10	2.06	1.13
25 mm Chipboard	125	28	2.02	1.99	1.11
22 mm Timber floor plus Alfoil with 100 mm air gap	122	32	0.845	0.840	0.630
25 mm Chipboard plus Alfoil with 100 mm air gap	125	28	0.833	0.828	0.623

*Values quoted are for the basic construction, and do not take into account variations due to the different finishes. The contribution of the finishes is given at the top of the appropriate column. The mass per unit area is in brackets.

†1120 kg/m³ has been assumed for timber bearers; 950 kg/m³ has been assumed for floor boards.

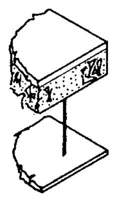
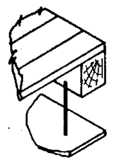
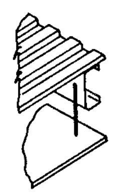
Equation: Heat loss W = (Area m²) × (U-Value) × 0.5 (Indoor temperature—outdoor temperature)‡

‡It is assumed that the temperature of the unconditioned space on the underside of the floor is midway between the outside temperature and the temperature inside the conditioned space.

TABLE 29—TRANSMISSION COEFFICIENT U—CEILING ROOF SYSTEMS

HEAT FLOW UP

Watts per square metre degree Celsius. Assumed still air on the inside and 7.0 m/s wind on the outside

CONSTRUCTION*		INTERIOR FINISH							
Description	Mass per Unit Area kg/m² §	12 mm Hardwood (11) Insulation: None	12 mm Hardwood (11) Insulation: Mineral Fibre 50 mm (3)	12 mm Hardwood (11) Insulation: Mineral Fibre 100 mm (6)	Plaster Tiles† 12 mm (24) ‖	Metal Pans‡ (18) ‖	Stramit Board‡ 50 mm (24) ‖	Glass Fibre Tiles‡ (11) ‖
 Bituminous Felt roof, with 100 mm of concrete & 25 mm of sand & cement topping	317	1.97	0.566	0.333	2.03	1.39	1.37	1.75
As above with 150 mm of concrete & 25 mm of topping	437	1.85	0.558	0.329	1.90	1.32	1.31	1.65
As above with 300 mm of concrete & 25 mm of topping	797	1.55	0.527	0.318	1.59	1.16	1.15	1.41
 22 mm Hardwood decking overlaid with 12 mm of bituminous felt	62	2.02	0.582	0.353	2.08	1.41	1.39	1.78
 Metal Deck	9.4	2.56	0.620	0.367	2.67	1.65	1.63	2.20

*Values given apply to construction where there is at least 100 mm of air between the underside of the roof and the top side of the suspended ceiling.

†Values listed are for ceilings with concealed supporting grids.

‡Account has been taken of the effects of the exposed grids.

§Values listed are for the roof only and do not include the ceiling. Values for the ceiling components e.g. hardwood, mineral fibre, etc., appear in brackets at the top of the appropriate column.

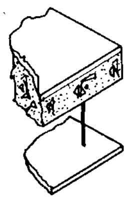
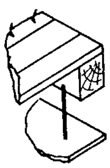
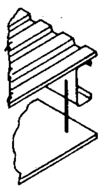
‖Mass per unit area of grid is assumed to be 8.5 kg/m².

Equation: Heat loss W = (Area m²) × (U-value) × (Indoor temperature—outdoor temperature)

TABLE 30—TRANSMISSION COEFFICIENT U—CEILING ROOF SYSTEMS

HEAT FLOW DOWN

Watts per square metre degree Celsius. Assumed still air on the inside and 3.5 m/s wind on the outside

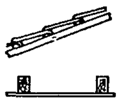
CONSTRUCTION*		INTERIOR FINISH						
Description	Mass per Unit Area kg/m² §	12 mm Hardwood (11) Insulation None	12 mm Hardwood (11) Insulation Mineral Fibre 50 mm (3)	12 mm Hardwood (11) Insulation Mineral Fibre 100 mm (6)	Plaster Tiles† 12 mm (24) ‖	Metal Pans‡ (18) ‖	Stramit Board‡ 50 mm (24) ‖	Glass Fibre Tiles (11)‡ ‖
 Bituminous Felt roof, with 100 mm of concrete & 25 mm of sand & cement topping	317	1.72	0.546	0.324	1.77	1.26	1.24	1.55
As above with 150 mm of concrete & 25 mm of topping	437	1.62	0.536	0.321	1.67	1.20	1.19	1.47
As above with 300 mm of concrete & 25 mm of topping	797	1.39	0.508	0.311	1.42	1.07	1.06	1.28
 22 mm Hardwood decking overlaid with 12 mm of bituminous felt	62	1.75	0.553	0.345	1.81	1.28	1.26	1.58
 Metal Deck	9.4	2.16	0.580	0.356	2.32	1.48	1.45	1.89

*Values given apply to construction where there is at least 100 mm of air between the underside of the roof and the top side of the suspended ceiling.
†Values listed are for ceilings with concealed supporting grids.
‡Account has been taken of the effects of the exposed grids.
§Values listed are for the roof only and do not include the ceiling. Values for the ceiling components, e.g., hardwood, mineral fibre, etc., appear in brackets at the top of the appropriate column.
‖Mass per unit area of grid is assumed to be 8.5 kg/m².
Equation: Heat gain W = (Area m²) × (U-Value) × (Equivalent temperature difference, *Table 22*).

TABLE 31—TRANSMISSION COEFFICIENT U—PITCHED ROOFS

HEAT FLOW UP

Watts per square metre degree Celsius. Assumed still air on the inside and 7.0 m/s wind on the outside

CONSTRUCTION		INTERIOR FINISH						
Description	Mass per Unit Area kg/m²*	Plasterboard 12 mm (23)‡		Hardboard 6 mm (27)‡		Caneite 18 mm (16)‡		Caneite 12 mm (14)‡
		Insulation						
		None	Mineral Fibre 100 mm (6)	None	Mineral Fibre 100 mm (6)	None	Mineral Fibre 100 mm (6)	None
 Concrete Tiles	69	2.84	0.381	2.48	0.374	1.66	0.348	2.01
Terracotta Tiles	74	2.81	0.380	2.46	0.373	1.65	0.347	1.99
Concrete Tiles and sarking†	69	1.64	0.347	1.51	0.341	1.17	0.320	1.31
Terracotta Tiles and sarking†	74	1.63	0.346	1.50	0.340	1.16	0.319	1.32

*These values are for the roof only, 15 kg/m² has been added to account for the rafters and tile battons. Values for the various ceilings appear in brackets at the top of the appropriate column.

†Sarking is assumed to be laid on top of the ceiling joists.

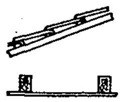
‡These values include 11 kg/m² for the ceiling joists.

Equation: Heat loss W = (Area m²) × (U-Value) × (Indoor temperature—outdoor temperature)

TABLE 32—TRANSMISSION COEFFICIENT U—PITCHED ROOFS

HEAT FLOW DOWN

Watts per square metre degree Celsius. Assumed still air on the inside and 3.5 m/s wind on the outside

CONSTRUCTION		INTERIOR FINISH						
Description	Mass per Unit Area kg/m²*	Plasterboard 12 mm (23)‡		Hardboard 6 mm (27)‡		Caneite 18 mm (16)‡		Caneite 12 mm (14)‡
		Insulation						
		None	Mineral Fibre 100 mm (6)	None	Mineral Fibre 100 mm (6)	None	Mineral Fibre 100 mm (6)	None
 Concrete Tiles	69	2.38	0.371	2.13	0.365	1.49	0.340	1.77
Terracotta Tiles	74	2.37	0.371	2.12	0.364	1.48	0.339	1.76
Concrete tiles and sarking†	69	1.04	0.309	0.989	0.305	0.825	0.287	0.903
Terracotta tiles and sarking†	74	1.04	0.309	0.987	0.305	0.823	0.287	0.901

*These values are for the roof only, 15 kg/m² has been added to account for the rafters and tile battons. Values for the various ceilings appear in brackets at the top of the appropriate column.

†Sarking is assumed to be laid on top of the ceiling joists.

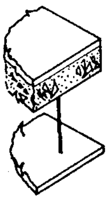
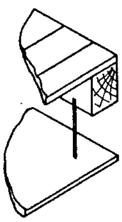
‡These values include 11 kg/m² for the ceiling joists.

Equation: Heat gain W = (Area m²) × (U-value) × (Equivalent temperature difference, *Table 22*)

TABLE 33—TRANSMISSION COEFFICIENT U—FLOOR CEILING SYSTEMS

HEAT FLOW UP

Watts per square metre degree Celsius. Still air is assumed on both sides

CONSTRUCTION*		INTERIOR FINISH						
		12 mm Hardwood						
		Insulation						
Description	Mass per Unit Area kg/m²§	None	Mineral Fibre 50 mm (3)	Mineral Fibre 100 mm (6)	Plaster Tiles 12 mm† (24)‖	Metal Pans‡ (18)‖	Stramit Board 50 mm‡ (24)‖	Glass Fibre Tiles‡ (11)‖
 Concrete Density = 2400 kg/m³								
No Floor Finish								
100 mm of concrete with 25 mm sand & cement topping.	287	1.76	0.555	0.326	1.81	1.28	1.26	1.58
As above with 150 mm of concrete.	407	1.66	0.540	0.322	1.70	1.23	1.21	1.50
As above with 300 mm of concrete.	767	1.42	0.511	0.312	1.45	1.09	1.07	1.30
3 mm Vinyl Tile Floors								
100 mm of concrete with 25 mm of sand and cement topping	292	1.73	0.547	0.326	1.78	1.26	1.25	1.56
As above with 150 mm of concrete	412	1.64	0.536	0.322	1.68	1.21	1.20	1.48
As above with 300 mm of concrete	772	1.40	0.508	0.312	1.42	1.08	1.06	1.29
Carpet and Underlay Floors								
100 mm of concrete with 25 mm sand and cement topping	298	1.03	0.448	0.288	1.05	0.843	0.835	0.964
As above with 150 mm of concrete	418	0.994	0.444	0.284	1.01	0.818	0.811	0.933
As above with 300 mm of concrete	778	0.898	0.422	0.276	0.915	0.754	0.748	0.850
 22 mm Hardwood Flooring Floor Finish	32	1.62	0.540	0.322	1.66	1.20	1.19	1.47
22 mm Hardwood with Vinyl Tiles	37	1.60	0.537	0.321	1.64	1.19	1.18	1.45
22 mm Hardwood with Carpet & Underlay	43	0.980	0.443	0.285	0.994	0.810	0.803	0.922

*Values given apply to construction where there is at least 100 mm of air between the underside of the roof and the top side of the suspended ceiling.

†Values listed are for ceiling with concealed supporting grids.

‡Account has been taken of the effects of the exposed grids.

‡Values listed do not take into account the effects due to the various finishes. Values for the finishes appear in brackets at the top of the appropriate column.

‖Mass per unit area of grid is assumed to be 8.5 kg/m²

Equations: Heat gain W = (Area m²) × (U-Value) × 0.5 (Outdoor temperature − indoor temperature)**

Heat loss W = (Area m²) × (U-Value) × 0.5 (Indoor temperature − outdoor temperature)††

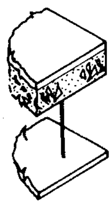
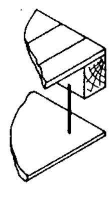
**It is assumed that the temperature of the unconditioned space adjacent to the ceiling below is midway between the outside temperature and the temperature inside the conditioned space.

††It is assumed that the temperature of the unconditioned space adjacent to the floor above is midway between the outside temperature and the temperature inside the conditioned space.

TABLE 34—TRANSMISSION COEFFICIENT U—FLOOR CEILING SYSTEMS

HEAT FLOW DOWN

Watts per square metre degree Celsius. Still air is assumed on both sides

CONSTRUCTION*		INTERIOR FINISH						
		12 mm Hardwood Insulation						
Description	Mass per Unit Area kg/m²§	None	Mineral Fibre 50 mm (3)	Mineral Fibre 100 mm (6)	Plaster Tiles 12 mm† (24) ‖	Metal Pans‡ (18) ‖	Stramit Board 50 mm‡ (24) ‖	Glass Fibre Tiles‡ (11) ‖
 Concrete Density = 2400 kg/m³ **No Floor Finish** 100 mm of concrete with 25 mm sand & cement	287	1.48	0.52	0.315	1.51	1.12	1.11	1.35
As above with 150 mm of concrete	407	1.40	0.510	0.312	1.43	1.08	1.07	1.29
As above with 300 mm of concrete	767	1.22	0.485	0.302	1.25	0.970	0.961	1.14
3 mm Vinyl Tile Floors								
100 mm of concrete with 25 mm of sand and cement topping	292	1.46	0.516	0.314	1.49	1.11	1.10	1.33
As above with 150 mm of concrete	412	1.39	0.507	0.314	1.42	1.07	1.06	1.28
As above with 300 mm of concrete	772	1.21	0.483	0.301	1.24	0.964	0.954	1.13
Carpet and Underlay Floors								
100 mm of concrete with 25 mm sand and cement topping	298	0.923	0.429	0.279	0.937	0.771	0.765	0.871
As above with 150 mm of concrete	418	0.895	0.421	0.275	0.906	0.750	0.745	0.845
As above with 300 mm of concrete	778	0.818	0.410	0.268	0.830	0.686	0.692	0.778
 22 mm Hardwood Flooring Floor Finish	32	1.32	0.502	0.308	1.34	1.03	1.02	1.21
22 mm Hardwood with Vinyl Tiles	37	1.30	0.500	0.308	1.33	1.02	1.01	1.20
22 mm Hardwood with Carpet & Underlay	43	0.859	0.417	0.274	0.871	0.726	0.720	0.814

*Values given apply to construction where there is at least 100 mm of air between the underside of the roof and the top side of the suspended ceiling.

†Values listed are for ceilings with concealed supporting grids.

‡Account has been taken of the effects of the exposed grids.

§Values listed do not take into account the effects due to the various finishes. Values for the finishes appear in brackets at the top of the appropriate column.

‖Mass per unit area of grid is assumed to be 8.5 kg/m²

Equations: Heat gain $W =$ (Area m²) × (U-Value) × 0.5 (Outdoor temperature−indoor temperature)**

Heat loss $W =$ (Area m²) × (U-value) × 0.5 (Indoor temperature−outdoor temperature)††

**It is assumed that the temperature of the unconditioned space adjacent to the floor above is midway between the outside temperature and the temperature inside the conditioned space.

††It is assumed that the temperature of the unconditioned space adjacent to the ceiling below is midway between the outside temperature and the temperature inside the conditioned space.

TABLE 35—TRANSMISSION COEFFICIENT U—WITH INSULATION AND AIR SPACES

SUMMER AND WINTER

Watts per square metre degree Celsius

U Value Before Adding Insulation to Wall, Ceiling, Roof or Floor	Addition of Fibrous Insulation			Addition of Air Space 20 mm or more	Addition of Reflective Sheets to Air Space (Aluminium Foil Average Emissivity = 0.05)								
					Direction of Heat Flow								
	Thickness mm				Winter and Summer Horizontal			Summer Down			Winter Up		
	25	50	75		Added to one or both sides	One Sheet in Air Space	Two Sheets in Air Space	Added to one or both sides	One Sheet in Air Space	Two Sheets in Air Space	Added to one or both sides	One Sheet in Air Space	Two Sheets in Air Space
3.6	1.11	0.65	0.46	2.28	1.98	1.05	0.62	0.68	0.37	0.28	2.10	1.18	0.83
3.4	1.09	0.65	0.46	2.20	1.89	1.03	0.62	0.66	0.37	0.27	2.04	1.15	0.81
3.2	1.07	0.64	0.46	2.12	1.81	1.00	0.61	0.65	0.36	0.27	1.96	1.12	0.79
3.0	1.04	0.63	0.45	2.03	1.73	0.97	0.60	0.64	0.36	0.26	1.87	1.09	0.78
2.8	1.02	0.62	0.45	1.93	1.65	0.94	0.58	0.62	0.35	0.26	1.78	1.05	0.76
2.6	0.99	0.61	0.44	1.84	1.57	0.91	0.57	0.61	0.34	0.25	1.69	1.02	0.74
2.4	0.96	0.60	0.44	1.73	1.49	0.87	0.56	0.60	0.34	0.24	1.59	0.99	0.72
2.2	0.93	0.59	0.43	1.63	1.41	0.84	0.54	0.58	0.32	0.24	1.49	0.95	0.69
2.0	0.89	0.57	0.42	1.52	1.33	0.80	0.52	0.57	0.32	0.23	1.39	0.91	0.66
1.9	0.87	0.56	0.42	1.46	1.28	0.78	0.51	0.56	0.31	0.23	1.34	0.89	0.65
1.8	0.85	0.55	0.41	1.40	1.24	0.76	0.49	0.55	0.31	0.23	1.28	0.86	0.63
1.7	0.82	0.54	0.41	1.34	1.19	0.74	0.48	0.54	0.30	0.22	1.23	0.83	0.62
1.6	0.80	0.53	0.40	1.27	1.14	0.72	0.47	0.53	0.30	0.22	1.17	0.80	0.60
1.5	0.77	0.52	0.39	1.21	1.08	0.70	0.46	0.52	0.30	0.22	1.11	0.77	0.58
1.4	0.75	0.51	0.39	1.14	1.82	0.67	0.45	0.50	0.29	0.22	1.05	0.73	0.56
1.3	0.72	0.50	0.38	1.08	0.96	0.64	0.43	0.48	0.28	0.21	0.99	0.70	0.53
1.2	0.69	0.48	0.37	1.01	0.89	0.61	0.42	0.47	0.28	0.21	0.92	0.67	0.51
1.1	0.65	0.46	0.36	0.94	0.83	0.58	0.40	0.45	0.27	0.21	0.86	0.64	0.49
1.0	0.62	0.44	0.35	0.86	0.77	0.55	0.38	0.43	0.27	0.20	0.79	0.60	0.47
0.9	0.58	0.42	0.33	0.79	0.70	0.52	0.37	0.41	0.26	0.20	0.74	0.56	0.44
0.8	0.53	0.40	0.32	0.71	0.63	0.48	0.35	0.38	0.25	0.20	0.68	0.51	0.41
0.7	0.49	0.37	0.30	0.63	0.56	0.45	0.33	0.36	0.24	0.20	0.60	0.48	0.39
0.6	0.44	0.34	0.28	0.55	0.48	0.41	0.31	0.33	0.23	0.19	0.53	0.41	0.36
0.5	0.38	0.31	0.26	0.46	0.42	0.37	0.28	0.31	0.22	0.19	0.46	0.36	0.33

TABLE 36—TRANSMISSION COEFFICIENT U—WINDOWS, SKYLIGHTS, DOORS AND GLASS BLOCK WALLS

Watts per square metre degree Celsius temperature difference

GLASS

Air Space Thickness mm	Vertical Glass						Horizontal Glass			
	Single		Double		Triple		Single		Double	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
—	5.89	6.42					4.88	7.95		
5			3.35	3.52	2.31	2.39			2.84	3.98
10			3.15	3.29	2.10	2.16				
15			2.97	3.10	1.93	1.99				
20–100			2.89	3.01	1.88	1.93				

DOORS

Thickness of Wood mm	U-Value	
	Summer	Winter
20	3.27	3.43
30	2.65	2.75
40	2.23	2.30
50	2.01	2.07

HOLLOW GLASS BLOCK WALLS

Size	Mass per Unit Area kg/m²	U-Value	
		Summer	Winter
196×196×40 mm thick	55	3.00	3.13
196×196×100 mm thick	90	2.89	3.01
196×196×100 mm thick with fibre glass screen dividing the cavity	90	2.69	2.79
300×300×100 mm thick	90	2.79	2.90
300×300×100 mm thick with fibre glass screen dividing the cavity	90	2.57	2.67

Equations: Heat gain W = (Area m²) × (U-Value) × (Outdoor temperature—indoor temperature)
Heat loss W = (Area m²) × (U-Value) × (Indoor temperature—outdoor temperature)

CALCULATION OF TRANSMISSION COEFFICIENT *U*

For types of construction not listed in *Tables 24* to *36*, calculate the U value as follows:

1. Determine the resistance of each component of a given structure and also the inside and outdoor air surface films from *Table 37.*
2. Add these resistances together,
$$\Sigma R = R_1 + R_2 + R_3 + \ldots R_n$$
3. Take the reciprocal, $U = \dfrac{1}{\Sigma R}$

Basis of Table 37
—Thermal Resistance *R*, Building and Insulating Materials, Air Films and Air Gaps

Table 37 was extracted from the 1970 CSIRO Report R–2: 'Thermal conductivity of building materials'. Information on sources and on Australian proprietary materials were also taken from Report R–2.

The resistances for air films and air spaces were taken from the ASHRAE Handbook of Fundamentals 1972, pp. 357–360. Air film resistances are for non-reflective surfaces, and resistances for air gaps are strictly correct only for effective emissivities of 0.82, air gaps 100 mm wide, mean temperatures of 10°C and temperature differences of 15°C. They are sufficiently accurate and safe in ordinary building work even though effective emissivities may be lower, air gaps down to 18 mm and temperatures different from those quoted. However, where reliance is placed on the reflective property of the material forming the air gap (the effective emissivity of an air space lined both sides with bright aluminium foil is 0.03) such as in cool room construction, consult the ASHRAE Handbook.

Example 6—Calculation of U Value

Given:

A wall as per *Fig. 30*

Find:

Transmission coefficient in winter.

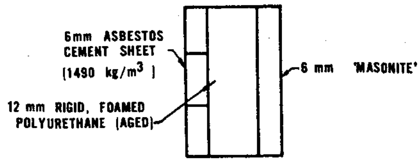


Fig. 30—Outdoor wall

Solution:
Refer to *Table 37*.

Construction	Resistance R	
1. Outdoor air surface (7 m/s)	0.03	
2. Asbestos cement sheet (6 mm, 1 490 kg/m³)	0.0189	
3. Rigid, foamed, aged Polyurethane (12 mm)	0.4895	(40.79 × 12/1000)
4. 'Masonite' (6 mm)	0.126	
5. Inside air surface (still air)	0.120	
Total resistance	0.7844	

$$U = \frac{1}{R} = \frac{1}{0.7844} = 1.27 \text{ W/m}^2.^\circ\text{C}$$

TABLE 37 THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity
Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature

Material		Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
Air Spaces (Temp. diff. 15°C)								
Position of Air Space	Direction of Heat Flow							
Horizontal	Up	—	1.2	10	100	—	0.150	1
Horizontal	Down	—	1.2	10	100	—	0.217	1
45° Slope	Up	—	1.2	10	100	—	0.155	1
45° Slope	Down	—	1.2	10	100	—	0.180	1
Vertical	Horizontal	—	1.2	10	100	—	0.166	1
Air Films (Temp. diff. 15°C)								
Still Air:								
Horizontal	Up	—	1.2	10	—	—	0.107	1
Horizontal	Down	—	1.2	10	—	—	0.162	1
45° Slope	Up	—	1.2	10	—	—	0.109	1
45° Slope	Down	—	1.2	10	—	—	0.134	1
Vertical	Horizontal	—	1.2	10	—	—	0.120	1
7 m/s wind: (Winter) any position	any direction	—	1.2	10	—	—	0.030	1
3.5 m/s wind: (Summer) any position	any direction	—	1.2	10	—	—	0.044	1
Aluminium			2675	0	1.2	4.74×10^{-3}	5.68×10^{-6}	1
Asbestos								
brick			400	499	90	10.7	0.960	2
cement board		0	945	33	6	5.42	0.0325	3
cement sheet ('fibro cement')		0	1490	29	6	3.15	0.0189	3
cement sheet ('fibro cement')			1362		6	5.0–3.0	0.03–0.018	4
cement sheet ('fibro cement')			1522		6	3.0–2.0	0.018–0.012	4
cement sheet ('fibro cement')			2002		6	2.0–1.5	0.012–0.009	4
felt, 1 lamination per mm			320	38	10	12.6	0.126	5
felt, 1 lamination per mm			320	149	10	10.4	0.104	5
felt, 1 lamination per mm			320	260	10	8.78	0.0878	5
felt, 2 laminations per mm			480	38	10	17.5	0.175	5
felt, 2 laminations per mm			480	38	10	17.3	0.173	5
felt, 2 laminations per mm			480	149	10	14.2	0.142	5
felt, 2 laminations per mm			480	260	10	11.8	0.118	5
fibre, loose		0	59.3	23	—	23.9	—	3
fibre, loose		0	28.8	23	—	21.7	—	3
millboard		0	721		22	9.25	0.203	4
millboard			1041		22	5.33	0.117	4
millboard			1041	66, 24	22	4.95	0.109	4
millboard			1041	204, 24	22	4.62	0.102	4
millboard			1041	482, 24	22	4.33	0.0954	4
Ash								
softwood			200	20	—	31.5	—	11
White			641	24	—	6.60	—	8
Asphalt			2243		—	0.82	—	7
Bark Fibre					—	19.8	—	9
eucalypt			54	0	—	22.4	—	10
redwood			48	32	—	24.8	—	10
redwood			80	32	—	6.30	—	4
Bitumen			1057		—	6.30	—	9
composition for floors			961	14	—	1.01	—	9
composition for floors			2403	26	—	2.17	—	7
emulsion, cement, aggregate			1602		—	1.65	—	7
emulsion, cement, aggregate			2002		—	0.77	—	24
pitch mastic, ordinary						1.78	—	24
pitch mastic, 8% sawdust coloured					—	1.39	—	24

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmopshere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
pitch mastic, 4.5% sawdust, coloured				—	1.28	—	24
Brick (see also **Silica Brick**)							
common	0	1762		90	1.24	0.111	4
common	6	1874		90	0.83	0.074	4
common	9	1922		90	0.70	0.063	4
common	12	1970		90	0.68	0.061	4
common	16	2034		90	0.60	0.054	4
diatomaceous (see also **Diatomaceous Earth**)		714	18	—	7.00	—	7
firebrick (see **Fireclay,** brick)							
red		1762	38	115	1.54	0.177	5
red		1762	538	115	1.02	0.117	5
red, hard burnt		2098	260	115	1.01	0.116	12
red, hard burnt		2098	816	115	0.65	0.075	12
red, soft		1762	260	115	1.65	0.190	12
red, soft		1762	816	115	1.20	0.138	12
sand-lime (calcium silicate)	0	1842		115	0.92	0.100	4
sand-lime (calcium silicate)	5	1922		115	0.63	0.073	4
Brickwork, common brick wall	3			90	0.87	0.078	4
Buckwheat, hulls		195	32	—	19.3	—	10
'Cabot's Quilt' (mat of Zostera marina between Kraft paper)		72		75	25.7	1.93	6
Cane Fibre (see **Sugar Cane** fibre)							
'Caneite' (pine fibreboard)	0	256	24	12	19.3	0.231	3
Carpet				6	19.8–15.4	0.119–0.09	36
Carpet Underlay				15	26.7–16.1	0.400–0.242	36
'Cellocol' (foamed animal glue)			32	—	27.7	—	7
Cellulose Fibre, fireproofed	0	42	21	—	28.9	—	3
Cellulose Fibre, fireproofed	0	83	20	—	23.8	—	3
Chaff, fireproofed		130	12	—	19.3	—	16
Charcoal	0	184	−4	—	19.8	—	9
from maple, beech and birch							
coarse		211	32	—	19.3	—	13
60 mesh		243	32	—	18.7	—	13
20 mesh		307	32	—	17.8	—	13
Coconut Fibre, husk		48	32	—	18.7	—	10
Coconut Fibre, husk		78	32	—	22.4	—	10
Concrete							
cellular		320		100	12.0	1.196	4
cellular		480*		100	9.25	0.925	4
cellular		641*		100	6.93	0.693	4
cellular		801*		100	4.95	0.495	4
cellular		961*		100	3.85	0.385	4
cellular		1281*		100	2.31	0.231	4
cellular		1601*		100	1.54	0.154	4
clinker aggregate, 1 : 2½ : 7	7	1522*		100	3.02	0.302	4
clinker aggregate, 1 : 2 : 4	4	1682*		100	2.48	0.248	4
clinker aggregate, 1 : 3½ : 6		1730*		100	1.31	0.131	4
coke breeze		1762	24	100	1.33	0.133	4
crushed rock, 1 : 2 : 4		2400*		100	0.69	0.069	4
expanded clay aggregate	5	801		100	3.47	0.347	4
expanded clay aggregate	5	961		100	3.30	0.330	4
expanded clay aggregate	5	1121		100	2.89	0.289	4
expanded clay aggregate	5	1281		100	2.10	0.210	4
gravel, 1 : 1 : 2		2339	30	100	1.07	0.107	9
'Haydite' aggregate		1281	24	100	3.15	0.315	17
insulating, refractory;		1041	260, 38	100	4.08	0.408	4
diatomaceous aggregate,		1041	538, 38	100	3.85	0.385	4
cement		1041	816, 38	100	3.65	0.365	4

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
insulating, refractory; refractory		1362	399, 38	100	2.24	0.224	4
aggregate, aluminous		1362	538, 38	100	2.17	0.217	4
cement, 4 : 1		1362	816, 38	100	2.04	0.204	4
no fines, clinker, 1 : 6		1313*		100	2.17	0.217	4
expanded clay, 1 : 6		1073*		100	2.89	0.289	4
slag, 1 : 8		1794*		100	1.69	0.169	35
slag, 1 : 12		1874		100	1.65	0.165	35
pumice, 1 : $2\frac{1}{2}$: $7\frac{1}{2}$	0	721		100	6.30	0.630	4
pumice, 1 : $2\frac{1}{2}$: $7\frac{1}{2}$ different	4.6	769		100	5.33	0.533	4
pumice, 1 : $2\frac{1}{2}$: $7\frac{1}{2}$ samples	8.6	929		100	3.85	0.385	4
pumice, 1 : $2\frac{1}{2}$: $7\frac{1}{2}$	30.7	1041		100	2.77	0.277	4
pumice, 1 : 2 : 4		1057		100	4.95	0.495	35
sawdust, 1 : 2	0	1057		100	3.30	0.330	4
sawdust, 1 : 2	12	1185*		100	2.67	0.267	4
sawdust, 1 : 4	0	721		100	5.78	0.578	4
sawdust, 1 : 4	9	785		100	5.14	0.514	4
slag aggregate, foamed 1 : $2\frac{1}{2}$: $7\frac{1}{2}$	0	1041		100	4.62	0.462	4
slag aggregate, foamed 1 : $2\frac{1}{2}$: $7\frac{1}{2}$	4.7	1089*		100	4.08	0.408	4
slag aggregate, foamed 1 : $2\frac{1}{2}$: $7\frac{1}{2}$	15	1249		100	3.15	0.315	4
vermiculite, 1 : 3		1121		100	2.31	0.231	35
vermiculite, 1 : 2 : 4		769		100	3.65	0.365	35
vermiculite, 1 : 3 : 6		577*		100	5.33	0.533	35
Copper, sheet		8794		1.2	2.6×10^{-3}	3.12×10^{-3}	4
Cork							
board	0	144	7	22	23.91	0.526	3
granulated, baked	5	104*		—	5.68	—	4
granulated, baked	0	104	82, 24	—	22.37	—	4
granulated, raw	7	117		—	21.67	—	4
slab, baked (density variation)	3–5	112*		12	25.68	0.308	4
slab, baked (density variation)		128		12	24.77	0.297	4
slab, baked (density variation)		144		12	23.91	0.287	4
slab, baked (density variation)		160		12	22.37	0.268	4
slab, baked (temp. variation)		128	16, −73	12	30.15	0.362	4
slab, baked (temp. variation)		128	16, −18	12	26.67	0.320	4
slab, baked (temp. variation)		128	16, −1	12	25.68	0.308	4
slab, baked (temp. variation)		128	66, 1	12	23.12	0.277	4
slab, baked (temp. variation)		128	93, 1	12	21.67	0.260	4
slab, baked, high density		264*		12	20.4	0.245	4
raw	7	160		—	20.4	—	4
raw, high density		464		—	12.61	—	4
with asphalt or bitumen binder		240		—	18.25	—	4
with asphalt or bitumen binder		641		—	6.93	—	4
with asphalt or bitumen binder		1041		—	3.47	—	4
with cement binder		280		—	13.87	—	4
with cement binder		400		—	9.91	—	4
with rubber latex binder		320		—	16.13	—	4
with rubber latex binder		801		—	7.71	—	4
Corn Stalks							
board, pitch, not ground		43	32	—	23.12	—	10
board, pitch, not ground		57.7	32	—	23.12	—	10
pulp		60.9	32	—	23.91	—	10
pulp		147	32	—	20.40	—	10
Diatomaceous Earth			38	—	18.25	—	5
Diatomaceous Earth		240–272	93	—	16.91	—	5
Diatomaceous Earth			204	—	14.45	—	5
Diatomaceous Earth			538	—	10.05	—	5
Diatomaceous Earth			816	—	8.06	—	5
brick (see also **Brick**)		513	499	115	9.25	1.063	2
brick (see also **Brick**)		721	499	115	6.94	0.794	2
brick (see also **Brick**)		801	499	115	5.14	0.591	2
Ebonite Expanded		64	16, −73	50	38.53	1.93	4
Ebonite Expanded		64	20, 0	50	33.02	1.65	4
Ebonite Expanded		64	38, 18	50	30.15	1.51	4

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
Eel Grass (Zostera marina)	0	21.1	24	—	21.67	—	3
Eel Grass (Zostera marina)	0	54.5	24	—	26.67	—	3
Felt							
hair		80		—	25.68	—	4
lightweight car body lining felt		32		—	25.68	—	4
undercarpet felt		120		—	21.67	—	4
wool		136–168		—	25.68	—	4
Fibreboard							
(see also **Wood Products**)	10–12	224		12	19.26	0.231	4
(see also **Wood Products**)	10–12	384		12	15.76	0.189	4
(see also **Wood Products**)	0	264		12	19.26	0.231	4
(see also **Wood Products**)	10	288		12	17.78	0.213	4
(see also **Wood Products**)	30	344		12	13.34	0.160	4
fireproofed	8	288		12	17.34	0.208	4
Fibreglass (see **Mineral Wool**)							
'Fibro-Cement' (see Asbestos. cement sheet)							
Fibrous Plaster (see **Gypsum**)							
Fireclay							
brick		625	499	115	5.14	0.591	2
brick		961	499	115	2.95	0.339	2
brick		1233	499	115	2.10	0.242	2
brick		1930	260	115	1.04	0.120	12
brick		1930	816	115	0.85	0.098	12
Glass							
cellular slab		144	10	50	18.25	0.913	1
cloth, woven		144	24	—	17.34	—	4
cloth, woven		480		—	17.34	—	4
cloth, woven		801		—	11.56	—	4
fibre (see **Mineral Wool**)							
sheet, window		2515		4	0.95	0.004	4
sheet, heat resisting		2243		4	0.99	0.004	4
Granite		2643		—	0.34	—	4
'Gyprock Wallboard' (Aerated gypsum core between tough millboard)		849		25	6.30	0.158	7
Gypsum							
fibrous plaster	0	1105	17	9	3.65	0.033	3
foamed plaster	0	301	−0.6	—	16.91	—	3
foamed plaster	0	301	41	—	15.76	—	3
plaster	0	1217	15	15	2.70	0.041	3
plasterboard	0	881	23	12	5.88	0.071	3
powder		320		—	15.41	—	4
'Hairinsul'							
75% hair, 25% jute		101	32	—	25.68	—	19
50% hair, 50% jute		97.7	32	—	26.67	—	19
Ice		926	−46	—	0.37	—	4
Ice		921	−18	—	0.41	—	4
Ice		918	−1	—	0.45	—	4
Jute, fibre		36.8	32	—	34.67	—	10
Jute, fibre		56	32	—	27.74	—	10
Jute, fibre		144	32	—	25.68	—	10
Jute, fibre		197	32	—	23.91	—	10
Kapok (see also **'Dry Zero'**)		1.44	32	—	15.08	—	10
Kapok (see also **'Dry Zero'**)		2.88	32	—	19.26	—	10
Kapok (see also **'Dry Zero'**)		8	10	—	26.67	—	9
Kapok (see also **'Dry Zero'**)		10.7		—	27.74	—	9
Kapok (see also **'Dry Zero'**)		12.8	11	—	30.15	—	9
Kapok (see also **'Dry Zero'**)		16	0	—	33.02	—	9
Lead, sheet		11410		1.8	0.029	5.2×10^{-5}	4
Limestone, Canadian varieties		2547	93	—	0.78	—	22
Limestone, Canadian varieties		2563	130	—	0.61	—	22

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m^3	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m^2.°C/W	Source of Info.
Limestone, Canadian varieties		2675	123	—	0.70	—	22
Linoleum, inlaid		1297	16	3	4.62	0.014	3
Magnesia Asbestos, 85%		192	93, 24	25	16.51	0.413	4
Magnesia Asbestos, 85%		192	204, 24	25	15.08	0.377	4
Magnesia Asbestos, 85%		192	316, 24	25	13.60	0.340	4
Magnesia Asbestos, 85%		192	427, 24	25	12.17	0.304	4
Magnesia Asbestos, 85%		224–240	163, 24	25	15.41	0.385	4
Magnesia Asbestos, 85%			274, 24	25	13.87	0.347	4
Magnesia Asbestos, 85%			385, 24	25	12.17		4
Magnesia Asbestos, 85%			496, 24	25	11.19	0.280	4
Magnesia Asbestos, 85%			607, 24	25	9.91	0.248	4
Magnesia Cements		336	38	—	14.45	—	5
Magnesia Cements		336	204	—	10.51	—	5
Magnesium Oxychloride (slabs of sawdust and magnesium oxychloride cement)		1273	−3	25	6.30	—	23
Maize Stalks (see **Corn Stalks**)							
Manila Hemp			32	—	20.40	—	10
Marble, various samples		2643–2804		—	0.77–0.6	—	
'Masonite' (building board from steam-exploded wood)		1'03	24	6	21.0	0.126	19
Mica, brick			499	25	6.30	—	2
Mineral Fibre							
batts	0	32	1	75	31.52	2.364	3
batts	0	32	14	75	30.15	2.261	3
batts	0	32	23	75	28.90	2.167	3
batts	0	104	22	75	31.52	2.364	3
batts	0	104	59	75	28.90	2.167	3
granulated ('loose fill')	0	80	23	—	2.77	—	3
granulated ('loose fill')		64	−18	—	27.74	—	15
granulated ('loose fill')		64	21	—	24.77	—	15
granulated ('loose fill')		64	38	—	23.12	—	15
granulated ('loose fill')		160	−18	—	31.52	—	15
granulated ('loose fill')		160	−21	—	28.89	—	15
granulated ('loose fill')		160	38	—	26.67	—	15
Mortar							
cement, sand, 1 : 3	0	1890		15	1.14	0.017	4
cement, sand, 1 : 3	6	2002		15	0.89	0.013	4
cement, sand, 1 : 3	10	2082		15	0.77	0.012	4
cement, sand, 1 : 4	0	1954		15	1.08	0.016	4
cement, sand, 1 : 4	2.5	2002		15	0.90	0.014	4
Paper		1089		0.2	7.30	0.002	4
kraft building paper				0.2	15.41	0.003	
Particle Board (see **Wood Products**)							
Perlite (see also **Plaster**)							
loose expanded granules		32–96		—	23.91	—	4
loose expanded granules		64	38, 24	—	23.12	—	4
loose expanded granules		64	149, 24	—	19.26	—	4
loose expanded granules		64	260, 24	—	15.41	—	4
loose expanded granules		64	371, 24	—	12.61	—	4
loose expanded granules		64	482, 24	—	10.67	—	4
loose expanded granules	0	72	−2	—	22.37	—	3
cement, sprayed	2	352		—	12.61	—	4
cement, sprayed	20	416		—	9.24	—	4
Phenolic Foam		32		—	25.68	—	33
Pise, clay, gravel 2 : 1				—	0.80	—	4
Pitch				—	6.94	—	4
Plaster (see also **Gypsum**)							
foamed		400		—	9.91	—	4
foamed		641		—	6.30	—	4
foamed		881		—	4.08	—	4
vermiculite		641		15	4.95	0.074	4

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
vermiculite		961		15	3.30	0.050	4
lime, cement		1442		15	2.10	0.032	7
lime, sand 1 : 1			29	15	2.10	0.032	26
cement, sand 1 : 4			29	15	1.87	0.028	26
gypsum plaster, sand		1410		15	1.54	0.023	7
gypsum plaster, perlite		617		15	8.69	0.130	15
Plywood			27		7.22	—	23
Plywood	12	529		5	7.22	0.036	4
fire proofed	12	561		5	6.60	0.033	4
Polystyrene							
expanded		16	38	—	25.68	—	33
expanded		16	10	—	28.90	—	33
expanded		16	0	—	31.52	—	33
expanded		16	−18	—	33.02	—	33
expanded		16	−33	—	36.50	—	33
expanded		16	−40	—	38.53	—	33
expanded		16	−88	—	49.53	—	33
Polyurethane							
rigid, foamed, new		24		—	63.04	—	34
rigid, foamed, aged		24		—	40.79	—	34
flexible, foamed		40		—	28.90–25.68	—	34
Polyvinylchloride (PVC)							
rigid		1362		—	5.78	—	4
expanded		9.6	1	—	34.67	—	3
expanded		96	32	—	31.52	—	3
expanded		48	3	—	38.53	—	3
expanded		48	34	—	33.02	—	3
expanded		64	5	—	38.53	—	3
expanded		64	32	—	31.52	—	3
Porcelain, (electrical grade)		2403		—	0.69	—	4
'Porex' (slabs made from mineralized wood fibre bound under pressure with Portland cement)		400		100	15.41	1.54	15
Pumice		641		—	6.30	—	27
Pebbles, about 18 mm		497	28	—	10.84	—	9
pebbles, smaller than 18 mm		216	28	—	14.15	—	9
powdered		785	165	—	5.25	—	28
powdered		785	260	—	4.88	—	28
powdered		785	371	—	4.47	—	28
powdered		785	482	—	3.90	—	28
(see also **Concrete,** pumice)							
Rammed Earth (see **Pise**)							
Rock Wool (see **Mineral Fibre**							
Rubber							
cellular slabs		80		50	24.77	1.24	4
cellular slabs		160		50	23.12	1.16	4
cellular slabs		240		50	18.25	0.913	
cellular slabs		400		50	11.96	0.598	4
sheet		929		4	6.30	0.025	4
synthetic		961		4	6.30	0.025	4
Sand							
building	0	1506		—	3.30	—	4
fine silver	0	1602	21	—	3.15	—	4
fine silver	0	1602	160	—	2.77	—	4
fine silver	0	1602	265	—	2.67	—	4
Sandstone		2002		—	0.77	—	4
various				—	0.87–0.43	—	26
Sawdust		200	30	—	16.91	—	11
bonded with urea-formaldehyde resin	0	440		—	9.91	—	7
soaked	30	825		—	2.57	—	7

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
bonded with Portland cement 1 : 2		1201		—	3.47–2.89	—	29
bonded with Portland cement 1 : 4		657		—	5.78–4.95	—	29
Portland cement, sand, sawdust 1 : 1½ : 1½		1602		—	1.73–1.39	—	29
(see also **Magnesium Oxychloride**)							
Shavings (see **Wood Products**)							
Silica Brick		737–1041	499	—	3.30–1.98	—	15
Silica Brick		2243	38	90	1.12	0.101	5
Silica Brick		2243	93	90	1.07	0.096	5
Silica Brick		2243	315	90	0.91	0.082	5
Silica Brick		2243	538	90	0.78	0.071	5
Silica Brick		2243	1371	90	0.53	0.047	5
Silk, noils waste		14.4	32	—	26.67	—	10
Sisal Fibre		109	32	—	25.68	—	10
Slag Wool (see **Mineral Fibre**)							
Slate		2947	120	—	0.65	—	22
Slate		2947	94	—	0.67	—	22
expanded		881		—	4.08	—	28
Soil							
clay soil, from depth 1.5 m			21	—	0.93	—	9
clay soil, from depth 3.0 m			21	—	0.93	—	9
clay soil, from depth 6.0 m			21	—	0.86	—	9
clay soil, from depth 8.2 m			21	—	0.80	—	9
clay soil, loosely packed	14	1201	20	—	2.67	—	9
clay soil, loaded 5 kPa	14	1281	20	—	1.42	—	9
clay soil, loaded 100 kPa	14	1538	20	—	0.83	—	9
Sponge							
marine, clippings		30.4	13	—	24.77	—	9
marine, clippings		72	13	—	28.90	—	9
Steel							
mild		7849		6	0.021	1.26×10^{-4}	4
wool, very fine		48	32	—	14.15	—	10
wool, very fine		78.5	32	—	13.60	—	10
wool, very fine		109	32	—	13.34	—	10
Stoneware		2162		—	0.69	—	7
Straw							
board		256		—	11.56	—	7
compressed, faced with paper	0	320	16	50	12.38	0.619	3
fibres, pressed		219	32	—	14.15	—	10
slabs of compressed wheat straw, wired		213		50	24.72	1.238	15
wheat, uncrushed		73.7	32	—	23.12	—	10
Sugar Cane							
fibre		64	32	—	24.77	—	13
fibre		96	32	—	23.91	—	13
fibre		128	32	—	22.37	—	13
fibre		160	32	—	19.81	—	13
fibre		192	32	—	18.74	—	13
fibre		224	32	—	17.78	—	13
fibreboard		216	23	—	16.13	—	9
fibreboard		216	21	—	21.02	—	30
Timber							
across grain:							
Balsa	10	96		25	21.02	0.525	4
Balsa	10	128		25	19.26		4
Balsa	10	160		25	17.78	0.444	4
Beech	15	705		25	5.98	0.150	4
Deal	12	609		25	7.97	0.199	4
Mahogany	10	705		25	6.42	0.160	4

TABLE 37—THERMAL RESISTANCE R—BUILDING AND INSULATING MATERIALS (Cont.)

Note: An asterisk appearing in the density column signifies that the specimens have been conditioned in an atmosphere at 18°C and 65% relative humidity. Where two values are given in the temperature column, separated by a comma, the first refers to the hot face and the second to the cold face temperature.

Material	Moisture Content %	Density kg/m³	Temp. °C	Thickness mm	Resistivity (1/k) m.°C/W	Resistance for listed thickness m².°C/W	Source of Info.
Oak	14	769		25	6.25	0.156	4
Pitch Pine	15	657		25	7.22	0.181	4
Plywood	12	529		5	7.22		4
Plywood, fire proofed	12	561		5	6.60		4
Spruce	12	416		25	9.50	0.238	4
Teak	10	721		25	7.22	0.181	4
Walnut	10	657		25	7.22	0.181	4
Along grain:							
Deal	12	609		—	4.62	—	4
Oak	14	769		—	3.47	—	4
'Unicon' Blocks (lightweight concrete, vermiculite aggregate)		320		—	10.20	—	15
'Unicon' Blocks (lightweight concrete, vermiculite aggregate)		561		—	8.06	—	15
'Unicon' Blocks (lightweight concrete, vermiculite aggregate)		801		—	6.30	—	15
Urea Formaldehyde, *foam*		8		—	31.52–28.90	—	34
Vermiculite							
bonded	0	208	20	—	13.34	—	3
bonded	0	299	16	—	9.50	—	3
exfoliated		128	38	—	14.45	—	5
exfoliated		272	38	—	12.17	—	5
exfoliated		272	165	—	10.50	—	5
exfoliated		272	260	—	9.13	—	5
expanded		112–131	−1	—	15.76	—	5
expanded		112–131	32	—	14.45	—	1
loose granules		80–112		—	15.41	—	1
Vinyl		1826	16	3	2.67	0.008	3
Vinyl-Asbestos, semi-flexible floor covering		1970	15	3	1.98	0.0059	3
Water		999	20	—	1.67	—	4
Water		983	60	—	1.54	—	4
Wood Products							
fibre and pulp boards (see also **Fibreboard**)		240	28	18	18.25	0.328	9
fibre and pulp boards		320	29	18	16.91	0.304	9
fibre and pulp boards		48	32	18	23.12	0.416	10
fibre and pulp boards		80	32	18	23.12	0.416	10
fibre and pulp boards		106	32	18	22.37	0.403	10
fibre and pulp boards		144	32	18	21.67	0.390	10
fibre and pulp boards		32		18	22.37	0.403	13
fibre and pulp boards		64		18	23.12	0.416	13
fibre and pulp boards		96		18	23.91	0.430	13
fibre and pulp boards		128		18	23.12	0.416	13
particle board (wood chips bonded with resin)		480		18	9.25	0.166	4
particle board (wood chips bonded with resin)		641		18	8.16	0.147	4
particle board (wood chips bonded with resin)		801		18	6.94	0.125	4
shavings			30		9.77		6
shavings, planer (various woods)		192	32	—	16.91	—	31
shredded wood		40	32	—	17.78	—	10
shredded wood		101	32	—	19.26	—	10
wood wool, acoustical, fluffy		41.6	20	—	24.77	—	9
Wool							
sheep's, low grade	0	20.8	27	—	26.67	—	3
sheep's, low grade		52.9	20	—	23.12	—	9

SOURCES OF INFORMATION

1. American Society of Heating, Refrigerating and Air-conditioning Engineers (1972)—'ASHRAE Handbook of Fundamentals'. (American Society of Heating, Refrigerating and Air-conditioning Engineers Inc.: New York).
2. Jay, A. H., and Lee, L. (1938)—Transactions of the Ceramic Society (U.K.), Vol. 37, p. 151.
3. Division of Building Research, CSIRO, Melbourne Australia.
4. The Institution of Heating and Ventilating Engineers (1965)—'IHVE Guide'. (Institution of Heating and Ventilating Engineers: London).
5. Saginor, S. V. (1941)—Chemical and Metallurgical Engineering, Vol. 48, p. 82.
6. 'Specification 1969'. (Architectural Press Ltd.: London).
7. National Physical Laboratory, Teddington, United Kingdom.
8. United States Department of Agriculture. Wood Handbook.
9. Griffiths, E. (1941)—Journal of the Institution of Heating and Ventilating Engineers, Vol. 9, p. 177.
10. Bureau of Standards Journal of Research, Vol. 5, p. 973, 1930.
11. 'International Critical Tables', Vol. 2., 1927 (McGraw-Hill Book Company Inc.: New York).
12. Proceedings of the American Society for Testing Materials, Vol. 28, p. 820.
13. Finch, J. L. (1939)—Industrial and Engineering Chemistry, Industrial Edition, Vol. 31, p. 824.
14. Teknologisk Institut, Copenhagen, Denmark.
15. Manufacturer.
16. Niven, C. O. (1935)—Canadian Journal of Research, Vol. 13*A*, p. 16.
17. United States Bureau of Mines, Information Circular No. 7195.
18. Bureau of Standards, Miscellaneous Publication No. 112.
19. Heating, Piping and Air Conditioning, Vol. 1, p. 245, 1929.
20. Electrochemical and Metallurgical Industry.
21. Staatliches Materialprofungsamt, Berlin, Germany.
22. Niven, C. O. (1940)—Canadian Journal of Research, Vol. 18*A*, p. 132.
23. Great Britain, D.S.I.R. Food Investigation Board, Special Report No. 35.
24. Great Britain, Ministry of Works Report—Pitch Mastic Flooring.
25. Great Britain, D.S.I.R. Building Research Board, Special Report No. 7, 1923.
26. Smithsonian Institute Tables, 1933.
27. Journal of the Institution of Heating and Ventilating Engineers, March 1937.
28. Wilkes, G. B. (1950)—'Heat Insulation'. (Chapman and Hall: London).
29. Journal of the Royal Institute of British Architecture, Vol. 50, p. 259, 1943.
30. Schaeffer, J. (1935)—Industrial and Engineering Chemistry, Industrial Edition, Vol. 27, p. 1298.
31. National Bureau of Standards, Washington, United States of America.
32. Great Britain, Ministry of Works, Post War Building Study No. 1, 1944.
33. Anon. (1966)—Insulation, Vol. 10, p. 23.
34. Anon. (1966)—British Plastics, Vol. 39, p. 504.
35. Billington, N. S. (1952)—'Thermal Properties of Buildings' (Cleaver-Hume Press Ltd.: London).
36. Rees, W. H. (1970)—Building Materials (U.K.) January 1970, p. 55.

AUSTRALIAN PROPRIETARY INSULATING MATERIALS

This table lists some Australian produced insulating materials. It does not claim to be complete but gives a representative sample

Trade Name	Composition	Manufacturer or Distributor
'Alpinite'	Eel grass (*Zostera marina*)	Alpinite Insulation Pty Ltd
'Asbestosfluf'	Asbestos fibre, loose	D. Jansen & Co.
'Coolite'	Polystyrene, expanded	Hardie Rubber Co.
'Fibreglass'	Mineral wool (glass fibre)	Aus. Fibreglass Pty Ltd
'Fibre-wool'	Cellulose fibre, fireproofed	Renhurst Industries Pty Ltd
'Fibretex'	Mineral wool (rock wool)	Bradford Insulation Pty Ltd
'Foamglas'	Glass, cellular	Bell's Thermalag Pty Ltd
'Foamglass'	Glass, cellular	George Fethers & Co. Pty Ltd
'Insulwool'	Mineral wool (rock wool), Mineral wool (glass fibre)	Insulwool Products Pty Ltd
'Insul-Fluf'	Cellulose fibre, fireproofed	Weathermaster Pty Ltd
'Isolite'	Polystyrene, expanded	Olympic General Products Pty Ltd
'Isothane'	Polyurethane, foamed, rigid	Olympic General Products Pty Ltd
'Korthane'	Polyurethane, foamed, rigid	Korthane Pty Ltd
'Micalox'	Vermiculite, exfoliated	Nonporite Ltd
'Onazote'	Ebonite, expanded	Olympic General Products Pty Ltd
'Pillofoam'	Polyurethane, foamed, flexible	Texfoam Pty Ltd
'Scandia'	Straw, compressed, faced with paper	Brownbuilt Ltd
'Solomit'	Straw, slabs of compressed wheat straw, wired	Solomit (S.A.) Ltd
'Stramit'	Straw, compressed, faced with paper	Stramit Industries Ltd
'Styrolite'	Polystyrene, expanded	Synthetic and Allied Products Pty Ltd
'Styropor'	Polystyrene, expanded	BASF Aus. Ltd
'Tuff-skin'	Mineral wool (glass fibre)	Bradford Insulation Pty Ltd
'Zeristo'	Corkboard	H. Brewer Pty Ltd

HEAT LOSS THROUGH BASEMENT WALLS AND FLOORS BELOW THE GROUND LEVEL

The loss through the floor is normally small and relatively constant year round because the ground temperature under the floor varies only a little throughout the year. The ground is a very good heat sink and can absorb or lose a large amount of heat without an appreciable change in temperature at about the 2.5 m level. Above the 2.5 m level, the ground temperature varies with the outdoor temperature, with the greatest variation at the surface and a decreasing variation down to the 2.5 m depth. The heat loss through a basement wall may be appreciable and it is difficult to calculate because the ground temperature varies with depth. *Tables 38* to *40* have been empirically calculated to simplify the evaluation of heat loss through basement walls and floors.

The heat loss through a slab floor is large around the perimeter and small in the centre. This is because the ground temperature around the perimeter varies with the outdoor temperature, whereas the ground temperature in the middle remains relatively constant, as with basement floors.

Basis of Tables 38 to 40 —Heat Loss Through Masonry Floors and Walls in Ground

Tables 38 to *40* are based on empirical data. The perimeter factors listed in *Table 39* were developed by calculating the heat transmitted in increments of 0.5 m of wall to a depth of 2.5 m. The ground was assumed to decrease the transmission coefficient, thus adding resistance between the wall and the outdoor air. The transmission coefficients were then added to arrive at the perimeter factors.

Use of Tables 35 to 40 —Heat Loss Through Masonry Floors and Walls in Ground

The transmission coefficients listed in *Table 38* may be used for any thickness of uninsulated masonry floors where there is good contact between the floor and the ground.

The perimeter factors listed in *Table 39* are used for estimating heat loss through basement walls and the outside strip of basement floors. This factor can be used only when the space is heated continuously. If there is only occasional heating, calculate the heat loss using the wall or floor transmission coefficients as listed in *Tables 24* to *36* and the temperature difference between the basement and outdoor air or ground as listed in *Table 40*.

The heat loss in a basement is determined by adding the heat transferred through the floor, the walls and the outside strip of the floor and the portion of the wall above the ground level.

Example 7—Heat Loss in a Basement

Given:

Basement—30 m × 12 m × 3 m
Basement temp.—18°C DB heated continuously
Outdoor temp.— −10°C DB
Grade line—2 m above basement floor
Walls and floors—300 mm concrete (2400 kg/m³)

Find:

Heat loss from basement

Solution:

1. Heat loss above ground
$Q = U_1 a_1 (t_b - t_{oa})$
$= 2.80 \times (60 + 24) \times 1 \times [18 - (-10)]$
$= 6590$ W

2. Heat loss through walls and outside strip of floor below ground.
$Q = L_p \lambda (t_b - t_{oa})$
$= (60 + 24) \times 1.90 \times [18 - (-10)]$
$= 4470$ W

3. Heat loss through floor
$Q = U_2 a_2 (t_b - t_g)$
$= 0.28 \times (30 \times 12) \times (18 - 2) = 1610$ W

Total Heat Loss = 12 670 W

where $U_{1,2}$ = Heat transmission coefficient of 12670 W (1) wall above ground (*Table 24*) and (2) floor (*Table 38*) in W/m².°C.
a_1 = Area of wall above ground, m²
a_2 = Entire floor area, m²
L_p = Perimeter of wall, m
λ = Perimeter factor (*Table 39*)
t_b = Basement dry-bulb temp., °C
t_g = Ground temp., °C, (*Table 40*)
t_{oa} = Outdoor design dry-bulb temp., °C

TRANSMISSION COEFFICIENTS—PIPES IN WATER OR BRINE

Heat transmission coefficients for copper and steel pipes are listed in *Tables 41* and *42*. These coefficients may be useful in applications such as cold water or brine storage systems and ice skating rinks.

TABLE 38
Transmission Coefficient U—Masonry Floors and Walls in Ground
(Use only in conjunction with Table 39)

Floor or Wall	Transmission Coefficient U W/m².°C
*Basement Floor	0.28
Portion of Wall exceeding 2.5 m below ground level	0.45

*Some additional floor loss is included in perimeter factor, see *Table 39*.
Equations:

Heat loss through floor, W = (area of floor, m²) × (U value) × (basement — ground temp.).
Heat loss through wall below 2.5 m line, W = (area of wall below 2.5 m line, m²) × (U value) × (basement—ground temp.).

NOTE: The factors in *Tables 38* and *39* may be used for any thickness of uninsulated masonry wall or floor, but there must be a good contact (no air space which may connect to the outdoors) between the ground and the floor or wall. Where the ground is dry and sandy, or where there is cinder fill along wall or where the wall has a low heat transmission coefficient, the perimeter factor may be reduced slightly.

TABLE 39
Perimeter Factors
FOR ESTIMATING HEAT LOSS THROUGH BASEMENT WALLS AND OUTSIDE STRIP OF BASEMENT FLOOR
(Use only in conjunction with Table 38)

Distance of Floor From Ground Level	Perimeter Factor λ
0.5 m above	1.46
At ground level	1.02
0.5 m below	1.24
1.0 m below	1.46
1.5 m below	1.68
2.0 m below	1.90
2.5 m below	2.12

Equation:
Heat loss about perimeter, W = (perimeter of wall, m²) × (perimeter factor) × (basement—outdoor temp.).

TABLE 40
Ground Temperatures
FOR ESTIMATING HEAT LOSS THROUGH BASEMENT FLOORS

Outdoor Design Temp °C	−10	−5	0	5	10
Ground Temp °C	2	4	6	8	10

Basis of Tables 41 and 42
– Transmission Coefficients, Pipes in Water or Brine

Table 41 is for ice coated pipes in water, based on a heat transfer film coefficient, inside the pipe, of

TABLE 41—TRANSMISSION COEFFICIENT—ICE COATED PIPES IN WATER

Watts per lineal metre of pipe degree Celsius between 0°C and refrig. temp.

INSIDE FILM COEFFICIENT 850 W/m²°C

Copper Pipe Nominal Size mm	Actual Outside Diameter mm	Wall Thickness mm	Copper Pipe with Ice Thickness mm				Steel Pipe Outside Diameter mm	Steel Pipe Inside Diameter mm	Steel Pipe with Ice Thickness mm				
			10	20	30	40			15	30	45	60	80
18	15.8	0.56	12.30	8.85	7.40	6.62	13.7	11.4	8.65	6.59	5.67	5.14	4.69
20	19.0	0.56	14.16	9.99	8.28	7.32	21.3	18.7	12.15	8.69	7.29	6.48	5.81
25	25.4	0.61	17.96	12.23	9.93	8.64	26.9	24.3	14.60	10.10	8.35	7.35	6.53
32	31.7	0.71	21.57	14.35	11.47	9.89	33.7	30.8	17.50	11.80	9.57	8.34	7.34

TABLE 42—TRANSMISSION COEFFICIENT U—PIPES IMMERSED IN WATER OR BRINE

Watts per lineal metre of pipe degree Celsius between 0°C and refrig. temp.

OUTSIDE WATER FILM COEFFICIENT = 100 W/m²°C
OUTSIDE BRINE FILM COEFFICIENT = 80 W/m²°C

Copper Pipe Nominal Size mm	Actual Outside Diameter mm	Wall Thickness mm	U-Value Pipes in Water	Steel Pipe Outside Diameter mm	Steel Pipe Thickness mm	U-Value Pipes in Water	U-Value Pipes in Brine
15	12.7	0.56	4.1	13.7	2.3	4.4	3.4
18	15.8	0.56	5.1	21.3	2.6	6.8	5.4
20	19.0	0.56	6.1	26.9	2.6	7.8	6.8
32	31.7	0.71	10.0	33.7	2.9	9.9	8.5

Water (brine) to refrigerant temperature 5°C–10°C.

850 watts per square metre of internal pipe surface degree Celsius.

Table 42 is for pipes in water or brine based on a heat transfer of 100 watts per square metre of external pipe surface degree Celsius in water, 80 W/m².°C in brine. It is also based on a low rate of circulation on the outside of the pipe and 5°C to 10°C temperature difference between water or brine and refrigerant. High rates of circulation will increase the heat transfer rate. For special problems, consult heat transfer reference books.

WATER VAPOUR FLOW THROUGH BUILDING STRUCTURES

Water vapour flows through building structures, resulting in a latent load whenever a vapour pressure difference exists across a structure. The latent load from this source is usually insignificant in comfort applications and need be considered only in low or high dewpoint applications.

Water vapour flows from high to lower vapour pressure at a rate determined by the permeability of the structure. This process is similar to heat flow, except that there is transfer of mass with water vapour flow. As heat flow can be reduced by adding insulation, vapour flow can be reduced by vapour barriers. The vapour barrier may be paint (aluminium or asphalt), aluminium foil or galvanized iron. *It should always be placed on the side of a structure having the higher vapour pressure, to prevent the water vapour from flowing up to the barrier and condensing within the wall.*

Basis of Table 43 —Water Vapour Transmission Through Various Materials

There is a considerable difference in available data for vapour transmission of various materials, partly because of the variability in porosity and partly because the transmission rate is dependent on the absolute value of the vapour pressure difference. Vapour migration is said to occur in a kind of series-parallel flow of vapour and liquid, and no adequate way of handling the general case theoretically has been found. Sources of values quoted in *Table 43* are listed in that table.

Use of Table 43 —Water Vapour Transmission Through Various Materials

Table 43 is used to determine latent heat gain from water vapour transmission through building structures in the high and low dewpoint applications where the air moisture content must be maintained.

Example 8—Water Vapour Transmission

Given:

A 3.0 m × 3.0 m × 2.5 m laboratory with inside conditions of 38°C DB, 31°C WB, constructed of 150 mm concrete (1 : 2 : 4 mix) without windows and with a small, sealed door of vapour permeability similar to concrete, finished on the inside walls and ceiling with 12 mm plasterboard is suspended inside a large laboratory in which conditions of 20°C DB and 50% RH are being maintained.

Find:

The latent heat gain from water vapour transmission.

Solution:

Calculations assume resistance to vapour flow through the various materials to be directly proportional to the thickness of the materials and that there is no resistance to vapour flow at the surface or at the interface of the materials.

Moisture content
at 38°C DB, 31°C WB = 25.9 g/kg (Psych. Chart)
at 20°C DB, 50% RH = 7.3 g/kg (Psych. Chart)

Diff. in moisture content = 18.6 g/kg

TABLE 43—WATER VAPOUR TRANSMITTANCE FOR VARIOUS MATERIALS

Material	Density kg/m^3	Mass per unit area kg/m^2	Permeance μg/N.s	Permeability μg.m/N.s	Latent Heat mW/m^2.(g/kg) Gain	Test Method	Source of Information
Materials used in Construction							
Concrete (1 : 2 : 4 mix)				0.00465	1.94*	ASTM C355 Water Method	ASHRAE 1972
100 mm		240	0.0465		19.4	ASTM C355 Water Method	ASHRAE 1972
150 mm		360	0.0310		13.0	ASTM C355 Water Method	ASHRAE 1972
300 mm		720	0.0155		6.48	ASTM C355 Water Method	ASHRAE 1972
Brick				0.00465	1.94*	—	ASHRAE 1972
				0.00700	2.93*	—	Carrier
90 mm		173	0.052–0.078		21.7–32.6	—	ASHRAE–CARRIER
240 mm		346	0.026–0.039		10.9–16.3	—	ASHRAE–CARRIER
(2 x 90 mm brick + 60 mm air)							
Plasterboard 12 mm		11	2.270		94.9	—	ASHRAE 1972
Hardboard (Tempered) 6 mm		16	0.150		62.7	—	ASHRAE 1972
Thermal Insulations							
Air (Still)				0.192	80.3	—	IHVE–Book A 1970
25 mm		—	7.68		3210	—	IHVE–Book A 1970
90 mm		—	2.13		890	—	IHVE–Book A 1970
Cellular Glass	144			0.000	0.000	ASTM C355 Dessicant Method	ASHRAE 1972
Corkboard	—			0.0031–0.0038	1.30–1.59*	ASTM C355 Dessicant Method	ASHRAE 1972
Mineral Fibre	—			0.169	70.6*	ASTM C355 Water Method	ASHRAE 1972
Expanded Polyurethane	29–35			0.0058	2.42*	ASTM C355	Olympic General Products
Expanded Polyurethane	48–70			0.0058	2.42*	ASTM C355	Olympic General Products
Expanded Polystyrene	32			0.00305	1.27*	A.S.K. 156	Olympic General Products
Expanded Polystyrene	28			0.00334	1.40*	A.S.K. 156	Olympic General Products
Expanded Polystyrene	24			0.00348	1.45*	A.S.K. 156	Olympic General Products
Expanded Polystyrene	20			0.00363	1.52*	A.S.K. 156	Olympic General Products
Expanded Polystyrene	17.6			0.00392	1.64*	A.S.K. 156	Olympic General Products
Expanded Polystyrene	16.0			0.00610	2.55*	A.S.K. 156	Olympic General Products

TABLE 43—WATER VAPOUR TRANSMITTANCE FOR VARIOUS MATERIALS (Cont.)

Material		Density kg/m³	Mass per unit area kg/m²	Permeance µg/N.s	Permeability µg.m/N.s	Latent Heat Gain mW/m².(g/kg)	Test Method	Source of Information
Plastic and Metals Foils and Films								
Sisalation	450		0.380	< 0.114x10⁻²		0.477	ASTM E96–E	St. Regis ACI
Vapastop	480		0.430	< 0.57x10⁻³		0.238	ASTM E96–E	St. Regis ACI
Polyethylene	0.05 mm		0.046	0.00916		3.83	ASTM E96	ASHRAE 1972
	0.1 mm		0.092	0.00460		1.92	ASTM E96	ASHRAE 1972
	0.2 mm		0.184	0.00230		0.961	ASTM E96	ASHRAE 1972
	0.25 mm		0.230	0.00170		0.711	ASTM E96	ASHRAE 1972
Building Papers								
Aquathene	S4		0.53	0.0104		4.35	ASTM E96	BRLS Data Sheet No. 22
Aquathene	S2		0.45	0.0096		4.01	ASTM E96	BRLS Data Sheet No. 22
Glaskraft	2044		0.45	0.0148		6.19	ASTM E96	BRLS Data Sheet No. 22
Glaskraft	2034		0.34	0.0113		4.72	ASTM E96	BRLS Data Sheet No. 22
Renthene	0.004		0.61	0.0043		1.80	ASTM E96	BRLS Data Sheet No. 22
Renthene	0.002		0.43	0.0104		4.35	ASTM E96	BRLS Data Sheet No. 22
Sisalthene	355		0.60	0.0078		3.26	ASTM E96	BRLS Data Sheet No. 22
Sisalthene	353		0.53	0.0087		3.64	ASTM E96	BRLS Data Sheet No. 22
Paint Films—								
2 coats aluminium paint			—	0.028–0.112		11.7–46.8	—	Carrier Design Manual
2 coats asphalt paint			—	0.028–0.056		11.7–23.4	—	Carrier Design Manual
2 coats lead & oil paint			—	0.056–0.336		23.4–140	—	Carrier Design Manual
2 coats water emulsion			—	2.80–4.50		1170–1881	—	Carrier Design Manual
Dept. of Works Standard Vapour Barriers—								
Type 1		—	—	0.0132		5.52	BS2972–1961	Balm Paints NATA Test Report No. 102
Type 2		—	—	0.0011		0.460	BS2972–1961	No. 108
Type 3		—	—	0.29x10⁻³		0.121	BS2972–1961	No. 117

*Latent Heat Gain for Unit Thickness—mW/m·(g/kg)·

Unit latent heat gain through walls and ceiling:

$$\frac{1}{\frac{1}{13.0}+\frac{1}{94.9}} = 11.4 \text{ m W/m}^2\text{. (g/kg)}$$

Unit latent heat gain through floor:
13.0 mW/m² (g/kg) . . . *Table 43*

Latent heat gains:

Walls and ceilings:
[(3.0 x 3.0) + (12.0 x 2.5)] x 18.6 x 11.4 = 8270

Floor:
(3.0 x 3.0) x 18.6 x 13.0 = 2176

Total 10446 mW
= 10.4 W

CONDENSATION OF WATER VAPOUR

Whenever there is a difference of temperature and pressure of water vapour across a structure, conditions may develop that lead to a condensation of moisture. This condensation occurs at the point of saturation temperature and pressure.

As water vapour flows through the structure, its temperature decreases and, if at any point it reaches the dewpoint or saturation temperature, condensation begins. As condensation occurs, the vapour pressure decreases, thereby lowering the dewpoint or saturation temperature until it corresponds to the actual temperature. The rate at which condensation occurs is determined by the rate at which heat is removed from the point of condensation. As the vapour continues to condense, latent heat of condensation is released, causing the dry-bulb temperature of the material to rise.

To illustrate this, assume a weatherboard wall, plastered on the inside and mineral wool insulation between the two. Also, assume that the inside conditions are 25°C DB and 50% RH and the outdoor conditions are −10°C DB and 80% RH. Refer to *Fig. 31.*

The temperature and vapour pressure gradient decreases approximately as shown by the solid and dashed lines until condensation begins (saturation point). At this point, the latent heat of condensation decreases the rate of temperature drop through the insulation. This is approximately indicated by the dotted line.

Another cause of concealed condensation may be evaporation of water from the ground or damp locations. This water vapour may condense on the underside of the floor joints (usually near the edges where it is coldest) or may flow up through the outdoor side of the walls because of stack effect and/or vapour pressure differences.

Concealed condensation may cause wood, iron and brickwork to deteriorate and insulation to lose its insulating value. These effects may be corrected by the following methods:

1. *Provide vapour barriers on the high vapour pressure side.*
2. In winter, ventilate the building to reduce the vapour pressure within. No great volume of air change is necessary, and normal infiltration alone is frequently all that is required.
3. In winter, ventilate the structure cavities to remove vapour that has entered. Outdoor air through vents shielded from entrance of rain and insects may be used.

Condensation may also form on the surface of a building structure. Visible condensation occurs when the surface of any material is colder than the dewpoint temperature of the surrounding air. In winter, the condensation may collect on cold walls and roofs and is on rare occasions observed as frost on window panes. *Fig. 32* illustrates the condensation on a window with inside winter design conditions of 20°C DB and 40% RH. Point A represents the room conditions; point B, the dewpoint temperature of the thin film of water vapour adjacent to the window surface; and point C, the point at which frost or ice appear on the window.

Once the temperature drops below the dewpoint,

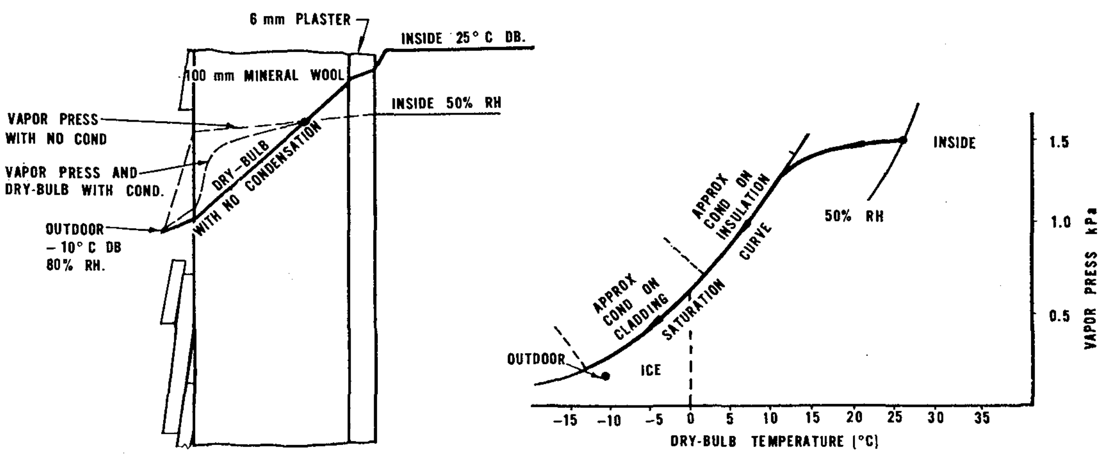


Fig. 31—Condensation within a weatherboard wall

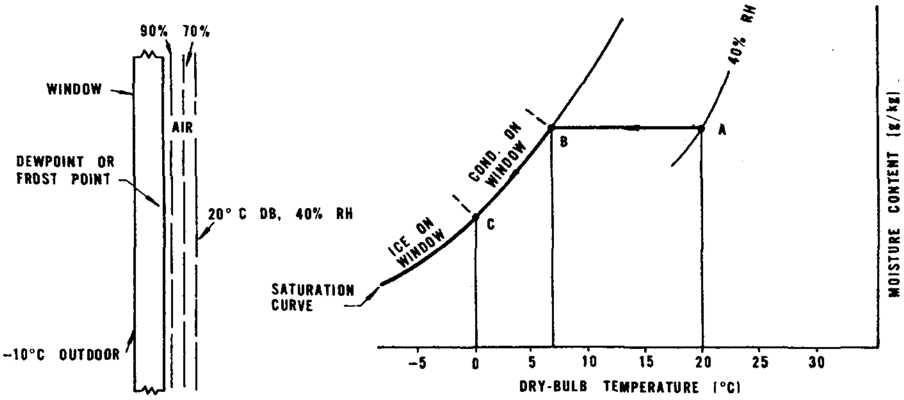


Fig. 32—Condensation on window surface

the vapour pressure at the window surface is also reduced, thereby establishing a gradient of vapour pressure from the room air to the window surface. This gradient operates, in conjunction with the convective action within the room, to move water vapour continuously to the window surface to be condensed as long as the concentration of the water vapour maintained in a space.

Visible condensation is objectionable as it causes staining of surfaces, dripping on machinery and furnishings, and damage to materials in process of manufacture. Condensation of this type may be corrected by the following methods:

1. Increase the thermal resistance of walls, roofs and floors by adding insulation with vapour barriers to prevent condensation within the structures.
2. Increase the thermal resistance of glass by installing two or three panes with air space(s) between. In extreme cases, controlled heat, electric or other, may be applied between the glass of double glazed windows.
3. Maintain a room dewpoint lower than the lowest expected surface temperature in the room.
4. Decrease surface resistance by increasing the velocity of air passing over the surface. Decreasing the surface resistance increases the window surface temperature and brings it closer to the room dry-bulb temperature.

Basis of Chart 2 —Maximum Room RH; No Wall, Roof or Glass Condensation

Chart 2 has been calculated from the equation used to determine the maximum room dewpoint temperature that can exist with condensation.

$$t_{DP} = t_{RM} - \frac{U(t_{RM}-t_{OA})}{f_i}$$

where t_{DP} = dewpoint temperature of room air, °C DB
t_{RM} = room temperature, °C
U = transmission coefficient, W/m².°C
t_{OA} = outdoor temperature, °C
f_i = inside air film or surface conductance, W/m².°C

Chart 2 is based upon a room dry-bulb temperature of 21°C DB and an inside film conductance of 8.4 W/m².°C (still air) vertical surface. Note that for roofs this film conductance would be between 9.15 and 9.30 W/m².°C (still air, horizontal or 45° sloping surfaces) and therefore condensation would occur at slightly higher relative humidities than shown on *Chart 2.*

Use of Chart 2 —Maximum Room RH; No Wall, Roof or Glass Condensation

Chart 2 gives a rapid means of determining the maximum room relative humidity which can be maintained and yet avoid condensation with a 21°C DB room.

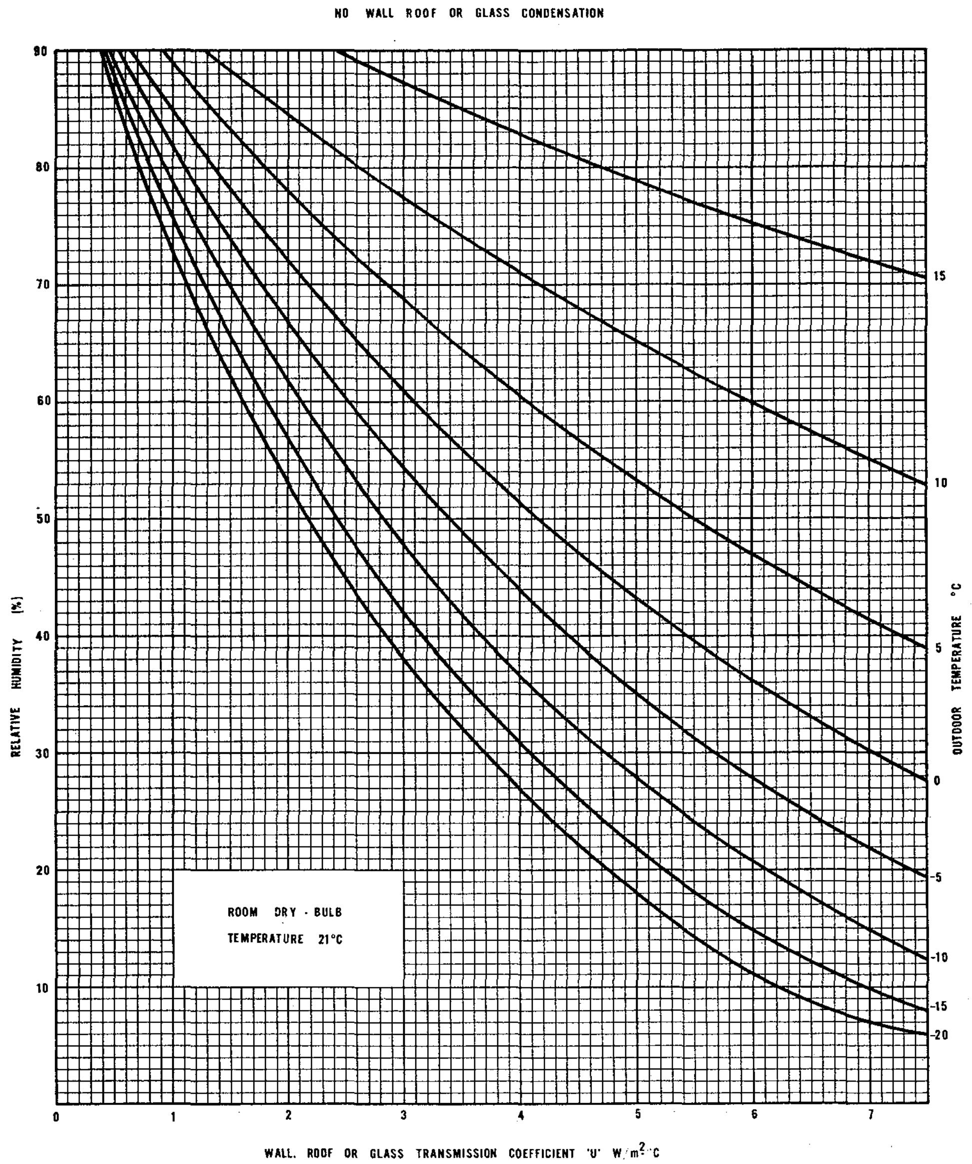
Example 9—Moisture Condensation

Given:
100 mm concrete wall (2400 kg/m³) with 15 mm gypsum plaster
Room temp.—21°C DB
Outdoor temp.— −10°C DB
Find:
Maximum room RH without wall condensation.
Solution:
Transmission coefficient U = 4.15 W/m².°C (*Table 24*)
Maximum room RH = 37%, (*Chart 2*)
Corrections in room relative humidity for room temperatures other than 21°C DB are listed in the table under *Chart 2.* Values other than those listed may be interpolated.

Example 10—Moisture Condensation

Given:
Same as *Example 9,* except room temp. is 26°C DB
Find:
Maximum room RH without wall condensation
Solution:
Transmission coefficient U = 4.15 W/m².°C (*Example 9*)
Maximum room RH for 21°C DB room temp. = 37% (*Example 9*)
RH correction for room temp. of 26°C DB with U factor of 4.15 = −5.5% (bottom *Chart 2*).
Maximum room RH = 37 − 5.5 = 31.5%

Chart 2—Maximum room relative humidity without condensation



CORRECTION IN ROOM RH (%)
For wall, roof or glass Transmission Coefficient U

Outdoor Temp. °C DB	U = 6		U = 4		U = 2	
	Room Temperature °C DB					
	16	26	16	26	16	26
°C DB	16 %	26 %	16 %	26 %	16 %	26 %
—20	+3.0	—2.5	+4.0	—4.0	+3.5	—2.5
—15	+4.0	—3.0	+5.0	—5.0	+3.5	—2.5
—10	+5.5	—4.0	+6.0	—5.5	+4.0	—3.0
—5	+7.5	—5.5	+7.0	—6.5	+4.5	—3.5
0	+10	—7.5	+8.5	—7.5	+5.0	—4.0
5	+13	—10	+10	—9.0	+6.0	—4.5
10	+17	—14	+13	—10	+6.5	—5.0
15	+25	—18	—17	—12	+7.5	—5.5

CHAPTER 6. INFILTRATION AND VENTILATION

INFILTRATION

THEORETICAL CONSIDERATIONS

The theoretical considerations governing infiltration are simple: the amount of infiltration into a building depends on the forces acting on it and on the resistance to these forces. The forces are wind pressure and temperature difference between inside and outside the building, and the resistances are those offered to these forces in the envelope *and* the interior of the building. (A force opposing that caused by wind pressure is present in a 'pressurised' building, i.e. when the outside air supply exceeds the exhaust air).

PRACTICAL CONSIDERATIONS

The practical considerations governing infiltration are extremely complex: wind forces on the building depend on the force recorded by the nearest meteorological station, the distance from that station, the surrounding terrain (open country, suburban or city areas) the immediate surroundings (e.g. in a city with high and low rise buildings, plazas, etc.) the height and shape of the building and the direction of the wind.

Forces due to temperature difference between inside and outside the building (stack effect) are directly proportional to these temperature differences and to the height of the building. Resistances to the forces of wind and temperature difference are presented by cracks or openings in the building shell (wall, windows, doors) and in the horizontal and vertical subdivisions inside the building.

AVAILABLE INFORMATION AND METHODS OF CALCULATION

There is little agreement in available information, even on the simplest issues.

Infiltration formula

For example the infiltration rate through the cracks of a window

$$\gamma = \Theta \Delta p^n \qquad (1)$$

Where γ is the flow rate per unit length of window opening joint in ℓ/s.m

Θ the window infiltration coefficient and

Δp the pressure difference across the window (Pa)

The exponent n is taken in the U.S.A. (ASHRAE) as 0.5, while in Britain (IHVE) a figure of 0.63 is normally used.

Window infiltration coefficients

The window infiltration coefficients also vary considerably. From formula (1) it can be seen that the coefficient Θ is the rate of air flow per unit length of window opening joint at unity pressure differential (ℓ/s.m) for 1 Pa. (Note that it is not *per* Pa because of the exponential relationship.)

According to IHVE, Θ varies from a minimum of 0.05 for pivoted, weather stripped windows to 0.25 for sliding, non-weather stripped windows, a ratio of five to one. This coincides with the recommendations of the research paper on which the IHVE values are based, in spite of the fact that windows examined by the researchers showed a variation in coefficient Θ from approximately 0.007 to 1.05 ℓ/s.m, a ratio of 150:1. On the American scene a ratio between the best and worst fitting windows of approximately 10:1 is used.

Pressure Differential Across the Building

In the U.S.A. it is customary to apply the meteorological wind speed in calculating the infiltration rate, whilst the latest British practice takes into account the fact that the mean pressure difference across the building depends on its height and location. Based on wind tunnel tests of a building 10 m high, at a meteorological windspeed of 9 m/s has a pressure differential of 58 Pa in open country, 21 Pa if located in a suburb and 6 Pa in a city centre; under the same conditions a building 100 m high would have a pressure differential of 111, 71 and 40 Pa respectively. (It can be seen therefore that for the same meteorological windspeed [9 m/s] the average pressure differential across a 100 m high building in a city area would be 40/6 = 6.67 times that of a 10 m high building. The infiltration rate would therefore be $6.67^{0.63} = 3.35$ times greater.)

Effect of Partitioning

American practice does not take into account the effect on infiltration rate of partitioning inside the building. This is correct when the resistance to air flow through the skin of the building is substantially greater than through the resistances offered by internal subdivision. British research has shown that for buildings with extensive fenestration of poorly fitting windows the calculated infiltration is reduced by as much as 60% where liberal partitioning occurs.

Effect of Type of Construction

Neither American nor British practice differentiates in the calculation of infiltration between 'dry' and 'wet' construction. (Curtain wall *vs.* brick or concrete poured *in situ.*) ASHRAE points out that infiltration through brick walls or plastered frame construction is negligible compared with infiltration through windows but no up-to-date information is given on curtain walling, because it is not available.

Stack Effect

The general equation for calculating the pressure in a building due to the inside/outside temperature difference is:

$$\Delta p = 3462x[1/(t_o+273)-1/(t_i+273)] \qquad (2)$$

where Δp = pressure arising (Pa)
x = vertical distance between inlet and outlet openings (m)
t_o = outside temperature (°C)
t_i = inside temperature (°C)

When the temperatures are not greatly different from 10°C formula (2) becomes

$$\Delta p = 0.043x\ (t_i-t_o) \qquad (3)$$

Combined Wind and Stack Effects

The pressure inside a building may be above or below the atmospheric pressure depending on the disposition and sizes of the orifices, and hence on the level of the neutral plane (where the pressure equals atmospheric pressure). For a chimney or a ventilating shaft, the neutral plane is at the base in winter or top in summer, but for most other applications it may be taken as the mid-height of the zone or building. Below the neutral plane in winter, air enters the building; above, it leaves the building. The converse is true in summer.

Stack effect is generally small in relation to wind pressures except in the unlikely case of a tall building with vertical shafts with unrestricted access to every floor. If it is necessary to consider both forces in the calculation of infiltration, the pressure difference to be used is the algebraic sum of the wind pressure and the stack pressure; where stack pressure opposes wind pressure it is customary to neglect it, i.e. not to reduce infiltration caused by wind pressure.

PRAGMATIC SOLUTION

Because of the complexities of the situation, the lack of infiltration data for Australian window types and the impracticability to determine (other than by wind tunnel tests) the pressure distribution external and internal to the building, the following pragmatic rules are recommended:

Allow a minimum ventilation rate (outside air less exhaust air, i.e. pressurisation) of half an air change per hour to be handled by the air conditioning plant. (The quantity of air is to be calculated on the basis of the actual ceiling height except in those cases where that height exceeds 4.5 m, when a fictitious height of 4.5 m shall be assumed.)

Neglect the stack effect in any air conditioned or ventilated building.

In an air conditioned building allow as infiltration the number of air changes for the various parameters listed in the following table:

TABLE 44—INFILTRATION DUE TO WIND FORCES

Parameter	Condition	Ch/h	Condition	Ch/h
Exposure	Sheltered	0	Exposed	$+\frac{1}{2}$
Construction	Wet	0	Dry	$+\frac{1}{2}$
Location of windows	1 wall or 2 adjacent walls	0	2 opposite walls, 3 or 4 walls	$+\frac{1}{2}$
Type of window	Gasketed	0	Not gasketed	$+\frac{1}{2}$
Degree of fenestration. (Openable window area per wall area)	Less 25%	0	50%	$+\frac{1}{4}$
Partitioning	Nil	0	Heavy	$-\frac{1}{2}$*

*Deductible only if the total air changes of the other parameters are equal to or greater than half.

If the outdoor air quantity exceeds half an air change per hour deduct the difference from the amount of infiltration established according to Table 44. As that amount cannot exceed $2\frac{1}{4}$ Ch/h it is evident that even in the worst case infiltration is completely offset by the outdoor (ventilation) air when the ventilation rate equals or exceeds $2\frac{3}{4}$ Ch/h.

For a naturally ventilated and heated building calculate the infiltration from *Table 44* and add half an air change per hour. Add 10% of the value so arrived at for stack effect, but only in case of buildings equal to or greater than 10 storeys high, *and* with unrestricted access from individual floors to stair well(s).

The quantity of infiltration due to stack effect so arrived at is to be used when establishing boiler capacity. However, when establishing the capacity of heating equipment (radiators) for individual floors, an additional 20% to 0% is to be allowed for the bottom floor to the floor midway up the building.

Example 1—Summer infiltration

Given:

20 storey, air conditioned building of curtain wall construction, located among other buildings of equal

height. Gasketed windows in four walls, occupying 50% of the wall area. The building is used for 'landscaped' (open planning) offices and the outdoor air requirements have been calculated at threequarters of an air change per hour.

Find:
Summer infiltration.

Solution:
From *Table 44* infiltration rates are:

Exposure:	$+\frac{1}{4}$	(The building can be considered halfway between sheltered and exposed)
Construction:	$+\frac{1}{2}$	
Location of windows:	$+\frac{1}{2}$	
Type of window:	0	
Degree of fenestration:	$+\frac{1}{4}$	
Partitioning:	0	
Total	$1\frac{1}{2}$ Ch/h	

As the outdoor air is $\frac{3}{4}$ Ch/h, i.e. $\frac{1}{4}$ above $\frac{1}{2}$ Ch/h, deduct $(\frac{3}{4} - \frac{1}{2}) = \frac{1}{4}$ Ch/h
The infiltration to be allowed in this case is:
$1\frac{1}{2} - \frac{1}{4} = 1\frac{1}{4}$ Ch/h

Example 2—Winter Infiltration. Air Conditioned Building

Given:
The same building as in *Example 1.*

Find:
Winter infiltration

Solution:
Stack effect is to be neglected, and the infiltration due to wind forces is $1\frac{1}{4}$ Ch/h as per *Example 1.*

Example 3—Winter Infiltration. Naturally Ventilated and Heated Building

Given:
20 storey building of in-situ concrete construction, located on top of a hill. Steel frame (non-gasketed) windows in two walls occupying 50% of the wall area. Open planning with badly leaking doors leading from each floor to a common stair well.

Find:
Winter infiltration

Solution:
Infiltration due to wind forces from *Table 44.*

Exposure:	$+\frac{1}{2}$
Construction:	0
Location of windows:	0
Type of window:	$+\frac{1}{2}$
Degree of fenestration:	$+\frac{1}{4}$
Partitioning:	0
Total	$1\frac{1}{4}$ changes per hour plus $\frac{1}{2}$ Ch/h $= 1\frac{3}{4}$ Ch/h

Infiltration due to stack effect $0.1 \times 1.75 = 0.175$, say 0.18 Ch/h
Total infiltration $= 1.75 + 0.18 = 1.93$ Ch/h, to be considered when calculating boiler capacity.

Infiltration rate on ground floor:
$1.2 \times 1.93 = 2.32$ Ch/h
Infiltration rate midway up the building (10th floor)
$1.0 \times 1.93 = 1.93$ Ch/h
Infiltration rate on floors between ground and 10th floor: in proportion.

VENTILATION

The amount of outside air to be introduced into the conditioned space after having passed through the air conditioning equipment is governed by a number of considerations.

Dilution of Odours

For an occupation density of 1 person per 4.5 to 7.0 m² an outdoor air quantity of 5 ℓ/s has been found adequate when there is no smoking. This quantity should be increased to 25 ℓ/s with very heavy smoking (company board rooms).

Dilution of Toxic or Explosive Mixtures

In certain laboratories and to a lesser extent in hospital operating theatres it is necessary to use all outdoor air to avoid hazards from poisoning or explosion.

Offsetting Infiltration

The greater the amount of outdoor air over and above any exhaust air the smaller will be the amount of infiltration. An amount of not less than half an air change per hour should be allowed for 'pressurisation'. The air change rate should be determined on the basis of the actual ceiling height unless such height exceeds 4.5 m, in which case a fictitious height of 4.5 m should be assumed.

Limitations of Equipment

The construction and control mechanism of outdoor air and return air dampers makes it difficult to control with reasonable accuracy the amount of outdoor air handled when its percentage of total air becomes too small. A figure of not less than 10% should be allowed for outdoor air compared with total (supply) air.

Economics

The greater the amount of outdoor air the greater the amount of grand total heat (GTH). If the dew point of the outdoor air is greater than that of the room air, the increase in size of refrigeration plant will be greater than the increase in grand total heat because of reduction in apparatus dew point. The greater the amount of outside air the more coil surface has to be provided (i.e. the smaller the bypass factor which has to be selected).

Capital and operating cost of plant therefore increases with increase in outdoor air.

Example 4—Outdoor Air Requirements for a Lecture Theatre

Given:
Dimensions:
18.0 m × 9.0 m × (3.0 m to 4.5 m) high (sloping ceiling)

Number of occupants:
160

Duration of occupancy:
(*a*) Intermittent (half an hour on, one hour off)
(*b*) Continuous (8 hours)
No smoking

Find:
Outdoor air requirements

Solution:
Check on odour dilution:
Occupation density: (18 × 9)/160 = 1.01 m²/occupant
(*a*) In spite of the high occupancy density a figure of 5 ℓ/s, person will be adequate for intermittent occupancy.
(*b*) Because of continued occupancy and high density a figure of 10 ℓ/s, person will be selected.
(*a*) 5 × 160 = 800 ℓ/s
(*b*) 10 × 160 = 1600 ℓ/s

Check of infiltration:
Half a change per hour
$= \frac{1}{2} \times (18 \times 9 \times (3 + 4.5)/2) \times 1000\ (\ell/m^3)/(3600\ s/h)$
= 84.4 ℓ/s which is less than the requirements for odour dilution.

Check on % outside air:
Assume that as a result of calculations (load estimate sheet) the total (supply) air quantity had been determined at 2000 ℓ/s (approx. 12 changes per hour).
The percentage outside air is therefore:
(*a*) 800/2000 × (100) = 40%
(*b*) 1600/2000 × (100) = 80%
The outdoor air requirements are in this case therefore governed by the requirement for odour dilution and are:
(*a*) 800 ℓ/s for intermittent occupancy, and
(*b*) 1600 ℓ/s for continuous occupancy.
i.e. in both cases more than 10%.

Example 5—Outdoor air requirements for a laboratory

Given:
Chemical laboratory
Dimensions: 9.0 m × 5.0 m × 5.5 m high (the laboratory is located in an old building with high ceilings)
Fume cupboard: 100 ℓ/s exhaust
Number of occupants: 3
No smoking

Find:
Outdoor air requirements

Solution:
Check on personal odour dilution 3 occupants at 5 ℓ/s = 15 ℓ/s
Check on chemical odour and toxicity dilution
Covered by fume cupboard exhaust: 100 ℓ/s
Check on infiltration:
$\frac{1}{2}$ Ch/h = $\frac{1}{2}$ (9 × 5 × 4.5) × 1000/3600 = 28.1, say 30 ℓ/s
Outdoor air requirements: 100 + 30 = 130 ℓ/s
Check on outside air percentage:
Assume that load sheet calculations have resulted in a total (supply) air requirement of 340 ℓ/s.
Percentage outside air: 130/340 × (100) = 38.2%, greater than 10%.
The outdoor air requirements are therefore governed by the amount of air exhausted and the requirement to avoid undue infiltration. 100 + 30 = 130 ℓ/s.

CHAPTER 7. INTERNAL AND SYSTEM HEAT GAIN

INTERNAL HEAT GAIN

Internal heat gain is the sensible and latent heat released within the air conditioned space by the occupants, lights, appliances, machines, pipes, etc. This chapter outlines the procedures for determining the instantaneous *heat gain* from these sources. A portion of the heat gain from internal sources is radiant heat which is partially absorbed in the building structure, thereby reducing instantaneous heat gain. *Chapter 3, 'Heat Storage, Diversity and Stratification'*, contains the data and methods for estimating the actual cooling load from the heat sources referred to in the following text.

PEOPLE

Heat is generated within the human body by oxidation, commonly called metabolic rate. The metabolic rate varies with the individual and with his activity level. The normal body processes are performed most efficiently at a deep tissue temperature of about 37°C; this temperature may vary only through a narrow range. However, the human body is capable of maintaining this temperature, through a wide ambient temperature range, by conserving or dissipating the heat generated within itself.

This heat is carried to the surface of the body by the blood stream and is dissipated by:

1. Radiation from the body surface to the surrounding surfaces.
2. Convection from the body surface and the respiratory tract to the surrounding air.
3. Evaporation of moisture from the body surface and in the respiratory tract to the surrounding air.

The amount of heat dissipated by radiation and convection is determined by the difference in temperature between the body surface and its surroundings. The body surface temperature is regulated by the quantity of blood being pumped to the surface; the more blood, the higher the surface temperature up to a limit of about 35.5°C. The heat dissipated by evaporation is determined by the difference in vapour pressure between the body and the air.

Basis of Table 45 —Heat Gain from People

Table 45 is based on the metabolic rate of an average adult male, with a mass of 68 kilograms, at different levels of activity, and generally for occupancies longer than 3 hours. These have been adjusted for typical compositions of mixed groups of males and females for the listed applications. The metabolic rate of women is about 85% of that for a male, and for children about 75%.

The heat gain for restaurant applications has been increased 10 W sensible and 10 W latent heat per person to include the food served.

The data in *Table 45* as noted are for continuous occupancy. The excess heat and moisture brought in by people, where short time occupancy is occurring (under 15 minutes), may increase the heat gain from people by as much as 10%.

Use of Table 45 —Heat Gain from People

To establish the proper heat gain, the room design temperature and the activity level of the occupants must be known. *Table 45* quotes values for typical examples.

LIGHTS

Lights generate sensible heat by the conversion of the electrical power input into light and heat. The heat is dissipated by radiation to the surrounding surfaces, by conduction into the adjacent materials and by convection to the surrounding air. The radiant portion of the light load is partially stored, and the convection portion may be stratified as described in the last section of *Chapter 3*. Refer *Table 11*, to determine the actual cooling load.

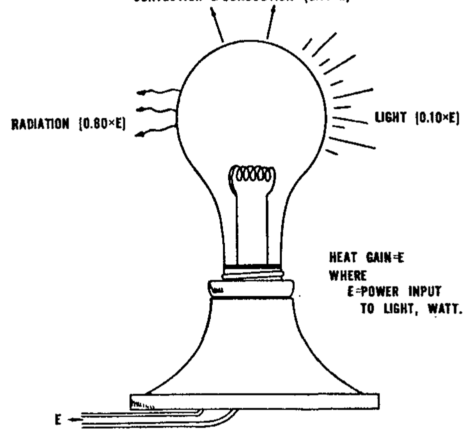


Fig. 33—Conversion of electric power to heat and light with incandescent lights, approximate

TABLE 45—HEAT GAIN FROM PEOPLE

Degree of Activity	Typical Application	Metabolic Rate (Adult Male) Watts	Average Adjusted Metabolic Rate* Watts	ROOM DRY-BULB TEMPERATURE											
				28°C		27°C		26°C		24°C		22°C		20°C	
				Watts		Watts		Watts		Watts		Watts		Watts	
				Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.	Sens.	Lat.
Seated at rest	Theatre	115	100	50	50	55	45	60	40	67	33	72	28	79	21
Seated, very light work	High School	130	120	50	70	55	65	60	60	70	50	78	42	84	36
Seated, Standing	Office, Hotels	140	130												
Standing, Walking Slowly	Dept., Retail Store	160		50	80	56	74	60	70	70	60	78	52	86	44
Walking, Seated	Airport Terminal	160	150	53	97	58	92	64	86	76	74	84	66	90	60
Standing Walking Slowly	Bank	160													
Sedentary Work	Restaurant†	150	160	55	105	60	100	68	92	80	80	90	70	98	62
Light bench work	Factory, light work	230	220	55	165	62	158	70	150	85	135	100	120	115	105
Moderate Dancing	Halls, Ballrooms	260	250	62	188	70	180	78	172	94	156	110	140	125	125
Walking, 1.5 m/s	Factory, fairly heavy work	300	300	80	220	88	212	96	204	110	190	130	170	145	155
Heavy Work	Factory	440	430	132	298	138	292	144	286	154	276	170	260	188	242

*Adjusted Metabolic Rate is the metabolic rate to be applied to a mixed group of people with a typical percent composition based on the following factors:
Metabolic rate, adult female = Metabolic rate, adult male × 0.85
Metabolic rate, child = Metabolic rate, adult male × 0.75

†Restaurant—Values for this application include 20 watts for food per individual (10 watts sensible and 10 watts latent heat).

TABLE 46—HEAT GAIN FROM PANTRY OR TEA ROOM EQUIPMENT

ELECTRIC HEATED—NOT HOODED*

Appliance	Type of Control	Miscellaneous Data	Manuf. max. Ratings kW	Recommended heat gain for average use		
				Sensible kW	Latent kW	Total kW
Boiling Water Urn 5 ℓ	Simmerstat or Man.	Single heat control	1.510	0.6	0.3	0.9
5 ℓ	Simmerstat or Man.	Three heat control	2.000	0.8	0.4	1.2
10 ℓ	Simmerstat or Man.	Three heat control	2.000	0.8	0.4	1.2
20 ℓ	Simmerstat or Man.	Three heat control	2.420	1.0	0.5	1.5
30 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
40 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
50 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
2x10 ℓ	Simmerstat or Man.	Three heat control	3.620	1.5	0.7	2.2
Boiling Top 150 mm dia.	Auto. or Man.	Coil type heavy duty	1.260	0.6	0.2	0.8
160 mm dia.	Auto. or Man.	Coil type heavy duty	1.510	0.6	0.3	0.9
200 mm dia.	Auto. or Man.	Coil type heavy duty	2.110	0.9	0.4	1.3
160 mm dia.	Auto. or Man.	Cast Plate	1.000	0.4	0.2	0.6
200 mm dia.	Auto. or Man.	Cast Plate	1.815	0.8	0.3	1.1
Griddle Plate 250 mm x 200 mm	Auto. or Man.	Coil Type	2.000	0.8	0.4	1.2
300 mm x 250 mm	Auto. or Man.	Coil Type	2.785	1.2	0.5	1.7
450 mm x 250 mm	Thermostat	Plate Type	2.420	1.0	0.5	1.5
450 mm x 400 mm	Thermostat	Plate Type	4.425	1.9	0.8	2.7
Bain Marie 2 x 7 ℓ pots	Simmerstat	Counter type	0.850	0.3	0.2	0.5
4 x 7 ℓ pots	Simmerstat	Counter type				
6 x 7 ℓ pots	Simmerstat	Mobile	1.500	0.6	0.3	0.9
6 x 7 ℓ pots & hot press	Thermostat	Mobile	3.000	1.3	0.5	1.8
6 x 7 ℓ pots, 1–250 mm x 200 mm meal dish & hot press	Thermostat	Mobile	2.400	1.0	0.4	1.4
Hot Trolley	Thermostat	Bulk Supplies 30 people	2.400	1.0	0.4	1.4
	Thermostat	Plated service 30 people	2.400	1.0	0.4	1.4
Dispensers 190 mm plates	Thermostat	Single Tube	0.38	0.1	0.1	0.2
	Thermostat	Double Tube	0.75	0.3	0.2	0.5
	Thermostat	Four Tube	1.50	0.6	0.3	0.9
Dishwasher 1000 pieces/hour 250 mm dinner plate		Rotary for crockery only, Electric boost Water 270 ℓ/h at 85°C	3.0 15.0 } 18.0	7.5	7.5	15.0
Glasswasher 1000 glasses/hour		Rotary basket, Electric boost Water 270 ℓ/h at 85°C	3.0 15.0 } 18.0	7.5	7.5	15.0
Toaster 6 slice	Variable	Bench mounted	3.160	1.3	0.6	1.9
12 slice	3 heat variable	Bench mounted single deck	3.600	1.5	0.7	2.2
Continuous 360 slices/hour	3 heat variable	Bench mounted rotary	4.100	2.4	1.1	3.5
Continuous 450 slices/hour	Variable	Horizontal type	3.000	1.8	0.8	2.6
Food Warmer 36 pies	Simmerstat	Bench Mounted	1.000	0.4	0.2	0.6
60 pies	Simmerstat	Bench Mounted	1.500	0.6	0.3	0.9
100 pies	Simmerstat	Bench Mounted	2.000	0.8	0.4	1.2
Stoves 3 plate	Auto.	Domestic type with coil plates	9.300	3.9	1.7	5.6
4 plate	Auto.	Domestic type with coil plates	11.500	4.8	2.1	6.9
Refrigerators:						
0.5 m³ standard temperature	Auto.	One 0.20 kW motor	0.520	0.3	—	0.3
0.5 m³ dual temperature	Auto.	Two 0.15 kW motors	0.510	0.3	—	0.3
0.5 m³ low temperature	Auto.	One 0.40 kW motor	0.670	0.4	—	0.4
Coffee Machine 10 ℓ	Auto.	2 x 5 ℓ containers	6.000	2.5	1.1	3.6
5 ℓ	Auto.	2 x 2.5 ℓ containers	6.000	2.5	1.1	3.6
Coffee Brewer 3 ℓ	Auto.	2 x 1.5 ℓ containers	1.500	0.6	0.3	0.9
Insect Control Unit	Auto.	Single Sided	0.040	0.04	—	0.04
	Auto.	Double Sided	0.080	0.08	—	0.08

*If properly designed positive exhaust hood is used, multiply recommended value by 0.50.

TABLE 47—HEAT GAIN FROM MISCELLANEOUS APPLIANCES

NOT HOODED*

Appliance	Type of Control	Miscellaneous Data	Manuf. Max. Ratings kW	Recommended heat gain for average use		
				Sensible kW	Latent kW	Total kW
Hair Dryer, Blower Type 7A, 240V A.C.	Man.	Fan 160W (Low 915W, high 1580W)	1.580	0.8	0.1	0.9
Hair Dryer, helmet type 3A, 240V A.C.	Man.	Fan 80W (low 300W, high 710W)	0.710	0.3	0.1	0.4
Permanent Wave Machine	Man.	60 heaters at 25W each, 36 in normal use	1.500	0.8	0.1	0.9
Pressurized instrument washer & sterilizer (free standing)†		280 x 280 x 560 mm		3.3	6.7	10.0
Solution and/or blanket warmer		450 x 750 x 1800 mm		0.8	0.4	1.2
		450 x 600 x 1800 mm		0.7	0.3	1.0
Sterilizer dressing	Auto.	400 x 600 mm		2.7	2.7	5.4
	Auto.	500 x 900 mm		6.9	7.0	13.9
Sterilizer, Rectangular bulk (free standing)†	Auto.	600 x 600 x 900 mm		9.8	6.6	16.4
	Auto.	600 x 600 x 1200 mm		12.1	8.0	20.1
	Auto.	600 x 900 x 1200 mm		16.2	10.8	27.0
	Auto.	600 x 900 x 1500 mm		20.0	13.3	33.3
	Auto.	900 x 1000 x 2000 mm		45.6	30.4	76.0
Sterilizer, Instrument (free standing)†	Auto.	150 x 200 x 430 mm		0.8	0.7	1.5
	Auto.	230 x 250 x 500 mm		1.3	1.3	2.6
	Auto.	250 x 300 x 550 mm		2.0	2.1	4.1
	Auto.	250 x 300 x 900 mm		2.9	2.8	5.7
	Auto.	300 x 410 x 600 mm		2.6	2.6	5.2
Sterilizer, Utensil (free standing)†	Auto.	400 x 400 x 600 mm		3.0	6.1	9.1
	Auto.	500 x 500 x 600 mm		3.7	7.4	11.1
Sterilizer, hot air (free standing)†	Auto.	Model 120 Amer Sterilizer Co.		0.6	1.2	1.8
	Auto.	Model 100 Amer Sterilizer Co.		0.3	0.7	1.0
Water Still		23 ℓ/h		0.5	0.8	1.3
X-ray machines for making pictures X-ray machines for therapy		Physicians & Dentists office heat load may be appreciable. Write to manufacturers for data.		None	None	None
Sterilizer Water (free standing)†	Auto.	50 ℓ		1.2	4.8	6.0
	Auto.	75 ℓ		1.8	7.2	9.0
GAS BURNING						
Burners, Laboratory small bunsen	Man.	10 mm dia. barrel with town gas	0.500	0.2	0.1	0.3
small bunsen	Man.	10 mm dia. barrel with natural gas	0.900	0.4	0.1	0.5
fishtail burner	Man.	10 mm dia. barrel with natural gas	1.000	0.5	0.1	0.6
fishtail burner	Man.	10 mm dia. barrel with natural gas	1.600	0.8	0.2	1.0
large bunsen	Man.	40 mm dia. adjacent orifice	1.800	0.9	0.2	1.1
Hair Dryer System 5 helmets	Man.	Consists of heater and fan which blows hot air	9.700	4.6	1.2	5.8
10 helmets	Man.	through duct system to helmets	9.700	6.9	1.8	8.7

*If properly designed positive exhaust hood is used, multiply recommended value by 0.50.
†For built-in equipment allow 15% of recommended sensible heat gain and 100% of recommended latent heat gain.

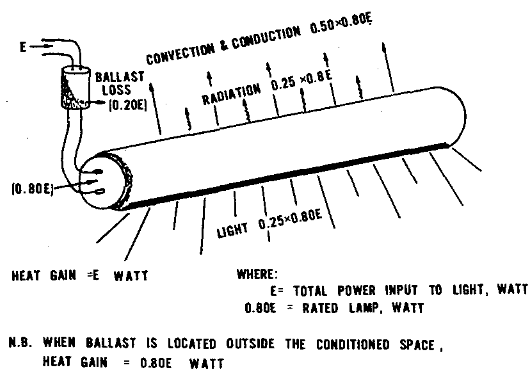


Fig. 34—Conversion of electric power to heat and light with fluorescent lights, approximate

Incandescent lights convert approximately 10% of the power input into light with the rest being generated as heat within the bulb and dissipated by radiation, convection and conduction. About 80% of the power input is dissipated by radiation and only about 10% by convection and conduction, *Fig. 33.*

Fluorescent lights convert about 25% of the power input into light, with about 25% being dissipated by radiation into the surrounding surfaces. The other 50% is dissipated by conduction and convection. In addition to this, approximately 25% more heat is generated as heat in the ballast of the fluorescent lamp. *Fig. 34.*

APPLIANCES

Most appliances contribute both sensible and latent heat to a space. Electric appliances contribute latent heat, only by virtue of the function they perform, that is, drying, cooking, etc., whereas gas burning appliances contribute additional moisture as a product of combustion. A properly designed hood with a positive exhaust system removes a considerable amount of the generated heat and moisture from most types of appliances.

Basis of Table 46
—Heat Gain from Pantry or Tea Room Equipment

The rating of equipment has been obtained from Australian manufacturers.

Because of the wide variation in available figures for recommended heat gain for average use, an arbitrary percentage of 60% of the manufacturer's rating has been assumed for the total recommended heat gain, and an arbitrary 30% of the total for the recommended latent heat gain.

As a result of Departmental experience, departures from the 60% rule have been made for dishwashers, glasswashers and continuous toasters, for which a figure of 85% has been assumed.

Departures from the 30% rule have been made for dishwashers and glasswashers where a figure of 50% has been used.

All recommended figures have been rounded off to the nearest first decimal.

Basis of Table 47
—Heat gain from miscellaneous appliances

The data of this table is in general a conversion to metric (SI) units of the figures published in *Table 51* of the Carrier System Design Manual (Part 1, page 103). The figures have been rationalised by allowing the same ratio of sensible to latent recommended heat gain for the various sizes of one and the same type of equipment (e.g. approximately 50 : 50 for instrument sterilizers) and have been rounded off to the nearest first decimal. In the case of the solution and blanket warmer the ratio has been changed from 30 : 70 to 70 : 30.

Heat emissions for built-in equipment have been added by the Department of Works and are covered in the footnote.

Use of Tables 46 and 47
—Heat Gain from Pantry and Tea Room Equipment and from Miscellaneous Appliances

The Recommended for Average Use values are those which the appliance generates under normal use. These appliances seldom operate at maximum capacity during peak load.

The values in *Tables 46* and *47* are for unhooded appliances. If the appliance has a properly designed positive exhaust hood, reduce the sensible and the latent heat gains by 50%. A hood, to be effective, should extend beyond the appliance approximately 100 mm per 300 mm of height between the appliance and the face of the hood. The lower edge should not be higher than 1200 mm above the appliance and the average face velocity across the hood should not be less than 0.35 m/s.

ELECTRIC MOTORS

Electric motors contribute sensible heat to a space by converting the electrical power input to heat. Some of this power input is dissipated as heat in the motor frame and can be evaluated as

$$\text{input} \times (1 - \text{motor eff.})$$

The rest of the power input (motor output) is dissipated by the driven machine and in the drive mechanism. The driven machine utilizes this motor output to do work which may or may not result in a heat gain to the space.

Motors driving fans and pumps: The power input increases the pressure and velocity of the fluid and the temperature of the fluid.

The increased energy level in the fluid is degenerated in pressure drop throughout the system and appears as a heat gain to the fluid at the point where pressure drop occurs. This heat gain does not appear as a temperature rise because, as the pressure reduces, the fluid expands. The fluid expansion is a cooling process which exactly offsets the heat generated by friction. The heat of compression required to increase the energy level is generated at the fan or pump *and* is a heat gain at this point.

If the fluid is conveyed outside of the air conditioned space, only the inefficiency of the motor driving fan or pump should be included in room sensible heat gain.

If the temperature of the fluid is maintained by a separate source, these heat gains to the fluid heat of compression are a load on this separate source only.

The heat gain or loss from the system should be calculated separately (see the section on 'System Heat Gain' later in this chapter).

Motors driving process machinery (lathe, press, etc.): The total power input to the machine is dissipated as heat at the machine. If the product is removed from the conditioned space at a higher temperature than it came in, some of the heat input into the machine is removed and should not be considered a heat gain to the conditioned space. The heat added to a product is determined by multiplying the number of kilograms of material handled per second by the specific heat and temperature rise. Expressed in watts, the heat gain = (kg/s) × (kJ/kg.°C × 1000 J/kJ) × (°C)

Basis of Table 48 —Heat Gain from Electric Motors

Table 48 is based on average efficiencies of squirrel cage induction open type integral horsepower and fractional horsepower motors. Power supply for fractional horsepower motors is 240 volts, 50 cycle, single phase; for integral horsepower motors, 415/240, 50 cycle, 3 phase constant speed, 16 or 24 r/s.

Use of Table 48 —Heat Gain from Electric Motors

The data in *Table 48* includes the heat gain from electric motors and their driven machines when both the motor and the driven machine are in the conditioned space, or when only the driven machine is in the conditioned space, or when only the motor is in the conditioned space.

Caution: The power input to electric motors does not necessarily equal the rated output divided by the motor efficiency. Frequently these motors may be operating under a continuous overload, or may be operating at less than rated capacity. It is always advisable to measure the power input wherever possible. This is especially important in estimates for industrial installations where the motor-machine load is normally a major portion of the cooling load.

Example 1—Electric Motor Heat Gain in a Factory

Given:

1. Forty-five 15 kW motors operated at 80% rated capacity, driving various types of machines located within air conditioned space (lathes, screw machines, etc.).

   Five 15 kW motors operated at 80% rated capacity, driving screw machines, each handling 2500 kg of bronze per h. Both the final product and the shavings from the screw machines are removed from the space on conveyor belts. Rise in bronze temperature is 15°C, and the specific heat is 0.042 kJ/kg°C.
2. Ten 7.5 kW motors (fully loaded) driving fans, exhausting air to the outdoors.
3. Three 30 kW motors (fully loaded) driving process water pumps, water discarded outdoors.

Find:

Total heat gain from motors.

Solution:

Use *Table 48*	Sensible Heat Gain kW
1. Machines—Heat gain to space $= 45 \times 17.2 \times 0.80 =$	620
Heat gain from screw machines $= 5 \times 17.2 \times 0.80 = 68.8$ kW	
Heat removed from space from screw machine work $= 2500/3600 \times 5 \times 15 \times 0.042 = 2.2$ kW	
Net heat gain from screw machines to space $= 68.8 - 2.2 =$	66.6
2. Fan exhausting air to the outdoors: Heat gain to space $= 10 \times 1.32 =$	13.2
3. Process water pumped to outside air conditioned space Heat gain to space $= 3 \times 3.7 =$	11.1
Total heat gain from motors on machines, fans, and pumps =	710.9 say 711 kW

Note:

If the process water were to be recirculated and cooled in the circuit from an outside source, the heat gain to the water

$3 \times (33.7 - 3.7) = 90$ kW

would become a load on this outside source.

PIPING, TANKS AND EVAPORATION OF WATER FROM A FREE SURFACE

Hot pipes and tanks add sensible heat to a space by convection and radiation. Conversely, cold pipes remove sensible heat. All open tanks containing hot water contribute not only sensible heat but also latent heat due to evaporation.

In industrial plants, furnaces or dryers are often encountered. These contribute sensible heat to the space by convection and radiation from the outside surfaces, and frequently dryers also contribute sensible and latent heat from the drying process.

Basis of Table 49 —Heat Transmission Coefficients for Horizontal Bare Pipes in Still Air

The figures in *Table 49* have been calculated from the basic equations for radiant and convective heat transfer. (See Section C–3 of the IHVE Guide Book C, 1970; Institution of Heating and Ventilating Engineers, London.) The figures are strictly applicable only for pipe material with an emissivity of 0.85 (e.g. weathered stainless steel). Emissivities vary from

TABLE 48—HEAT GAIN FROM ELECTRIC MOTORS kW

CONTINUOUS OPERATION*

Output Power kW†	Full Load Motor Efficiency Percent	Location of Equipment with Respect to Conditioned Space or Air Stream‡		
		Motor in— Driven Machine in— $\frac{\text{Output Power}}{\text{\% Efficiency}}$	Motor out— Driven Machine in— *Output Power*	Motor in— Driven Machine out— $\frac{\text{Output Power (1 – \% Eff)}}{\text{\% Efficiency}}$
0.04	41	0.10	0.04	0.06
0.06	49	0.12	0.06	0.06
0.09	55	0.16	0.09	0.07
0.12	60	0.20	0.12	0.08
0.19	64	0.30	0.19	0.11
0.25	67	0.37	0.25	0.12
0.37	70	0.53	0.37	0.16
0.55	72	0.76	0.55	0.21
0.75	73	1.03	0.75	0.28
1.1	79	1.39	1.1	0.29
1.5	80	1.88	1.5	0.38
2.2	82	3.66	2.2	0.66
4.0	83	4.82	4.0	0.82
5.5	84	6.55	5.5	1.05
7.5	85	8.82	7.5	1.32
11	86	12.8	11	1.8
15	87	17.2	15	2.2
18.5	88	21.0	18.5	2.5
22	88	25.0	22	3.0
30	89	33.7	30	3.7
37	89	41.6	37	4.6
45	90	50.0	45	5.0
55	90	61.1	55	6.1
75	90	83.3	75	8.3
90	90	100	90	10.0
110	91	121	110	11
132	91	145	132	13
150	91	165	150	15
185	91	203	185	18
220	92	239	220	19
250	92	272	250	22

*For intermittent operation, an appropriate usage factor should be used, preferably measured.

‡For a fan or pump in air conditioned space, exhausting air and pumping fluid to outside of space, use values in last column.

as low as 0.04 (polished aluminium) to 0.97 (matt black paint).

Emissivity also varies slightly with pipe surface temperature. The figures normally are sufficiently accurate and safe. However, for air conditioned spaces with a large amount of piping of emissivity other than 0.85, consult Guide Book C for correct values of heat transmission coefficients.

Heat transfer increases with air movement, e.g. at a velocity of 1.0 m/s it is approximately double that in still air for small pipes, but only 50% greater than in still air for large pipes.

Heat transfer for vertical pipes is generally slightly less than for horizontal pipes. However, it is safe and reasonable for the purpose of establishing cooling loads to use the figures for horizontal pipes.

Basis of Table 50
—Heat Transmission Coefficients for Insulated Pipes in Still Air

The figures in *Table 50* have been calculated from the basic heat emission equation for radial flow through circular cylinders. (See Section C–3 of IHVE Guide Book C, 1970). Although the film coefficient at the insulation–air interface varies from 5.7 $W/m^2.°C$ for polished surfaces to 10.0 $W/m^2.°C$ for dull surfaces, the table is based on a figure of 8.4 $W/m^2.°C$ as are all other heat transfer tables. For an air velocity of 1.0 m/s the film coefficient increases by approximately 30%.

Basis of Table 51
—Heat Transmission Coefficients for Bare Plane Surfaces in Still Air

The figures in *Table 51* have been calculated from basic heat transfer equations. (See Section C–3, IHVE Guide Book C, 1970.) They are based on an emissivity of 0.85, a film coefficient at the surface–air interface of 8.4 $W/m^2.°C$ and on the assumption that the mean radiant temperature of the enclosure is the same as the ambient air dry-bulb temperature. Where the conditioned space contains a large number of tanks or one tank which is large in comparison with the conditioned space and where such a tank or tanks have emissivities differing substantially from 0.85 (e.g. 0.04 for polished aluminium), consult Guide Book C for correct values of heat transmission coefficients.

Basis of Table 52
—Evaporation from a Free Water Surface: Latent Heat Gain

Table 52 is based on the following formula for still air: Heat of evaporation (W/m^2) = 88.5 × difference in water vapour pressure (kPa) between water and room at 24°C DB and 50% RH.

Use of Tables 49 to 52
—Heat Gain from Piping, Tanks and Evaporation of Water

Example 2—Heat Gain from Steam Pipe and Hot Water Storage Tank

Given:

Room conditions—24°C DB, 50% RH.
2.0 m of 2.19 mm uninsulated steam (110°C) pipe. Hot water (50°C) is stored in a 2.0 m wide × 3.0 m long × 2.0 m high weathered stainless steel tank with the top open to the atmosphere. The tank is supported on open steel framework.

Find:

Sensible and latent heat gain

Solution:

Use *Tables 49, 51* and *52*	Watt
Piping—Sensible heat gain $= 2 \times (110 - 24) \times 9.23 =$	1588
Tank—Sensible heat gain, sides $= (2+3) \times 2 \times 2 \times (50-24) \times 10.04 =$	5221
—Sensible heat gain, bottom $= 2 \times 3 \times (50 - 24) \times 8.7 =$	1357
Total sensible heat gain =	8166 say 8200
Total latent heat gain, top $= 2 \times 3 \times 960 =$	5760 say 5800

STEAM

When steam is escaping into the conditioned space, the room sensible heat gain is only that heat represented by the difference in heat content of steam at the steam temperature and at the room dry-bulb temperature (g/s × temp. diff. × specific heat). The sensible heat gain expressed in watts = (g/s) × (°C) × 1.883 kJ/kg.°C. The latent heat gain is equal to the grams per second escaping times 2500 kJ/kg.

MOISTURE ABSORPTION

When moisture (regain) is absorbed by hygroscopic materials, sensible heat is added to the space. The heat so gained is equal to the latent heat of vapourization which is approximately 2500 kJ/kg times the grams per second of water absorbed. This sensible heat is an addition to room sensible heat, and a deduction from room latent heat if the hygroscopic material is removed from the conditioned space.

LATENT HEAT GAIN—CREDIT TO ROOM SENSIBLE HEAT

Some forms of latent heat gain reduce room sensible heat. Moisture evaporating at the room wet-bulb temperature (not heated or cooled from external source) utilizes room sensible heat for heat of evaporation. This form of latent heat gain should be deducted from room sensible heat and added to room latent heat. This does not change the total

TABLE 49—HEAT TRANSMISSION COEFFICIENTS FOR HORIZONTAL BARE PIPES IN STILL AIR

Watts per lineal metre degree Celsius between pipe and surrounding air at 15°C*

Pipe Outside Diameter mm	TEMPERATURE DIFFERENCE °C																	
	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	260	280	300
21.3	0.90	0.96	1.01	1.06	1.11	1.15	1.20	1.24	1.33	1.41	1.50	1.58	1.67	1.77	1.86	1.96	2.07	2.18
26.9	1.10	1.17	1.24	1.30	1.35	1.41	1.46	1.52	1.62	1.73	1.83	1.94	2.05	2.17	2.29	2.41	2.54	2.68
33.7	1.33	1.42	1.50	1.57	1.64	1.71	1.77	1.84	1.97	2.10	2.23	2.36	2.50	2.64	2.79	2.95	3.11	3.28
42.4	1.63	1.73	1.83	1.91	2.00	2.08	2.16	2.24	2.40	2.56	2.72	2.89	3.06	3.24	3.42	3.62	3.82	4.03
48.3	1.82	1.94	2.04	2.14	2.24	2.33	2.42	2.51	2.69	2.87	3.05	3.24	3.43	3.63	3.84	4.06	4.29	4.53
60.3	2.20	2.34	2.47	2.59	2.71	2.82	2.93	3.04	3.26	3.48	3.71	3.94	4.18	4.43	4.69	4.96	5.24	5.54
73.0	2.60	2.77	2.92	3.06	3.20	3.33	3.46	3.59	3.85	4.11	4.38	4.66	4.95	5.25	5.56	5.89	6.23	6.58
88.9	3.09	3.28	3.46	3.63	3.79	3.95	4.11	4.27	4.58	4.89	5.22	5.55	5.90	6.26	6.64	7.03	7.44	7.87
101.6	3.47	3.69	3.89	4.08	4.26	4.44	4.62	4.79	5.15	5.51	5.87	6.25	6.65	7.06	7.49	7.94	8.40	8.89
114.3	3.84	4.09	4.31	4.52	4.72	4.92	5.12	5.32	5.71	6.11	6.52	6.95	7.39	7.85	8.33	8.83	9.35	9.90
141.3	4.63	4.92	5.19	5.44	5.69	5.93	6.17	6.41	6.89	7.37	7.88	8.40	8.94	9.50	10.09	10.71	11.35	12.03
168.3	5.40	5.74	6.05	6.35	6.64	6.92	7.20	7.48	8.04	8.62	9.21	9.82	10.46	11.13	11.83	12.56	13.32	14.12
219.1	6.82	7.24	7.64	8.01	8.38	8.74	9.09	9.45	10.17	10.90	11.67	12.45	13.28	14.14	15.04	15.98	16.97	18.01
273.0	8.29	8.81	9.28	9.74	10.19	10.62	11.06	11.50	12.38	13.29	14.22	15.20	16.22	17.28	18.40	19.57	20.79	22.08
323.9	9.65	10.25	10.81	11.34	11.86	12.37	12.88	13.39	14.43	15.49	16.59	17.74	18.94	20.20	21.51	22.89	24.34	25.86

*For an emissivity of 0.85.

TABLE 50—HEAT TRANSMISSION COEFFICIENTS FOR INSULATED PIPES

Watts per lineal metre degree Celsius temperature difference between surface and surrounding air*

Pipe Outside Diameter mm	Thermal Conductivity W/m.°C								
	0.040			0.055			0.070		
	Insulation Thickness mm								
	25	40	50	25	40	50	25	40	50
21.3	0.19	0.15	0.14	0.25	0.21	0.19	0.31	0.26	0.23
26.9	0.21	0.17	0.15	0.28	0.23	0.21	0.35	0.29	0.26
33.7	0.25	0.19	0.17	0.32	0.26	0.23	0.40	0.32	0.29
42.4	0.29	0.22	0.20	0.38	0.30	0.27	0.46	0.37	0.33
48.3	0.31	0.24	0.21	0.41	0.32	0.29	0.50	0.40	0.36
60.3	0.36	0.28	0.24	0.48	0.37	0.33	0.58	0.46	0.41
73.0	0.42	0.31	0.27	0.55	0.42	0.37	0.67	0.52	0.46
88.9	0.49	0.36	0.31	0.64	0.48	0.42	0.78	0.59	0.52
101.6	0.54	0.40	0.34	0.71	0.53	0.46	0.86	0.65	0.57
114.3	0.60	0.43	0.37	0.78	0.58	0.50	0.95	0.71	0.62
141.3	0.71	0.51	0.44	0.93	0.68	0.59	1.13	0.84	0.73
168.3	0.83	0.59	0.50	1.08	0.78	0.67	1.31	0.96	0.83
219.1	1.04	0.73	0.62	1.36	0.97	0.83	1.64	1.20	1.03
273.0	1.27	0.89	0.74	1.65	1.17	1.00	2.00	1.44	1.23
323.9	1.49	1.03	0.86	1.93	1.36	1.15	2.34	1.68	1.43

OUTSIDE FILM COEFFICIENT = 8.4 W/m².°C

*For an emissivity of 0.85.

room heat gain, but may have considerable effect on the sensible heat factor.

HEAT GAINS—STEAM OR ELECTRIC HUMIDIFIERS

When the evaporation of moisture derives its heat from another source such as steam or electric heating coils, sensible and latent heat gains to the room are calculated in the same manner as for steam escaping into the room. (Because the sensible heat is small compared with the latent heat it is frequently neglected.) The power input into steam or electric coils equals the room sensible plus latent heat gains, and in addition the heat required to bring the water from its initial temperature to boiling point. (Theoretically any heat lost to the surroundings from the humidifying equipment should also be added.)

TABLE 52
Evaporation from a free water surface—latent heat gain

Still air, room at 24°C DB, 50% RH

Water Temp °C	20	35	50	65	80	95
W/m²	75	366	960	2080	4060	7350

SYSTEM HEAT GAIN

The system heat gain is considered as the heat added to or lost by the system components, such as the ducts, piping, air conditioning fan, and pump, etc. This heat gain must be estimated and included in the load estimate but can be accurately evaluated only after the system has been designed.

SUPPLY AIR DUCT HEAT GAIN

The supply duct normally has 10°C DB to 15°C DB air flowing through it. The duct may pass through an unconditioned space having a temperature of, say, 30°C DB and up. This results in a heat gain to the duct before it reaches the space to be conditioned. This, in effect, reduces the cooling capacity of the conditioned air. To compensate for it, the cooling capacity of the air quantity must be increased. For this reason ducts in unconditioned spaces are always insulated to minimize heat gain. (For long duct runs it may be necessary to apply insulation even where the duct is located in the conditioned space.)

Basis of Chart 3
—Percent Room Sensible Heat to be Added for Heat Gain to Supply Duct

Chart 3 is based on a difference of 18°C DB between supply air entering the duct and unconditioned space, a supply duct velocity of 10 m/s in a duct with a 2 : 1 aspect ratio, still air on the outside of the duct and a supply air rise of 10°C DB. Correction factors for different room temperatures, duct velocities and temperature differences are included below *Chart 3.* Values are plotted for use with uninsulated, furred and insulated ducts.

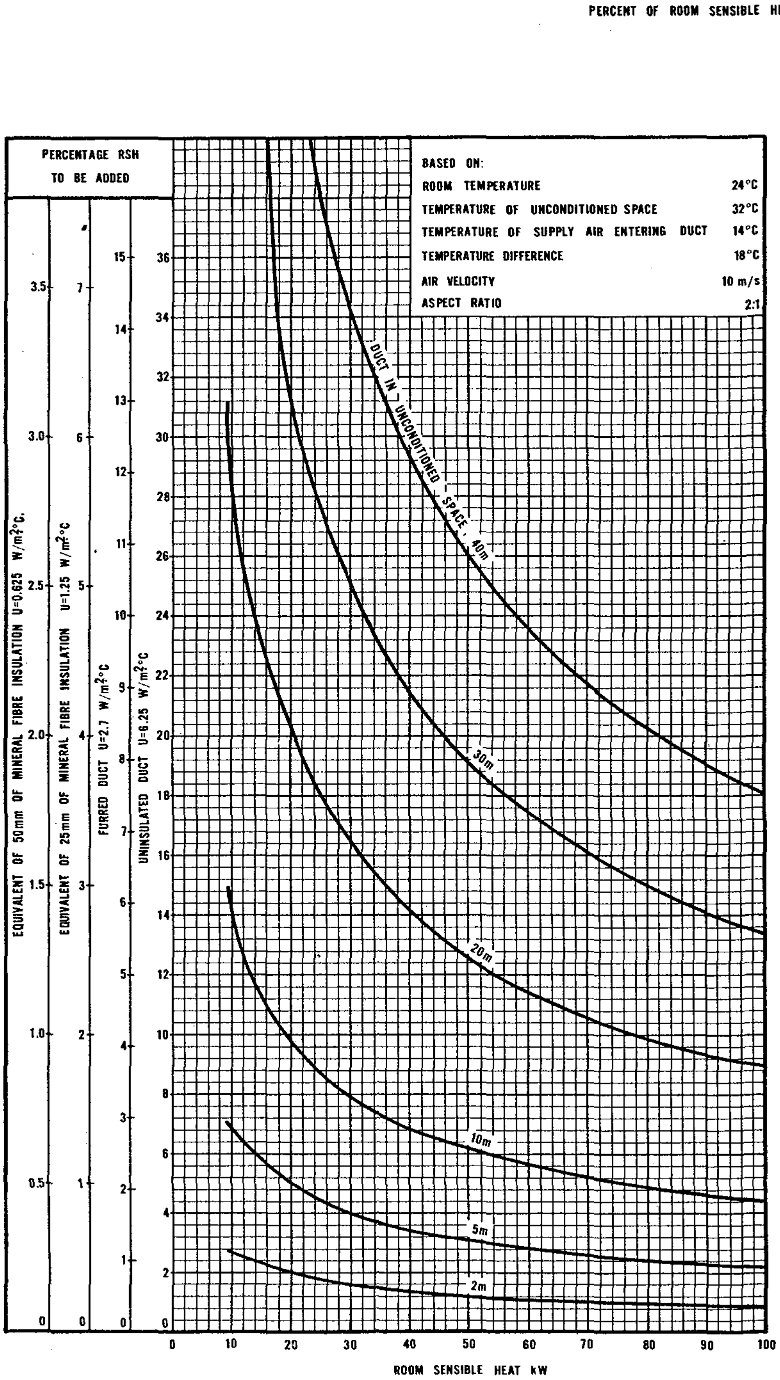
TABLE 51—HEAT TRANSMISSION COEFFICIENTS FOR BARE PLANE SURFACES IN STILL AIR

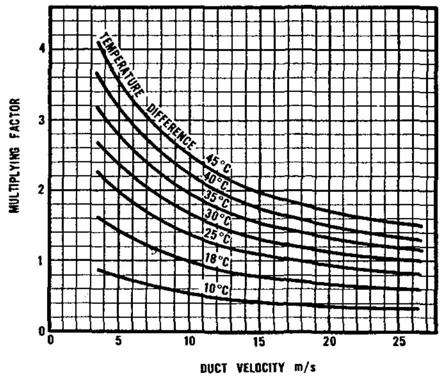
Watts per square metre degree Celsius temperature difference between surface and surrounding air*

Surface Temperature °C	Horizontal Looking Down							Vertical							Horizontal Looking Up						
	Ambient (Mean Radiant) Temperature °C																				
	10.0	12.5	15.0	17.5	20.0	22.5	25.0	10.0	12.5	15.0	17.5	20.0	22.5	25.0	10.0	12.5	15.0	17.5	20.0	22.5	25.0
20	6.93	6.83	6.68	6.44	–	–	–	8.00	7.82	7.58	7.19	–	–	–	9.07	8.82	8.48	7.95	–	–	–
30	7.62	7.59	7.55	7.50	7.43	7.33	7.19	8.89	8.82	8.73	8.63	8.50	8.33	8.09	10.16	10.04	9.91	9.76	9.56	9.32	8.99
40	8.17	8.17	8.16	8.15	8.13	8.11	8.07	9.58	9.54	9.50	9.46	9.40	9.34	9.26	10.98	10.92	10.85	10.76	10.67	10.56	10.44
50	8.67	8.68	8.69	8.70	8.70	8.71	8.70	10.18	10.17	10.15	10.13	10.11	10.08	10.05	11.69	11.65	11.61	11.57	11.51	11.45	11.39
60	9.14	9.16	9.19	9.20	9.22	9.24	9.25	10.74	10.74	10.74	10.74	10.73	10.72	10.71	12.33	12.31	12.29	12.27	12.24	12.21	12.17
70	9.60	9.63	9.66	9.69	9.71	9.74	9.76	11.27	11.28	11.29	11.30	11.31	11.31	11.32	12.94	12.93	12.93	12.92	12.90	12.89	12.87
80	10.05	10.09	10.12	10.16	10.19	10.22	10.25	11.79	11.81	11.82	11.84	11.86	11.87	11.89	13.52	13.53	13.53	13.53	13.53	13.53	13.52
90	10.50	10.54	10.58	10.62	10.66	10.70	10.74	12.30	12.32	12.35	12.37	12.39	12.42	12.44	14.09	14.10	14.11	14.12	14.13	14.14	14.14
100	10.95	11.00	11.04	11.08	11.13	11.17	11.22	12.80	12.83	12.86	12.89	12.92	12.95	12.98	14.65	14.67	14.68	14.70	14.72	14.73	14.75
120	11.87	11.92	11.97	12.02	12.08	12.13	12.18	13.81	13.85	13.89	13.93	13.97	14.01	14.05	15.76	15.79	15.81	15.84	15.87	15.90	15.93
140	12.82	12.88	12.93	12.99	13.05	13.11	13.17	14.84	14.89	14.94	14.99	15.04	15.08	15.13	16.87	16.91	16.95	16.98	17.02	17.06	17.10
160	13.81	13.87	13.93	13.99	14.06	14.12	14.19	15.91	15.96	16.01	16.07	16.12	16.18	16.23	18.01	18.05	18.10	18.14	18.19	18.23	18.28

*For an emissivity of 0.85.

Chart 3—Heat gain to supply duct





MULTIPLYING FACTORS FOR OTHER ROOM TEMPERATURES

Room Temperature	Multiplying Factor
24.0	1.00
24.5	0.95
25.0	0.91
25.5	0.88
26.0	0.86
26.5	0.84
27.0	0.82

$$Q = UPL \frac{2420 \times aV}{(2420 \times aV + UPL)} (t_3 - t_1)$$

where Q = duct heat gain (W)
U = duct heat transmission factor ($W/m^2.°C$)
P = rectangular duct perimeter (m)
L = duct length (m)
a = duct area (m^2)
V = air velocity through duct (m/s)
t_1 = temperature of supply air entering duct (°C)
t_3 = temperature of air surrounding duct (°C)
Based on formulae in ASHRAE Handbook of Fundamentals 1972 pp. 479 and 480.

Use of Chart 3
—Percent Room Sensible Heat to be Added for Heat Gain to Supply Duct

To use this chart, evaluate the length of duct running through the unconditioned space, the temperature of unconditioned space, the duct velocity, the supply air temperature entering the duct and room sensible heat sub-total.

Example 3—Heat Gain to Supply Duct

Given:
10.0 m of uninsulated duct in unconditioned space at 40°C DB
Duct velocity—15 m/s
Supply air temperature entering the duct—15°C DB.
Room sensible heat gain—50 kW

Find:
Percent addition to room sensible heat

Solution:
The supply air to unconditioned space temperature difference = 40 − 15 = 25°C DB.
From *Chart 3*, percent addition = 6.1%
Correction for 25°C DB temperature difference and 15 m/s duct velocity = 1.1
Actual percent addition = 6.1 × 1.1 = 6.7%

SUPPLY AIR DUCT LEAKAGE LOSS

Air leakage from the supply duct may be a serious loss of cooling effect, except when it leaks into the conditioned space. This loss of cooling effect must be added to the room sensible and latent heat load.

Experience indicates that the average air leakage from the entire length of *low velocity* supply ducts, whether large or small systems, averages around 10% of the supply air quantity. Smaller leakage per metre of length for larger perimeter ducts appears to be counterbalanced by the longer length of run. Individual workmanship is the greatest variable, and duct leakages from 5% to 30% have been found. The following is a guide to the evaluation of duct leakages under various conditions:

1. Bare ducts within conditioned space—usually not necessary to figure leakage.
2. Furred or insulated ducts within conditioned space—a matter of judgment, depending on whether the leakage air actually gets into the room.
3. All ducts outside the conditioned space—assume 10% leakage. This leakage is a total loss and the full amount must be included. When only part of the supply duct is outside the conditioned space, include that fraction of 10% as the leakage. (Fraction is ratio of length outside of conditioned space to total length of supply duct.)

High velocity systems usually limit leakage to 1%.

HEAT GAIN FROM AIR CONDITIONING FAN

The inefficiency of the air conditioning equipment fan and the heat of compression adds heat to the system as described under '*Electric Motors*'. In the case of draw-through systems, this heat is an addition to the supply air heat gain and should be added to the room sensible heat. With blow-through systems (fan blowing air through the coil, etc.) the fan heat added is a load on the dehumidifier and, therefore, should be added to the grand total heat (see '*Percent Addition to Grand Total Heat*').

Basis of Table 53
—Heat Gain from Air Conditioning Fan

The air conditioning fan adds heat to the system in the following manner:

1. Immediate temperature rise in the air due to the inefficiency of the fan.
2. Energy gain in the air as a pressure and/or velocity rise.
3. With the motor and drive in the air stream or conditioned space, the heat generated by the inefficiency of the motor and drive is also an immediate heat gain.

The fan efficiencies are about 70% for central station type fans and about 50% for packaged equipment fans.

Use of Table 53
—Heat Gain from Air Conditioning Fan

The approximate system pressure loss and dehumidified air rise (room minus supply air temperature) differential must be estimated from the system characteristics and type of application. These should be checked from the final system design.

The normal comfort application has a dehumidified air rise of between 8°C DB and 16°C DB and the fan total pressure depends on the amount of ductwork involved, the number of fittings (elbows, etc.) in the ductwork and the type of air distribution system used. Normally, the fan total pressure can be approximated as follows:

1. No ductwork (packaged equipment)—0.125 to 0.25 kPa.
2. Moderate amount of ductwork, low velocity systems—0.2 to 0.4 kPa.
3. Considerable ductwork, low velocity system—0.3 to 0.5 kPa.
4. Moderate amount of ductwork, high pressure system—0.5 to 1.0 kPa.
5. Considerable ductwork, high pressure system—0.75 to 2.0 kPa.

TABLE 53—HEAT GAIN FROM AIR CONDITIONING FAN kW, DRAW-THROUGH SYSTEM¶

	Fan Total Pressure† kPa	CENTRAL STATION SYSTEMS‡				APPLIED OR UNITARY SYSTEM§			
		Temperature Difference Room to Supply Air				Temperature Difference Room to Supply Air			
		6°C	10°C	14°C	18°C	6°C	10°C	14°C	18°C
		Per Cent of Room Sensible Heat*							
Fan Motor not in Conditioned Space or Air Stream	0.1	1.0	0.6	0.4	0.3	1.7	1.0	0.7	0.6
	0.2	2.0	1.2	0.8	0.6	3.5	2.1	1.5	1.2
	0.3	3.5	2.1	1.5	1.1	5.8	3.3	2.5	2.0
	0.4	4.8	2.8	2.0	1.6	7.8	4.6	3.3	2.7
	0.5	6.0	3.5	2.4	2.0	9.7	5.7	4.2	3.4
	0.6	7.5	4.0	3.2	2.6	12.0	7.1	5.2	4.1
	0.8	10.7	5.5	4.6	3.5	16.7	10.1	7.1	5.6
	1.0	14.3	8.4	6.1	4.6				
	1.2	17.4	10.2	7.3	5.7				
	1.4	20.9	12.4	9.0	7.0				
	1.6	25.3	15.0	10.9	8.6				
	1.8	30.3	17.1	13.0	10.4				
	2.0	35.3	21.0	15.0	12.2				
Fan Motor‖ in Conditioned Space or Air Stream	0.1	1.2	0.7	0.5	0.4	2.0	1.2	0.9	0.6
	0.2	2.6	1.6	1.1	0.8	4.2	2.5	1.8	1.4
	0.3	4.5	2.6	1.9	1.4	6.8	4.0	2.9	2.3
	0.4	6.0	3.6	2.6	2.0	9.1	5.4	3.9	3.1
	0.5	7.6	4.6	3.2	2.6	11.4	6.8	4.9	3.9
	0.6	9.5	5.6	4.0	3.2	14.0	8.4	6.0	4.7
	0.8	13.5	7.9	5.6	4.5	19.3	11.7	8.3	6.5
	1.0	17.8	10.5	7.5	6.0				
	1.2	21.4	12.7	9.0	7.2				
	1.4	25.7	15.3	11.0	8.9				
	1.6	30.6	18.4	13.1	10.6				
	1.8	36.1	21.8	15.6	12.4				
	2.0	41.6	25.2	18.0	14.2				

*Exclude from heat gain, typical values for bearing losses, etc., which are dissipated in apparatus room.

†Fan Total Pressure equals fan static pressure plus velocity pressure at fan discharge. Below 6 m/s the fan total pressure is approximately equal to the fan static. Above 6 m/s the total pressure should be calculated.

‡70% fan efficiency assumed.

§50% fan efficiency assumed.

‖80% motor and drive efficiency assumed.

¶For draw-through systems, this heat is an addition to the supply air gain and is added to the room sensible heat. For blow-through systems this fan heat is added to the grand total heat; use the RSH times the percentage listed and add to the GTH.

Example 4—Heat Gain from Air Conditioning Fan

Given:

Same data as *Example 3*

20.0 m of supply duct in conditioned space

Find:

Percent addition to room sensible heat.

Solution:

Assume 0.3 kPa, fan total pressure. For (24°C − 15°C approx.) = 9°C DB dehumidifier rise, heat gain from fan = 2.5% (*Table 53*, interpolated)

SAFETY FACTOR AND PERCENT ADDITIONS TO ROOM SENSIBLE AND LATENT HEAT

A safety factor to be added to the room sensible heat sub-total should be considered as strictly a factor of probable error in the survey or estimate, and should usually be between 0% and 5%.

The total room sensible heat is the sub-total plus percentage additions to allow for (1) supply duct heat gain, (2) supply duct leakage losses, (3) fan power and (4) safety factor, as explained in the preceding paragraph.

Example 5—Percent Addition to Room Sensible Heat

Given:
Same data as *Examples 3* and *4*

Find:
Percent addition to room sensible heat gain sub-total

Solution:

Supply duct heat gain	= 6.7%
Supply duct leakage (10.0 m duct of total 30.0 m)	= 1.5%
Fan power	= 2.5%
Safety factor	= 0.0%
Total percent addition to RSH	= 10.7%

The percent additions to room latent heat for supply duct leakage loss and safety factor should be the same as the corresponding percent additions to room sensible heat.

RETURN AIR DUCT HEAT AND LEAKAGE GAIN

The evaluation of heat and leakage effects on return air ducts is made in the same manner as for supply air ducts, except that the process is reversed; there is inward gain of hot moist air instead of loss of cooling effect.

Chart 3 can be used to approximate heat gain to the return duct system in terms of percent of RSH, using the following procedure:

1. Using RSH and the length of return air duct, use *Chart 3* to establish the percent heat gain.
2. Use the multiplying factor from table below *Chart 3* to adjust the percent heat gain for actual temperature difference between the air surrounding the return air duct and the air inside the duct, and also for the actual velocity.
3. Multiply the resulting percentage of heat gain by the ratio of RSH to GTH.
4. Apply the resulting heat gain percentage to GTH.

To determine the return air duct leakage, apply the following reasoning:

1. Bare duct within conditioned space—no inleakage.
2. Furred duct within conditioned space or furred space used for return air—a matter of judgment, depending on whether the furred space may connect to unconditioned space.
3. Ducts outside conditioned space—assume up to 3% inleakage, depending on the length of duct. If there is only a short connection between conditioned space and apparatus, inleakage may be disregarded. If there is a long run of duct, then apply judgment as to the amount of inleakage.

HEAT GAIN FROM DEHUMIDIFIER PUMP

With dehumidifier systems, the horsepower required to pump the water adds heat to the system as outlined under '*Electric Motors*'. This heat will be an addition to the grand total heat.

TABLE 54—HEAT GAIN FROM DEHUMIDIFIER PUMP

Pump Pressure kPa	SMALL PUMPS* 0–7.5 ℓ/s					LARGE PUMPS† 7.5 ℓ/s AND LARGER				
	CHILLED WATER TEMP RISE °C					CHILLED WATER TEMP RISE °C				
	2	4	6	8	10	2	4	6	8	10
	Per Cent of Grand Total Heat									
100	2.5	1.5	1.0	0.5	0.5	2.0	1.0	0.5	0.5	—
200	4.0	2.5	1.5	1.0	1.0	3.0	2.0	1.0	1.0	0.5
300	6.0	4.0	2.0	1.5	1.5	5.0	3.0	2.0	1.5	1.0

*Efficiency 50% †Efficiency 70%

Basis of Table 54
—Heat Gain from Dehumidifier Pump

Table 54 is based on pump efficiencies of 50% for small pumps and 70% for large pumps. Small pumps are considered to have a capacity of less than 7.5 ℓ/s; large pumps, more than 7.5 ℓ/s.

Use of Table 54
—Heat Gain from Dehumidifier Pump

The chilled water temperature rise in the dehumidifier and the pump head must be approximated to use *Table 54*.

1. Large systems with considerable piping and fittings may require up to 300 kPa pump head; normally, 200 kPa head is the average.
2. The normal water temperature rise in the dehumidifier is between 4°C and 7°C.

PERCENT ADDITION TO GRAND TOTAL HEAT

The percent additions to the grand total heat to compensate for various external losses consist of heat and leakage gain to return air ducts, heat gain from the dehumidifier pump, and the heat gain to the dehumidifier and piping system.

These heat gains can be estimated as follows:

1. Heat and leakage gain to return air ducts, see above.
2. Heat gain from dehumidifier pump, *Table 54*.
3. Dehumidifier and piping losses:
   (*a*) Very little external piping—1% of GTH.
   (*b*) Average external piping—2% of GTH.
   (*c*) Extensive external piping—4% of GTH.
4. Blow-through fan system—add percent room sensible heat from *Table 53* to GTH.
5. Dehumidifier in conditioned apparatus room—reduce the above percentages by one half.

CHAPTER 8. APPLIED PSYCHROMETRICS

The preceding chapters contain the practical data to properly evaluate the heating and cooling loads. They also recommend outdoor air quantities for ventilation purposes.

This chapter describes practical psychrometrics as applied to apparatus selection. It is divided into three parts:

1. *Description of terms, processes and factors*—as encountered in normal air conditioning applications.
2. *Air conditioning apparatus*—factors affecting common processes and the effect of these factors on selection of air conditioning equipment.
3. *Psychrometrics of partial load control*—the effect of partial load on equipment selection and on the common processes.

To help recognize terms, factors and processes described in this chapter, a brief definition of psychrometrics is offered at this point, along with an illustration and definition of terms appearing on a standard psychrometric chart (*Fig. 35*).

Dry-bulb Temperature—The temperature of air as registered by an ordinary thermometer.

Wet-bulb Temperature—The temperature registered by a thermometer whose bulb is covered by a wetted wick and exposed to a current of rapidly moving air.

Dewpoint Temperature—The temperature at which condensation of moisture begins when the air is cooled.

Relative Humidity—Ratio of the actual water vapour pressure of the air to the saturated water vapour pressure of the air at the same temperature.

Specific Humidity or Moisture Content—The weight of water vapour in grams of moisture per kilogram of dry air.

Enthalpy—A thermal property indicating the quantity of heat in the air above an arbitrary datum, in kilojoules per kilogram of dry air. The datum for dry air is 0°C and, for the moisture content, 0°C water.

Enthalpy Deviation—Enthalpy indicated above, for any given condition, is the enthalpy of saturation. It should be corrected by the enthalpy deviation due to the air not being in the saturated state. Enthalpy deviation is in kilojoules per kilogram of dry air. Enthalpy deviation is applied where extreme accuracy is required; however, on normal air conditioning estimates it is omitted.

Specific Volume—The cubic metre of the mixture per kilogram of dry air.

Sensible Heat Factor—The ratio of sensible to total heat.

Alignment Circle—Located at 24°C DB and 50% RH and used in conjunction with the sensible heat factor to plot the various air conditioning process lines.

Kilograms of Dry Air—The basis for all psychrometric calculations. Remains constant during all psychrometric processes.

The dry-bulb, wet-bulb, and dewpoint temperatures and the relative humidity are so related that, if two properties are known, all other properties shown may then be determined. When air is saturated, dry-bulb, wet-bulb, and dewpoint temperatures are all equal.

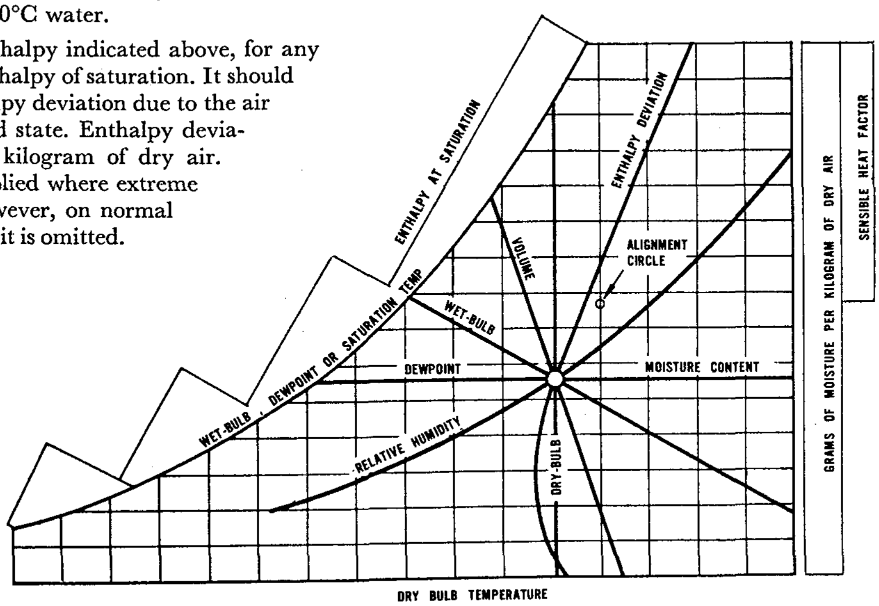


Fig. 35—Skeleton psychrometric chart

PSYCHROMETRIC CHART

BAROMETRIC PRESSURE: 101·325 kPa

AIR CONDITIONING PROCESS

1. RETURN AIR FROM THE ROOM ① IS MIXED WITH OUTDOOR AIR ② REQUIRED FOR VENTILATION.
2. THIS MIXTURE OF OUTDOOR AND RETURN AIR ENTERS THE APPARATUS ③ WHERE IT IS CONDITIONED TO ④ AND SUPPLIED TO THE SPACE ①
3. THEN THE AIR CYCLE IS REPEATED AGAIN.

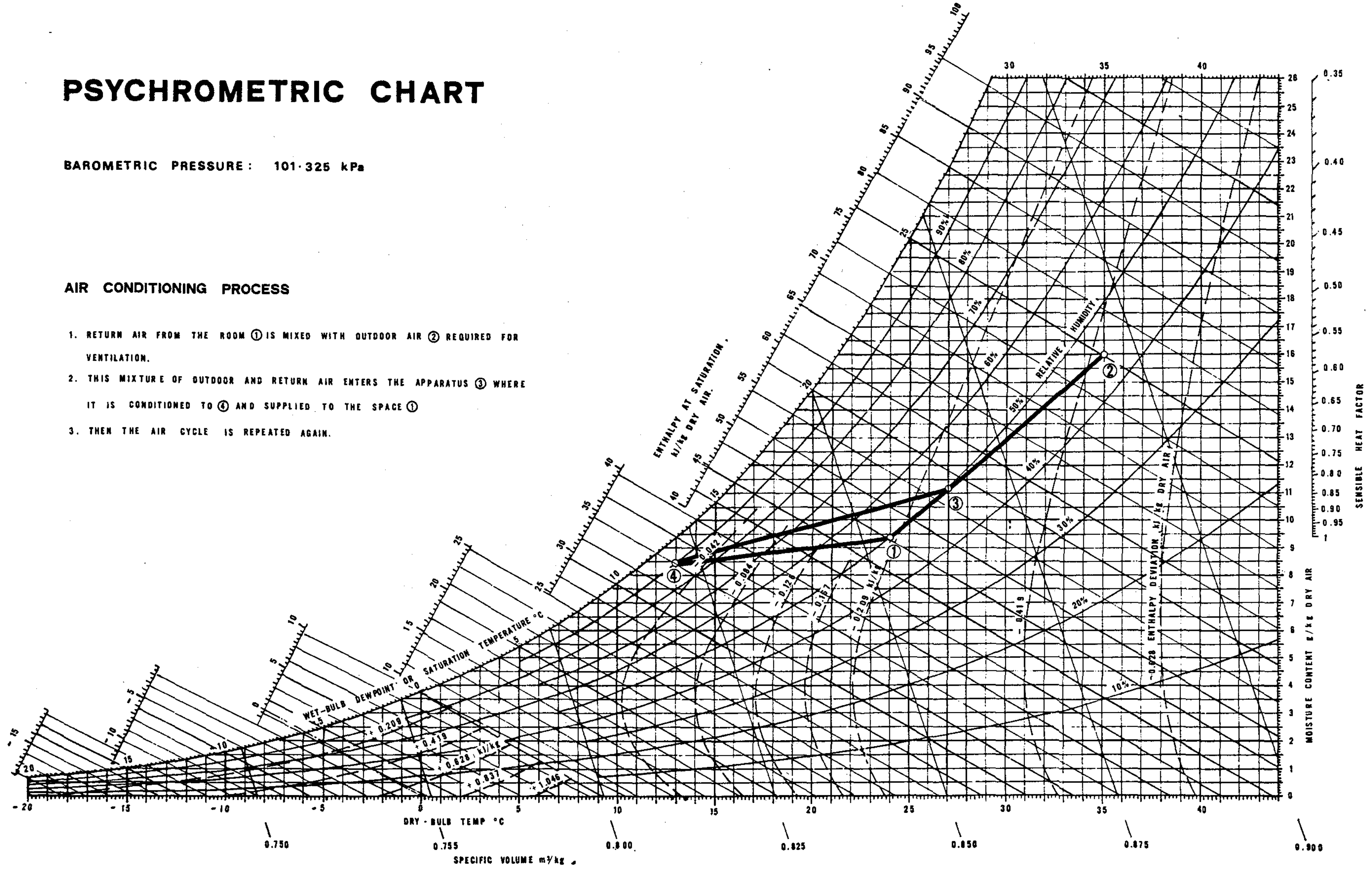


Fig. 36—Typical air conditioning process traced on a standard psychrometric chart

DEFINITION

Psychrometrics is the science involving thermodynamic properties of moist air and the effect of atmospheric moisture on materials and human comfort. As it applies to this chapter, the definition must be broadened to include the method of controlling the thermal properties of moist air.

AIR CONDITIONING PROCESSES

Fig. 36 shows a typical air conditioning process traced on a psychrometric chart. Outdoor air (*2*)* is mixed with return air from the room (*1*) and enters the apparatus (*3*). Air flows through the conditioning apparatus (*3–4*) and is supplied to the space (*4*). The air supplied to the space moves along line (*4–1*) as it picks up the room loads, and the cycle is repeated. Normally most of the air supplied to the space by the air conditioning system is returned to the conditioning apparatus. There, it is mixed with outdoor air required for ventilation. The mixture then passes through the apparatus where heat and moisture are added or removed, as required, to maintain the desired conditions.

The selection of proper equipment to accomplish this conditioning and to control the thermodynamic properties of the air depends upon a variety of elements. However, only those which affect the psychrometric properties of air will be discussed in this chapter. These elements are: room sensible heat factor (RSHF)†, grand sensible heat factor (GSHF), effective surface temperature (t_{ES}), bypass factor (BF), and effective sensible heat factor (ESHF).

DESCRIPTION OF TERMS, PROCESSES AND FACTORS

SENSIBLE HEAT FACTOR

The thermal properties of air can be separated into latent and sensible heat. The term *sensible heat factor* is the ratio of sensible to total heat, where total heat is the sum of sensible and latent heat. This ratio may be expressed as:

$$\text{SHF} = \frac{\text{SH}}{\text{SH}+\text{LH}} = \frac{\text{SH}}{\text{TH}}$$

where: SHF = sensible heat factor
SH = sensible heat
LH = latent heat
TH = total heat

ROOM SENSIBLE HEAT FACTOR (RSHF)

The *room sensible heat factor* is the ratio of room sensible heat to the summation of room sensible and room latent heat. This ratio is expressed in the following formula:

$$\text{RSHF} = \frac{\text{RSH}}{\text{RSH}+\text{RLH}} = \frac{\text{RSH}}{\text{RTH}}$$

The supply air to a conditioned space must have the capacity to offset simultaneously both the room sensible and room latent heat loads. The room and the supply air conditions to the space may be plotted on the standard psychrometric chart and these points connected with a straight line (*1–2*), *Fig. 37*. This line represents the psychrometric process of the supply air within the conditioned space and is called the room sensible heat factor line.

The slope of the RSHF line illustrates the ratio of sensible to latent loads within the space and is illustrated in *Fig. 37* by Δh_s (sensible heat) and Δh_l (latent heat). Thus, if adequate air is supplied to offset these room loads, the room requirements will be satisfied, provided both the dry- and wet-bulb temperatures of the supply air fall on this line.

The room sensible heat factor line can also be drawn on the psychrometric chart without knowing the condition of supply air. The following procedure illustrates how to plot this line, using the calculated RSHF, the room design conditions, the sensible heat factor scale in the upper right hand corner of the psychrometric chart, and the alignment circle at 24°C dry-bulb and 50% relative humidity:

1. Draw a base line through the alignment circle and the calculated RSHF shown on the sensible heat factor scale in the upper right corner of psychrometric chart (*1–2*), *Fig. 38*.

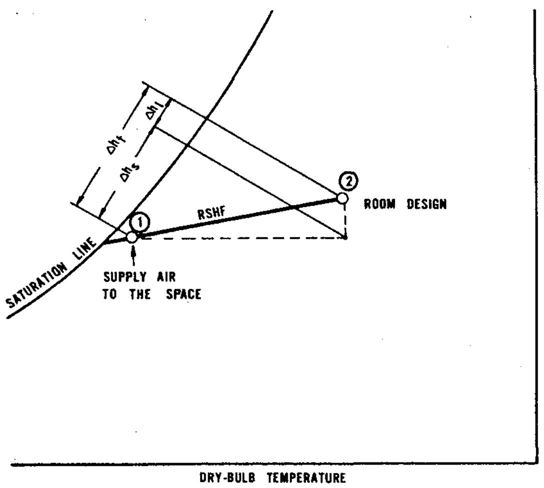


Fig. 37—RSHF line plotted between room and supply air conditions

*One italic number in parentheses represents a point, and two italic numbers in parentheses represent a line, plotted on the accompanying psychrometric chart examples.

†Refer to the end of this chapter for a description of all abbreviations and symbols used in this chapter.

J

2. Draw the actual room sensible heat factor line through the room design conditions parallel to the base line in *Step 1* (*3–4*), *Fig. 38*. As shown, this line may be drawn to the saturation line on the psychrometric chart.

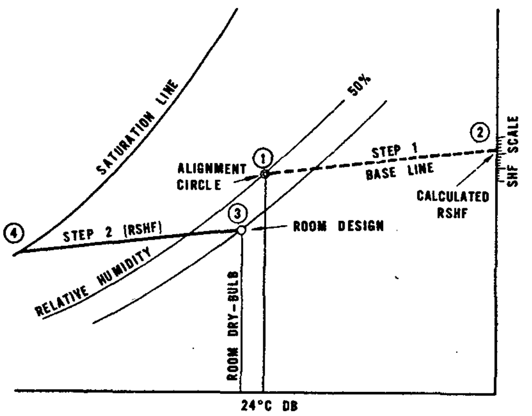


Fig. 38—RSHF line plotted on skeleton psychrometric chart

GRAND SENSIBLE HEAT FACTOR (GSHF)

The *grand sensible heat factor* is the ratio of the total sensible heat to the grand total heat load that the conditioning apparatus must handle, including the outdoor air heat loads. This ratio is determined from the following equation:

$$\text{GSHF} = \frac{\text{TSH}}{\text{TLH}+\text{TSH}} = \frac{\text{TSH}}{\text{GTH}}$$

Air passing through the conditioning apparatus increases or decreases in temperature and/or moisture content. The amount of rise or fall is determined by the total sensible and latent heat loads that the conditioning apparatus must handle. The condition of the air entering the apparatus (mixture condition of outdoor and return room air) and the condition of the air leaving the apparatus may be plotted on the psychrometric chart and connected by a straight line (*1–2*), *Fig. 39*. This line represents the psychrometric process of the air as it passes through the conditioning apparatus, and is referred to as the grand sensible heat factor line.

The slope of the GSHF line represents the ratio of sensible and latent heat that the apparatus must handle. This is illustrated in *Fig. 39* by Δh_s (sensible heat) and Δh_l (latent heat).

The grand sensible heat factor line can be plotted on the psychrometric chart without knowing the condition of supply air, in much the same manner as the RSHF line. *Fig. 40*, *Step 1* (*1–2*) and *Step 2* (*3–4*) show the procedure, using the calculated GSHF, the mixture condition of air to the apparatus, the sensible heat factor scale, and the alignment

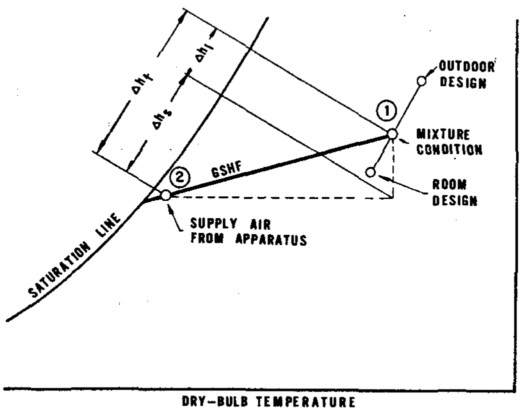


Fig. 39—GSHF line plotted between mixture conditions to apparatus and leaving condition from apparatus

circle on the psychrometric chart. The resulting GSHF line is plotted through the mixture conditions of the air to the apparatus.

REQUIRED AIR QUANTITY

The air quantity required to offset simultaneously the room sensible and latent loads and the air quantity required through the apparatus to handle the total sensible and latent loads may be calculated, using the conditions on their respective RSHF and GSHF lines. For a particular application, when both the RSHF and GSHF ratio lines are plotted on the psychrometric chart, the intersection of the two lines (*1*) *Fig. 41*, represents the condition of the supply air to the space. It is also the condition of the air leaving the apparatus.

This neglects fan and duct heat gain, duct leakage losses, etc. In actual practice, these heat gains and

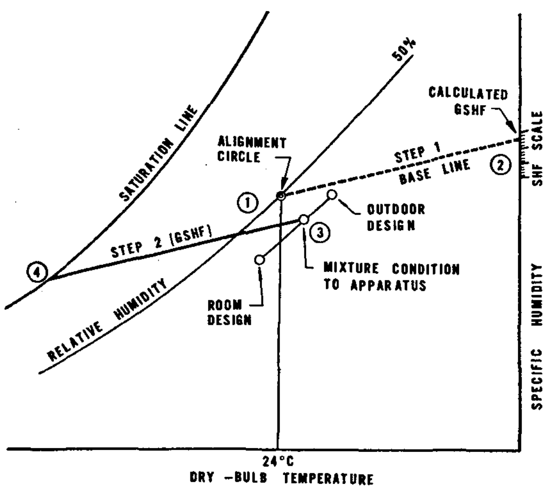


Fig. 40—GSHF line plotted on skeleton psychrometric chart

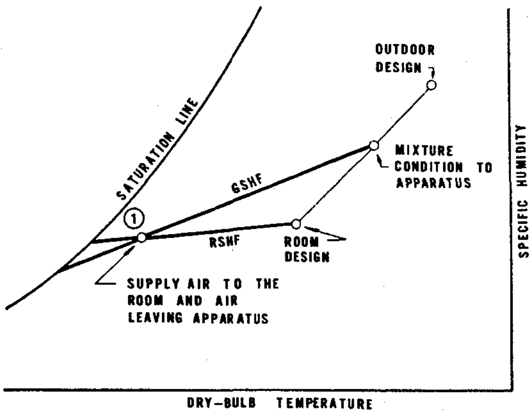


Fig. 41—RSHF and GSHF lines plotted on skeleton psychrometric chart

losses are taken into account in estimating the cooling load. *Chapter 7* gives the necessary data for evaluating these supplementary loads. Therefore, the temperature of the air leaving the apparatus is not necessarily equal to the temperature of the air supplied to the space as indicated in *Fig. 41.*

Fig. 42 illustrates what actually happens when these supplementary loads are considered in plotting the RSHF and GSHF lines.

Point (*1*) is the condition of air leaving the apparatus and point (*2*) is the condition of supply air to the space. Line (*1–2*) represents the temperature rise of the air stream resulting from supply fan and heat gain to the supply air duct. Line (*3–4*) represents the temperature rise of the air stream resulting from heat gain to the return air duct and return air fan.

The air quantity required to satisfy the room load may be calculated from the following equation:

$$\ell/s_{\mathrm{SA}} = \frac{\mathrm{RSH}}{1.20\,(t_{\mathrm{RM}} - t_{\mathrm{SA}})}$$

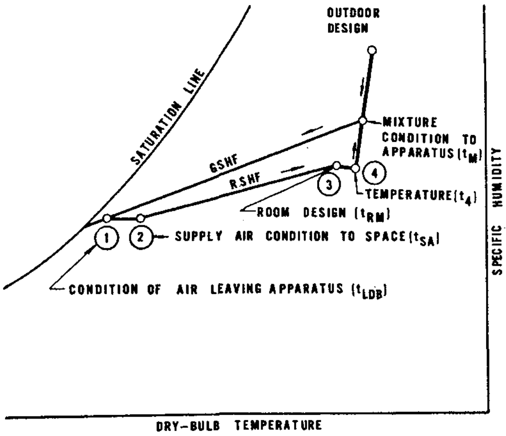


Fig. 42—RSHF and GSHF lines plotted with supplementary load lines

The air quantity required through the conditioning apparatus to satisfy the total air conditioning load (including the supplementary loads) is calculated from the following equation:

$$\ell/s_{\mathrm{DA}} = \frac{\mathrm{TSH}}{1.20\,(t_{\mathrm{M}} - t_{\mathrm{LDB}})}$$

The required air quantity supplied to the space is equal to the air quantity required through the apparatus, neglecting leakage losses. The above equation contains the term t_{M} which is the mixture condition of air entering the apparatus. With the exception of an all outdoor air application, the term t_{M} can only be determined by trial and error.

One possible procedure to determine the mixture temperature and the air quantities is outlined below. This procedure illustrates one method of apparatus selection and is presented to show how cumbersome and time consuming it may be.

1. Assume a rise $(t_{\mathrm{RM}} - t_{\mathrm{SA}})$ in the supply air to the space, and calculate the supply air quantity (ℓ/s_{SA}) to the space.
2. Use this air quantity and the estimated heat gains from return air duct and return air fan to calculate the temperature rise due to these heat gains. This will establish temperature t_4 (point (4), *Fig. 42*).
3. From the supply air quantity, the outdoor design temperature and temperature t_4 calculate the temperature of the mixture condition t_{M} (*Equation 2,* Psychrometric Formulae at the end of this chapter, substituting t_4 for t_{RM}).
4. Substitute the supply air quantity and mixture condition of the air in the formula for air quantity through the apparatus (ℓ/s_{DA}) and determine the leaving condition of the air from the conditioning apparatus (t_{LDB}).
5. The rise between the leaving condition from the apparatus and supply air condition to the space $(t_{\mathrm{SA}} - t_{\mathrm{LDB}})$ must be able to handle the loads due to supply duct heat gain and supply fan heat. If they cannot, a new rise in supply air is assumed and the trial-and-error procedure repeated.

Normally this difference in supply air temperature and the condition of the air leaving the apparatus $(t_{\mathrm{SA}} - t_{\mathrm{LDB}})$ and the temperature rise due to return air duct and return air fan $(t_4 - t_{\mathrm{RM}})$ are not more than a few degrees. To simplify the discussion on the interrelationship of RSHF and GSHF, the supplementary loads have been neglected in the various discussions, formulae and problems in the remainder of this chapter. It is emphasized, however, that these supplementary loads must be recognized when estimating the cooling and heating loads. These loads are taken into account on the air conditioning load estimate in *Chapter 1*, and are evaluated in *Chapter 7*.

The RSHF ratio will be constant (at full load) under a specified set of conditions; however, the GSHF ratio may increase or decrease as the outdoor air quantity and mixture conditions are varied for design purposes. As the GSHF ratio changes, the supply air condition to the space varies along the RSHF line (*Fig. 41*).

The difference in temperature between the room and the air supply to the room determines the air quantity required to satisfy the room sensible and room latent loads. As this temperature difference increases (supplying colder air, since the room conditions are fixed), the required air quantity to the space decreases. This temperature difference can increase up to a limit where the RSHF line crosses the saturation line on the psychrometric chart, *Fig. 41*, assuming, of course, that the available conditioning equipment is able to take the air to 100% saturation. Since this is impossible, the condition of the air normally falls on the RSHF line close to the saturation line. How close to the saturation line depends on the physical operating characteristics and the efficiency of the conditioning equipment.

In determining the required air quantity, when neglecting the supplementary loads, the supply air temperature is assumed to equal the condition of the air leaving the apparatus ($t_{SA} = t_{LDB}$). This is illustrated in *Fig. 41*. The calculation for the required air quantity still remains a trial-and-error procedure, since the mixture temperature of the air (t_{M4}) entering the apparatus is dependent on the required air quantity. The same procedure previously described for determining the air quantity is used. Assume a supply air rise and calculate the supply air quantity and the mixture temperature to the conditioning apparatus. Substitute the supply air quantity and mixture temperature in the equation for determining the air quantity through the apparatus and calculate the leaving condition of the air from the apparatus. This temperature must equal the supply air temperature; if it does not, a new supply air rise is assumed and the procedure repeated.

Determining the required air quantity by either method previously described is a tedious process, since it involves a trial-and-error procedure, and in actual practice accounting for the supplementary loads in determining the supply air, mixture and leaving air temperatures.

This procedure has been simplified, by relating all the conditioning loads to the physical performance of the conditioning equipment, and then including this equipment performance in the actual calculation of the load.

This relationship is generally recognized as a psychrometric correlation of loads to equipment performance. The correlation is accomplished by calculating the 'effective surface temperature', 'bypass factor' and 'effective sensible heat factor'. These will permit a simplified calculation of supply air quantity.

EFFECTIVE SURFACE TEMPERATURE (t_{ES})

The surface temperature of the conditioning equipment varies throughout the surface of the apparatus as the air comes in contact with it. However, the effective surface temperature can be considered to be the uniform surface temperature which would produce the same leaving air conditions as the non-uniform surface temperature that actually occurs when the apparatus is in operation. This is more clearly understood by illustrating the heat transfer effect between the air and the cooling (or heating) medium. *Fig. 43* illustrates this process and is applicable to a chilled water cooling medium with the supply air counterflow in relation to the chilled water.

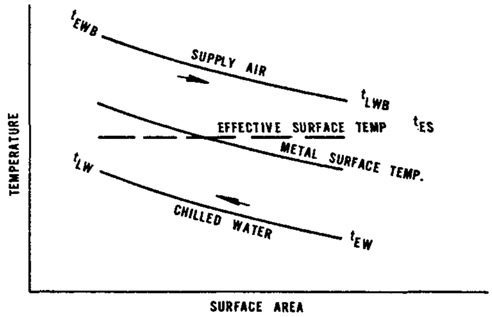


Fig. 43—Relationship of effective surface temperature to supply air and chilled water

The relationship shown in *Fig. 43* may also be illustrated for heating, direct expansion cooling and for air flowing parallel to the cooling or heating medium. The direction, slope and position of the lines change, but the theory is identical.

Since conditioning the air through the apparatus reduces to the basic principle of heat transfer between the heating or cooling media of the conditioning apparatus and the air through that apparatus, there must be a common reference point. This point is the effective surface temperature of the apparatus. The two heat transfers are relatively independent of each other, but are quantitatively equal when referred to the effective temperature.

Therefore, to obtain the most economical apparatus selection, the effective surface temperature is used in calculating the required air quantity and in selecting the apparatus.

For applications involving cooling and dehumidification, the effective surface temperature is at the point where the GSHF line crosses the saturation line on the psychrometric chart (*Fig. 39*). As such, this effective surface temperature is considered to be the dewpoint of the apparatus, and hence the term apparatus dewpoint (ADP) has come into common usage for cooling and dehumidifying processes.

Since cooling and dehumidification is one of the most common applications for central station apparatus, the 'Air Conditioning Load Estimate' form, *Fig. 47*, is designed around the term apparatus dewpoint (ADP). The term is used exclusively in this chapter when referring to cooling and dehumidifying applications. The psychrometrics of air can be applied equally well to other types of heat transfer applications such as sensible heating, evaporative cooling, sensible cooling, etc., but for these applications the effective surface temperature will not necessarily fall on the saturation line.

BYPASS FACTOR (BF)

Bypass factor is a function of the physical and operating characteristics of the conditioning apparatus and, as such, represents that portion of the air which is considered to pass through the conditioning apparatus completely unaltered.

The physical and operating characteristics affecting the bypass factor are as follows:

1. A decreasing amount of available apparatus heat transfer surface results in an increase in bypass factor, i.e. less rows of coil, less coil surface area, wider spacing of coil tubes.
2. A decrease in the velocity of air through the conditioning apparatus results in a decrease in bypass factor, i.e. more time for the air to contact the heat transfer surface.

Decreasing or increasing the amount of heat transfer surface has a greater effect on bypass factor than varying the velocity of air through the apparatus.

There is a psychrometric relationship of bypass factor to GSHF and RSHF. Under specified room, outdoor design conditions and quantity of outdoor air, RSHF and GSHF are fixed. The position of RSHF is also fixed, but the relative position of GSHF may vary as the supply air quantity and supply air condition change.

To properly maintain room design conditions the air must be supplied to the space at some point along the RSHF line. Therefore, as the bypass factor varies, the relative position of GSHF to RSHF changes, as shown by the dotted lines in *Fig. 44*. As the position of GSHF changes, the entering and leaving air conditions at the apparatus, the required air quantity, bypass factor and the apparatus dewpoint also change.

The effect of varying the bypass factor on the conditioning equipment is as follows:

1. Small bypass factor—
   (*a*) Higher ADP—DX equipment selected for higher refrigerant temperature and chilled water equipment would be selected for less or higher temperature chilled water. Possibly smaller refrigeration machine.
   (*b*) Less air—smaller fan and fan motor.
   (*c*) More heat transfer surface—more rows of coil or more coil surface available.
   (*d*) Smaller piping if less chilled water is used.
2. Larger bypass factor—
   (*a*) Lower ADP—Lower refrigerant temperature to select DX equipment, and more water or lower temperature for chilled water equipment. Possibly larger refrigeration machine.
   (*b*) More air—larger fan and fan motor.
   (*c*) Less heat transfer surface—less rows of coil or less coil surface available.
   (*d*) Larger piping if more chilled water is used.

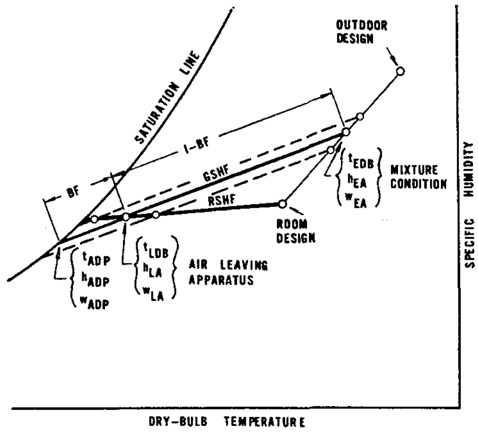


Fig. 44—RSHF and GSHF lines plotted on skeleton psychrometric chart

It is, therefore, an economic balance of first cost and operating cost in selecting the proper bypass factor for a particular application. *Table 56* lists suggested bypass factors for various applications and is a guide for the engineer to proper bypass factor selection for use in load calculations.

Tables have also been prepared to illustrate the various configurations of heat transfer surfaces and the resulting bypass factor for different air velocities. *Table 55* lists bypass factors for various coil surfaces. Spray washer equipment is normally rated in terms of saturation efficiency which is the complement of bypass factor (1—BF). *Table 57* is a guide to representative saturation efficiencies for various spray arrangements.

As previously indicated, the entering and leaving air conditions at the conditioning apparatus and the apparatus dewpoint are related psychrometrically to the bypass factor. Although it is recognized that bypass factor is not a true straight line function, it can be accurately evaluated mathematically from the following equations:

$$\mathrm{BF} = \frac{t_{LDB} - t_{ADP}}{t_{EDB} - t_{ADP}} = \frac{h_{LA} - h_{ADP}}{h_{EA} - h_{ADP}} = \frac{w_{LA} - w_{ADP}}{w_{EA} - w_{ADP}}$$

and

$$1 - \mathrm{BF} = \frac{t_{EDB} - t_{LDB}}{t_{EDB} - t_{ADP}} = \frac{h_{EA} - h_{LA}}{h_{EA} - h_{ADP}} = \frac{w_{EA} - w_{LA}}{w_{EA} - w_{ADP}}$$

Note:
The quantity (1 − BF) is frequently called contact factor and is considered to be that portion of the air leaving the apparatus at the ADP.

EFFECTIVE SENSIBLE HEAT FACTOR (ESHF)

To relate bypass factor and apparatus dewpoint to the load calculation, the *effective sensible heat factor* term was developed. ESHF is interwoven with BF and ADP, and thus greatly simplifies the calculation of air quantity and apparatus selection.

The effective sensible heat factor is the ratio of effective room sensible heat to the sum of the effective room sensible and latent heats. Effective room sensible heat is composed of room sensible heat (see RSHF) plus that portion of the outdoor air sensible load which is considered as being bypassed, unaltered through the conditioning apparatus. The effective room latent heat is composed of the room latent heat (see RSHF) plus that portion of the outdoor air latent heat load which is considered as being bypassed, unaltered, through the conditioning apparatus. This ratio is expressed in the following formula:

$$\text{ESHF} = \frac{\text{ERSH}}{\text{ERSH}+\text{ERLH}} = \frac{\text{ERSH}}{\text{ERTH}}$$

The bypassed outdoor air loads that are included in the calculation of ESHF are, in effect, loads imposed on the conditioned space in exactly the same manner as the infiltration load. The infiltration load comes through the doors and windows; the bypassed outdoor air load is supplied to the space through the air distribution system.

Plotting RSHF and GSHF on the psychrometric chart defines the ADP and BF as explained previously. Drawing a straight line between the ADP and room design conditions (*1–2*), *Fig. 45* represents the ESHF ratio. (The ESHF line intersects the saturation line at the apparatus dewpoint and not elsewhere for the following reason: by having added the bypassed sensible and latent heat loads of the outside air to the room loads, the non-bypassed air now leaves a 100% efficient apparatus, i.e. at its dewpoint.) The interrelationship of RSHF and GSHF to BF, ADP and ESHF is graphically illustrated in *Fig. 45*.

The effective sensible heat factor line may also be drawn on the psychrometric chart without initially knowing the ADP. The procedure is identical to the one previously described for RSHF. The calculated ESHF, however, is plotted through the room design conditions to the saturation line (*1–2*), *Fig. 46*, thus indicating the ADP.

Tables have been prepared to simplify the method of determining ADP from ESHF. ADP can be obtained by entering *Table 59* at room design conditions and at the calculated ESHF. It is not necessary to plot ESHF on a psychrometric chart.

AIR QUANTITY USING ESHF, ADP AND BF

A simplified approach for determining the required air quantity is to use the psychrometric correlation of effective sensible heat factor, apparatus dewpoint and

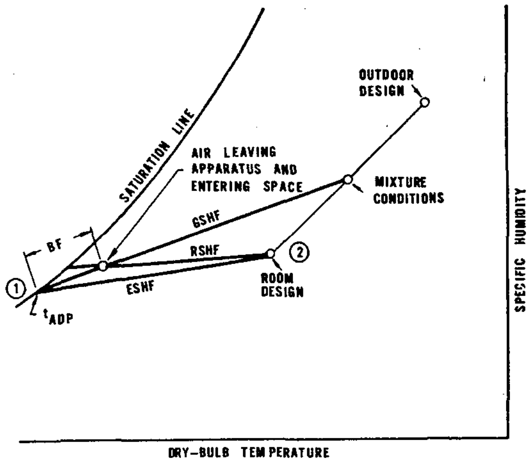


Fig. 45—RSHF, GSHF and ESHF lines plotted on skeleton psychrometric chart

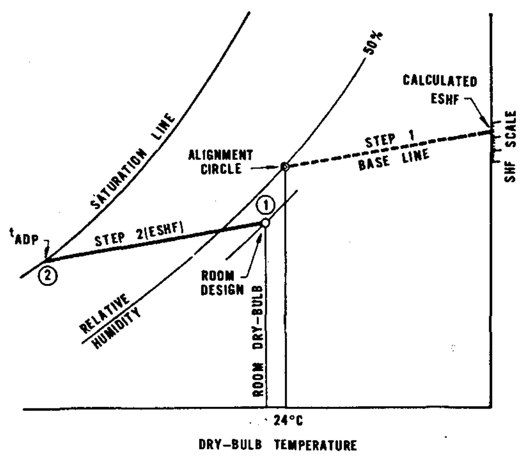


Fig. 46—ESHF line plotted on skeleton psychrometric chart

bypass factor. Previously in this chapter, the interrelationship of ESHF, BF, and ADP was shown with GSHF and RSHF. These two factors need not be calculated to determine the required air quantity, since the use of ESHF, BF, and ADP results in the same air quantity.

The formula for calculating air quantity, using BF and t_{ADP}, is:

$$\ell/s_{DA} = \frac{\text{ERSH}}{1.20\,(t_{RM}-t_{ADP})\,(1-\text{BF})}$$

(*ESHF is used to determine* t_{ADP})

This air quantity simultaneously offsets the room sensible and room latent loads, and also handles the total sensible and latent loads for which the conditioning apparatus is designed, including the outdoor air loads and the supplementary loads.

AIR CONDITIONING LOAD ESTIMATE FORM

The 'Air Conditioning Load Estimate' form is designed for cooling and dehumidifying applica-

SPACE USED FOR

SIZE × = m2 × = m3

ITEM	AREA OR QUANTITY	SUN GAIN OR TEMP. DIFF.	FACTORS	LOAD (WATTS)	SUB TOTAL (WATTS)	TOTAL (WATTS)
SOLAR GAIN – GLASS						
GLASS	m2 ×		× × ×			(16)
GLASS	m2 ×		× × ×			(9)
GLASS	m2 ×		× × ×			(15)
GLASS	m2 ×		× × ×			
SKYLIGHT	m2 ×		× × ×			
SOLAR AND TRANSMISSION GAIN – WALLS AND ROOF						
WALL	m2 ×		×			
WALL	m2 ×		×			
WALL	m2 ×		×			
WALL	m2 ×		×			
ROOF – SUN	m2 ×		×			
ROOF – SHADED	m2 ×		×			
TRANSMISSION GAIN EXCEPT WALLS AND ROOF						
ALL GLASS	m2 ×		×			
PARTITION	m2 ×		×			
CEILING	m2 ×		×			
FLOOR	m2 ×		×			
INFILTRATION	ℓ/s ×		× 1.20			
INTERNAL HEAT						
PEOPLE			PEOPLE × ×			(8)
POWER			W ×			
LIGHTS			W × ×			(10)
APPLIANCES ETC.			W × ×			
						(12)
STORAGE FROM SWING (DEDUCT)			m2 × ×			(13)
SAFETY FACTOR			%	(1)		
			ROOM SENSIBLE HEAT ■			
SUPPLY DUCT HEAT GAIN	%+ SUPPLY DUCT LEAK LOSS	%+ FAN kW	%			(14)
OUTDOOR AIR	ℓ/s ×	°C ×	BF × (11) 1.20	( )		
			EFFECTIVE ROOM SENSIBLE HEAT ■			
LATENT HEAT						
INFILTRATION	ℓ/s ×		g/kg × 3.0			
PEOPLE	PEOPLE ×		×			(17)
STEAM	g/s × 2500					
APPLIANCES ETC.	W ×		×			(18)
VAPOUR TRANS.	m2 × 0.001 ×		g/kg ×			
SAFETY FACTOR	%			(2)		
			LATENT ROOM HEAT ■			
SUPPLY DUCT LEAKAGE LOSS			%			
OUTDOOR AIR	ℓ/s ×	g/kg × ( ) BF × 3.0		(6)		
			EFFECTIVE ROOM LATENT HEAT	(7)		
			EFFECTIVE ROOM TOTAL HEAT ■			
OUTDOOR AIR HEAT				(4)		
SENSIBLE:	ℓ/s ×	°C × (1 – (11) BF)	× 1.20			
LATENT:	ℓ/s ×	g/kg × (1 – (11) BF)	× 3.0			
RETURN DUCT HEAT GAIN	%+ RETURN DUCT LEAK GAIN	%+ PUMP	%+ DEHUM & PIPE LOSS %	(5)		
			GRAND TOTAL HEAT ■			

ESTIMATE FOR	LOCAL TIME / SUN TIME	PEAK LOAD	LOCAL TIME / SUN TIME

HOURS OF OPERATION

DESIGN CONDITIONS	DRY BULB °C	WET BULB °C	% RH	DEW POINT °C	g/kg
OUTDOOR AIR (OA)					
ROOM AIR (RM)					
DIFFERENCE					

OUTDOOR AIR

(a) EXHAUST AIR = ...ℓ/s

(b) ½ CHANGE PER HOUR = ...ℓ/s

(c) MINIMUM VENTILATION AIR = (a) + (b) = ...ℓ/s

(d) CHECK ON ODOUR DILUTION: .... PEOPLE × ....ℓ/s PERSON = ...ℓ/s

(e) CHECK ON OUTDOOR AIR PERCENTAGE: .... ℓ/s_{OA} ÷ .... ℓ/s_{SA} × 100 = %

Allow not less than 10 % ....ℓ/s

(f) VENTILATION AIR = OUTDOOR AIR THROUGH APPARATUS = HIGHEST VALUE OF (c), (d) OR (e) = ...ℓ/s = ...Ch/h

INFILTRATION

(a) ΣCHANGES PER HOUR (FROM TABLE 44 CHAPTER 6) = ...ℓ/s

(b) VENTILATION AIR: (f) ABOVE = ...ℓ/s

(c) ½ CHANGE PER HOUR = ...ℓ/s

(d) = (b) – (c) = ...ℓ/s

= ....ℓ/s

(e) INFILTRATION = (a) – (d) = ...ℓ/s

APPARATUS DEWPOINT

$$\text{EFFECTIVE SENSIBLE HEAT FACTOR} = \frac{(3)\ \text{EFFECTIVE ROOM SENSIBLE HEAT}}{(7)\ \text{EFFECTIVE ROOM TOTAL HEAT}} = \underline{\qquad}$$

INDICATED ADP = ...°C SELECTED ADP = ...°C

DEHUMIDIFIED AIR QUANTITY

$$\text{TEMPERATURE RISE} = (1 - \underset{(11)}{\ldots}\ \text{BF}) \times (\underset{(9)}{\ldots}\ °C_{RM} - \underset{(10)}{\ldots}\ °C_{ADP}) = \ldots\ °C$$

$$\text{DEHUMIDIFIED AIR}\ \ell/s = \frac{(3)\ \text{EFFECTIVE ROOM SENSIBLE HEAT}}{1.20 \times (12)\ °C\ \text{TEMPERATURE RISE}} = \underline{\qquad}\ \ell/s\ DA$$

$$\text{OUTLET TEMP. DIFF.} = \frac{(1)\ \text{ROOM SENSIBLE HEAT}}{1.20 \times (13)\ \ell/s\ DA} = \underline{\qquad}\ °C\ (RM - \text{OUTLET AIR})^{*}$$

SUPPLY AIR QUANTITY

$$\text{SUPPLY FLOW RATE} = \frac{\text{ROOM SENSIBLE HEAT}}{1.20 \times °C\ \text{DESIRED DIFFERENTIAL}} = \underline{\qquad}\ \ell/s\ SA$$

BY PASS FLOW RATE ......(14)...... ℓ/s SA – ......(13)...... ℓ/s DA = ... ℓ/s BA

RESULTING ENTERING AND LEAVING CONDITIONS AT APPARATUS

$$\text{ENTERING DRY BULB TEMP.} = \underset{(9)}{\ldots}\ °C_{RM} + \frac{(15)\ \ell/s\ OA}{(13)\ \text{OR}\ (14)\ \ell/s\ ‡} \times (\underset{(16)}{\ldots}\ °C_{OA} - \underset{(9)}{\ldots}\ °C_{RM}) = \ldots\ °C_{EDB}$$

$$\text{LEAVING DRY BULB TEMP.} = \underset{(10)}{\ldots}\ °C_{ADP} + \underset{(11)}{\ldots}\ \text{BF} \times (\underset{(17)}{\ldots}\ °C_{EDB} - \ldots\ °C_{ADP}) = \ldots\ °C_{LDB}$$

FROM PSYCHROMETRIC CHART .... $°C_{EWB}$, ... $°C_{LWB}$

CHECK FIGURES

ℓ/s_{SA} PER kW ERTH .... ℓ/s_{SA} PER kW GTH ....

ℓ/s_{SA} PER m2 FLOOR AREA .... ℓ/s_{SA} PER m2 WALL AREA ....

GTH (kW) PER m2 FLOOR AREA .... TOTAL CHANGES PER HOUR ....

NOTES

* IF THIS ΔT IS TOO HIGH, DETERMINE SUPPLY ℓ/s FOR DESIRED TEMPERATURE DIFFERENCE BY SUPPLY AIR QUANTITY FORMULA.

‡ WHEN BY PASSING A MIXTURE OF OUTDOOR AND RETURN AIR, USE SUPPLY ℓ/s. WHEN BY PASSING RETURN AIR ONLY, USE DEHUMIDIFIED ℓ/s.

NOTE : THE CIRCLED NUMBERS ARE EXPLAINED IN THE TEXT UNDER THE HEADING 'AIR CONDITIONING LOAD ESTIMATE FORM'

Fig. 47—Air conditioning load estimate

tions, and may be used for psychrometric calculations. Normally, only ESHF, BF and ADP are required to determine air quantity and to select the apparatus. But for those instances when it is desirable to know RSHF and GSHF, this form is designed so that these factors may also be calculated. *Fig. 47*, in conjunction with the following items, explains how each factor is calculated. (The circled numbers correspond to numbers in *Fig. 47.*)

1. $\text{RSHF} = \dfrac{\text{RSH}}{\text{RSH}+\text{RLH}} = \dfrac{(1)}{(1)+(2)}$

2. $\text{GSHF} = \dfrac{\text{TSH}}{\text{GTH}} = \dfrac{(3)+(4)}{(5)}$

3. $\text{ESHF} = \dfrac{\text{ERSH}}{\text{ERSH}+\text{ERLH}} = \dfrac{\text{ERSH}}{\text{ERTH}}$

   $(8) = \dfrac{(3)}{(3)+(6)} = \dfrac{(3)}{(7)}$

4. ADP located where ESHF crosses the saturation line, or from *Table 59*. ESHF (8) and room conditions (9) give ADP (10).

5. BF (11) used in the outdoor air calculations is obtained from the equipment performance table or charts. Typical bypass factors for different surfaces and for various applications are given in *Table 56*. These are to guide the engineer and may be used in the outdoor air calculation when the actual equipment performance tables are not readily available.

6. $\ell/s_{\text{DA}} = \dfrac{\text{ERSH}}{1.20\ (t_{\text{RM}}-t_{\text{ADP}})\ (1-\text{BF})}$

   $(13) = \dfrac{(3)}{1.20\ ((9)-(10))\ (1-(11))}$

   Once the dehumidified air quantity is calculated, the conditioning apparatus may be selected. The usual procedure is to use the grand total heat (5), dehumidified air quantity (13), and the apparatus dewpoint (10), to select the apparatus.

   Since guides are available, the bypass factor of the apparatus selected is usually in close agreement with the originally assumed bypass factor. If, because of some peculiarity in loading a particular application, there is a wide divergence in bypass factor, that portion of the load estimate form involving bypass factor should be adjusted accordingly.

7. Outlet temperature difference—*Fig. 47* shows a calculation for determining the temperature difference between room design dry-bulb and the supply air dry-bulb to the room. Frequently a maximum temperature difference is established for the application involved. If the outlet temperature difference calculation is larger than desired, the total air quantity in the system is increased by bypassing air around the conditioning apparatus. This temperature difference calculation is:

   $$\text{Outlet temp. diff.} = \frac{\text{RSH}}{1.20 \times \ell/s_{\text{DA}}} = \frac{(1)}{1.20 \times (13)}$$

8. Total air quantity when outlet temperature difference is greater than desired—The calculation for the total supply air quantity for a desired temperature difference (between room and outlet) is:

   $$\ell/s_{\text{SA}} = \frac{\text{RSH}}{1.20 \times \Delta t} = \frac{(1)}{1.20 \times \Delta t}$$

   The amount of air that must be bypassed around the conditioning apparatus to maintain this desired temperature difference (Δt) is the difference between ℓ/s_{SA} and ℓ/s_{DA}.†

9. Entering and leaving conditions at the apparatus—Often it is desired to specify the selected conditioning apparatus in terms of entering and leaving air conditions at the apparatus. Once the apparatus has been selected from ESHF, ADP, BF and GTH, the entering and leaving air conditions are easily determined. The calculations for the entering and leaving dry-bulb temperatures at the apparatus are illustrated in *Fig. 47*.

   The entering dry-bulb calculation contains the term 'ℓ/s‡'*. This air quantity 'ℓ/s‡' depends on whether a mixture of outdoor and return air or return air only is bypassed around the conditioning apparatus.

   The total supply air quantity ℓ/s_{SA} (14) is used for 'ℓ/s‡' when bypassing a mixture of outdoor and return air. *Fig. 48* is a schematic sketch of a system bypassing a mixture of outdoor and return air.

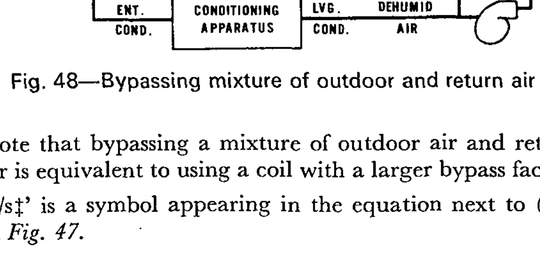


Fig. 48—Bypassing mixture of outdoor and return air

†Note that bypassing a mixture of outdoor air and return air is equivalent to using a coil with a larger bypass factor.

*'ℓ/s‡' is a symbol appearing in the equation next to (17) in *Fig. 47*.

When bypassing a mixture of return air only or when there is no need for a bypass around the apparatus, use the ℓ/s_{DA} (13) for the value of '$\ell/s\ddagger$'. *Fig. 49* is a schematic sketch of a system bypassing room return air only.

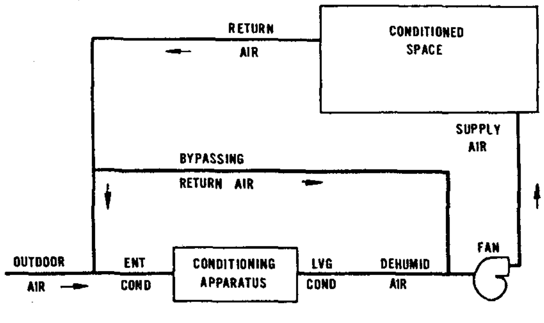


Fig. 49—Bypassing return air only or no fixed bypass

The entering and leaving wet-bulb temperatures at the apparatus are determined on the standard psychrometric chart, once the entering and leaving dry-bulb temperatures are calculated. The procedure for determining the wet-bulb temperatures at the apparatus is illustrated in *Fig. 50* and described in the following items:

(*a*) Draw a straight line connecting room design conditions and outdoor design conditions.

(*b*) The point at which entering dry-bulb crosses the line plotted in *Step* (*a*) defines the entering conditions to the apparatus. The entering wet-bulb is read on the psychrometric chart.

(*c*) Draw a straight line from the ADP (10) to the entering mixture conditions at the apparatus (*Step* (*b*)). (This line defines the GSHF line of the apparatus.)

(*d*) The point at which the leaving dry-bulb crosses the line drawn in *Step* (*c*) defines the leaving conditions of the apparatus. Read the leaving wet-bulb from the apparatus at this point. (This point defines the intersection of the RSHF and GSHF as described previously.)

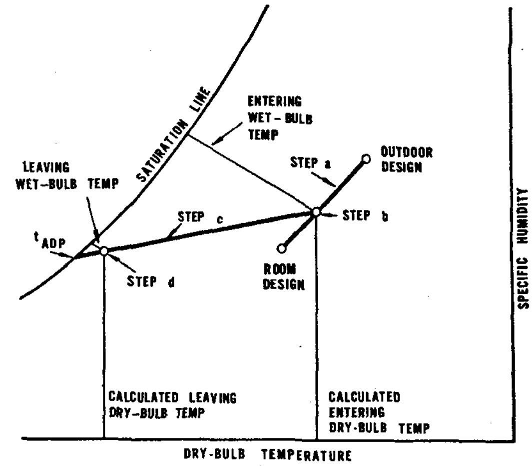


Fig. 50—Entering and leaving conditions at apparatus

AIR CONDITIONING APPARATUS

The following section describes the characteristic psychrometric performance of air conditioning equipment.

Coils, sprays and sorbent dehumidifiers are the three basic types of heat transfer equipment required for air conditioning applications. These components may be used singly or in combination to control the psychrometric properties of the air passing through them.

The selection of this equipment is normally determined by the requirements of the specific application. The components must be selected and integrated to result in a practical system; that is, one having the most economical owning and operating cost.

An economical system requires the optimum combination of air conditioning components. It also requires an air distribution system that provides good air distribution within the conditioned space, using a practical rise between supply air and room air temperatures and adequate total air circulation.

Since the only known items are the load in the space and the conditions to be maintained within the space, the selection of the various components is based on these items. Normally, performance requirements are established and then equipment is selected to meet the requirements.

COIL CHARACTERISTICS

In the operation of coils, air is drawn or forced over a series of tubes through which chilled water, brine, volatile refrigerant, hot water or steam is flowing. As the air passes over the surface of the coil, it is cooled, cooled and dehumidified, or heated, depending upon the temperature of the media flowing through the tubes. The media in turn is heated or cooled in the process.

The amount of coil surface not only affects the heat transfer but also the bypass factor of the coil. The bypass factor, as previously explained, is the measure of air side performance. Consequently, it is a function of the type and amount of coil surface and the time available for contact as the air passes through the coil. *Table 55* gives approximate bypass factors for various finned coil surfaces and air velocities.

TABLE 55
Typical Bypass Factors
FOR FINNED COILS

Depth of Coils	Without Sprays		With Sprays	
	Series 8*	Series 14*	Series 8	Series 14
	Velocity (m/s)			
(rows)	1.5–3.5	1.5–3.5	1.5–3.0	1.5–3.0
2	0.42–0.55	0.22–0.38		
3	0.27–0.40	0.10–0.23		
4	0.15–0.28	0.05–0.14	0.12–0.22	0.04–0.10
5	0.10–0.22	0.03–0.09	0.08–0.16	0.02–0.06
6	0.06–0.15	0.01–0.05	0.05–0.11	0.01–0.03
8	0.02–0.08	0.00–0.02	0.02–0.06	0.00–0.02

*Series 8 represents 315.0 fins/m (8 fins/inch) and series 14 represents 551.2 fins/m (14 fins/inch). This method of designation will be used until manufacturers produce rationalized metric fin spacings on their coils.

These bypass factors apply to coils with 16 mm O.D. tubes and spaced on approximately 32 mm centres. The values are approximate. Bypass factors for coils with plate fins, or for combinations other than those shown, should be obtained from the coil manufacturer.

TABLE 56
Typical Bypass Factors
FOR VARIOUS APPLICATIONS

Coil Bypass Factor	Type of Application	Example
0.30 to 0.50	A *small* total load or a load that is somewhat larger with a low sensible heat factor (high latent load).	Residence
0.20 to 0.30	Typical comfort application with a *relatively small* total load or a low sensible heat factor with a somewhat larger load.	Residence, Small Retail Shop, Factory
0.10 to 0.20	Typical comfort application.	Dept. Store, Bank, Factory
0.05 to 0.10	Applications with high internal sensible loads or requiring a large amount of outdoor air for ventilation.	Office Block, Dept. Store, Restaurant, Factory
0 to 0.10	All outdoor air applications.	Hospital Operating Room, Factory

Table 55 contains bypass factors for a wide range of coils. This range is offered to provide sufficient latitude in selecting coils for the most economical system. *Table 56* lists some of the more common applications with representative coil bypass factors. This table is intended only as a guide for the design engineer.

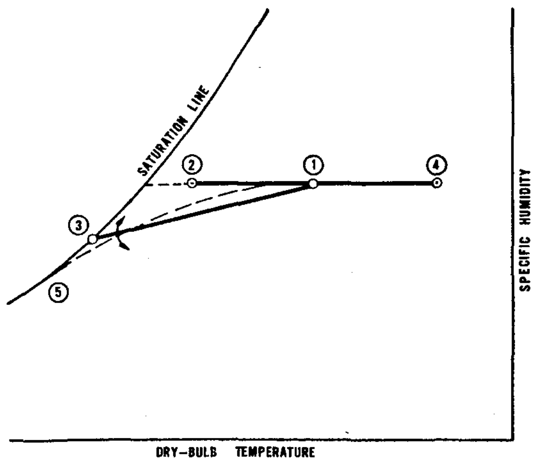


Fig. 51—Coil processes

COIL PROCESSES

Coils are capable of heating or cooling air at a constant moisture content, or simultaneously cooling and dehumidifying the air. They are used to control dry-bulb temperature and maximum relative humidity at peak load conditions. Since coils alone cannot *raise* the moisture content of the air, a water spray on the coil surface must be added if humidification is required. If this spray water is recirculated, it will not materially affect the psychrometric process when the air is being cooled and dehumidified.

Fig. 51 illustrates the various processes that can be accomplished by using coils.

Sensible Cooling

The first process, illustrated by line (*1–2*), represents a sensible cooling application in which the heat is removed from the air at a constant moisture content.

Cooling and Dehumidification

Line (*1–3*) represents a cooling and dehumidification process in which there is a simultaneous removal of heat and moisture from the air.

For practical considerations, line (*1–3*) has been plotted as a straight line. It is, in effect, a line that starts at point (*1*) and curves toward the saturation line below point (*3*). This is indicated by line (*1–5*). Both lines assume perfect contact between air and coil (i.e. BF = 0).

Sensible Heating

Sensible heating is illustrated by line (*1–4*); heat is added to the air at constant moisture content.

COIL PROCESS EXAMPLES

To better understand these processes and their variations, a description of each with illustrated examples is presented in the following: (Refer to the end of this chapter for definition of symbols and abbreviations.)

Cooling and Dehumidification

Cooling and dehumidification is the simultaneous removal of the heat and moisture from the air, line *(1–3)*, *Fig. 51*. Cooling and dehumidification occurs when the ESHF and GSHF are less than 1.0. The ESHF for these applications can vary from 0.95, where the load is predominantly sensible, to 0.45 where the load is predominantly latent.

The air conditioning load estimate form illustrated in *Fig. 47* presents the procedure that is used to determine the ESHF, dehumidified air quantity, and entering and leaving air conditions at the apparatus. *Example 1* illustrates the psychrometrics involved in establishing these values.

Example 1—Cooling and Dehumidification

Given:
- Application—Office Building
- Summer design—35°C DB, 25°C WB
- Inside design—24°C DB, 50% RH
- RSH—60 000 W
- RLH—15 000 W
- Ventilation—1000 ℓ/s_{OA}

Find:
1. Outdoor air load (OATH)
2. Grand total heat (GTH)
3. Effective sensible heat factor (ESHF)
4. Apparatus dewpoint temperature (t_{ADP})
5. Dehumidified air quantity (ℓ/s_{DA})
6. Entering and leaving conditions at the apparatus (t_{EDB}, t_{EWB}, t_{LDB}, t_{LWB})

Solution:

1. OASH $= 1.20 \times 1000 \times (35 - 24) = 13\,200$ W (14)
   OALH $= 3.0 \times 1000 \times (15.9 - 9.4) = 19\,500$ W (15)
   OATH $= 13\,200 + 19\,500 = 32\,700$ W (17)
2. TSH $= 60\,000 + 13\,200 = 73\,200$ W (7)
   TLH $= 15\,000 + 19\,500 = 34\,500$ W (8)
   GTH $= 73\,200 + 34\,500 = 107\,700$ W (9)
3. Assume a bypass factor of 0.15 from *Table 56*

$$\text{ESHF} = \frac{60\,000 + (0.15)\ (13\,200)}{60\,000 + (0.15)\ (13\,200) + 15\,000 + (0.15)\ (19\,500)} = 0.776 \quad (26)$$

4. Determine the apparatus dewpoint from the room design conditions and the ESHF, by either plotting on the psychrometric chart or using *Table 59*. *Fig. 52* illustrates the ESHF plotted on the psychrometric chart.

   $t_{ADP} = 10°C$

5. $$\ell/s_{DA} = \frac{60\,000 + (0.15)\ (13\,200)}{1.20\ (24 - 10)\ (1 - 0.15)} = 4340\ \ell/s \quad (36)$$

6. Assume for this example that the apparatus selected for 4340 ℓ/s, 10°C ADP and GTH = 107 700, has a bypass factor that is equal, or nearly equal, to the assumed BF = 0.15. Also, assume that it is not necessary to physically bypass air around the apparatus.

$$t_{EDB} = \frac{(1000 \times 35) + (3350 \times 24)}{4340} = 26.6°C\ \text{DB} \quad (31)$$

Note:
Numbers in parentheses at right edge of column refer to equations given under the heading 'Psychrometric Formulae', at the end of this chapter.

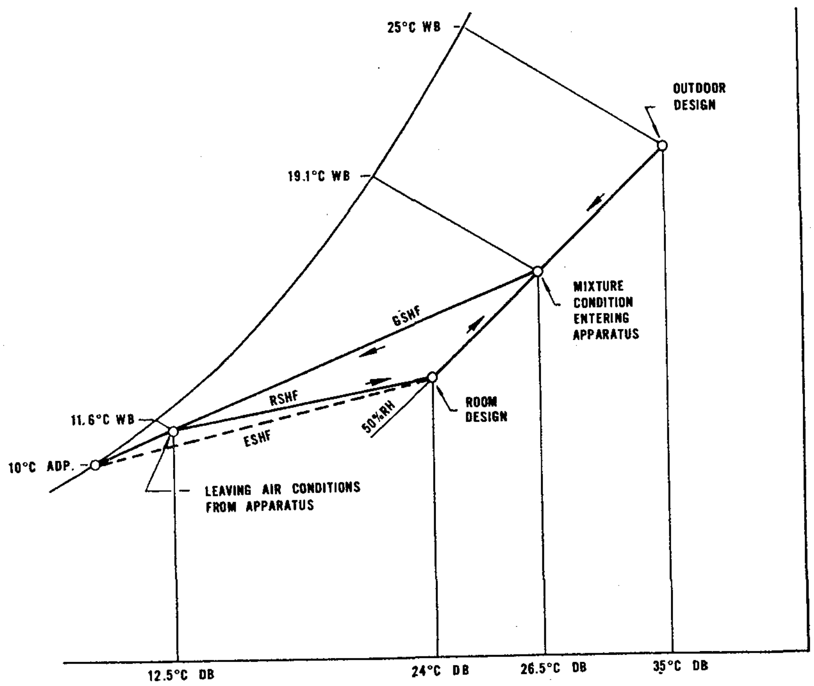


Fig. 52—Cooling and dehumidification

Read t_{EWB} where the t_{EDB} crosses the straight line plotted between the outdoor and room design conditions on the psychrometric chart, *Fig. 52.*

t_{EWB} = 19.1°C WB

t_{LDB} = 10+0.15 (26.5−10) = 12.5°C DB (32)

Determine the t_{LWB} by drawing a straight line between the ADP and the entering conditions at the apparatus. (This is the GSHF line.) Where t_{LDB} intersects this line, read t_{LWB}

t_{LWB} = 11.6°C WB

Example 2

Given:

The same office building as in *Example 1,* with the exception that the internal design conditions are 24°C DB, 65% RH instead of 24°C DB, 50% RH.

Find:

1. Grand total heat (GTH)
2. Dehumidified air quantity (ℓ/s_{DA})

Solution:

1. The only change is in the outside air latent heat which is now OALH = 3.0 × 1000 (15.9 − 12.2) = 11 100 W instead of 19 500 W, a difference of 8400 W. GTH = 107 700 − 8400 = 99 300 W, a decrease of $\dfrac{8400}{107\,700} \times 100 = 7.8\%$
2.

$$\text{ESHF} = \frac{60\,000 + (0.15)\,(13\,200)}{60\,000 + (0.15)\,(13\,200) + 15\,000 + (0.15)\,(11\,100)} = 0.788$$

t_{ADP} = 15.8°C

$$\ell/s_{DA} = \frac{60\,000 + (0.15)\,(13\,200)}{1.20\ (24 - 15.8)\ (1 - 0.15)} = 7410\ \ell/s \text{ against}$$

4350 ℓ/s in *Example 1,* an increase of $\dfrac{7420 - 4340}{4340} \times 100 = 70.7\%$

As the unit cost of refrigeration plant is smaller than that of air handling plant and ductwork, it can be seen that an increase in room design relative humidity is not an economic proposition. This statement holds in spite of the fact that the higher relative humidity results in a higher apparatus dew point (in this case 15.8°C instead of 10°C) and therefore in a decrease in the size of the refrigeration plant slightly greater than the decrease in grand total heat (in this case greater than 7.8%).

Cooling and Dehumidification—High Latent Load Application

On some applications a special situation exists if the ESHF and GSHF lines do not intersect the saturation line when plotted on the psychrometric chart or if they do the ADP is absurdly low. This may occur where the latent load is high with respect to the total loads (dance halls, etc.). In such applications, an appropriate apparatus dewpoint is selected and the air is reheated to the RSHF line. Occasionally, altering the room design conditions eliminates the need for reheat, or reduces the quantity of reheat required. Similarly, the utilization of a large air side surface (low bypass factor) coil may eliminate the need for reheat or reduce the required reheat.

Once the ventilation air requirement is determined, and if the supply air quantity is not fixed, the best approach to determining the apparatus dew point is to assume a maximum allowable temperature difference between the supply air and the room. Then, calculate the supply air conditions to the space. The supply air conditions to the space must fall on the RSHF line to properly offset the sensible and latent loads in the space.

There are four criteria which should be examined, to aid in establishing the supply air requirements to the space. These are:

1. Air movement in the space.
2. Maximum temperature difference between the supply air and the room.
3. The selected ADP should provide an economical refrigeration machine selection.
4. In some cases, the ventilation air quantity required may result in an all outdoor air application.

Example 3 is a laboratory application with a high latent load. In this example the ESHF intersects the saturation line, but the resulting ADP is too low.

Example 3—Cooling and Dehumidification—High Latent Load

Given:

Application—Laboratory
Summer design—32°C DB, 23°C WB
Inside design—24°C DB, 50% RH
RSH—35 000 W
RLH—19 000 W
Ventilation—1200 ℓ/s_{OA}
Temp. diff. between room and supply air, 10°C maximum

Find:

1. Outdoor air load (OATH)
2. Effective sensible heat factor (ESHF)
3. Apparatus dewpoint (t_{ADP})
4. Reheat required
5. Supply air quantity (ℓ/s_{SA})
6. Entering conditions to coil (t_{EDB}, t_{EWB}, w_{EA})
7. Leaving conditions from coil (t_{LDB}, t_{LWB})
8. Supply air condition to the space (t_{SA}, w_{SA})
9. Grand total heat (GTH)

Solution:

1. OASH = 1.20 × 1200 × (32 − 24) = 11 500 W (14)
   OALH = 3.0 × 1200 × (14.0 − 9.4) = 16 500 W (15)
   OATH = 11 500 + 16 500 = 28 000 W (17)
2. Assume a bypass factor of 0.05 because of high latent load.

$$\text{ESHF} = \frac{35\,000 + (0.05)\,(11\,500)}{35\,000 + (0.05)\,(11\,500) + 19\,000 + (0.05)\,(16\,500)} = 0.642 \qquad (26)$$

When plotted on the psychrometric chart, this ESHF (0.642) intersects the saturation curve at 2°C. With such a low ADP an appropriate apparatus dewpoint should be selected and the air reheated to the RSHF line.

3. Refer to *Table 59.* For inside design conditions of 24°C DB, 50% RH, an ESHF of 0.74 results in an ADP of 9°C which is a reasonable minimum figure.
4. Determine amount of reheat (W) required to produce an ESHF of 0.74

$$\text{ESHF (0.74)} = \frac{35\,000+0.05\,(11\,500)+\text{reheat}}{35000+0.05\,(11500)+\text{reheat}+19500+(0.05)\,16\,500}$$

$$0.74 = \frac{35\,575+\text{reheat}}{55\,400+\text{reheat}} \qquad (25)$$

$$\text{reheat} = 20\,850 \text{ W}$$

5. Determine dehumidifier air quantity (ℓ/s_{DA})

$$\ell/s_{DA} = \frac{\text{ERSH}}{1.20\times(1-\text{BF})\ (t_{RM}-t_{ADP})} \qquad (36)$$

$$= \frac{35\,575+20\,850}{1.20\ (1-0.05)\ (24-9.0)} = 3\,300\ \ell/s$$

ℓ/s_{DA} is also ℓ/s_{SA} when no air is to be physically by-passed around the cooling coil.

6. $$t_{EDB} = \frac{(1200\times32)+(2100\times24)}{3300}$$

$$= 26.9°\text{C} \qquad (31)$$

Note:
Numbers in parentheses at right edge of column refer to equations in the section 'Psychrometric Formulae' at the end of this chapter.

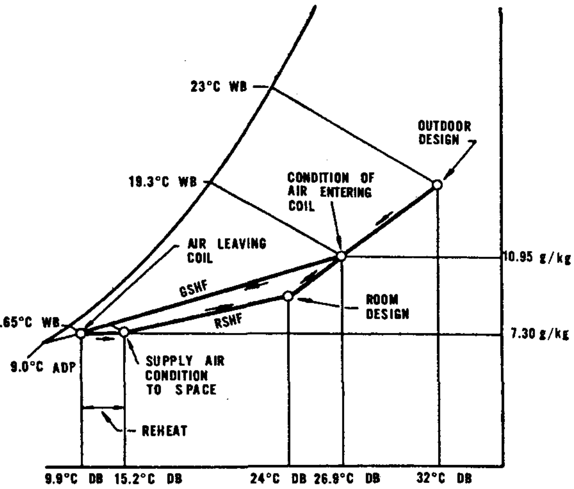


Fig. 53—Cooling and dehumidification with high latent load

Read t_{EWB} where the t_{EDB} crosses the straight line plotted between the outdoor air and room design conditions on the psychrometric chart, *Fig. 53*

$t_{EWB} = 19.3°\text{C}$

The moisture content at the entering conditions to the coil is read from the psychrometric chart.

$w_{EA} = 10.95$ g/kg

7. Determine leaving conditions of air from cooling coil.

$$t_{LDB} = t_{ADB}+\text{BF}\ (t_{EDB}-t_{ADP}) \qquad (32)$$
$$= 9.0+0.05\ (26.9-9.0)$$
$$= 9.9°\text{C}$$

$$h_{SA} = h_{ADP}+\text{BF}\ (h_{EA}-h_{ADP}) \qquad (34)$$
$$= 27.2+0.05\ (55.2-27.2)$$
$$= 28.65 \text{ kJ/kg}$$

$t_{LWB} = 9.65°\text{C}$

8. Determine supply air temperature to space

$$t_{SA} = t_{RM} - \frac{\text{RSH}}{1.20\ (\ell/s_{SA})} \qquad (35)$$
$$= 24 - \frac{(35\,000)}{1.20\ (3300)}$$
$$= 15.16°\text{C}$$

$$t_{SA} \text{ should also equal } t_{LDB} + \frac{\text{reheat}}{1.20\ (\ell/s_{SA})}$$
$$= 9.9 + \frac{20\,850}{1.20\ (3\,300)}$$
$$= 15.16°\text{C}$$

$w_{SA} = 7.3$ g/kg

Temp. diff. between room and supply air
$= t_{RM}-t_{SA} = 24-15.15 = 8.85°\text{C}$
Which is less than 10°C

9. $\text{GTH} = 1.19\times3300\,(55.25-28.6) = 104\,000\text{W}$ (24)
10. Check on GTH $= \text{RSH}+\text{RLH}+\text{OATH}+\text{reheat}$
$= 35\,000+19\,000+28\,000+21\,000$
$= 103\,000$ W

Cooling and Dehumidification—Using All Outdoor Air

In some applications it may be necessary to supply all outdoor air; for example, a hospital operating room or an area that requires large quantities of ventilation air. For such applications, the ventilation or code requirements may be equal to, or more than, the air quantity required to handle the room loads.

Items 1 to *5* inclusive explain the procedure for determining the dehumidified air requirements using the 'Air Conditioning Load Estimate' form when all outdoor air is required.

1. Calculate the various loads and determine the apparatus dewpoint and dehumidified air quantity.
2. If the dehumidified air quantity is *equal* to the outdoor air requirements, the solution is self-evident.
3. If the dehumidified air quantity is *less* than the outdoor air requirements, a coil with a larger bypass factor should be investigated when the difference in air quantities is small. If a large difference exists, however, reheat is required. This situation sometimes occurs when the application requires large exhaust air quantities.
4. If the dehumidified air quantity is *greater* than the outdoor air requirements, substitute ℓ/s_{DA} for ℓ/s_{OA} in the outdoor air load calculations.
5. Use the recalculated outdoor air loads to determine a new apparatus dewpoint and dehumidified air quantity. This new dehumidified air quantity should check reasonably close to the ℓ/s_{DA} in *Item 1.*

A special situation may arise when the condition explained in *Item 4* occurs. This happens when the

ESHF, as plotted on the psychrometric chart, does not intersect the saturation line. This situation is handled in a manner similar to that previously described under '*Cooling and Dehumidification—High Latent Load Application*'.

Example 4 illustrates an application where all outdoor air is to be supplied to the space.

Example 4—Cooling and Dehumidification—All Outdoor Air

Given:

Application—Laboratory
Summer design—35°C DB, 24°C WB
Inside design—24°C DB, 55% RH
RSH—14 500 W
RLH—3200 W
Ventilation—750 ℓ/s_{OA}
All outdoor air to be supplied to space.

Find:

1. Outdoor air load (OATH)
2. Effective sensible heat factor (ESHF)
3. Apparatus dewpoint (t_{ADP})
4. Dehumidified air quantity (ℓ/s_{DA})
5. Recalculated outdoor air load (OATH)
6. Recalculated effective sensible heat factor (ESHF)
7. Final apparatus dewpoint temperature (t_{ADP})
8. Recalculated dehumidified air quantity (ℓ/s_{DA})

Solution:

1. OASH $= 1.20 \times 750 \times (35-24) = 9900$ W (14)
   OALH $= 3.0 \times 750 \times (14.3-10.25) = 9100$ W (15)
   OATH $= 9900+9100 = 19\,000$ W (17)
2. Assume a bypass factor of 0.05 from *Tables 55* and *56*
   $$\text{ESHF} = \frac{14\,500+(0.05)\,(9900)}{14\,500+(0.05)\,(9100)+3200+(0.05)\,(9100)} = 0.805 \quad (26)$$
3. *Table 59* shows that, at the given room design conditions and effective sensible heat factor, $t_{ADP} = 12.6$°C
4. $$\ell/s_{DA} = \frac{14\,500+(0.05)\,(9900)}{1.20\,(1-0.05)\,(24-12.6)} = 1150\ \ell/\text{s} \quad (36)$$
   Since 1150 ℓ/s is larger than the ventilation requirements, and by code all OA is required, the OA loads, the ADP and the dehumidified air quantity must be recalculated using 1150 ℓ/s as the OA requirements.
5. Recalculating outdoor air load
   OASH $= 1.20 \times 1150 \times (35-24) = 15\,180$ W (14)
   OALH $= 3.0 \times 1150 \times (14.3-10.25) = 13\,970$ W (15)
   OATH $= 15\,180+13\,970 = 29\,150$ W (17)
6. $$\text{ESHF} = \frac{14\,500+(0.05)\,(15\,180)}{14\,500+(0.05)\,(15\,180)+3200+(0.05)\,(13\,970)} = 0.795 \quad (26)$$
7. $t_{ADP} = 12.6$°C
8. $$\ell/s_{DA} = \frac{14\,500+(0.05)\,(15\,180)}{1.20\,(1-0.05)\,(24-12.6)} = 1174\ \ell/\text{s} \quad (36)$$
   This checks reasonably close to the value in *Step 4*, and recalculation is not necessary.

Note:

Numbers in parentheses at right edge of column refer to equations in the section 'Psychrometric Formulae' at the end of this chapter.

Cooling With Evaporative Humidification*

Cooling with evaporative humidification may be used at design conditions for applications having relatively high sensible loads and high room relative humidity requirements. Without humidification, excessively high supply air quantities may be required. This not only creates air distribution problems but also is often economically unsound. Excessive supply air quantity requirements can be avoided by introducing moisture into the space to convert sensible heat to latent heat. This is sometimes referred to as a 'split system'. The moisture is introduced into the space by using water sprays.

When humidification is performed in the space, the room sensible load is decreased by an amount equal to the latent heat added, since the process is merely an interchange of heat. The spray pump motor adds sensible heat to the room but the amount is negligible and is usually ignored. A credit to the room sensible heat should be taken in the amount of the latent heat from the added moisture and the latent load introduced into the space should be added to the room latent load.

The introduction of this moisture into the space to reduce the required air quantity decreases the RSHF, ESHF and the apparatus dewpoint. This method of reducing the required air quantity is normally advantageous when designing for high room relative humidities.

The method of determining the amount of moisture necessary to reduce the required air quantity results in a trial-and-error procedure. The method is outlined in the following steps:

1. Assume an amount of moisture to be added and determine the latent heat available from this moisture. *Table 53* gives the maximum moisture that may be added to a space without causing condensation on supply air ducts and equipment.
2. Deduct this assumed latent heat from the original effective room sensible heat and use the difference in the following equation for ERSH to determine t_{ADP}.
   $$t_{ADP} = t_{RM} - \frac{\text{ERSH}}{1.20 \times (1-\text{BF})\ \ell/s_{DA}}$$
   ℓ/s_{DA} is the reduced air quantity permissible in the air distribution system.
3. The ESHF is obtained from a psychrometric chart or *Table 59*, using the apparatus dewpoint (from *Step 2*) and room design conditions.
4. The new effective room latent load is determined from the following equation:
   $$\text{ERLH} = \text{ERSH} \times \frac{1-\text{ESHF}}{\text{ESHF}}$$
   The ERSH is from *Step 2* and ESHF is from *Step 3*.

*For cooling with humidification at near constant dry-bulb temperature, refer to the heading after next.

5. Deduct the original ERLH (before adding sprays or humidifier in the space) from the new effective room latent heat in *Step 4*. The result is equal to the latent heat from the added moisture, and must check with the value assumed in *Step 1*. If it does not check, assume another value and repeat the procedure.

Example 5 illustrates the procedure for investigating an application where humidification is accomplished within the space to reduce the air quantity.

Example 5—Cooling With Evaporative Humidification in the Space

Given:

Application—A high humidity chamber
Summer design—35°C DB, 25°C WB
Inside design—21°C DB, 70% RH
RSH—47 000 W
RLH—3000 W
RSHF—0.94
Ventilation—1900 ℓ/s_{OA}

Find:

A. When space humidification is not used:
1. Outdoor air load (OATH)
2. Grand total heat (GTH)
3. Effective sensible heat factor (ESHF)
4. Apparatus dewpoint (t_{ADP})
5. Dehumidified air quantity (ℓ/s_{DA})
6. Entering and leaving conditions at the apparatus (t_{EDB}, t_{EWB}, t_{LDB}, t_{LWB})

B. When humidification is used in the space:
1. Assume maximum air quantity and assume an amount of moisture added to the space.
2. New effective room sensible heat (ERSH)
3. New apparatus dewpoint (t_{ADP})
4. New effective sensible heat factor (ESHF)
5. New effective room latent heat (ERLH)
6. Check calculated latent heat from the moisture added with amount assumed in *Item 1*.
7. Theoretical conditions of the air entering the evaporative humidifier before humidification.
8. Entering and leaving conditions at the apparatus (t_{EDB}, t_{EWB}, t_{LDB}, t_{LWB})

Solution:

A. When space humidification is not used:
1. OASH $= 1.20 \times 1900 \times (35-21) = 32\,000$ W (14)
   OALH $= 3.0 \times 1900 \times (15.9-11) = 27\,900$ W (15)
   OATH $= 32\,000 + 27\,900 = 59\,900$ W (17)
2. GTH $= 47\,000 + 3000 + 32\,000 + 27\,900$ (9)
   $= 109\,900$ W
3. Assume a bypass factor of 0.05 from *Tables 55* and *56*.
   $$\text{ESHF} = \frac{47\,000 + (0.05)\,(32\,000)}{47\,000 + 3000 + (0.05)\,(32\,000) + (0.05)\,(27\,900)} = 0.92 \quad (26)$$
4. Plot the ESHF on a psychrometric chart and read the ADP (dotted line in *Fig. 54*).
   $t_{ADP} = 15.0$°C
5. $$\ell/s_{DA} = \frac{47\,000 + (0.05)\,(32\,000)}{1.20\,(1-0.05)\,(21-15)} = 7100\ \ell/s \quad (36)$$
6. $$t_{EDB} = \frac{(1900 \times 35) + (5200 \times 21)}{7100} = 24.7\text{°C DB} \quad (31)$$
   Read t_{EWB} where the t_{EDB} crosses the straight line plotted between the outdoor and room design conditions on the psychrometric chart (*Fig. 54*)
   $t_{EWB} = 19.0$°C WB
   $t_{LDB} = 15.0 + 0.05\,(24.7-15) = 15.5$°C DB (32)
   Determine the t_{LWB} by drawing a straight line between the ADP and the entering conditions to the apparatus (the GSHF line). Where t_{LDB} intersects this line, read the t_{LWB} (*Fig. 54*)
   $t_{LWB} = 15.2$°C WB

B. When humidification is used in the space:
1. Assume, for the purpose of illustration in this problem, that the maximum air quantity permitted in the air distribution system is 4500 ℓ/s. Assume 0.8 gram of moisture per kilogram of dry air is to be added to convert sensible to latent heat. The latent heat is calculated by multiplying the air quantity times the moisture added times the factor 3.0
   $0.8 \times 4500 \times 3.0 = 10\,800$ W
2. New ERSH = Original ERSH − latent heat of added moisture
   $= [47\,000 + (0.05 \times 32\,000)] - 10\,800$
   $= 37\,800$ W
3. $$t_{ADP} = 21 - \frac{37\,800}{1.20\,(1-0.05)\,(4500)} = 13.65\text{°C} \quad (36)$$
4. ESHF is read from the psychrometric chart as 0.715 (dotted line in *Fig. 55*).
5. $$\text{New ERLH} = \text{New ERSH} \times \frac{1-\text{ESHF}}{\text{ESHF}} = 37\,800 \times \frac{1-0.715}{0.715} = 15\,100\ \text{W}$$
6. Check for latent heat of added moisture.
   Latent heat of added moisture
   = New ERLH − Original ERLH
   $= 15\,100 - [3000 + (0.05 \times 27\,900)]$
   $= 10\,700$ W
   This checks reasonably close with the assumed value in *Step 1* (10 800 W)*.
7. Psychrometrically, it can be assumed that the atomized water from the spray heads in the space absorbs part of the room sensible heat and turns into water vapour at the final room wet-bulb temperature. The theoretical dry-bulb of the air entering the sprays is at the intersection of the room design wet-bulb line and the moisture content of the air entering the sprays. This moisture content is determined by subtracting the moisture added by the room sprays from the room design moisture content.
   Moisture content of air entering humidifier
   $10.95 - 0.8 = 10.15$ g/kg
   The theoretical dry-bulb is determined from the psychrometric chart as 23.0°C DB illustrated on *Fig. 55*.

Note:
Numbers in parentheses at right edge of column refer to equations in the section 'Psychrometric Formulae' at the end of this chapter.

*The trial and error method will reveal the criticality of choosing the relative values of air quantity and moisture content.

8. $t_{EDB} = \dfrac{(1900 \times 35) + (2600 \times 21)}{4500} = 26.9°C$ (31)

Read t_{EWB} where the t_{EDB} crosses the straight line plotted between the outdoor and room design conditions on the psychrometric chart (*Fig. 55*).

$t_{EWB} = 20.8°C$ WB

$t_{LDB} = 13.65 + (0.05)\ (26.9 - 13.65)$
$= 14.3°C$ DB (32)

Determine t_{LWB} by drawing a straight line between the ADP and the entering conditions to the apparatus (GSHF line). Where t_{LDB} interescts this line, read the t_{LWB} (*Fig. 55*).

$t_{LWB} = 14.1°C$ WB

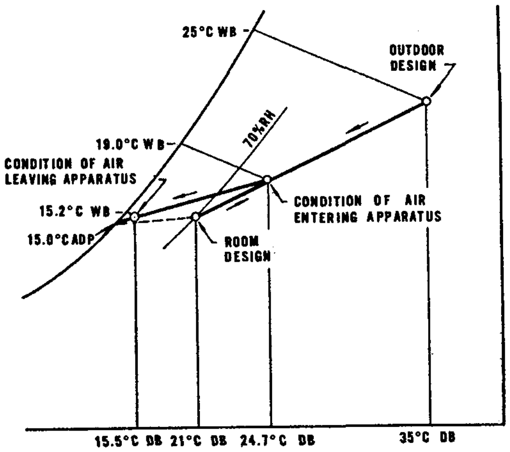


Fig. 54—Cooling and dehumidification adding no moisture to the space

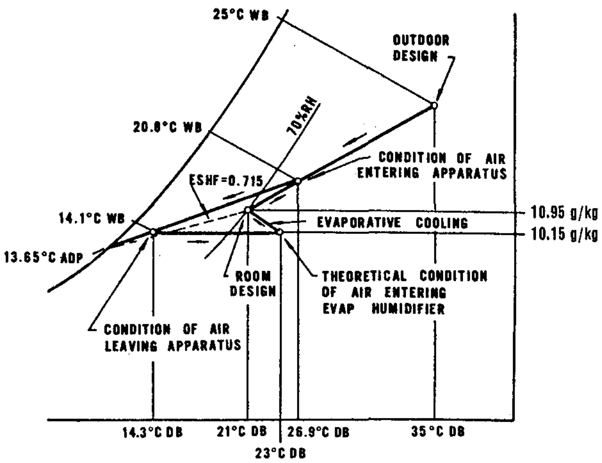


Fig. 55—Cooling and dehumidification adding moisture into the space

The straight line connecting the leaving conditions at the apparatus with the theoretical condition of the air entering the evaporative humidifier represents the theoretical process line of the air. This theoretical condition of the air entering the humidifier represents what the room conditions are if the humidifier is not operating. The slope of this theoretical process line is the same as RSHF (0.94).

The heavy lines on *Fig. 55* illustrate the theoretical air cycle as air passes through the conditioning apparatus to the evaporative humidifier, then to the room, and finally back to the apparatus where the return air is mixed with the ventilation air. Actually, if a straight line were drawn from the leaving conditions of the apparatus (14.3°C DB, 14.1°C WB) to the room design conditions, this line would be the RSHF line and would be the process line for the supply air as it picks up the sensible and latent loads in the space (including the latent heat added by the sprays).

The following two methods of laying out the system are recommended when the humidifier is to be used for both partial load control and reducing the air quantity.

1. Use two humidifiers; one to operate continuously, adding the moisture to reduce the air quantity, and the other to operate intermittently to control the humidity. The humidifier used for partial load is sized for the effective room latent load, not including that produced by the other humidifier. If the winter requirements for moisture addition are larger than summer requirements, then the humidifier is selected for these conditions. This method of using two humidifiers gives the best control.

2. Use one humidifier of sufficient capacity to handle the effective room latent heat plus the calculated amount of latent heat from the added moisture required to reduce the air quantity. In *Part B, Step 5,* the humidifier would be sized for a latent load of 15 100 W.

Sensible Cooling

A sensible cooling process is one that removes heat from the air at a constant moisture content, line (*1–2*), *Fig. 51.* Sensible cooling occurs when either of the following conditions exist:

1. The GSHF as calculated or plotted on the psychrometric chart is 1.0.

2. The ESHF calculated on the air conditioning load estimate form is equal to 1.0.

In a sensible cooling application, the GSHF equals 1.0. The ESHF and the RSHF may equal 1.0. When only the RSHF equals 1.0, however, it does not necessarily indicate a sensible cooling process because latent load, introduced by outdoor air can give a GSHF less than 1.0.

The apparatus dewpoint is referred to as the effective surface temperature (t_{ES}) in sensible cooling applications. The effective surface temperature must be equal to, or higher than, the dewpoint temperature of the entering air. In most instances, the t_{ES} does not lie on the saturated line and, therefore, will not be the dewpoint of the apparatus. However, the calculations may still be performed on the air conditioning load estimate form by substituting the term t_{ES} for t_{ADP}.

The use of the term ℓ/s_{DA} in a sensible cooling application should not be construed to indicate that dehumidification is occurring. It is used in the 'Air Conditioning Load Estimate' form and in *Example 6* to determine the air quantity required through the apparatus to offset the conditioning loads.

The leaving air conditions from the coil are dictated by the room design conditions, the load and the required air quantity.

Example 6 illustrates the method of determining the apparatus dewpoint or the effective surface temperature for a sensible cooling application.

Example 6—Sensible Cooling

Given:

Application: Factory
Summer design: 40°C DB, 21°C WB
Inside design: 24°C DB
RSH—60 000 W
RLH—15 000 W
Ventilation: 6000 ℓ/s; all outside air.

1. Moisture content of room air (w_{RM})
2. Room wet-bulb temperature ($t_{RM\ WB}$)
3. RSHF
4. Air leaving conditions (t_{LDB}, t_{LWB})
5. Outside air sensible heat (OASH)
6. Grand total heat (GTH)
7. Effective surface temperature, assuming BF = 0.05
8. Highest bypass factor which can be used in this instance

Solution:

1. $w_{RM} - 7.7 = \dfrac{15\,000}{6\,000 \times 3.0}$ (43)

   $w_{RM} = 8.54$ g/kg.
2. The room condition is 24°C DB, 8.54 g/kg. From psychrometric chart read $t_{RM\ WB} = 16.3$°C Fig. 56
3. $\text{RSHF} = \dfrac{60\,000}{60\,000 + 15\,000} = 0.80$ (25)
4. $1.20\,(24 - t_{LDB}) \times 6000 = 60\,000$ (35)

   $t_{LDB} = 15.65$°C, $t_{LWB} = 12.4$°C (from psychrometric chart)
5. $\text{OASH} = 1.20 \times 6000\,(40 - 24) = 115\,200$ W (14)
6. $\text{GTH} = 60\,000 + 15\,000 + 115\,200 = 190\,200$ W (9)
7. $\text{BF} = 0.05 = \dfrac{15.65 - t_{ES}}{40 - t_{ES}}$ (28)

   $t_{ES} = 14.4$°C
8. The dewpoint temperature of the air entering the equipment is 10°C (from psychrometric chart). This is the lowest possible surface temperature with sensible cooling.

$$\text{BF}_{\max} = \frac{15.65 - 10}{40 - 10} = 0.1885$$

Note:

Numbers in parentheses at right edge of column refer to equations in the section 'Psychrometric Formulae' at the end of this chapter.

K

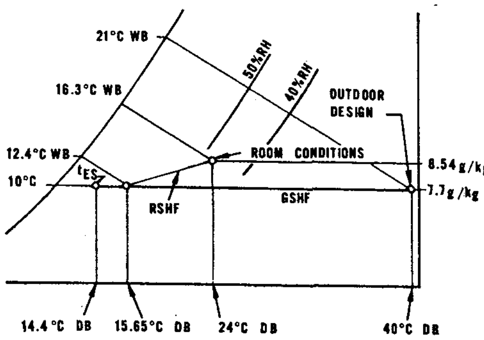


Fig. 56—Sensible cooling

Cooling With Humidification at Near Constant Dry-Bulb Temperature

When steam is injected or water vapour released into the conditioned space from say electric humidifiers, humidification becomes a near isothermal process. This method of humidifying can be used at design or partial load conditions when the room latent heat load is insufficient to permit the design room relative humidity to be reached. *Example 7* illustrates the method of determining the amount of steam required for a sensible cooling application.

Example 7—Sensible Cooling and Near-Isothermal Humidification

Given:

Application: Operating Theatre
Summer design: 40°C DB, 21°C WB
Inside design: 24°C DB, 60% RH
RSH—60 000 W
RLH—15 000 W
Ventilation: 6000 ℓ/s; all outside air

Find:

1. Room conditions without humidification ($t'_{RM\ DB}$, $t'_{RM\ WB}$)
2. Air leaving conditions (t_{LDB}, t_{LWB})
3. Effective surface temperature, assuming BF = 0.05
4. Amount of moisture (steam) required to raise room relative humidity to the design figure of 60% RH.

Solution:

It will be noted that the answers to the first three points are identical to those given in *Example 6*, i.e.

1. $t'_{RM\ DB} = 24$°C, $t'_{RM\ WB} = 16.3$°C
2. $t_{LDB} = 15.65$°C, $t_{LWB} = 12.4$°C
3. $t_{ES} = 14.4$°C
4. Difference between moisture content of room at 60% RH (w_1) and that achievable without humidification ($w_2 = 8.54$ g/kg, from *Example 5*): $w_1 = 11.4$ g/kg (from psychrometric chart, *Fig. 57*).

   With an air flow of 6000 ℓ/s and air at a specific volume of 0.842 m³/kg, the amount of moisture (steam) required is:

$$\frac{6000}{1000\ (\ell/\text{m}^3)} \times 2.86 \times \frac{1}{0.842} = 20.38 \text{ g/s}$$

This is equivalent to 20.38×2500 (kJ/kg) = 51 000 W (This could have been arrived at by application of formula (23), i.e. $\text{TLH} = 3.0 \times 6000 \times (11.4 - 8.54) = 51\,000$ W)

If humidification were done by an electric humidifier, its rating would be 51 000 W (neglecting heat losses in the humidifier).

5. The rise in dry-bulb temperature due to steam humidification is usually neglected. In this instance and assuming steam injection at 100°C, the rise would be 0.405°C. Air leaving temperature (t_{LDB}) and effective surface temperature (t_{ES}) would have to be reduced by that amount.

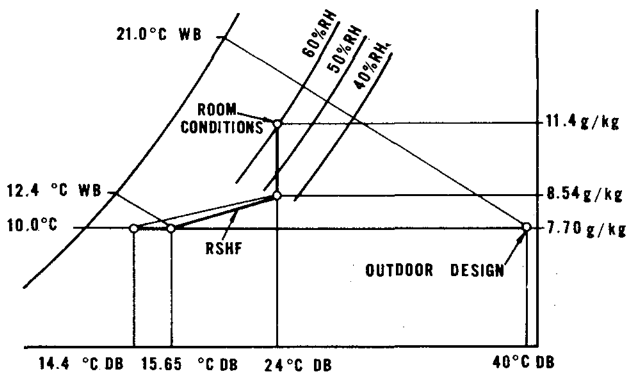


Fig 57—Sensible cooling and steam humidifying

SPRAY CHARACTERISTICS

In the operation of spray type equipment, air is drawn or forced through a chamber where water is sprayed through nozzles into the air stream. The spray nozzles may be arranged within the chamber to spray the water counter to air flow, parallel to air flow, or in a pattern that is a combination of these two. Generally, the counter-flow sprays are the most efficient: parallel flow sprays are the least efficient; and when both are employed, the efficiency falls somewhere in between these extremes.

SATURATION EFFICIENCY

In a spray chamber, air is brought into contact with a dense spray of water. The air approaches the state of complete saturation. The degree of saturation is termed saturation efficiency (sometimes called contact or performance factor). Saturation efficiency is, therefore, a measure of the spray chamber efficiency. It can be considered to represent that portion of the air passing through the spray chamber which contacts the spray water surface. This contacted air is considered to be leaving the spray chamber at the effective surface temperature of the spray water. This effective surface temperature is the temperature at complete saturation of the air.

Though not a straight line function, the effect of saturation efficiency on the leaving air conditions from a spray chamber may be determined with a sufficient degree of accuracy from the following equation:

$$\text{Sat. eff.} = \frac{t_{EDB}-t_{LDB}}{t_{EDB}-t_{ES}} = \frac{w_{EA}-w_{LA}}{w_{EA}-w_{SA}} = \frac{h_{EA}-h_{LA}}{h_{EA}-h_{ES}}$$

The saturation efficiency is the complement of bypass factor, and with spray equipment the bypass factor is used in the calculation of the cooling load. Bypass factor, therefore, represents that portion of the air passing through the spray equipment which is considered to be leaving the spray chamber completely unaltered from its entering condition.

This efficiency of the sprays in the spray chamber is dependent on the spray surface available and on the time available for the air to contact the spray water surface. The available surface is determined by the water particle size in the spray mist (pressure at the spray nozzle and the nozzle size), the quantity of water sprayed, number of banks of nozzles, and the number of nozzles in each bank. The time available for contact depends on the velocity of the air through the chamber, the length of the effective spray chamber, and the direction of the sprays relative to the air flow. As the available surface decreases or as the time available for contact decreases, the saturation efficiency of the spray chamber decreases. *Table 57* illustrates the relative efficiency of different spray chamber arrangements.

The relationship of the spray water temperatures to the air temperatures is essential in understanding the psychrometrics of the various spray processes. It can be assumed that the leaving water temperature from a spray chamber, after it has contacted the air, is equal to the leaving air wet-bulb temperature. The leaving water temperature will not usually vary more than a degree from the leaving air wet-bulb temperature. Then the entering water temperature is, therefore, dependent on the water quantity and the heat required to be added or removed from the air.

Table 57 illustrates the relative efficiency of different spray chamber arrangements.

SPRAY PROCESSES

Sprays are capable of cooling and dehumidifying, sensible cooling, cooling and humidifying, and heating and humidifying. Sensible cooling may be accomplished only when the entering air dewpoint is the same as the effective surface temperature of the spray water.

The various spray processes are represented on the psychrometric chart in *Fig. 58*. All process lines must go toward the saturation line, in order to be at or near saturation.

Adiabatic Saturation or Evaporative Cooling

Line (*1–2*) represents the evaporative cooling process. This process occurs when air passes through

TABLE 57
Typical Saturation Efficiency*
FOR SPRAY CHAMBERS

No. of Banks	Direction of Water Spray	6 mm Nozzle 170 kPa Nozzle Pressure 2 ℓ/s.m² †		3 mm Nozzle 210 kPa Nozzle Pressure 1.7 ℓ/s.m² †	
		Velocity‡ (m/s)			
		1.5	3.5	1.5	3.5
1	Parallel	70%	50%	80%	60%
	Counter	75%	65%	82%	70%
2	Parallel	90%	85%	92%	87%
	Opposing	98%	92%	98%	93%
	Counter	99%	93%	99%	94%

*Saturation efficiency = 1—BF
†ℓ/s.m² of chamber face area.
‡Velocities above 3.5 m/s and below 1.5 m/s normally do not permit eliminators to adequately remove moisture from the air. Reference to manufacturers' data is suggested for limiting velocity and performance.

a spray chamber where heat has not been added to or removed from the spray water. (This does not include heat gain from the water pump and through the apparatus casing.) When plotted on the psychrometric chart, this line approximately follows up the line of the wet-bulb temperature of the air entering the spray chamber. The spray water temperature remains essentially constant at this wet-bulb temperature.

Cooling and Humidification—With Chilled Spray Water

If the spray water receives limited cooling before it is sprayed into the air stream, the slope of the process line will move down from the evaporative cooling line. This process is represented by line (*1–3*).

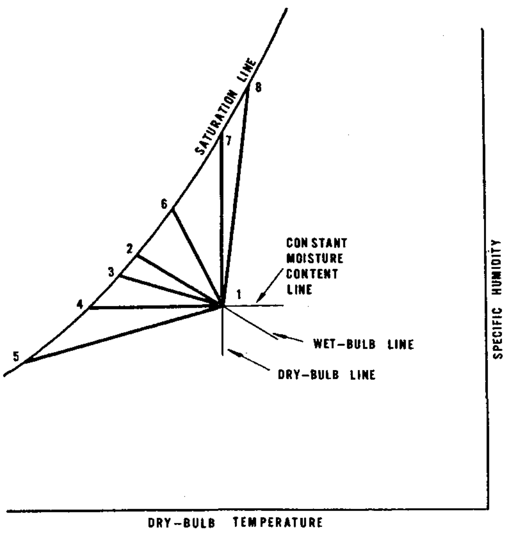


Fig. 58—Spray processes

Limited cooling causes the leaving air to be lower in dry-and wet-bulb temperatures, but higher in moisture content, than the air entering the spray chamber.

Sensible Cooling

If the spray water is cooled further, sensible cooling occurs. This process is represented by line (*1–4*). Sensible cooling occurs only when the entering air dewpoint is equal to the effective surface temperature of the spray water; this condition is rare. In a sensible cooling process, the air leaving the spray chamber is lower in dry- and wet-bulb temperatures but equal in moisture content to the entering air.

Cooling and Dehumidification

If the spray water is cooled still further, cooling and dehumidification takes place. This is illustrated by line (*1–5*). The leaving air is lower in dry- and wet-bulb temperatures and in moisture content than the air entering the spray chamber.

Cooling and Humidification—With Heated Spray Water

When the spray water is heated to a limited degree before it is sprayed into the air stream, the slope of the process line rises to a point above the evaporative cooling line. This is illustrated by line (*1–6*). Note that the leaving air is lower in dry-bulb temperature, but higher in wet-bulb temperature and moisture content, than the air entering the spray chamber.

Humidification Without Cooling or Heating

If the spray water is heated to approximately the dry-bulb temperature of the air stream, isothermal humidification occurs. This is illustrated by line (*1–7*).

Heating and Humidification

If the spray water is sufficiently heated, a heating and humidification process results. This is represented by line (*1–8*). In this process the dry-bulb temperature, wet-bulb temperature, and moisture content of the leaving air is greater than that of the entering air.

SPRAY PROCESS EXAMPLES

The following descriptions and examples provide a better understanding of the various psychrometric processes involved in spray washer equipment.

Cooling and Dehumidification

When a spray chamber is to be used for cooling and dehumidification, the procedure for estimating the load and selecting the equipment is identical to the procedure described previously in this chapter for coils. The 'Air Conditioning Load Estimate' form is used to evaluate the load; bypass factor is determined by subtracting the selected saturation efficiency from one. Spray chamber dehumidifiers may not be rated in terms of apparatus dewpoint but in terms of entering and leaving wet-bulb temperatures at the apparatus. The apparatus dewpoint must still be determined, however, to evaluate properly the entering and leaving wet-bulb temperatures and the dehumidified air quantity.

Although originally prepared to exemplify the operation of a coil, *Example 1* of this chapter is also typical of the cooling and dehumidifying process using sprays.

Cooling and Dehumidification—Using All Outdoor Air

When a spray chamber is to be used for cooling and dehumidifying with all outdoor air, the procedure for determining ADP, entering and leaving conditions at the chamber, ESHF and ℓ/s_{DA} is identical to the procedure for determining these items for coils using all outdoor air. Therefore, the description given previously for coils and *Example 4* may be used to analyze this type of application.

Evaporative Cooling

An evaporative cooling application is the simultaneous removal of sensible heat and the addition of moisture to the air, line (*1–2*), *Fig. 58.* The spray water temperature remains essentially constant at the wet-bulb temperature of the air. This is a process in which heat is not added to or removed from the spray water. (Heat gain from the water pump and heat gain through the apparatus casing are not included.)

Evaporative cooling is commonly used in dry climates to give some measure of relief by removing sensible heat, and also in industrial applications where the relative humidity is to be controlled but where no control is required for the room dry-bulb temperature, except to hold it above a predetermined minimum. When the dry-bulb temperature is to be maintained during the winter or intermediate season, heat must be available to the system. This is usually accomplished by adding a reheat coil. When relative humidity is to be maintained in addition to room dry-bulb during the winter or intermediate season, a combination of preheat and reheat coils, or a reheat coil and spray water heating, is required. The latter method changes the process from evaporative cooling to one of the humidification processes illustrated by lines (*1–6*), (*1–7*) or (*1–8*) in Fig. 58.

Example 8 illustrates an industrial application designed to maintain the space relative humidity only.

Example 8—Evaporative Cooling

Given:
An industrial application
Summer design—35°C DB, 25°C WB
Inside design—60% RH
RSH—600 000 W
RSHF—1.0
Use all outdoor air at design load conditions.

Find:
1. Room dry-bulb temperature at design (t_{RM})
2. Supply air quantity (ℓ/s_{SA})

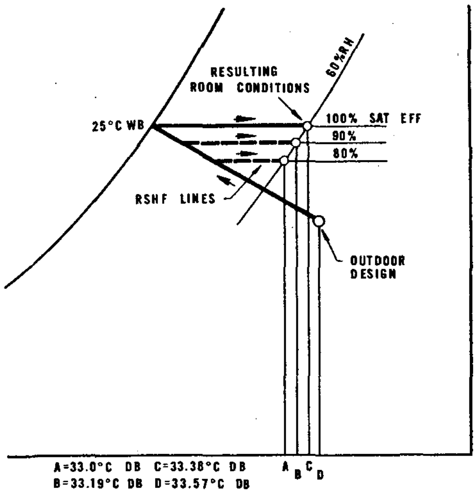


Fig. 59—Evaporative cooling, with varying saturation efficiency

Solution:
1. Determine the room dry-bulb temperature by compromising between the spray saturation efficiency, the acceptable room dry-bulb temperature, and the supply air quantity. To evaluate these items, use the following equation to determine the leaving conditions from the spray for various saturation efficiencies:

   $t_{LDB} = t_{EDB} - (\text{Sat. Eff.})\ (t_{EDB} - t_{EWB})$*

   The room dry-bulb temperature in the following table results from various spray saturation efficiencies and is determined by plotting the RSHF through the various leaving conditions, to the design relative humidity, *Fig. 59.* Note that the supply air temperature rise decreases more rapidly than the room dry-bulb temperature. Correspondingly, as the supply air temperature rise decreases, the supply air quantity increases in the same proportion.

Sat. Eff. (%)	Dry-Bulb Temp. Leaving Sprays (t_{LDB})	Supply Air Temp. Rise (Δt)	Room Dry-Bulb Temp. at 60% RH (t_{RM})
100	25.0	8.76	33.76
95	25.5	8.07	33.57
90	26.0	7.38	33.38
85	26.5	6.69	33.19
80	27.0	6.00	33.00

2. Calculate the supply air quantity for the various temperature rises from the following equation:

$$\ell/s_{SA} = \frac{RSH}{1.20\ (t_{RM} - t_{LDB})}$$

*This equation is applicable only to evaporative cooling applications where the entering air wet-bulb temperature, the leaving air wet-bulb temperature, and the entering and leaving water temperature to the sprays are all equal.

Supply Air Temp. Rise ($t_{RM} - t_{LDB}$)	Supply Air Quantity (ℓ/s_{SA})
8.76	57 000
8.07	62 000
7.38	67 600
6.69	74 600
6.00	83 300

The spray chamber and supply air quantity should then be selected to result in the best owning and operating costs. The selection is based primarily on economic considerations.

Evaporative Cooling Used With a Split System

There are occasions when using straight evaporative cooling results in excessive air quantity requirements and an unsatisfactory air distribution system. This situation usually arises in applications that are to be maintained at higher relative humidities (70% or more). To use straight evaporative cooling with the large air quantity, or to use a split system with the auxiliary sprays in the space, becomes a problem of economics which should be analyzed for each particular application.

When a split system is used, supplemental spray heads are usually added to the straight evaporative cooling system. These spray heads atomize water and add supplementary moisture directly to the room. This added moisture is evaporated at the final room wet-bulb temperature, and the room sensible heat is reduced by the amount of heat required to evaporate the sprayed water.

Table 58 gives the recommended maximum moisture to be added, based on an 18°C DB room temperature or over, without causing condensation on the ductwork.

TABLE 58
Maximum Recommended Moisture Added to Supply Air
WITHOUT CAUSING CONDENSATION ON DUCTS*

Room Design RH	Moisture g/kg Dry Air	Room Design RH	Moisture g/kg Dry Air
85	2.40	65	2.91
80	2.50	60	3.09
75	2.61	55	3.28
70	2.76	50	3.48

*These are arbitrary limits which have been established by a combination of theory and field experience. These limits apply where the room dry-bulb temperature is 18°C DB or over.

As a rule of thumb, the air is reduced in temperature approximately 2.4°C for every gram of moisture per kilogram added. This value is often used as a check on the final room temperature as read from the psychrometric chart.

Example 9 illustrates an evaporative cooling application with supplemental spray heads used in the space.

Example 9—Evaporative Cooling—With Auxiliary Sprays

Given:

An industrial application
Summer design—35°C DB, 24°C WB
Inside design—70% RH
RSH—600 000 W
RSHF—1.0
Moisture added by auxiliary spray heads—2.76 g/kg (From *Table 58*)
Use all outdoor air through a spray chamber with 90% saturation efficiency.

Find:

1. Leaving conditions from spray chamber (t_{LDB}, t_{LWB})
2. Room dry-bulb temperature (t_{RM})
3. Supply air quantity (ℓ/s_{SA}) with auxiliary sprays
4. Supply air quantity (ℓ/s_{SA}) without auxiliary sprays.

Solution:

1. $t_{LDB} = t_{EDB} - (\text{Sat. Eff.})\,(t_{EDB} - t_{EWB})$
   $= 35 - 0.90\,(35 - 24) = 25.1°C$ DB
   t_{LWB} is the same as the t_{EWB} in an evaporative cooling process, *Fig. 60*.
2. Room dry-bulb temperature is evaluated by determining the moisture content of the space.
   $w_{RM} = w_{SA} + 2.76 = 18.40 + 2.76 = 21.16$ g/kg
   The 2.76 g/kg is the moisture added to the space by the auxiliary spray heads.
   The t_{RM} is the point on the psychrometric chart where the w_{RM} intersects the 70% design relative humidity line, *Fig. 60*.
   $t_{RM} = 31.9°C$ DB
3. Psychrometrically, it can be assumed that the atomized water from the spray heads absorbs part of the room sensible heat and turns into water vapour at

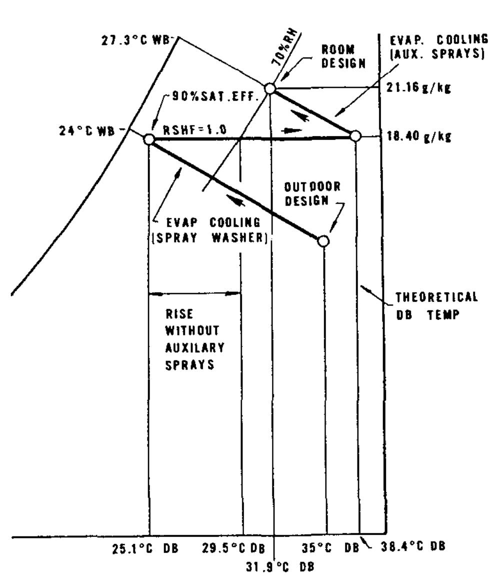


Fig. 60—Evaporative cooling, with auxiliary sprays within the space

the final room wet-bulb temperature. The intersection of this wet-bulb temperature with the moisture content of the air leaving the evaporative cooler is the theoretical dry-bulb equivalent temperature if the auxiliary sprays were not operating. The difference between this theoretical dry-bulb equivalent temperature and the temperature of the spray chamber, t_{LDB}, is used to determine the supply air quantity.

t_{LDB} (from spray chamber) = 25.1°C

The theoretical dry-bulb temp. is 38.4°C, *Fig. 60.*

Temp. rise = 13.3°C

$$\ell/s_{SA} = \frac{\text{RSH}}{1.20 \times \text{temp. rise}} = \frac{600\,000}{1.20 \times 13.3} = 37\,600\ \ell/s$$

4. If no auxiliary sprays were to be used, the room design dry-bulb would be where the RSHF line intersects the room design relative humidity. From *Fig. 60,* the room dry-bulb is read

   $t_{RM} = 29.5°C$

   The supply air quantity required to maintain the room design relative humidity is determined from the following equation:

$$\ell/s_{SA} = \frac{\text{RSH}}{1.20\,(t_{RM} - t_{LDB})} = \frac{600\,000}{1.20\,(29.5 - 25.1)}$$
$$= 113\,500\ \ell/s.$$

   This air quantity is over three times the air quantity required when auxiliary sprays are used in the space. However, it should be noted that, by reducing the air quantity, the room dry-bulb temperature increased from 29.5°C to 31.9°C.

Heating and Humidification—With Sprays

A heating and humidifying application is one in which heat and moisture are simultaneously added to the air, line *(1–8)*, *Fig. 58.* This may be required during the intermediate and winter seasons or during partial loads where both the dry-bulb temperature and relative humidity are to be maintained.

Heating and humidification may be accomplished by either of the following methods:

1. Add heat to the spray water before it is sprayed into the air stream.
2. Preheat the air with a steam or hot water coil and then evaporatively cool it in the spray chamber.

Spray water is heated, by a steam to water interchanger or by direct injection of steam into the water system. Since the supply air quantity and the spray water quantity have been determined from the summer design conditions, the only other requirement is to determine the amount of heat to be added to the spray water or to the preheater.

For applications requiring humidification, the room latent load is usually not calculated and the room sensible heat factor is assumed to be 1.0.

Example 10 illustrates the psychrometric calculations for a heating and humidifying application when the spray water is heated. It should be noted that this type of application occurs only when the quantity of outdoor air required is large in relation to the total air quantity.

Example 10—Heating and Humidification—With Heated Spray Water

Given:

An industrial application
Winter design— −1°C DB, −2°C WB
Inside design—21°C DB, 40% RH
Ventilation—25 000 ℓ/s_{OA} (see explanation above)
Supply air—40 000 ℓ/s_{SA}
Design room heat loss—700 000 W
Spray saturation efficiency—95%
RSHF (winter conditions)—1.0
Make-up water—10°C

Find:

1. Supply air conditions to the space (t_{SA})
2. Entering and leaving spray water temperature (t_{EW}, t_{LW})
3. Heat added to spray water to select water heater.

Solution:

1. $$t_{SA} = \frac{\text{design room heat loss}}{1.20 \times \ell/s_{SA}} + t_{RM}$$
$$= \frac{700\,000}{1.20 \times 40\,000} + 21 = 35.6°\text{C DB}$$

   To determine the wet-bulb temperature, plot the RSHF line on the psychrometric chart and read the wet-bulb at the point where t_{SA} crosses this line (*Fig. 61*). Supply air wet-bulb to the space = 18.55°C DB.

2. To determine the entering and leaving spray water temperature, calculate the entering and leaving air conditions at the spray chamber:

$$t_{EDB} = \frac{(-1 \times 25\,000) + (21 \times 15\,000)}{40\,000}$$
$$= 7.25°\text{C DB} \qquad (31)$$

   To determine wet-bulb temperature of the air entering the spray chamber, plot the mixture line of outdoor and return room air on the psychrometric chart, and read the wet-bulb temperature where t_{EDB} crosses the mixture line, *Fig. 58.*

   $t_{EWB} = 4.45°C$ WB

   The air leaving the spray chamber must have the same moisture content as the air in the room.

   $w_{RM} = w_{LA} = 6.2$ g/kg

   Since the spray chamber has a saturation efficiency of 95%, the moisture content of completely saturated air is calculated as follows:

$$w_{sat} = \frac{w_{LA} - w_{EA}}{\text{Sat. Eff.}} + w_{EA}$$
$$= \frac{6.2 - 4.1}{0.95} + 4.1 = 6.3\ \text{g/kg}$$

   The heating and humidification process line is plotted on the psychrometric chart between the moisture content of saturated air (6.3 g/kg) and the entering conditions to the spray chamber (7.25°C DB and 4.45°C WB, *Fig. 61*). The leaving conditions are read from the psychrometric chart where the room

Note:
Numbers in parentheses at right edge of column refer to equations in the section 'Psychrometric Formulae' at the end of this chapter.

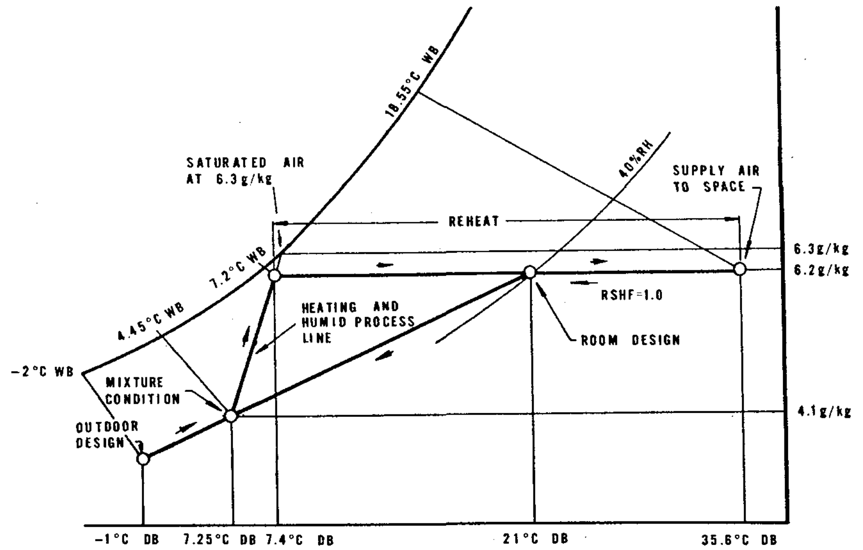


Fig. 61—Heating and humidification, with heating spray water

moisture content line (6.2 g/kg) intersects the heating and humidification process line, *Fig. 61.*

$t_{LDB} = 7.4°C$ DB

$t_{LWB} = 7.2°C$ WB

The temperature of the leaving spray water is approximately equal to the wet-bulb temperature of the air leaving the spray chamber.

$t_{LW} = 7.2°C$

The temperature of the entering spray water is dependent on the water quantity and the heat to be added or removed from the air. In this type of application, the water quantity is usually dictated by the cooling load design requirements. Assume, for illustration purposes, that this spray washer is selected for 7.0 ℓ/s for cooling.

The heat added to the air as it passes through the washer $= \ell/s_{SA} \times 1.19 \times (h_{LA} - h_{EA})$

$= 40\,000 \times 1.19 \times (23.0 - 17.5)$

$= 262\,000$ W.

The entering water temperature is determined from the following equation:

$$t_{EW} = t_{LW} + \frac{\text{heat added to air}}{4190 \times \ell/s^*}$$

$$= 7.2 + \frac{262\,000}{4190 \times 7}$$

$$= 16.1°C.$$

3. The heat added to the spray water (for selecting spray water heater) is equal to the heat added to the air plus the heat added to the make-up water. The amount of make-up water is equal to the amount of moisture evaporated into the air and is determined from the following equation:

Make-up water (g/s)

$$= \ell/s_{SA}\,(w_{LA} - w_{EA}) \times \frac{1}{1000\ (\ell/m^3)} \times \frac{1}{0.815}$$

where:

w_{EA}, w_{LA} = moisture content of the air entering and leaving the spray washer in gram per kilogram of dry air

0.815 = volume of the mixture in cubic metre per kilogram of dry air, determined from psychrometric chart.

Make-up water

$$= \frac{25\,000\,(6.2 - 4.1)}{1000 \times 0.815 \times 1000} = 64.4 \text{ g/s}$$

The heat added to the make-up spray water is determined from the following equation:

Heat added to make-up water

$$= \text{g/s} \times \frac{4190}{(1000 \text{ g/kg})} \times (t_{EW} - \text{make-up water temp.})$$

$$= 64.42 \times \frac{4190}{1000}(16.13 - 10.00)$$

$$= 1650 \text{ W}$$

To select a water heater, the total amount of heat added to the spray water is determined by totaling the heat added to the air and the heat added to the make-up spray water.

Heat added to spray water

$= 262\,000 + 1650$

$= 263\,650$ say $264\,000$ W

If the make-up water was at a higher temperature than the required entering water temperature to the sprays, then a credit to the heat added to the spray water may be taken.

In this example a reheat coil is required to heat the air leaving the spray chamber, at 7.2°C DB and at a constant moisture content of 6.2 g/kg to the required supply air temperature of 35.6°C DB.

The requirements of the application illustrated in *Example 10* can also be met by preheating the outdoor air and mixing it with the return air from the space. This mixture must then be evaporatively cooled to the room dewpoint (or room moisture content). And finally, the air leaving the spray chamber must be reheated to the required supply air temperature.

*Heat added to water (W) = (ℓ/s) × 1 (kg/ℓ) × Δt (°C) × 4190 (J/kg°C)

SORBENT DEHUMIDIFIERS

Sorbent dehumidifiers contain liquid absorbent or solid adsorbent which are either sprayed directly into, or located in, the path of the air stream. The liquid absorbent changes either physically or chemically, or both, during the sorption process. The solid adsorbent does not change during the sorption process.

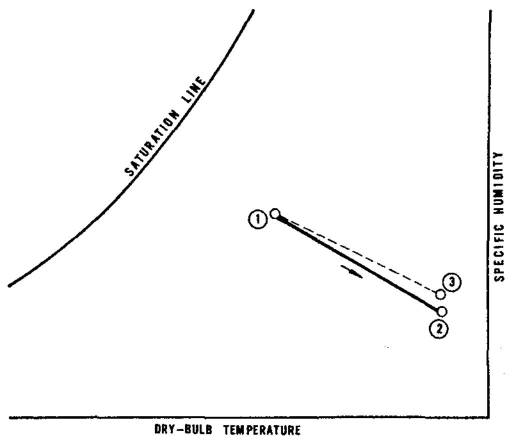


Fig. 62—Sorbent dehumidification processes

As moist air comes in contact with either the liquid absorbent or solid adsorbent, moisture is removed from the air by the difference in vapour pressure between the air stream and the sorbent. As this moisture condenses, latent heat of condensation is liberated, causing a rise in the temperature of the air stream and the sorbent material. This process occurs at a wet-bulb temperature that is approximately constant. However, instead of adding moisture to the air as in an evaporative cooling process, the reverse occurs. Heat is added to the air and moisture is removed from the air stream; thus it is a dehumidification and heating process as illustrated in *Fig. 62*. Line (*1–2*) is the theoretical process and the dotted line (*1–3*) approximates what actually happens. Line (*1–3*) can vary, depending on the type of sorbent used.

PSYCHROMETRICS OF PARTIAL LOAD CONTROL

The apparatus required to maintain proper space conditions is normally selected for peak load operation. Actually, peak load occurs but a few times each year and operation is predominantly at partial load conditions. Partial load may be caused by a reduction in sensible or latent loads in the space, or in the outdoor air load. It may also be caused by a reduction in these loads in any combination.

PARTIAL LOAD ANALYSIS

Since the system operates at partial load most of the time and must maintain conditions commensurate with job requirements, partial load analysis is at least as important as the selection of equipment. Partial load analysis should include a study of resultant room conditions at minimum total load. Usually this will be sufficient. Certain applications, however, should be evaluated at minimum latent load with design sensible load, or minimum sensible load and full latent load. Realistic minimum and maximum loads should be assumed for the particular application so that, psychrometrically, the resulting room conditions are properly analyzed.

The six most common methods, used singly or in combination, of controlling space conditions for cooling applications at partial load are the following:

1. Reheat the supply air.
2. Bypass the heat transfer equipment.
3. Control the volume of the supply air.
4. Use on–off control of the air handling equipment.
5. Use on–off control of the refrigeration machine
6. Control the refrigeration capacity.

The type of control selected for a specific application depends on the nature of the loads, the conditions to be maintained within the space, and available plant facilities.

REHEAT CONTROL

Reheat control maintains the dry-bulb temperature within the space by replacing any decrease in the sensible loads by an artificial load. As the internal latent load and/or the outdoor latent load decreases, the space relative humidity decreases. If humidity is to be maintained, rehumidifying is required in addition to reheat. This was described previously under '*Spray Process, Heating and Humidifying*'.

Figure 63 illustrates the psychrometrics of reheat control. The solid lines represent the process at design load, and the broken lines indicate the resulting process at partial load. The RSHF value, plotted from room design conditions to point (*2*), must be calculated for the minimum practical room sensible load. The room thermostat then controls the temperature of the air leaving the reheat coil along line (*1–2*). This type of control is applicable for any RSHF ratio that intersects line (*1–2*).

If the internal latent loads decrease, the resulting room conditions are at point (3), and the new RSHF process line is along line (*2–3*). However, if humidity is to be maintained within the space, the reduced latent load is compensated by humidifying, thus returning to the design room conditions.

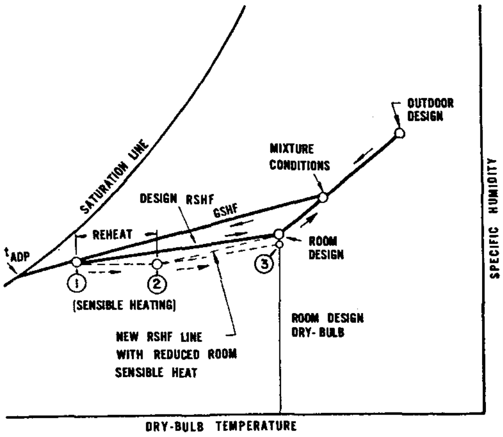


Fig. 63—Psychrometrics of reheat control

A reduction in room sensible load causes the bypass control to reduce the amount of air through the dehumidifier. This reduced air quantity results in equipment operation at a lower apparatus dewpoint. Also, the air leaves the dehumidifier at a lower temperature so that there is a tendency to adjust for a decrease in sensible load that is proportionately greater than the decrease in latent load.

Bypass control maintains the room dry-bulb temperature but does not prevent the relative humidity from rising above design. With bypass control, therefore, increased relative humidity occurs under conditions of decreasing room sensible load and relatively constant room latent load and outdoor air load.

The heavy lines in *Fig. 64* represents the cycle for design conditions. The light lines illustrate the initial cycle of the air when bypass control first begins to function. The new room conditions, mixture conditions and apparatus dewpoint continue to change until the equilibrium point is reached.

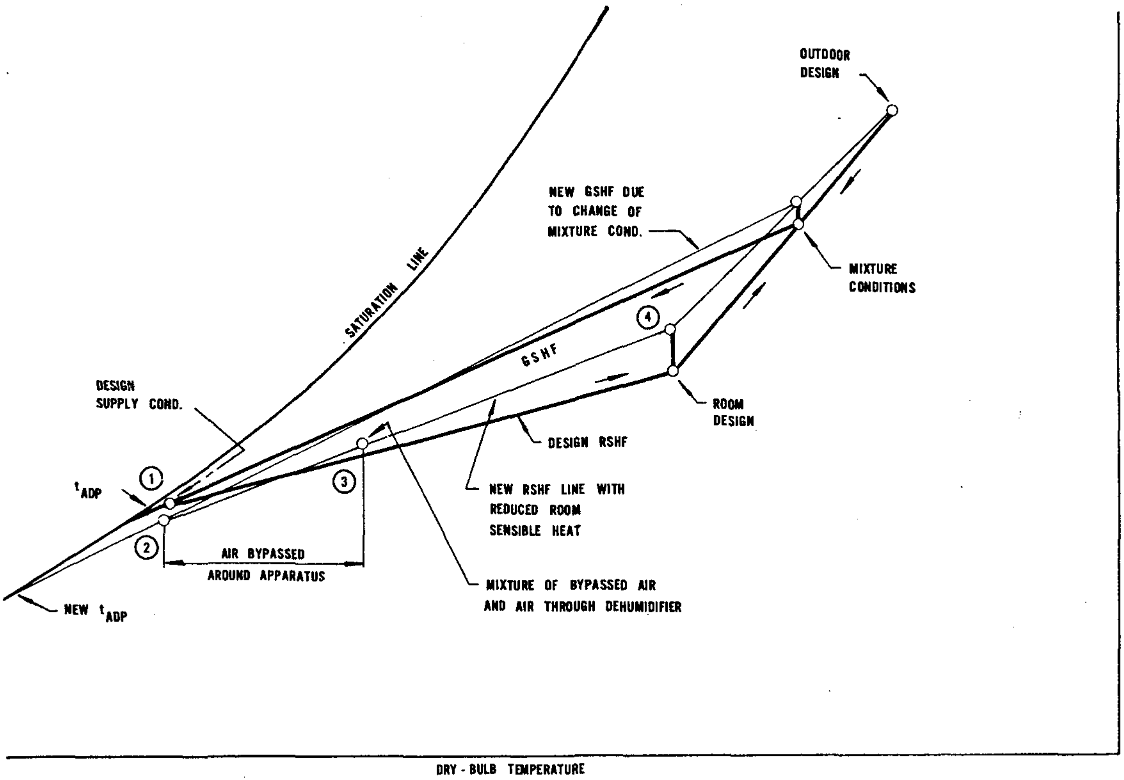


Fig. 64—Psychrometrics of bypass control with return air only

BYPASS CONTROL

Bypass control maintains the dry-bulb temperature within the space by modulating the amount of air to be cooled, thus varying the supply air temperature to the space. *Fig. 64* illustrates one method of bypass control when bypassing return air only.

Bypass control may also be accomplished by bypassing a mixture of outdoor and return air around the heat transfer equipment. This method of control is inferior to bypassing return air only since it introduces raw unconditioned air into the space, thus allowing an increase in room relative humidity.

Point (*2*) on *Figs. 64* and *65* is the condition of air leaving the dehumidifier. This is a result of a smaller bypass factor and lower apparatus dewpoint caused by less air through the cooling equipment and a smaller load on the equipment. Line (*2–3–4*) represents the new RSHF line caused by the reduced room sensible load. Point (*3*) falls on the new RSHF line when bypassing return air only.

Bypassing a mixture of outdoor and return air causes the mixture point (*3*) to fall on the GSHF line, *Fig. 64*. The air is then supplied to the space along the new RSHF line (not shown in *Fig. 64*) at a higher moisture content than the air supplied when bypassing return air only. Thus it can be readily observed that humidity control is further hindered with the introduction of unconditioned outdoor air into the space.

VOLUME CONTROL

Volume control of the supply air quantity provides essentially the same type of control that results from bypassing return air around the heat transfer equipment, *Fig. 64*. However, this type of control may produce problems in air distribution within the space and, therefore, the required air quantity at partial load should be evaluated for proper air distribution.

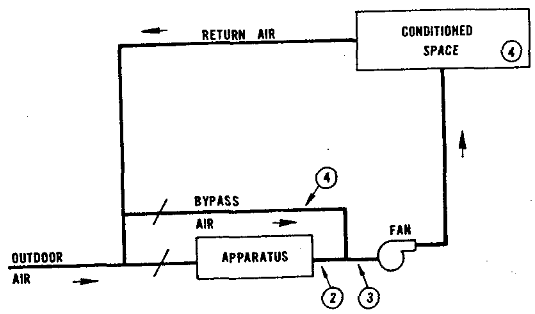


Fig. 65—Schematic sketch of bypass control with bypass of return air only

ON–OFF CONTROL OF AIR HANDLING EQUIPMENT

On–off control of air handling equipment (fan-coil units) results in a fluctuating room temperature and space relative humidity. During the 'off' operation the ventilation air supply is shut off, but chilled water continues to flow through the coils. This method of control is not recommended for high latent load applications, as control of humidity may be lost at reduced room sensible loads.

ON—OFF CONTROL OF REFRIGERATION EQUIPMENT

On–off control of refrigeration equipment (large packaged equipment) results in a fluctuating room temperature and space relative humidity. During the 'off' operation air is available for ventilation purposes but the coil does not provide cooling. Thus, any outdoor air in the system is introduced into the space unconditioned. Also the condensed moisture that remains on the cooling coil, when the refrigeration equipment is turned off, is re-evaporated in the warm air stream. This is known as re-evaporation. Both of these conditions increase the space latent load, and excessive humidity results. This method of control is not recommended for high latent load applications since control of humidity may be lost at decreased room sensible loads.

REFRIGERATION CAPACITY CONTROL

Refrigeration capacity control may be used on either chilled water or direct expansion refrigeration equipment. Partial load control is accomplished on chilled water equipment by bypassing the chilled water around the air side equipment (fan-coil units) or by shutting down one or more of a multiplicity of chilled water units operating either in series or in parallel. Direct expansion refrigeration equipment is controlled either by unloading the compressor cylinders or by back pressure regulation in the refrigeration suction line.

Refrigeration capacity control is normally used in combination with bypass or reheat control. When used in combination, results are excellent. When used alone, results are not as effective. For example, temperature can be maintained reasonably well, but relative humidity will rise above design at partial load conditions, because the latent load may not reduce in proportion to the sensible load.

PARTIAL LOAD CONTROL

Generally, reheat control is more expensive but provides the best control of conditions in the space. Bypass control, volume control and refrigeration capacity control provide reasonably good humidity control in average or high sensible heat factor applications, and poor humidity control in low sensible heat factor applications. On–off control usually results in the least desirable method of maintaining space conditions. However, this type of control is frequently used for high sensible heat factor applications with reasonably satisfactory results.

TABLE 59—APPARATUS DEWPOINTS

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
12	45	6.7	3.9	ESHF	1.00	0.93	0.85	0.81	0.80*				
				ADP	0.5	−1.0	−4.0	−8.0	−14.0				
	50	7.2	4.3	ESHF	1.00	0.94	0.89	0.83	0.79	0.78	0.77*		
				ADP	2.0	1.0	0	−2.0	−5.0	−7.0	−12.0		
	55	7.8	4.8	ESHF	1.00	0.97	0.90	0.82	0.77	0.75	0.74		
				ADP	3.3	3.0	2.0	0	−3.0	−6.0	−11.0		
	60	8.3	5.3	ESHF	1.00	0.93	0.90	0.86	0.79	0.73	0.72	0.71*	
				ADP	4.6	4.0	3.5	3.0	1.0	−3.0	−4.0	−8.0	
	65	8.7	5.7	ESHF	1.00	0.93	0.87	0.84	0.79	0.74	0.71	0.70	0.69*
				ADP	5.6	5.0	4.5	4.0	3.0	1.0	−1.0	−3.0	−6.0
	70	9.3	6.0	ESHF	1.00	0.91	0.87	0.81	0.76	0.73	0.69	0.68	0.66*
				ADP	6.6	6.0	5.5	5.0	4.0	3.0	1.0	−1.0	−5.0
	75	9.7	6.5	ESHF	1.00	0.87	0.81	0.77	0.72	0.67	0.65	0.63*	
				ADP	7.6	7.0	6.5	6.0	5.0	3.0	1.0	−3.5	
	80	10.2	7.0	ESHF	1.00	0.98	0.84	0.73	0.67	0.62	0.61	0.60*	
				ADP	8.7	8.5	8.0	7.0	6.0	4.0	2.0	−1.0	
	85	10.6	7.4	ESHF	1.00	0.82	0.75	0.68	0.63	0.58	0.57*		
				ADP	9.5	9.0	8.5	8.0	7.0	5.0	2.0		
	90	11.1	7.9	ESHF	1.00	0.78	0.69	0.63	0.57	0.55	0.53*		
				ADP	10.4	10.0	9.5	9.0	8.0	7.0	4.0		
	95	11.6	8.3	ESHF	1.00	0.76	0.62	0.55	0.51	0.49*			
				ADP	11.2	11.0	10.5	10.0	9.0	6.0			

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\,\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air

w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air

t_{RM} = room dry-bulb temperature

t_{ADP} = apparatus dewpoint temperature

1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air

2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS DB °C	RH %	WB °C	w g/kg	EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
14	45	8.4	4.5	ESHF	1.00	0.95	0.90	0.85	0.79	0.77*			
				ADP	2.5	1.5	0.5	−1.0	−5.0	−12.0			
	50	8.9	5.0	ESHF	1.00	0.93	0.88	0.81	0.78	0.75	0.74*		
				ADP	4.0	3.0	2.0	0	−2.0	−5.0	−11.0		
	55	9.5	5.5	ESHF	1.00	0.96	0.92	0.89	0.85	0.77	0.73	0.71*	
				ADP	5.3	5.0	4.5	4.0	3.0	0	−3.0	−9.0	
	60	10.0	6.0	ESHF	1.00	0.93	0.89	0.85	0.80	0.77	0.73	0.70	0.68*
				ADP	6.6	6.0	5.5	5.0	4.0	3.0	1.0	−2.0	−6.0
	65	10.6	6.5	ESHF	1.00	0.91	0.87	0.82	0.78	0.72	0.68	0.67	0.66*
				ADP	7.6	7.0	6.5	6.0	5.0	3.0	0	−1.0	−5.0
	70	11.0	7.0	ESHF	1.00	0.90	0.85	0.80	0.74	0.71	0.68	0.66	0.63*
				ADP	8.6	8.0	7.5	7.0	6.0	5.0	4.0	2.0	−4.0
	75	11.6	7.5	ESHF	1.00	0.99	0.86	0.81	0.75	0.70	0.64	0.62	0.61*
				ADP	9.7	9.5	9.0	8.5	8.0	7.0	5.0	3.0	−1.5
	80	12.0	8.0	ESHF	1.00	0.97	0.82	0.78	0.72	0.65	0.61	0.59	0.58*
				ADP	10.7	10.5	10.0	9.5	9.0	8.0	7.0	5.0	1.0
	85	12.6	8.5	ESHF	1.00	0.80	0.73	0.67	0.61	0.56	0.55	0.54*	
				ADP	11.6	11.0	10.5	10.0	9.0	7.0	5.0	3.5	
	90	13.0	9.0	ESHF	1.00	0.78	0.68	0.62	0.56	0.52	0.51*		
				ADP	12.4	12.0	11.5	11.0	10.0	8.0	5.5		
	95	13.5	9.5	ESHF	1.00	0.80	0.60	0.53	0.51	0.49	0.47*		
				ADP	13.2	13.0	12.5	12.0	11.5	10.0	7.5		

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\dfrac{(w_{\text{RM}}-w_{\text{ADP}})}{(t_{\text{RM}}-t_{\text{ADP}})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{\text{RM}}-t_{\text{ADP}})}{1.02\,(t_{\text{RM}}-t_{\text{ADP}}) + \dfrac{2500}{1000}\,(w_{\text{RM}}-w_{\text{ADP}})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH. kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS DB °C	RH %	WB °C	w g/kg	EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
16	45	9.9	5.2	ESHF	1.00	0.92	0.88	0.82	0.78	0.76	0.75*		
				ADP	4.2	3.0	2.0	0	−3.0	−7.0	−11.0		
	50	10.6	5.7	ESHF	1.00	0.94	0.88	0.83	0.79	0.74	0.72*		
				ADP	5.8	5.0	4.0	3.0	1.0	−3.0	−9.0		
	55	11.2	6.3	ESHF	1.00	0.97	0.94	0.88	0.83	0.76	0.72	0.70	0.69*
				ADP	7.2	7.0	6.5	6.0	5.0	3.0	0	−3.0	−7.0
	60	11.8	6.8	ESHF	1.00	0.93	0.88	0.83	0.78	0.72	0.69	0.67	0.66*
				ADP	8.4	8.0	7.5	7.0	6.0	4.0	2.0	−2.0	−5.0
	65	12.3	7.4	ESHF	1.00	0.92	0.86	0.81	0.75	0.69	0.65	0.63*	
				ADP	9.6	9.0	8.5	8.0	7.0	5.0	2.0	−3.5	
	70	12.9	8.0	ESHF	1.00	0.88	0.84	0.78	0.71	0.65	0.62	0.61*	
				ADP	10.6	10.0	9.5	9.0	8.0	6.0	3.0	−2.0	
	75	13.4	8.5	ESHF	1.00	0.86	0.80	0.75	0.68	0.64	0.59	0.58*	
				ADP	11.6	11.0	10.5	10.0	9.0	8.0	5.0	1.0	
	80	13.9	9.1	ESHF	1.00	0.84	0.74	0.70	0.63	0.58	0.55*		
				ADP	12.6	12.0	11.5	11.0	10.0	8.0	3.0		
	85	14.5	9.7	ESHF	1.00	0.82	0.71	0.66	0.59	0.54	0.51*		
				ADP	13.4	13.0	12.5	12.0	11.0	9.0	5.0		
	90	15.0	10.3	ESHF	1.00	0.78	0.65	0.58	0.53	0.49	0.48*		
				ADP	14.4	14.0	13.5	13.0	12.0	10.0	6.5		
	95	15.5	10.8	ESHF	1.00	0.74	0.58	0.49	0.45	0.44*			
				ADP	15.2	15.0	14.5	14.0	13.0	10.0			

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\,\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS DB °C	RH %	WB °C	w g/kg	EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
18	45	11.6	5.9	ESHF	1.00	0.93	0.88	0.85	0.80	0.75	0.73*		
				ADP	6.0	5.0	4.0	3.0	1.0	−3.0	−9.5		
	50	12.2	6.5	ESHF	1.00	0.95	0.88	0.84	0.78	0.74	0.72	0.70*	
				ADP	7.6	7.0	6.0	5.0	3.0	1.0	−2.0	−8.0	
	55	12.9	7.2	ESHF	1.00	0.90	0.83	0.79	0.73	0.70	0.68	0.67*	
				ADP	8.9	8.0	7.0	6.0	4.0	2.0	−1.0	−5.5	
	60	13.5	7.8	ESHF	1.00	0.89	0.85	0.81	0.78	0.74	0.69	0.66	0.64*
				ADP	10.2	9.5	9.0	8.5	8.0	7.0	5.0	2.0	−4.0
	65	14.1	8.5	ESHF	1.00	0.93	0.87	0.81	0.75	0.67	0.64	0.62	0.61*
				ADP	11.4	11.0	10.5	10.0	9.0	7.0	5.0	2.0	−2.0
	70	14.7	9.1	ESHF	1.00	0.89	0.81	0.76	0.70	0.66	0.63	0.60	0.58*
				ADP	12.5	12.0	11.5	11.0	10.0	9.0	8.0	6.0	0.5
	75	15.2	9.7	ESHF	1.00	0.87	0.77	0.74	0.66	0.62	0.58	0.56	0.55*
				ADP	13.5	13.0	12.5	12.0	11.0	10.0	8.0	6.0	2.5
	80	15.8	10.4	ESHF	1.00	0.83	0.73	0.68	0.61	0.58	0.54	0.52*	
				ADP	14.5	14.0	13.5	13.0	12.0	11.0	9.0	4.5	
	85	16.4	11.0	ESHF	1.00	0.79	0.62	0.56	0.53	0.50	0.49*		
				ADP	15.4	15.0	14.0	13.0	12.0	10.0	6.5		
	90	17.0	11.7	ESHF	1.00	0.72	0.61	0.55	0.50	0.46	0.45*		
				ADP	16.4	16.0	15.5	15.0	14.0	12.0	9.0		
	95	17.5	12.3	ESHF	1.00	0.72	0.53	0.46	0.42	0.41*			
				ADP	17.2	17.0	16.5	16.0	15.0	12.5			

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to *simplify estimating procedures. Use the same equation as in Note 1.* The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
20	20	9.3	3.0	ESHF	1.00	0.98	0.95	0.92	0.90	0.89	0.88*		
				ADP	−3.0	−4.0	−6.0	−8.0	−10.0	−12.0	−20.0		
	25	10.2	3.7	ESHF	1.00	0.98	0.96	0.93	0.90	0.87	0.86	0.85*	
				ADP	−0.4	−1.0	−2.0	−3.0	−5.0	−8.0	−11.0	−16.0	
	30	11.0	4.4	ESHF	1.00	0.96	0.93	0.89	0.85	0.83	0.82	0.81*	
				ADP	2.0	1.0	0	−2.0	−4.0	−7.0	−10.0	−14.5	
	35	11.7	5.0	ESHF	1.00	0.95	0.91	0.88	0.86	0.82	0.79	0.78*	
				ADP	4.2	3.0	2.0	1.0	0	−3.0	−6.0	−13.0	
	40	12.4	5.9	ESHF	1.00	0.94	0.89	0.86	0.83	0.81	0.77	0.75*	
				ADP	6.0	5.0	4.0	3.0	2.0	1.0	−2.0	−10.0	
	45	13.2	6.6	ESHF	1.00	0.94	0.88	0.84	0.79	0.76	0.73	0.71*	
				ADP	7.7	7.0	6.0	5.0	3.0	1.0	−2.0	−8.0	
	50	13.8	7.3	ESHF	1.00	0.97	0.88	0.83	0.73	0.72	0.70	0.68*	
				ADP	9.3	9.0	8.0	7.0	5.0	3.0	0	−5.5	
	55	14.5	8.1	ESHF	1.00	0.97	0.92	0.83	0.78	0.71	0.67	0.65*	
				ADP	10.8	10.5	10.0	9.0	8.0	6.0	3.0	−4.5	
	60	15.2	8.9	ESHF	1.00	0.92	0.85	0.78	0.73	0.67	0.64	0.62	0.61*
				ADP	12.1	11.5	11.0	10.0	9.0	7.0	5.0	3.0	−3.0
	65	15.8	9.6	ESHF	1.00	0.94	0.87	0.82	0.73	0.69	0.63	0.60	0.59*
				ADP	13.3	13.0	12.5	12.0	11.0	10.0	8.0	5.0	0
	70	16.5	10.3	ESHF	1.00	0.89	0.81	0.76	0.69	0.64	0.61	0.58	0.56*
				ADP	14.5	14.0	13.5	13.0	12.0	11.0	10.0	8.0	2.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\,\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB	RH	WB	ω										
°C	%	°C	g/kg										
21	20	9.9	3.1	ESHF	1.00	0.98	0.96	0.94	0.93*	0.88*			
				ADP	−2.3	−2.8	−4.3	−5.7	−6.0	−20.0			
	25	10.8	3.8	ESHF	1.00	0.96	0.94	0.90	0.88*	0.84*			
				ADP	0.5	−1.0	−2.0	−4.0	−6.0	−15.0			
	30	11.7	4.6	ESHF	1.00	0.96	0.93	0.88	0.84	0.82*	0.80*		
				ADP	2.9	2.0	1.0	−1.0	−4.0	−7.0	−13.0		
	35	12.4	5.4	ESHF	1.00	0.95	0.92	0.86	0.82	0.80	0.77*		
				ADP	5.0	4.0	3.0	1.0	−1.0	−3.0	−12.0		
	40	13.2	6.2	ESHF	1.00	0.94	0.89	0.86	0.81	0.78	0.75	0.74*	0.73*
				ADP	7.0	6.0	5.0	4.0	2.0	0	−3.0	−5.0	−9.0
	45	13.8	7.0	ESHF	1.00	0.95	0.88	0.83	0.78	0.74	0.72	0.71	0.70*
				ADP	8.6	8.0	7.0	6.0	4.0	1.0	0	−2.0	−8.0
	50	14.7	7.8	ESHF	1.00	0.98	0.89	0.83	0.76	0.72	0.69	0.68	0.67*
				ADP	10.2	10.0	9.0	8.0	6.0	4.0	1.0	0	−5.5
	55	15.3	8.5	ESHF	1.00	0.91	0.87	0.83	0.77	0.74	0.69	0.65	0.64*
				ADP	11.7	11.0	10.5	10.0	9.0	8.0	6.0	3.0	−3.5
	60	16.0	9.3	ESHF	1.00	0.93	0.86	0.78	0.72	0.66	0.63	0.61	0.60*
				ADP	13.0	12.5	12.0	11.0	10.0	8.0	6.0	3.0	−1.5
	65	16.7	10.2	ESHF	1.00	0.94	0.86	0.81	0.73	0.68	0.62	0.59	0.57*
				ADP	14.2	14.0	13.5	13.0	12.0	11.0	9.0	7.0	1.5
	70	17.4	10.9	ESHF	1.00	0.89	0.81	0.75	0.67	0.63	0.58	0.55	0.54*
				ADP	15.4	15.0	14.5	14.0	13.0	12.0	10.0	7.0	3.5
	75	18.0	11.7	ESHF	1.00	0.86	0.77	0.70	0.66	0.62	0.58	0.52	0.51*
				ADP	16.4	16.0	15.5	15.0	14.5	14.0	13.0	8.5	6.0
	80	18.6	12.5	ESHF	1.00	0.83	0.73	0.65	0.61	0.57	0.53	0.49	0.48*
				ADP	17.4	17.0	16.5	16.0	15.5	15.0	14.0	10.5	7.0
	85	19.2	13.3	ESHF	1.00	0.79	0.68	0.60	0.52	0.47	0.46	0.45*	
				ADP	18.4	18.0	17.5	17.0	16.0	14.0	13.5	9.0	
	90	19.8	14.1	ESHF	1.00	0.73	0.60	0.52	0.45	0.43	0.41*		
				ADP	19.3	19.0	18.5	18.0	17.0	16.0	13.0		
	95	20.4	14.8	ESHF	1.00	0.71	0.53	0.44	0.41	0.39	0.37*		
				ADP	20.2	20.0	19.5	19.0	18.5	18.0	16.0		

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
22	20	10.6	3.3	ESHF	1.00	0.96	0.93	0.90	0.88	0.87*			
				ADP	−1.6	−3.0	−5.0	−8.0	−12.0	−20.0			
	25	11.6	4.2	ESHF	1.00	0.96	0.91	0.87	0.84	0.82*			
				ADP	1.3	0	−2.0	−5.0	−9.0	−15.0			
	30	12.2	5.0	ESHF	1.00	0.97	0.93	0.88	0.83	0.81	0.79*		
				ADP	3.8	3.0	2.0	0	−3.0	−7.0	−14.0		
	35	13.3	5.8	ESHF	1.00	0.95	0.91	0.85	0.81	0.78	0.76*		
				ADP	5.9	5.0	4.0	2.0	0	−3.0	−11.0		
	40	14.0	6.7	ESHF	1.00	0.94	0.89	0.82	0.77	0.73	0.72*		
				ADP	7.8	7.0	6.0	4.0	1.0	−3.0	−9.0		
	45	14.7	7.4	ESHF	1.00	0.96	0.88	0.83	0.77	0.74	0.71	0.69*	
				ADP	9.5	9.0	8.0	7.0	5.0	3.0	0	−6.0	
	50	15.5	8.3	ESHF	1.00	0.94	0.88	0.83	0.75	0.71	0.68	0.66	0.65*
				ADP	11.1	10.5	10.0	9.0	7.0	5.0	2.0	−1.0	−5.0
	55	16.3	9.1	ESHF	1.00	0.93	0.88	0.83	0.77	0.70	0.67	0.64	0.62*
				ADP	12.5	12.0	11.5	11.0	10.0	8.0	6.0	3.0	−3.5
	60	16.9	9.9	ESHF	1.00	0.93	0.88	0.78	0.72	0.66	0.62	0.60	0.59*
				ADP	13.8	13.5	13.0	12.0	11.0	9.0	7.0	4.0	0
	65	17.6	10.9	ESHF	1.00	0.95	0.87	0.80	0.72	0.68	0.61	0.57	0.56*
				ADP	15.2	15.0	14.5	14.0	13.0	12.0	10.0	7.0	2.0
	70	18.3	11.7	ESHF	1.00	0.89	0.81	0.73	0.66	0.62	0.56	0.54	0.53*
				ADP	16.4	16.0	15.5	15.0	14.0	13.0	11.0	9.0	4.5

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB	RH	WB	ω										
°C	%	°C	g/kg										
23	20	11.4	3.5	ESHF	1.00	0.97	0.93	0.89	0.87	0.86*			
				ADP	−0.7	−2.0	−4.0	−7.0	−10.0	−20.0			
	25	12.2	4.4	ESHF	1.00	0.96	0.91	0.86	0.84	0.83	0.82*		
				ADP	2.2	1.0	−1.0	−4.0	−7.0	−10.0	−15.0		
	30	13.1	5.3	ESHF	1.00	0.96	0.94	0.88	0.84	0.81	0.79	0.78*	
				ADP	4.6	4.0	3.0	1.0	−1.0	−4.0	−8.0	−13.0	
	35	13.9	6.1	ESHF	1.00	0.96	0.91	0.85	0.81	0.78	0.76	0.75*	
				ADP	6.7	6.0	5.0	3.0	1.0	−2.0	−5.0	−10.5	
	40	14.8	7.0	ESHF	1.00	0.95	0.89	0.82	0.76	0.73	0.72	0.71*	
				ADP	8.7	8.0	7.0	5.0	2.0	−1.0	−4.0	−8.5	
	45	15.5	7.9	ESHF	1.00	0.95	0.88	0.79	0.75	0.72	0.69	0.68*	
				ADP	10.5	10.0	9.0	7.0	5.0	3.0	0	−6.0	
	50	16.3	8.9	ESHF	1.00	0.94	0.88	0.82	0.74	0.70	0.66	0.65	0.64*
				ADP	12.1	11.5	11.0	10.0	8.0	6.0	3.0	0	−4.0
	55	17.0	9.7	ESHF	1.00	0.94	0.88	0.83	0.77	0.70	0.66	0.62	0.61*
				ADP	13.5	13.0	12.5	12.0	11.0	9.0	7.0	4.0	−2.0
	60	17.8	10.5	ESHF	1.00	0.95	0.87	0.78	0.72	0.65	0.62	0.59	0.58*
				ADP	14.9	14.5	14.0	13.0	12.0	10.0	8.0	5.0	1.0
	65	18.5	11.5	ESHF	1.00	0.88	0.80	0.75	0.71	0.66	0.60	0.56	0.55*
				ADP	16.1	15.5	15.0	14.5	14.0	13.0	11.0	8.0	3.5
	70	19.2	12.4	ESHF	1.00	0.91	0.81	0.74	0.66	0.61	0.56	0.53	0.51*
				ADP	17.3	17.0	16.5	16.0	15.0	14.0	12.0	10.0	5.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\,\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB	RH	WB	w										
°C	%	°C	g/kg										
24	20	12.0	3.8	ESHF	1.00	0.97	0.93	0.89	0.86	0.85*			
				ADP	0.2	−1.0	−3.0	−6.0	−10.0	−20.0			
	25	12.9	4.7	ESHF	1.00	0.96	0.91	0.86	0.82	0.81*			
				ADP	3.0	2.0	0	−3.0	−7.0	−14.5			
	30	13.8	5.6	ESHF	1.00	0.97	0.91	0.84	0.80	0.78	0.77*		
				ADP	5.6	5.0	3.0	0	−3.0	−7.0	−12.5		
	35	14.6	6.5	ESHF	1.00	0.96	0.91	0.85	0.79	0.76	0.75	0.74*	
				ADP	7.6	7.0	6.0	4.0	1.0	−2.0	−5.0	−9.5	
	40	15.5	7.5	ESHF	1.00	0.95	0.89	0.81	0.76	0.73	0.71	0.70*	
				ADP	9.6	9.0	8.0	6.0	3.0	0	−3.0	−7.5	
	45	16.4	8.4	ESHF	1.00	0.97	0.89	0.83	0.79	0.74	0.70	0.68	0.67*
				ADP	11.3	11.0	10.0	9.0	8.0	6.0	3.0	0	−5.0
	50	17.1	9.4	ESHF	1.00	0.94	0.89	0.82	0.74	0.69	0.65	0.64	0.63*
				ADP	13.0	12.5	12.0	11.0	9.0	7.0	4.0	1.0	−3.5
	55	17.9	10.3	ESHF	1.00	0.93	0.87	0.82	0.76	0.69	0.64	0.61	0.60*
				ADP	14.5	14.0	13.5	13.0	12.0	10.0	8.0	5.0	−1.0
	60	18.6	11.2	ESHF	1.00	0.95	0.87	0.77	0.71	0.64	0.60	0.58	0.57*
				ADP	15.8	15.5	15.0	14.0	13.0	11.0	9.0	6.0	2.0
	65	19.3	12.2	ESHF	1.00	0.88	0.81	0.71	0.65	0.59	0.56	0.55	0.54*
				ADP	17.0	16.5	16.0	15.0	14.0	12.0	10.0	9.0	4.0
	70	20.1	13.2	ESHF	1.00	0.92	0.82	0.73	0.65	0.56	0.52	0.51	0.50*
				ADP	18.3	18.0	17.5	17.0	16.0	14.0	11.0	10.0	6.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\,\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB	RH	WB	w										
°C	%	°C	g/kg										
25	20	12.6	4.0	ESHF	1.00	0.97	0.93	0.88	0.87	0.85	0.84*		
				ADP	1.00	0	−2.0	−5.0	−8.0	−11.0	−16.0		
	25	13.5	5.0	ESHF	1.00	0.97	0.91	0.85	0.82	0.81	0.80*		
				ADP	4.0	3.0	1.0	−3.0	−6.0	−8.0	−14.0		
	30	14.6	6.0	ESHF	1.00	0.93	0.87	0.82	0.78	0.77	0.76*		
				ADP	6.5	5.0	3.0	0	−4.0	−7.0	−12.0		
	35	15.4	6.9	ESHF	1.00	0.97	0.92	0.87	0.84	0.78	0.75	0.74	0.73*
				ADP	8.5	8.0	7.0	6.0	5.0	2.0	−2.0	−4.0	−9.5
	40	16.3	7.9	ESHF	1.00	0.97	0.90	0.85	0.79	0.75	0.72	0.70	0.69*
				ADP	10.4	10.0	9.0	8.0	6.0	4.0	1.0	−3.0	−7.0
	45	17.1	8.9	ESHF	1.00	0.97	0.88	0.83	0.79	0.73	0.69	0.67	0.66*
				ADP	12.4	12.0	11.0	10.0	9.0	7.0	4.0	1.0	−5.0
	50	17.9	10.0	ESHF	1.00	0.94	0.89	0.82	0.73	0.68	0.64	0.63	0.62*
				ADP	14.0	13.5	13.0	12.0	10.0	8.0	5.0	3.0	−3.0
	55	18.7	10.9	ESHF	1.00	0.94	0.88	0.83	0.76	0.68	0.62	0.60	0.59*
				ADP	15.4	15.0	14.5	14.0	13.0	11.0	8.0	5.0	0
	60	19.5	11.9	ESHF	1.00	0.96	0.86	0.76	0.70	0.63	0.59	0.57	0.56*
				ADP	16.7	16.5	16.0	15.0	14.0	12.0	10.0	8.0	2.5
	65	20.2	13.0	ESHF	1.00	0.88	0.79	0.69	0.64	0.58	0.54	0.53	0.52*
				ADP	18.0	17.5	17.0	16.0	15.0	13.0	10.0	8.0	5.0
	70	21.0	14.0	ESHF	1.00	0.92	0.81	0.73	0.63	0.58	0.53	0.50	0.49*
				ADP	19.2	19.0	18.5	18.0	17.0	16.0	14.0	11.0	6.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\mathrm{ESHF} = \frac{1}{1 + 2.45\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\mathrm{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH, kJ/kg.°C *of dry air*
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
26	20	13.2	4.3	ESHF	1.00	0.95	0.90	0.86	0.84*				
				ADP	1.6	0	−3.0	−8.0	−15.0				
	25	14.2	5.3	ESHF	1.00	0.94	0.87	0.83	0.81	0.80*			
				ADP	4.8	3.0	0	−3.0	−7.0	−13.5			
	30	15.2	6.3	ESHF	1.00	0.94	0.87	0.81	0.78	0.76*			
				ADP	7.2	6.0	4.0	1.0	−3.0	−11.5			
	35	16.1	7.3	ESHF	1.00	0.92	0.84	0.78	0.76	0.74	0.73	0.72*	
				ADP	9.4	8.0	6.0	3.0	1.0	−1.0	−3.0	−9.0	
	40	17.1	8.4	ESHF	1.00	0.97	0.90	0.81	0.76	0.72	0.69	0.68*	
				ADP	11.4	11.0	10.0	8.0	6.0	3.0	−2.0	−6.0	
	45	17.9	9.5	ESHF	1.00	0.98	0.89	0.83	0.75	0.69	0.66	0.65	0.64*
				ADP	13.2	13.0	12.0	11.0	9.0	6.0	2.0	−2.0	−4.5
	50	18.8	10.6	ESHF	1.00	0.96	0.90	0.81	0.76	0.69	0.66	0.63	0.61*
				ADP	14.9	14.5	14.0	13.0	12.0	10.0	8.0	6.0	−2.0
	55	19.5	11.6	ESHF	1.00	0.95	0.86	0.82	0.75	0.67	0.63	0.59	0.57*
				ADP	16.3	16.0	15.5	15.0	14.0	12.0	10.0	7.0	2.0
	60	20.3	12.7	ESHF	1.00	0.88	0.82	0.76	0.69	0.62	0.57	0.55	0.54*
				ADP	17.6	17.0	16.5	16.0	15.0	13.0	10.0	8.0	3.0
	65	21.1	13.8	ESHF	1.00	0.90	0.80	0.70	0.63	0.57	0.53	0.52	0.51*
				ADP	19.0	18.5	18.0	17.0	16.0	14.0	11.0	10.0	5.5
	70	21.8	14.9	ESHF	1.00	0.83	0.73	0.64	0.54	0.50	0.49	0.48	0.47*
				ADP	20.1	19.5	19.0	18.0	16.0	14.0	12.0	10.0	8.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\,\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(r_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
27	20	13.8	4.5	ESHF	1.00	0.96	0.90	0.86	0.84	0.83*			
				ADP	2.4	1.0	−2.0	−6.0	−10.0	−15.0			
	25	14.9	5.6	ESHF	1.00	0.95	0.89	0.86	0.81	0.80	0.79*		
				ADP	5.5	4.0	2.0	0	−4.0	−6.0	−13.5		
	30	15.9	6.8	ESHF	1.00	0.95	0.87	0.81	0.78	0.76	0.75*		
				ADP	8.1	7.0	5.0	2.0	−1.0	−5.0	−10.5		
	35	16.9	7.8	ESHF	1.00	0.93	0.88	0.81	0.76	0.73	0.72	0.71*	
				ADP	10.3	9.0	8.0	6.0	3.0	0	−2.0	−8.0	
	40	17.8	8.9	ESHF	1.00	0.99	0.91	0.85	0.78	0.74	0.70	0.68	0.67*
				ADP	12.3	12.0	11.0	10.0	8.0	6.0	3.0	0	−5.5
	45	18.7	10.0	ESHF	1.00	0.94	0.90	0.83	0.78	0.72	0.67	0.64	0.63*
				ADP	14.1	13.5	13.0	12.0	11.0	9.0	6.0	2.0	−4.0
	50	19.5	11.2	ESHF	1.00	0.97	0.90	0.82	0.76	0.69	0.65	0.61	0.60*
				ADP	15.8	15.5	15.0	14.0	13.0	11.0	9.0	6.0	−0.5
	55	20.4	12.4	ESHF	1.00	0.88	0.82	0.75	0.66	0.61	0.58	0.57	0.56*
				ADP	17.2	16.5	16.0	15.0	13.0	11.0	8.0	6.0	2.0
	60	21.1	13.4	ESHF	1.00	0.90	0.82	0.77	0.69	0.64	0.59	0.55	0.53*
				ADP	18.6	18.0	17.5	17.0	16.0	15.0	13.0	10.0	4.5
	65	22.0	14.6	ESHF	1.00	0.90	0.80	0.75	0.69	0.58	0.52	0.50	0.49*
				ADP	19.8	19.5	19.0	18.5	18.0	16.0	13.0	10.0	6.0
	70	22.7	15.8	ESHF	1.00	0.84	0.74	0.68	0.63	0.57	0.53	0.49	0.46*
				ADP	21.0	20.5	20.0	19.5	19.0	18.0	17.0	15.0	8.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
28	20	14.4	4.8	ESHF	1.00	0.94	0.89	0.85	0.83	0.82*			
				ADP	3.2	1.0	−2.0	−6.0	−10.0	−15.0			
	25	15.6	5.9	ESHF	1.00	0.95	0.89	0.84	0.80	0.79	0.78*		
				ADP	6.2	5.0	3.0	0	−4.0	−8.0	−13.0		
	30	16.5	7.1	ESHF	1.00	0.96	0.91	0.85	0.81	0.77	0.75	0.74*	
				ADP	8.8	8.0	7.0	5.0	3.0	0	−4.0	−10.0	
	35	17.6	8.3	ESHF	1.00	0.96	0.93	0.87	0.81	0.77	0.73	0.71	0.70*
				ADP	11.1	10.5	10.0	9.0	7.0	5.0	2.0	−1.0	−7.0
	40	18.6	9.5	ESHF	1.00	0.95	0.90	0.85	0.77	0.72	0.69	0.67	0.66*
				ADP	13.2	12.5	12.0	11.0	9.0	7.0	4.0	0	−5.0
	45	19.5	10.7	ESHF	1.00	0.95	0.89	0.82	0.74	0.69	0.65	0.63	0.62*
				ADP	15.0	14.5	14.0	13.0	11.0	9.0	6.0	3.0	−3.0
	50	20.4	11.9	ESHF	1.00	0.91	0.86	0.82	0.75	0.68	0.64	0.60	0.59*
				ADP	16.6	16.0	15.5	15.0	14.0	12.0	10.0	7.0	0
	55	21.3	13.1	ESHF	1.00	0.90	0.83	0.75	0.65	0.61	0.57	0.56	0.55*
				ADP	18.1	17.5	17.0	16.0	14.0	12.0	9.0	8.0	3.0
	60	22.1	14.2	ESHF	1.00	0.90	0.83	0.72	0.68	0.63	0.57	0.54	0.52*
				ADP	19.4	19.0	18.5	18.0	17.0	16.0	14.0	11.0	5.0
	65	22.9	15.5	ESHF	1.00	0.81	0.75	0.69	0.62	0.57	0.51	0.49	0.48*
				ADP	20.8	20.0	19.5	19.0	18.0	17.0	14.0	11.0	6.5
	70	23.6	16.8	ESHF	1.00	0.84	0.71	0.67	0.62	0.56	0.49	0.46	0.45*
				ADP	22.0	21.5	21.0	20.5	20.0	19.0	17.0	14.0	9.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(r_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21°C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB	RH	WB	w										
°C	%	°C	g/kg										
30	20	15.8	5.4	ESHF	1.00	0.94	0.90	0.85	0.83	0.81*			
				ADP	4.8	3.0	1.0	−3.0	−6.0	−14.0			
	25	17.0	6.7	ESHF	1.00	0.92	0.87	0.81	0.79	0.77	0.76*		
				ADP	7.8	6.0	4.0	1.0	−3.0	−6.0	−12.0		
	30	18.1	8.0	ESHF	1.00	0.92	0.84	0.80	0.76	0.73	0.72*		
				ADP	10.6	9.0	7.0	5.0	2.0	−2.0	−9.0		
	35	19.1	9.3	ESHF	1.00	0.93	0.87	0.80	0.74	0.70	0.69	0.68*	
				ADP	12.9	12.0	11.0	9.0	6.0	2.0	0	−5.5	
	40	20.1	10.5	ESHF	1.00	0.95	0.91	0.84	0.76	0.70	0.66	0.65	0.64*
				ADP	15.0	14.5	14.0	13.0	11.0	8.0	5.0	3.0	−4.0
	45	21.1	12.0	ESHF	1.00	0.96	0.90	0.81	0.76	0.70	0.64	0.61	0.60*
				ADP	16.8	16.5	16.0	15.0	14.0	12.0	9.0	5.0	−2.0
	50	22.0	13.4	ESHF	1.00	0.91	0.80	0.74	0.66	0.63	0.59	0.57	0.56*
				ADP	18.5	18.0	17.0	16.0	14.0	13.0	10.0	7.0	2.0
	55	22.9	14.7	ESHF	1.00	0.91	0.83	0.74	0.67	0.60	0.55	0.53	0.52*
				ADP	20.0	19.5	19.0	18.0	17.0	15.0	11.0	7.0	4.5
	60	23.8	16.1	ESHF	1.00	0.94	0.82	0.75	0.67	0.61	0.55	0.50	0.49*
				ADP	21.4	21.0	20.5	20.0	19.0	18.0	16.0	11.0	6.5
	65	24.7	17.5	ESHF	1.00	0.92	0.80	0.73	0.67	0.59	0.55	0.46	0.45*
				ADP	22.7	22.5	22.0	21.5	21.0	20.0	19.0	13.0	9.0
	70	25.6	19.0	ESHF	1.00	0.81	0.71	0.64	0.58	0.53	0.47	0.43	0.42*
				ADP	24.0	23.5	23.0	22.5	22.0	21.0	19.0	16.0	12.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1+2.45\dfrac{(w_{RM}-w_{ADP})}{(t_{RM}-t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(r_{RM}-t_{ADP})}{1.02\,(t_{RM}-t_{ADP})+\dfrac{2500}{1000}\,(w_{RM}-w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*

3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of gusion which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 59—APPARATUS DEWPOINTS (Continued)

ROOM CONDITIONS				EFFECTIVE SENSIBLE HEAT FACTOR AND APPARATUS DEWPOINT									
DB °C	RH %	WB °C	w g/kg										
32	20	17.0	6.0	ESHF	1.00	0.95	0.91	0.85	0.82	0.81	0.80*		
				ADP	6.5	5.0	3.0	0	−3.0	−6.0	−13.5		
	25	18.3	7.5	ESHF	1.0	0.92	0.87	0.81	0.78	0.76	0.75*		
				ADP	9.6	8.0	6.0	3.0	0	−3.0	−11.0		
	30	19.5	8.9	ESHF	1.00	0.99	0.92	0.88	0.81	0.76	0.73	0.71	0.70*
				ADP	12.4	12.0	11.0	10.0	8.0	5.0	2.0	−1.0	−8.0
	35	20.5	10.5	ESHF	1.00	0.94	0.88	0.83	0.79	0.74	0.68	0.66	0.65*
				ADP	14.8	14.0	13.0	12.0	11.0	9.0	5.0	0	−5.0
	40	21.6	12.0	ESHF	1.00	0.92	0.84	0.79	0.72	0.66	0.63	0.62	0.61*
				ADP	16.8	16.0	15.0	14.0	12.0	9.0	6.0	3.0	−2.5
	45	22.6	13.5	ESHF	1.00	0.92	0.82	0.76	0.71	0.65	0.61	0.58	0.57*
				ADP	18.6	18.0	17.0	16.0	15.0	13.0	10.0	6.0	1.5
	50	23.7	15.1	ESHF	1.00	0.93	0.87	0.81	0.73	0.68	0.61	0.54	0.53*
				ADP	20.4	20.0	19.5	19.0	18.0	17.0	15.0	8.0	4.0
	55	24.6	16.6	ESHF	1.00	0.92	0.83	0.72	0.66	0.61	0.56	0.51	0.50*
				ADP	21.9	21.5	21.0	20.0	19.0	18.0	16.0	12.0	6.0
	60	25.5	18.1	ESHF	1.00	0.94	0.83	0.75	0.65	0.59	0.53	0.47	0.46*
				ADP	23.3	23.0	22.5	22.0	21.0	20.0	18.0	13.0	8.0
	65	26.5	19.8	ESHF	1.00	0.80	0.73	0.66	0.58	0.53	0.47	0.44	0.43*
				ADP	24.6	24.0	23.5	23.0	22.0	21.0	19.0	16.0	11.0
	70	27.4	21.4	ESHF	1.00	0.83	0.71	0.64	0.58	0.51	0.47	0.41	0.39*
				ADP	26.0	25.5	25.0	24.5	24.0	23.0	22.0	18.0	14.0

Notes:

1. *For room conditions not given:* The apparatus dewpoint may be determined from the scale on the chart, or may be calculated as shown in the following equation:

$$\text{ESHF} = \frac{1}{1 + 2.45\,\dfrac{(w_{RM} - w_{ADP})}{(t_{RM} - t_{ADP})}}$$

This equation in more familiar form is:

$$\text{ESHF} = \frac{1.02\,(t_{RM} - t_{ADP})}{1.02\,(t_{RM} - t_{ADP}) + \dfrac{2500}{1000}\,(w_{RM} - w_{ADP})}$$

2. *For high elevations:* For effective sensible heat factors at high elevations see *Table 60.*
3. *For apparatus dewpoint below freezing:* The latent heat of fusion of the moisture removed is not included in the calculation of apparatus dewpoint below freezing or in the calculation of room load, in order to simplify estimating procedures. Use the same equation as in Note 1. The selection of equipment on a basis of 16 to 18 hour operating time provides a safety factor large enough to cover the omission of this latent heat of fusion, which is a small part of the total load.

*The values shown with an asterisk indicate the lowest effective sensible heat factor possible without the use of reheat. This limiting condition is the lowest effective sensible heat factor line that intersects the saturation curve. Note that the room dewpoint is equal to the required apparatus dewpoint for an effective sensible heat factor of 1.0.

where w_{RM} = room moisture content, g/kg of dry air
w_{ADP} = moisture content at apparatus dewpoint, g/kg of dry air
t_{RM} = room dry-bulb temperature
t_{ADP} = apparatus dewpoint temperature
1.02 = specific heat of moist air at 21 °C DB, 50% RH, kJ/kg.°C of dry air
2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg

TABLE 60—EQUIVALENT EFFECTIVE SENSIBLE HEAT FACTORS FOR VARIOUS ELEVATIONS*

For use with sea level psychrometric chart or tables

Effective Sensible Heat Factor from Air Conditioning Load Estimate	Elevation (m) and Barometric Pressure (kPa) at Installation						
	500 95.4	1000 89.8	1500 84.3	2000 79.4	2500 74.8	3000 69.6	3500 65.5
	Equivalent Effective Sensible Heat Factor Referred to a Sea Level Psychrometric Chart or Tables						
0.95	0.95	0.95	0.96	0.96	0.96	0.96	0.96
0.90	0.91	0.91	0.92	0.92	0.92	0.93	0.93
0.85	0.86	0.86	0.87	0.88	0.88	0.89	0.89
0.80	0.81	0.82	0.83	0.83	0.84	0.85	0.86
0.75	0.76	0.77	0.78	0.79	0.80	0.81	0.82
0.70	0.72	0.73	0.74	0.75	0.76	0.77	0.79
0.65	0.67	0.68	0.69	0.70	0.71	0.73	0.74
0.60	0.61	0.63	0.64	0.66	0.67	0.69	0.70
0.55	0.57	0.58	0.60	0.61	0.62	0.64	0.65
0.50	0.52	0.53	0.55	0.56	0.58	0.59	0.61

*Values obtained by use of equation

$$ESHF_e = \frac{1}{\dfrac{(p_1)\ (1-ESHF)}{(p_0)\ (ESHF)} + 1}$$

Where p_0 = barometric pressure at sea level
p_1 = barometric pressure at high elevation
ESHF = ESHF obtained from air conditioning load estimate
$ESHF_e$ = equivalent ESHF referred to a sea level psychrometric chart or *Table 60*

Notes:

1. The required apparatus dewpoint for the high elevation is determined from the sea level chart or *Table 59* by use of the equivalent effective sensible heat factor. The relative humidity and dry-bulb temperature must be used to define the room condition when using this table because the above equation was derived on this basis. The room wet-bulb temperature must not be used because the wet-bulb temperature corresponding to any particular condition, for example, 21°C DB, 40% RH at a high elevation is lower (except for saturation) than that corresponding to the same condition (21°C DB 40% RH) at sea level. For the same value of room relative humidity and dry-bulb temperature, and the same apparatus dewpoint, there is a greater difference in moisture content between the two conditions at high elevation than at sea level. Therefore, a higher apparatus dewpoint is required at high elevation for a given effective sensible heat factor.
2. Air conditioning load estimate (See *Fig. 47*). The factors 1.20 and 3.0 on the air conditioning load estimate should be multiplied by the direct ratio of the barometric pressures $\frac{(p_1)}{(p_0)}$. Using this method, it is assumed that the air quantity (ℓ/s) is measured at actual conditions rather than at standard air conditions. The outdoor and room moisture contents, gram per kilogram must also be corrected for high elevations.
3. Reheat—Where the equivalent effective sensible heat factor is lower than the asterisked values in *Table 59* reheat is required.

PSYCHROMETRIC FORMULAE

A. AIR MIXING EQUATIONS (Outdoor and Return Air)

$$t_M = \frac{(\ell/s_{OA} \times t_{OA}) + (\ell/s_{RA} \times t_{RM})}{\ell/s_{SA}} \quad (1)$$

$$h_M = \frac{(\ell/s_{OA} \times h_{OA}) + (\ell/s_{RA} \times h_{RM})}{\ell/s_{SA}} \quad (2)$$

$$w_M = \frac{(\ell/s_{OA} \times w_{OA}) + (\ell/s_{RA} \times w_{RM})}{\ell/s_{SA}} \quad (3)$$

B. COOLING LOAD EQUATIONS

$$\text{ERSH} = \text{RSH} + (\text{BF})\ (\text{OASH}) + \text{RSHS}^* \quad (4)$$
$$\text{ERLH} = \text{RLH} + (\text{BF})\ (\text{OALH}) + \text{RLHS}^* \quad (5)$$
$$\text{ERTH} = \text{ERLH} + \text{ERSH} \quad (6)$$
$$\text{TSH} = \text{RSH} + \text{OASH} + \text{RSHS}^* \quad (7)$$
$$\text{TLH} = \text{RLH} + \text{OALH} + \text{RLHS}^* \quad (8)$$
$$\text{GTH} = \text{TSH} + \text{TLH} + \text{GTHS}^* \quad (9)$$
$$\text{RSH} = 1.20^\dagger \times \ell/s_{SA} \times (t_{RM} - t_{SA}) \quad (10)$$
$$\text{RLH} = 3.0^\dagger \times \ell/s_{SA} \times (w_{RM} - w_{SA}) \quad (11)$$
$$\text{RTH} = 1.19^\dagger \times \ell/s_{SA} \times (h_{RM} - h_{SA}) \quad (12)$$
$$\text{RTH} = \text{RSH} + \text{RLH} \quad (13)$$
$$\text{OASH} = 1.20 \times \ell/s_{OA}\ (t_{OA} - t_{RM}) \quad (14)$$
$$\text{OALH} = 3.0 \times \ell/s_{OA}\ (w_{OA} - w_{RM}) \quad (15)$$
$$\text{OATH} = 1.19 \times \ell/s_{OA}\ (h_{OA} - h_{RM}) \quad (16)$$
$$\text{OATH} = \text{OASH} + \text{OALH} \quad (17)$$
$$(\text{BF})\ (\text{OATH}) = (\text{BF})\ (\text{OASH}) + (\text{BF})\ (\text{OALH}) \quad (18)$$
$$\text{ERSH} = 1.20 \times \ell/s_{DA}^\ddagger \times (t_{RM} - t_{ADP})\ (1 - \text{BF}) \quad (19)$$
$$\text{ERLH} = 3.0 \times \ell/s_{DA}^\ddagger \times (w_{RM} - w_{ADP})\ (1 - \text{BF}) \quad (20)$$
$$\text{ERTH} = 1.19 \times \ell/s_{DA}^\ddagger \times (h_{RM} - h_{ADP})\ (1 - \text{BF}) \quad (21)$$
$$\text{TSH} = 1.20 \times \ell/s_{DA}^\ddagger \times (t_{EDB} - t_{LDB})^{**} \quad (22)$$
$$\text{TLH} = 3.0 \times \ell/s_{DA}^\ddagger \times (w_{EA} - w_{LA})^{**} \quad (23)$$
$$\text{GTH} = 1.19 \times \ell/s_{DA}^\ddagger \times (h_{EA} - h_{LA})^{**} \quad (24)$$

C. SENSIBLE HEAT FACTOR EQUATIONS

$$\text{RSHF} = \frac{\text{RSH}}{\text{RSH} + \text{RLH}} = \frac{\text{RSH}}{\text{RTH}} \quad (25)$$

$$\text{ESHF} = \frac{\text{ERSH}}{\text{ERSH} + \text{ERLH}} = \frac{\text{ERSH}}{\text{ERTH}} \quad (26)$$

$$\text{GSHF} = \frac{\text{TSH}}{\text{TSH} + \text{TLH}} = \frac{\text{TSH}}{\text{GTH}} \quad (27)$$

*RSHS, RLHS and GTHS are supplementary loads due to duct heat gain, duct leakage loss, fan and pump power gains, etc. To simplify the various examples, these supplementary loads have *not* been used in the calculations. However, in actual practice, these supplementary loads should be used where appropriate. *Chapter 7* gives the values for the various supplementary loads. *Fig. 1, Chapter 1*, illustrates the method of accounting for these supplementary loads on the air conditioning load estimate.

†*Item H*, of this section gives the derivation of these air constants.

‡When no air is to be physically bypassed around the conditioning apparatus, $\ell/s_{DA} = \ell/s_{SA}$.

D. BYPASS FACTOR EQUATIONS

$$\text{BF} = \frac{t_{LDB} - t_{ADP}}{t_{EDB} - t_{ADP}};\ (1 - \text{BF}) = \frac{t_{EDB} - t_{LDB}}{t_{EDB} - t_{ADP}} \quad (28)$$

$$\text{BF} = \frac{w_{LA} - w_{ADP}}{w_{EA} - w_{ADP}};\ (1 - \text{BF}) = \frac{w_{EA} - w_{LA}}{w_{EA} - w_{ADP}} \quad (29)$$

$$\text{BF} = \frac{h_{LA} - h_{ADP}}{h_{EA} - h_{ADP}};\ (1 - \text{BF}) = \frac{h_{EA} - h_{LA}}{h_{EA} - h_{ADP}} \quad (30)$$

E. TEMPERATURE EQUATIONS AT APPARATUS

$$t_{EDB}^{**} = \frac{(\ell/s_{OA} \times t_{OA}) + (\ell/s_{RA} \times t_{RM})}{\ell/s_{SA}^\ddagger} \quad (31)$$

$$t_{LDB} = t_{ADP} + \text{BF}\ (t_{EDB} - t_{ADP}) \quad (32)$$

t_{EWB} and t_{LWB} correspond to the calculated values of h_{EA} and h_{LA} on the psychrometric chart.

$$h_{EA}^{**} = \frac{(\ell/s_{OA} \times h_{OA}) + (\ell/s_{RA} \times h_{RM})}{\ell/s_{SA}^\ddagger} \quad (33)$$

$$h_{LA} = h_{ADP} + \text{BF}\ (h_{EA} - h_{ADP}) \quad (34)$$

F. TEMPERATURE EQUATIONS FOR SUPPLY AIR

$$t_{SA} = t_{RM} - \frac{\text{RSH}}{1.20\ (\ell/s_{SA}^\ddagger)} \quad (35)$$

G. AIR QUANTITY EQUATIONS

$$\ell/s_{DA} = \frac{\text{ERSH}}{1.20 \times (1 - \text{BF})\ (t_{RM} - t_{ADP})} \quad (36)$$

$$\ell/s_{DA} = \frac{\text{ERLH}}{3.0 \times (1 - \text{BF})\ (w_{RM} - w_{ADP})} \quad (37)$$

$$\ell/s_{DA} = \frac{\text{ERTH}}{1.19 \times (1 - \text{BF})\ (h_{RM} - h_{ADP})} \quad (38)$$

$$\ell/s_{DA}^\ddagger = \frac{\text{TSH}}{1.20\ (t_{EDB} - t_{LDB})} \quad (39)$$

$$\ell/s_{DA}^\ddagger = \frac{\text{TLH}}{3.0\ (w_{EA} - w_{LA})} \quad (40)$$

$$\ell/s_{DA}^\ddagger = \frac{\text{GTH}}{1.19\ (h_{EA} - h_{LA})} \quad (41)$$

$$\ell/s_{SA} = \frac{\text{RSH}}{1.20 \times (t_{RM} - t_{SA})} \quad (42)$$

$$\ell/s_{SA} = \frac{\text{RLH}}{3.0 \times (w_{RM} - w_{SA})} \quad (43)$$

$$\ell/s_{SA} = \frac{\text{RTH}}{1.19 \times (h_{RM} - h_{SA})} \quad (44)$$

$$\ell/s_{BA} = l/s_{SA} - l/s_{DA} \quad (45)$$

Note:

ℓ/s_{DA} will be less than ℓ/s_{SA} only when air is physically bypassed around the conditioning apparatus.

$$\ell/s_{SA} = \ell/s_{OA} + \ell/s_{DA} \quad (46)$$

**When t_M, w_M and h_M are equal to the entering conditions at the cooling apparatus, they may be substituted for t_{EDB}, w_{EA} and h_{EA} respectively.

H. DERIVATION OF AIR CONSTANTS

$$1.20 = 1.02 \times \frac{1}{0.842} = 1.21 \text{ say } 1.20$$

where 1.02 = specific heat of moist air at 21°C DB and 50% RH, $kJ/(kg_{DRY\ AIR})(°C)$

0.842 = specific volume of moist air at 21°C DB and 50% RH, m^3/kg.

$$3.0 = \frac{1}{0.842} \times \frac{2500}{1000} = 2.97 \text{ say } 3.0$$

where 0.842 = specific volume of moist air at 21°C DB and 50%RH, m^3/kg.

2500 = average heat removal required to condense one kilogram of water vapour from the room air, kJ/kg.

1000 = gram per kilogram

$$1.19 = \frac{1}{0.842} = 1.19$$

where 0.842 = specific volume of moist air at 21°C DB and 50% RH, m^3/kg.

CHAPTER 9. NOMENCLATURE AND SI SYMBOLS, PREFIXES AND DERIVED UNITS

NOMENCLATURE

A	solar altitude angle	(°)
A.C.	alternating current	(A)
ADP	apparatus dewpoint	(°C)
a	area, duct area, wall area, floor area, etc.	(m²)
B	wall solar azimuth angle	(°)
BF	bypass factor	—
BF (OALH)	bypassed outdoor air latent heat	(W)
BF (OASH)	bypassed outdoor air sensible heat	(W)
BF (OATH)	bypassed outdoor air total heat	(W)
Ch/h	Changes per hour	—
c	convective heat exchange	(W/m²)
DB	dry-bulb	(°C)
DP	dewpoint	(°C)
E_{cl}	non-dimensional clothing insulation factor	—
ERLH	effective room latent heat load	(W)
ERSH	effective room sensible heat load	(W)
ERTH	effective room total heat load	(W)
ESHF	effective sensible heat factor	—
$ESHF_e$	equivalent effective sensible heat factor referred to a sea level psychrometric chart or *Table 60*	—
f_i	inside air film or surface conductance	(W/m².°C)
GSHF	grand sensible heat factor	—
GTH	grand total heat	(W)
GTHS	grand total heat supplement	(W)
g	glass	—
h	specific enthalpy	(kJ/kg)
h_{ADP}	apparatus dewpoint enthalpy	(kJ/kg)
h_{ES}	effective surface temperature enthalpy	(kJ/kg)
h_{EA}	entering air enthalpy	(kJ/kg)
h_{LA}	leaving air enthalpy	(kJ/kg)
h_{M}	mixture of outdoor and return air enthalpy	(kJ/kg)
h_{OA}	outdoor air enthalpy	(kJ/kg)
h_{RA}	room air enthalpy	(kJ/kg)
h_{SA}	supply air enthalpy	(kJ/kg)
k	conductivity	(*W*/m.°C)
L	duct length	(m)
L_p	wall perimeter	(m)
ℓ/s_{BA}	bypassed air quantity around apparatus	(ℓ/s)
ℓ/s_{DA}	dehumidified air quantity	(ℓ/s)
ℓ/s_{OA}	outdoor air quantity	(ℓ/s)
ℓ/s_{RA}	return air quantity	(ℓ/s)
ℓ/s_{SA}	supply air quantity	(ℓ/s)
OALH	outdoor air latent heat	(W)
OASH	outdoor air sensible heat	(W)
OATH	outdoor air total heat	(W)
P	rectangular duct perimeter	(m)
p_o	barometric pressure at sea level	(kPa)
p_1	barometric pressure at high elevation	(kPa)
Q	heat flow rate	(W)
Q′	solar heat gain to space	(W/m²)
q	combined heat transfer coefficient	(W/m².°C)
q_c	coefficient of convective heat transfer	(W/m².°C)
q_r	coefficient of linear radiation	(W/m².°C)

R	incident solar energy	(W/m^2)
R	thermal resistance	($m^2.°C/W$)
RH	relative humidity	—
RLH	room latent heat	(W)
RLHS	room latent heat supplement	(W)
RSH	room sensible heat	(W)
RSHF	room sensible heat factor	—
RSHS	room sensible heat supplement	(W)
RTH	room total heat	(W)
r	radiant heat exchange	(W/m^2)
SHF	sensible heat factor	—
Sat Eff	saturation efficiency of sprays	—
sd	shading device	—
t	temperature	(°C)
t_{ADP}	apparatus dewpoint temperature	(°C)
t_{DP}	dewpoint temperature	(°C)
t_{EDB}	entering air dry-bulb temperature	(°C)
t_{ES}	effective surface temperature	(°C)
t_{EW}	entering water temperature	(°C)
t_{EWB}	entering air wet-bulb temperature	(°C)
t_{LDB}	leaving air dry-bulb temperature	(°C)
t_{LW}	leaving water temperature	(°C)
t_{LWB}	leaving air wet-bulb temperature	(°C)
t_M	mixture of outdoor and return air dry-bulb temperature	(°C)
t_{OA}	outdoor air dry-bulb temperature	(°C)
t_{RM}	room dry-bulb temperature	(°C)
t_{SA}	supply air dry-bulb temperature	(°C)
t_a	ambient temperature	(°C)
t_b	basement dry-bulb temperature	(°C)
t_g	ground temperature	(°C)
t_o	operative temperature	(°C)
t_r	mean radiant temperature	(°C)
t_{sk}	skin temperature	(°C)
t_{sur}	surface temperature	(°C)
U	transmission coefficient (U-value)	($W/m^2.°C$)
V	air velocity through duct	(m/s)
WB	wet-bulb	(°C)
w	moisture content or specific humidity	(g/kg)
w_{ADP}	apparatus dewpoint moisture content	(g/kg)
w_{EA}	entering air moisture content	(g/kg)
w_{ES}	effective surface temperature moisture content	(g/kg)
w_{LA}	leaving air moisture content	(g/kg)
w_M	moisture of outdoor and return air mixture content	(g/kg)
w_{OA}	outdoor air moisture content	(g/kg)
w_{RM}	room moisture content	(g/kg)
w_{SA}	supply air moisture content	(g/kg)
x	vertical distance	(m)
α	solar absorbtivity	—
γ	air flow rate per unit length	(ℓ/s.m)
Δt_e	equivalent temperature difference for latitude, month and time of day desired	(°C)
Δt_{em}	equivalent temperature difference for wall or roof exposed to the sun at 40° South and at desired time of day, corrected if necessary for design conditions	(°C)
Δt_{es}	equivalent temperature difference for wall or roof in shade at 40° South and at desired time of day, corrected if necessary for design conditions	(°C)
Δp	pressure difference across a window	(Pa)
Θ	window infiltration coefficient	—
λ	perimeter factor	—
ρ	reflectivity	—
Σ	'the summation of'	—
σ_m	maximum solar heat gain through glass for wall facing or horizontal for roofs, for January at 40° South latitude	—

σ_s	maximum solar heat gain through glass for wall facing or horizontal for roofs, for month and latitude desired	(W/m²)
τ	solar transmissibility	—

SI Symbols

m	metre	(base unit of length)
kg	kilogram	(base unit of mass)
s	second	(base unit of time)
A	ampere	(base unit of electric current)
K*	kelvin	(base unit of thermodynamic temperature)
rad*	radian	(base unit for plane angle)

SI Prefixes for multiples and submultiples

μ—micro $= 10^{-6}$
m—milli $= 10^{-3}$
k—kilo $= 10^{3}$
M—mega $= 10^{6}$

Derived SI Units with Special Names

Quantity	*Unit*	*Symbol*	*Derivation*
electrical potential	volt	V	W/A
energy	joule	J	N.m
force	newton	N	kg.m/s²
frequency	hertz	Hz	s^{-1}
heat flow	watt	W	J/s
heat quantity	joule	J	N.m
power	watt	W	J/s
pressure	pascal	Pa	N/m²
temperature	degree Celsius	°C	°C = K−273.15
temperature interval	degree Celsius	°C	1 K = 1°C
work	joule	J	N.m

Derived SI Units with Complex Names

Quantity	*Unit*	*Symbol*
acceleration	metre per second squared	m/s²
angular velocity	radian per second	rad/s
area	square metre	m²
calorific value	joule per cubic metre	J/m³
density	kilogram per cubic metre	kg/m³
intensity of heat flow	watt per square metre	W/m²
thermal conductance	watt per square metre degree Celsius	W/m².°C
thermal conductivity	watt per metre degree Celsius	W/m.°C
thermal resistance	square metre degree Celsius per watt	m².°C/W
thermal resistivity	metre degree Celsius per watt	m.°C/W
velocity (speed)	metre per second	m/s
volume	cubic metre	m³
volume rate of flow	cubic metre per second	m³/s
water vapour permeability	microgram metre per newton second	μg.m/N.s
water vapour permeance	microgram per newton second	μg/N.s

*This unit is not used in this manual, see Table 61 for preferred non-SI unit.

TABLE 61—NON-SI UNITS USED IN THIS MANUAL

Quantity	SI Unit	Non-SI Unit	Non-SI Symbol	Relationship
Angular measurement	radian	degree minute	(°) (′)	$1° = 1.745\ 33 \times 10^{-2}$ rad $1' = 2.908\ 88 \times 10^{-4}$ rad
Angular velocity	radian per second	revolution per second	r/s	1 rev/s = 6.283 19 rad/s
Temperature	kelvin	degree Celsius	°C	1°C = K − 273.15
Time	second	hour	h	$1\ h = 3.6 \times 10^3 s$
Volume	cubic metre	litre	ℓ	$1\ell = 1 \times 10^{-3}\ m^3$

APPENDIX 1

DESIGN CONDITIONS

For detailed description, derivation and application of the data in these tables refer to *Chapter 2 pages 9 & 10*. The data for the Australian States and Countries listed below, commences on the page indicated.

State or Country	*Table 1A* Annual design conditions	*Table 1B* Monthly design conditions	Maps
Australian Capital Territory	164	184	213
New South Wales	164	184	209
Northern Territory	168	189	210
Queensland	169	190	211
South Astralia	172	194	212
Tasmania	174	197	213
Victoria	175	199	214
Western Australia	178	202	215
New Zealand	181	206	-
Papua New Guinea	181	207	216
Solomon Islands	182	207	-
Vanuatu	182	207	-
Bangladesh	183	208	-
Hong Kong	183	208	-
Philippines	183	208	-
Singapore	183	208	-
Thailand	183	208	-
Viet Nam	183	208	-

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER

LOCATION	SUMMER Comfort (or non-critical process) CWB	SUMMER Comfort DB	SUMMER Comfort WB	SUMMER Comfort CDB	SUMMER Critical process 24-hour DB	SUMMER Critical process 24-hour WB	SUMMER Critical process 08-1800 DB	SUMMER Critical process 08-1800 WB	WINTER Comfort DB	WINTER Critical 24-hr DB	WINTER Critical 08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of Data
A. C. T.																	
CANBERRA AMO	17.8	34.1	19.2	30.2	35.0	20.0	36.0	20.5	-3.1	-5.0	-3.1	571	35° 19'	149° 12'	15.6	37.2	79-88
CANBERRA CITY	18.1	34.3	19.6	31.3	35.0	20.0	36.0	20.5	-2.2	-4.0	-2.2	564	35° 16'	149° 07'	15.4	36.5	79-88
CANBERRA FORESTRY	18.0	32.5	19.7	29.5	-	-	-	-	-1.7	-	-	581	35° 18'	149° 06'	13.3	34.2	65-74
HONEYSUCKLE CREEK	16.3	28.5	18.8	26.0	-	-	-	-	-2.2	-	-	1116	35° 35'	148° 59'	12.7	30.7	72-81
ORRORAL VALLEY (STADAN)	17.1	30.7	18.6	27.7	-	-	-	-	-4.5	-	-	924	35° 38'	148° 57'	15.0	35.2	75-84
NEW SOUTH WALES																	
ADELONG P.O.	20.1	35.8	21.4	32.5	-	-	-	-	-1.6	-	-	333	35° 19'	148° 04'	18.0	37.4	75-84
ALBURY AIRPORT	18.5	35.0	20.5	32.9	-	-	-	-	-0.5	-	-	180	36° 04'	146° 55'	16.3	35.5	84-88
ALBURY (GRAMMAR SCHOOL)	18.1	35.4	20.8	32.7	-	-	-	-	-0.5	-	-	182	36° 04'	146° 56'	16.9	35.9	64-68
ALBURY (PUMPING STATION)	20.4	36.4	21.6	33.9	-	-	-	-	-0.5	-	-	152	36° 05'	146° 57'	16.3	36.9	76-85
ALBURY (HUME RESERVOIR)	21.4	34.3	22.5	30.1	-	-	-	-	1.1	-	-	184	36° 06'	147° 02'	13.5	33.2	68-76
ARMIDALE (RADIO STATION 2AD)	17.0	31.8	19.6	28.5	-	-	-	-	-0.6	-	-	980	30° 31'	151° 40'	13.3	32.4	77-86
BANKSTOWN AMO	21.1	33.8	22.8	31.5	-	-	-	-	3.3	-	-	9	33° 56'	150° 59'	9.9	30.5	70-78
BARRABA P.O.	20.7	33.4	22.4	30.6	-	-	-	-	-0.6	-	-	500	30° 23'	150° 37'	14.2	34.0	69-78
BATHURST (AGRICULTURE RESEARCH STATION)	18.7	33.4	20.5	31.0	-	-	-	-	-2.4	-	-	713	33° 26'	149° 34'	15.1	35.8	77-86
BATHURST GAOL *	19.6	32.6	20.4	28.2	-	-	-	-	-2.1	-	-	704	33° 25'	149° 33'	14.1	34.3	73-79
BEGA COMPOSITE	23.4	34.3	24.4	31.4	-	-	-	-	-1.2	-	-	11	36° 40'	149° 50'	12.8	35.5	76-85
BELLINGEN P.O.	25.1	34.8	26.0	33.1	-	-	-	-	4.5	-	-	15	30° 27'	152° 54'	11.8	30.3	70-79
BOMBALA COMPOSITE	17.9	31.7	19.6	29.0	-	-	-	-	-4.0	-	-	705	36° 55'	149° 14'	14.7	35.7	75-84
BOURKE P.O.	21.3	39.7	23.4	36.2	-	-	-	-	3.8	-	-	106	30° 06'	145° 56'	14.5	35.9	78-87
BOWRAL (PARRY DRIVE)	19.2	32.7	20.5	28.0	-	-	-	-	-0.7	-	-	690	34° 29'	150° 24'	12.1	33.4	75-84
BROKEN HILL AERO *	19.1	37.7	21.0	34.1	-	-	-	-	2.1	-	-	289	32° 00'	141° 28'	13.5	35.6	57-62
CAMDEN AIRPORT	20.3	36.5	22.7	31.6	-	-	-	-	1.1	-	-	70	34° 03'	150° 41'	12.8	35.4	77-86
CAMPBELLTOWN (SWIMMING CENT) *	20.9	34.1	22.6	31.0	-	-	-	-	3.1	-	-	75	34° 05'	150° 49'	10.9	30.4	69-78
CAPE BYRON (LIGHTHOUSE)	23.3	28.7	24.7	27.2	-	-	-	-	10.5	-	-	91	28° 38'	153° 38'	6.7	18.2	76-85
CESSNOCK (NULKABA)	20.5	37.3	23.2	32.1	-	-	-	-	2.8	-	-	62	32° 49'	151° 21'	12.5	34.5	75-84
COBAR MO	19.7	38.4	21.8	34.5	39.0	23.0	40.0	23.5	2.7	1.5	2.7	221	31° 29'	145° 50'	13.8	35.7	79-88
COBAR P.O.	21.4	40.9	22.6	36.7	-	-	-	-	1.8	-	-	250	31° 30'	145° 48'	15.1	39.1	57-63
COFFS HARBOUR MO	23.0	28.4	23.9	27.6	30.0	24.5	31.0	25.0	8.2	3.5	8.2	5	30° 19'	153° 07'	7.2	20.2	79-88
CONDOBOLIN P.O. *	22.3	37.9	23.5	32.4	-	-	-	-	0.8	-	-	199	33° 05'	147° 09'	13.4	36.0	74-83
COOMA (CREEK STREET)	18.0	32.5	19.2	28.9	-	-	-	-	-5.2	-	-	786	36° 14'	149° 07'	16.4	37.7	77-86
COONABARABRAN P.O.	20.6	36.3	22.3	34.8	-	-	-	-	-0.3	-	-	509	31° 17'	149° 17'	16.4	36.6	79-88
COONAMBLE P.O. *	21.2	36.9	23.2	33.4	-	-	-	-	3.3	-	-	180	30° 58'	148° 23'	13.8	33.6	76-85

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER Comfort (or non-critical process) CWB	DB	WB	CDB	Critical process 24-hour DB	WB	08-1800 DB	WB	WINTER Comfort DB	Critical 24-hr DB	08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
NEW SOUTH WALES (Continued)																	
COOTAMUNDRA P.O.	20.5	**36.7**	**21.6**	34.2	-	-	-	-	**-1.4**	-	-	318	34° 38'	148° 01'	15.4	38.1	77-86
COROWA COMPOSITE	20.4	**37.0**	**21.5**	34.0	-	-	-	-	**0.1**	-	-	143	36° 00'	146° 21'	16.2	36.9	75-84
COWRA AIRPORT	20.1	**37.2**	**21.3**	34.0	-	-	-	-	**-0.5**	-	-	300	33° 51'	148° 39'	16.9	37.7	77-86
COWRA P.O.	21.7	**36.8**	**24.1**	35.0	-	-	-	-	**-0.9**	-	-	-	33° 54'	148° 42'	17.7	37.7	57-64
DEEPWATER P.O. *	18.5	**30.0**	**20.2**	26.7	-	-	-	-	**-2.1**	-	-	970	29° 27'	151° 51'	12.8	30.8	68-75
DENILIQUIN (FALKINER MEMORIAL)	18.7	**36.8**	**21.8**	32.3	-	-	-	-	**0.5**	-	-	91	35° 22'	145° 03'	15.3	36.3	65-74
DENILIQUIN P.O.	20.0	**38.1**	**21.9**	35.4	-	-	-	-	**-0.1**	-	-	93	35° 33'	144° 57'	16.4	38.2	78-87
DUBBO (COOREENA RD)	20.9	**36.9**	**22.9**	33.6	-	-	-	-	**0.5**	-	-	275	32° 13'	148° 34'	14.5	36.4	79-88
DUNEDOO P.O.	20.8	**37.3**	**22.1**	34.1	-	-	-	-	**0.0**	-	-	388	32° 01'	149° 24'	14.9	37.3	77-81
FORBES (CHURCH STREET) *	22.0	**36.3**	**23.3**	33.9	-	-	-	-	**0.2**	-	-	237	33° 23'	148° 30'	14.9	36.1	76-85
FROGMORE	18.8	**35.2**	**20.6**	29.7	-	-	-	-	**0.0**	-	-	500	34° 16'	148° 50'	15.1	34.7	71-80
GLEN INNES P.O.	18.8	**30.3**	**20.5**	27.2	-	-	-	-	**0.1**	-	-	1062	29° 44'	151° 44'	12.2	30.2	76-85
GOULBURN (PROGRESS ST.)	18.9	**33.5**	**21.7**	31.0	-	-	-	-	**-1.9**	-	-	650	34° 43'	149° 44'	14.1	35.4	80-86
GRAFTON (OLYMPIC POOL)	24.0	**34.4**	**25.0**	32.0	-	-	-	-	**5.3**	-	-	9	29° 41'	152° 56'	10.2	29.1	76-85
GREEN CAPE (LIGHTHOUSE)	21.2	**23.3**	**21.8**	22.5	-	-	-	-	**7.2**	-	-	18	37° 16'	150° 03'	5.6	16.1	75-84
GRENFELL P.O.	19.9	**36.6**	**22.4**	32.2	-	-	-	-	**1.6**	-	-	384	33° 54'	148° 10'	14.7	35.0	74-83
GRIFFITH CSIRO	20.3	**36.4**	**22.2**	32.9	-	-	-	-	**0.2**	-	-	126	34° 19'	146° 04'	14.7	36.2	69-78
GULGONG P.O.	19.8	**35.4**	**22.9**	31.7	-	-	-	-	**0.5**	-	-	475	32° 22'	149° 32'	13.9	34.8	75-84
GUNDAGAI (RIDGE STREET)	20.3	**36.9**	**22.0**	34.3	-	-	-	-	**-0.8**	-	-	232	35° 05'	148° 06'	17.3	37.7	79-88
GUNNEDAH COMPOSITE *	21.6	**35.3**	**23.4**	31.6	-	-	-	-	**3.5**	-	-	306	30° 59'	150° 15'	12.5	31.8	75-84
HARDEN P.O. *	19.8	**36.1**	**21.2**	32.2	-	-	-	-	**-0.5**	-	-	416	34° 33'	148° 22'	14.9	35.8	68-72
HAY P.O.	21.2	**39.5**	**22.2**	35.7	-	-	-	-	**1.6**	-	-	94	34° 31'	144° 50'	15.7	37.3	78-87
HILLSTON P.O.	20.9	**39.0**	**22.2**	35.1	-	-	-	-	**1.1**	-	-	123	33° 29'	145° 32'	14.9	37.9	75-84
INVERELL P.O.	20.0	**34.1**	**22.1**	30.9	-	-	-	-	**-0.4**	-	-	584	29° 47'	151° 07'	15.4	34.5	76-85
IVANHOE P.O. *	20.8	**40.6**	**22.7**	36.2	-	-	-	-	**0.9**	-	-	85	32° 54'	144° 18'	16.1	39.2	74-82
JERRYS PLAINS P.O.	20.8	**37.3**	**23.8**	34.3	-	-	-	-	**2.6**	-	-	90	32° 30'	150° 55'	13.2	34.7	75-84
JERVIS BAY (PT PERPENDICULAR)	21.1	**27.6**	**22.5**	25.7	-	-	-	-	**7.9**	-	-	85	35° 06'	150° 48'	6.6	19.7	75-84
KATOOMBA COMPOSITE	16.4	**29.5**	**19.2**	25.2	-	-	-	-	**0.4**	-	-	1030	33° 43'	150° 18'	10.5	29.1	77-86
KEMPSEY (NORTH STREET)	23.0	**32.2**	**24.7**	31.1	-	-	-	-	**5.2**	-	-	10	31° 03'	152° 50'	10.6	27.0	75-84
KIANDRA CHALET	16.3	**24.4**	**20.5**	21.1	-	-	-	-	**-9.4**	-	-	1395	35° 53'	148° 30'	14.4	33.8	58-67
KIRKCONNELL (PRISON CAMP) *	16.4	**28.6**	**18.4**	25.0	-	-	-	-	**-1.9**	-	-	1067	33° 25'	149° 51'	15.1	30.0	69-75
KULNURA (WILLIAM ROAD)	19.9	**33.2**	**22.5**	28.3	-	-	-	-	**4.7**	-	-	312	33° 14'	151° 12'	9.9	28.5	71-80
LEETON *	20.4	**35.6**	**22.1**	33.0	-	-	-	-	**0.0**	-	-	140	34° 34'	146° 25'	14.2	34.7	66-75
LISMORE (CENTRE STREET)	23.8	**33.9**	**25.2**	32.6	-	-	-	-	**5.2**	-	-	11	28° 49'	153° 16'	10.5	28.7	76-85

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER Comfort (or non-critical process)				SUMMER Critical process 24-hour		SUMMER Critical process 08-1800		WINTER Com-fort	WINTER Critical 24-hr	WINTER Critical 08-18	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
							NEW SOUTH WALES (Continued)										
LITHGOW COMPOSITE *	18.5	**31.0**	**20.3**	28.3	-	-	-	-	**-1.5**	-	-	950	33° 30'	150° 09'	13.9	32.5	76-85
LIVERPOOL COUNCIL	21.5	**35.1**	**23.4**	31.2	-	-	-	-	**3.3**	-	-	21	33° 55'	150° 55'	10.8	31.8	77-86
LORD HOWE ISLAND	22.2	**25.9**	**23.6**	25.1	26.0	24.0	26.5	24.5	**13.7**	12.0	12.5	5	31° 33'	159° 05'	4.4	12.2	78-87
LOSTOCK DAM SITE	21.2	**35.8**	**23.4**	31.3	-	-	-	-	**4.7**	-	-	200	32° 20'	151° 28'	11.0	31.1	74-81
LUCAS HEIGHTS (AAEC)	20.3	**33.1**	**22.5**	28.6	-	-	-	-	**6.2**	-	-	140	34° 03'	150° 59'	8.6	26.9	73-82
MARSFIELD (MACQUARIE UNIVERSITY)	20.8	**33.5**	**23.3**	28.8	-	-	-	-	**5.1**	-	-	55	33° 46'	151° 07'	9.9	28.4	73-82
MARYVILLE HVRF	21.3	**32.5**	**23.7**	27.9	-	-	-	-	**6.5**	-	-	8	32° 55'	151° 45'	8.0	26.0	76-85
MERIMBULA AIRPORT	20.9	**26.3**	**21.8**	26.2	-	-	-	-	**4.0**	-	-	2	36° 55'	149° 54'	9.2	22.3	73-82
MOLONG P.O.	19.5	**35.1**	**22.2**	31.0	-	-	-	-	**-1.4**	-	-	529	33° 06'	148° 52'	16.7	36.5	59-68
MONTAGUE ISLAND (LIGHTHOUSE)	21.6	**24.9**	**22.9**	23.7	-	-	-	-	**8.4**	-	-	52	36° 15'	150° 14'	5.8	16.5	75-84
MOREE MO	20.7	**36.9**	**23.1**	33.2	37.5	24.0	39.0	24.5	**2.7**	0.0	2.7	212	29° 28'	149° 51'	13.6	34.2	79-88
MOREE P.O.	20.1	**39.5**	**24.4**	36.5	-	-	-	-	**2.7**	-	-	207	29° 30'	149° 54'	15.3	36.8	57-65
MORUYA HEADS (PILOT STATION)	20.3	**25.9**	**21.8**	25.6	-	-	-	-	**4.4**	-	-	17	35° 55'	150° 09'	7.5	21.5	78-87
MT VICTORIA (SELSDON ST)	17.1	**30.1**	**18.6**	26.8	-	-	-	-	**0.4**	-	-	1064	33° 36'	150° 15'	10.8	29.7	77-84
MUDGEE P.O.	20.2	**35.1**	**22.3**	31.1	-	-	-	-	**-0.7**	-	-	454	32° 36'	149° 35'	14.6	35.8	76-85
MURWILLUMBAH (BRAY PARK)	24.1	**32.6**	**25.5**	30.9	-	-	-	-	**7.0**	-	-	18	28° 21'	153° 23'	10.7	25.6	76-85
NALBAUGH (STATE FOREST) *	19.3	**28.5**	**19.5**	25.7	-	-	-	-	**-1.4**	-	-	675	37° 04'	149° 21'	11.8	29.2	70-76
NARADHAN P.O.	20.3	**39.2**	**21.8**	35.8	-	-	-	-	**1.1**	-	-	192	33° 37'	146° 19'	15.6	38.1	79-88
NARRABRI WEST P.O.	20.4	**37.1**	**23.6**	32.9	-	-	-	-	**2.4**	-	-	212	30° 20'	149° 45'	13.6	34.7	75-80
NARRANDERA (COUNCIL DEPOT)	21.1	**38.6**	**22.8**	36.7	-	-	-	-	**0.1**	-	-	173	34° 44'	146° 34'	16.2	38.5	79-88
NARRANDERA P.O. *	19.6	**37.7**	**21.3**	33.7	-	-	-	-	**1.1**	-	-	151	34° 45'	146° 33'	13.5	36.6	62-67
NERRIGA COMPOSITE	18.3	**33.3**	**19.9**	30.2	-	-	-	-	**-1.7**	-	-	630	35° 07'	150° 05'	14.1	35.0	78-87
NEWCASTLE (NOBBYS SIGNAL STATION)	20.2	**30.4**	**22.6**	25.6	-	-	-	-	**6.6**	-	-	33	32° 55'	151° 48'	5.8	23.8	77-86
NORAH HEAD (LIGHTHOUSE)	21.9	**27.5**	**23.6**	26.6	-	-	-	-	**8.4**	-	-	27	33° 17'	151° 35'	5.7	19.1	75-84
NORFOLK ISLAND (A) MO	22.1	**25.5**	**23.2**	24.8	25.5	24.0	26.0	24.0	**13.2**	11.5	13.0	113	29° 03'	167° 56'	5.6	12.3	75-84
NOWRA (RAN AIR STATION)	19.2	**32.6**	**22.6**	30.2	35.0	23.0	37.5	23.5	**5.4**	3.0	5.4	109	34° 57'	150° 32'	10.2	27.2	79-88
NYNGAN P.O.	21.3	**38.8**	**23.0**	35.4	-	-	-	-	**2.7**	-	-	177	31° 34'	147° 12'	14.0	36.1	76-85
OBERON PRIS CMP (GURNANG S. F.)	17.2	**28.1**	**18.4**	24.7	-	-	-	-	**-2.6**	-	-	1148	34° 01'	149° 50'	12.9	30.7	65-74
ORANGE AIRPORT	17.5	**30.6**	**19.1**	27.6	31.5	19.5	32.0	20.0	**-0.3**	-2.5	-0.5	948	33° 23'	149° 08'	14.5	30.9	79-88
ORANGE P.O.	18.2	**32.1**	**19.3**	28.7	-	-	-	-	**-1.3**	-	-	863	33° 17'	149° 06'	14.8	33.4	58-67
ORCHARD HILLS (BRINGELLY)	22.2	**34.5**	**23.8**	32.1	-	-	-	-	**4.3**	-	-	93	33° 48'	150° 43'	11.3	30.2	74-82
PARKES P.O.	20.2	**36.8**	**22.3**	33.1	-	-	-	-	**2.5**	-	-	339	33° 08'	148° 11'	13.6	34.3	78-87
PARRAMATTA NORTH	22.2	**34.6**	**23.9**	32.4	-	-	-	-	**5.8**	-	-	60	33° 48'	151° 01'	10.6	28.8	76-85
PATERSON (TOCAL AGRIC. COLLEGE)	21.8	**36.3**	**23.5**	32.6	-	-	-	-	**4.9**	-	-	30	32° 38'	151° 35'	11.5	31.4	77-84

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	**DB**	**WB**	CDB	Critical process 24-hour DB	WB	08-1800 DB	WB	WINTER: Comfort **DB**	Critical 24-hr DB	08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
									NEW SOUTH WALES (Continued)								
PEAK HILL P.O.	20.0	**37.6**	**22.2**	34.4	-	-	-	-	**3.2**	-	-	267	32° 43'	148° 11'	14.6	34.4	79-88
PERISHER VALLEY (SKI CENTRE)	12.7	**22.5**	**14.8**	21.1	-	-	-	-	**-7.3**	-	-	1735	36° 24'	148° 25'	11.8	29.8	77-83
PORT KEMBLA (SIGNAL STATION)	20.4	**26.5**	**22.8**	24.6	-	-	-	-	**9.1**	-	-	11	34° 29'	150° 55'	5.4	17.4	66-75
PORT MACQUARIE (HILL ST)	23.2	**27.1**	**23.9**	27.1	-	-	-	-	**7.1**	-	-	7	31° 27'	152° 55'	6.9	20.0	78-87
PROSPECT DAM	20.9	**35.3**	**22.7**	31.8	-	-	-	-	**4.5**	-	-	61	33° 49'	150° 55'	10.8	30.8	75-84
QUANDIALLA P.O.	21.0	**38.2**	**22.3**	35.3	-	-	-	-	**0.9**	-	-	250	34° 01'	147° 48'	15.3	37.3	78-84
RATHMINES AMO	20.2	**32.9**	**23.6**	30.7	-	-	-	-	**6.0**	-	-	9	33° 03'	151° 36'	8.3	26.9	41-49
RICHMOND AMO	20.8	**37.1**	**23.4**	31.9	37.1	24.5	38.5	25.0	**1.2**	-0.5	1.2	19	33° 36'	150° 47'	12.4	35.9	79-88
SCONE P.O.	21.4	**37.6**	**23.7**	33.8	-	-	-	-	**2.9**	-	-	208	32° 03'	150° 52'	14.3	34.7	75-84
SINGLETON ARMY	20.9	**37.0**	**23.5**	32.9	-	-	-	-	**4.3**	-	-	73	32° 37'	151° 10'	12.0	32.7	71-80
SMOKY CAPE (LIGHTHOUSE)	23.4	**27.7**	**24.5**	26.5	-	-	-	-	**10.2**	-	-	117	30° 55'	153° 05'	6.6	17.5	77-86
SYDNEY AIRPORT MO	20.2	**32.8**	**22.6**	29.4	34.5	23.5	36.5	23.5	**6.3**	4.0	6.0	6	33° 56'	151° 10'	7.9	26.5	79-88
SYDNEY R.O.	19.8	**31.1**	**22.7**	29.5	33.0	23.5	35.5	24.0	**7.2**	6.0	7.0	42	33° 52'	151° 12'	7.0	23.9	79-88
TABULAM (MUIRNE)	20.2	**31.8**	**23.0**	29.4	-	-	-	-	**5.7**	-	-	555	28° 45'	152° 27'	9.5	26.1	71-80
TAMWORTH AIRPORT	20.6	**35.1**	**21.8**	31.5	35.5	22.0	36.5	22.5	**1.6**	-0.5	1.5	404	31° 05'	150° 51'	13.3	33.5	75-84
TARALGA P.O.	17.4	**31.9**	**19.4**	26.6	-	-	-	-	**-1.3**	-	-	845	34° 24'	149° 49'	14.3	33.2	57-66
TAREE RADIO STATION 2RE	23.6	**33.8**	**25.3**	30.9	-	-	-	-	**6.1**	-	-	5	31° 54'	152° 29'	10.9	27.7	78-87
TENTERFIELD P.O.	19.5	**32.2**	**21.2**	29.5	-	-	-	-	**-0.1**	-	-	845	29° 03'	152° 01'	11.9	32.3	75-84
THREDBO (CRACKENBACK STATION)	12.0	**19.6**	**14.2**	18.5	-	-	-	-	**-7.3**	-	-	1957	36° 29'	148° 17'	9.5	26.9	67-76
THREDBO VILLAGE	15.4	**25.3**	**16.3**	23.8	-	-	-	-	**-7.1**	-	-	1380	36° 30'	148° 18'	13.9	32.4	75-84
TIBOOBURRA P.O.	19.9	**40.3**	**22.8**	36.3	-	-	-	-	**2.9**	-	-	183	29° 26'	142° 01'	13.6	37.4	79-88
TOCUMWAL P.O.	21.4	**38.6**	**22.6**	35.5	-	-	-	-	**-0.3**	-	-	111	35° 49'	145° 34'	16.3	38.9	76-85
TULLAMORE P.O. *	21.4	**37.7**	**23.3**	33.8	-	-	-	-	**1.4**	-	-	239	32° 38'	147° 34'	14.7	35.7	76-85
TYALGUM (COODGEE STREET)	22.8	**33.8**	**24.7**	31.9	-	-	-	-	**4.5**	-	-	55	28° 22'	153° 12'	11.1	29.3	76-85
WAGGA AMO	19.4	**37.1**	**21.1**	33.7	38.0	21.5	39.0	22.5	**-0.8**	-2.0	-0.8	221	35° 10'	147° 28'	16.5	37.9	79-88
WALGETT P.O. *	21.4	**39.0**	**24.8**	34.8	-	-	-	-	**4.1**	-	-	131	30° 01'	148° 07'	13.2	34.8	73-82
WELLINGTON P.O. *	20.9	**36.5**	**22.3**	32.8	-	-	-	-	**0.0**	-	-	304	32° 34'	148° 57'	14.6	36.0	71-80
WENTWORTH FALLS (BLAXLAND ROAD)*	18.0	**28.5**	**20.5**	26.1	-	-	-	-	**1.3**	-	-	900	33° 42'	150° 22'	9.9	27.2	68-72
WENTWORTH P.O.	19.9	**38.9**	**21.9**	36.5	-	-	-	-	**1.6**	-	-	37	34° 07'	141° 55'	15.9	37.3	57-66
WHITE CLIFFS P.O.	20.3	**41.1**	**22.4**	35.5	-	-	-	-	**2.8**	-	-	151	30° 51'	143° 05'	14.5	38.3	78-87
WILCANNIA P.O. *	21.6	**40.4**	**23.0**	36.3	-	-	-	-	**3.6**	-	-	76	31° 34'	143° 23'	15.6	36.8	74-83
WILLIAMTOWN AMO	22.2	**34.9**	**23.9**	31.5	36.0	24.5	38.0	25.0	**5.5**	2.5	5.5	9	32° 48'	151° 50'	10.6	29.4	79-88
WOLLONGONG (UNIVERSITY)	19.7	**29.6**	**22.6**	26.2	-	-	-	-	**8.0**	-	-	30	34° 24'	150° 53'	7.8	21.6	77-86
WOOLBROOK P.O. *	18.2	**31.1**	**20.1**	28.2	-	-	-	-	**-2.5**	-	-	900	30° 58'	151° 21'	14.9	33.6	76-85

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process 24-hour		Critical process 08-1800		Com-fort	Critical 24-hr	Critical 08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB	(m)					
							NEW SOUTH WALES (Continued)										
WYALONG P.O.	20.7	**37.6**	**22.4**	33.5	-	-	-	-	**0.3**	-	-	253	33° 56'	147° 15'	15.0	37.3	73-82
YAMBA (PILOT STATION)	23.5	**27.4**	**24.4**	26.4	-	-	-	-	**8.6**	-	-	29	29° 26'	153° 22'	6.0	18.8	76-85
YARRAS (MOUNT SEAVIEW)	22.5	**34.8**	**24.2**	31.0	-	-	-	-	**5.1**	-	-	155	31° 23'	152° 15'	11.5	29.7	77-84
YASS COMPOSITE	20.2	**35.7**	**21.1**	32.8	-	-	-	-	**-2.0**	-	-	500	34° 52'	148° 54'	16.1	37.7	76-85
YENDA *	20.9	**37.6**	**23.0**	34.8	-	-	-	-	**0.3**	-	-	129	34° 15'	146° 13'	15.0	37.3	76-82
							NORTHERN TERRITORY										
ALICE SPRINGS AMO	18.8	**40.1**	**22.8**	34.2	40.5	23.5	41.0	24.0	**1.1**	-1.0	1.1	545	23° 49'	133° 54'	15.5	39.0	79-88
ANGURUGU	24.4	**34.9**	**27.5**	31.8	-	-	-	-	**16.5**	-	-	14	13° 59'	136° 26'	8.0	18.4	73-82
AUVERGNE	23.9	**39.9**	**27.5**	35.1	-	-	-	-	**10.6**	-	-	18	15° 41'	130° 00'	10.9	29.3	75-80
BARROW CREEK	19.8	**39.7**	**24.2**	32.3	-	-	-	-	**6.6**	-	-	511	21° 32'	133° 53'	12.6	33.1	73-82
BRUNETTE DOWNS	21.3	**41.6**	**26.0**	35.1	-	-	-	-	**8.2**	-	-	218	18° 39'	135° 57'	13.3	33.4	78-87
CAPE DON LIGHTSTATION	26.8	**33.5**	**27.8**	32.0	-	-	-	-	**20.7**	-	-	19	11° 19'	131° 46'	6.1	12.8	76-85
CENTRE ISLAND	26.2	**36.0**	**29.0**	34.2	-	-	-	-	**16.1**	-	-	4	15° 44'	136° 49'	7.1	19.9	78-87
CURTIN SPRINGS	20.0	**41.1**	**23.2**	35.9	-	-	-	-	**0.4**	-	-	488	25° 19'	131° 45'	15.7	40.7	77-86
DALY WATERS AMO	21.4	**39.7**	**25.5**	33.1	-	-	-	-	**10.9**	-	-	210	16° 16'	133° 23'	11.6	28.8	58-67
DALY WATERS COMPOSITE	22.3	**39.6**	**26.8**	34.0	-	-	-	-	**11.1**	-	-	212	16° 16'	133° 23'	12.0	28.4	72-81
DARWIN AIRPORT	23.6	**34.4**	**27.7**	32.1	34.5	27.5	34.5	28.0	**18.1**	16.5	18.1	31	12° 25'	130° 52'	6.9	16.3	79-88
ELCHO ISLAND	25.0	**34.3**	**28.2**	32.2	-	-	-	-	**18.8**	-	-	18	12° 02'	135° 34'	6.3	15.5	78-87
FINKE POST OFFICE	19.7	**42.9**	**23.1**	35.5	-	-	-	-	**2.8**	-	-	267	25° 35'	134° 34'	15.3	40.1	70-79
GARDEN POINT (POLICE STATION)	25.4	**33.9**	**28.0**	32.5	-	-	-	-	**17.4**	-	-	12	11° 25'	130° 25'	6.7	16.5	80-86
GOVE AIRPORT *	25.4	**34.1**	**27.0**	33.0	-	-	-	-	**21.2**	-	-	54	12° 17'	136° 49'	7.3	12.9	85-88
GUNBALUNYA (OENPELLI) *	23.2	**38.7**	**27.6**	33.5	-	-	-	-	**17.7**	-	-	7	12° 19'	133° 03'	8.8	20.9	78-87
JERVOIS *	20.8	**41.9**	**24.4**	37.2	-	-	-	-	**3.8**	-	-	325	22° 57'	136° 09'	16.3	38.1	78-87
KATHERINE (COUNCIL DEPOT)	23.6	**39.1**	**26.9**	35.2	-	-	-	-	**11.9**	-	-	103	14° 29'	132° 16'	10.7	27.2	75-84
LARRIMAH COMPOSITE *	23.0	**39.2**	**26.8**	34.8	-	-	-	-	**10.9**	-	-	184	15° 35'	133° 13'	11.1	28.1	74-83
MANINGRIDA (GUDGERAMA)	26.6	**33.8**	**28.4**	32.6	-	-	-	-	**17.0**	-	-	11	12° 03'	134° 13'	7.6	16.8	81-87
MILINGIMBI AWS	25.9	**34.2**	**28.0**	31.9	-	-	-	-	**17.4**	-	-	4	12° 06'	134° 55'	8.0	16.8	65-74
MINJILANG *	25.7	**33.4**	**27.7**	31.2	-	-	-	-	**20.4**	-	-	25	11° 09'	132° 35'	6.5	12.7	67-76
NEWCASTLE WATERS P.O. *	23.0	**41.4**	**26.4**	34.2	-	-	-	-	**9.7**	-	-	210	17° 23'	133° 24'	12.0	30.8	67-76
NHULUNBUY (TRANSPORT & WORKS) *	26.5	**33.6**	**27.8**	32.6	-	-	-	-	**21.3**	-	-	20	12° 11'	136° 46'	6.5	12.3	76-84
RABBIT FLAT	20.7	**41.8**	**24.4**	34.2	-	-	-	-	**4.4**	-	-	340	20° 13'	130° 01'	14.4	37.4	76-85
RINGWOOD	20.0	**41.2**	**23.7**	34.1	-	-	-	-	**0.7**	-	-	416	23° 50'	134° 57'	15.0	40.5	65-74
ROPER BAR STORE	23.4	**40.3**	**27.6**	36.2	-	-	-	-	**12.9**	-	-	18	14° 45'	134° 32'	11.5	27.4	77-86

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process				Com-fort	Critical							
					24-hour		08-1800			24-hr	08-18						
	CWB	**DB**	WB	CDB	DB	WB	DB	WB	**DB**	DB	DB						
						NOTHERN TERRITORY (Continued)											
TEMPE DOWNS *	20.1	**41.2**	23.0	33.5	-	-	-	-	**-1.5**	-	-	518	24° 23'	132° 25'	16.5	42.4	70-79
TENNANT CREEK MO	19.7	**40.5**	24.4	33.2	40.5	25.0	41.0	25.0	**10.0**	8.5	10.0	375	19° 38'	134° 11'	12.0	30.5	79-88
TENNANT CREEK P.O.	21.0	**40.7**	25.1	35.0	-	-	-	-	**8.8**	-	-	377	19° 38'	134° 11'	12.8	31.9	58-67
WARRUWI	26.3	**34.4**	28.1	32.2	-	-	-	-	**20.0**	-	-	4	11° 39'	133° 24'	6.5	14.4	78-87
WAVE HILL NEW STATION *	22.6	**40.7**	26.2	34.8	-	-	-	-	**8.1**	-	-	196	17° 23'	131° 07'	12.8	32.6	75-84
WONARAH	20.6	**41.3**	24.8	35.4	-	-	-	-	**9.1**	-	-	240	19° 54'	136° 20'	13.7	32.2	57-66
YIRRKALA MISSION *	26.9	**34.1**	27.8	32.3	-	-	-	-	**21.0**	-	-	9	12° 15'	136° 53'	7.3	12.8	65-74
YUENDUMU	19.6	**39.7**	23.5	33.7	-	-	-	-	**4.1**	-	-	561	22° 16'	131° 48'	13.6	35.6	77-86
						QUEENSLAND											
ADAVALE P.O.	19.7	**39.8**	23.3	35.4	-	-	-	-	**3.5**	-	-	229	25° 55'	144° 36'	13.8	36.3	62-66
AMBERLEY AERO	22.0	**34.9**	24.8	32.3	35.0	25.5	36.5	26.0	**3.9**	2.0	3.9	27	27° 38'	152° 43'	11.5	31.0	79-88
ARCHERFIELD AIRPORT *	22.7	**33.1**	24.8	31.1	-	-	-	-	**7.5**	-	-	23	27° 34'	153° 00'	10.5	25.6	85-88
BARALABA P.O.	22.7	**36.9**	25.4	33.9	-	-	-	-	**5.8**	-	-	94	24° 11'	149° 49'	12.6	31.1	75-84
BARCALDINE P.O.	21.8	**39.2**	24.5	35.3	-	-	-	-	**6.3**	-	-	267	23° 33'	145° 17'	11.8	32.9	75-84
BEAUDESERT COMPOSITE *	22.4	**34.5**	24.7	31.0	-	-	-	-	**4.2**	-	-	46	28° 00'	153° 00'	12.2	30.1	68-77
BIRDSVILLE (POLICE STATION)	21.5	**43.1**	24.8	37.1	-	-	-	-	**4.2**	-	-	47	25° 54'	139° 21'	15.0	38.9	78-87
BLACKALL	20.4	**39.9**	23.3	34.7	-	-	-	-	**5.1**	-	-	283	24° 25'	145° 28'	14.3	34.8	65-69
BLACKALL P.O. *	21.9	**39.6**	24.4	35.5	-	-	-	-	**5.4**	-	-	283	24° 26'	145° 28'	13.9	34.2	79-88
BOLLON P.O. *	21.5	**40.0**	24.6	35.0	-	-	-	-	**2.3**	-	-	183	28° 02'	147° 29'	14.0	37.7	75-84
BOULIA P.O. *	21.1	**41.8**	25.4	35.5	-	-	-	-	**6.1**	-	-	157	22° 55'	139° 54'	13.4	35.7	75-84
BOWEN P.O.	26.4	**32.6**	27.7	31.2	-	-	-	-	**13.3**	-	-	6	20° 01'	148° 15'	6.9	19.3	76-85
BRISBANE AMO	22.8	**30.8**	24.9	29.7	32.0	25.5	33.5	26.0	**9.2**	6.0	9.2	4	27° 23'	153° 07'	8.2	21.6	79-88
BRISBANE R.O.	23.4	**31.9**	24.9	30.6	-	-	-	-	**9.3**	-	-	38	27° 29'	153° 02'	7.9	22.6	76-85
BULBURIN FORESTRY	20.5	**29.5**	23.1	28.2	-	-	-	-	**7.0**	-	-	602	24° 32'	151° 28'	8.3	22.5	59-68
BUNDABERG AERO	23.1	**30.7**	24.9	29.5	-	-	-	-	**9.4**	-	-	31	24° 54'	152° 19'	8.4	21.3	61-70
BUNDABERG P.O.	23.8	**31.4**	25.3	29.8	-	-	-	-	**10.5**	-	-	14	24° 52'	152° 21'	8.7	20.9	78-87
BURKETOWN P.O. *	23.2	**38.5**	27.6	34.5	-	-	-	-	**11.6**	-	-	6	17° 45'	139° 33'	9.4	26.3	78-87
BUSTARD HEAD	25.0	**29.1**	25.7	27.8	-	-	-	-	**11.7**	-	-	89	24° 01'	151° 46'	5.8	17.4	76-85
CAIRNS AMO	25.3	**32.8**	26.8	31.5	33.0	27.0	33.5	27.5	**15.1**	12.5	15.1	3	16° 53'	145° 45'	7.6	17.7	79-88
CALOUNDRA (SIGNAL STATION)	24.2	**28.4**	25.1	27.9	-	-	-	-	**10.1**	-	-	46	26° 48'	153° 09'	6.4	18.3	75-84
CAMOOWEAL P.O.	20.8	**41.6**	25.4	35.2	-	-	-	-	**6.2**	-	-	234	19° 55'	138° 07'	13.3	35.4	79-88
CAPE CAPRICORN (LIGHTHOUSE)	24.7	**28.4**	25.7	27.6	-	-	-	-	**12.3**	-	-	76	23° 29'	151° 14'	4.1	16.1	75-84
CAPE CLEVELAND (LIGHTHOUSE)	26.5	**32.6**	27.4	31.7	-	-	-	-	**16.0**	-	-	58	19° 11'	147° 01'	5.2	16.6	77-86

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	SUMMER: Comfort DB	SUMMER: Comfort WB	SUMMER: CDB	SUMMER: Critical process 24-hour DB	SUMMER: Critical process 24-hour WB	SUMMER: Critical process 08-1800 DB	SUMMER: Critical process 08-1800 WB	WINTER: Comfort DB	WINTER: Critical 24-hr DB	WINTER: Critical 08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
QUEENSLAND (Continued)																	
CAPE MORETON (LIGHTHOUSE)	24.0	27.0	24.3	26.5	-	-	-	-	11.9	-	-	96	27° 02'	153° 28'	4.7	15.1	79-88
CARDWELL	27.2	34.0	28.0	32.7	-	-	-	-	12.3	-	-	6	18° 16'	146° 01'	8.0	21.7	77-86
CHARLEVILLE AMO	20.0	39.4	23.0	34.3	39.5	24.5	40.5	24.5	2.4	−1.5	2.4	306	26° 25'	146° 16'	13.9	37.0	79-88
CHARTERS TOWERS P.O.	22.3	37.6	25.1	33.3	-	-	-	-	10.9	-	-	310	20° 05'	146° 16'	11.4	26.7	78-87
CLERMONT P.O. *	22.8	37.5	25.5	35.6	-	-	-	-	5.5	-	-	267	22° 50'	147° 38'	12.1	32.0	78-87
CLONCURRY AMO	20.5	40.8	25.7	34.1	41.5	25.5	42.5	26.0	8.5	7.0	8.5	189	20° 40'	140° 31'	12.8	32.3	65-74
COEN AERO	22.8	35.2	25.7	30.2	-	-	-	-	16.9	-	-	162	13° 46'	143° 07'	8.1	18.3	72-81
COEN P.O.	23.7	35.0	26.9	31.5	-	-	-	-	15.6	-	-	193	13° 57'	143° 12'	8.5	19.4	62-71
COLLINSVILLE P.O.	22.1	36.5	26.1	32.5	-	-	-	-	8.1	-	-	187	20° 33'	147° 51'	11.9	28.4	57-65
COOKTOWN AIRPORT (COMPOSITE)	26.8	32.5	27.6	31.2	-	-	-	-	17.6	-	-	6	15° 27'	145° 11'	6.6	14.9	77-86
COOLANGATTA AERO	22.8	28.4	24.7	27.0	-	-	-	-	9.6	-	-	6	28° 10'	153° 30'	7.5	18.8	62-70
COOLANGATTA COMP.	23.9	28.9	25.3	28.2	-	-	-	-	11.0	-	-	6	28° 11'	153° 32'	6.2	17.9	73-80
CROYDON P.O.	22.9	38.6	27.1	33.9	-	-	-	-	11.9	-	-	116	18° 12'	142° 15'	10.0	26.7	72-81
CUNNAMULLA P.O.	20.2	39.9	23.2	35.0	-	-	-	-	4.3	-	-	189	28° 04'	145° 45'	13.7	35.6	78-87
DALBY P.O. *	21.4	35.6	23.5	31.4	-	-	-	-	4.6	-	-	344	27° 11'	151° 16'	12.0	31.0	71-80
DOUBLE ISLAND POINT (LIGHTHOUSE)	24.3	28.0	25.3	27.8	-	-	-	-	12.3	-	-	77	25° 56'	153° 12'	5.0	15.7	79-88
EMERALD P.O. *	22.8	37.7	25.3	34.3	-	-	-	-	7.5	-	-	179	23° 32'	148° 10'	12.9	30.1	79-88
FITZROY ISLAND	26.8	32.3	27.4	30.8	-	-	-	-	17.9	-	-	107	16° 56'	146° 00'	6.0	14.4	77-86
GAYNDAH P.O.	22.6	36.0	24.3	33.3	-	-	-	-	6.1	-	-	106	25° 38'	151° 37'	12.1	29.9	79-88
GEORGETOWN P.O.	22.0	38.8	25.7	33.8	-	-	-	-	10.3	-	-	292	18° 18'	143° 33'	11.6	28.5	79-88
GLADSTONE MO	25.1	32.0	26.5	31.1	33.0	26.5	34.0	27.5	11.8	10.0	11.0	76	23° 51'	151° 16'	8.5	20.2	79-88
GOONDIWINDI P.O.	21.1	36.9	23.5	32.9	-	-	-	-	4.1	-	-	217	28° 33'	150° 18'	12.8	32.8	75-84
HERBERTON P.O.	19.5	31.3	22.8	28.0	-	-	-	-	7.5	-	-	899	17° 23'	145° 23'	9.4	23.8	75-84
HERON ISLAND	24.6	29.9	25.9	29.3	-	-	-	-	15.2	-	-	5	23° 27'	151° 55'	5.3	14.7	70-79
HUGHENDEN P.O. *	21.8	39.4	26.2	34.6	-	-	-	-	8.0	-	-	324	20° 51'	144° 12'	11.8	31.4	77-86
INGHAM COMPOSITE	26.1	34.1	27.0	32.7	-	-	-	-	12.1	-	-	13	18° 39'	146° 10'	8.6	22.0	78-87
INNISFAIL	26.1	31.0	26.8	31.3	-	-	-	-	12.6	-	-	4	17° 31'	146° 02'	7.0	18.4	77-86
JIMBOOMBA (GLENLOGAN FIELD STATION)	22.3	32.9	24.5	30.4	-	-	-	-	5.1	-	-	20	27° 50'	153° 00'	10.5	27.8	72-79
KALPOWAR FORESTRY	21.7	33.7	23.6	29.8	-	-	-	-	3.7	-	-	339	24° 42'	151° 19'	11.3	30.0	62-69
KARUMBA FLYING BASE	21.6	35.8	28.6	31.9	-	-	-	-	12.3	-	-	3	17° 28'	140° 50'	8.0	23.5	41-50
KINGAROY P.O.	20.6	33.2	23.8	31.0	-	-	-	-	3.5	-	-	429	26° 33'	151° 50'	11.7	29.7	79-88
LADY ELLIOT ISLAND (LIGHTHOUSE) *	25.2	30.1	26.5	29.1	-	-	-	-	15.1	-	-	4	24° 07'	152° 43'	5.0	14.9	78-87
LOCKHART RIVER AIRPORT	25.4	32.7	26.7	30.3	-	-	-	-	18.1	-	-	23	12° 47'	143° 18'	7.8	14.6	78-87
LONGREACH AMO *	21.3	40.9	24.4	36.2	41.5	25.0	42.0	25.5	5.1	2.5	5.1	192	23° 26'	144° 17'	14.5	35.7	79-88

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER Comfort (or non-critical process) CWB	SUMMER Comfort DB	SUMMER Comfort WB	SUMMER Comfort CDB	SUMMER Critical process 24-hour DB	SUMMER Critical process 24-hour WB	SUMMER Critical process 08-1800 DB	SUMMER Critical process 08-1800 WB	WINTER Comfort DB	WINTER Critical 24-hr DB	WINTER Critical 08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
							QUEENSLAND (Continued)										
LONGREACH P.O.	20.5	**40.9**	**24.2**	35.2	-	-	-	-	**6.0**	-	-	191	23° 27'	144° 15'	14.3	34.9	62-71
LOW ISLES	27.1	**33.7**	**28.2**	32.8	-	-	-	-	**19.2**	-	-	3	16° 23'	145° 34'	6.3	14.5	79-88
MACKAY MO	25.6	**31.4**	**26.5**	30.0	32.0	27.0	32.5	27.0	**11.2**	8.5	11.2	6	21° 07'	149° 13'	6.5	20.2	79-88
MARYBOROUGH COMPOSITE	23.6	**32.8**	**25.5**	30.8	-	-	-	-	**8.1**	-	-	11	25° 33'	152° 41'	10.0	24.7	79-88
MILES P.O. *	20.7	**36.0**	**23.4**	32.9	-	-	-	-	**3.2**	-	-	305	26° 40'	150° 11'	13.4	32.8	79-88
MITCHELL P.O. *	19.2	**37.5**	**22.4**	32.0	-	-	-	-	**0.7**	-	-	335	26° 29'	147° 59'	13.8	36.2	69-77
MONTO P.O.	21.7	**35.7**	**24.3**	32.6	-	-	-	-	**3.9**	-	-	249	24° 52'	151° 08'	13.1	31.8	79-88
MORETON (TELEGRAPHIC OFFICE) *	23.9	**35.4**	**26.6**	31.2	-	-	-	-	**16.5**	-	-	39	12° 27'	142° 38'	8.4	18.9	75-84
MOUNT GLORIOUS	20.7	**27.4**	**22.5**	25.4	-	-	-	-	**6.7**	-	-	625	27° 20'	152° 46'	7.0	20.7	75-84
MOUNT ISA AMO	20.0	**39.9**	**24.3**	33.6	40.5	25.0	41.5	25.0	**6.8**	3.5	6.8	342	20° 40'	139° 29'	12.9	33.1	79-88
MOUNT ISA MINES	19.4	**40.1**	**24.6**	33.5	-	-	-	-	**9.3**	-	-	381	20° 44'	139° 30'	11.2	30.8	79-85
MOUNT ISA P.O.	21.4	**40.7**	**24.9**	36.6	-	-	-	-	**7.8**	-	-	356	20° 44'	139° 29'	13.0	32.9	59-66
MOUNT SURPRISE	19.6	**37.6**	**24.3**	32.1	-	-	-	-	**8.6**	-	-	453	18° 09'	144° 19'	12.3	29.0	60-69
MOUNT TAMBORINE	21.2	**28.9**	**22.7**	28.0	-	-	-	-	**7.5**	-	-	525	27° 59'	153° 12'	8.0	21.4	68-77
NORMANTON P.O.	21.9	**38.1**	**27.3**	34.0	-	-	-	-	**13.1**	-	-	8	17° 40'	141° 04'	9.0	25.0	78-87
NORTH REEF (LIGHTHOUSE) *	25.1	**30.6**	**26.5**	29.2	-	-	-	-	**16.4**	-	-	1	23° 11'	151° 54'	5.5	14.2	67-76
OAKEY AERO MET OFFICE	19.9	**33.8**	**22.9**	30.5	35.0	23.5	36.5	24.0	**2.1**	–3.0	2.1	406	27° 25'	151° 44'	12.0	31.7	74-81
PALMERVILLE	22.5	**37.8**	**26.2**	32.4	-	-	-	-	**13.2**	-	-	207	16° 00'	144° 04'	10.0	24.6	78-87
PINE ISLET (LIGHTHOUSE)	25.6	**31.7**	**26.7**	30.5	-	-	-	-	**15.9**	-	-	58	21° 40'	150° 13'	6.1	15.8	77-86
QUILPIE P.O.	20.9	**40.9**	**23.7**	36.4	-	-	-	-	**4.4**	-	-	197	26° 37'	144° 16'	13.5	36.5	78-87
RICHMOND P.O.	22.9	**41.0**	**26.2**	36.1	-	-	-	-	**7.1**	-	-	211	20° 42'	143° 08'	13.9	33.9	79-88
ROCKHAMPTON AMO	23.1	**35.0**	**25.7**	32.8	35.0	26.5	36.0	26.5	**8.8**	4.5	8.8	10	23° 23'	150° 28'	9.7	26.2	79-88
ROMA P.O.	21.3	**38.1**	**24.1**	34.0	-	-	-	-	**1.9**	-	-	299	26° 34'	148° 47'	13.1	36.2	74-83
SANDY CAPE (LIGHTHOUSE)	23.4	**28.9**	**24.8**	28.2	-	-	-	-	**13.1**	-	-	99	24° 44'	153° 13'	6.4	15.8	75-84
SOMERSET DAM (STANLEY RIVER) *	21.1	**34.8**	**24.3**	31.5	-	-	-	-	**4.1**	-	-	73	27° 07'	152° 33'	10.9	30.7	60-69
SOUTHPORT	23.8	**30.1**	**25.0**	29.7	-	-	-	-	**9.1**	-	-	20	27° 57'	153° 24'	8.2	21.0	79-88
ST GEORGE P.O.	20.6	**38.7**	**23.8**	34.8	-	-	-	-	**4.4**	-	-	201	28° 02'	148° 35'	12.9	34.3	77-86
ST LAWRENCE P.O.	23.4	**32.6**	**26.0**	30.6	-	-	-	-	**10.6**	-	-	11	22° 21'	149° 32'	8.5	22.0	69-78
STANTHORPE P.O.	18.0	**31.6**	**21.0**	28.7	-	-	-	-	**–0.3**	-	-	792	28° 39'	151° 56'	11.7	31.9	75-84
SURAT P.O. *	21.5	**37.6**	**23.8**	33.3	-	-	-	-	**3.0**	-	-	246	27° 09'	149° 04'	13.1	34.6	75-84
TAMBO P.O.	20.1	**38.3**	**24.3**	32.6	-	-	-	-	**2.8**	-	-	395	24° 53'	146° 15'	14.1	35.5	65-74
TAROOM P.O.	21.6	**36.6**	**24.4**	32.7	-	-	-	-	**2.8**	-	-	200	25° 39'	149° 48'	12.1	33.8	73-82
TEWANTIN P.O.	23.6	**30.4**	**25.4**	29.6	-	-	-	-	**9.9**	-	-	8	26° 24'	153° 02'	7.7	20.5	79-88
THARGOMINDAH P.O.	21.1	**40.8**	**23.2**	36.8	-	-	-	-	**4.0**	-	-	125	28° 00'	143° 49'	13.6	36.8	78-87

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	DB	WB	CDB	Critical process 24-hour DB	WB	08-1800 DB	WB	WINTER: Comfort DB	Critical 24-hr DB	08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
QUEENSLAND (Continued)																	
THURSDAY ISLAND MO	25.8	**31.6**	**26.8**	30.6	-	-	-	-	**22.1**	-	-	60	10° 35'	142° 13'	5.3	9.5	75-84
TOOWOOMBA COMPOSITE *	20.5	**31.1**	**22.8**	28.3	-	-	-	-	**4.6**	-	-	675	27° 35'	151° 56'	10.5	26.5	79-88
TOWNSVILLE AMO	24.7	**32.8**	**26.7**	31.0	33.5	27.0	34.5	27.5	**13.1**	8.0	13.1	4	19° 15'	146° 46'	6.7	19.7	79-88
TWIN HILLS P.O.	21.7	**38.0**	**24.7**	33.9	-	-	-	-	**5.9**	-	-	195	21° 57'	146° 57'	12.1	32.1	75-84
URANDANGIE	20.7	**42.0**	**25.2**	35.0	-	-	-	-	**3.9**	-	-	174	21° 37'	138° 19'	15.7	38.1	67-76
WARWICK	20.1	**33.8**	**22.5**	30.7	-	-	-	-	**1.7**	-	-	477	28° 13'	152° 02'	12.6	32.1	75-84
WEIPA COMPOSITE	23.8	**35.6**	**27.9**	32.8	-	-	-	-	**19.1**	-	-	18	12° 38'	141° 53'	8.1	16.5	79-88
WINDORAH P.O.	21.6	**42.0**	**24.4**	37.0	-	-	-	-	**4.5**	-	-	126	25° 26'	142° 39'	14.2	37.5	79-88
WINTON	21.8	**41.4**	**25.2**	36.1	-	-	-	-	**6.8**	-	-	185	22° 23'	143° 02'	13.8	34.6	78-87
SOUTH AUSTRALIA																	
ADELAIDE (WEST TERRACE)	19.4	**34.8**	**21.3**	31.3	36.5	22.0	38.0	22.5	**6.4**	5.0	6.4	40	34° 56'	138° 35'	10.5	28.4	67-76
ADELAIDE AIRPORT	18.1	**36.0**	**20.8**	31.4	37.5	21.5	39.0	22.5	**4.5**	2.5	4.5	4	34° 57'	138° 32'	12.2	31.5	79-88
ADELAIDE R.O. (KENTTOWN)	20.1	**37.0**	**21.4**	35.1	38.5	22.5	40.0	23.0	**4.9**	3.0	4.9	47	34° 55'	138° 37'	12.3	32.1	79-88
ALTHORPE ISLAND (LIGHTHOUSE)	17.9	**29.2**	**19.5**	25.3	-	-	-	-	**8.2**	-	-	80	35° 22'	136° 52'	8.5	20.6	71-80
ANDAMOOKA (OPAL FIELDS)	20.9	**41.8**	**22.5**	37.6	-	-	-	-	**4.4**	-	-	76	30° 27'	137° 10'	14.8	37.4	78-84
BELAIR (KALYRA)	17.8	**34.7**	**20.3**	30.9	-	-	-	-	**5.4**	-	-	305	35° 00'	138° 37'	11.9	29.3	63-72
BERRI P.O.	20.7	**38.7**	**21.6**	35.8	-	-	-	-	**3.6**	-	-	31	34° 17'	140° 36'	16.6	35.1	62-69
CAPE BORDA (LIGHTHOUSE)	17.0	**28.1**	**18.4**	25.0	-	-	-	-	**7.0**	-	-	143	35° 45'	136° 36'	9.4	21.1	78-87
CAPE NORTHUMBERLAND	19.0	**26.1**	**19.3**	23.6	-	-	-	-	**4.1**	-	-	5	38° 04'	140° 40'	7.9	22.0	76-85
CAPE WILLOUGHBY (LIGHTHOUSE)	18.0	**28.2**	**19.4**	24.9	-	-	-	-	**8.0**	-	-	55	35° 51'	138° 08'	5.7	20.2	76-85
CEDUNA AMO	19.0	**39.1**	**21.4**	34.4	41.0	22.0	42.5	22.5	**2.5**	1.0	2.5	24	32° 08'	133° 43'	14.0	36.6	79-88
CLARE P.O.	17.7	**36.0**	**20.8**	30.1	-	-	-	-	**1.3**	-	-	385	33° 50'	138° 37'	15.3	34.7	65-74
CLEVE P.O.	19.4	**37.1**	**20.7**	33.9	-	-	-	-	**5.2**	-	-	193	33° 42'	136° 30'	12.8	31.9	60-69
COOBER PEDY	20.3	**41.6**	**21.8**	37.9	-	-	-	-	**5.0**	-	-	215	29° 01'	134° 45'	15.6	36.3	77-86
COOK HOSPITAL COMPOSITE *	20.2	**41.3**	**22.0**	37.2	-	-	-	-	**1.1**	-	-	120	30° 37'	130° 25'	18.5	39.4	78-87
ELLISTON P.O.	19.5	**31.2**	**20.4**	28.0	-	-	-	-	**5.3**	-	-	4	33° 39'	134° 53'	9.9	25.9	78-87
ERNABELLA *	18.8	**38.8**	**21.2**	35.1	-	-	-	-	**0.2**	-	-	676	26° 18'	132° 08'	13.9	38.4	62-67
FOWLERS BAY	18.1	**33.8**	**21.2**	28.8	-	-	-	-	**2.7**	-	-	5	31° 59'	132° 27'	9.7	31.1	57-66
GEORGETOWN P.O.	19.7	**38.0**	**21.5**	33.3	-	-	-	-	**2.6**	-	-	273	33° 22'	138° 24'	15.9	35.4	60-69
HAWKER P.O.	18.5	**37.7**	**21.7**	33.7	-	-	-	-	**2.8**	-	-	315	31° 54'	138° 26'	15.7	34.9	67-73
KADINA P.O.	19.5	**38.2**	**21.8**	34.4	-	-	-	-	**4.1**	-	-	44	33° 58'	137° 43'	14.4	34.1	75-84
KAPUNDA P.O.	19.5	**37.0**	**21.2**	33.6	-	-	-	-	**2.4**	-	-	245	34° 21'	138° 55'	16.4	34.6	57-62
KEITH P.O.	19.3	**37.8**	**21.1**	33.7	-	-	-	-	**2.6**	-	-	29	36° 06'	140° 21'	16.7	35.2	78-87

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process 24-hour		Critical process 08-1800		Com-fort	Critical 24-hr	Critical 08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
SOUTH AUSTRALIA (Continued)																	
KIMBA P.O.	18.9	**38.3**	**21.6**	35.5	-	-	-	-	**3.1**	-	-	263	33° 09'	136° 25'	15.6	35.2	68-74
KINGSCOTE P.O. *	21.0	**29.4**	**21.6**	30.0	-	-	-	-	**6.7**	-	-	20	35° 39'	137° 38'	9.9	22.7	64-68
KYANCUTTA P.O.	20.2	**40.5**	**22.1**	36.6	-	-	-	-	**1.4**	-	-	57	33° 08'	135° 34'	18.6	39.1	75-84
LAMEROO P.O.	20.3	**38.7**	**21.3**	35.8	-	-	-	-	**2.7**	-	-	99	35° 20'	140° 31'	17.3	36.0	78-87
LEIGH CREEK AERO	19.2	**40.4**	**23.1**	34.3	-	-	-	-	**4.1**	-	-	194	30° 28'	138° 24'	13.6	36.3	72-81
LOXTON (RESEARCH CENTRE)	21.2	**38.9**	**22.4**	36.1	-	-	-	-	**1.7**	-	-	66	34° 26'	140° 36'	16.2	37.2	74-83
LUCINDALE P.O. *	20.0	**37.2**	**20.9**	34.5	-	-	-	-	**2.0**	-	-	30	36° 58'	140° 22'	17.2	34.6	76-85
MAITLAND P.O.	18.7	**36.8**	**21.2**	33.3	-	-	-	-	**5.7**	-	-	186	34° 23'	137° 41'	13.2	31.1	78-87
MARALINGA *	18.8	**39.0**	**21.0**	33.5	-	-	-	-	**4.4**	-	-	290	30° 10'	131° 35'	15.7	34.6	58-67
MARREE *	21.4	**43.0**	**23.4**	39.1	-	-	-	-	**3.7**	-	-	50	29° 39'	138° 03'	16.3	38.0	70-79
MINNIPA (RESEARCH CENTRE) *	19.4	**38.5**	**22.4**	34.0	-	-	-	-	**5.0**	-	-	168	32° 50'	135° 09'	16.1	33.5	73-82
MOOMBA	20.7	**42.0**	**23.6**	35.9	-	-	-	-	**5.1**	-	-	39	28° 07'	140° 13'	13.8	36.9	76-85
MT BARKER P.O.	19.8	**35.2**	**21.3**	34.4	-	-	-	-	**1.2**	-	-	330	35° 04'	138° 52'	15.1	34.0	76-85
MT GAMBIER AERO AMO	18.1	**34.2**	**19.3**	29.6	35.5	20.0	38.0	21.0	**3.1**	1.0	3.1	63	37° 45'	140° 47'	13.7	31.1	79-88
MURRAY BRIDGE P.O.	19.6	**37.9**	**21.6**	34.6	-	-	-	-	**1.7**	-	-	15	35° 07'	139° 17'	14.6	35.4	77-86
NARACOORTE P.O. *	19.7	**35.3**	**20.5**	33.6	-	-	-	-	**3.2**	-	-	58	36° 57'	140° 44'	16.4	32.0	72-81
NEPTUNE ISLAND (LIGHTHOUSE) *	20.0	**24.6**	**20.9**	23.6	-	-	-	-	**9.6**	-	-	32	35° 20'	136° 07'	6.1	14.7	76-85
NONNING	18.8	**39.2**	**21.0**	34.5	-	-	-	-	**1.7**	-	-	205	32° 31'	136° 29'	16.6	37.5	77-86
NURIOOTPA VITICULTURAL	18.6	**36.5**	**20.4**	30.8	-	-	-	-	**2.0**	-	-	274	34° 29'	139° 00'	15.4	34.5	78-87
OODNADATTA AMO	20.2	**41.6**	**23.1**	36.0	42.0	24.5	42.5	24.5	**3.3**	2.5	3.3	113	27° 34'	135° 27'	14.7	38.3	69-78
PARNDANA EAST (RESEARCH STATION)	17.7	**33.1**	**20.5**	27.8	-	-	-	-	**4.9**	-	-	155	35° 48'	137° 20'	12.5	28.2	74-83
PENFIELD (WEAPONS RESARCH) *	20.7	**36.3**	**21.6**	34.0	-	-	-	-	**4.8**	-	-	24	34° 44'	138° 39'	13.6	31.5	69-78
POLDA BASIN	18.4	**39.4**	**20.7**	35.0	-	-	-	-	**1.7**	-	-	37	33° 31'	135° 17'	16.6	37.7	76-85
PORT AUGUSTA P.O.	20.7	**40.0**	**23.9**	33.9	-	-	-	-	**4.7**	-	-	5	32° 30'	137° 46'	13.5	35.3	57-61
PORT AUGUSTA (POWER STATION)	19.5	**39.6**	**22.8**	33.9	-	-	-	-	**5.6**	-	-	4	32° 32'	137° 47'	12.9	34.0	79-88
PORT LINCOLN P.O.	19.4	**30.7**	**21.4**	28.5	-	-	-	-	**7.2**	-	-	4	34° 44'	135° 52'	9.7	23.5	78-87
PORT PIRIE BHAS SITE	20.0	**39.2**	**22.1**	34.2	-	-	-	-	**6.0**	-	-	4	33° 11'	138° 01'	13.9	33.2	76-85
RENMARK P.O.	19.8	**39.6**	**21.9**	35.4	-	-	-	-	**2.7**	-	-	20	34° 10'	140° 45'	16.1	36.9	78-87
ROBE P.O. *	18.3	**25.9**	**19.4**	24.7	-	-	-	-	**6.4**	-	-	3	37° 10'	139° 46'	8.5	19.5	76-85
ROSEWORTHY (AGRICULTURAL COLLEGE)	19.1	**36.8**	**21.3**	32.4	-	-	-	-	**4.7**	-	-	114	34° 32'	138° 41'	14.0	32.1	71-80
SNOWTOWN P.O. *	19.7	**37.7**	**21.5**	34.7	-	-	-	-	**2.3**	-	-	103	33° 47'	138° 13'	16.9	35.4	60-69
STIRLING	18.2	**33.6**	**19.0**	30.0	-	-	-	-	**2.4**	-	-	496	35° 02'	138° 43'	14.4	31.2	57-62
STIRLING P.O.	19.0	**33.1**	**19.8**	31.2	-	-	-	-	**3.0**	-	-	496	35° 00'	138° 43'	12.6	30.1	75-84
STRATHALBYN P.O. *	19.4	**36.4**	**21.4**	34.1	-	-	-	-	**3.0**	-	-	70	35° 16'	138° 53'	13.0	32.7	76-85

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	SUMMER: Comfort DB	SUMMER: Comfort WB	SUMMER: Comfort CDB	SUMMER: Critical process 24-hour DB	SUMMER: Critical process 24-hour WB	SUMMER: Critical process 08-1800 DB	SUMMER: Critical process 08-1800 WB	WINTER: Comfort DB	WINTER: Critical 24-hr DB	WINTER: Critical 08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
SOUTH AUSTRALIA (Continued)																	
STREAKY BAY P.O.	20.6	**36.8**	**22.3**	33.2	-	-	-	-	**5.2**	-	-	13	32° 48'	134° 13'	12.8	31.6	75-84
TARCOOLA P.O.	20.0	**41.6**	**21.4**	37.5	-	-	-	-	**2.3**	-	-	120	30° 43'	134° 34'	17.0	39.3	78-87
TROUBRIDGE SHOAL (LIGHTHOUSE)	20.7	**27.4**	**21.0**	26.9	-	-	-	-	**8.9**	-	-	3	35° 07'	137° 50'	7.5	18.5	75-80
TURRETFIELD (RESEARCH CENTRE)	18.8	**38.1**	**20.8**	33.0	-	-	-	-	**2.9**	-	-	116	34° 30'	138° 50'	15.2	35.2	76-85
VICTOR HARBOUR P.O.	18.4	**33.6**	**21.0**	27.9	-	-	-	-	**5.5**	-	-	5	35° 33'	138° 37'	8.3	28.1	75-84
WHYALLA	19.1	**38.7**	**22.3**	34.5	-	-	-	-	**6.0**	-	-	13	33° 02'	137° 32'	10.0	32.7	76-85
WOOMERA AMO	19.4	**40.6**	**21.9**	36.2	41.5	23.0	42.5	23.5	**4.4**	3.5	4.4	165	31° 09'	136° 49'	15.1	36.2	79-88
YONGALA P.O. *	19.4	**36.1**	**20.3**	34.3	-	-	-	-	**-1.8**	-	-	515	33° 02'	138° 45'	17.4	37.3	68-77
YUNTA	18.4	**38.9**	**20.6**	36.5	-	-	-	-	**0.4**	-	-	303	32° 35'	139° 34'	17.2	38.5	62-66
TASMANIA																	
BICHENO COMPOSITE *	15.7	**21.9**	**17.8**	21.1	-	-	-	-	**3.8**	-	-	10	41° 52'	148° 18'	7.9	17.8	83-86
BUSHY PARK	17.7	**29.4**	**18.2**	26.8	-	-	-	-	**-1.7**	-	-	60	42° 43'	146° 54'	12.8	31.1	79-88
BUTLERS GORGE	16.0	**26.6**	**18.8**	23.2	-	-	-	-	**-4.0**	-	-	666	42° 17'	146° 16'	13.1	30.6	59-68
CAMBRIDGE AERO AMO	17.6	**26.4**	**18.3**	25.3	-	-	-	-	**0.6**	-	-	10	42° 50'	147° 29'	11.2	25.8	49-57
CAMPBELL TOWN	17.8	**28.1**	**18.0**	25.9	-	-	-	-	**-3.8**	-	-	200	41° 56'	147° 29'	14.6	31.9	73-77
CAPE BRUNY (LIGHTHOUSE)	15.6	**22.7**	**17.2**	22.0	-	-	-	-	**4.0**	-	-	55	43° 30'	147° 09'	6.8	18.7	79-88
CAPE SORELL (LIGHTHOUSE)	18.5	**21.7**	**18.9**	21.7	-	-	-	-	**4.1**	-	-	22	42° 12'	145° 10'	6.6	17.6	58-67
CRESSY RESEARCH	17.5	**27.8**	**18.6**	26.9	-	-	-	-	**-2.9**	-	-	150	41° 43'	147° 05'	13.7	30.7	74-83
DEAL ISLAND *	18.5	**23.9**	**19.2**	23.2	-	-	-	-	**6.8**	-	-	76	39° 29'	147° 19'	5.8	17.1	84-88
DEVONPORT	18.4	**23.6**	**19.6**	22.2	-	-	-	-	**0.7**	-	-	12	41° 11'	146° 22'	9.0	22.9	65-74
DEVONPORT EAST	16.9	**22.9**	**19.0**	22.2	-	-	-	-	**0.5**	-	-	46	41° 11'	146° 23'	9.1	22.4	79-88
EDDYSTONE POINT (LIGHTHOUSE)	17.5	**22.0**	**18.8**	21.4	-	-	-	-	**4.9**	-	-	13	41° 00'	148° 21'	6.9	17.1	75-84
ERRIBA	15.9	**23.6**	**16.7**	22.3	-	-	-	-	**-0.9**	-	-	590	41° 27'	146° 07'	10.0	24.5	78-87
FLINDERS IS.AIRPORT	18.6	**25.5**	**19.5**	27.1	-	-	-	-	**3.1**	-	-	7	40° 06'	148° 00'	8.9	22.4	62-67
GROVE RESEARCH	17.7	**28.4**	**19.4**	27.0	-	-	-	-	**-1.7**	-	-	60	42° 59'	147° 05'	12.4	30.1	67-76
HASTINGS CHALET *	18.0	**25.2**	**18.7**	24.2	-	-	-	-	**-0.7**	-	-	40	43° 25'	146° 53'	11.6	24.4	71-80
HOBART AIRPORT AMO	16.8	**27.1**	**18.5**	25.3	29.0	19.0	31.0	19.5	**1.5**	0.5	1.5	4	42° 50'	147° 30'	10.4	25.6	79-88
HOBART R.O.	17.1	**27.0**	**18.0**	25.8	29.0	19.0	31.0	19.5	**1.9**	1.0	1.5	55	42° 53'	147° 20'	9.4	25.1	79-88
KING I. (CURRIE P.O.)	19.2	**25.5**	**19.9**	25.0	-	-	-	-	**6.2**	-	-	24	39° 56'	143° 51'	7.1	19.3	79-88
KINGSTON *	18.5	**26.3**	**18.5**	24.3	-	-	-	-	**-0.5**	-	-	52	42° 58'	147° 19'	12.0	26.3	66-74
LAKE LEAKE CHALET	16.1	**24.7**	**17.1**	23.0	-	-	-	-	**-3.3**	-	-	580	42° 01'	147° 48'	12.0	28.0	76-85
LAUNCESTON (TI TREE BEND)	18.4	**28.4**	**19.4**	26.4	-	-	-	-	**-1.5**	-	-	5	41° 25'	147° 07'	12.7	29.9	81-85
LAUNCESTON (ELPHIN)	19.3	**28.1**	**20.1**	27.1	-	-	-	-	**-2.5**	-	-	8	41° 27'	147° 10'	12.9	30.6	72-78

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level	Lat.	Long.	Daily range	Yearly range	Years of data
	Comfort (or non-critical process)				Critical process				Com-fort	Critical							
					24-hour		08-1800			24-hr	08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB	(m)	South	East	(K)	(K)	
TASMANIA (Continued)																	
LAUNCESTON AIRPORT	17.6	**27.2**	**18.4**	25.3	28.0	18.5	30.0	19.0	**-1.2**	-2.5	-1.2	171	41° 33'	147° 13'	13.2	28.4	79-88
LOW HEAD (LIGHTHOUSE)	18.6	**24.7**	**19.7**	23.2	-	-	-	-	**2.7**	-	-	28	41° 03'	146° 47'	8.2	22.0	79-88
MAATSUYKER ISLAND (LIGHTHOUSE)	15.9	**20.7**	**16.4**	19.5	-	-	-	-	**4.6**	-	-	147	43° 39'	146° 16'	5.7	16.1	79-88
MARRAWAH (MARSHALL)	18.0	**23.8**	**18.9**	23.3	-	-	-	-	**3.7**	-	-	107	40° 55'	144° 43'	8.5	20.1	79-88
MAYDENA	17.3	**28.2**	**18.8**	27.4	-	-	-	-	**-1.5**	-	-	270	42° 46'	146° 36'	13.9	29.7	65-73
MOUNT WELLINGTON	12.6	**19.1**	**12.5**	16.9	-	-	-	-	**-4.9**	-	-	1249	42° 54'	147° 14'	9.2	24.0	63-68
NEW NORFOLK	18.6	**29.3**	**19.3**	27.5	-	-	-	-	**-0.9**	-	-	5	42° 47'	147° 05'	12.4	30.2	68-77
OATLANDS P.O. *	16.3	**26.1**	**17.3**	27.5	-	-	-	-	**-1.9**	-	-	400	42° 18'	147° 22'	12.9	28.0	62-66
ORFORD P.O. *	18.4	**25.3**	**18.6**	23.0	-	-	-	-	**0.6**	-	-	15	42° 33'	147° 53'	11.1	24.3	77-86
PALMERS LOOKOUT	16.7	**22.6**	**17.3**	22.2	-	-	-	-	**3.0**	-	-	192	43° 10'	147° 50'	7.7	19.6	81-88
PALMERSTON (COMPOSITE)	18.4	**28.5**	**19.1**	26.1	-	-	-	-	**-3.4**	-	-	180	41° 47'	146° 59'	15.0	31.7	76-85
PREOLENNA	17.5	**24.1**	**18.4**	22.8	-	-	-	-	**1.7**	-	-	251	41° 05'	145° 33'	9.1	22.4	76-85
QUEENSTOWN (7XS) *	18.7	**28.2**	**18.8**	26.7	-	-	-	-	**-2.1**	-	-	129	42° 06'	145° 33'	13.2	29.1	72-81
QUOIBA	17.0	**23.7**	**18.8**	22.6	-	-	-	-	**-0.4**	-	-	11	41° 13'	146° 21'	10.0	24.1	75-84
REDPA	17.7	**23.6**	**18.4**	22.9	-	-	-	-	**2.9**	-	-	82	40° 56'	144° 50'	8.4	20.7	59-68
RISDON	17.1	**27.7**	**19.1**	25.9	-	-	-	-	**1.5**	-	-	31	42° 50'	147° 19'	10.6	25.8	65-74
SAVAGE RIVER *	17.7	**25.0**	**17.9**	23.5	-	-	-	-	**0.8**	-	-	365	41° 30'	145° 11'	10.1	23.5	67-75
SCAMANDER (NORTH)	16.7	**25.7**	**19.1**	22.7	-	-	-	-	**1.8**	-	-	10	41° 27'	148° 17'	9.5	23.9	77-86
SCOTTSDALE 2	18.9	**25.8**	**19.6**	25.6	-	-	-	-	**0.1**	-	-	190	41° 11'	147° 30'	12.2	25.7	73-78
SCOTTSDALE (KRAFT FOODS)	18.1	**24.7**	**19.2**	23.2	-	-	-	-	**1.2**	-	-	199	41° 09'	147° 31'	10.6	23.5	64-70
SHANNON HEC	13.7	**23.8**	**16.4**	21.5	-	-	-	-	**-4.1**	-	-	939	42° 03'	146° 45'	12.0	27.9	57-66
SMITHTON COMPOSITE	17.9	**23.2**	**18.9**	22.8	-	-	-	-	**1.2**	-	-	8	40° 51'	145° 07'	9.1	21.8	69-78
ST HELENS P.O. *	17.0	**27.6**	**19.8**	25.2	-	-	-	-	**0.2**	-	-	5	41° 20'	148° 14'	11.4	27.2	74-83
STANLEY P.O.	19.2	**24.0**	**19.3**	22.7	-	-	-	-	**2.5**	-	-	10	40° 46'	145° 18'	8.8	21.5	58-67
STRATHGORDON	15.2	**25.4**	**16.7**	23.7	-	-	-	-	**-0.2**	-	-	320	42° 46'	146° 03'	9.7	25.6	73-80
SWANSEA	17.6	**26.3**	**19.2**	24.3	-	-	-	-	**0.0**	-	-	7	42° 08'	148° 05'	10.6	26.3	79-88
TASMAN (LIGHTHOUSE)	15.0	**19.4**	**17.0**	19.1	-	-	-	-	**3.0**	-	-	239	43° 15'	148° 00'	6.1	16.4	66-75
WARATAH P.O.	15.7	**24.4**	**16.5**	23.6	-	-	-	-	**-1.1**	-	-	623	41° 26'	145° 31'	11.3	25.5	60-69
WYNYARD *	16.8	**23.2**	**18.4**	21.9	-	-	-	-	**0.5**	-	-	16	41° 00'	145° 44'	11.2	21.7	61-66
VICTORIA																	
ARARAT P.O.	18.2	**34.6**	**19.2**	31.2	-	-	-	-	**1.3**	-	-	332	37° 17'	142° 57'	15.5	33.3	62-68
ARARAT PRISON	17.9	**34.0**	**19.1**	30.2	-	-	-	-	**-1.0**	-	-	295	37° 17'	142° 59'	15.6	35.0	75-84
BAIRNSDALE COMPOSITE	20.7	**32.1**	**21.5**	28.9	-	-	-	-	**0.8**	-	-	5	37° 50'	147° 39'	12.5	31.3	73-82

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process 24-hour		Critical process 08-1800		Com-fort	Critical 24-hr	Critical 08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
VICTORIA (Continued)																	
BAIRNSDALE P.O.	18.7	**31.5**	**20.5**	30.2	-	-	-	-	**1.3**	-	-	14	37° 49'	147° 37'	12.2	30.2	60-69
BALLAN (FISKVILLE)	20.5	**32.6**	**20.8**	31.3	-	-	-	-	**0.2**	-	-	442	37° 36'	144° 12'	16.4	32.4	57-66
BALLARAT COMPOSITE	17.8	**31.0**	**19.0**	29.2	-	-	-	-	**1.3**	-	-	441	37° 31'	143° 47'	12.3	29.7	69-78
BEECHWORTH COMPOSITE	18.1	**32.1**	**19.4**	27.8	-	-	-	-	**-0.2**	-	-	580	36° 23'	146° 44'	13.9	32.3	68-77
BENALLA *	19.9	**36.9**	**21.5**	34.0	-	-	-	-	**-1.0**	-	-	170	36° 33'	145° 59'	16.5	37.3	75-84
BENDIGO PRISON	19.6	**35.3**	**21.2**	32.6	-	-	-	-	**0.7**	-	-	225	36° 45'	144° 17'	14.5	34.6	75-84
BEULAH P.O.	19.4	**37.2**	**21.1**	33.3	-	-	-	-	**0.6**	-	-	89	35° 57'	142° 25'	17.2	36.6	57-66
BLACKWOOD (ARMSTRONG)	18.1	**31.5**	**19.6**	29.6	-	-	-	-	**-1.9**	-	-	533	37° 28'	144° 19'	14.4	33.4	76-82
BOGONG	17.4	**30.2**	**20.0**	27.3	-	-	-	-	**-1.7**	-	-	732	36° 48'	147° 13'	15.2	31.9	62-67
BONEGILLA	19.7	**35.9**	**22.1**	30.9	-	-	-	-	**0.5**	-	-	198	36° 08'	147° 00'	14.8	35.4	75-84
CAPE NELSON (LIGHTHOUSE)	18.0	**26.6**	**19.3**	24.6	-	-	-	-	**5.7**	-	-	45	38° 26'	141° 33'	6.3	20.7	73-82
CAPE OTWAY (LIGHTHOUSE)	16.8	**26.6**	**19.3**	24.2	-	-	-	-	**6.1**	-	-	82	38° 52'	143° 31'	7.2	20.5	75-84
CAPE SCHANCK (LIGHTHOUSE)	18.7	**28.4**	**20.0**	26.6	-	-	-	-	**6.2**	-	-	79	38° 30'	144° 53'	7.2	22.2	68-77
CASTERTON/MCCALLUM	20.3	**35.7**	**21.1**	33.6	-	-	-	-	**0.1**	-	-	73	37° 36'	141° 25'	15.6	35.6	74-83
CASTLEMAINE PRISON	19.9	**35.3**	**20.7**	32.7	-	-	-	-	**-1.7**	-	-	300	37° 04'	144° 13'	15.7	37.0	75-84
CHARLTON P.O. *	19.6	**37.2**	**20.9**	34.0	-	-	-	-	**0.0**	-	-	116	36° 18'	143° 24'	17.3	37.1	65-69
COLAC	18.6	**33.5**	**20.9**	31.7	-	-	-	-	**-0.2**	-	-	134	38° 20'	143° 36'	17.0	33.7	58-67
COLAC SHIRE OFFICE	20.5	**34.2**	**21.3**	31.7	-	-	-	-	**1.3**	-	-	134	38° 20'	143° 35'	14.4	32.9	73-82
CORRYONG	19.6	**35.2**	**20.9**	32.4	-	-	-	-	**-1.6**	-	-	314	36° 12'	147° 54'	17.1	36.8	75-84
DONALD WATER TRUST	18.1	**35.9**	**20.3**	34.0	-	-	-	-	**0.3**	-	-	118	36° 23'	143° 00'	15.8	35.6	75-84
EAST TARWIN NO.10 (MIRBOO PAST CO)	20.0	**30.7**	**20.8**	29.5	-	-	-	-	**3.6**	-	-	240	38° 31'	146° 12'	11.2	27.1	75-83
ECHUCA (COMPUTER SERVICE)	20.8	**37.2**	**22.3**	35.6	-	-	-	-	**-0.6**	-	-	96	36° 10'	144° 46'	16.1	37.8	75-84
ESSENDON AIRPORT AMO	17.8	**33.9**	**20.3**	29.8	35.5	20.5	37.0	21.0	**2.1**	1.0	2.1	86	37° 44'	144° 54'	13.1	31.8	57-66
EUROA *	19.0	**34.0**	**20.5**	31.6	-	-	-	-	**1.1**	-	-	175	36° 46'	145° 33'	14.8	32.2	69-75
GABO ISLAND (LIGHTHOUSE)	20.4	**23.3**	**20.9**	23.1	-	-	-	-	**7.3**	-	-	15	37° 34'	149° 55'	4.9	16.0	75-84
GEELONG (NORLANE)	19.1	**33.8**	**21.3**	30.1	-	-	-	-	**1.9**	-	-	55	38° 05'	144° 20'	12.0	31.9	76-84
GEELONG SEC	17.6	**32.8**	**20.7**	29.7	-	-	-	-	**2.4**	-	-	17	38° 07'	144° 22'	11.5	30.4	64-69
GELLIBRAND RIVER (FORESTRY) *	20.5	**33.6**	**20.7**	30.4	-	-	-	-	**-0.1**	-	-	75	38° 32'	143° 32'	15.1	32.2	68-77
HAMILTON COMPOSITE	19.1	**32.9**	**20.3**	30.6	-	-	-	-	**0.7**	-	-	209	37° 44'	142° 01'	14.3	32.2	70-79
HORSHAM COMPOSITE	19.1	**36.6**	**20.5**	34.5	-	-	-	-	**-0.6**	-	-	141	36° 39'	142° 06'	16.3	37.2	75-84
KERANG P.O.	20.7	**38.3**	**22.1**	35.2	-	-	-	-	**1.0**	-	-	78	35° 44'	143° 55'	16.0	37.3	75-84
KYABRAM (RESEARCH STATION)	19.7	**36.1**	**22.0**	33.0	-	-	-	-	**-0.8**	-	-	104	36° 20'	145° 04'	16.0	36.9	75-84
KYNETON (POLICE STATION)	18.2	**31.1**	**20.1**	27.5	-	-	-	-	**-0.2**	-	-	519	37° 15'	144° 27'	14.2	31.3	70-75
LAKE EILDON	19.3	**34.6**	**20.7**	31.7	-	-	-	-	**-0.1**	-	-	262	37° 14'	145° 55'	16.0	34.7	75-84

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER Comfort (or non-critical process) CWB	DB	WB	CDB	Critical process 24-hour DB	WB	08-1800 DB	WB	WINTER Comfort DB	Critical 24-hr DB	08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
VICTORIA (Continued)																	
LAKES ENTRANCE (PINE HILL)	19.3	**29.0**	**20.8**	27.1	-	-	-	-	**3.4**	-	-	73	37° 52'	148° 00'	9.9	25.6	75-84
LAVERTON AERO AMO	19.1	**34.6**	**20.6**	32.3	36.5	21.5	38.5	21.5	**1.1**	0.0	1.1	16	37° 52'	144° 45'	11.9	33.5	75-84
LEMNOS	20.8	**36.4**	**22.0**	33.4	-	-	-	-	**−0.3**	-	-	113	36° 22'	145° 28'	15.5	36.7	75-84
LISMORE P.O.	19.3	**33.5**	**20.5**	31.8	-	-	-	-	**2.0**	-	-	160	37° 58'	143° 21'	14.3	31.5	73-82
LORNE	18.7	**27.4**	**20.3**	25.4	-	-	-	-	**5.9**	-	-	4	38° 32'	143° 59'	9.6	21.5	75-84
MACEDON FORESTRY	17.9	**30.1**	**19.4**	27.8	-	-	-	-	**0.0**	-	-	503	37° 25'	144° 33'	13.3	30.1	70-77
MANGALORE COMPOSITE *	18.8	**33.6**	**20.5**	31.8	-	-	-	-	**0.1**	-	-	142	36° 53'	145° 11'	14.9	33.2	71-78
MARYBOROUGH	19.9	**35.4**	**20.7**	32.7	-	-	-	-	**0.9**	-	-	249	37° 03'	143° 44'	15.3	34.3	75-84
MELBOURNE AIRPORT	19.3	**34.6**	**20.4**	32.9	36.0	21.0	38.0	21.5	**2.4**	1.0	2.4	132	37° 41'	144° 51'	12.9	32.2	75-84
MELBOURNE R.O.	19.4	**34.3**	**20.5**	32.3	36.0	21.0	37.5	21.5	**3.5**	2.5	3.5	112	37° 49'	144° 58'	10.5	30.8	75-84
MILDURA AIRPORT AMO	19.7	**39.5**	**21.4**	35.5	40.0	22.0	41.5	22.5	**0.8**	0.5	0.8	51	34° 14'	142° 05'	15.6	38.7	75-84
MOUNT BEAUTY	18.9	**33.7**	**20.7**	30.5	-	-	-	-	**0.1**	-	-	366	36° 45'	147° 10'	16.0	33.6	74-83
MOUNT DANDENONG GTV9	18.3	**29.5**	**19.4**	27.9	-	-	-	-	**1.4**	-	-	632	37° 50'	145° 21'	10.9	28.1	68-77
MOUNT HOTHAM *	13.4	**22.1**	**14.6**	20.8	-	-	-	-	**−5.7**	-	-	1750	36° 59'	147° 09'	9.8	27.8	78-82
NHILL COMPOSITE	18.6	**37.5**	**19.9**	33.2	-	-	-	-	**−0.4**	-	-	129	36° 21'	141° 39'	16.9	37.9	75-84
OLSENS BRIDGE	21.0	**31.8**	**21.5**	28.7	-	-	-	-	**−1.2**	-	-	183	38° 29'	146° 19'	13.0	32.5	75-84
OMEO	18.0	**32.0**	**18.9**	29.1	-	-	-	-	**−2.8**	-	-	677	37° 06'	147° 36'	15.7	34.8	74-83
ORBOST	21.0	**33.0**	**22.5**	30.1	-	-	-	-	**2.2**	-	-	41	37° 42'	148° 27'	12.1	30.4	75-84
OUYEN P.O.	20.4	**38.7**	**21.8**	35.6	-	-	-	-	**1.6**	-	-	50	35° 04'	142° 19'	16.5	37.1	73-81
POINT HICKS (LIGHTHOUSE)	20.5	**26.4**	**21.7**	25.0	-	-	-	-	**6.5**	-	-	24	37° 48'	149° 16'	7.4	19.9	75-84
POINT LONSDALE (LIGHTHOUSE)	19.8	**30.1**	**20.7**	29.2	-	-	-	-	**3.6**	-	-	12	38° 18'	144° 37'	8.1	26.4	73-82
PORTSEA *	19.9	**27.9**	**21.8**	27.0	-	-	-	-	**4.6**	-	-	6	38° 19'	144° 40'	9.1	22.9	69-76
POWELLTOWN *	20.0	**33.0**	**21.4**	30.3	-	-	-	-	**0.5**	-	-	189	37° 52'	145° 45'	13.8	32.1	68-77
QUEENSCLIFF *	20.5	**27.3**	**23.2**	26.6	-	-	-	-	**4.3**	-	-	-	38° 16'	144° 40'	9.4	22.4	58-67
RUBICON SEC	16.9	**29.7**	**18.8**	26.7	-	-	-	-	**0.3**	-	-	838	37° 18'	145° 49'	11.0	29.4	74-83
SALE EAST AMO	19.7	**32.7**	**21.1**	29.8	34.5	21.5	36.5	22.0	**−0.4**	−1.5	−0.4	5	38° 06'	147° 09'	13.1	33.1	75-84
SERVICETON	20.7	**36.2**	**22.2**	33.1	-	-	-	-	**0.9**	-	-	118	36° 22'	140° 59'	17.3	35.3	57-66
SPRING CREEK (BASIN TWO)	18.7	**34.4**	**20.2**	30.6	-	-	-	-	**−0.9**	-	-	360	37° 06'	145° 42'	16.4	35.3	74-83
ST ARNAUD FORESTRY	19.9	**36.2**	**21.1**	32.7	-	-	-	-	**0.3**	-	-	239	36° 37'	143° 16'	15.7	35.9	73-82
STAWELL COMPOSITE	18.7	**35.2**	**20.3**	33.0	-	-	-	-	**1.1**	-	-	203	37° 04'	142° 48'	15.0	34.1	75-84
STONY POINT	20.2	**29.2**	**21.5**	30.1	-	-	-	-	**5.3**	-	-	2	38° 23'	145° 13'	8.1	23.9	73-81
STRATHBOGIE	17.8	**33.2**	**20.0**	30.4	-	-	-	-	**−3.4**	-	-	506	36° 52'	145° 44'	16.2	36.6	75-84
SWAN HILL P.O.	19.7	**38.6**	**21.3**	34.5	-	-	-	-	**1.1**	-	-	70	35° 21'	143° 33'	16.4	37.5	75-84
TATURA (IRRIGATION RESEARCH INST.)	20.1	**35.5**	**21.3**	33.1	-	-	-	-	**−0.1**	-	-	114	36° 26'	145° 16'	15.1	35.6	75-84

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	DB	WB	CDB	Critical process 24-hour DB	WB	08-1800 DB	WB	WINTER: Comfort DB	Critical 24-hr DB	08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
VICTORIA (Continued)																	
WANALTA (DAEN STATION)	20.2	**37.7**	**21.8**	35.0	-	-	-	-	**-0.6**	-	-	114	36° 37'	144° 52'	16.6	38.3	75-83
WANGARATTA COMPOSITE	19.8	**35.7**	**22.0**	32.6	-	-	-	-	**-0.6**	-	-	150	36° 22'	146° 18'	16.1	36.3	58-67
WARRACKNABEAL	20.2	**37.9**	**21.4**	35.8	-	-	-	-	**0.4**	-	-	113	36° 16'	142° 24'	16.7	37.5	74-83
WARRAGUL P.O.	19.7	**33.5**	**20.8**	31.9	-	-	-	-	**0.4**	-	-	116	38° 10'	145° 56'	13.5	33.1	65-74
WARRAMBINE (BASIN NO. 3)	19.6	**32.4**	**20.2**	30.1	-	-	-	-	**1.5**	-	-	311	37° 50'	143° 53'	14.9	30.9	74-80
WARRNAMBOOL P.O.	19.3	**30.3**	**20.0**	27.7	-	-	-	-	**3.3**	-	-	21	38° 24'	142° 29'	10.0	27.0	73-82
WILSONS PROM (LIGHTHOUSE)	18.0	**23.6**	**19.0**	23.0	-	-	-	-	**7.1**	-	-	89	39° 08'	146° 25'	6.0	16.5	75-84
WODONGA	19.8	**36.5**	**21.6**	34.5	-	-	-	-	**0.1**	-	-	152	36° 07'	146° 54'	16.2	36.4	58-67
WON WRON *	21.0	**32.6**	**22.0**	30.8	-	-	-	-	**4.1**	-	-	83	38° 29'	146° 40'	11.2	27.8	68-74
WONTHAGGI (MERRIM CRESCENT)	21.4	**31.1**	**21.5**	28.2	-	-	-	-	**1.9**	-	-	39	38° 36'	145° 36'	11.4	29.2	74-83
WOODS POINT	18.5	**31.4**	**20.8**	28.2	-	-	-	-	**-4.8**	-	-	685	37° 35'	146° 15'	19.5	36.2	59-68
YALLOURN	19.5	**32.7**	**20.4**	31.5	-	-	-	-	**1.6**	-	-	54	38° 11'	146° 20'	12.1	31.1	75-84
WESTERN AUSTRALIA																	
ALBANY (ECLIPSE ISLAND)	19.0	**23.6**	**19.9**	23.1	29.0	22.0	31.0	22.5	**8.2**	5.5	7.5	103	35° 11'	117° 53'	6.6	15.4	60-69
ALBANY AMO	19.2	**28.5**	**20.3**	27.1	32.0	21.0	33.5	21.5	**6.1**	4.0	6.1	71	34° 57'	117° 48'	11.7	22.4	79-88
AUGUSTA (CAPE LEEUWIN)	20.0	**24.9**	**21.5**	23.9	-	-	-	-	**9.7**	-	-	22	34° 22'	115° 08'	6.4	15.2	78-87
BENCUBBIN	18.8	**38.9**	**21.1**	35.0	-	-	-	-	**4.1**	-	-	350	30° 49'	117° 52'	16.0	34.8	78-87
BEVERLEY P.O. *	20.7	**39.1**	**22.9**	35.1	-	-	-	-	**2.8**	-	-	199	32° 07'	116° 55'	17.3	35.8	71-80
BRIDGETOWN P.O.	21.4	**35.3**	**21.9**	33.2	-	-	-	-	**2.0**	-	-	150	33° 58'	116° 08'	17.1	33.3	78-87
BROOME AMO	22.1	**37.4**	**28.5**	32.9	38.5	28.5	39.5	28.5	**15.4**	9.0	15.4	17	17° 57'	122° 15'	6.8	22.0	79-88
BROOME (LA GRANGE MISSION)	23.2	**37.8**	**29.1**	33.5	-	-	-	-	**15.0**	-	-	11	18° 41'	121° 48'	8.4	22.8	79-88
BROOME (CAPE LEVEQUE)	26.6	**33.7**	**28.8**	31.9	-	-	-	-	**19.8**	-	-	25	16° 24'	122° 56'	5.6	13.9	74-82
BULLSBROOK (PEARCE AMO) *	21.6	**37.7**	**25.8**	36.2	-	-	-	-	**7.3**	-	-	40	31° 40'	116° 01'	14.8	30.4	41-45
BUNBURY P.O. *	20.5	**29.7**	**22.0**	27.5	-	-	-	-	**6.5**	-	-	4	33° 20'	115° 38'	11.7	23.2	72-81
BUSSELTON (CAPE NATURALISTE)	19.9	**30.2**	**21.6**	26.6	-	-	-	-	**8.6**	-	-	97	33° 32'	115° 01'	10.4	21.6	78-87
BUSSELTON P.O.	20.5	**32.9**	**22.0**	30.7	-	-	-	-	**5.3**	-	-	4	33° 39'	115° 20'	14.0	27.6	65-74
CARNARVON AMO	23.1	**35.0**	**25.6**	33.0	38.0	26.5	40.0	26.5	**9.4**	7.5	9.4	4	24° 53'	113° 40'	9.3	25.6	79-88
COLLIE P.O	20.4	**36.3**	**21.3**	34.2	-	-	-	-	**1.5**	-	-	190	33° 22'	116° 09'	17.0	34.8	64-73
CORRIGIN P.O.	18.8	**37.3**	**20.9**	34.8	-	-	-	-	**3.1**	-	-	295	32° 20'	117° 52'	16.7	34.2	78-87
CUE P.O.	20.3	**41.0**	**22.3**	36.9	-	-	-	-	**6.6**	-	-	453	27° 26'	117° 54'	14.7	34.4	75-84
CUNDERDIN P.O.	20.7	**39.3**	**22.2**	35.3	-	-	-	-	**4.7**	-	-	221	31° 39'	117° 14'	16.7	34.6	78-87
DALWALLINU P.O.	20.5	**39.9**	**22.5**	36.1	-	-	-	-	**5.7**	-	-	335	30° 17'	116° 40'	16.7	34.1	73-82
DERBY P.O.	23.5	**38.8**	**28.1**	35.2	40.0	28.5	41.0	28.5	**16.1**	10.5	16.1	12	17° 18'	123° 38'	9.4	22.7	64-68

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process 24-hour		Critical process 08-1800		Com-fort	Critical 24-hr	Critical 08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
WESTERN AUSTRALIA (Continued)																	
DERBY (KOOLAN ISLAND)	24.2	**34.2**	**27.7**	31.7	-	-	-	-	**20.2**	-	-	144	16° 08'	123° 47'	6.4	14.0	83-87
DERBY (COCKATOO ISLAND)	25.5	**33.7**	**27.7**	31.8	-	-	-	-	**21.3**	-	-	13	16° 05'	123° 36'	5.2	12.4	65-70
DONNYBROOK P.O.	21.2	**36.2**	**22.3**	33.6	-	-	-	-	**3.6**	-	-	63	33° 34'	115° 49'	16.5	32.6	75-84
DWELLINGUP FORESTRY	19.6	**35.4**	**21.2**	32.6	-	-	-	-	**3.0**	-	-	267	32° 43'	116° 03'	15.7	32.4	72-81
ENEABBA P.O.	20.2	**40.5**	**23.1**	36.1	-	-	-	-	**7.8**	-	-	100	29° 49'	115° 16'	16.8	32.7	74-81
ESPERANCE P.O.	18.6	**29.4**	**21.6**	30.0	-	-	-	-	**6.5**	-	-	4	33° 51'	121° 53'	9.3	22.9	57-66
ESPERANCE M.O.	19.2	**32.8**	**20.8**	29.9	36.0	21.5	38.0	22.0	**7.3**	5.0	7.3	25	33° 50'	121° 54'	10.7	25.5	79-88
EUCLA *	17.1	**33.7**	**20.8**	27.4	-	-	-	-	**8.3**	-	-	96	31° 41'	128° 53'	8.9	24.8	71-80
FITZROY CROSSING *	23.1	**42.0**	**26.9**	35.0	-	-	-	-	**15.1**	-	-	114	18° 12'	125° 34'	12.6	26.9	73-81
FORREST AMO	18.8	**39.8**	**21.0**	35.0	41.5	22.0	43.0	22.5	**6.3**	1.0	6.3	156	30° 50'	128° 07'	17.5	33.5	79-88
GERALDTON AMO	20.2	**38.4**	**22.7**	33.6	40.0	23.5	41.0	24.0	**7.4**	5.0	7.4	38	28° 48'	114° 42'	14.2	31.0	79-88
GILES MO	18.5	**40.1**	**22.7**	32.7	41.0	23.5	41.5	23.5	**5.0**	3.5	4.5	580	25° 02'	128° 18'	13.7	35.1	79-88
GOLDSWORTHY	21.8	**43.5**	**26.9**	37.7	-	-	-	-	**15.6**	-	-	45	20° 21'	119° 31'	13.0	27.9	79-88
HALLS CREEK AMO	20.0	**41.0**	**24.5**	33.0	-	-	-	-	**13.9**	-	-	410	18° 14'	127° 40'	12.1	27.1	79-88
HALLS CREEK (TURKEY CREEK) *	21.6	**41.6**	**25.8**	34.4	-	-	-	-	**15.5**	-	-	203	17° 01'	128° 13'	12.4	25.9	76-85
HAMELIN POOL	22.7	**40.4**	**27.1**	36.2	-	-	-	-	**8.8**	-	-	3	26° 25'	114° 11'	16.7	31.6	70-79
HYDEN COMPOSITE *	19.8	**38.9**	**21.4**	33.6	-	-	-	-	**3.3**	-	-	299	32° 29'	118° 54'	18.3	35.4	75-84
JARRAHWOOD	20.4	**34.1**	**21.5**	31.8	-	-	-	-	**3.3**	-	-	130	33° 48'	115° 40'	16.2	30.8	76-81
JURIEN	20.3	**33.1**	**23.4**	29.2	-	-	-	-	**7.1**	-	-	3	30° 18'	115° 02'	12.9	26.0	78-87
KALBARRI P.O.	21.1	**37.7**	**24.5**	32.6	-	-	-	-	**8.6**	-	-	6	27° 43'	114° 10'	14.0	29.1	76-85
KALGOORLIE AMO	18.5	**39.3**	**20.4**	33.9	40.0	21.5	41.0	22.0	**4.1**	0.5	4.1	360	30° 47'	121° 28'	15.6	35.2	79-88
KALUMBURU (MITCHELL PLATEAU)	22.5	**36.9**	**26.7**	33.4	-	-	-	-	**15.8**	-	-	268	14° 49'	125° 50'	9.6	21.1	76-85
KALUMBURU *	25.2	**37.9**	**28.2**	34.9	-	-	-	-	**14.9**	-	-	23	14° 18'	126° 39'	9.7	23.0	76-85
KARRATHA (DAMPIER SALT)	22.3	**38.9**	**27.6**	34.2	-	-	-	-	**15.0**	-	-	11	20° 43'	116° 45'	9.3	23.9	70-76
KATANNING P.O.	18.5	**35.1**	**21.4**	32.9	-	-	-	-	**3.9**	-	-	310	33° 41'	117° 33'	16.3	31.2	78-87
KELLERBERRIN COMP. *	20.2	**39.4**	**21.9**	35.1	-	-	-	-	**3.4**	-	-	247	31° 38'	117° 43'	16.6	35.6	69-78
KUNUNURRA P.O.	23.0	**40.3**	**27.3**	35.2	-	-	-	-	**18.1**	-	-	47	15° 47'	128° 44'	11.1	22.2	75-84
KURI BAY	24.9	**35.1**	**27.6**	32.6	-	-	-	-	**20.2**	-	-	28	15° 29'	124° 31'	7.0	14.7	73-82
LAKE GRACE P.O.	19.5	**36.9**	**20.9**	34.5	-	-	-	-	**4.6**	-	-	286	33° 06'	118° 28'	16.1	32.3	78-87
LANCELIN	21.5	**32.5**	**23.6**	29.1	-	-	-	-	**7.3**	-	-	4	31° 01'	115° 20'	12.2	25.2	77-86
LAVERTON (YAMARNA)	19.1	**40.2**	**21.6**	35.8	-	-	-	-	**5.5**	-	-	436	28° 09'	123° 41'	15.2	34.7	78-87
LAVERTON P.O.	20.0	**40.1**	**22.1**	36.0	-	-	-	-	**6.0**	-	-	461	28° 38'	122° 24'	15.2	34.0	59-68
LEARMONTH AMO	21.2	**41.9**	**25.9**	33.9	-	-	-	-	**11.3**	-	-	5	22° 14'	114° 05'	15.1	30.6	79-88
LEONORA P.O.	19.1	**41.3**	**21.7**	36.1	-	-	-	-	**4.3**	-	-	376	28° 53'	121° 19'	14.8	37.0	76-85

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER								WINTER			Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	Comfort (or non-critical process)				Critical process 24-hour		Critical process 08-1800		Com-fort	Critical 24-hr	Critical 08-18						
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
							WESTERN AUSTRALIA (Continued)										
MANDORA	22.9	**39.6**	**29.1**	35.1	-	-	-	-	**15.0**	-	-	7	19° 45'	120° 51'	10.1	24.6	73-81
MANDURAH PARK	21.7	**35.4**	**23.1**	31.9	-	-	-	-	**7.3**	-	-	15	32° 30'	115° 46'	12.3	28.1	76-85
MANJIMUP P.O.	19.7	**32.9**	**21.3**	30.4	-	-	-	-	**5.3**	-	-	280	34° 15'	116° 09'	13.8	27.6	76-85
MARBLE BAR *	21.9	**44.6**	**25.8**	36.9	-	-	-	-	**13.4**	-	-	189	21° 11'	119° 45'	13.7	31.1	78-87
MARDIE	23.4	**41.0**	**27.6**	35.8	-	-	-	-	**12.6**	-	-	11	21° 11'	115° 59'	13.4	28.4	77-86
MEEKATHARRA AMO	18.7	**41.0**	**21.7**	36.1	41.0	23.0	42.0	23.0	**6.4**	4.5	6.4	522	26° 37'	118° 33'	14.0	34.6	79-88
MEEKATHARRA P.O. *	19.3	**41.3**	**24.8**	34.2	-	-	-	-	**7.2**	-	-	511	26° 36'	118° 29'	14.3	33.6	44-49
MENZIES (DIEMALS)	19.3	**40.7**	**21.6**	37.0	-	-	-	-	**3.4**	-	-	434	29° 40'	119° 18'	16.2	37.3	75-84
MENZIES P.O. *	19.8	**40.3**	**21.6**	35.2	-	-	-	-	**4.7**	-	-	426	29° 41'	121° 02'	15.5	35.6	73-82
MERREDIN SHIRE COUNCIL	20.5	**39.1**	**22.0**	36.4	-	-	-	-	**4.5**	-	-	315	31° 29'	118° 17'	15.9	34.6	76-85
MOUNT MAGNET P.O.	21.5	**42.1**	**23.5**	36.9	-	-	-	-	**5.9**	-	-	426	28° 04'	117° 51'	15.7	36.2	57-64
MT BARKER COMPOSITE	19.8	**33.4**	**21.5**	30.4	-	-	-	-	**5.2**	-	-	280	34° 38'	117° 39'	13.3	28.2	58-67
MULLEWA *	20.6	**40.5**	**23.0**	35.3	-	-	-	-	**6.5**	-	-	282	28° 32'	115° 30'	16.6	33.7	65-74
NAREMBEEN P.O. *	20.0	**38.1**	**22.1**	34.9	-	-	-	-	**3.1**	-	-	276	32° 04'	118° 24'	17.3	34.2	67-75
NEWMAN (MUNDIWINDI) *	19.3	**40.4**	**22.9**	34.6	-	-	-	-	**7.6**	-	-	571	23° 48'	120° 15'	14.3	32.5	68-77
NEWMAN P.O. *	19.5	**41.2**	**23.1**	35.1	-	-	-	-	**8.1**	-	-	544	23° 22'	119° 44'	13.8	33.1	78-87
NORSEMAN P.O.	20.2	**37.7**	**21.6**	34.7	-	-	-	-	**4.3**	-	-	277	32° 12'	121° 47'	16.0	33.4	76-85
NORTHAM (MURESK AGRIC. COLLEGE)	21.2	**38.8**	**25.8**	32.9	-	-	-	-	**2.6**	-	-	166	31° 45'	116° 41'	17.3	36.2	58-67
NORTHAM COMPOSITE *	21.5	**39.6**	**22.0**	36.4	-	-	-	-	**3.8**	-	-	150	31° 39'	116° 40'	16.9	35.8	72-81
NYANG STATION *	22.0	**43.8**	**25.4**	37.7	-	-	-	-	**10.5**	-	-	111	23° 02'	115° 02'	16.9	33.3	77-86
ONGERUP	18.9	**35.3**	**20.4**	32.4	-	-	-	-	**4.4**	-	-	286	33° 58'	118° 29'	14.9	30.9	76-85
ONSLOW AMO	22.3	**40.4**	**27.6**	33.8	41.5	28.0	43.0	28.5	**12.5**	10.0	12.5	3	21° 40'	115° 07'	11.9	27.9	65-74
ONSLOW P.O. *	24.8	**37.9**	**28.7**	34.1	40.0	29.0	41.5	29.5	**12.1**	9.5	12.2	4	21° 38'	115° 07'	10.4	25.4	78-87
PEMBERTON FORESTRY	20.1	**32.6**	**21.3**	30.3	-	-	-	-	**5.3**	-	-	174	34° 27'	116° 03'	13.0	27.3	75-84
PERTH AIRPORT MO (BELMONT)	19.4	**37.4**	**21.9**	33.6	38.5	22.5	40.0	23.0	**5.9**	3.5	5.9	20	31° 56'	115° 58'	15.0	31.5	79-88
PERTH REGIONAL OFFICE	20.1	**36.6**	**22.4**	31.8	38.5	22.5	40.0	23.0	**7.4**	3.5	6.5	19	31° 57'	115° 52'	11.4	29.2	79-88
PINGELLY P.O.	19.5	**37.4**	**20.8**	34.4	-	-	-	-	**4.5**	-	-	297	32° 32'	117° 05'	15.9	32.9	76-85
PORT HEDLAND (REDMONT) *	20.2	**43.0**	**24.0**	36.0	-	-	-	-	**11.1**	-	-	387	22° 00'	119° 01'	14.7	31.7	77-86
PORT HEDLAND AMO	22.0	**39.5**	**28.0**	35.0	41.0	28.5	42.5	28.5	**14.4**	9.0	14.4	9	20° 22'	118° 37'	10.5	25.1	79-88
RAVENSTHORPE P.O.	17.9	**34.5**	**19.2**	32.2	-	-	-	-	**5.6**	-	-	232	33° 35'	120° 03'	14.7	28.9	62-67
RAWLINNA P.O. *	19.4	**40.4**	**21.6**	34.6	-	-	-	-	**6.4**	-	-	182	31° 01'	125° 19'	16.7	33.3	67-76
ROEBOURNE P.O.	22.6	**42.6**	**27.8**	36.8	-	-	-	-	**15.2**	-	-	12	20° 46'	117° 08'	12.5	27.4	75-84
ROTTNEST	21.2	**30.5**	**21.6**	26.8	-	-	-	-	**10.1**	-	-	46	32° 00'	115° 30'	7.4	20.3	79-88
SANDSTONE (CASHMERE DOWNS)	19.2	**40.5**	**21.5**	36.4	-	-	-	-	**4.9**	-	-	500	28° 58'	119° 34'	14.8	35.6	77-86

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process)				SUMMER: Critical process 24-hour		SUMMER: Critical process 08-1800		WINTER: Comfort	WINTER: Critical 24-hr	WINTER: Critical 08-18	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
	CWB	**DB**	**WB**	CDB	DB	WB	DB	WB	**DB**	DB	DB						
					WESTERN AUSTRALIA (Continued)												
SANDSTONE (YEELIRRIE)	19.8	**41.3**	**22.0**	35.8	-	-	-	-	**3.9**	-	-	487	27° 17'	120° 06'	14.9	37.4	75-84
SERPENTINE (KARNET)	19.5	**34.4**	**22.3**	31.2	-	-	-	-	**4.0**	-	-	286	32° 26'	116° 04'	14.9	30.4	65-71
SHARK BAY (NANGA)	23.9	**36.8**	**26.1**	33.2	-	-	-	-	**9.7**	-	-	20	26° 15'	113° 48'	10.9	27.1	81-87
SOUTHERN CROSS P.O.	18.6	**38.5**	**20.9**	34.6	-	-	-	-	**3.2**	-	-	355	31° 14'	119° 19'	16.4	35.3	78-87
THREE RIVERS	19.8	**42.3**	**22.1**	36.3	-	-	-	-	**6.0**	-	-	520	25° 07'	119° 09'	15.8	36.3	70-79
TROUGHTON ISLAND	27.7	**33.0**	**28.5**	32.1	-	-	-	-	**21.8**	-	-	6	13° 46'	126° 09'	5.2	11.2	58-67
WAGIN P.O. *	19.8	**35.2**	**21.5**	34.0	-	-	-	-	**3.6**	-	-	256	33° 18'	117° 20'	16.2	31.6	76-85
WANDERING SHIRE	19.8	**38.1**	**20.9**	34.8	-	-	-	-	**2.1**	-	-	335	32° 41'	116° 40'	17.6	36.0	76-85
WILUNA P.O. *	19.4	**40.6**	**23.0**	35.2	-	-	-	-	**5.7**	-	-	521	26° 35'	120° 13'	13.9	34.9	73-81
WITTENOOM P.O.	19.8	**42.6**	**23.7**	35.2	-	-	-	-	**11.0**	-	-	460	22° 14'	118° 20'	13.4	31.6	79-88
WONGAN HILLS P.O.	20.2	**40.1**	**21.6**	36.8	-	-	-	-	**5.2**	-	-	283	30° 54'	116° 43'	16.1	34.9	76-85
WYNDHAM P.O.	23.7	**41.8**	**27.5**	36.2	-	-	-	-	**18.8**	-	-	15	15° 29'	128° 07'	10.7	23.0	77-86
WYNDHAM P.O. OLD SITE	24.1	**41.0**	**29.0**	38.0	-	-	-	-	**19.8**	-	-	-	15° 27'	128° 07'	10.2	21.2	57-64
YALGOO P.O.	19.5	**41.2**	**22.7**	36.3	-	-	-	-	**4.9**	-	-	318	28° 21'	116° 41'	16.6	36.3	58-67
YALGOO (MURGOO)	20.3	**42.2**	**22.6**	37.3	-	-	-	-	**6.4**	-	-	335	27° 22'	116° 25'	15.3	35.7	75-84
YORK	21.5	**39.3**	**22.3**	37.9	-	-	-	-	**3.5**	-	-	174	31° 53'	116° 45'	17.9	35.7	75-84
					NEW ZEALAND												
AUCKLAND	-	**27.0**	**21.1**	-	-	-	-	-	**4.1**	-	-	49	36° 51'	174° 46'	7.0	22.9	70-74
CHRISTCHURCH	-	**27.7**	**17.8**	-	-	-	-	-	**-0.8**	-	-	7	43° 32'	172° 37'	9.3	28.5	69-73
INVERCARGILL	-	**24.3**	**18.2**	-	-	-	-	-	**-2.0**	-	-	0	46° 25'	168° 20'	8.6	26.3	70-74
WELLINGTON	-	**24.0**	**19.3**	-	-	-	-	-	**3.2**	-	-	126	42° 17'	174° 46'	7.0	20.8	70-74
					PAPUA NEW GUINEA												
AITAPE (2) SDHQ	26.9	**31.3**	**29.3**	30.2	-	-	-	-	**22.2**	-	-	2	3° 08'	142° 21'	6.3	9.1	57-64
AIYURA (MC3) *	17.9	**25.4**	**20.4**	23.2	-	-	-	-	**12.6**	-	-	1569	6° 19'	145° 55'	10.7	12.4	65-72
ANGORAM SDHQ (MB28) *	26.4	**34.3**	**28.2**	32.0	-	-	-	-	**21.7**	-	-	15	4° 04'	144° 04'	9.7	12.6	59-63
BALIMO SDHQ *	25.7	**33.9**	**27.6**	32.0	-	-	-	-	**20.8**	-	-	9	8° 01'	142° 57'	9.2	12.8	62-69
BEREINA AGRIC. STATION	25.6	**32.3**	**27.6**	30.8	-	-	-	-	**21.0**	-	-	15	8° 39'	146° 30'	10.5	11.3	57-65
BUIN (COASTAL SITE KANGU)	26.1	**31.6**	**28.8**	29.6	-	-	-	-	**22.9**	-	-	61	6° 50'	155° 44'	8.7	8.7	58-67
BULOLO (FORESTRY SCHOOL) *	21.7	**32.4**	**23.6**	29.9	-	-	-	-	**17.8**	-	-	745	7° 12'	146° 37'	12.0	14.6	66-70
BWAGAOIA	26.1	**31.0**	**26.8**	30.3	-	-	-	-	**23.2**	-	-	7	10° 42'	152° 50'	7.5	7.8	57-65
DOGURA	25.4	**32.3**	**27.0**	31.3	-	-	-	-	**23.4**	-	-	64	10° 06'	150° 05'	7.2	8.9	62-71

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process) CWB	Comfort DB	Comfort WB	CDB	Critical process 24-hour DB	24-hour WB	08-1800 DB	08-1800 WB	WINTER: Comfort DB	Critical 24-hr DB	Critical 08-18 DB	Elev. above sea level (m)	Lat. South	Long. East	Daily range (K)	Yearly range (K)	Years of data
PAPUA NEW GUINEA (Continued)																	
ERAVE P.P. MD52 COMP. *	21.9	**27.1**	**24.4**	25.9	-	-	-	-	**13.8**	-	-	1091	6° 39'	143° 57'	13.8	13.0	64-72
GARAINA (TEA PROJECT)(MGI)	23.5	**31.2**	**24.7**	29.4	-	-	-	-	**16.4**	-	-	716	7° 53'	147° 08'	11.2	14.8	60-69
GOROKA AERADIO A/F	17.6	**27.9**	**19.6**	26.1	-	-	-	-	**12.9**	-	-	1566	6° 04'	145° 23'	10.5	15.0	64-73
KAGAMUGA (MT.HAGEN A/F)	17.4	**26.8**	**19.7**	24.5	-	-	-	-	**11.8**	-	-	1630	5° 50'	144° 16'	10.6	15.0	68-73
KAIAPIT SDHQ (ME13)	23.8	**33.9**	**26.5**	31.4	-	-	-	-	**20.3**	-	-	301	6° 16'	146° 16'	10.7	13.6	62-66
KAINANTU A/F SDHQ (MC1)	18.9	**26.5**	**21.3**	24.3	-	-	-	-	**13.0**	-	-	1579	6° 17'	145° 52'	11.2	13.5	62-67
KUNDIAWA	18.7	**28.5**	**23.0**	25.4	-	-	-	-	**12.7**	-	-	1493	6° 01'	144° 58'	11.0	15.8	65-72
LAE A/F (ME1)	25.7	**31.9**	**26.9**	30.8	32.5	26.5	33.0	27.0	**21.8**	21.0	21.8	7	6° 44'	147° 00'	6.9	10.1	64-73
LAKE KUTUBU *	22.9	**29.9**	**26.6**	26.9	-	-	-	-	**17.2**	-	-	807	6° 25'	143° 20'	10.8	12.7	59-66
LUMI A/S SDHQ	23.8	**29.3**	**27.9**	27.9	-	-	-	-	**20.0**	-	-	533	3° 29'	142° 02'	7.3	9.3	57-65
MADANG A/F	26.0	**31.0**	**26.8**	29.7	-	-	-	-	**23.1**	-	-	4	5° 13'	145° 47'	6.8	7.9	64-73
MENDI DHQ (M026(CP)) *	18.7	**24.6**	**22.5**	23.6	-	-	-	-	**11.8**	-	-	1676	6° 09'	143° 39'	10.9	12.6	63-72
MOMOTE	25.6	**30.9**	**26.8**	30.2	-	-	-	-	**23.9**	-	-	3	2° 03'	147° 26'	5.9	7.0	64-73
POPONDETTA (HIGH SCHOOL)	25.9	**32.9**	**26.9**	31.6	-	-	-	-	**22.1**	-	-	90	8° 45'	148° 15'	9.7	10.8	62-69
PORT MORESBY (JACKSON A/F) (MF16)	25.4	**32.9**	**27.3**	31.7	33.0	27.0	33.5	27.0	**21.2**	18.0	21.2	35	9° 27'	147° 12'	8.7	11.7	64-73
PUT NONU PLANTATION.	25.9	**31.9**	**26.8**	29.7	-	-	-	-	**23.5**	-	-	27	3° 29'	153° 12'	5.5	8.4	63-68
RABAUL (2) A/F	25.4	**31.9**	**27.5**	30.5	32.0	27.5	32.5	27.5	**24.0**	21.0	23.0	4	4° 13'	152° 12'	6.9	7.9	64-73
SALAMO MISSION	25.9	**31.8**	**27.4**	30.3	-	-	-	-	**22.0**	-	-	9	9° 40'	150° 47'	8.5	9.8	63-72
SOHANO	26.2	**31.9**	**27.2**	30.7	-	-	-	-	**23.9**	-	-	-	5° 27'	154° 40'	6.6	8.0	57-66
TARI (1) SDHQ	18.1	**24.9**	**20.2**	22.9	-	-	-	-	**11.3**	-	-	1634	5° 52'	142° 55'	11.6	13.6	61-69
WABAG (SUB DISTRICT OFFICE)	16.0	**23.6**	**20.9**	21.5	-	-	-	-	**11.2**	-	-	1981	5° 29'	143° 43'	11.4	12.4	57-64
WAU HOMESTEAD	21.1	**30.7**	**22.7**	28.5	-	-	-	-	**16.1**	-	-	1127	7° 20'	146° 43'	11.7	14.6	60-69
WEWAK A/F *	25.9	**31.9**	**27.2**	30.6	-	-	-	-	**23.2**	-	-	4	3° 35'	143° 40'	7.4	8.6	63-72
SOLOMON ISLANDS																	
AUKI	26.4	**31.8**	**27.6**	30.6	-	-	-	-	**22.4**	-	-	11	8° 47'	160° 44'	7.0	9.4	77-86
HONIARA	25.5	**32.0**	**27.2**	30.7	32.0	27.0	32.5	27.0	**21.3**	20.0	21.3	7	9° 25'	160° 03'	7.6	10.7	77-86
HONIARA (VAVAYA RIDGE)	25.8	**31.9**	**26.9**	30.9	32.0	27.0	32.0	27.0	**21.6**	21.0	21.6	55	9° 25'	159° 58'	7.5	10.3	64-73
MUNDA (NEW GEORGIA)	26.2	**31.8**	**27.5**	30.7	-	-	-	-	**23.2**	-	-	2	8° 20'	157° 16'	6.6	8.6	77-86
TARO IS. (CHOISEUL)	26.7	**31.8**	**27.7**	30.5	-	-	-	-	**23.5**	-	-	1	6° 24'	156° 24'	6.2	8.3	77-86
VANUATU																	
ANEITYUM AERODROME	25.7	**30.6**	**26.6**	29.5	31.0	26.5	31.0	27.0	**17.6**	14.5	17.5	8	20° 12'	169° 47'	7.5	13.0	57-66

TABLE 1A - OUTSIDE DESIGN CONDITIONS - SUMMER AND WINTER (Continued)

LOCATION	SUMMER: Comfort (or non-critical process)				SUMMER: Critical 24-hour		SUMMER: Critical process 08-1800		WINTER: Comfort	WINTER: Critical 24-hr	WINTER: Critical 08-18	Elev. above sea level (m)	Lat. North	Long. East	Daily range (K)	Yearly range (K)	Years of Data
	CWB	DB	WB	CDB	DB	WB	DB	WB	DB	DB	DB						
BANGLADESH																	
DHAKA	-	36.9	29.5	-	-	-	-	-	12.0	-	-	-	23° 42'	90° 22'	8.9	24.9	88-92
HONG KONG																	
CHEUNG CHAU	-	33.6	29.6	-	-	-	-	-	8.3	-	-	-	22° 12'	114° 01'	6.3	25.3	81-90
HONG KONG AIRPORT	-	33.2	27.8	-	-	-	-	-	9.3	-	-	-	22° 18'	114° 12'	5.0	23.9	81-90
HONG KONG RO	-	32.6	27.7	-	-	-	-	-	9.6	-	-		22° 18'	114° 10'	3.9	23.0	81-90
KOREA																	
PUSAN	-	31.8	26.7	-	-	-	-	-	-4.3	-	-	-	35° 06'	129° 01'	4.7	36.1	85-94
SEOUL	-	33.4	25.9	-	-	-	-	-	-10.3	-	-	-	37° 34'	126° 58'	5.9	43.8	85-94
TAEJON	-	34.2	25.9	-	-	-	-	-	-9.6	-	-		36° 30'	127° 24'	7.0	43.8	85-94
PHILIPPINES																	
DAVAO CITY †	-	35.4	27.6	-	-	-	-	-	20.1	-	-	18	7° 07'	125° 39'	8.1	15.3	81-90
MACTAN, AIRPORT †	-	34.7	27.8	-	-	-	-	-	21.5	-	-	13	10° 19'	123° 59'	6.7	13.2	81-90
MANILA, PORT AREA †	-	35.4	27.5	-	-	-	-	-	20.2	-	-	15	14° 35'	120° 59'	5.7	15.2	81-90
SINGAPORE																	
SINGAPORE	-	32.7	27.6	-	-	-	-	-	22.6	-	-	10	1° 18'	103° 50'	3.8	10.1	77-81
THAILAND																	
BANGKOK ‡	-	36.4	28.0	-	-	-	-	-	17.0	-	-	12	13° 44'	100° 34'	5.8	19.4	83-92
CHIANG MAI ‡	-	38.7	26.7	-	-	-	-	-	10.7	-	-	-	18° 47'	98° 59'	2.3	28.0	83-92
HAT YAI ‡	-	35.0	27.0	-	-	-	-	-	19.9	-	-	-	6° 55'	100° 26'	7.5	19.9	83-92
VEIT NAM																	
CAN THO ‡	-	34.3	27.6	-	-	-	-	-	19.4	-	-	3	10° 02'	105° 47'	6.7	14.9	76-85
HO CHI MINH ‡	-	34.7	27.5	-	-	-	-	-	18.0	-	-	3	10° 02'	105° 47'	9.0	16.7	76-85
LANG-HANOI ‡	-	35.9	28.9	-	-	-	-	-	9.0	-	-	5	21° 01'	105° 51'	6.1	26.9	76-85

* Significant proportion of missing records. † Maximum DB and WB temperatures not 3 p.m. ‡ 4 p.m. DB and WB temperatures not 3 p.m.

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10)

Monthly Dry Bulb Temperature °C (first line); Monthly Wet Bulb Temperature °C (second line)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A.C.T.												
CANBERRA AMO	36.9	36.2	33.2	26.8	20.5	15.9	14.7	20.1	25.3	27.5	33.9	34.4
	20.8	20.7	19.4	16.9	15.5	12.0	10.5	11.8	15.0	17.0	18.2	20.8
CANBERRA CITY	37.1	36.5	33.1	27.0	21.0	16.1	15.0	20.3	25.6	27.8	33.6	34.7
	21.4	20.9	19.8	17.4	16.0	12.0	10.8	11.9	15.2	17.6	18.2	19.7
CANBERRA FORESTRY	35.8	35.3	32.3	26.3	22.6	16.0	14.7	19.1	23.8	26.2	30.0	33.6
	21.2	22.2	19.2	17.1	14.7	12.0	10.7	13.2	15.1	17.4	18.8	19.7
HONEYSUCKLE CREEK	31.3	30.2	26.0	21.2	18.1	12.8	12.9	16.5	20.9	22.5	26.8	29.4
	21.3	21.1	17.5	14.9	12.4	9.5	8.5	9.4	13.4	14.8	16.3	19.8
ORRORAL VALLEY	33.4	32.3	29.4	23.2	18.9	14.1	14.0	19.2	22.0	24.9	30.5	31.2
	21.3	20.3	18.3	15.6	12.9	9.5	8.8	9.7	13.2	15.9	18.2	19.1
NEW SOUTH WALES												
ADELONG	38.3	38.2	35.5	28.7	24.2	18.5	18.3	22.2	26.1	29.3	35.3	36.1
	25.3	23.5	22.3	19.7	16.1	14.0	12.5	14.5	17.4	20.2	20.9	22.1
ALBURY AIRPORT	40.2	37.5	35.6	31.0	25.7	17.9	16.1	19.0	26.4	27.9	33.4	35.5
	21.0	21.7	21.1	19.1	17.9	13.4	12.8	13.5	17.4	17.7	19.9	21.2
ALBURY GRAMMAR SCHOOL	39.8	40.6	37.1	30.1	24.0	17.8	15.8	18.9	25.7	30.0	35.9	34.8
	21.8	23.3	20.3	21.2	16.9	14.8	12.9	14.2	17.1	19.5	23.0	22.6
ALBURY PUMPING STATION	40.0	39.7	37.0	29.4	24.5	18.1	16.0	21.1	24.5	30.3	33.0	38.0
	24.2	25.7	21.8	19.1	19.4	13.8	12.1	14.7	18.8	19.8	21.8	21.8
ARMIDALE	33.6	33.5	30.7	26.9	21.4	17.3	17.1	20.9	25.9	28.2	30.7	32.7
	21.0	21.2	19.3	17.2	14.9	11.7	11.2	12.0	14.4	17.3	18.4	20.1
BANKSTOWN	39.1	38.8	33.4	29.6	25.9	22.6	23.1	25.3	29.5	32.9	34.7	38.5
	24.6	25.4	23.0	21.2	18.2	15.5	15.6	16.4	18.1	19.4	22.4	23.2
BARRABA	33.7	35.1	33.4	30.6	25.6	20.7	21.1	24.2	28.4	31.2	33.9	36.5
	25.3	25.5	22.9	22.8	17.5	14.8	14.5	15.7	18.3	19.8	21.8	23.5
BATHURST AGRI.RESEARCH STATION	35.6	35.3	32.8	26.9	21.0	16.0	14.9	20.7	25.8	28.7	33.5	33.8
	23.2	21.9	20.1	17.7	15.0	11.6	10.7	13.0	15.0	18.0	18.5	19.7
BATHURST GAOL	35.2	34.4	29.8	26.2	21.5	18.1	15.7	21.7	23.8	27.1	30.7	33.9
	22.3	23.2	20.4	18.1	14.8	12.6	11.1	14.5	16.4	18.8	20.5	21.8
BEGA	39.5	37.1	35.0	28.5	26.0	20.4	20.2	25.6	29.9	32.5	35.6	36.0
	26.7	26.3	25.2	21.4	19.5	15.4	14.4	16.7	19.0	21.8	24.2	24.3
BELLINGEN	38.5	37.2	33.2	31.4	27.0	25.2	24.9	27.4	30.8	32.4	37.9	39.3
	28.3	26.4	26.3	25.3	21.3	19.4	17.2	19.5	20.9	22.9	26.2	26.7
BOMBALA	35.7	34.7	32.3	24.2	20.6	16.1	15.7	19.2	23.4	27.3	31.9	33.9
	21.3	21.3	20.7	16.8	13.7	11.0	10.1	11.2	14.8	16.2	19.5	20.7
BOURKE	43.0	41.8	38.8	33.8	28.7	24.2	23.9	27.2	33.0	36.3	40.2	40.9
	25.0	26.2	23.0	21.3	19.4	16.3	15.3	15.7	20.0	20.7	22.2	23.1
BOWRAL	35.7	35.3	32.1	25.6	21.0	17.1	17.3	21.0	25.2	28.9	32.9	33.9
	23.0	21.8	20.8	18.6	15.5	11.8	11.6	12.7	15.3	17.4	20.2	21.1
BROKEN HILL AERO	42.1	38.6	35.8	32.1	26.9	23.0	21.7	24.5	30.4	34.8	39.0	41.4
	24.8	21.9	19.7	19.7	15.6	14.9	13.2	14.3	15.0	16.8	20.8	22.1
CAMDEN	40.2	39.4	37.0	32.1	25.0	20.7	21.6	25.7	31.0	33.4	38.4	39.0
	25.1	24.7	22.9	21.0	18.0	14.9	13.8	14.6	17.2	20.4	22.3	22.8
CAMPBELLTOWN	39.3	36.8	33.0	30.6	24.3	21.7	22.2	24.0	28.0	32.2	34.3	37.1
	24.0	23.7	23.2	21.1	17.3	14.6	14.6	18.3	17.8	19.6	22.4	23.2
CAPE BYRON	30.3	29.8	28.7	27.5	24.7	22.1	21.9	22.8	26.1	25.1	27.0	29.4
	25.9	25.9	25.2	23.6	21.1	18.6	18.5	18.7	20.2	21.8	23.1	25.6
CESSNOCK	40.1	39.1	36.4	30.4	25.4	23.3	22.9	25.6	31.1	34.5	38.1	39.3
	25.5	25.6	23.0	21.2	18.2	15.2	14.5	16.1	18.1	20.2	23.1	23.1
COBAR MO	41.5	40.0	38.0	31.3	25.9	21.5	19.9	25.9	31.5	36.3	39.7	39.4
	23.2	23.1	21.1	19.7	18.1	14.9	13.7	14.4	16.8	19.2	21.6	22.7

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C											
	NEW SOUTH WALES (Continued)											
COBAR PO	43.7	41.1	37.4	32.7	27.6	22.9	24.1	26.1	30.9	37.3	40.9	43.6
	25.0	24.6	22.1	20.9	20.1	16.5	15.1	16.1	17.9	19.3	22.4	24.0
COFFS HARBOUR	29.6	29.5	28.5	27.2	24.6	22.7	23.4	24.6	28.0	30.7	29.4	30.0
	25.1	25.4	24.3	22.4	20.0	17.6	17.5	17.9	19.6	21.5	22.6	24.2
CONDOBOLIN	41.7	41.6	37.1	30.8	26.5	21.4	22.0	27.5	31.3	33.0	36.2	39.3
	25.9	24.2	24.6	21.6	19.0	14.9	15.5	16.9	19.5	20.2	22.3	25.8
COOMA	34.6	34.5	32.6	27.2	21.3	16.1	15.4	20.8	25.0	27.8	32.0	32.5
	20.8	20.1	19.5	17.4	14.2	10.2	9.6	10.9	13.9	16.8	18.1	19.7
COONABARABRAN	39.2	37.5	35.7	29.7	24.9	20.3	19.2	24.5	30.1	35.1	36.1	38.1
	24.7	24.3	21.8	19.1	17.6	14.6	13.0	14.4	17.4	19.9	21.4	22.6
COONAMBLE	40.5	40.3	37.7	31.0	27.4	22.4	21.3	26.4	32.2	35.6	38.5	39.8
	26.1	26.0	24.3	20.3	18.8	16.5	15.0	15.9	19.0	24.3	23.1	24.6
COOTAMUNDRA	39.8	38.9	35.9	29.8	24.7	18.3	17.4	23.8	26.5	30.6	36.7	37.4
	23.1	23.0	21.8	19.5	16.6	13.9	12.5	14.4	17.3	19.8	20.0	22.2
COROWA	40.1	40.2	37.7	29.9	26.0	18.8	19.4	22.9	25.2	32.5	38.4	38.4
	23.6	24.8	22.8	20.7	16.9	13.9	13.2	14.1	17.8	19.4	21.6	23.2
COWRA PO	40.4	37.2	34.9	30.2	25.8	21.8	18.9	22.0	26.8	32.2	38.4	39.0
	29.6	25.8	22.9	21.0	20.9	15.5	13.6	14.8	18.3	23.1	24.9	28.2
COWRA AIRPORT	40.2	39.5	36.5	30.7	24.2	19.7	18.0	23.6	27.0	32.3	38.5	38.0
	23.3	22.8	21.6	19.6	16.8	14.5	12.9	15.0	16.8	19.7	20.6	21.0
DEEPWATER	31.3	31.0	29.1	28.2	21.2	17.4	17.9	19.9	21.9	28.3	33.6	31.2
	23.3	23.9	20.5	23.1	15.5	11.5	11.9	14.0	15.3	17.6	20.9	20.4
DENILIQUIN (FALKINER MEMORIAL)	40.5	41.2	38.1	30.9	25.2	19.5	18.1	22.2	27.6	31.6	36.3	39.7
	23.3	24.0	21.9	21.5	18.6	14.6	13.9	15.6	17.8	20.5	20.7	22.6
DENILIQUIN P.O.	42.5	41.7	38.3	31.3	26.2	19.9	18.7	24.7	30.7	32.1	38.7	39.1
	24.0	24.1	22.5	19.7	17.5	14.2	12.9	14.6	17.4	18.7	21.1	21.6
DUBBO	39.7	39.1	36.7	30.5	25.1	20.7	19.2	25.4	29.6	34.3	37.7	38.3
	26.5	25.4	24.0	19.5	18.2	15.0	13.9	15.3	17.5	19.5	21.1	23.8
DUNEDOO	39.8	38.1	35.6	29.7	25.2	19.7	20.0	25.7	31.3	33.6	38.2	39.0
	23.1	23.6	24.2	21.0	16.4	14.8	13.2	15.0	17.2	19.9	21.2	24.3
FORBES	40.6	38.9	37.1	31.6	26.4	21.0	19.6	26.0	27.5	32.9	37.7	38.0
	26.3	24.7	23.3	21.3	17.8	14.5	14.2	16.3	17.7	20.5	22.3	25.0
FROGMORE	38.0	36.4	33.2	27.0	22.7	18.5	18.3	19.2	23.6	28.4	34.8	36.2
	23.1	25.6	20.9	17.7	15.4	12.9	12.7	12.4	17.0	17.4	20.1	23.2
GLEN INNES	32.8	32.6	29.8	25.7	20.9	17.2	16.7	20.6	25.3	27.7	30.0	31.7
	21.7	22.4	20.0	17.9	15.0	12.0	10.4	12.4	15.1	17.4	19.6	20.9
GOULBURN	35.8	36.2	33.0	27.6	19.9	15.6	15.6	20.6	25.3	28.7	34.9	34.4
	24.0	22.5	22.7	21.5	15.0	11.4	11.4	11.8	15.7	19.3	20.0	21.4
GRAFTON	36.7	35.2	34.8	31.1	26.2	24.2	24.6	27.3	31.7	34.4	36.5	39.1
	26.8	26.1	25.6	23.7	20.6	18.0	16.9	17.7	20.8	23.1	24.5	25.5
GREEN CAPE	23.8	25.1	24.2	21.9	20.7	16.9	17.3	17.3	18.8	21.4	22.3	22.4
	22.1	23.7	23.1	20.4	18.1	15.3	14.2	14.9	15.5	17.8	19.6	20.9
GRENFELL	39.3	38.7	36.9	29.1	24.5	19.5	18.9	24.4	27.5	31.1	37.9	37.7
	26.0	23.2	22.3	19.6	17.2	14.6	12.8	14.6	17.6	18.5	21.4	24.6
GRIFFITH	39.3	38.8	34.8	30.8	26.4	21.2	21.6	25.9	27.5	32.3	36.0	39.2
	23.6	24.0	21.4	18.7	17.3	14.1	13.6	15.9	17.8	20.7	21.2	23.8
GULGONG	37.3	38.0	35.7	27.9	23.9	20.5	20.8	23.7	28.6	31.5	36.9	37.6
	25.2	24.8	23.2	19.6	16.9	12.9	15.4	15.5	17.4	19.5	21.4	24.3
GUNDAGAI	40.6	39.3	36.0	29.4	24.3	17.8	16.0	22.2	26.9	28.9	37.4	36.8
	23.1	24.0	23.2	19.8	18.6	13.7	13.0	14.1	18.0	20.0	21.2	23.1
GUNNEDAH	38.3	38.8	35.4	30.8	25.5	21.7	21.7	23.1	30.8	32.3	37.2	38.8
	27.1	25.9	24.9	22.0	19.4	16.4	15.2	16.5	19.3	22.7	23.7	26.0
HARDEN	39.7	39.4	33.3	29.3	24.7	18.6	17.1	23.2	25.7	28.4	33.2	37.5
	23.0	22.3	21.5	18.5	16.4	12.4	10.7	16.3	17.4	20.2	22.2	22.0

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NEW SOUTH WALES (Continued)												
HAY	43.6	42.4	38.1	32.1	26.7	19.9	18.6	25.1	31.4	32.5	41.1	39.8
	24.5	24.7	23.4	20.0	17.6	15.1	13.4	14.9	18.0	19.3	21.3	22.9
HILLSTON	41.7	41.2	38.4	31.5	27.5	22.0	22.2	27.8	31.6	34.1	39.7	39.8
	24.3	23.3	22.7	20.6	17.3	14.8	14.0	14.8	18.5	19.5	21.8	22.6
HUME RESERVOIR	38.3	37.4	33.1	28.9	22.4	17.7	17.7	20.4	22.8	27.4	33.1	37.6
	24.2	27.0	25.0	19.5	16.2	13.4	12.6	14.6	17.2	19.0	21.0	24.5
INVERELL	35.8	36.4	33.9	29.2	24.3	20.0	19.5	24.2	29.3	31.2	33.6	36.1
	23.6	23.9	23.0	20.3	17.0	14.2	12.9	14.4	17.2	19.0	21.5	22.5
IVANHOE	43.2	42.3	39.4	33.0	29.6	21.9	21.1	29.7	33.9	36.3	42.9	42.0
	24.7	26.0	23.0	20.9	17.5	14.6	13.7	17.6	19.8	19.8	22.2	23.7
JERRYS PLAINS	40.5	40.6	36.3	31.4	26.2	23.5	23.3	26.5	31.2	35.6	38.2	39.3
	26.8	25.0	24.5	21.6	18.4	16.3	14.6	16.2	19.2	22.6	23.9	24.2
JERVIS BAY (PT PERPENDICULAR)	31.1	32.2	27.5	25.2	22.7	20.3	20.1	21.8	26.1	28.0	28.8	31.9
	23.8	23.9	23.6	21.6	19.1	15.8	14.6	16.1	17.6	19.4	21.5	23.0
KATOOMBA	32.4	31.9	29.1	23.4	18.5	14.0	13.3	17.7	23.0	25.7	30.3	30.7
	21.5	20.3	19.2	16.1	13.6	9.5	8.7	10.4	13.4	15.6	18.2	19.3
KEMPSEY	34.1	34.1	31.8	29.7	26.6	24.3	24.4	26.3	30.2	30.2	34.5	34.4
	26.0	26.6	24.8	23.1	19.7	17.4	17.5	18.4	20.1	22.1	24.1	25.7
KIANDRA CHALET	27.7	26.2	25.3	19.4	15.5	11.9	9.1	11.7	16.7	21.0	24.8	25.4
	24.4	22.5	23.5	14.0	9.9	7.0	6.0	7.0	9.0	16.5	16.9	20.4
KIRKCONNELL	30.6	30.0	25.3	22.3	18.4	14.5	15.0	15.9	17.7	23.6	27.6	30.2
	22.1	19.5	17.9	18.4	12.7	11.0	10.0	11.5	12.7	14.5	16.6	23.8
KULNURA	37.0	35.8	32.2	27.6	23.7	20.6	20.8	23.3	28.3	30.6	33.8	36.5
	25.3	24.1	22.4	20.1	17.1	14.5	14.0	15.6	17.4	18.8	21.4	23.8
LEETON	40.7	37.9	35.4	30.0	24.8	19.8	22.6	20.9	26.8	31.8	36.9	37.6
	24.8	25.8	21.2	19.1	17.4	14.9	14.3	14.5	18.4	19.6	21.5	23.7
LISMORE	36.6	35.1	33.6	30.6	26.6	24.1	24.9	26.4	31.6	33.8	35.4	37.3
	26.6	26.3	24.9	23.6	20.5	18.0	17.1	20.1	21.9	22.7	25.3	26.4
LITHGOW	34.2	33.9	30.5	24.6	20.9	15.3	15.1	19.4	25.1	28.3	32.6	33.3
	23.7	21.6	19.5	17.5	15.6	10.8	10.0	11.3	13.5	16.7	19.4	29.8
LIVERPOOL	40.5	38.7	36.8	31.7	25.4	21.1	21.9	25.8	31.4	33.3	37.2	38.5
	25.3	24.9	23.8	21.3	18.6	15.4	14.4	15.7	18.1	21.9	23.3	24.1
LORD HOWE ISLAND	26.5	26.8	25.7	24.6	22.6	20.5	20.3	20.0	21.3	22.2	23.6	25.5
	23.9	24.9	23.9	22.1	21.4	18.8	18.3	17.8	19.4	20.2	21.4	23.9
LOSTOCK DAM	37.6	36.7	34.5	29.2	25.1	22.1	22.8	24.5	31.2	33.1	37.3	37.9
	24.8	25.5	23.9	21.6	17.7	14.6	14.6	15.2	18.1	21.6	22.5	23.9
LUCAS HTS	38.2	37.8	32.6	28.5	23.9	20.9	20.8	24.1	28.6	31.2	36.7	36.9
	24.8	25.8	22.2	21.1	18.6	16.2	14.4	17.3	19.5	20.4	21.8	23.9
MARSFIELD (MACQUARIE UNI)	38.3	38.1	33.6	29.5	25.2	21.9	22.1	25.3	30.5	31.9	36.5	37.0
	25.6	25.9	23.4	22.0	18.4	15.4	15.2	16.4	17.9	20.0	22.4	23.4
MARYVILLE HVRF	38.4	37.4	34.5	30.3	25.3	21.3	21.5	25.1	29.0	33.1	33.3	37.4
	25.5	24.7	24.0	21.6	19.4	16.6	15.4	16.9	18.9	21.6	22.5	24.1
MERIMBULA	30.3	29.4	27.5	25.5	22.5	19.6	19.0	20.1	23.7	26.3	29.3	30.1
	23.3	23.5	22.1	20.9	18.6	15.7	14.3	14.7	16.8	18.5	19.7	22.2
MOLONG	38.5	37.5	34.8	29.3	23.2	18.5	18.0	20.4	28.2	31.2	35.6	36.4
	25.9	23.3	20.6	18.9	16.8	14.2	12.4	13.1	15.4	20.6	23.8	28.0
MONTAGUE ISLAND	26.1	28.6	25.4	23.6	21.4	18.6	18.8	20.0	22.0	25.3	24.6	26.6
	24.1	23.8	23.8	21.3	19.9	15.8	15.0	16.2	17.7	19.3	20.9	21.5
MOREE MO	39.7	38.3	36.8	33.6	26.5	22.5	22.1	25.6	32.5	36.4	36.5	39.8
	24.6	24.4	23.4	21.2	19.2	16.3	15.7	16.3	18.7	20.6	21.7	23.5
MOREE PO	42.2	39.5	37.2	33.6	28.7	25.3	25.0	27.5	33.6	36.5	40.0	41.7
	26.6	25.7	24.8	22.6	20.4	17.5	16.0	17.7	18.6	20.3	22.9	25.0
MORUYA HEADS	33.2	29.4	28.7	27.3	23.4	19.8	20.0	24.2	27.7	30.4	27.1	30.5
	22.5	23.4	22.6	20.6	18.5	15.5	14.3	14.5	17.1	18.2	19.9	21.1

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
NEW SOUTH WALES (Continued)												
MOUNT VICTORIA	32.6	32.6	29.2	22.6	18.5	14.3	13.6	17.8	24.3	26.3	31.1	31.3
	20.7	20.7	18.6	16.4	13.1	9.8	8.2	10.8	14.5	15.9	18.4	18.9
MUDGEE	37.8	37.3	34.6	28.2	24.0	18.8	17.7	23.2	28.4	31.8	36.1	36.5
	25.9	25.5	21.6	20.6	17.6	13.4	12.3	13.9	17.0	19.3	22.3	24.1
MURWILLUMBAH	35.1	33.7	32.3	30.3	26.9	24.6	25.2	25.8	31.2	31.3	33.4	36.1
	27.6	26.8	25.3	24.0	21.3	18.6	17.6	18.7	21.5	23.1	25.5	27.1
NALBAUGH	31.9	32.2	26.2	22.8	18.5	14.5	16.4	15.5	20.1	25.9	28.3	33.1
	21.4	22.0	19.4	16.8	15.4	12.3	10.5	11.7	13.9	17.3	18.6	21.3
NARADHAN	42.3	41.7	38.2	32.0	25.9	20.6	19.6	25.3	31.9	33.8	40.1	39.6
	23.9	24.0	21.4	20.1	17.8	15.5	13.8	15.0	17.1	18.9	20.3	22.8
NARRABRI WEST	39.4	38.2	36.8	33.4	27.6	23.5	23.8	26.8	33.0	34.5	38.1	40.0
	25.8	25.1	23.9	21.7	18.1	16.0	15.3	16.8	19.2	21.2	22.7	23.7
NARRANDERA PO	40.0	40.6	38.5	31.5	26.2	19.8	18.5	22.3	30.3	33.8	38.0	38.6
	23.0	22.6	20.9	21.0	18.9	14.2	13.8	14.4	17.0	24.0	20.1	21.8
NARRANDERA COUNCIL DEPOT	43.2	42.0	38.6	31.1	25.2	19.8	18.3	24.0	30.2	32.6	40.7	39.7
	24.9	28.9	22.5	19.6	18.3	14.6	14.1	14.2	17.1	19.1	21.9	22.7
NERRIGA	37.5	36.9	32.9	25.1	20.5	15.7	15.1	20.3	25.2	28.6	32.6	34.5
	21.2	21.5	20.6	17.2	15.1	12.0	10.3	11.6	14.5	18.1	20.0	20.5
NEWCASTLE	35.6	34.6	32.4	31.2	24.3	21.3	21.2	24.4	28.7	31.9	32.7	36.2
	23.6	24.2	23.3	21.6	18.9	16.1	15.6	17.2	17.9	19.4	21.3	22.8
NORAH HEAD	34.6	31.8	29.1	27.5	24.1	22.4	22.0	23.3	28.2	28.4	31.2	35.7
	24.1	25.3	24.3	22.7	19.8	16.6	16.7	17.5	18.7	19.8	22.7	23.9
NORFOLK ISLAND (A) M.O.	26.2	26.1	26.1	24.3	22.9	20.9	19.8	19.4	20.4	21.5	23.7	25.7
	24.3	23.8	23.9	22.1	20.9	19.7	18.0	17.4	18.5	19.9	20.8	22.8
NOWRA	39.2	37.7	34.6	29.4	24.3	20.5	19.3	25.1	30.4	32.6	35.8	36.2
	24.6	24.2	23.0	20.4	18.2	15.5	14.3	15.1	17.4	20.4	21.6	23.3
NYNGAN	41.8	40.8	37.7	31.7	27.1	22.1	21.5	26.4	31.5	35.2	39.9	40.1
	25.2	24.9	23.7	20.6	18.5	15.2	14.5	15.3	17.6	19.9	21.4	23.1
OBERON	30.9	30.6	27.9	22.1	18.2	14.5	12.4	16.9	19.9	23.0	26.9	29.4
	20.3	20.9	17.9	15.2	14.2	12.0	9.4	13.2	12.5	16.5	16.9	19.6
ORANGE AIRPORT	32.7	32.7	30.5	24.2	18.9	14.7	13.2	17.6	22.3	26.4	29.7	31.2
	20.1	20.4	18.9	16.6	14.6	11.0	9.9	10.6	13.6	16.8	18.4	19.9
ORANGE	35.8	34.3	31.9	27.4	21.4	16.3	16.0	18.7	25.4	27.9	32.3	33.2
	21.4	20.8	19.6	17.6	15.0	12.3	11.3	12.2	13.7	17.3	19.3	20.4
ORCHARD HILLS	38.6	38.8	34.8	30.9	24.9	21.7	22.7	26.6	31.5	32.8	37.9	37.4
	25.8	26.7	23.7	22.4	18.4	15.5	16.3	17.8	19.6	20.2	23.3	25.8
PARKES	39.8	38.9	35.9	30.3	24.8	20.3	18.3	24.1	29.0	32.2	37.4	37.9
	24.6	23.3	22.6	19.8	17.7	14.7	13.0	14.0	17.9	19.4	21.2	22.8
PARRAMATTA NORTH	40.4	38.7	35.9	30.3	24.8	20.9	21.1	26.0	28.0	32.5	35.5	37.7
	26.0	25.8	24.4	21.7	18.6	15.8	14.6	16.2	17.5	21.0	24.3	24.3
PATERSON TOCAL AGRIC COLLEGE	39.7	38.1	36.3	31.5	24.9	21.1	21.1	25.7	32.5	33.7	38.4	39.6
	26.0	26.8	25.9	21.5	19.0	16.4	14.7	16.2	18.3	21.2	23.5	23.4
PEAK HILL	40.9	40.4	37.5	31.1	25.9	22.0	19.4	25.0	29.9	34.4	38.4	39.0
	24.3	24.0	21.9	19.8	18.3	15.7	13.9	15.6	17.6	21.5	22.1	24.0
PERISHER VALLEY	25.3	24.6	23.3	16.2	12.8	8.5	4.7	8.4	11.9	17.3	21.7	22.7
	19.4	17.1	14.5	11.7	8.1	5.1	3.7	4.4	6.6	10.8	13.4	14.5
PORT KEMBLA	30.7	26.4	26.5	26.6	23.5	20.6	21.0	21.5	26.3	28.2	32.7	29.7
	23.8	24.4	23.4	21.6	20.0	16.2	16.2	17.2	17.5	19.0	21.1	21.9
PORT MACQUARIE	28.1	28.6	27.7	25.9	24.2	21.9	21.8	22.8	24.3	24.9	26.2	27.9
	24.7	25.7	24.9	22.4	20.4	17.6	17.3	17.7	19.5	20.9	22.5	23.7
PROSPECT DAM	39.8	38.6	35.3	29.8	24.9	21.8	22.1	24.9	29.7	33.0	36.3	38.0
	25.4	25.2	23.3	20.9	17.9	15.3	14.9	15.3	17.8	19.7	22.6	23.1
QUANDIALLA	40.6	40.3	36.3	29.2	26.5	19.9	18.0	24.6	28.5	31.5	39.8	39.3
	24.3	24.3	22.2	20.8	16.7	14.2	12.9	15.0	17.4	19.8	21.1	22.9

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
	NEW SOUTH WALES (Continued)											
RATHMINES	38.4	37.9	32.0	30.5	28.3	21.9	22.9	25.9	30.0	34.7	38.1	36.0
	24.7	26.8	24.3	23.1	20.0	17.2	15.0	15.7	17.7	20.4	22.7	23.3
RICHMOND	40.7	39.8	37.1	32.1	25.7	22.0	21.7	26.6	31.5	35.2	38.5	38.8
	25.4	25.1	23.1	20.7	18.9	16.2	14.8	15.4	17.6	20.8	22.5	24.1
SCONE	39.8	39.4	37.5	31.5	26.0	23.0	23.5	25.9	31.5	34.2	37.9	39.1
	25.7	25.9	24.2	21.5	17.7	15.1	14.8	16.1	18.3	21.3	22.5	23.7
SINGLETON	39.1	39.1	35.6	31.5	25.8	22.8	23.0	25.7	32.4	35.1	38.5	40.3
	24.2	25.4	24.6	21.6	20.0	15.8	15.8	16.2	20.6	20.9	24.4	25.4
SMOKY CAPE	28.9	28.9	27.4	26.2	23.5	20.9	20.7	22.2	24.1	24.4	26.6	28.3
	25.2	25.8	25.1	24.1	20.5	17.8	17.4	17.9	19.7	21.9	22.9	24.6
SYDNEY AIRPORT	37.6	35.9	35.2	29.8	25.5	21.4	21.6	25.2	30.8	34.0	36.4	37.5
	24.5	24.1	22.6	20.8	19.1	16.0	14.7	15.7	17.3	19.3	21.4	23.4
SYDNEY REGIONAL OFFICE	35.1	34.4	35.3	29.5	25.3	21.4	21.9	24.7	29.2	32.4	35.4	36.1
	24.0	24.3	22.9	21.0	19.2	16.6	15.0	16.2	17.9	19.5	21.7	23.3
TABULAM	35.3	31.9	31.3	29.8	24.6	20.9	20.8	23.9	28.4	30.5	31.9	36.2
	24.0	24.5	22.9	21.6	18.1	15.5	14.2	15.5	17.8	19.5	21.8	22.8
TAMWORTH	37.2	36.5	34.2	30.0	24.7	20.8	20.6	24.1	29.7	31.7	34.3	37.4
	23.2	23.5	21.5	19.7	17.1	14.0	13.4	14.9	16.8	18.9	20.7	22.0
TARALGA	35.2	32.3	31.7	24.6	19.7	16.7	14.8	17.2	23.0	26.1	31.1	34.0
	20.2	20.6	19.3	17.0	14.0	11.7	10.8	11.2	13.5	17.2	21.1	20.8
TAREE	36.9	36.0	33.5	31.9	26.2	23.2	23.7	25.4	30.5	32.0	36.1	36.7
	28.3	27.5	25.0	23.0	19.8	17.4	16.8	19.1	19.8	23.1	24.6	24.9
TENTERFIELD	34.2	34.4	31.6	29.1	23.7	19.3	18.4	22.7	26.9	29.5	31.7	34.5
	22.1	22.1	21.3	19.5	16.5	13.3	12.0	13.4	16.6	18.1	20.1	21.4
THREDBO (CRACKENBACK STATION)	22.6	22.0	18.7	14.4	12.2	7.2	6.8	4.0	9.5	13.4	18.3	21.5
	17.8	16.7	13.3	10.1	7.1	4.8	4.1	2.9	6.0	7.8	11.6	15.4
THREDBO VILLAGE	28.2	27.8	26.5	19.2	14.9	9.6	7.9	12.3	15.8	20.0	24.3	25.8
	20.2	18.7	16.3	13.4	9.9	6.9	5.9	6.9	9.6	12.6	15.2	17.2
TIBOOBURRA	42.6	41.3	40.4	35.4	29.4	24.7	23.2	28.8	34.4	39.3	40.3	42.6
	25.1	24.4	23.9	19.2	19.6	16.2	15.0	17.1	18.8	19.9	21.4	24.5
TOCUMWAL	42.5	41.3	38.4	31.5	26.3	20.3	19.1	24.7	28.6	34.7	39.4	40.3
	24.4	24.8	22.6	20.2	17.5	14.3	13.4	15.4	18.1	19.5	22.2	23.0
TULLAMORE	40.3	39.8	37.9	30.4	25.0	21.3	19.9	26.3	28.1	33.2	37.1	38.3
	26.5	26.0	23.2	21.5	17.7	13.9	15.1	14.8	17.6	21.1	22.5	23.5
TYALGUM	36.3	34.8	32.5	30.4	26.4	23.1	24.9	26.0	31.3	33.4	35.3	37.1
	26.4	26.2	25.1	23.5	20.8	18.0	16.8	18.2	21.2	22.4	25.2	26.1
WAGGA	40.8	39.4	36.9	29.9	24.5	18.6	16.7	22.3	26.7	29.4	37.5	37.3
	23.2	22.1	20.9	18.8	16.8	13.7	12.9	14.0	17.2	19.0	19.5	21.1
WALGETT	44.0	40.4	37.6	33.6	27.9	24.1	25.2	27.8	34.7	35.5	39.6	42.8
	27.1	26.3	25.1	22.6	18.5	16.9	16.1	16.5	19.4	21.7	23.9	25.1
WELLINGTON	39.2	37.4	35.1	29.5	26.0	21.5	21.4	24.9	29.6	32.9	36.0	38.9
	23.5	23.4	22.7	20.8	17.1	15.1	14.5	14.9	17.5	21.1	22.1	25.4
WENTWORTH FALLS	31.7	31.5	27.5	25.7	19.2	16.8	15.6	20.1	22.0	27.4	29.1	31.5
	21.3	23.7	20.9	17.0	14.4	10.5	10.5	12.6	13.3	16.4	18.0	20.8
WENTWORTH	43.2	40.1	39.2	32.6	26.5	23.5	20.3	25.2	31.4	36.0	40.8	41.1
	23.8	23.5	24.2	22.0	19.5	16.1	14.2	14.8	17.0	19.6	22.6	23.0
WHITE CLIFFS	43.3	42.3	40.1	35.0	30.0	23.6	22.4	27.9	34.1	36.8	42.0	42.2
	26.3	24.6	22.6	20.2	18.2	15.9	14.5	15.6	17.5	19.1	20.9	22.3
WILCANNIA	43.1	42.9	39.9	34.7	28.3	25.0	26.1	28.8	35.0	36.5	42.1	42.6
	25.5	24.8	23.2	21.1	19.3	15.6	15.6	16.3	19.3	19.8	22.1	25.5
WILLIAMTOWN	39.1	37.2	35.5	31.8	25.1	21.6	20.9	24.9	31.6	33.8	36.5	38.7
	25.8	25.6	23.8	21.4	19.7	16.7	15.5	16.4	18.6	21.6	23.0	24.6
WOLLONGONG	33.7	33.2	32.7	28.3	24.2	20.6	21.3	24.2	28.5	30.8	31.3	33.5
	24.6	24.7	22.7	21.2	18.9	15.2	15.1	16.6	17.3	19.3	21.6	25.6

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C											
NEW SOUTH WALES (Continued)												
WOOLBROOK	33.3	33.6	30.3	26.2	21.2	16.7	16.4	20.7	24.5	27.8	31.2	33.1
	24.3	21.9	20.8	16.5	15.2	11.8	10.6	12.1	15.8	17.7	19.3	21.7
WYALONG	41.0	39.7	35.7	30.4	25.4	20.9	21.2	25.3	29.3	32.0	39.1	38.4
	25.6	25.1	21.2	19.7	16.4	13.9	14.0	14.4	17.6	20.3	21.6	23.0
YAMBA	28.1	28.1	27.5	27.1	23.8	22.6	23.0	24.7	28.0	26.8	29.4	29.7
	25.7	25.7	25.0	24.0	20.6	18.7	17.6	18.6	20.0	21.4	22.8	24.4
YARRAS	38.0	37.4	34.3	30.4	24.9	21.7	22.8	26.8	31.4	33.3	37.3	38.0
	26.4	25.9	24.7	22.8	19.2	16.7	15.6	17.5	19.9	22.8	24.2	26.2
YASS	38.6	37.6	34.8	27.2	22.6	15.8	16.1	21.2	24.3	28.9	35.3	35.4
	22.8	22.1	20.7	18.9	15.8	12.2	11.1	13.3	16.3	19.2	20.8	21.0
YENDA	41.2	40.6	37.1	32.0	28.2	20.7	19.8	27.1	31.9	33.7	40.6	39.5
	24.9	25.2	22.3	21.2	17.7	15.2	13.8	15.8	18.6	19.4	22.6	26.3
NORTHERN TERRITORY												
ALICE SPRINGS	42.0	41.1	38.7	35.4	31.1	26.8	27.2	31.3	35.1	38.3	40.7	41.8
	23.9	23.7	24.1	21.6	18.6	16.2	13.7	16.8	18.2	19.5	21.9	23.0
ANGURUGU	35.7	34.2	34.2	33.0	32.1	31.5	30.5	31.4	33.7	35.9	37.4	36.1
	27.3	27.4	28.7	26.7	27.3	25.3	24.9	28.3	26.0	31.1	30.3	27.7
AUVERGNE	39.4	38.4	38.6	37.5	37.0	33.8	34.3	35.9	38.3	40.6	41.6	40.5
	27.9	28.1	28.1	26.3	24.3	23.0	21.1	22.4	24.4	26.8	26.7	27.6
BARROW CREEK	41.6	39.7	37.9	35.1	31.3	29.4	29.9	31.9	34.7	37.9	40.0	41.7
	24.5	24.7	24.5	23.1	19.9	18.6	18.2	19.3	21.3	22.9	23.4	24.5
BRUNETTE DOWNS	43.0	42.2	39.9	37.6	34.5	33.0	32.2	35.6	37.3	40.8	41.9	42.6
	26.7	27.3	27.3	24.4	22.5	19.7	20.3	20.4	21.6	23.3	25.5	26.2
CAPE DON	33.6	33.3	32.6	32.9	32.1	31.1	30.1	31.0	32.4	32.6	34.1	34.6
	28.3	28.0	27.9	27.7	26.6	25.7	25.3	25.5	25.5	27.1	28.2	28.4
CENTRE ISLAND	36.8	36.7	35.1	34.7	32.3	29.5	28.5	30.1	32.3	35.4	36.3	37.8
	29.7	30.3	28.1	27.5	26.4	24.2	23.9	24.4	25.4	28.3	29.3	29.0
CURTIN SPRINGS	43.5	42.6	40.1	36.6	30.6	26.7	26.4	31.2	35.3	39.0	42.3	42.5
	24.6	24.7	24.8	23.3	18.1	17.1	14.7	17.2	18.4	22.2	23.4	23.7
DALY WATERS AMO	40.4	39.1	38.6	36.7	34.4	33.0	32.0	34.3	36.6	39.3	41.1	40.8
	26.7	25.8	25.6	25.0	24.7	22.4	20.2	20.1	22.7	23.6	24.5	25.6
DALY WATERS	40.8	37.4	36.8	36.6	34.8	32.9	33.4	35.3	37.2	40.0	40.7	41.0
	29.0	27.3	26.9	26.0	24.1	23.7	22.0	24.1	23.8	25.1	25.7	27.2
DARWIN AIRPORT	33.8	33.4	34.0	35.0	34.5	32.8	32.7	33.8	34.5	35.3	34.9	34.7
	28.0	27.8	27.9	26.9	26.4	24.2	23.7	24.5	26.4	27.2	27.9	27.8
ELCHO ISLAND	34.4	34.2	33.7	33.2	32.7	31.8	30.9	32.4	34.1	35.6	34.4	34.8
	28.7	28.4	28.7	27.3	27.8	25.4	25.0	24.5	25.6	27.1	27.7	28.4
FINKE	45.0	43.5	41.4	36.7	31.6	28.6	30.4	32.9	36.0	40.8	41.7	44.3
	25.5	24.5	23.2	20.5	19.6	16.8	16.2	16.5	20.1	20.4	22.4	22.9
GARDEN POINT	33.6	33.5	33.6	34.6	33.3	32.4	32.2	33.1	34.6	34.6	34.1	34.8
	28.4	28.4	29.5	29.1	28.0	25.5	25.1	26.9	27.6	28.1	28.6	28.1
GOVE AIRPORT	33.9	34.9	34.9	32.4	33.2	29.8	29.2	30.6	32.8	34.0	34.7	36.0
	27.2	27.9	27.7	26.8	28.0	24.3	23.8	24.1	28.1	26.6	26.7	27.4
GUNBALUNYA	36.8	35.8	35.0	36.2	35.7	34.1	34.6	36.6	38.3	40.9	40.0	38.2
	28.0	27.8	27.8	28.0	26.3	26.1	24.5	25.7	24.5	26.2	27.3	28.8
JERVOIS	43.3	43.4	40.9	37.1	32.5	29.3	29.6	34.0	36.7	40.2	42.2	44.1
	25.6	25.8	24.7	24.4	20.0	18.6	17.4	18.7	19.9	21.6	24.2	28.3
KATHERINE	38.5	37.2	36.8	36.8	34.9	33.2	33.6	35.7	37.8	40.1	40.5	39.5
	27.5	27.1	27.2	25.3	24.3	23.3	22.2	24.5	26.2	26.2	27.3	27.5
LARRIMAH	39.5	40.0	34.8	35.1	33.6	33.6	33.8	36.4	38.1	39.7	42.4	39.6
	27.8	27.2	27.5	25.9	23.2	22.5	20.2	22.9	26.5	26.8	25.8	27.5

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C											
NORTHERN TERRITORY (Continued)												
MANINGRIDA	34.8	34.2	33.0	33.9	32.6	31.5	31.7	31.9	33.4	33.7	34.3	34.6
	29.1	29.6	28.4	27.4	26.5	25.8	25.6	24.8	25.9	27.9	28.5	28.9
MILINGIMBI	34.7	34.7	33.9	33.5	32.7	30.9	30.6	32.2	32.9	34.2	34.6	35.2
	28.7	28.3	27.7	27.7	27.3	25.4	26.8	25.2	25.8	27.1	28.7	29.4
MINJILANG	32.9	32.1	32.5	32.0	30.7	29.4	29.0	30.2	31.9	33.9	35.1	34.5
	27.9	27.8	27.3	28.0	26.4	24.8	24.1	25.1	26.1	27.3	27.7	28.8
NEWCASTLE WATERS	42.2	38.1	36.3	36.6	34.2	32.9	33.2	35.6	38.0	40.8	43.0	42.3
	26.7	27.1	26.9	25.3	24.3	21.3	22.4	23.4	23.8	23.8	26.3	26.9
NHULUNBUY	34.3	34.5	33.3	32.8	32.2	30.8	29.9	31.0	31.3	34.1	33.5	33.9
	28.2	28.2	28.3	27.3	27.1	25.3	25.0	24.6	25.3	26.6	27.4	28.3
RABBIT FLAT	43.1	41.5	40.3	37.1	33.9	30.9	30.2	34.9	37.0	40.0	42.4	43.0
	25.3	25.5	25.0	23.7	20.8	19.3	17.5	19.6	20.4	22.1	23.8	24.3
RINGWOOD	43.1	42.6	39.7	36.1	31.4	29.2	29.0	33.4	35.4	39.5	41.7	42.8
	24.9	25.2	24.3	21.2	19.4	16.5	17.1	17.5	18.6	19.9	21.0	23.5
ROPER BAR	40.9	39.9	37.6	36.8	35.1	32.9	33.4	35.8	38.4	41.2	41.0	41.8
	27.9	28.1	27.8	27.4	24.8	24.5	23.3	24.5	26.0	27.7	31.3	27.7
TEMPE DOWNS	43.2	42.3	40.1	35.5	31.0	28.5	28.4	31.7	33.8	39.4	40.2	42.4
	24.5	24.8	23.1	21.0	19.4	16.7	16.7	16.9	19.2	21.3	22.3	23.6
TENNANT CREEK MO	41.7	41.6	39.2	36.2	33.7	31.0	30.3	34.1	36.4	39.7	40.9	41.9
	25.0	24.8	25.0	22.7	20.6	18.3	18.1	18.9	20.7	21.7	23.5	24.3
TENNANT CRK PO	41.9	40.9	39.6	36.9	34.1	32.1	31.0	33.0	35.8	39.4	41.4	42.0
	26.4	25.5	24.7	24.6	22.7	19.5	20.5	21.2	21.8	25.7	25.7	26.8
WARRUWI	34.5	34.8	33.6	33.8	32.0	31.2	30.2	31.2	32.8	34.7	35.6	35.4
	29.5	28.7	29.0	27.8	27.2	25.5	24.9	25.7	26.3	28.2	28.5	28.4
WAVE HILL	41.8	39.9	38.3	37.3	34.0	32.8	32.5	35.8	37.2	40.5	41.9	42.2
	28.6	27.4	26.8	25.4	22.9	21.2	21.2	22.9	23.7	24.1	26.1	27.7
WONARAH	43.0	41.6	40.7	37.9	34.7	32.8	31.4	34.0	36.9	40.5	42.8	42.6
	25.7	26.1	24.7	24.1	22.2	19.5	18.8	19.6	23.1	23.2	24.6	26.6
YIRRKALA	35.0	33.6	33.5	32.9	30.9	29.1	28.5	29.7	31.4	32.7	34.3	34.9
	28.6	28.5	27.6	27.7	26.9	26.2	25.8	25.7	25.7	26.7	28.2	29.1
YUENDUMU	41.7	41.0	38.3	34.8	31.0	27.1	27.3	31.6	34.7	37.7	40.4	41.4
	24.4	24.4	24.3	22.7	19.4	17.7	15.4	17.6	19.6	20.1	23.1	25.2
QUEENSLAND												
ADAVALE	41.9	40.4	38.9	36.3	32.0	27.8	27.8	30.1	34.6	38.4	42.1	42.6
	25.4	25.2	23.5	25.2	22.0	22.9	17.4	17.9	22.2	21.3	22.7	25.2
AMBERLEY	38.3	35.7	35.4	32.6	28.2	24.4	25.6	27.5	33.9	35.7	36.2	37.5
	26.3	25.8	24.8	22.9	21.1	18.2	19.0	18.5	20.5	22.7	24.4	25.7
ARCHERFIELD	36.3	33.6	33.5	30.8	26.8	24.6	25.0	25.7	29.9	35.5	34.0	35.5
	27.1	24.9	25.3	23.4	20.9	19.8	19.5	19.3	21.1	23.8	23.8	25.6
BARALABA	38.6	37.3	35.5	33.3	30.4	26.7	26.5	29.4	33.7	35.6	37.7	39.6
	26.6	26.8	25.5	23.8	21.3	19.7	19.4	20.0	22.8	23.7	25.3	26.2
BARCALDINE	40.6	40.0	37.4	34.2	30.4	27.9	27.8	31.5	34.7	37.7	40.4	43.2
	25.6	25.5	24.7	22.9	21.0	18.5	18.7	18.7	20.0	21.4	23.0	25.0
BEAUDESERT	35.1	35.6	34.3	34.8	29.1	25.4	24.0	27.6	30.2	34.7	39.3	36.5
	25.7	26.0	25.2	22.8	20.7	17.5	17.4	18.6	19.4	24.2	24.2	26.2
BIRDSVILLE	44.7	44.1	41.8	37.7	33.1	28.0	28.3	33.0	37.2	40.4	44.3	46.0
	27.7	26.0	24.5	22.5	20.5	17.5	17.2	17.4	19.9	21.1	24.3	24.6
BLACKALL PO	41.9	39.7	39.1	35.6	31.2	27.5	27.4	31.3	35.3	38.3	40.3	42.1
	25.6	26.1	24.7	22.7	21.6	18.5	19.3	18.4	21.1	22.6	24.6	25.9
BLACKALL	42.4	40.9	37.6	36.4	29.3	26.6	26.1	30.8	33.6	38.3	42.3	40.7
	24.4	24.2	24.8	20.9	19.8	17.5	18.4	18.3	19.0	20.3	21.8	23.9

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
QUEENSLAND (Continued)												
BOLLON	42.9	41.0	37.8	32.4	27.9	26.1	26.1	28.4	34.5	38.1	41.1	42.3
	27.4	25.7	25.3	23.2	19.7	17.1	17.7	16.9	19.9	22.0	22.8	24.1
BOULIA	43.2	42.2	39.3	37.7	32.1	30.3	30.4	33.6	36.8	39.4	42.4	43.7
	28.0	26.4	25.8	24.0	20.9	18.9	19.0	18.8	21.9	22.8	24.2	25.9
BOWEN	34.2	33.3	32.3	31.3	28.6	27.3	26.9	27.3	28.4	29.7	31.5	33.6
	28.7	28.9	27.4	27.0	24.7	24.3	22.0	22.2	24.0	26.1	27.2	28.0
BRISBANE AMO	32.8	31.3	30.8	28.5	26.7	24.0	24.3	26.2	28.9	30.8	30.2	34.9
	26.5	26.0	24.4	22.7	21.1	19.1	18.7	19.0	20.8	22.7	24.2	25.9
BRISBANE	35.2	33.3	31.9	30.4	27.1	23.8	25.3	26.4	30.2	31.0	32.2	35.4
	26.4	26.3	24.9	23.1	20.8	18.8	18.4	18.8	20.8	22.3	24.8	25.7
BULBURIN	31.1	31.5	30.0	26.9	24.1	22.5	22.5	24.9	26.7	29.1	30.3	32.0
	24.7	24.9	22.7	22.5	19.4	17.4	16.8	16.9	18.9	21.0	22.9	23.8
BUNDABERG AERO	32.2	31.8	30.9	29.0	27.0	26.2	24.7	25.9	28.1	30.0	30.8	31.2
	26.6	26.2	25.0	24.1	21.7	19.9	19.6	20.0	20.7	22.7	24.4	25.2
BUNDABERG	33.7	32.5	32.0	30.2	27.2	25.2	25.1	25.7	28.2	29.9	30.6	31.7
	27.2	26.4	25.2	23.3	22.1	20.3	20.1	21.2	21.8	23.8	25.2	27.2
BURKETOWN	40.7	38.6	37.9	37.1	35.1	31.5	31.0	34.1	36.8	39.1	39.6	40.5
	28.2	28.7	27.7	25.8	26.2	22.2	22.6	22.8	23.7	26.3	28.0	28.6
BUSTARD HEAD	29.7	29.8	29.0	27.5	24.8	22.5	21.8	21.9	24.1	26.1	27.5	29.4
	26.6	26.6	25.7	24.3	22.7	20.2	19.8	19.8	21.2	23.1	25.2	26.6
CAIRNS	33.8	33.7	33.4	31.2	29.2	27.6	27.7	28.8	29.9	31.0	31.8	33.5
	27.6	27.2	26.9	26.4	24.8	23.9	22.8	22.8	24.1	25.3	26.9	27.3
CALOUNDRA	29.9	29.4	28.6	27.9	24.8	23.1	24.3	25.4	26.3	27.5	27.0	29.9
	26.6	25.8	25.4	23.8	21.3	19.0	18.8	19.7	21.2	22.4	24.1	25.8
CAMOOWEAL	43.1	42.7	40.1	37.9	35.5	32.0	30.6	35.0	39.0	40.8	42.6	42.6
	25.9	27.1	26.0	23.9	21.8	19.2	19.5	20.1	21.0	23.7	24.8	26.1
CAPE CAPRICORN	29.1	29.7	28.9	27.1	24.9	22.2	21.7	22.6	24.5	25.6	27.2	29.2
	27.3	26.5	25.6	24.6	22.6	20.6	20.1	20.1	21.8	23.5	24.7	26.5
CAPE CLEVELAND	33.9	33.0	32.3	31.0	28.5	26.5	26.5	27.3	29.4	30.4	32.0	33.4
	28.6	27.9	26.9	26.0	24.5	23.0	22.4	22.4	24.0	25.4	27.1	28.1
CAPE MORETON	28.1	27.6	27.1	25.8	23.6	21.7	21.2	21.5	24.1	26.3	25.8	27.4
	25.6	25.3	24.2	23.2	21.4	19.8	19.3	18.8	20.5	22.1	23.3	24.7
CARDWELL	35.3	35.1	35.8	33.2	30.0	28.1	28.2	29.1	29.4	31.0	33.0	34.4
	29.0	29.1	28.6	27.4	25.3	23.8	23.7	23.5	25.0	26.3	27.9	27.9
CHARLEVILLE	42.2	40.0	38.1	34.6	29.8	25.2	25.9	28.8	34.3	38.0	38.9	41.4
	24.0	24.2	23.4	20.8	19.6	16.6	16.7	17.0	18.5	20.4	21.8	23.5
CHARTERS TOWERS	39.8	37.2	35.9	33.6	31.0	28.5	28.4	31.1	34.5	37.7	38.6	40.0
	25.6	25.7	24.9	24.9	23.8	20.7	20.2	20.7	22.4	24.3	24.6	26.7
CLERMONT	39.4	37.3	36.8	33.5	29.7	27.6	27.6	30.7	34.0	37.3	38.3	40.9
	29.2	25.3	26.9	22.4	21.9	19.9	19.2	18.7	21.0	22.7	26.6	28.0
CLONCURRY	42.6	40.9	39.1	38.0	33.0	30.8	30.3	34.0	36.0	39.1	42.3	42.7
	26.2	26.2	25.4	22.5	21.4	19.4	18.7	19.7	20.7	22.9	23.6	25.2
COEN PO	34.6	33.4	32.4	32.4	30.8	30.8	30.0	31.9	33.7	36.8	38.5	37.0
	26.7	27.6	27.0	27.1	25.1	26.0	23.2	24.3	23.4	26.3	26.0	26.6
COEN AERO	35.4	34.0	33.0	31.9	31.2	31.4	30.6	31.9	33.3	36.7	36.8	37.1
	25.9	26.3	26.2	25.6	24.7	23.7	23.3	22.6	23.7	24.9	25.4	26.2
COLLINSVILLE	37.8	36.8	33.6	33.5	30.8	30.2	29.2	31.0	33.3	37.4	37.1	38.1
	26.6	27.0	26.6	24.9	22.5	24.7	24.6	21.8	22.1	26.0	26.3	30.3
COOKTOWN AIRPORT	34.5	34.3	33.0	30.8	28.6	28.1	27.1	27.3	28.6	30.0	31.2	34.3
	28.4	28.2	27.7	26.7	25.3	24.7	23.6	23.1	24.1	27.5	26.7	28.0
COOLANGATTA AERO	29.2	29.2	28.4	28.2	25.5	24.1	23.3	23.9	25.7	27.3	29.7	28.5
	26.2	25.6	24.7	23.7	21.9	18.7	18.5	21.1	21.0	21.8	23.0	24.8
COOLANGATTA	29.6	29.7	28.8	28.8	25.7	24.1	23.7	23.7	26.3	26.3	29.8	29.5
	27.8	25.8	25.7	23.9	22.1	19.1	18.1	19.6	21.2	21.9	23.9	26.1

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
QUEENSLAND (Continued)												
CROYDON	38.6	37.2	37.7	36.0	34.3	33.2	32.9	34.9	36.7	39.2	40.5	40.0
	28.1	27.9	28.6	25.3	24.4	22.7	21.1	21.3	23.2	24.8	26.8	27.5
CUNNAMULLA	42.9	41.1	38.7	35.0	29.8	25.1	25.0	28.6	34.1	37.4	39.8	42.1
	26.3	25.6	23.6	20.9	19.0	16.9	16.1	17.3	18.7	20.1	22.2	23.4
DALBY	39.5	36.4	34.4	33.2	27.1	24.0	24.6	25.8	33.2	33.8	36.0	38.6
	26.2	24.7	23.6	22.6	18.9	16.7	16.4	17.7	20.0	21.5	24.3	24.0
DOUBLE ISLAND POINT	29.3	28.9	28.1	26.8	24.5	22.9	23.0	23.1	24.9	27.1	27.3	29.2
	26.6	26.0	25.2	23.5	22.2	20.2	19.5	19.8	21.4	23.2	24.9	26.1
EMERALD	40.4	38.7	37.1	35.1	30.7	26.5	27.5	31.3	36.8	38.1	38.9	42.1
	26.9	26.3	24.7	23.3	21.5	19.0	20.0	19.3	20.9	22.4	24.3	26.7
FITZROY ISLAND	33.8	32.9	32.4	30.1	27.7	27.0	26.4	27.2	29.0	30.4	32.1	33.1
	28.7	28.3	27.6	26.8	24.8	24.2	23.3	23.4	24.5	25.4	26.9	27.9
GAYNDAH	39.3	37.1	36.2	33.5	29.3	26.2	26.7	28.3	34.3	35.9	37.1	39.4
	25.7	25.3	24.3	22.8	21.5	19.2	19.6	20.0	21.4	23.2	24.1	25.4
GEORGETOWN	39.3	38.9	36.1	35.0	33.7	31.2	31.4	33.9	37.3	38.9	39.8	40.5
	26.7	26.9	25.7	25.1	23.2	21.3	21.9	21.9	21.2	23.9	25.3	25.7
GLADSTONE	33.6	32.4	32.2	30.7	27.3	25.4	25.7	26.9	29.0	31.1	32.1	33.8
	27.7	27.4	26.1	24.7	22.9	21.0	20.9	20.8	22.8	24.6	25.3	27.3
GOONDIWINDI	40.4	38.1	35.3	32.6	26.2	23.7	22.7	26.4	32.2	34.3	37.6	39.6
	24.4	24.7	23.9	21.8	19.0	16.5	16.2	16.6	19.5	20.9	23.1	24.5
HERBERTON	32.2	31.8	30.8	28.5	26.8	26.3	25.1	28.0	29.6	32.4	32.5	32.9
	23.3	23.4	22.8	22.0	20.9	19.6	18.6	18.8	20.3	22.9	25.5	25.6
HERON ISLAND	30.7	30.7	30.5	28.3	27.1	24.0	23.7	24.6	25.1	26.9	29.4	30.7
	27.0	26.8	27.1	24.2	23.5	21.2	21.0	21.6	22.5	24.0	25.8	26.7
HUGHENDEN	40.2	39.7	37.4	36.0	32.6	31.1	31.0	32.5	36.7	38.2	40.6	41.8
	28.5	27.1	25.2	24.2	22.2	19.5	20.8	20.2	22.2	24.9	26.6	27.4
INGHAM	37.3	34.8	34.2	31.7	28.7	28.2	27.2	29.7	31.8	33.4	35.0	36.3
	28.4	28.4	27.5	26.1	24.0	23.5	22.5	22.7	24.5	25.9	27.2	28.7
INNISFAIL	33.0	32.7	32.8	29.5	27.7	27.1	26.3	26.3	28.0	29.7	30.5	32.7
	27.7	27.0	27.4	25.6	24.8	23.5	23.0	22.4	23.6	25.1	26.8	27.9
JIMBOOMBA	34.4	33.4	32.5	32.1	28.8	25.6	25.3	27.4	29.8	33.1	33.5	37.5
	25.6	24.6	27.7	23.4	20.3	17.8	19.0	20.2	23.3	22.3	24.6	25.7
KALPOWAR	35.9	35.4	32.5	30.3	26.9	24.7	24.8	26.9	29.1	32.7	35.4	34.9
	25.6	24.5	23.8	21.2	20.6	18.5	17.7	19.3	20.3	21.2	24.2	24.2
KARUMBA	36.7	34.9	35.7	36.6	33.4	31.3	30.9	32.1	34.9	37.0	38.0	36.8
	29.5	28.3	27.7	27.0	24.7	23.6	24.7	26.5	25.6	26.8	29.3	29.1
KINGAROY	35.9	34.2	33.0	30.6	26.5	23.2	23.8	25.2	31.4	34.0	34.3	36.7
	25.0	25.2	23.9	20.8	19.4	18.1	17.3	16.7	18.8	20.5	23.7	24.8
LADY ELLIOT ISLAND	31.8	30.6	30.2	27.9	26.2	23.7	23.1	23.6	25.6	27.9	28.7	30.3
	27.6	27.4	26.4	25.0	23.6	22.2	20.9	21.9	22.7	24.6	25.6	26.9
LOCKHART RIVER	35.2	34.1	33.2	31.4	29.5	29.0	28.6	28.3	30.1	31.2	33.2	35.0
	27.4	27.4	27.0	26.6	25.9	25.4	24.6	23.7	24.8	25.8	26.3	27.4
LONGREACH AMO	42.6	41.0	40.5	35.9	32.3	29.9	29.4	32.7	37.2	39.4	41.8	43.0
	27.1	25.1	24.4	21.5	21.6	18.9	19.2	18.3	19.4	22.0	24.3	25.2
LONGREACH	42.4	41.4	38.3	36.9	31.9	28.7	29.3	32.3	36.0	39.5	43.0	41.9
	26.1	25.9	25.5	23.0	20.3	19.5	18.8	19.5	23.6	21.9	24.6	23.9
LOW ISLES	35.1	34.1	34.6	32.1	29.6	28.0	27.6	29.1	30.2	32.5	33.6	35.0
	28.7	28.9	28.5	27.8	25.8	24.8	24.0	24.1	25.0	26.6	28.0	28.5
MACKAY	32.8	31.3	31.0	28.8	26.6	24.4	24.6	25.1	27.5	29.1	30.6	32.2
	27.6	27.4	26.2	25.1	23.3	21.7	21.5	21.2	23.4	24.8	26.1	27.2
MARYBOROUGH	35.4	34.1	33.3	30.9	28.4	25.7	26.2	27.0	30.9	32.2	33.0	35.4
	27.0	26.6	25.0	23.7	22.0	20.4	20.0	20.0	21.8	23.5	25.1	26.7
MILES	39.9	38.2	35.7	33.4	28.3	24.2	24.6	26.6	32.7	37.4	36.3	39.2
	27.2	24.9	23.0	21.8	19.8	17.3	17.4	17.5	19.3	21.6	23.6	24.5

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Monthly Dry Bulb Temperature °C
Monthly Wet Bulb Temperature °C

QUEENSLAND (Continued)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MITCHELL	38.3	41.2	35.2	31.1	29.0	25.4	27.2	28.9	33.6	35.5	37.6	38.8
	25.1	23.4	23.0	20.3	18.3	15.4	15.4	16.1	18.8	21.2	23.2	24.0
MONTO	38.2	36.4	34.9	32.5	28.4	25.3	26.4	28.1	33.0	35.8	37.1	38.5
	25.7	25.4	24.6	22.6	20.5	18.9	18.9	19.5	20.6	22.7	24.0	25.6
MORETON	34.6	34.7	34.0	33.2	32.2	32.0	31.3	32.9	34.8	36.3	36.8	37.6
	26.9	27.0	27.2	27.3	26.2	25.7	24.5	25.9	24.5	26.3	28.7	26.8
MOUNT GLORIOUS	30.5	29.6	28.6	24.0	21.2	18.8	19.3	20.9	27.3	27.1	28.7	30.7
	23.9	24.9	23.0	20.3	18.1	15.4	15.1	15.0	19.1	20.2	22.5	23.3
MOUNT ISA AMO	41.9	41.0	38.4	36.1	33.4	30.8	29.6	33.4	36.9	39.1	41.0	42.0
	25.0	25.3	24.4	23.0	20.6	18.0	18.8	18.4	20.0	22.2	23.7	24.8
MOUNT ISA PO	42.2	41.0	38.2	37.5	32.7	32.1	31.1	32.9	36.3	39.5	41.8	42.4
	29.5	25.1	25.4	22.9	20.4	19.8	18.7	18.9	22.0	22.4	23.5	25.7
MOUNT ISA MINES	42.0	40.8	38.3	36.0	31.7	29.8	29.3	33.6	35.9	38.4	41.0	41.6
	26.0	25.4	24.2	23.4	20.5	17.9	18.6	18.5	19.7	22.8	23.7	24.2
MOUNT SURPRISE	37.4	36.2	35.0	34.1	32.2	31.0	31.3	33.1	35.2	38.0	40.2	39.0
	24.8	25.8	24.9	22.8	21.9	19.7	21.1	21.8	20.3	22.2	24.1	23.9
MOUNT TAMBORINE	30.7	28.8	28.6	28.8	23.6	20.6	20.3	22.8	25.8	28.6	32.4	32.3
	23.8	23.4	22.8	21.7	18.7	15.9	14.6	17.1	19.0	20.3	22.4	24.1
NORMANTON	39.0	37.2	38.3	36.8	34.9	32.3	32.5	34.8	36.7	38.9	39.9	41.1
	28.0	27.8	27.4	25.3	24.0	22.6	22.7	22.7	24.7	25.6	26.9	27.6
NORTH REEF	32.1	31.0	30.9	29.2	26.5	24.5	24.3	26.2	26.9	27.9	30.9	31.3
	27.4	27.3	26.2	25.1	23.5	21.1	21.9	22.8	23.1	24.5	26.3	26.7
OAKEY	37.7	34.6	32.6	31.7	27.0	23.0	23.7	24.8	31.6	32.2	34.5	37.7
	24.0	24.6	22.9	20.5	18.2	16.0	16.9	15.6	17.8	20.9	21.8	24.1
PALMERVILLE	37.5	37.1	34.7	34.2	33.6	32.4	32.2	34.6	37.2	39.0	39.5	39.0
	26.8	26.9	26.8	25.2	24.8	23.2	22.3	22.0	23.1	24.4	25.4	26.6
PINE ISLET	33.0	32.3	31.6	29.7	26.8	24.3	24.0	25.1	26.8	29.3	30.8	32.9
	27.6	27.9	26.5	25.2	23.8	21.9	21.6	21.8	23.6	25.0	25.8	27.8
QUILPIE	43.3	42.2	39.4	36.0	31.2	26.4	26.3	30.3	35.0	38.2	41.0	43.1
	25.2	25.0	24.0	21.2	19.9	17.6	16.6	17.6	18.1	21.1	22.4	24.5
RICHMOND	41.9	41.2	39.0	37.6	34.3	31.1	32.2	35.0	38.4	40.7	42.3	43.7
	27.1	27.5	26.3	24.4	22.8	20.7	21.2	20.8	21.2	23.7	25.8	26.7
ROCKHAMPTON	37.6	35.4	34.2	32.9	29.6	26.8	27.1	29.1	32.9	35.5	36.3	38.4
	27.8	26.6	25.4	23.9	22.1	20.6	20.8	20.5	21.6	24.2	24.8	26.8
ROMA	41.6	39.2	36.7	34.8	28.1	25.5	26.2	28.4	34.5	36.3	38.9	40.4
	26.2	25.4	24.7	22.2	19.4	17.4	17.6	17.1	20.3	20.3	22.8	24.6
SANDY CAPE	29.7	30.0	28.8	27.5	25.7	23.2	23.0	23.3	24.7	26.2	27.2	29.0
	26.3	26.0	25.0	23.8	22.0	20.2	19.9	19.8	21.5	23.1	23.9	25.7
SOMERSET DAM	37.0	37.4	34.1	31.9	26.3	24.6	23.8	26.8	31.0	34.3	38.5	36.3
	26.4	25.9	24.5	22.2	22.4	18.3	18.3	19.5	19.8	25.6	24.8	25.8
SOUTHPORT	32.3	31.7	31.4	30.3	26.8	23.8	24.6	25.3	29.9	30.8	31.3	33.6
	26.5	26.1	25.4	23.2	21.6	19.0	19.1	19.0	21.5	23.5	23.8	26.2
ST GEORGE	41.6	40.5	37.6	35.0	28.5	24.8	24.1	28.1	33.6	37.3	38.9	41.6
	25.1	25.4	24.3	22.3	19.2	16.2	16.6	16.2	20.7	21.7	23.1	23.9
ST LAWRENCE	33.5	34.2	34.5	31.5	29.4	27.2	26.8	28.4	31.2	31.9	34.6	34.0
	26.9	27.1	26.5	23.8	22.8	21.7	19.9	21.4	22.8	24.4	26.2	26.3
STANTHORPE	35.3	33.9	30.7	28.0	22.7	19.2	18.7	22.2	27.4	29.2	31.7	34.1
	23.7	22.8	21.0	18.9	16.5	13.8	13.1	14.2	17.0	18.2	20.2	21.6
SURAT	41.8	40.2	36.8	34.2	28.3	25.4	24.3	27.4	34.4	36.1	39.3	39.6
	26.1	25.7	24.3	22.8	18.6	17.1	16.2	17.0	20.5	22.8	24.8	25.1
TAMBO	41.2	39.3	36.4	34.3	29.2	25.9	26.8	29.8	32.6	37.3	40.3	40.5
	25.3	25.4	24.2	21.3	20.5	18.5	16.5	18.6	21.5	23.0	22.7	24.6
TAROOM	40.3	37.3	37.0	34.2	30.3	26.2	25.9	28.4	33.9	34.5	37.9	39.5
	26.5	25.4	25.1	22.7	19.7	17.6	18.8	18.0	19.5	24.3	24.4	25.1

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Monthly Dry Bulb Temperature °C
Monthly Wet Bulb Temperature °C

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
QUEENSLAND (Continued)												
TEWANTIN	36.0	30.4	30.8	29.7	26.3	25.0	25.2	26.9	30.5	32.9	32.7	34.4
	27.4	26.3	26.2	23.2	23.2	20.0	20.0	19.9	22.8	24.3	24.7	26.6
THARGOMINDAH	44.2	43.1	39.2	35.4	30.8	26.2	25.3	29.1	35.6	38.1	41.3	43.9
	25.2	25.2	24.4	21.3	19.4	17.2	15.7	17.2	20.1	20.7	22.8	25.2
THURSDAY ISLAND	32.0	31.3	31.1	30.5	30.1	29.2	28.5	28.5	29.2	30.6	31.7	32.3
	27.2	27.3	27.2	27.0	26.5	25.0	24.8	24.2	24.4	25.8	26.6	26.8
TOOWOOMBA	36.4	31.9	31.2	28.6	24.5	20.3	20.8	23.5	28.1	32.6	32.3	34.1
	25.3	24.8	23.6	20.9	18.9	16.5	16.2	16.2	17.7	21.4	22.4	24.7
TOWNSVILLE	34.4	33.0	33.7	32.0	29.1	27.5	26.8	28.6	31.2	31.7	33.5	36.3
	27.7	27.8	26.6	25.5	24.0	22.4	21.5	21.7	22.8	24.8	26.3	27.2
TWIN HILLS	40.2	38.0	36.5	33.8	30.6	28.7	29.5	31.7	35.1	37.7	39.4	41.8
	25.5	26.4	24.8	23.0	21.6	19.1	19.7	19.8	21.6	22.1	23.8	25.1
URANDANGIE	44.0	41.7	40.3	37.1	33.3	30.1	32.1	35.0	37.5	40.0	42.2	43.6
	26.1	26.2	25.8	21.9	20.7	18.2	18.9	19.5	21.9	22.9	24.8	25.8
WARWICK	37.8	36.3	33.4	30.3	25.3	21.6	21.1	24.2	30.3	32.1	34.8	36.8
	23.7	24.3	23.3	20.3	17.7	15.1	14.5	15.2	18.2	19.7	21.6	23.3
WEIPA	34.8	34.3	33.6	33.6	33.2	32.5	32.1	34.0	35.7	36.6	36.9	36.0
	28.4	28.2	28.3	27.8	26.5	25.7	24.8	24.8	25.8	27.2	28.4	28.4
WINDORAH	45.0	42.7	40.3	37.3	33.4	28.2	27.6	32.0	36.7	40.7	42.9	44.3
	26.0	25.6	24.9	21.9	21.2	18.4	18.6	18.7	20.3	23.0	23.6	24.4
WINTON	42.5	41.9	38.9	37.2	33.1	30.6	30.4	33.6	37.0	39.5	42.1	43.8
	26.4	26.4	25.1	23.1	21.6	19.4	19.0	18.8	20.9	22.1	24.8	25.8
SOUTH AUSTRALIA												
ADELAIDE (KENTTOWN)	40.5	41.2	36.7	32.3	26.2	21.7	19.8	23.9	29.8	34.1	36.8	38.8
	23.0	23.3	23.0	20.2	17.9	14.6	13.8	14.2	16.7	18.0	20.3	22.6
ADELAIDE (WEST TERRACE)	38.4	37.8	34.3	32.0	26.1	20.8	19.9	21.9	26.4	31.2	33.4	37.2
	22.8	22.6	21.4	19.6	17.2	14.6	14.2	14.0	16.3	18.6	20.3	20.5
ADELAIDE AIRPORT	39.6	40.0	35.8	32.1	25.7	20.9	19.3	22.8	29.1	33.1	36.1	38.6
	21.9	22.5	21.9	20.2	17.8	15.0	13.6	14.5	16.2	18.1	19.7	21.3
ALTHORPE ISLAND	33.2	35.2	29.6	26.6	21.4	17.7	16.8	18.3	22.9	27.2	30.7	35.9
	22.1	21.3	19.5	19.6	17.1	14.5	14.5	14.4	15.1	16.7	18.4	19.6
ANDAMOOKA	44.6	43.3	41.1	34.8	29.2	22.2	23.0	28.7	34.5	38.0	42.0	42.8
	24.6	24.1	24.9	21.4	17.9	14.5	13.8	15.6	17.8	18.9	22.1	23.4
BELAIR	38.3	38.4	36.4	31.0	24.6	18.6	15.9	20.3	25.1	30.2	33.1	36.2
	21.5	22.3	20.8	19.8	16.2	13.4	12.3	13.9	14.8	18.4	18.6	20.4
BERRI	43.0	42.8	39.5	34.5	26.7	23.4	21.0	27.2	31.0	34.2	40.8	40.5
	24.6	23.7	22.0	19.9	18.0	15.9	14.4	15.7	16.9	19.7	21.3	23.0
CAPE BORDA	31.8	31.7	28.9	24.5	19.8	16.3	15.8	17.0	20.9	24.6	28.3	29.8
	20.3	20.0	19.3	18.3	16.1	14.5	13.4	13.6	14.5	15.6	18.0	18.5
CAPE NORTHUMBERLAND	31.9	31.1	30.3	28.1	23.6	17.2	16.7	20.1	23.6	27.4	30.1	31.4
	21.7	22.1	20.5	19.0	16.9	14.5	13.8	14.9	16.8	19.0	20.4	20.9
CAPE WILLOUGHBY	34.6	33.5	29.3	25.9	21.1	17.3	16.5	18.8	21.5	25.5	29.7	32.8
	20.3	20.9	20.3	19.6	16.7	14.0	13.4	13.8	14.9	16.9	17.8	19.6
CEDUNA	43.5	42.7	41.2	35.7	29.3	24.1	23.4	28.3	36.0	38.1	40.8	41.8
	23.0	23.0	21.4	20.2	17.2	15.5	14.3	14.7	17.5	17.9	20.3	21.9
CLARE	40.0	38.1	36.7	31.0	26.0	19.6	17.1	21.3	26.4	31.0	35.6	37.6
	23.3	22.6	20.7	18.5	16.0	14.5	12.4	13.9	15.5	18.2	17.7	20.5
CLEVE	40.8	39.5	37.6	33.1	26.3	21.9	19.3	23.5	30.8	34.6	38.1	38.4
	24.7	22.4	20.6	19.3	16.8	14.4	13.5	15.0	15.7	17.7	18.0	21.0
COOBER PEDY	44.2	43.3	41.5	37.5	29.1	23.9	25.6	30.3	35.6	39.1	42.5	43.3
	24.4	25.0	24.0	20.7	17.8	15.0	13.9	15.3	17.4	18.5	21.9	22.4

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Monthly Dry Bulb Temperature °C
Monthly Wet Bulb Temperature °C

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
SOUTH AUSTRALIA (Continued)												
COOK	45.5	44.0	41.8	37.1	30.9	24.3	24.2	30.5	35.5	39.8	41.9	41.7
	23.8	23.2	22.4	19.2	17.5	15.3	14.5	16.3	17.8	20.0	20.9	23.8
ELLISTON	37.0	33.7	33.9	29.1	25.1	21.4	19.6	23.7	26.8	33.2	35.1	32.5
	21.9	21.5	20.4	19.9	17.4	15.6	14.8	15.3	17.1	19.3	20.5	21.6
ERNABELLA	40.5	40.6	38.8	34.8	27.6	26.3	24.8	28.3	32.5	37.2	39.7	40.5
	23.2	23.4	22.2	20.7	17.8	15.6	14.3	16.7	20.1	24.2	19.8	22.2
FOWLERS BAY	38.1	35.7	38.0	34.4	28.3	26.5	23.5	26.9	33.5	36.0	39.1	39.0
	23.3	22.1	21.4	20.2	19.8	17.6	15.6	16.5	18.9	19.4	20.8	23.1
GEORGETOWN	41.4	39.9	37.7	32.7	25.8	20.8	18.7	22.5	29.6	34.5	38.7	38.7
	23.5	22.7	22.1	19.5	17.0	14.4	13.2	14.9	16.2	20.1	21.0	22.9
HAWKER	41.9	40.4	36.2	32.7	27.2	21.2	20.4	25.9	27.8	34.9	36.2	39.2
	23.7	23.5	21.8	18.9	16.3	15.2	14.2	15.7	16.6	20.0	20.7	21.0
KADINA	42.0	42.1	37.2	31.1	25.7	19.3	20.0	26.4	29.2	33.5	38.7	40.9
	23.1	24.6	21.9	21.1	16.7	14.5	13.8	14.9	17.5	19.3	21.7	22.3
KAPUNDA	41.4	38.4	35.3	32.1	24.5	24.6	18.6	21.5	29.1	32.4	38.4	39.3
	23.8	21.8	20.3	19.1	15.8	14.6	12.3	13.3	17.2	19.0	20.6	24.7
KEITH	42.1	41.8	37.5	32.4	26.1	19.9	18.9	22.6	30.1	32.2	38.3	39.7
	23.2	22.8	22.7	20.0	17.1	14.6	13.4	14.1	16.8	18.3	20.7	21.3
KIMBA	43.1	41.2	36.7	33.5	27.6	20.6	20.0	23.6	29.0	34.6	37.1	39.8
	23.2	22.8	21.3	20.2	18.7	13.3	16.7	13.9	14.9	18.2	23.2	21.2
KINGSCOTE	34.2	33.1	32.5	27.6	22.7	18.0	16.7	17.4	21.6	26.3	30.6	30.3
	22.9	25.5	22.6	19.9	17.6	14.7	13.8	13.8	15.6	20.6	20.8	20.4
KYANCUTTA	44.7	42.9	39.7	34.2	29.5	22.3	23.4	28.9	34.2	37.0	41.3	43.6
	23.9	24.9	22.3	21.1	17.0	14.7	15.4	15.2	17.8	19.5	21.7	23.1
LAMEROO	42.6	42.3	38.6	33.0	26.9	20.5	19.7	25.1	30.8	33.5	38.9	40.2
	23.4	23.3	23.0	19.8	17.4	14.9	14.3	14.6	17.4	18.3	21.0	21.8
LEIGH CREEK	43.3	42.1	39.2	33.2	28.3	22.9	24.3	28.5	33.6	36.2	40.3	42.5
	24.8	25.3	23.4	20.5	18.4	14.1	15.2	15.5	18.9	19.9	21.4	22.9
LOXTON	42.2	42.3	38.6	32.5	28.1	21.1	24.2	29.1	31.5	34.2	39.7	40.5
	24.8	24.4	23.3	20.5	18.2	14.3	15.1	15.5	18.4	19.6	22.2	22.5
LUCINDALE	41.7	42.2	37.5	30.9	24.6	18.4	17.8	21.3	26.2	28.9	35.9	38.9
	23.6	22.2	22.4	19.2	16.9	14.2	13.4	14.4	17.3	18.2	22.2	21.5
MAITLAND	40.7	41.0	36.9	31.9	25.3	19.2	18.8	23.2	28.9	32.7	37.2	39.0
	23.8	23.5	21.6	20.1	16.4	13.6	13.6	13.9	16.6	18.1	20.6	20.7
MARALINGA	42.9	41.0	39.2	34.9	29.2	25.0	24.3	27.7	33.9	37.6	40.2	41.1
	25.9	22.6	21.5	19.9	17.5	15.1	14.4	15.2	17.0	19.7	20.0	22.8
MARREE	46.1	43.0	41.5	35.7	30.3	25.7	28.6	28.4	34.8	36.8	42.6	44.0
	25.3	25.8	23.9	20.4	20.5	16.0	16.2	15.8	21.4	22.3	22.7	24.7
MINNIPA	43.4	41.3	38.4	31.4	28.4	20.4	22.1	27.4	32.5	33.6	39.5	41.7
	24.8	25.8	23.1	21.3	18.5	14.5	15.5	17.6	17.1	21.3	24.9	24.8
MOOMBA	43.8	42.5	40.3	35.7	31.6	26.8	25.9	30.4	35.6	39.2	41.7	43.9
	25.3	24.6	25.8	21.3	21.6	17.8	15.8	16.9	18.7	20.8	22.5	23.2
MOUNT BARKER	39.4	39.3	34.6	29.6	24.2	18.0	18.3	21.4	26.1	30.2	34.1	37.7
	24.3	23.9	23.3	20.0	17.3	12.5	12.6	13.6	16.5	20.9	20.1	21.8
MOUNT GAMBIER	39.9	39.1	35.2	30.3	24.4	17.7	16.8	19.6	25.5	28.2	33.5	37.3
	20.8	21.1	21.7	19.3	17.2	13.9	12.9	13.7	16.5	17.0	19.7	20.3
MURRAY BRIDGE	41.3	42.5	38.1	33.1	26.3	20.8	21.0	25.9	28.6	33.0	38.3	39.6
	23.6	23.3	22.4	21.3	16.5	14.0	13.6	14.4	17.5	19.8	20.7	21.6
NARACOORTE	41.3	41.3	35.4	31.3	25.5	18.0	18.7	23.0	26.5	31.1	36.5	40.3
	24.3	23.6	21.1	19.7	17.9	14.6	13.2	15.3	17.3	19.2	21.3	22.8
NEPTUNE ISLAND	27.3	27.7	25.2	22.8	20.7	18.5	17.6	18.4	19.9	23.3	24.6	25.9
	22.0	22.1	21.6	19.6	17.8	16.0	14.9	15.3	16.9	17.7	18.8	20.6
NONNING	42.6	42.6	39.2	35.0	27.3	20.9	21.2	27.9	33.1	34.6	40.0	40.7
	22.7	22.5	22.1	20.2	15.8	13.5	13.5	15.9	15.9	17.6	20.4	23.6

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C											
	SOUTH AUSTRALIA (Continued)											
NURIOOTPA	40.3	40.1	36.6	31.7	24.9	19.3	17.9	22.5	27.4	31.7	36.2	37.7
	22.0	23.1	21.6	19.1	16.1	13.6	12.3	12.9	16.8	17.7	20.3	21.2
OODNADATTA	43.7	41.9	40.0	35.8	31.0	27.7	29.6	32.7	35.5	40.5	40.9	43.6
	25.7	25.0	23.4	20.8	18.9	15.5	16.5	16.6	19.6	20.7	21.1	24.2
PARNDANA EAST	39.1	39.6	34.6	28.9	22.5	16.2	17.0	19.4	22.9	28.9	33.1	37.6
	22.5	22.3	21.5	18.7	16.4	13.6	14.0	13.7	16.1	17.7	19.5	21.3
PENFIELD	39.9	40.5	35.5	32.8	26.1	19.7	22.3	27.5	25.7	33.0	36.7	39.2
	25.0	24.9	23.0	19.8	17.9	14.9	14.9	15.2	16.6	19.6	21.7	22.9
POLDA BASIN	43.8	42.4	38.8	33.9	28.2	21.5	21.6	27.1	32.3	35.9	39.6	41.6
	22.8	23.3	21.4	19.8	16.6	14.7	14.6	15.1	17.9	18.5	20.7	21.3
PORT AUGUSTA POWER STATION	43.4	42.3	40.0	35.3	27.9	22.5	21.7	27.9	33.3	36.1	40.8	40.8
	24.4	24.4	23.6	21.2	18.4	15.4	14.1	14.9	17.1	18.4	22.3	23.1
PORT AUGUSTA	44.1	41.3	38.4	34.4	28.3	26.0	21.7	26.2	33.4	36.6	41.2	43.6
	25.8	25.1	24.1	22.4	18.4	16.3	14.7	14.8	20.0	21.0	24.7	25.1
PORT LINCOLN	35.3	34.2	33.6	33.8	24.9	20.5	20.2	23.7	30.3	32.2	35.3	34.5
	23.0	22.7	21.7	20.5	17.6	15.4	15.3	16.9	17.0	18.7	20.6	21.5
PORT PIRIE	41.8	42.0	38.6	33.0	27.4	20.2	21.1	26.9	30.9	34.1	39.2	40.2
	23.7	23.7	22.3	21.7	17.9	14.5	13.8	15.0	17.3	19.4	21.4	22.1
RENMARK	43.2	42.4	39.8	35.3	27.4	22.2	21.6	26.9	33.0	33.9	40.1	40.7
	24.0	22.6	23.2	20.4	17.4	15.3	14.1	14.7	18.9	18.9	21.7	22.5
ROBE	30.8	32.6	29.9	25.7	21.7	16.6	15.9	17.8	19.9	24.1	28.1	32.2
	22.6	21.4	23.1	19.1	17.9	14.8	13.8	14.6	16.0	18.3	20.2	22.2
ROSEWORTHY	40.5	40.3	36.4	32.5	27.3	20.8	22.4	25.0	28.2	32.0	36.8	40.6
	23.8	22.4	21.6	20.5	16.9	14.2	14.4	14.9	17.4	19.3	20.6	21.8
SNOWTOWN	42.7	40.1	38.4	33.4	27.0	21.9	19.3	23.3	30.6	35.5	38.8	39.9
	26.3	22.6	22.0	19.5	17.2	15.2	13.8	15.6	18.6	22.7	19.8	22.5
STIRLING PO	37.0	37.4	32.2	27.0	22.0	16.7	16.6	20.4	24.3	28.3	32.3	35.2
	22.3	22.4	20.9	18.6	14.8	11.4	11.7	11.9	14.5	16.5	20.1	20.6
STIRLING	37.1	35.0	32.2	28.3	21.4	20.2	14.4	18.6	26.1	28.1	34.7	36.0
	22.0	19.7	18.9	17.9	13.8	13.9	11.1	12.1	14.1	17.3	19.5	20.6
STRATHALBYN	40.6	41.5	36.5	31.8	26.4	20.5	19.8	24.6	27.2	32.5	36.2	39.9
	22.5	24.2	21.3	20.9	17.1	14.9	13.5	15.4	17.3	19.2	20.7	22.4
STREAKY BAY	40.9	41.0	37.0	31.3	27.0	20.1	20.3	25.3	30.2	33.2	39.1	40.4
	24.7	24.5	23.0	20.8	18.6	15.8	15.0	15.7	19.0	19.9	22.2	24.4
TARCOOLA	45.5	43.3	40.3	37.5	29.4	23.8	23.7	28.9	36.4	39.0	41.9	42.6
	23.1	23.0	23.0	20.0	17.3	15.2	13.2	15.5	17.6	18.4	21.0	22.4
TROUBRIDGE SHOAL	31.7	34.5	28.7	25.9	22.9	18.3	18.3	21.6	24.7	24.6	27.6	36.8
	22.5	23.1	21.4	20.4	18.0	15.1	14.5	14.7	16.6	18.3	20.4	22.4
TURRETFIELD	42.0	42.6	37.3	32.6	26.2	20.0	19.9	25.5	27.8	32.6	37.7	40.5
	22.7	22.1	21.3	20.2	16.4	13.4	13.1	14.1	16.9	18.7	20.4	20.9
VICTOR HARBOUR	39.8	39.9	34.7	30.4	26.1	19.7	20.2	23.8	27.4	32.0	35.9	39.8
	23.4	22.9	22.0	20.4	17.1	14.5	14.4	14.7	16.3	18.4	20.1	21.5
WHYALLA	43.9	42.5	38.6	34.3	28.7	22.6	22.8	29.6	34.4	36.7	40.2	42.1
	24.3	23.9	23.5	20.9	17.2	14.5	13.9	15.0	16.9	19.0	20.7	22.2
WOOMERA	44.3	42.8	40.0	35.7	27.3	22.7	21.7	28.2	34.2	38.5	40.4	41.1
	23.1	23.1	22.3	19.6	18.0	14.8	13.0	13.7	16.7	17.7	20.5	21.9
YONGALA	40.2	39.0	33.7	31.0	22.5	20.1	21.8	25.6	26.9	33.5	37.4	38.6
	21.9	22.0	20.0	17.9	15.8	12.0	12.6	13.5	16.6	21.3	22.2	26.6
YUNTA	42.1	42.0	39.1	33.0	25.6	22.2	20.3	25.7	32.9	36.4	41.1	42.1
	23.6	23.4	20.2	17.1	18.3	14.4	12.9	13.5	16.5	18.3	21.8	22.0

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
TASMANIA												
BICHENO	24.7	29.2	24.9	23.0	21.1	16.5	16.6	16.7	19.2	21.7	23.8	26.8
	18.9	19.8	20.1	18.9	16.1	12.6	11.6	12.3	13.2	15.3	16.6	18.2
BUSHY PARK	34.1	35.7	29.4	26.9	21.1	16.2	15.4	17.6	23.0	25.5	30.9	31.4
	19.8	20.5	19.9	18.2	15.2	12.1	11.7	12.1	15.0	16.3	19.3	19.1
BUTLERS GORGE	31.5	28.1	27.0	21.3	17.3	12.6	10.2	13.3	17.6	22.3	25.2	28.6
	22.7	23.0	20.1	15.3	11.6	9.4	7.8	9.0	10.7	14.4	20.2	19.2
CAMBRIDGE	31.9	31.1	30.1	25.0	19.6	16.8	15.4	17.9	22.2	24.3	25.3	31.1
	20.4	19.8	18.8	18.4	14.4	13.0	11.4	12.1	15.0	16.1	16.5	19.1
CAMPBELL TOWN	33.9	32.5	29.4	22.7	18.2	15.4	14.5	15.4	18.8	25.4	26.7	30.9
	21.3	19.5	19.0	16.1	14.2	12.6	10.7	10.4	13.7	17.3	18.2	19.0
CAPE BRUNY	26.7	32.2	25.7	23.7	19.0	16.6	14.2	16.5	18.7	23.4	25.2	24.7
	18.4	19.1	18.7	17.6	14.7	12.9	11.2	11.6	13.4	15.3	16.8	17.3
CAPE SORELL	24.6	22.8	22.6	20.5	16.9	15.6	13.9	15.6	16.9	19.6	21.3	23.2
	21.1	20.3	19.4	17.9	15.7	13.8	12.8	13.5	14.8	16.5	17.8	20.3
CRESSY	32.2	32.7	28.2	23.5	18.1	14.9	14.0	16.1	18.8	23.2	27.3	30.2
	21.2	20.3	19.5	17.5	14.8	13.1	11.1	11.9	13.9	16.2	18.7	19.0
DEAL ISLAND	27.6	26.9	24.7	21.6	19.1	16.6	14.7	14.5	21.3	20.7	26.9	24.0
	21.0	20.2	19.8	18.1	17.4	14.2	13.2	12.5	15.3	15.0	18.3	20.0
DEVONPORT EAST	25.1	25.5	23.5	21.6	18.8	16.0	14.6	15.7	17.1	20.1	21.7	24.4
	20.0	20.0	19.6	18.6	16.6	13.9	12.3	12.5	14.0	15.7	17.4	18.7
DEVONPORT	25.7	26.1	25.4	21.3	18.6	16.3	15.2	15.5	16.9	19.7	21.2	24.2
	20.6	20.9	21.1	17.8	15.9	13.8	12.1	12.7	13.4	15.3	16.2	19.4
EDDYSTONE POINT	25.4	24.4	23.3	20.3	17.6	15.2	15.0	16.8	18.5	20.3	24.8	22.9
	20.1	20.6	19.9	18.2	15.9	13.8	12.6	13.6	13.9	15.9	17.9	18.7
ERRIBA	26.4	28.0	24.1	19.7	15.6	11.2	10.9	13.6	17.9	17.9	23.5	25.0
	18.6	18.6	18.3	16.0	12.8	10.1	8.4	9.5	13.1	14.3	16.5	18.7
FLINDERS IS.AIRPORT	33.0	29.2	30.5	24.2	21.6	16.0	14.8	16.6	19.8	24.3	27.5	28.5
	20.8	23.7	19.3	17.3	15.6	14.1	12.6	13.2	14.5	17.8	18.3	21.2
GROVE	33.0	32.8	30.3	25.7	21.4	16.0	16.2	17.3	21.7	25.3	25.9	30.9
	21.0	22.4	19.9	17.1	14.8	12.5	11.7	12.2	13.9	16.0	18.3	20.4
HASTINGS	30.7	29.3	26.9	24.6	19.4	14.6	16.3	18.3	19.6	25.8	26.6	28.5
	21.1	19.7	20.0	18.0	16.2	13.1	12.0	12.5	14.0	17.9	18.2	21.2
HOBART AIRPORT	31.4	36.1	28.9	25.8	21.5	17.9	16.2	18.8	22.2	24.8	29.8	30.2
	19.4	20.4	20.0	18.1	15.5	13.0	11.7	12.6	14.7	16.0	18.7	18.4
HOBART REGIONAL OFFICE	31.7	36.6	29.0	25.9	21.8	17.2	16.3	18.6	23.2	25.3	31.3	29.2
	19.5	20.1	19.5	17.8	14.9	12.5	11.4	12.2	14.5	16.0	18.3	18.3
KING I. (CURRIE PO)	29.8	31.4	28.2	24.1	19.6	16.7	14.9	16.8	19.5	22.9	26.6	28.5
	23.2	21.5	20.3	18.8	16.9	13.9	13.1	13.8	15.4	16.5	20.6	20.7
KINGSTON	32.7	29.9	27.9	25.0	21.9	17.1	15.9	17.4	24.1	26.2	26.4	30.2
	24.3	24.1	19.8	17.6	15.9	13.9	12.6	12.2	15.5	15.9	17.9	19.1
LAKE LEAKE	29.9	30.5	26.4	21.2	16.6	11.3	10.7	14.2	15.7	20.6	25.0	26.8
	20.0	18.1	18.6	16.5	12.7	9.7	8.4	9.8	12.6	14.1	16.4	16.7
LAUNCESTON (ELPHIN)	32.0	31.2	29.1	23.8	20.2	16.5	15.7	16.7	19.6	24.2	25.3	29.3
	23.2	21.2	20.7	17.5	15.8	14.1	12.6	12.7	14.1	18.1	18.6	20.9
LAUNCESTON (TI TREE BEND)	33.1	32.7	29.8	25.5	19.9	16.3	14.7	16.9	19.8	23.0	27.3	29.1
	21.2	23.4	21.2	18.9	15.7	13.0	11.4	13.0	13.8	16.2	18.4	18.7
LAUNCESTON AMO	31.8	31.6	27.2	24.8	18.9	15.1	13.3	15.8	19.6	21.3	26.2	30.4
	19.8	19.6	19.2	17.4	15.5	12.3	11.0	11.6	13.9	15.1	17.7	19.4
LOW HEAD	26.6	26.7	25.2	23.1	20.4	16.3	15.0	15.7	17.7	19.7	22.7	24.9
	21.0	21.3	20.5	18.7	17.6	14.0	12.9	13.3	14.6	16.5	18.0	19.7
MAATSUYKER ISLAND	24.3	25.3	25.3	23.4	19.2	15.9	14.4	15.9	16.7	21.3	22.1	23.6
	18.4	18.9	18.4	17.3	14.7	12.9	11.5	12.0	12.5	14.7	17.1	17.9

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
	TASMANIA (Continued)											
MARRAWAH	26.1	27.4	24.9	21.3	18.3	14.3	13.9	15.3	17.2	18.8	22.8	26.2
	20.3	20.8	19.7	18.8	16.2	12.9	12.1	12.9	14.4	15.5	17.7	20.0
MAYDENA	31.9	31.5	30.2	23.8	19.7	13.6	14.0	16.6	19.7	23.0	26.9	31.4
	20.4	21.9	19.0	17.0	14.3	11.1	11.0	12.1	12.4	14.8	16.4	18.9
MOUNT WELLINGTON	21.7	23.9	22.3	14.8	11.7	7.7	5.6	7.7	11.8	17.5	20.7	21.4
	14.1	16.9	14.3	10.5	7.8	5.8	4.6	5.2	7.5	10.4	11.2	12.4
NEW NORFOLK	34.0	34.4	29.5	26.1	19.6	15.9	15.7	18.0	21.4	26.1	27.6	31.4
	20.8	22.1	19.4	16.8	14.0	12.5	11.7	12.1	14.0	15.8	18.2	20.0
OATLANDS	31.4	29.4	29.9	20.5	16.7	14.1	11.9	15.1	17.3	24.0	26.5	30.4
	19.9	17.7	17.7	15.1	12.8	10.8	9.4	10.3	13.4	15.9	20.4	19.2
ORFORD	28.9	30.4	26.7	23.3	19.7	16.2	15.1	19.3	20.1	25.7	29.1	25.5
	20.4	21.9	20.4	18.1	16.4	13.0	11.9	13.2	13.9	17.4	18.2	19.4
PALMERS LOOKOUT	28.1	32.7	24.8	22.8	18.9	15.9	13.6	16.1	19.6	22.3	24.8	25.2
	19.0	19.3	19.3	17.4	14.8	12.3	10.9	11.2	12.6	14.9	17.9	17.1
PALMERSTON	33.5	33.2	29.6	24.5	18.7	15.0	14.2	16.1	18.3	25.4	28.7	28.9
	22.7	21.6	20.4	17.9	15.4	12.8	11.7	12.0	14.4	17.4	19.8	20.1
PREOLENNA	26.2	27.1	24.2	20.1	16.3	12.8	12.4	15.1	15.9	21.2	24.7	26.4
	20.7	20.6	19.4	17.7	14.5	11.3	10.2	11.7	12.9	15.3	17.2	19.2
QUEENSTOWN	32.3	31.9	28.5	26.5	21.6	15.7	14.8	17.8	20.3	24.6	27.4	33.2
	20.4	20.3	19.5	19.5	15.7	12.5	11.5	12.0	14.3	16.3	17.8	19.2
QUOIBA	26.4	26.9	24.6	22.1	18.0	15.7	15.4	15.9	17.2	20.9	23.9	26.0
	20.9	21.0	20.4	18.5	15.4	13.1	12.0	12.4	14.2	16.6	18.5	19.0
REDPA	29.5	27.4	26.4	20.1	17.5	14.8	13.3	14.7	16.7	20.8	20.5	26.2
	20.9	19.8	19.5	16.9	14.5	13.4	12.3	12.3	13.7	16.2	16.4	20.3
RISDON	33.5	31.8	32.0	25.1	21.5	16.9	15.5	18.5	22.8	26.5	28.0	31.3
	21.0	22.5	19.7	17.0	15.6	13.2	12.0	13.5	15.1	22.3	18.6	18.8
SAVAGE RIVER	28.1	32.0	27.0	22.5	18.3	13.9	11.9	15.4	17.0	21.5	21.7	27.3
	21.7	21.1	20.3	17.8	15.2	12.4	10.9	12.4	12.5	15.1	17.3	18.8
SCAMANDER	30.8	30.8	27.4	25.0	20.7	17.1	16.4	19.4	21.3	25.4	29.2	26.9
	20.4	20.6	19.7	18.0	16.1	13.5	12.5	13.4	15.1	16.2	18.0	17.7
SCOTTSDALE (KRAFT FOODS)	27.2	30.2	27.5	22.2	18.4	14.1	13.2	16.3	16.6	21.5	23.6	25.8
	21.8	22.2	20.8	17.5	15.0	12.3	11.0	13.2	14.2	15.8	18.4	20.0
SCOTTSDALE 2	31.0	28.9	27.8	21.7	18.6	15.4	14.5	16.0	18.5	22.8	24.5	25.9
	22.4	21.4	21.0	17.0	15.7	13.5	11.6	11.8	14.1	16.4	18.8	20.0
SHANNON HEC	28.6	24.3	25.0	18.9	14.6	12.4	8.7	11.7	15.8	19.3	22.7	26.4
	20.8	15.4	15.0	13.1	9.3	7.7	6.4	7.1	9.4	14.8	15.1	18.5
SMITHTON	24.5	26.7	24.3	21.7	17.7	15.6	14.6	15.9	16.7	21.9	22.4	24.1
	19.9	21.7	20.0	17.9	15.3	12.9	12.9	12.8	13.1	16.2	17.6	18.3
ST HELENS	31.7	34.7	29.2	25.6	21.4	17.7	17.6	19.0	22.3	26.3	29.8	29.2
	22.1	22.9	20.5	19.1	16.3	14.9	13.9	14.3	14.9	17.6	20.2	20.6
STANLEY	27.0	26.2	23.1	20.3	22.8	15.8	13.9	15.8	17.5	19.8	22.2	24.2
	21.1	20.6	19.6	17.9	15.2	14.0	12.5	13.1	14.0	15.9	17.7	20.0
STRATHGORDON	31.0	27.8	24.4	22.6	16.6	12.6	13.4	15.5	18.5	22.5	24.6	29.1
	19.8	18.0	17.3	15.1	12.9	10.9	9.9	9.7	11.6	13.8	15.8	17.3
SWANSEA	31.6	32.3	28.3	24.6	21.5	18.2	16.4	19.1	25.8	24.6	32.1	28.4
	20.6	20.7	20.4	18.6	16.2	13.4	12.5	12.8	15.8	16.3	19.6	20.2
TASMAN	23.8	25.3	21.5	20.7	17.3	14.2	13.3	13.1	17.2	18.6	19.7	19.8
	18.1	19.5	17.8	15.8	13.9	12.3	10.9	11.2	12.8	14.2	15.0	15.8
WARATAH	29.0	27.7	27.3	18.0	15.9	11.3	9.6	13.4	16.2	20.8	21.0	26.4
	19.9	18.5	18.0	14.6	12.0	9.9	8.5	10.1	10.8	14.1	14.9	17.9
WYNYARD	27.2	26.4	23.4	19.7	17.4	15.0	14.3	15.0	16.5	20.5	22.5	26.1
	20.2	18.8	19.0	17.5	14.7	13.3	11.7	12.3	13.2	15.6	16.0	18.8

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location — Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C

VICTORIA

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ARARAT PO	37.7	38.0	36.3	29.1	21.8	16.9	14.4	18.8	22.6	28.7	34.8	34.9
	23.6	20.4	19.5	17.5	15.4	13.6	10.7	12.9	14.8	17.5	18.3	20.7
ARARAT PRISON	37.1	36.9	33.9	28.0	22.3	15.5	16.8	21.3	22.7	29.4	34.2	37.0
	21.0	20.5	20.2	17.3	14.8	12.0	11.3	12.3	14.9	17.0	19.3	20.0
BAIRNSDALE PO	38.5	37.5	33.6	29.3	24.4	20.4	19.5	20.9	25.2	30.5	32.5	34.1
	22.2	21.6	20.9	18.9	16.5	14.0	13.4	14.5	16.7	18.9	19.3	21.5
BAIRNSDALE	38.0	37.0	32.9	27.5	24.2	19.2	20.0	24.2	27.4	29.5	33.9	35.8
	23.6	23.9	22.2	19.8	17.8	14.5	13.8	14.3	16.6	20.2	20.7	22.1
BALLAN	38.2	35.4	33.3	26.7	19.9	17.8	14.0	17.9	22.5	26.9	31.3	35.1
	23.2	26.4	23.3	18.4	15.4	12.7	10.9	13.4	15.4	19.2	22.9	22.6
BALLARAT	34.8	33.7	31.1	26.2	21.8	13.8	14.7	17.4	19.5	26.8	28.1	33.7
	20.3	20.7	18.8	16.9	14.9	11.1	10.6	12.6	14.6	17.3	18.6	20.1
BEECHWORTH	34.7	35.4	30.9	24.9	19.1	16.7	16.6	19.3	20.6	26.1	29.8	32.6
	21.8	20.8	19.7	16.5	14.5	11.2	11.7	13.8	15.3	16.7	18.4	20.1
BENALLA	40.2	38.6	37.2	29.2	23.5	18.9	16.5	22.1	24.0	32.0	36.6	37.9
	23.0	22.8	22.0	19.6	16.0	13.6	11.9	14.0	17.3	19.0	20.4	21.7
BENDIGO	39.1	39.0	34.7	28.2	23.1	16.8	18.4	22.2	24.0	31.4	34.4	37.1
	23.6	22.0	21.6	18.3	15.3	12.5	12.5	12.9	16.4	17.7	20.5	22.8
BEULAH	40.5	39.7	37.7	31.9	24.3	22.5	18.5	21.5	28.9	34.0	39.0	39.4
	23.1	22.0	23.7	19.5	18.5	15.9	13.8	15.1	18.6	19.4	20.8	23.7
BLACKWOOD	35.6	35.7	31.7	26.0	21.3	13.7	12.8	19.2	20.9	27.9	32.5	33.0
	22.7	21.0	18.7	17.1	14.2	10.5	9.0	11.5	13.9	18.5	18.7	21.3
BOGONG	32.5	32.8	31.7	25.4	20.9	15.4	13.9	17.0	20.2	24.6	29.8	30.6
	24.9	20.5	24.3	18.2	15.8	11.7	10.1	12.5	14.9	18.5	19.1	20.4
BONEGILLA	39.2	39.0	36.4	28.7	23.8	17.6	16.7	20.3	23.8	29.8	37.6	37.1
	25.4	23.6	24.6	19.4	16.7	13.5	12.4	15.1	17.9	20.7	21.9	22.4
CAPE NELSON	32.7	33.6	27.2	28.3	22.1	16.8	17.3	20.1	22.9	26.7	28.4	32.1
	21.2	20.5	19.3	19.2	16.5	13.5	12.9	13.7	15.6	18.1	18.6	20.2
CAPE OTWAY	32.4	35.6	28.3	27.1	21.5	16.6	16.4	19.6	22.4	25.8	29.9	34.3
	21.5	21.8	19.5	18.6	16.4	13.3	12.5	13.3	15.7	18.1	19.7	20.4
CAPE SCHANCK	34.3	34.1	31.3	27.1	20.4	15.6	16.0	20.0	21.3	27.1	28.1	32.6
	21.8	22.0	20.9	18.4	16.3	12.8	12.5	13.8	14.9	17.8	19.8	20.7
CASTERTON/MCCALLUM	39.7	39.9	35.6	30.7	23.9	17.0	18.0	21.0	24.4	29.2	35.9	38.2
	23.1	22.1	22.4	19.3	17.2	13.3	13.4	14.0	16.8	18.2	22.2	21.5
CASTLEMAINE	38.5	38.9	34.5	28.6	22.7	16.2	18.4	22.1	24.0	31.1	35.8	36.7
	22.2	21.8	21.3	18.6	15.5	12.4	13.2	13.4	16.3	18.3	20.3	21.0
CHARLTON	42.3	40.8	38.3	32.4	25.7	19.1	17.4	21.9	29.0	34.1	37.5	38.0
	22.1	23.7	21.2	18.1	16.4	14.4	12.6	15.4	16.6	19.4	20.1	21.3
COLAC SHIRE OFFICE	38.6	38.0	34.2	28.7	23.0	16.2	16.7	20.5	22.8	28.7	33.1	36.6
	23.2	22.9	21.1	19.3	17.0	12.9	12.4	13.4	16.6	19.7	21.7	21.7
COLAC	39.3	36.9	36.0	28.8	22.5	17.6	14.5	19.0	23.0	27.3	32.5	36.9
	23.6	21.7	20.3	19.3	15.5	13.9	12.0	13.6	15.9	19.8	19.4	22.6
CORRYONG	38.4	37.5	35.9	27.7	23.2	15.9	16.6	19.7	24.2	28.7	34.1	35.9
	23.3	22.6	20.4	19.2	15.7	12.3	11.8	13.5	17.2	18.7	20.7	21.7
DONALD	39.3	38.6	34.7	29.5	25.1	18.2	20.0	23.7	26.6	32.6	37.0	37.9
	21.8	21.1	21.7	18.5	16.0	13.1	12.3	13.2	16.5	17.9	19.6	21.3
EAST TARWIN	35.8	36.6	30.2	25.7	20.1	15.0	15.4	18.7	21.3	26.3	30.8	34.1
	23.7	25.0	21.0	19.4	15.2	12.2	12.7	12.7	16.5	17.9	20.9	21.9
ECHUCA	40.9	41.1	37.3	30.4	25.6	19.7	21.1	25.9	28.1	33.1	37.9	38.5
	24.7	24.7	23.2	20.8	16.8	13.9	13.2	14.8	18.3	19.8	22.0	24.4
ESSENDON	39.3	36.5	35.0	29.2	21.8	19.7	15.8	18.9	23.9	29.2	33.7	36.4
	21.7	20.8	20.0	18.3	15.5	13.9	12.0	13.3	15.8	18.4	21.0	21.4

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
	VICTORIA (Continued)											
EUROA	38.1	36.7	33.9	27.6	20.5	17.1	19.1	20.1	21.7	26.5	32.5	36.6
	21.3	21.3	20.5	18.6	16.2	13.3	13.7	15.4	17.2	19.0	21.3	22.4
GABO ISLAND	24.7	25.3	24.5	21.7	20.3	16.7	17.0	17.9	18.8	22.5	22.3	23.3
	22.2	22.5	21.5	19.6	17.5	14.6	14.4	14.8	15.5	17.3	19.0	20.1
GEELONG (NORLANE)	39.1	39.2	33.3	29.4	24.2	18.3	17.2	23.8	25.3	31.6	36.1	37.9
	22.8	23.7	22.6	20.0	17.0	13.4	12.8	14.1	16.8	19.6	20.4	21.7
GEELONG SEC	37.5	38.3	38.4	30.7	25.2	17.9	17.1	19.6	23.3	29.8	33.3	33.5
	21.3	23.1	21.2	18.6	18.1	13.8	12.9	14.1	16.8	18.0	19.0	21.5
GELLIBRAND RIVER	35.8	37.5	34.8	29.3	21.7	16.1	17.9	18.8	20.4	28.2	30.8	34.5
	22.7	22.6	21.3	18.2	16.7	12.8	13.0	13.2	15.3	19.2	20.7	20.6
HAMILTON	36.9	36.3	34.1	29.1	24.0	16.1	17.4	20.1	23.6	28.3	31.0	36.1
	22.0	21.1	20.6	18.0	16.4	12.5	12.3	13.0	16.2	18.2	19.8	21.6
HORSHAM	40.0	40.0	35.7	30.3	25.5	18.2	19.1	24.0	25.5	32.0	36.3	38.7
	22.0	21.5	21.8	18.7	16.5	13.2	12.6	13.5	16.7	18.0	20.2	20.4
KERANG	42.1	41.6	38.3	30.4	25.5	19.9	21.6	25.1	29.4	34.4	39.2	40.1
	26.2	24.0	22.6	19.8	17.1	14.1	13.7	14.4	18.6	19.9	23.4	27.5
KYABRAM	40.8	39.5	37.0	28.4	23.7	18.5	18.8	23.6	25.9	32.3	35.9	38.8
	23.4	24.6	24.3	18.9	16.5	13.3	13.7	15.4	17.7	19.4	20.6	22.9
KYNETON	34.8	34.4	30.7	25.5	21.9	14.7	16.4	15.8	19.2	22.6	27.1	34.5
	20.2	22.6	21.2	18.1	14.5	11.1	10.5	11.5	15.9	17.7	19.9	22.2
LAKE EILDON	37.6	37.5	34.8	28.2	22.4	16.8	16.7	20.0	23.4	29.3	33.5	35.7
	25.2	21.8	21.3	18.6	15.5	12.6	11.6	12.7	16.0	18.2	20.5	21.0
LAKES ENTRANCE	35.0	38.6	31.6	27.6	23.0	19.8	19.8	24.0	25.7	30.5	32.7	31.7
	23.3	23.0	21.7	19.7	17.3	14.1	13.8	15.4	16.9	19.6	21.0	21.7
LAVERTON	39.5	39.7	33.5	29.6	24.5	17.6	20.2	22.8	24.5	31.1	34.6	38.2
	22.4	22.3	21.7	18.7	16.5	13.2	12.8	13.3	16.2	18.9	20.5	21.4
LEMNOS	40.6	40.1	36.9	29.1	24.7	18.5	18.6	23.8	25.8	31.7	36.2	38.5
	23.0	23.2	23.2	19.4	16.3	13.5	13.6	14.3	17.2	19.4	20.9	22.9
LISMORE	37.9	39.0	34.7	29.0	23.6	16.5	17.1	21.1	24.5	29.9	34.9	37.5
	24.9	22.0	21.2	18.8	16.9	12.7	13.2	13.4	17.1	18.8	21.0	21.6
LORNE	29.5	36.8	30.4	27.4	22.5	17.5	17.4	20.9	23.9	26.8	31.5	35.4
	21.9	22.2	20.5	19.2	17.3	14.6	12.8	14.3	17.3	18.0	19.3	20.9
MACEDON	34.9	33.5	30.2	24.8	21.7	14.7	15.9	17.1	19.4	28.0	28.2	32.8
	20.4	20.8	19.7	17.0	14.8	10.9	11.0	11.5	14.5	16.7	19.0	20.3
MANGALORE	38.7	37.6	34.7	28.6	24.2	18.1	18.3	20.6	23.7	31.7	33.9	37.4
	21.2	22.4	21.4	17.9	17.1	13.3	12.7	13.6	16.5	18.6	21.0	22.2
MARYBOROUGH	35.4	34.1	33.3	30.9	28.4	25.7	26.2	27.0	30.9	32.2	33.0	35.4
	22.7	22.9	22.5	20.3	15.6	12.8	12.3	13.4	16.4	19.1	19.9	20.6
MELBOURNE AIRPORT	38.9	38.9	34.3	28.9	23.7	17.3	18.7	21.7	23.7	30.5	34.7	37.6
	22.1	21.7	21.0	18.6	16.0	12.8	12.6	13.2	16.2	18.9	20.5	20.6
MELBOURNE REGIONAL OFFICE	38.4	38.8	33.7	29.1	24.7	18.3	19.3	22.3	23.5	30.8	34.3	37.0
	21.9	21.2	21.6	19.1	15.6	13.4	12.8	13.3	15.9	18.1	19.6	20.8
MILDURA	42.7	41.7	38.4	31.9	27.4	21.3	22.6	27.6	31.5	34.6	40.3	41.2
	24.1	23.2	21.7	19.5	17.4	14.1	14.3	15.0	17.8	19.0	20.5	21.9
MOUNT BEAUTY	37.4	36.5	35.0	27.0	22.2	18.1	16.3	19.0	22.8	27.6	32.4	33.7
	23.3	22.7	21.8	18.9	15.3	13.6	11.8	12.4	15.9	17.8	20.9	21.6
MOUNT DANDENONG	33.4	34.1	30.6	23.1	18.7	12.7	11.5	16.6	18.4	24.3	26.2	32.0
	20.6	20.4	19.4	16.4	14.2	10.2	9.8	11.9	13.8	16.4	18.6	21.2
MOUNT HOTHAM	26.7	26.2	22.2	17.5	11.7	8.1	5.1	8.8	11.4	16.3	22.9	23.2
	17.5	17.2	14.3	11.1	8.7	6.0	3.3	4.4	7.7	10.2	15.4	15.9
NHILL	41.8	41.2	36.7	31.2	26.3	19.3	20.5	25.3	26.7	32.2	38.6	39.0
	23.5	21.3	21.9	18.6	17.2	13.4	13.4	13.5	16.8	17.9	19.5	20.9
OLSENS BRIDGE	37.2	36.5	30.4	25.2	18.7	14.8	16.9	19.6	21.3	28.8	32.2	35.6
	25.8	23.8	22.4	20.5	16.4	12.9	11.8	13.9	16.1	18.7	21.3	23.1

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
VICTORIA (Continued)												
OMEO	35.8	34.4	33.2	24.9	19.8	15.4	14.3	19.2	22.4	27.3	31.5	32.7
	20.8	20.6	18.9	16.4	13.9	11.1	9.5	10.5	13.7	16.9	19.3	19.2
ORBOST	39.1	39.1	33.1	27.8	24.6	19.4	21.2	23.9	25.8	31.3	32.8	36.1
	24.8	23.9	22.8	21.2	18.2	14.6	13.5	15.4	18.4	19.7	21.4	23.9
OUYEN	42.2	42.1	38.2	32.0	27.8	20.3	23.0	26.5	31.0	34.8	39.8	41.1
	23.3	24.7	22.0	20.1	18.3	14.4	15.0	14.8	17.2	19.2	21.4	23.0
POINT HICKS	34.1	30.7	28.6	24.6	21.8	17.2	19.1	21.3	22.6	25.3	29.8	27.2
	23.2	23.1	22.8	19.6	18.0	14.6	13.8	14.6	16.7	18.7	20.4	21.5
POINT LONSDALE	37.3	36.5	32.3	28.5	23.1	17.2	18.6	22.4	22.8	29.5	33.3	37.1
	22.7	22.7	21.4	19.0	16.6	13.8	12.9	13.8	16.9	18.9	20.7	20.3
PORTSEA	31.4	32.5	28.9	24.9	20.0	16.3	17.3	18.2	20.0	23.6	27.3	32.3
	24.7	23.8	23.1	19.8	16.8	13.5	14.1	14.6	16.1	18.8	21.1	22.3
POWELLTOWN	36.3	36.9	33.0	27.2	20.0	16.4	18.8	19.8	22.9	29.4	30.7	33.3
	22.8	22.9	22.0	18.5	16.2	13.3	12.8	13.7	15.9	18.9	21.0	21.6
QUEENSCLIFF	33.3	33.8	34.1	27.7	21.0	17.0	15.4	17.4	21.4	27.4	28.6	32.1
	28.2	24.4	25.6	21.8	16.6	14.5	13.1	14.4	17.6	21.7	23.4	25.5
RUBICON	32.4	32.4	30.1	22.7	17.7	12.7	11.7	14.8	17.9	23.5	28.9	30.5
	20.5	19.9	19.0	16.5	13.5	10.1	8.8	9.7	13.1	14.9	17.9	19.0
SALE EAST	38.3	38.2	33.0	27.2	23.2	17.5	19.3	23.0	25.6	29.1	35.1	35.6
	22.7	22.3	21.7	19.5	16.3	13.9	13.1	13.8	16.6	18.1	21.0	21.7
SERVICETON	40.8	38.6	36.9	31.5	24.0	22.2	16.8	20.2	27.3	31.4	36.3	38.1
	29.4	22.7	20.4	19.4	17.7	14.9	12.8	13.9	17.6	19.3	22.3	23.7
SPRING CREEK	38.0	37.2	34.5	27.4	21.4	15.4	16.5	19.5	21.5	27.4	33.7	35.3
	21.4	21.8	20.4	17.8	14.9	12.0	11.7	12.1	15.5	17.4	20.1	20.5
ST ARNAUD	39.9	38.7	35.3	29.2	23.4	16.1	18.6	23.6	25.7	31.9	36.9	38.7
	23.4	22.9	21.1	18.7	16.6	12.4	15.6	13.4	16.2	19.0	20.3	23.3
STAWELL	38.0	38.2	34.6	29.2	23.4	16.4	17.3	22.5	24.0	30.5	35.8	37.3
	22.2	21.0	21.4	18.5	15.4	12.4	11.8	13.0	15.3	18.0	19.7	21.0
STONY POINT	34.6	34.1	30.9	25.3	20.6	16.2	17.0	18.7	22.7	25.4	29.5	34.0
	23.1	23.2	21.3	19.1	16.2	13.1	12.7	12.7	17.3	19.9	20.5	22.2
STRATHBOGIE	36.8	36.2	33.6	26.2	20.6	15.7	14.7	18.7	20.8	28.0	32.8	34.2
	22.0	21.8	20.5	17.4	14.7	11.3	10.9	12.6	15.4	17.6	19.3	20.5
SWAN HILL	42.8	41.2	37.5	31.3	26.8	20.5	22.0	26.0	30.2	34.5	40.7	40.0
	23.6	22.9	22.6	19.9	17.2	13.6	13.3	14.6	17.7	18.6	20.5	21.9
TATURA	38.9	38.4	35.7	28.2	23.7	18.5	18.5	23.2	25.1	30.1	35.9	36.5
	23.4	23.1	22.3	19.2	16.5	13.4	13.1	13.8	17.0	19.4	20.7	21.9
WANALTA	41.7	41.8	37.7	29.4	24.7	17.6	19.1	23.5	25.8	32.8	37.7	39.8
	23.6	23.0	22.5	19.6	16.9	13.5	13.5	14.8	17.4	20.1	21.2	22.2
WANGARATTA	38.7	37.4	36.0	28.6	23.5	19.6	17.1	19.8	23.6	30.4	36.1	36.2
	24.4	22.8	20.8	18.7	16.8	14.3	12.7	13.6	16.9	20.2	21.7	23.0
WARRACKNABEAL	41.9	41.2	37.0	31.1	25.4	18.5	21.5	26.1	27.6	33.3	39.2	40.8
	24.1	22.0	22.7	19.8	18.0	13.9	14.4	14.4	19.0	18.4	21.4	22.4
WARRAGUL	37.5	37.5	36.6	28.8	24.1	17.3	16.5	20.1	24.6	28.0	30.7	35.7
	21.9	22.7	21.4	19.2	16.7	14.0	13.2	14.4	17.2	19.8	19.3	21.7
WARRAMBINE	35.8	37.2	33.9	28.1	22.7	15.1	17.3	18.7	21.0	27.4	30.3	36.4
	24.4	22.0	22.5	17.2	16.8	12.2	12.2	13.2	16.6	20.1	20.9	22.2
WARRNAMBOOL	38.5	37.8	31.3	30.0	23.4	17.2	18.2	22.3	26.0	28.8	32.2	37.8
	22.0	21.3	20.1	19.1	17.4	13.3	13.4	13.7	16.8	19.1	20.9	20.6
WILSONS PROMONTORY	31.1	30.3	28.9	21.4	19.7	15.7	16.5	19.6	21.3	23.5	28.5	27.6
	21.3	20.7	20.7	17.9	15.3	13.0	11.8	12.6	14.4	16.5	17.5	19.1
WODONGA	41.2	38.2	36.1	29.7	24.4	19.4	17.2	20.2	25.0	31.6	36.2	37.5
	22.8	22.9	20.6	19.0	16.3	14.3	12.7	13.6	17.4	20.0	22.9	22.1
WON WRON	38.1	35.8	34.5	28.4	24.2	17.7	17.6	20.8	23.4	27.0	28.2	32.7
	24.7	23.4	24.3	21.3	19.9	14.0	13.9	15.2	17.0	18.5	20.7	22.8

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
	VICTORIA (Continued)											
WONTHAGGI	36.6	37.3	31.4	28.3	22.8	17.2	17.4	20.4	23.2	28.8	31.6	35.3
	23.1	23.7	22.4	19.6	17.3	13.9	13.8	14.7	18.0	20.3	22.4	22.3
WOODS POINT	34.6	33.2	32.0	26.3	19.6	14.1	13.0	16.3	21.0	24.7	29.5	31.9
	22.6	21.0	23.2	17.9	14.5	11.8	9.8	11.1	14.7	18.0	22.4	22.4
YALLOURN	36.8	37.0	31.5	27.3	21.8	16.5	17.7	21.3	23.0	28.9	32.8	35.2
	22.8	21.5	21.3	18.7	15.7	12.8	12.0	13.5	16.2	18.4	20.4	21.0
	WESTERN AUSTRALIA											
ALBANY (ECLIPSE ISLAND)	24.2	25.8	25.2	24.6	23.2	20.2	18.5	19.8	20.7	20.8	22.1	22.5
	20.2	21.6	21.8	19.6	18.9	17.1	15.2	15.0	16.2	17.7	18.7	19.9
ALBANY AMO	33.8	33.3	32.3	28.7	24.7	21.2	19.0	21.1	24.3	29.1	27.7	27.9
	21.9	21.6	21.5	19.4	17.1	16.5	14.7	15.6	17.5	18.3	20.1	20.3
AUGUSTA (CAPE LEEUWIN)	26.5	26.6	27.1	26.8	23.6	21.3	19.3	20.8	21.1	22.7	23.7	24.1
	23.0	23.0	22.7	21.2	20.3	18.1	17.1	16.9	17.5	18.6	20.3	21.6
BELMONT (PERTH AMO)	40.6	40.7	38.2	33.0	27.6	24.2	22.4	23.6	27.8	31.8	35.3	37.7
	23.2	23.3	22.0	20.4	18.5	18.4	15.9	16.9	18.0	19.1	20.8	22.3
BENCUBBIN	42.3	41.7	39.1	34.3	28.4	23.9	22.4	24.4	31.0	36.1	37.9	40.0
	22.4	24.0	21.6	19.0	17.9	15.1	14.5	15.3	16.7	17.8	19.4	22.1
BEVERLEY	44.8	43.3	40.3	33.8	28.2	22.1	23.8	24.1	27.6	31.5	37.6	41.7
	26.1	24.2	28.6	25.0	18.1	16.9	16.6	16.2	18.6	19.8	23.5	24.4
BRIDGETOWN	40.5	37.6	36.0	30.7	25.0	20.6	19.5	21.6	25.8	29.4	33.9	36.4
	25.2	23.4	22.7	20.5	18.1	17.8	15.5	15.8	17.5	18.5	20.8	23.3
BROOME (CAPE LEVEQUE)	33.6	33.9	34.2	34.1	32.4	29.8	29.7	31.1	33.8	36.2	35.7	34.2
	28.9	28.8	29.4	29.2	26.8	25.4	26.3	25.2	27.0	27.6	28.7	28.9
BROOME (LA GRANGE MISSION)	38.1	38.5	39.4	40.1	36.4	33.2	32.6	35.0	37.7	40.4	40.3	40.4
	29.8	30.1	30.6	29.8	26.8	25.9	22.1	24.1	26.4	27.7	27.9	29.8
BROOME AMO	36.8	38.6	38.7	39.0	35.6	33.3	32.7	34.2	37.7	39.4	38.9	39.4
	28.5	28.6	29.5	28.3	25.5	23.0	22.5	22.7	25.0	26.2	27.3	28.5
BULLSBROOK (PEARCE AMO)	42.4	39.0	37.9	33.9	28.5	23.7	21.2	24.7	28.0	32.4	37.2	39.5
	29.7	27.3	24.4	22.8	20.2	19.0	17.9	17.3	18.9	22.6	24.9	26.8
BUNBURY	36.9	33.1	31.0	31.3	25.0	21.6	20.7	20.8	22.8	28.4	32.5	31.3
	24.4	25.2	22.9	24.1	20.1	17.5	17.3	16.8	17.5	19.3	23.4	23.6
BUSSELTON (CAPE NATURALISTE)	34.4	32.6	31.7	26.0	22.5	21.0	18.7	19.2	21.6	25.1	29.3	30.8
	23.9	23.6	22.0	20.8	19.9	18.1	16.1	16.8	17.5	18.8	20.8	21.0
BUSSELTON PO	35.8	35.9	32.3	28.0	22.5	19.7	18.2	19.4	22.3	28.3	30.5	34.7
	22.6	24.3	23.0	20.8	18.8	17.2	15.8	15.5	16.8	19.5	21.4	22.4
CARNARVON	36.9	38.4	36.8	34.6	31.3	28.2	26.2	28.1	30.2	31.2	33.3	33.3
	25.9	27.1	26.1	24.2	22.6	20.7	19.7	20.1	20.5	21.8	23.1	24.0
COLLIE	40.9	39.1	38.3	31.2	25.5	20.6	19.4	20.7	24.6	32.0	34.5	38.6
	22.7	23.9	21.6	20.9	17.3	16.2	15.2	15.0	15.5	20.2	20.0	22.2
CORRIGIN	41.3	40.5	37.5	33.1	26.6	22.4	20.2	22.6	28.1	33.9	36.9	38.9
	25.7	22.5	21.0	19.0	16.7	15.9	14.1	15.4	16.6	17.1	19.5	21.4
CUE	43.4	42.9	40.0	35.6	30.9	24.9	25.3	27.8	34.0	37.7	39.1	41.5
	24.6	24.1	23.5	20.7	19.3	15.9	15.2	15.7	17.1	22.0	20.3	23.6
CUNDERDIN	43.4	42.2	39.7	34.5	28.2	23.4	21.8	23.9	29.9	33.9	38.3	41.5
	24.6	24.6	22.4	20.3	17.9	16.1	15.2	15.9	17.8	22.7	21.9	27.2
DALWALLINU	42.7	42.6	39.9	34.5	28.3	23.6	23.0	25.3	30.0	35.8	38.4	40.3
	23.9	24.1	24.0	20.4	18.8	15.7	15.1	16.4	17.9	18.9	22.1	22.6
DERBY (COCKATOO ISLAND)	33.6	32.9	35.1	35.0	33.2	32.0	30.6	32.0	31.4	32.7	34.1	34.0
	28.0	28.1	28.7	27.6	26.0	24.4	24.1	24.5	25.7	27.0	27.3	27.8
DERBY (KOOLAN ISLAND)	33.8	34.0	34.2	35.2	32.8	30.0	29.7	32.8	34.3	36.1	35.1	35.9
	28.8	28.0	28.2	29.3	25.9	23.5	24.7	24.3	25.4	26.1	27.1	29.5

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location: Monthly Dry Bulb Temperature °C (first line); Monthly Wet Bulb Temperature °C (second line)

WESTERN AUSTRALIA (Continued)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DERBY	39.4	39.9	39.1	37.9	36.6	33.3	33.5	35.7	37.2	40.6	42.8	40.8
	28.6	28.7	28.6	27.2	25.0	24.3	22.5	25.0	28.1	27.5	28.2	28.7
DONNYBROOK	40.5	39.5	36.7	31.4	25.8	22.6	21.7	21.6	24.7	30.5	34.3	37.2
	24.0	24.4	22.5	23.9	19.1	16.7	15.6	16.1	18.1	18.7	21.1	23.1
DWELLINGUP	39.0	37.3	35.2	31.0	24.8	20.5	20.7	20.4	23.7	30.2	33.6	37.6
	22.1	23.6	21.7	20.1	17.3	15.6	14.5	16.0	16.1	18.0	19.9	21.0
ENEABBA	44.2	42.9	41.0	36.0	30.5	25.9	25.8	25.0	30.5	36.5	38.1	41.6
	24.5	24.6	24.2	22.1	19.1	17.2	16.8	17.1	18.7	20.9	21.4	23.1
ESPERANCE MO	39.0	38.3	36.8	33.9	28.1	24.0	22.2	26.0	29.0	34.1	35.8	36.2
	22.3	22.0	21.1	19.9	18.0	16.9	15.2	16.4	17.1	18.4	19.8	21.3
ESPERANCE PO	36.9	34.5	39.5	31.6	27.1	24.4	22.5	24.9	27.2	32.4	35.9	32.6
	22.1	23.1	22.4	21.8	19.4	18.4	16.3	16.4	17.4	19.3	20.9	21.1
EUCLA	36.5	38.3	39.1	34.6	29.4	22.9	25.9	29.6	34.4	35.3	37.2	38.2
	25.7	21.4	21.4	21.8	18.8	16.1	17.8	16.3	17.5	19.0	20.0	21.7
FITZROY CROSSING	42.5	41.9	38.6	38.3	34.8	33.5	33.4	36.6	39.4	41.2	43.3	43.3
	27.5	28.3	27.3	25.1	22.2	22.4	21.4	23.1	22.4	25.2	24.7	26.4
FORREST	44.3	42.5	40.5	36.3	28.6	25.3	25.0	30.1	34.3	37.9	41.1	42.5
	22.5	22.7	21.5	19.3	17.5	15.3	13.9	15.1	18.2	17.8	20.4	21.8
GERALDTON	42.0	42.4	39.6	34.5	30.7	26.3	23.4	24.7	30.2	34.4	35.6	38.8
	23.8	24.3	24.0	21.9	20.2	19.2	18.5	18.2	19.8	19.7	20.5	22.9
GILES MO	41.7	40.2	39.2	36.0	30.0	25.7	25.5	30.1	34.9	38.0	40.4	41.0
	23.0	23.7	23.7	21.9	18.1	15.8	14.1	16.2	16.7	19.4	21.2	23.4
GOLDSWORTHY	45.4	44.0	44.2	41.5	35.8	32.4	32.2	34.3	39.6	41.7	43.7	45.4
	28.0	28.3	28.3	25.4	23.3	21.9	20.8	21.6	22.4	24.6	26.1	26.7
HALLS CREEK (TURKEY CREEK)	43.4	40.1	40.0	38.0	35.0	33.3	32.5	36.6	38.5	41.2	43.2	42.8
	27.8	26.3	27.6	24.4	24.5	20.9	20.9	21.9	22.7	24.1	24.4	28.5
HALLS CREEK AMO	41.7	40.4	40.4	37.0	35.1	31.9	30.9	34.5	37.6	40.4	41.8	42.0
	25.2	25.0	24.8	23.3	21.6	19.9	18.7	19.1	21.4	21.9	23.6	24.2
HAMELIN POOL	44.1	44.6	41.6	36.0	30.1	26.7	25.2	28.0	29.9	38.0	37.8	41.1
	28.2	28.6	27.5	25.4	21.5	19.0	18.7	19.0	19.9	22.5	24.0	27.7
HYDEN	43.7	42.3	39.5	33.7	27.5	23.0	22.6	24.7	30.5	33.8	37.1	41.5
	28.2	22.7	24.8	19.7	18.6	16.5	14.7	15.7	17.6	18.8	23.7	31.1
JARRAHWOOD	38.5	35.4	35.5	30.6	25.7	21.0	21.6	21.3	23.4	29.0	32.9	35.7
	24.0	23.7	23.1	20.0	18.6	16.1	15.6	14.7	16.2	18.3	19.1	21.8
JURIEN	38.5	37.5	36.3	31.6	28.0	23.4	22.7	23.7	28.8	31.8	31.9	33.1
	24.3	24.4	24.5	22.5	21.6	19.5	17.1	18.3	19.0	21.1	21.7	22.7
KALBARRI	42.1	41.7	39.8	34.6	30.7	26.3	26.3	26.2	30.0	35.1	36.8	39.0
	25.7	26.6	26.9	24.2	21.9	20.5	18.7	19.7	20.8	21.7	22.6	24.2
KALGOORLIE	42.4	40.8	39.0	34.8	28.6	24.4	23.9	27.0	33.0	36.6	38.9	40.5
	21.7	21.9	21.3	18.7	17.3	15.4	13.8	14.5	16.3	17.4	20.0	21.4
KALUMBURU (MITCHELL PLATEAU)	37.9	35.6	35.5	35.4	33.7	32.2	32.5	34.8	36.8	37.7	38.7	38.2
	27.1	27.4	26.9	25.7	27.5	25.8	22.8	22.7	24.2	28.9	26.2	28.5
KALUMBURU	37.9	37.1	37.1	37.5	35.9	35.0	34.4	35.9	37.7	38.2	38.9	39.6
	28.8	28.8	28.9	27.3	26.3	26.0	26.3	25.2	25.5	27.4	28.0	28.7
KARRATHA	40.1	42.6	41.1	37.2	33.9	30.3	29.2	30.2	33.8	37.6	37.8	41.4
	28.0	29.0	28.6	26.6	23.2	22.9	22.3	22.5	23.0	25.2	26.1	27.4
KATANNING	39.6	39.2	35.0	31.1	25.0	21.1	18.7	20.5	26.3	31.2	35.9	37.6
	24.0	23.3	21.8	21.1	19.5	15.5	14.1	14.7	16.5	18.8	21.3	21.9
KELLERBERRIN	42.1	42.3	38.8	34.4	28.5	23.6	23.5	23.8	28.3	33.5	38.4	40.6
	22.9	23.5	23.0	20.5	17.2	15.2	14.9	15.7	16.2	19.2	20.8	23.1
KUNUNURRA	40.5	39.0	39.0	37.5	36.0	33.7	34.7	36.5	38.1	41.0	41.4	41.3
	27.8	29.1	28.6	25.9	24.4	24.6	23.2	22.5	24.5	26.5	27.0	27.7
KURI BAY	35.0	34.8	35.3	35.6	35.3	33.1	33.1	33.7	35.2	35.3	36.9	36.3
	27.9	27.8	28.1	27.7	26.3	25.0	24.6	24.2	25.8	26.8	27.6	28.4

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
WESTERN AUSTRALIA (Continued)												
LAKE GRACE	40.6	40.3	36.9	33.1	26.3	22.5	20.4	22.5	28.7	33.3	37.0	38.0
	23.1	22.2	20.7	18.9	17.2	15.6	14.2	15.3	16.8	17.7	19.7	21.1
LANCELIN	36.1	37.3	36.6	31.4	27.3	24.3	23.8	23.6	27.5	30.1	32.5	34.6
	24.0	25.1	24.5	22.8	20.5	18.7	17.5	18.0	18.4	19.9	21.6	23.4
LAVERTON (YAMARNA)	43.5	41.8	40.3	36.5	31.3	23.9	24.8	28.0	34.2	38.0	40.2	42.4
	22.4	23.7	22.5	20.1	17.7	15.0	14.5	16.8	18.0	18.1	21.3	22.0
LAVERTON	42.6	40.7	41.0	36.0	31.0	26.6	25.2	28.9	33.3	38.1	41.1	40.7
	25.6	22.8	23.8	21.2	17.7	16.2	15.8	16.7	18.2	21.4	21.8	23.6
LEARMONTH	43.9	43.6	42.8	38.6	33.3	28.2	27.9	30.5	34.8	39.6	39.7	43.1
	26.3	27.2	26.9	25.0	23.2	22.3	20.4	21.0	20.8	22.4	23.2	24.9
LEONORA	43.9	42.4	40.2	36.7	31.6	25.0	25.2	28.6	34.2	37.7	40.3	42.0
	22.9	23.8	22.7	19.8	18.4	15.4	14.8	15.6	18.0	19.4	19.9	24.5
MANDORA	42.0	41.5	40.5	38.7	36.1	33.0	33.1	34.5	38.5	41.5	43.1	42.0
	29.6	29.7	30.2	27.5	24.9	23.2	23.9	22.6	25.4	25.9	27.6	30.0
MANDURAH	39.9	39.4	36.4	31.4	26.5	22.2	22.0	22.6	25.3	32.0	36.4	36.9
	26.6	25.0	23.4	23.2	20.1	18.7	16.8	18.0	17.6	20.4	20.3	23.4
MANJIMUP	38.6	36.1	34.8	28.8	24.0	20.5	18.9	19.8	23.3	28.2	33.6	34.9
	23.9	23.9	21.8	19.9	17.5	15.9	14.0	14.7	15.7	17.3	20.8	23.1
MARBLE BAR	46.2	43.9	43.3	41.3	35.2	32.0	31.8	33.7	38.9	42.0	45.1	46.1
	26.5	26.4	28.8	25.2	24.4	20.5	20.5	19.8	23.7	22.4	24.6	26.4
MARDIE	43.9	42.5	42.9	40.9	36.2	31.4	30.8	33.9	37.7	40.0	42.1	44.3
	28.6	28.6	29.2	26.7	26.7	22.3	22.0	22.2	21.5	25.2	27.7	27.8
MEEKATHARRA AMO	43.0	42.4	41.2	35.9	31.3	25.1	25.9	28.6	34.5	37.8	39.7	41.3
	23.2	23.2	22.7	19.8	18.4	16.3	14.8	15.5	17.2	17.5	19.2	21.8
MEEKATHARRA PO	43.3	42.2	39.3	36.6	29.4	25.8	26.8	27.9	34.1	38.0	39.0	40.6
	24.7	24.6	27.0	23.9	20.7	16.8	17.2	18.9	21.0	23.2	22.8	22.6
MENZIES (DIEMALS)	43.5	43.0	39.8	35.5	30.2	24.0	24.8	28.5	34.0	37.2	39.0	41.0
	23.6	23.4	22.3	20.1	18.5	15.2	14.9	15.4	17.5	18.3	21.5	22.0
MENZIES	43.1	42.3	41.3	35.7	29.3	22.9	24.1	28.3	33.1	37.8	40.4	42.1
	24.2	24.1	24.7	21.4	18.0	14.4	14.9	15.1	17.1	18.7	19.9	22.1
MERREDIN	42.2	41.9	39.5	34.1	28.7	24.0	22.8	24.4	31.1	36.0	38.0	40.5
	26.6	23.8	23.1	19.7	18.4	15.3	15.0	16.7	16.6	18.9	22.4	23.4
MOUNT MAGNET	43.9	42.3	42.1	38.6	32.6	26.2	25.6	28.9	32.4	38.7	42.4	44.1
	25.3	24.9	24.4	21.6	20.2	18.0	16.8	16.3	18.5	21.4	21.4	23.6
MT BARKER	39.1	37.1	36.4	30.3	26.5	20.1	18.9	21.5	24.8	29.7	34.2	33.6
	24.1	22.8	23.0	20.1	18.0	16.3	14.6	14.4	16.5	19.2	21.4	21.7
MULLEWA	42.5	42.4	41.3	37.0	31.0	26.5	23.0	24.4	32.3	36.1	40.0	42.5
	26.6	25.1	24.6	22.1	19.0	18.3	15.6	16.9	19.5	22.2	23.5	23.7
NAREMBEEN	42.1	42.6	37.0	33.6	26.5	22.3	20.5	22.7	28.2	33.1	36.8	40.4
	23.8	23.7	22.6	20.6	18.1	15.7	14.3	15.1	16.9	18.2	20.7	22.5
NEWMAN (MUNDIWINDI)	43.2	43.0	40.0	36.2	32.3	26.4	28.2	31.4	33.9	37.2	40.6	42.3
	24.4	24.4	24.4	22.8	20.6	18.1	17.4	16.5	18.4	20.8	20.5	23.3
NEWMAN PO	43.0	41.5	40.7	37.4	31.8	27.7	27.1	30.3	35.3	38.5	41.4	41.6
	27.6	24.1	25.6	21.7	20.1	17.9	16.5	18.0	24.4	20.0	24.1	23.5
NORSEMAN	41.3	39.7	37.0	33.7	27.2	22.7	22.4	26.4	31.4	35.3	38.2	40.0
	22.8	24.0	21.9	18.9	17.4	15.2	14.0	15.4	17.7	18.3	21.8	22.5
NORTHAM (MURESK AGRIC.COLLEGE)	42.6	40.9	39.5	34.2	30.0	22.0	21.1	23.0	28.1	35.2	38.6	39.7
	29.2	29.8	27.0	22.1	21.2	18.0	17.0	18.7	19.5	22.7	27.0	26.1
NORTHAM	43.2	42.2	39.7	36.3	28.0	22.8	22.8	23.0	29.4	34.9	38.3	41.1
	23.7	24.4	22.4	21.0	19.6	16.8	15.9	16.1	18.6	19.3	20.2	23.5
NYANG STATION	46.8	46.0	44.0	40.7	35.7	29.8	30.4	32.6	38.2	41.9	41.5	44.2
	26.9	26.9	25.9	23.9	22.3	20.7	18.2	19.8	21.5	21.0	25.2	27.0
ONGERUP	39.6	39.2	36.4	30.8	24.8	22.2	20.8	21.6	26.7	31.2	35.7	38.3
	21.9	22.6	21.4	18.8	16.7	15.8	13.9	14.7	15.9	17.1	19.1	20.5

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C Monthly Wet Bulb Temperature °C											
WESTERN AUSTRALIA (Continued)												
ONSLOW AMO	45.3	43.1	40.5	38.1	34.1	29.4	28.6	30.1	32.7	39.3	41.8	42.1
	28.0	28.7	28.5	26.9	24.6	23.2	21.7	21.2	22.8	24.5	26.0	28.1
ONSLOW PO	43.4	39.2	42.7	40.6	33.0	28.8	29.1	29.5	35.2	38.3	38.3	44.4
	29.1	29.9	29.1	27.8	25.6	23.0	21.5	22.1	23.8	27.0	25.5	28.8
PEMBERTON	38.3	36.9	34.2	29.1	23.4	20.8	19.7	20.1	22.7	27.7	32.4	34.1
	22.5	23.8	21.4	20.6	18.0	15.7	14.9	15.2	16.0	18.2	19.9	22.0
PERTH	39.7	39.2	38.0	31.9	28.1	24.7	22.9	24.1	27.6	32.2	35.4	36.5
	23.6	24.0	22.9	20.6	19.5	18.2	16.2	16.9	17.7	19.0	20.6	22.4
PINGELLY	40.9	40.7	36.9	31.2	26.3	21.3	21.0	21.4	26.5	32.8	36.4	39.1
	22.5	22.9	20.9	18.9	16.9	16.0	15.0	15.8	16.6	18.4	21.5	20.5
PORT HEDLAND (REDMONT)	44.3	43.8	41.8	39.0	33.6	29.4	29.3	33.4	37.1	40.1	43.1	43.7
	24.7	26.7	24.5	22.5	20.0	18.5	17.4	19.3	19.0	20.4	21.6	24.6
PORT HEDLAND	40.8	41.2	40.9	39.8	35.1	31.3	30.8	32.7	37.5	39.7	40.7	41.7
	28.5	29.0	29.2	27.1	24.6	22.3	21.9	21.4	22.4	25.3	26.1	27.8
RAVENSTHORPE	38.3	39.0	37.9	33.7	28.4	22.6	19.9	24.5	27.3	33.0	37.5	36.8
	20.2	21.9	20.9	19.6	17.6	14.7	14.1	14.5	17.3	18.1	19.1	20.6
RAWLINNA	43.6	43.4	40.4	33.9	30.8	23.9	25.6	29.7	33.1	35.2	40.3	42.3
	23.0	23.9	23.8	20.9	18.7	16.3	15.0	15.8	18.3	18.7	20.0	22.7
ROEBOURNE	44.5	43.6	43.4	39.5	35.5	31.3	31.1	34.3	38.0	41.5	43.1	44.3
	27.8	28.4	27.8	26.3	27.0	22.6	21.5	22.6	25.5	26.5	28.5	27.9
ROTTNEST	36.8	33.3	34.1	27.8	24.6	22.2	20.4	20.4	22.8	26.8	29.3	27.8
	22.7	25.7	22.9	20.6	19.1	18.8	16.4	17.2	17.8	19.0	20.0	20.9
SANDSTONE (CASHMERE DOWNS)	43.3	42.3	39.7	35.2	30.3	24.7	24.6	27.7	32.9	37.2	38.9	40.8
	23.1	23.3	22.1	19.1	17.5	15.4	14.4	15.0	17.6	18.0	20.2	22.9
SANDSTONE (YEELIRRIE)	43.6	42.7	40.8	36.5	31.6	25.0	25.9	28.8	34.8	37.5	39.9	41.6
	24.0	23.6	23.0	20.8	18.9	16.5	14.7	16.0	18.8	17.8	20.6	22.7
SERPENTINE	38.7	37.6	35.6	30.5	23.8	20.3	18.7	20.8	24.2	30.6	33.1	35.9
	23.2	24.7	25.4	22.5	17.2	15.6	14.4	14.3	16.2	19.5	20.8	22.0
SHARK BAY	45.4	43.4	41.6	36.3	33.2	28.1	26.2	29.5	34.3	35.4	33.8	35.0
	26.2	27.6	25.8	23.6	22.2	20.1	19.6	19.2	20.8	21.8	23.0	24.2
SOUTHERN CROSS	42.1	41.2	38.8	34.5	29.0	24.4	21.9	26.6	32.5	35.7	37.4	38.9
	22.1	22.4	21.9	18.9	17.5	15.6	14.1	14.9	16.5	18.2	20.4	20.5
THREE RIVERS	44.1	44.7	40.7	36.4	32.2	27.3	27.3	30.2	33.2	37.2	40.2	42.0
	24.2	24.1	23.4	21.8	17.8	16.2	16.7	17.5	17.9	17.9	21.2	22.6
TROUGHTON ISLAND	33.2	33.4	33.1	33.0	31.8	30.6	29.0	29.5	30.3	31.6	32.7	33.5
	29.0	28.8	28.4	27.8	27.0	26.1	25.7	25.2	26.5	27.0	28.0	30.2
WAGIN	40.4	40.7	35.9	31.7	25.3	21.9	20.7	20.7	26.2	32.3	36.2	38.4
	25.5	23.4	23.3	19.3	18.4	15.5	14.8	15.2	16.4	20.1	20.4	24.8
WANDERING	42.2	40.4	37.5	31.7	26.1	22.3	21.5	21.6	26.7	32.1	35.7	39.2
	21.8	22.4	21.7	19.3	17.0	16.5	15.0	15.5	16.9	17.7	19.5	20.7
WILUNA	43.0	42.6	40.1	35.9	31.9	25.9	26.3	29.6	34.6	37.7	39.6	42.7
	23.4	24.4	25.5	21.6	17.6	16.4	17.0	16.2	18.8	18.0	20.7	22.9
WITTENOOM	44.3	42.8	42.4	38.6	32.9	29.1	28.8	31.2	36.3	39.6	42.7	43.4
	24.5	24.7	23.7	21.6	20.3	19.1	17.8	17.4	19.3	19.8	21.3	23.4
WONGAN HILLS	43.3	42.3	39.3	34.3	28.3	23.9	23.9	24.1	30.4	35.8	37.9	41.1
	23.6	23.5	21.2	19.7	17.6	15.5	15.6	15.8	17.8	17.7	20.1	21.9
WYNDHAM PO (OLD SITE)	42.4	41.2	40.7	39.7	37.4	35.7	34.8	36.1	39.0	41.3	42.3	42.6
	29.6	29.6	29.5	28.8	26.4	24.8	25.7	29.0	28.3	27.5	29.2	29.9
WYNDHAM PO	42.4	40.4	40.1	39.2	37.1	34.4	34.7	37.1	39.2	41.6	42.7	43.7
	27.8	28.1	27.3	26.3	24.9	23.4	22.7	23.6	24.7	26.7	27.8	27.9
YALGOO (MURGOO)	44.9	43.8	41.3	36.8	32.4	25.7	26.1	28.7	34.4	38.1	39.7	42.3
	23.7	24.6	23.6	20.3	19.4	16.9	15.5	17.2	18.5	19.5	21.2	22.8
YALGOO PO	43.4	42.5	41.9	37.5	32.6	25.5	23.9	28.1	33.1	38.0	40.1	41.7
	23.4	24.9	23.4	21.0	20.7	18.6	16.0	15.2	16.6	18.9	19.6	21.3

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
WESTERN AUSTRALIA (Continued)												
YORK	44.4	43.1	38.4	33.5	27.5	23.8	22.5	23.1	28.8	35.6	37.6	40.8
	23.0	24.3	23.5	20.5	18.6	16.6	15.8	16.5	18.4	19.7	21.6	24.1
NEW ZEALAND												
AUCKLAND	28.0	28.5	26.3	23.8	21.0	19.8	17.8	18.0	19.6	21.0	23.5	25.5
	22.3	22.3	21.6	20.0	17.9	17.6	15.0	15.8	17.3	18.0	18.8	20.8
CHRISTCHURCH	31.0	31.5	30.5	26.0	22.5	17.5	17.0	20.0	23.3	25.7	27.7	28.8
	20.3	19.8	18.8	16.8	14.8	11.7	10.7	12.6	13.8	15.0	16.7	17.7
INVERCARGILL	27.5	27.3	25.5	23.3	19.3	15.8	14.5	17.5	19.5	20.8	23.2	26.3
	20.5	20.5	17.9	16.5	13.8	11.5	10.8	11.9	12.9	14.6	17.3	18.3
WELLINGTON	26.5	26.9	24.3	21.6	18.8	16.5	15.3	15.6	17.9	18.3	22.2	23.5
	20.5	19.9	19.8	16.9	15.4	14.3	12.0	13.2	13.9	14.8	16.6	18.4
PAPUA NEW GUINEA												
AITAPE (2) SDHQ	30.8	30.8	31.1	31.5	31.7	31.7	31.2	31.2	31.1	31.1	31.2	30.5
	26.6	26.6	26.6	29.4	29.4	30.3	29.7	28.5	28.4	28.4	29.0	29.0
AIYURA (MC3)	25.9	25.1	25.1	25.1	25.0	24.1	24.8	24.0	25.3	25.5	26.1	25.0
	21.2	20.6	20.6	22.1	20.7	20.2	20.3	20.2	20.2	22.4	20.5	21.1
ANGORAM SDHQ (MB28)	36.1	35.0	34.0	33.7	34.3	33.4	33.2	33.4	33.9	34.7	34.4	33.9
	30.3	27.1	30.0	28.9	29.7	30.5	28.2	28.1	29.8	29.3	29.1	28.0
BALIMO SDHQ	34.2	33.4	33.5	32.6	31.9	31.2	30.0	32.1	32.0	33.6	35.6	34.9
	27.1	28.1	28.2	27.7	27.0	26.7	27.1	25.8	27.6	27.5	28.8	28.7
BEREINA AG.ST.	33.1	32.7	32.6	31.6	31.4	31.2	31.0	31.6	30.9	31.8	32.3	32.6
	27.1	28.5	29.8	27.2	29.2	29.3	26.4	26.9	26.2	27.4	27.3	27.1
BUIN (COASTAL SITE KANGU)	32.3	32.0	32.2	31.3	30.6	30.6	30.2	30.2	30.6	30.9	30.8	31.3
	27.8	26.8	28.6	29.6	28.6	28.9	27.1	28.2	28.2	28.8	28.5	30.2
BULOLO FORESTRY SCHOOL	33.1	32.6	33.4	32.8	31.6	31.9	31.1	31.8	31.3	31.2	32.4	32.8
	24.5	25.3	24.2	24.3	23.4	22.9	22.5	23.0	22.9	24.9	23.6	23.7
BWAGAOIA	32.0	31.8	31.2	31.1	30.0	29.5	28.6	28.7	29.4	30.1	30.7	30.9
	27.7	27.4	27.0	26.7	26.5	25.9	25.8	26.5	26.9	26.3	26.8	27.2
DOGURA	33.1	32.4	32.1	31.8	31.3	30.9	30.7	31.5	32.2	32.2	32.5	32.5
	27.6	27.1	27.3	26.7	26.8	26.0	25.5	25.7	26.1	26.3	26.9	26.9
ERAVE P.P. MD52 COMPOSITE	27.8	27.6	27.3	26.8	26.6	26.5	26.2	25.8	25.5	27.2	29.2	28.1
	25.6	25.8	24.9	24.7	24.8	21.8	21.4	21.1	21.3	22.3	22.0	22.5
GARAINA (TEA PROJECT)(MGI)	31.3	31.4	31.1	30.0	29.8	29.2	29.0	29.4	30.3	30.6	31.3	30.7
	24.6	24.9	25.8	25.8	24.1	23.5	23.1	23.7	24.5	24.5	24.7	25.2
GOROKA AERADIO A/F	28.3	27.8	28.2	28.1	27.4	27.6	26.8	27.4	28.0	28.6	28.7	27.9
	20.2	20.1	20.1	19.6	19.7	19.0	19.6	18.9	19.1	19.6	19.5	19.8
KAGAMUGA (MT.HAGEN A/F)	26.9	26.8	26.8	26.4	26.8	26.6	26.1	26.7	27.3	26.9	27.1	26.6
	21.6	19.8	20.0	19.7	19.3	19.8	19.3	18.7	22.9	19.0	19.3	20.0
KAIAPIT SDHQ (ME13)	34.1	34.4	34.5	32.7	32.5	32.1	31.2	33.4	33.2	34.7	35.6	33.6
	25.6	26.0	25.9	26.6	25.6	25.3	27.8	26.4	27.7	26.8	26.3	25.6
KAINANTU A/F SDHQ (MC1)	28.4	27.6	26.5	25.0	25.5	24.5	24.5	24.7	25.1	25.8	27.1	25.9
	21.3	22.9	21.4	21.0	20.4	19.7	18.8	18.8	19.1	20.6	21.8	22.3
KUNDIAWA	28.8	28.4	28.3	28.3	28.0	28.4	27.8	28.7	28.3	29.0	28.9	28.1
	22.5	23.0	25.1	23.8	24.6	21.3	20.1	21.7	20.3	23.1	20.8	23.1
LAE A/F (ME1)	32.0	33.5	32.1	31.5	31.0	30.6	29.9	30.1	30.1	31.0	32.0	31.9
	26.8	27.3	26.9	26.9	26.2	25.8	25.3	25.4	25.8	26.0	26.6	27.3
LAKE KUTUBU	30.1	30.2	30.3	30.1	30.1	29.1	28.2	29.6	28.8	30.7	31.1	30.4
	27.0	25.2	26.7	26.7	26.3	26.0	24.0	24.1	25.3	26.0	25.3	27.1
LUMI A/S SDHQ	29.5	29.5	29.0	29.5	29.1	28.5	28.8	29.4	29.6	29.9	29.8	29.4
	27.6	25.2	24.4	26.2	26.0	27.6	27.8	28.5	28.2	25.9	25.2	26.2

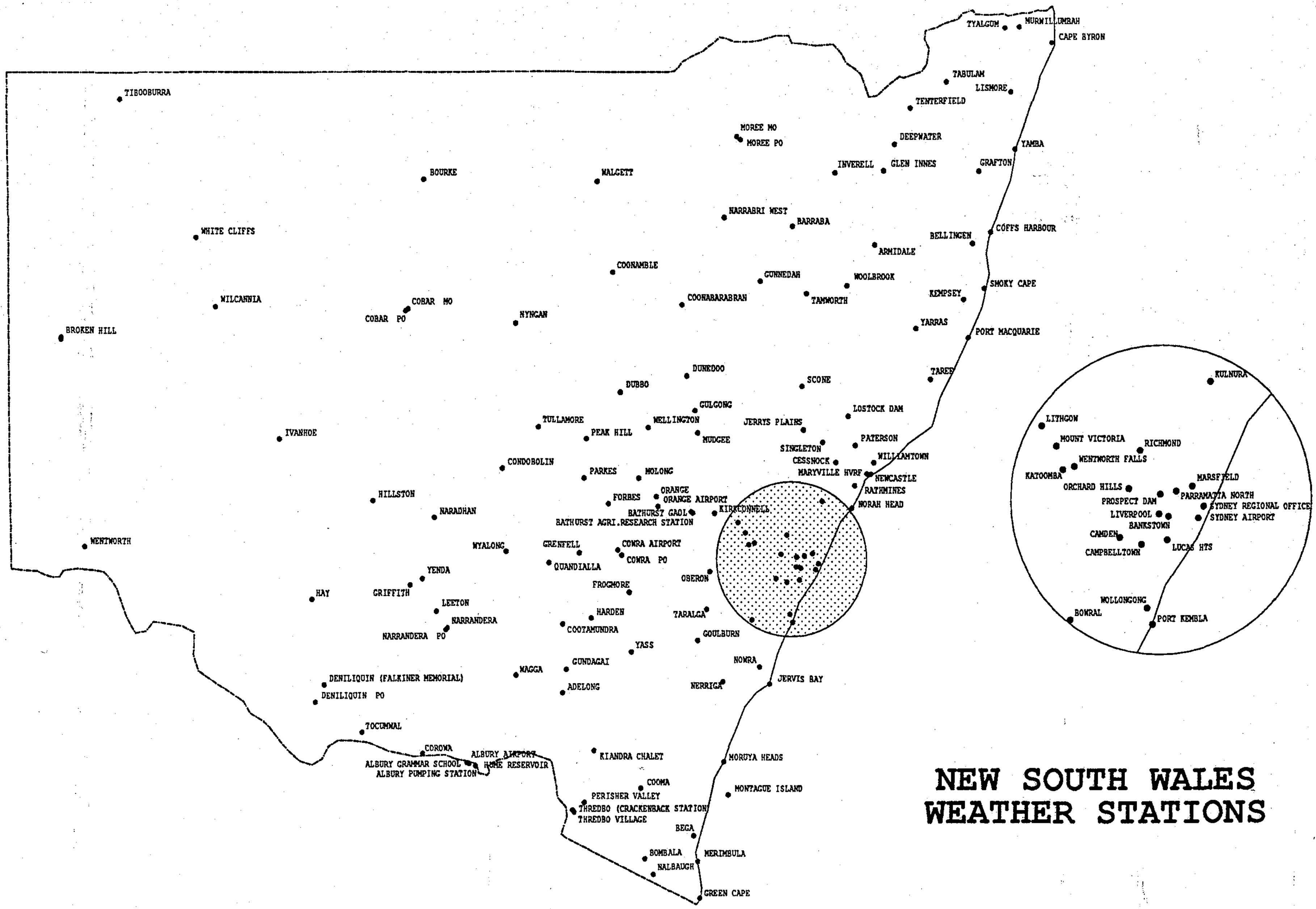
TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

Location (Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C)	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
PAPUA NEW GUINEA (Continued)												
MADANG A/F	31.4	31.6	31.1	31.2	30.8	30.6	30.2	30.7	30.7	30.9	31.1	31.3
	26.8	26.9	26.8	26.8	26.6	26.1	25.9	26.1	25.9	26.2	26.5	26.8
MENDI DHQ (M026(CP))	25.7	24.9	24.5	24.7	24.8	24.2	23.7	23.6	23.5	24.4	25.3	25.2
	23.2	23.2	21.2	21.5	22.2	21.9	21.3	21.0	20.5	22.3	23.0	23.0
MOMOTE	30.6	30.8	30.8	31.0	30.6	30.8	30.5	30.3	30.7	30.9	30.8	30.8
	26.9	26.6	26.7	26.8	27.2	26.8	26.4	26.5	26.4	26.4	26.5	26.6
POPONDETTA HIGH SCHOOL	33.2	33.8	33.5	32.4	32.2	32.0	31.1	31.8	31.6	32.3	32.0	32.4
	27.0	27.1	29.9	27.1	26.7	26.5	25.9	25.5	25.6	26.5	26.5	26.8
PORT MORESBY JACKSON A/F	33.5	33.3	32.6	32.3	31.8	31.3	31.0	31.3	31.8	32.8	32.9	33.1
	27.0	27.3	27.2	27.1	27.0	26.4	25.6	25.4	25.8	26.7	26.7	26.7
PUT NONU PLTN.	31.9	32.9	31.6	31.6	31.6	31.1	30.2	30.8	30.7	30.7	30.6	30.6
	27.1	26.7	27.0	26.6	26.6	26.4	26.4	26.7	26.6	26.3	26.5	26.6
RABAUL (2) A/F	31.5	31.2	31.3	31.6	31.7	32.1	31.8	31.9	32.3	32.2	32.2	31.4
	27.1	27.2	27.6	27.4	27.4	26.8	26.8	26.4	26.7	27.3	27.0	27.4
SALAMO MSSN.	32.0	32.3	31.7	31.7	31.0	30.3	29.3	29.9	30.1	30.7	31.7	32.0
	27.2	27.0	28.4	27.7	26.6	26.1	25.6	26.0	27.4	27.3	26.6	27.3
SOHANO	32.4	32.6	31.7	31.7	31.1	31.1	30.8	30.9	31.1	31.7	31.7	31.7
	27.0	27.8	28.0	26.9	27.0	26.6	26.3	26.5	26.5	26.6	26.6	27.2
TARI (1) SDHQ	25.4	24.9	25.4	25.0	25.8	24.7	24.5	24.7	24.6	24.6	25.8	25.5
	19.7	19.7	19.7	19.7	20.4	19.1	19.1	21.7	20.5	21.8	20.1	19.7
WABAG (SUB DISTRICT OFFICE)	24.5	23.5	24.0	23.0	23.9	23.4	23.4	23.3	23.5	23.5	24.0	24.4
	22.2	18.6	19.6	20.2	22.4	19.2	21.1	21.3	17.2	18.3	19.1	19.6
WAU HOMESTEAD	31.7	31.2	30.9	30.0	30.0	29.8	29.2	29.8	30.6	30.3	31.0	30.6
	22.9	22.8	23.0	22.9	22.7	22.3	21.7	22.0	22.2	22.2	22.5	22.8
WEWAK A/F (MB2)	31.8	31.4	31.5	31.6	32.4	32.0	31.1	31.4	31.7	31.9	31.5	30.9
	26.8	26.6	26.7	26.9	27.2	27.3	26.9	26.6	26.6	26.7	27.1	26.8
SOLOMON ISLANDS												
AUKI	32.0	31.7	31.7	31.6	31.5	31.3	30.9	30.7	31.1	31.6	31.6	32.0
	27.6	27.7	27.4	27.5	27.6	27.2	26.8	27.2	27.2	27.4	27.4	27.4
HONIARA (HENDERSON AIRPORT)	32.8	31.9	32.0	32.1	32.3	31.9	31.7	31.9	32.0	32.6	32.0	32.0
	27.3	27.4	27.3	27.1	27.2	26.8	26.6	26.3	26.4	26.9	26.8	27.3
HONIARA (VAVAYA RIDGE)	32.1	32.3	31.9	31.5	31.6	31.6	31.9	31.8	31.7	31.4	31.8	31.9
	26.9	27.1	27.0	27.0	27.1	26.5	26.5	26.1	26.4	26.5	26.9	26.9
MUNDA (NEW GEORGIA)	32.0	32.1	32.5	31.9	31.9	31.3	30.9	30.6	31.0	31.8	31.7	32.1
	27.7	27.3	27.5	27.2	27.1	26.8	26.5	26.3	26.5	27.0	27.4	27.5
TARO IS. (CHOISEUL)	32.1	31.9	31.6	31.4	31.8	31.0	30.8	30.7	30.8	31.8	32.1	32.1
	27.6	27.5	27.6	27.5	27.7	27.2	26.9	27.0	27.7	27.6	27.7	27.9
VANUATU												
ANEITYUM AERODROME	31.1	31.5	31.0	29.7	28.7	28.3	28.0	27.3	27.6	29.2	30.0	30.8
	26.8	27.5	26.8	25.9	25.5	24.6	23.8	23.2	24.0	24.6	25.6	26.6

TABLE 1B - MONTHLY ONE DAY IN TWO YEARS DESIGN CONDITIONS (REFER PAGE 10) (Cont'd)

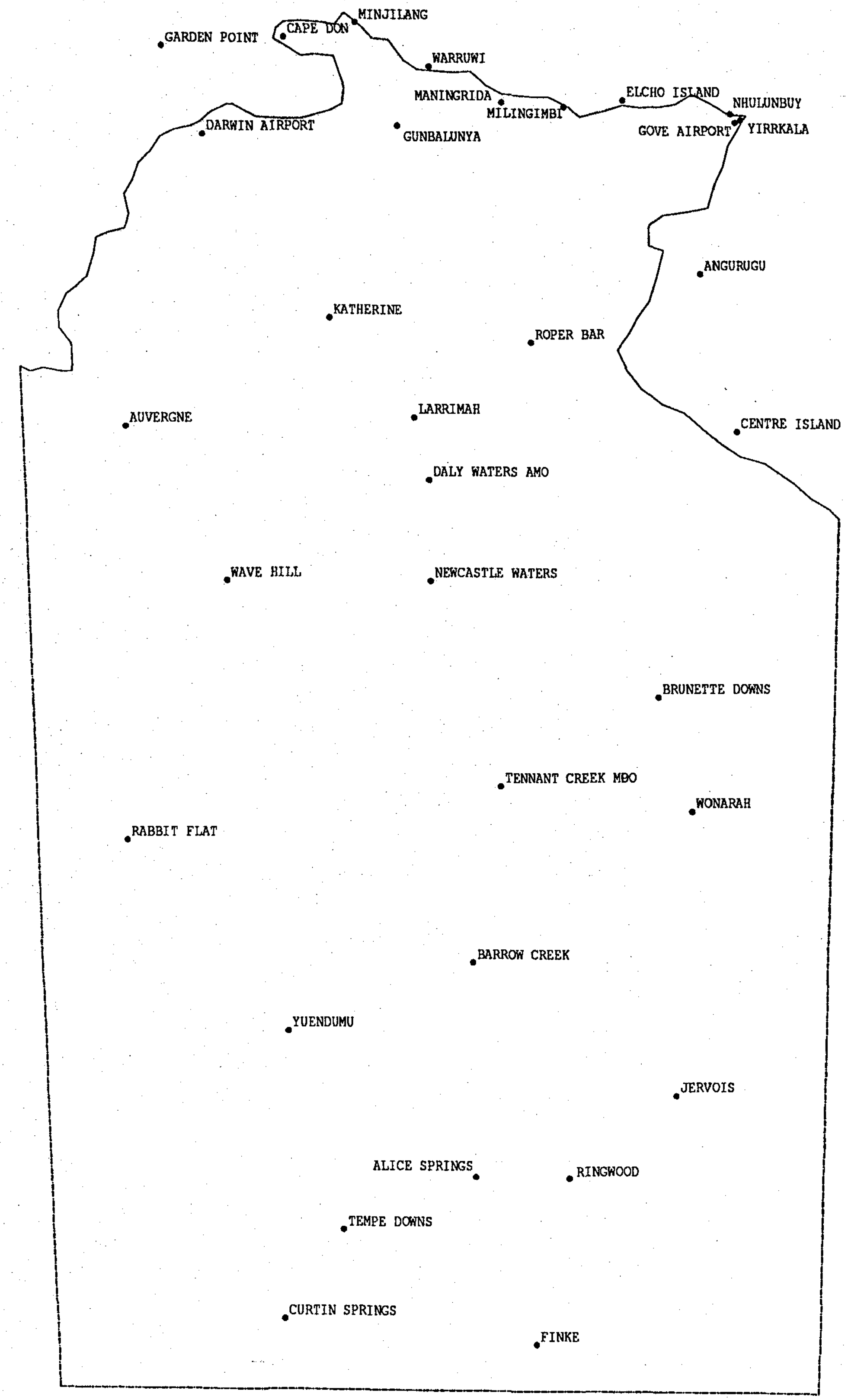
Location	JAN	FEB	MAR	APL	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Monthly Dry Bulb Temperature °C / Monthly Wet Bulb Temperature °C											
BANGLADESH												
DHAKA	28.2	31.9	36.7	38.2	37.8	35.5	33.9	34.8	34.9	34.4	32.4	28.8
	22.2	23.5	26.9	29.4	29.9	29.9	29.6	29.2	29.8	28.9	25.9	22.4
HONG KONG												
CHEUNG CHAU	24.9	25.9	27.5	30.0	32.6	35.2	34.2	33.9	33.5	31.8	29.6	26.3
	20.9	22.2	24.5	27.2	29.2	30.3	30.0	29.9	29.2	27.6	25.3	21.9
HONG KONG AIRPORT	24.3	25.0	27.0	29.9	31.7	33.6	34.3	34.3	34.3	31.7	28.9	25.9
	19.8	21.0	23.9	25.4	27.4	28.0	28.0	28.4	27.7	26.6	23.8	20.9
HONG KONG REGIONAL OFFICE	22.6	24.1	26.7	29.3	30.9	32.6	33.9	33.3	32.6	30.6	27.2	24.4
	19.6	21.0	23.8	25.4	27.0	28.0	28.0	28.2	27.8	26.6	23.7	20.4
KOREA												
PUSAN	14.0	17.2	18.0	23.7	26.2	28.2	34.0	33.6	31.2	27.1	22.7	19.3
	10.5	13.7	13.2	17.3	19.4	23.5	27.4	28.1	26.6	21.3	17.3	14.0
SEOUL	9.3	13.0	18.3	26.8	30.1	32.0	35.5	35.3	31.0	26.3	19.5	13.3
	6.0	9.4	10.5	16.4	20.5	23.9	27.4	27.1	24.5	18.5	14.3	10.0
TAEJON	10.6	15.4	19.7	27.5	30.1	32.5	36.5	35.8	31.7	27.0	21.2	16.0
	6.5	9.9	11.0	18.0	20.7	25.0	27.3	27.0	25.3	19.5	16.0	10.7
PHILIPPINES												
DAVAO CITY †	35.0	35.1	35.5	36.4	36.1	34.5	34.3	34.9	34.9	35.2	35.2	34.9
	27.3	27.3	27.4	28.3	28.4	28.4	28.3	28.2	28.3	28.2	28.0	27.4
MACTAN, AIRPORT †	33.4	33.4	34.3	35.2	35.9	35.3	34.3	35.0	34.5	34.4	34.2	33.4
	27.3	27.3	27.4	28.3	28.4	28.4	28.3	28.2	28.3	28.2	28.0	27.4
MANILA, PORT AREA †	33.3	34.3	36.0	36.4	36.4	35.8	34.8	34.3	34.9	34.4	34.2	32.7
	26.2	26.2	27.1	27.4	28.4	28.3	28.3	28.0	27.8	27.4	27.3	26.4
SINGAPORE												
SINGAPORE	32.7	32.8	33.0	33.2	33.6	33.2	32.6	32.7	31.9	32.7	32.0	31.5
	26.9	27.0	27.8	27.9	27.9	27.8	27.2	27.2	27.5	27.0	27.0	26.9
THAILAND												
BANGKOK ‡	34.0	35.0	35.9	37.5	37.7	35.7	35.0	34.9	34.6	33.8	33.8	33.8
	26.8	26.9	27.9	28.6	28.6	28.0	27.9	27.8	27.8	27.7	26.9	25.7
CHIANG MAI ‡	33.0	35.8	38.2	40.5	38.7	36.2	35.5	34.8	34.5	33.9	32.8	30.8
	23.3	23.6	24.8	26.9	26.9	26.8	27.0	26.9	26.9	26.6	25.0	22.4
HAT YAI ‡	31.6	34.5	35.6	36.6	34.9	34.9	34.8	34.8	33.9	33.0	31.7	30.7
	25.8	26.7	26.9	27.2	27.7	27.6	26.9	26.9	26.9	26.9	26.7	25.9
VEIT NAM												
CAN THO ‡	31.4	32.7	34.6	35.0	35.0	32.9	32.6	32.0	32.5	31.8	31.4	30.9
	25.9	26.0	27.0	27.7	27.9	27.9	27.8	27.6	27.6	27.0	26.9	26.0
HO CHI MINH ‡	34.3	34.3	34.7	36.6	36.1	35.3	34.6	34.1	34.2	33.0	33.2	33.3
	26.4	26.4	28.0	28.7	28.4	28.3	27.9	27.7	27.9	27.4	27.3	26.4
LANG-HANOI ‡	25.8	27.8	31.0	33.5	37.0	38.0	37.3	36.5	35.2	32.0	29.8	26.9
	22.2	23.2	26.4	27.7	29.5	29.5	29.4	29.4	28.8	27.3	25.4	22.5

† Daily Maximum DB and WB temperatures not 3 p.m.
‡ 4 p.m. DB and WB temperatures not 3 p.m.

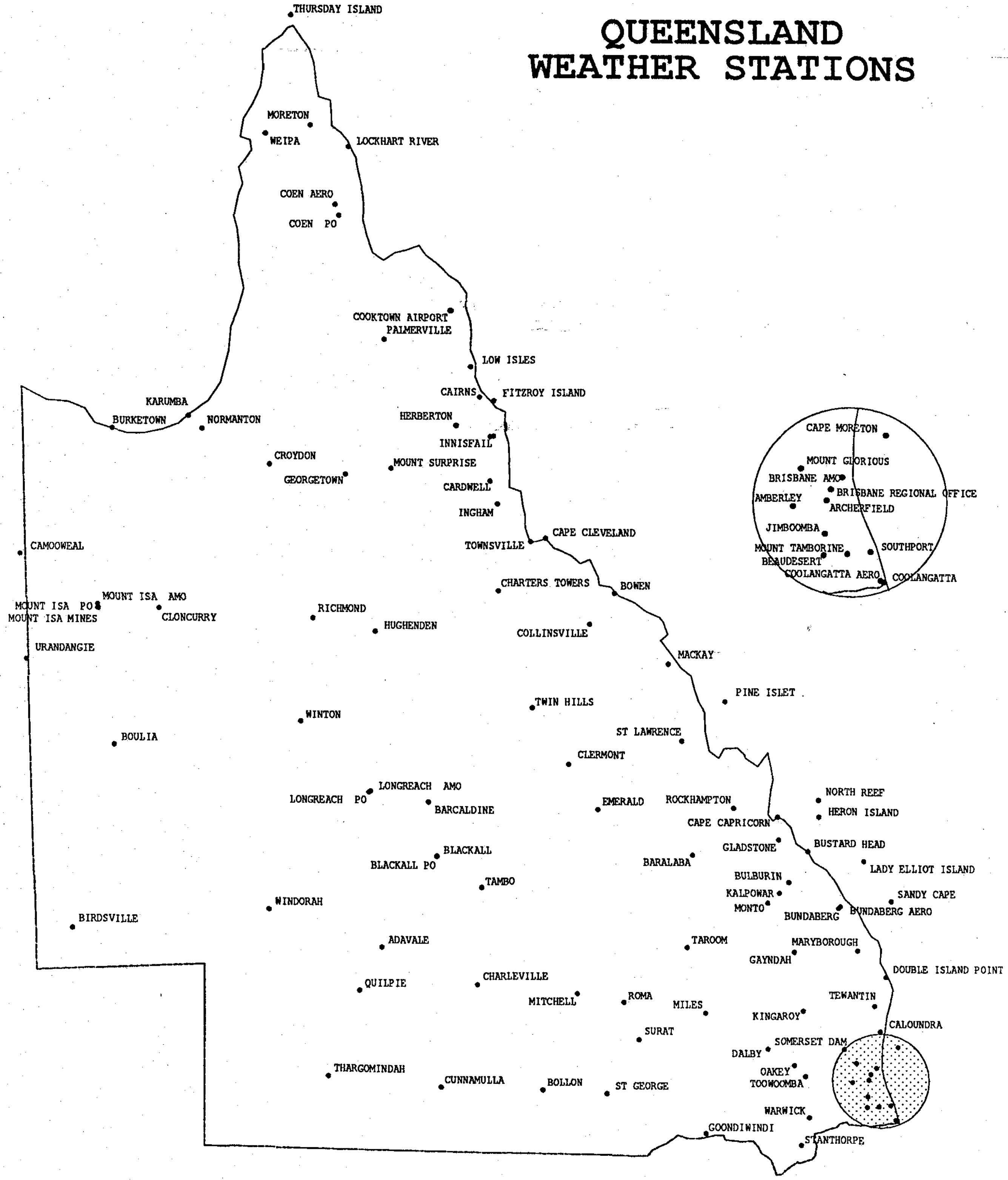


NEW SOUTH WALES WEATHER STATIONS

NORTHERN TERRITORY WEATHER STATIONS

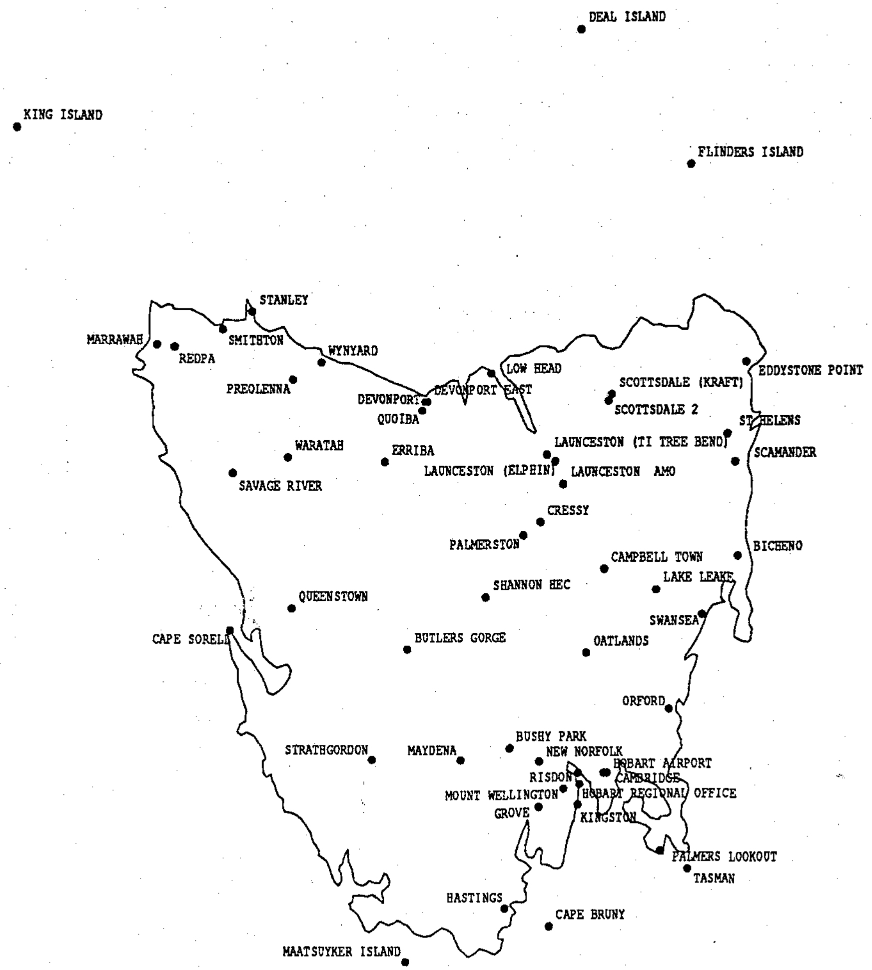


QUEENSLAND WEATHER STATIONS

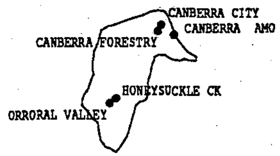


SOUTH AUSTRALIAN WEATHER STATIONS

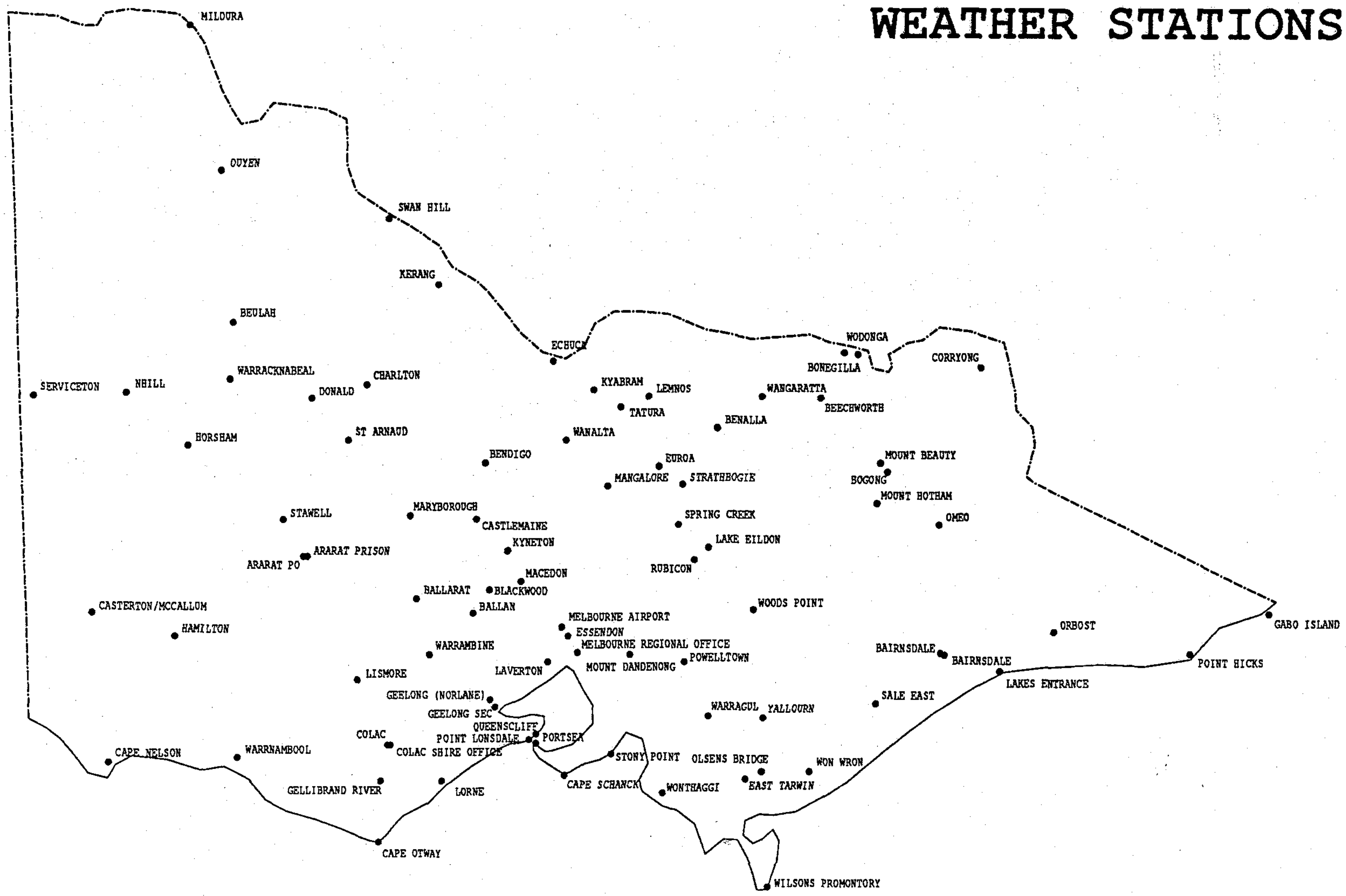
TASMANIAN WEATHER STATIONS



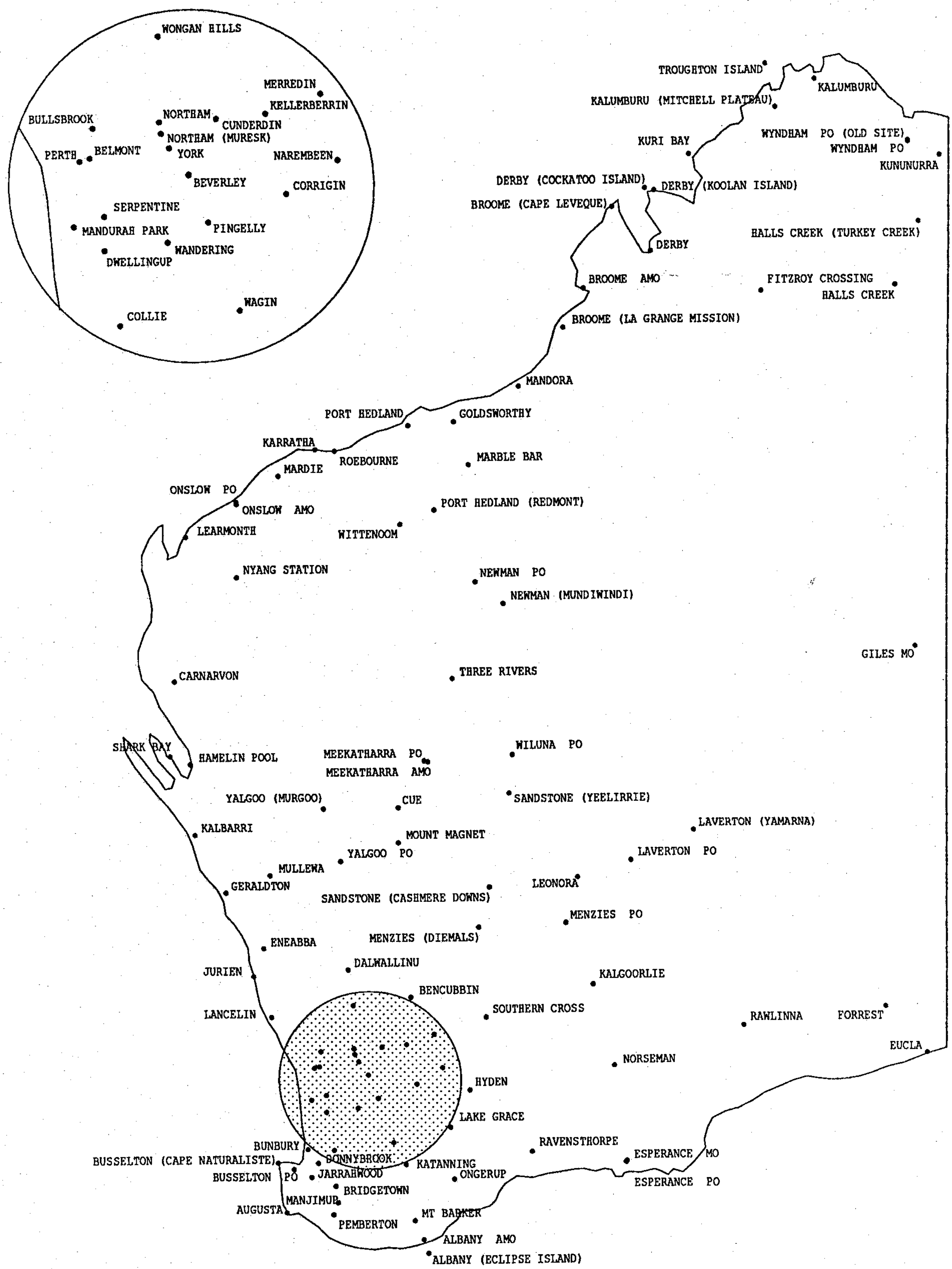
AUSTRALIAN CAPITAL TERRITORY WEATHER STATIONS



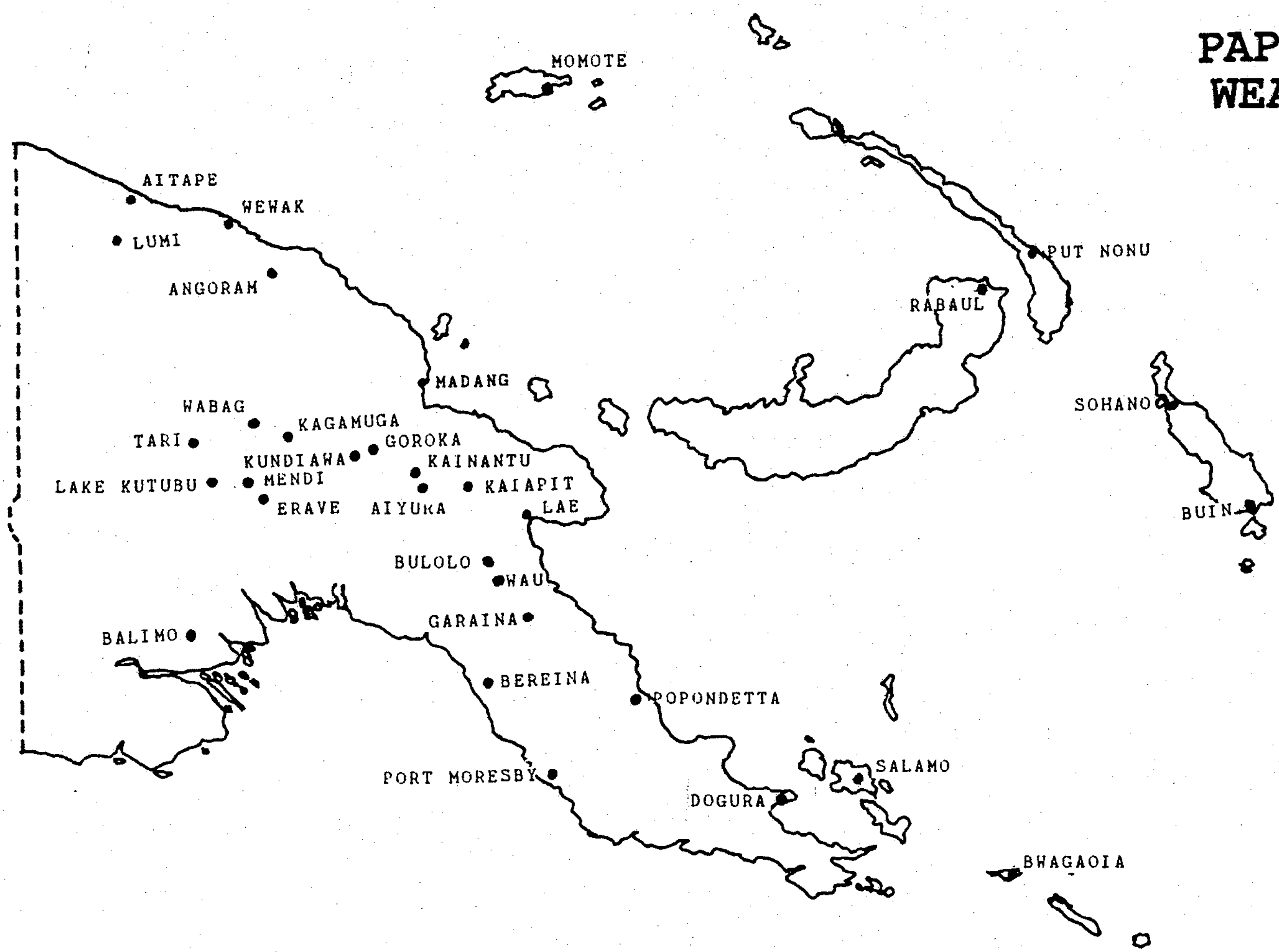
VICTORIAN WEATHER STATIONS



WESTERN AUSTRALIAN WEATHER STATIONS



PAPUA NEW GUINEA WEATHER STATIONS



INDEX

INDEX

RM 82/30059 Cat. No. 82 3224 4

Publications in this series
application manuals

AIRAH

achieving **recognition**

Australian Institute of Refrigeration Air Conditioning and Heating (Inc.)

Level 3, 1 Elizabeth Street Melbourne Victoria 3000
Ph +61 3 8623 3000 Fax +61 3 9614 8949

www.airah.org.au