Department of Primary Industry

AUSTRALIAN CODE OF PRACTICE FOR DAIRY FACTORIES

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Section E

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Section E— Principles of ventilation

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Principles of ventilation

Note:
Mandatory requirements related to ventilation are included in Section A, clauses 26 to 32 inclusive.

Part I—General

Aim

E1.1 Proper ventilation should achieve the following benefits:

(a) condensation control;

(b) air filtration and extraneous matter control; and

(c) operator comfort.

Part II—Types of ventilation

Natural ventilation

E2.1 Whilst natural ventilation is not acceptable in manufacturing areas, it may be used elsewhere in dairy factories, e.g. dry storage areas where product or packaging materials are not exposed.

E2.2 Natural ventilation can be described as the movement of air into and out of a building under the action of natural atmospheric forces. Such air movement is variable in quantity and quality with regard to volume, velocity, microbiological contamination, temperature, relative humidity, and dust levels.

E2.3 The principal agencies that promote ventilation by natural means include temperature differences which cause air to rise and circulate within a building, wind action, and leakages into or out of a building.

Mechanical ventilation

E3.1 Mechanical ventilation relies on the use of powered ventilators or fans to assist in moving air through a building.

E3.2 Air movement from this system is general and does not always cope with the load imposed on it, leading to isolated problems of condensation and "dead" pockets in a room.

E3.3 In common with E2 above, mechanical ventilation requires ceilings to have a slope of at least 1:20 to assist in a rapid movement of air from the room via ceiling exhaust ducts.

E3.4 A limitation exists with powered exhaust fans in their ability to "pull" air from remote parts of a room.

E3.5 Exhaust fans then, are only effective for pinpoint placement near problem spots or if a positive movement of air towards their inlet side exists.

Ducted systems

E4.1 These systems usually comprise a central, high capacity fan which blows air through an extensive duct work to designated points throughout the room being treated. The location of outlets or grills is usually calculated to ensure that general and specific ventilation loads of a room are accommodated. The air flow can be on a once through basis or returned for purification before re-use.

E4.2 In both cases, the system is designed to achieve desirable air-conditioning in the room being treated. Proper filtration, temperature and humidity controls should be used to minimise the risk of contamination being spread from this source.

Part III—Condensation control

General

E5.1 In the absence of adequate ventilation, condensation is a widespread problem in many areas of dairy factories. Condensation is capable of promoting a breakdown of surface finishes on buildings and plant, thus having an accelerated ageing effect. Also, by encouraging the development of micro-organisms, it can lead to contamination of plant surfaces and/or dairy products. Condensation occurs when moisture laden air comes into contact with surfaces which are below the dew-point temperature.

E5.2 Weather conditions have a strong influence on condensation levels, such levels usually being heaviest in winter. Steps which can be taken to reduce condensation to acceptable levels concern:

(a) building design aspects;

(b) process operating conditions; and

(c) air treatment and movement.

Building design aspects

E6.1 Insulated walls and, especially, ceilings will help to raise the surface temperatures in a room to above dew-point conditions. However, it is essential that the insulation is sealed to prevent moisture as well as heat penetration, otherwise condensation may occur within the actual wall or ceiling, and lead to loss of insulation ability and, perhaps, breakdown of the material.

E6.2 Dead spots can promote condensation and act as collection points for dust, micro-organisms and bacteriophage.

E6.3 It is difficult to completely seal the processing room from the outside air. Obvious faults such as open or poorly fitting doors and other openings or gaps to the outside should be corrected. Processing areas should be shielded from outside winds to maintain an internal pressure of 50 pascals above the outside air. This can best be achieved by using less critical building areas as a buffer on the windward side, air locks to isolate processing areas, and careful maintenance of seals around all openings, especially doors and windows.

E6.4 Covered or under floor drains aid in reducing the amount of heat and moisture release to the air and are preferred to an open system.

Process operating conditions

E7.1 Steps should be taken to control condensation and should aim to reduce possible sources of heat and high relative humidity originating from the process, e.g. enclosing of cheese and casein vats.

E7.2 *Wet conditions*:
Wherever possible, enclose drains and eliminate wet floors by piping liquid wastes direct to drains and attaching flow control devices to hoses. Generally, dry floor operation is possible in dairy factories and should be achieved. As well as a reduction in condensate problems, other benefits that can be achieved include increased safety in the plant, less corrosion of building and equipment surfaces, and a reduction in effluent levels.

E7.3 *Wash up period*:
Ensure that special or boosted air exhausting is used in this period to reduce fogging and excessive condensation.

E7.4 *Open processes*:
Wherever practicable, these should be undertaken in isolated or enclosed areas, especially if the processes result in the emission of large amounts of heat or moisture into the surrounding air.

E7.5 *Steam, water, heated-air leaks*:
Avoid these by proper care and maintenance.

Air treatment and movement

E8.1 Conditions in processing areas will improve if every step mentioned above is followed to reduce the amount of heat and moisture emission into the surrounding air. In some instances however, it is unlikely that such efforts alone will solve the problem. A suitable ventilation or air-conditioning system may then be required.

E8.2 Adequate air-conditioning or ventilation systems are not always economically feasible in plants with high concentrations of heat or moisture where few people are working. The best approach is to isolate or remove the source of heat or moisture production from the occupied areas. The building structure itself should be suitable for the process, with effective insulation and adequate ceiling height.

It may be more economical to reduce, to remove to an unoccupied place, or to eliminate entirely a source of heat than to install equipment to overcome the problems created by it. First consideration should be given to local exhaust hoods and radiation shielding. A second alternative is to construct an air-conditioned section or room within the hot area.

Components of system design

E9.1 *Heating*:
Raising the air temperature increases its moisture carrying capacity. Air heating is therefore desirable, but if not applied on a 24 hour a day basis, condensation could occur when heating is turned off.

E9.2 *Air changes*:
Air changes required will be governed by-

(a) the worst ambient conditions existing during any stage of processing, including the wash-up period;

(b) process layout which will influence distribution and exhausting of air, short process lines are desirable; and

(c) operator comfort.

E9.3 It is not satisfactory to set ventilation requirements for the different types of factory processing areas in terms of air changes, because the internal dimensions of similar processing zones, the equipment used, the production rate, the building design and the ambient conditions of the locality vary extensively from factory to factory. For this reason, the recommended number of air changes required at one factory could be totally inadequate, or grossly excessive, in another factory manufacturing the same dairy product. Therefore, the air change requirements should be determined separately for each plant.

As a guide, over the normal range of dairy factory operations, the number of air changes per hour could vary from 6 (suggested minimum for dry areas) to 15 or 20 for wet manufacturng areas/spray dryer rooms, etc.

In considering air change rates in manufacturing areas, the need to maintain a minimum positive pressure of 50 pascals at all times must be recognised.

E9.4 *Air distribution*:
Ducting should be constructed to British Standard 5720:1979 requirements in every respect thus ensuring smooth air flow at all changes in direction. Ideally, air should be side distributed to produce a "brushing" effect over the wall and ceiling surfaces and centrally exhausted from the ceiling to use the advantage of natural thermal convection of air. Air should not be directed onto areas where product is exposed.

Relief or spot exhausting units should be installed to cope with isolated or periodic heavy loads on the ventilation system.

E9.5 *Dehumidification*:
Sophisticated units are available commercially to chemically absorb moisture from the air prior to recycling. A simple but effective way of achieving this physically is to insert a cooling coil in the duct work.

E9.6 *Air intake*:
The air intake must be positioned to obtain the cleanest and coolest air possible. The inlet chamber should be arranged as shown in Fig.1 with weather-proof and bird-proof louvres.

Primary filters ("roughing filters") to remove gross dust, insects, etc., should be used in front of the final filters to extend their life.

The final filters, which are protected by the primary filters, should have an arrestance efficiency of 95% when tested with No.2 dust in the Australian Standard air filter test.

Part IV—Air filtration

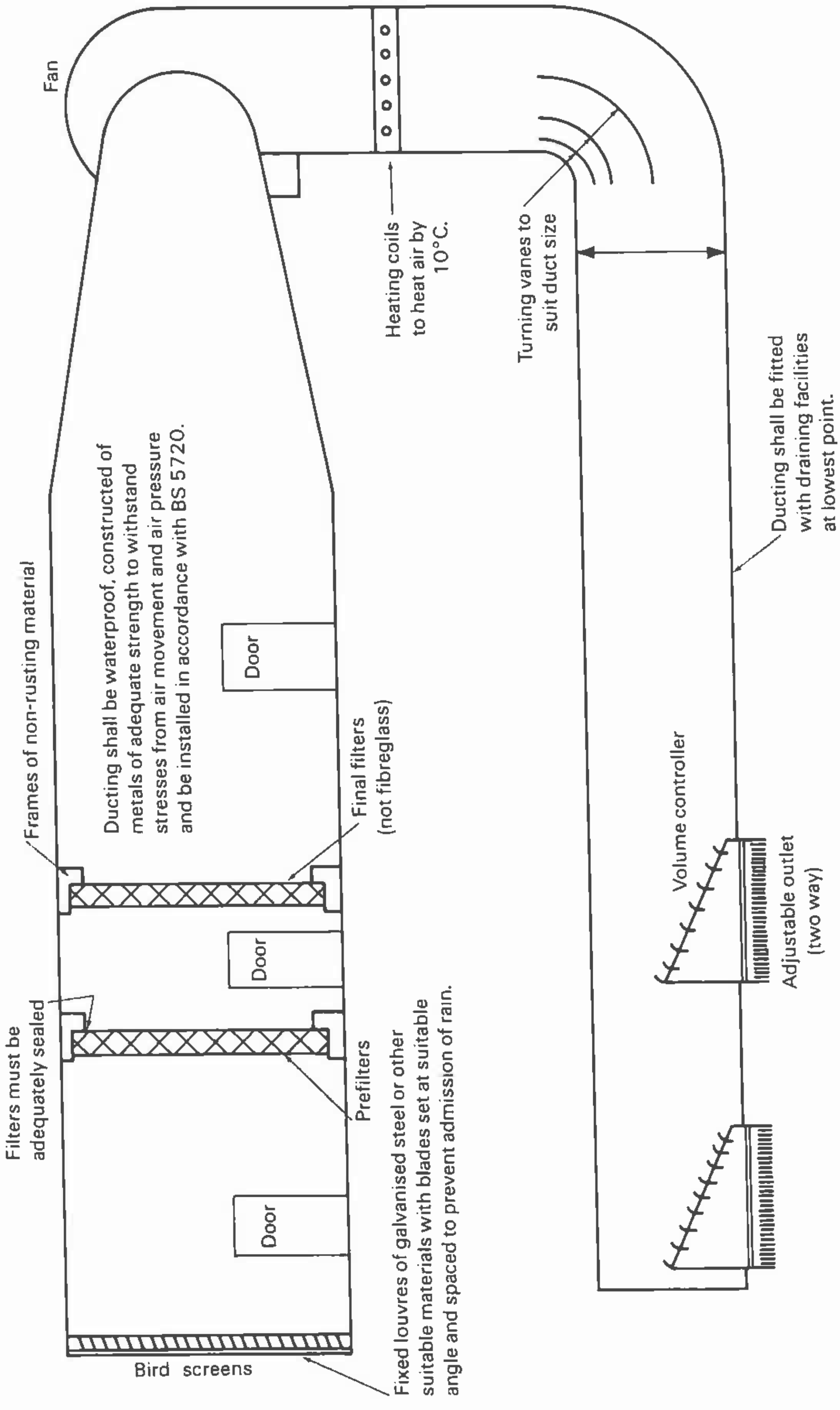
General

E10.1 All ventilation systems expose the factory environment to contamination from external airborne contaminants.

Nature of air contaminants

E11.1 The substance known as "atmospheric dust" is actually a combination of many different varieties of solid matter. The relative proportions of each constituent are not fixed and can vary over a wide range.

Figure E1 — Typical ducted ventilation system



E11.2 Included in the list of constituents are solid particles of soot and other carbonaceous matter, ash, earth, sand and siliceous material, fibre, road dirt, and other animal, vegetable and mineral matter, together with mould spores, bacteria, viruses and pollens.

E11.3 The sizes of individual airborne particles are expressed in the unit "micron" (or micrometre), which is one thousandth part of one millimetre (0.001mm). The smallest particle visible to the naked eye under ideal conditions is about 10microns. Particles larger than about 10microns generally settle out on horizontal surfaces, such as shelves and pipes. The smaller particles remain more or less continually in suspension or are deposited on horizontal or vertical surfaces, independent of gravity by impingement or electrostatic attraction.

The necessity for air filtration

E12.1 It is quite apparent that dust, soot and other airborne contaminants must be removed wherever air is used in food manufacturing areas for ventilation, cooling, drying, heating or industrial processes.

E12.2 All dust is more or less objectionable but certain types of dust are particularly dangerous to humans and harmful to industry.

Types of filters

E13.1 Although there are many different types of filters available commercially, all fall into one of, or a combination of the following three basic categories:

(a) metal viscous oil;

(b) dry arrestance (including absolute type); and

(c) electrostatic.

E13.2 There is no precise correlation between these filter types and efficiency ranges, but electrostatic units are generally high efficiency, metal viscous oil filters low to medium efficiency, and depending on the type of media used, dry arrestance filters can exhibit virtually any efficiency.

E13.3 In addition to those mentioned, sometimes air washers used for humidification or dehumidification purposes also act as air cleaning devices.

E13.4 The selection of the most suitable type or combination of types of filter for a particular application is governed by:

(a) the anticipated dust load, quantity, type and size;

(b) the degree of cleanliness required; and

(c) economic aspects including capital cost, operating and maintenance costs and potential savings from using the system.

E13.5 Often the most acceptable selection may involve a combination of two different types operating in tandem, e.g. metal viscous oil filters as a prefilter to dry arrestance or electrostatic type filters. This allows the latter to concentrate on particles smaller than 5microns, the larger particles being removed by the metal viscous filter.

Filter standards

E14.1 The reference test suggested for this purpose is contained in AS1132-1973: "Methods of Test for Air Filters for use in Air-Conditioning and General Ventilation". The method applicable to the dairy industry would be a gravimetric test utilising No.2 dust.

E14.2 Section 3 of this Standard describes this gravimetric test utilising the No.2 aluminium oxide test dust. In the test, dust is fed into the airstream ahead of the filter, which has previously been weighed, and after a known mass of dust has been introduced the filter is again weighed.

From the increase in weight of the filter which corresponds to the amount of dust retained, and the amount of dust fed, the gravimetric arrestance efficiency can be calculated from the formula:

$$\frac{\text{Weight of dust retained on filter}}{\text{Weight of dust fed}} \times 100\%$$

No.2 dust contains 60% to 80% by weight of the particles within the range 3.5micron to 7micron size, 99.5% finer than 13micron and 2% finer than 2.5micron.

Refer A28.1 for minimum Standards for filters used in the dairy industry.

Part V—Operator comfort

Note:
As a guide to operator comfort refer to Table 1, Heat Stress Index Table of the American Society of Heat, Refrigeration and Air-Conditioning Engineers.

Conditions

E15.1 The conditions conducive to comfort have been found to depend upon temperature, humidity, air motion and air purity.

Temperature

E16.1 Proper control of temperature of the atmosphere surrounding the body removes a physiological stress of accommodation, thereby making for greater comfort and improved physical well-being and health.

Humidity

E17.1 A large proportion of body heat is lost by evaporation from the skin. Humidity control therefore has an important effect on comfort. Extremes of humidity not only result in undesirable physiological reactions but also affect (usually adversely) the properties of many substances in the treated space, clothing and furniture in particular.

Air motion

E18.1 Movement of air over the body increases the rate of heat and moisture dissipation above the still-air rate, thereby modifying the feeling of warmth and coldness.

Air purity

E19.1 The physical and chemical composition of the air embraces a number of diverse elements, and in food factories is normally complied with as far as operator comfort is concerned.

Table 1 — Heat stress index

The heat stress index combines the subjective effect of temperature and relative humidity and is chosen to be numerically equal to the actual dry bulb temperature when the relative humidity is 50 per cent.

	Temp Deg C	Per cent relative humidity 10	20	30	40	50	60	70	80	90
Comfortable	21	20.5	20.5	21	21	21	21	21	21	21
	21.5	21	21	21	21.5	21.5	21.5	22	22	23
	22	21	21.5	21.5	22	22	22	23	23.5	24
	23	21.5	22	22	22	23	23.5	23.5	24	24.5
	24	22	22	23	23	23.5	24	24.5	25	25.5
	24	22	23	23.5	23.5	24	24.5	25	25.5	26.5
	24.5	23	23.5	23.5	24	24.5	25	25.5	26.5	27
	25	23	23.5	24	24.5	25	25.5	26	27	28
	25.5	23.5	24	24.5	25	25.5	26	27	27.5	29.5
	26	24	24.5	25	25.5	26	26.5	27.5	29	30
	26.5	24	24.5	25.5	26	26.5	27	28	29.5	31
	27	24.5	25	25.5	26.5	27	28	29	30.5	31.5
	27.5	25	25.5	26	26.5	27.5	29	30	31	32.5
	28	25	26	26.5	27	28	29.5	30.5	32	34
	29	25.5	26	27	27.5	29	30	31	32.5	34.5
	29.5	25.5	26.5	27	28	29.5	30.5	32	33	35.5
Mild discomfort no heat stress	30	26	27	27.5	29	30	31	32.5	34.5	36.5
	30.5	26.5	27	28	29.5	30.5	31.5	33	35	37
	31	26.5	27.5	29	30	31	32	34	36	38
	31.5	27	28	29.5	30.5	31.5	33	35	36.5	39.5
	32	27	28	29.5	31	32	34	35.5	37.5	40
	32.5	27.5	29	30	31.5	32.5	34.5	36	38	41
	33	28	29.5	30.5	31.5	33	35	36.5	39.5	42
	34	28	30	31	32	34	35.5	37.5	40	42.5
	34.5	29	30	31.5	32.5	34.5	36	38	40.5	44
Discomfort mild stress	35	29	30.5	31.5	33	35	36.5	39	41.5	
	35.5	29.5	31	32	34	35.5	37	40	42	
	36	30	31	32.5	34.5	36	38	40.5	43	
	36.5	30	31.5	33	35	36.5	39	41	44	
	37	30.5	32	34	35.5	37	39.5	41.5		
	37.5	31	32	34	36	37.5	40	42.5		
	38	31	32.5	34.5	36	38	40.5	43		
	39	31.5	33	35	36.5	39	41	44		
	39.5	31.5	34	35.5	37	39.5	41.5	44.5		
Definite stress	40	32	34	36	37.5	40	42			
	40.5	32.5	34.5	36	38	40.5	43			
	41	32.5	35	36.5	39	41	44			
	41.5	33	35	37	39.5	41.5	44.5			
	42	33	35.5	37.5	40	42				
	42.5	34	36	38	40.5	42.5				
	43	34.5	36	38	40.5	43				
	44	34.5	36.5	39	41	44				
	44.5	35	37	39.5	41.5	44.5				
Severe stress	45	35.5	37.5	40	42					
	45.5	35.5	37.5	40.5	42.5					
	46	36	38	40.5	43					
	46.5	36	39	41	44					
	47	36.5	39	41.5	44.5					
	48	37	39.5	42						
	58.5	37	40	42						
	49	37.5	40.5	42.5						

Ref: American Society for Heat Refrigeration and Air Conditioning Engineers

Other factors

E20.1 The degree of comfort experienced by an operator will depend on the effective temperature which these factors create. Other factors to consider in relation to this temperature are:

(a) climatic and seasonal differences;

(b) occupancy duration under conditions of processing;

(c) clothing;

(d) transition from outside to inside conditions;

(e) activity;

(f) radiant heat; and

(g) individual differences.

Summary

E21.1 Ventilation and air-conditioning have a vital role to play in the smooth running of a dairy factory interested in productivity and quality aspects of dairy manufacture. From the above, it can be concluded that to develop the right system at an economical level requires the use of skills and knowledge of consultants in this field.

Further reading

Vickers, V.T. and McRoberts, A.G. (1977), "Dairy Factory Ventilation and Air Treatment", *N.Z. Journal of Dairy Science and Technology*, **12**, pp. 5–14.