CAPITAL WORKS GUIDELINES

6.3 Air-Conditioning in Health Care Buildings

Capital Management Branch

Department of Human Services

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C O N T E N T S

INTRODUCTION

The term "air-conditioning" in this Guideline means the automatic control of all the factors affecting the bacteriological, physical and chemical conditions of the atmosphere within any structure. The factors include temperature, humidity, air motion, air distribution, dust, bacteria, odours and toxic gases.

This Guideline, CMG 6.001, replaces Technical Memorandum H.C.C./M001C. It prescribes the minimum desired standards to accommodate current health care procedures and to provide a desirable environment for protection and comfort of the patients and staff at a reasonable cost with emphasis on infection control, occupational health and safety and energy conservation.

The Guideline is performance oriented for desired results. It is assumed that accepted engineering practice and relevant codes and statutory regulations will be observed as part of normal professional services and that these aspects require no specific reference. The Guideline is not intended to restrict innovation and in some circumstances, it may be desirable to exceed the prescribed standard.

Although an important function of hospital air-conditioning is to reduce the risks of nosocomial infection in theatres, it must also be recognised that by itself air-conditioning cannot provide a complete solution. In the case of the application of Ultra-clean-air (UCA) systems, Lidwell et. al. reported in 1982 (Ref. 1) that when operating an UCA system, it is necessary to adopt specially designed clothing, eg total body exhaust gowns to achieve the minimum standard of not more than 1 Bacteria-carrying particle (BCP) per cubic metre (cu.m.). The bacteria counts at the wound site when operating a UCA system without special clothing were approximately 10BCP/cu.m. Therefore, it is essential that other appropriate infection control measures shall also be given equally careful attention.

Consultants should also consider when selecting air filters, the recent overseas findings (Ref. 2) that:

- Bacteria-carrying particles in room air have a medium equivalent diameter of 12um.

- Filters of 90% efficiency when tested by the sodium flame test will not allow the penetration of BCP.

This Guideline does not address the Prevention of Legionnaire's Disease in Health Care Buildings which is adequately covered in other publications.

For the purpose of this Guideline, areas such as the Operating Theatre, Delivery Room, Casualty Treatment Room, Burns Room and Intensive Care Unit are classified as "STERILE" areas. Areas such as, Administration, Kitchen, Dining Area, Laundries and Workshop are classified as "SERVICE".

In places where the word "shall" is used, it is to be understood as mandatory and the word "should" as advisory.

Ref 1: Effect of ultra-clean air in operating rooms on deep sepsis in the joint after total hip or knee replacement by Lidwell, Lowbury Whyte, Blowers, Stanley & Lowe. British Medical Journal 1982.

Ref 2: Requirements for UCA systems for operating departments DHSS, England.

1.0 GENERAL DESIGN CRITERIA

1.1 Air-conditioning systems shall be designed to achieve the specified performance at a minimum total life cycle cost to provide an appropriate environment for the various types of occupancy and special function within the Health Care Buildings.

1.2 Works involving alteration or addition to operational systems shall be programmed to minimise disruption. Works affecting fire protection and other safety systems shall be so planned that safety will not be jeopardised.

1.3 Care shall be taken in design to avoid large temperature differentials, excessive noise and stagnation.

1.4 The air distribution system shall be zoned as necessary to maintain uniform temperature throughout the air-conditioned areas and to cater for variation in load due to solar effect, heat emission from equipment and differing population densities.

1.5 Room Air-Conditioners

Room Air-conditioners are not recommended for use in "STERILE" areas and certain "SERVICE" areas such as kitchen and laundry because of the noise generated, the poor air distribution patterns and lack of positive ventilation and humidity control.

1.6 Fan-Coil Units

Fan-coil units shall not be used in areas that require an extremely clean environment or those areas that may be subject to heavy contamination because of the difficulty of maintaining them in an aseptic condition, the low efficiency of their air filters and their dependency on re-circulation of air within the room.

1.7 Evaporative Cooling Installation

In "HARD" water districts, only rainwater or treated water shall be supplied to evaporative coolers. If there is insufficient suitable water, evaporative cooling shall not be adopted.

1.8 All occupied areas shall be heated including patients' toilets and bathrooms which are for elderly persons.

1.9 To satisfy the certification requirement of the building regulations, the works involved with Health Care Buildings shall be carried out by competent and qualified persons.

2.0 INFECTION CONTROL

2.1 Pressurisation

To minimise the risk of infection, the ventilation system shall be designed and balanced to provide directional flow from "CLEAN" to "LESS CLEAN" areas. Room pressurisation shall be maintained as prescribed in Table 1.

2.2 "STERILE" areas

2.2.1 Supply air and exhaust air grilles shall be made of non-corrodible material, eg anodised aluminium section.

2.2.2 Supply air ductwork shall be carefully designed and manufactured to prevent possible induction of contaminated air.

2.2.3 Exhaust registers shall be so located that the whole room is effectively scavenged, particularly at floor level.

2.2.4 The air supply shall be from ceiling outlets near the centre of the work area to effectively control air movement so that clean air continuously sweeps past the patient first.

2.2.5 The system design shall take into account the effect of air turbulence and other factors of air movement so that the fall of particulate into the wound site is minimised.

2.2.6 Extraordinary surgical procedures, eg organ transplants, total joint replacement, may justify a UCA system. The performance requirements of UCA systems as set out in Section 7.4 shall be fulfilled when adopting such a system.

2.3 Filter Efficiency

All air-conditioning systems shall be equipped with filters having filtration efficiencies not less than those specified in Table 1. Filter efficiency should be the average efficiency tested according to AS 1132-1973 Methods of Test for Air Filters.

2.4 Humidification

2.4.1 The relative humidity shall be in the range of 40 to 70 percent. When flammable or explosive anaesthetic gases are used, the relative humidity shall be maintained at not less than 55% to reduce the probability of static electrical charges.

2.4.2 Humidification, where used, shall be achieved by the direct injection of low pressure steam into the supply air stream. Where reticulated steam is not available, an electrode type humidifier should be used.

2.4.3 Ductwork surrounding the humidifier discharge shall be constructed to minimise the possibility of corrosion. For example, copper or type 321 stainless steel could be used for a distance of 1500 mm downstream and 500 mm upstream of the unit.

2.4.4 The bottom of the humidifier duct shall be graded into an open tundish next to the outlet.

2.4.5 An electrical interlock shall be provided so that the humidifier can operate only when the supply air fan is operating.

2.5 Bio-Safety Cabinets

If air change rates of Table 1 do not provide sufficient air for a Bio-safety cabinet, adequate makeup air should be separately provided to maintain the required air flow direction.

2.6 Exhaust Outlets

Exhaust outlets from areas that may be contaminated shall be above the roof level and arranged to minimise the probability of entraining exhaust air into the building.

2.7 Installation

2.7.1 Friable duct linings shall not be used in ducts, terminal boxes or other system elements supplying air to any of the "STERILE" areas.

2.7.2 Insulation on cold surfaces shall include an exterior vapour barrier. (Material that will not absorb or transmit moisture will not require a separate vapour barrier). Asbestos insulation shall not be used. Insulation of a "soft" type, spray on etc. should not be used where it is subject to air or mechanical erosion, or where loose particles may create a maintenance problem.

2.7.3 Existing accessible insulation within affected areas shall be inspected, repaired and replaced as appropriate.

2.7.4 All supply air ducts to "STERILE" areas shall be insulated externally, leaving only clean bare sheet metal duct surface in contact with the supply air.

2.8 Provision of Bio-safety cabinets shall be in accordance with AS 2252 Biological Safety Cabinets and AS 2567 Cytotoxic Drug Safety Cabinets.

2.9 Laundries

The dirty linen areas shall be maintained at a negative pressure relative to adjacent areas always, whereas the clean linen area shall have positive pressure relative to adjacent areas.

2.10 Completion Certificate

On completion of an installation, the supplier shall certify that the installation meets the infection control requirements of this Guideline also the requirements of all other relevant Regulations and Codes. The installation shall be fully tested and the test results shall be properly documented for future reference.

3.0 OCCUPATIONAL HEALTH AND SAFETY

3.1 Ethylene Oxide

Where Ethylene Oxide (ETO) is used for sterilisation:

3.1.1 The ETO Steriliser shall be designed, installed, operated and maintained in accordance with AS 1714-1975 Ethylene Oxide Steriliser, and AS 1862-1976 Aeration Cabinets (for use with the Ethylene Oxide steriliser)

3.1.2 Sterilisation operations involving ETO shall be isolated from all non-ETO work areas.

3.1.3 ETO work areas, except outdoor systems, shall be maintained under negative pressure, with respect do non-ETO work areas.

3.1.4 The fan blades and other associated components of the ventilation system shall be made of a non-sparking material.

3.1.5 Local exhaust pick ups shall be located at areas close to the steriliser and aerators.

3.1.6 The design shall ensure that gases are pulled away from the operator when the door of the steriliser is opened.

3.1.7 Exhaust air shall not be discharged into any work area or into the general environment without major decontamination, for instance by using a catalytic Converter or other equivalent.

3.2 Anaesthesia Gases

Each space regularly used for administering inhalation of anaesthesia gases shall be provided with an approved scavenging system to exhaust the waste gases directly to atmosphere. If a vacuum system is used, it must be so arranged that it does not interfere with the patient's respiratory system. The Australian National Health and Medical Research Council has adopted a Threshold limit value - Time Weighted Average (TLV - TWA) of 1ppm in October 1983. Anaesthetic storage rooms shall be mechanically exhausted to atmosphere from low level outlets.

3.3 Provision of Cooling

3.3.1 Cooling shall be provided on the following basis:

(a) Where heat release from equipment and lighting etc. would make working conditions intolerable.

(b) In areas where there are approximately 15 days or more per year when the temperature equals or exceeds 26^{o}C (DB).

3.3.2 Laundries and workshops shall be cooled using ducted evaporative cooling systems. Depending on the proximity of the individual to the heat source and the intensity of it, spot cooling may be required. Provision for individual adjustment shall also be made.

3.3.3 Kitchens should either be served by evaporative cooling systems which shall be provided with facilities for tempering the supply air during winter months or be fully air conditioned if a cook-chill facility is to be provided.

3.4 Plant Room

Boiler rooms and other plant rooms shall be provided with sufficient outdoor air to maintain equipment combustion rates where appropriate to limit work area temperature to a reasonably comfortable range.

3.5 Bio-Safety Cabinets

Bio-Safety Cabinets shall be provided, designed, installed, operated and maintained according to AS 2252 Biological Safety Cabinets and AS 2567 Cytotoxic Drug Safety Cabinets.

3.6 Shielded Rooms

Ducts which penetrate shielded rooms (eg X-Ray) shall not impair the effectiveness of the protection.

3.7 Deodorisers

Deodorisers and air fresheners shall not be added to any air handling system to control odours.

3.8 Cadaver Storage

Refrigerated facility shall be provided in the Morgue and Autopsy room and any other room used for lengthy storage of cadavers.

3.9 Provision of Ventilation

Adequate ventilation shall be provided at all times in any occupied area to ensure that the level of gaseous contamination is maintained at an acceptable level.

3.10 Film Processing

Dark Rooms, Barium Preparation Areas (for mixing of contrast media) or any film processing area shall be provided with sufficient mechanical exhaust capable of ridding any vapour released from the process.

3.11 Installation

3.11.1 All piping or ducting shall be installed only by qualified personnel registered with the Plumbers and Gas Fitters Board for a particular Class of work.

3.11.2 All flow and safety controls shall be installed, tested and commissioned by personnel fully trained and experienced in the field and should preferably be employees of the control manufacturers.

3.12 Inspection and Test

Inspection and tests shall be made on completion of an installation. The owner should be provided with written certification that the installation meets the requirements set forth and all applicable safety Regulations and Codes.

4.0 FIRE PROTECTION

4.1 Provision for fire protection in relation to Air-conditioning shall be designed to meet the various regulations in force at the design stage. In particular, the design shall allow for provision made in the Building Code of Australia 1988, (BCA) relating to smoke exhaust system, stair pressurisation and lift-well pressurisation for smoke control during fire conditions.

4.2 Penetration of Partitions

Where smoke partitions are required, the zones for air-conditioning shall be coordinated with the compartmentalisation in so far as practical to minimise need to penetrate fire and smoke partitions.

4.3 Dampers

Fire and smoke dampers shall be constructed, located and installed according to the AS 1668 Part 1 - Fire Precautions in Building with Air Handling Systems. Fans and dampers should be interconnected so that activation of dampers will not damage the duct.

Switching for restarting the fan may be installed, provided that provision is made to avoid possible damage to the system because of closed dampers.

Smoke damper should be equipped with remote control reset devices. However, manual reopening may be used, provided the dampers are located for convenient access.

Access for maintenance should be provided for all dampers.

4.4 Insulation Ratings

Insulation, including finisher, vapour barrier, facing linings and adhesive on exterior surfaces of ducts and equipment should have a flame spread index of 0, a smoke developed index of not greater than 3 and Ignitability index of 0, tested according to AS 1530 Part 3 - Methods for Fire Tests on Building Materials, Components and Structures.

4.5 Storage of Flammable Material

X-ray film, solvent and other flammable liquid storage shall not be warmer than the air of the adjacent occupied area. If refrigerated cooling is used, the temperature should be controlled within a range of 10ºC and 21ºC and Relative Humidity should be controlled within a range of 30-50 percent. Ventilation shall be provided according to AS 1668 Part 2 -Ventilation Requirements.

4.6 **Flammable Agents**

Where flammable agents are intended to be used in the room, low level exhaust in accordance with AS 1169 Minimising of Combustion Hazards Arising from the Medical Use of Flammable Anaesthetic Agents shall be provided. Where no provision is made in accordance with this standard, operating rooms shall have a notice, affixed as required by the standard, indicating that flammable agents must not be used.

4.7 **Automatic Shutdown**

Where systems fall outside the jurisdiction of AS 1668 Part 1 - Fire Precautions in Buildings with Air Handling Systems, all systems shall automatically shut down on any fire alarm signal in the area served by such systems.

5.0 OPERATIONAL CONTROL

5.1 Control Section

All the controls should be selected for their respective duties in accordance with the recommendation of the manufacturers and have such operating tolerance as required to fulfil the guaranteed plant performance. As far as practical, the controls of a system should be of the same manufacture. Where this is not possible, the controls of different manufacturers should have similar operational characteristics and response.

5.2 Operating Theatre

5.2.1 Each theatre air-conditioning system shall be provided with remote control and indicating wall panels in the appropriate nurses' station or other suitable location. This panel shall consist of on/off buttons and indicator lamps to show whether the air-conditioning plant is operating or not.

5.2.2 Thermostats and humidistats (where applicable) shall be wall mounted at approximately 1500mm from the floor.

5.3 Delivery Room

5.3.1 Remote control and indication shall be provided in the appropriate nurses' station or other suitable location.

5.2.2 The controls shall be wired so that remote shutdown of the air-conditioning system is possible at the appropriate nurses' station.

5.4 General Works & Services Areas

Controls for general wards and service areas should be made as simple as possible.

5.5 Adjustable Control

All adjustable controls such as thermostats and the like should be provided with locking covers to prevent unauthorised tampering.

6.0 VENTILATION, FILTRATION, TEMPERATURE, HUMIDITY AND SOUND LEVEL

6.1 Ventilation

6.1.1 The ventilation rates as shown in Table 1 should be used as model standards, they do not preclude the use of higher rates that may be appropriate, eg those for UCA systems. Modification of the total air volume may be necessary to accommodate the thermal requirement.

Where class of occupancy is not specifically listed in Table 1, an equivalent class of occupancy from other area of the Table should be used.

6.1.2 Special requirements for "STERILE" areas.

6.1.2.1 Operating Theatre Suites

(a) Supply air to operating rooms shall be supplied at high level in a way that minimises recirculation of potentially contaminated room air and provides the cleanest practical air supply over the theatre table area.

(b) The directions of air flows within operating theatre suites shall always be from the operating room, through immediately adjacent inner lobby or lobbies, scrub up and anaesthetic rooms to entrance lobby, recovery, changing and post operative clean up rooms: i.e. from the cleaner to the less clean areas.

Graduated pressurisation relative to pressure in areas adjacent to the theatres suite ranging from not less than 0.10mbar positive in the operating room(s) to slightly positive pressure in areas like entrance lobby, recovery and change rooms and slightly negative in clean up room(s) can be achieved by using carefully balanced supply air and exhaust air systems. (Refer Table 1 for details of pressurisation requirement).

(c) Exhaust arrangement

Exhaust registers shall be so located that the whole room is effectively scavenged, particularly at floor level.

Special arrangement, eg provision of balanced counter weighted flap to each low level exhaust point to prevent an outflow of air from exhaust point due to adverse air pressure when opening any of the theatre doors.

(d) The consultant shall account for the adverse effect of air flow pattern near the surgical field created by surgical lamps due to their shape, size location and the heat generated by the lamps.

(e) Provision of an all fresh air purge cycle shall be made in operating theatres having heavy usage.

(f) Theatres for special procedures, eg orthopaedic surgery, organ transplants or total joint replacement may require special provision of an UCA system to suit their intended use. The performance requirements as set out in Section 7.4 shall be fulfilled when adopting such a system.

6.1.2.2 Ventilation systems for Isolation Wards shall be designed so that nursing staff can readily select positive or negative pressurisation.

6.1.2.3 When administration or aspiration of gaseous anaesthetics or analgesics is necessary in an area, adequate ventilation shall be provided to ensure that the level of gaseous contamination is maintained at an acceptable level.

6.1.2.4 "STERILE" areas shall not be ventilated by a system which serves also sanitary compartments, dirty utility rooms and similar spaces.

6.1.3 Preparation Room

Special consideration relating to air velocity, pressure and flow pattern shall be given to cater for the function of the room.

6.1.4 Special Requirement for "SERVICE" areas

6.1.4.1 Laboratory and Dispensing Areas in Pharmacy

These areas shall be investigated for the necessary to control air flow and exhaust to avoid any possible of contamination to any adjacent areas.

6.1.4.2 Pathology areas

Systems serving these areas shall be independent of other systems. Exhaust from these areas shall be designed not to create any harmful effect to personnel involved or contamination to any adjacent areas.

6.1.5 To satisfy the exhaust needs in some areas, outside make up air will be necessary in addition to the outside air quantities prescribed in Table 1.

6.1.6 Exhaust System in Sanitary Compartments

Exhaust system for these compartments, apart from single toilet, shower or bath, shall be fitted with:

(a) Dual twin fans of 100% capacity or one fan with dual motors.

(b) Visual indication of failure of each fan or motor shall be provided at the mechanical switchboard or the nurses' station.

(c) Automatic changeover to standby fan or motor

These requirements are essential in areas where desired directional air flow is required to be maintained at all times.

6.2 Filtration

6.2.1 All air-conditioning systems shall be equipped with air filters having efficiency equal to or greater than those prescribed in Table 1. Filter efficiency shall be average efficiency tested following AS 1132 Methods of Test for Air Filters.

6.2.2 Where two filters are required, filter No. 1 should be located upstream of air-handling equipment and filter No. 2 should be located downstream of any humidifier, fan or blower.

6.2.3 Filter frames should be durable and dimensioned to provide an airtight fit with the enclosing ductwork. All joints between filter segments and the enclosing ductwork would be fitted with a gasket or sealed to provide a positive seal against air leakage. A manometer should be installed across each filter.

6.3 Temperature and Humidity

6.3.1 Provision shall be made to operate the air-conditioning system within the temperature and humidity range prescribed in Table 1. The range may need to be adjusted to suit local preference or medical needs, when, for instance elderly patients and babies may require higher temperature.

6.3.2 Direct injection low pressure steam shall be used for humidification.

6.3.3 Ducted heating and cooling systems shall incorporate mechanically forced ventilation providing ventilation rates according to those prescribed in Table 1.

6.4 Sound Level

Precautions shall be taken against the transmission of noise and vibration from air-conditioning and mechanical services equipment to ensure that operation of the equipment installed does not result in sound levels above the allowable limits prescribed in Table 1.

6.5 Design Requirements for UCA Systems

6.5.1 The systems shall provide sufficient filtered air moving in the correct direction to remove efficiently the bacteria dispersed by the operating team.

6.5.2 The air issuing from the final filter shall contain not more than 0.5 Bacteria-carrying particles per cubic metre of air (BCP/cu.m).

6.5.3 Air Flow

(a) Down flow system: The air flow at 1m from the filter face shall have a minimum average velocity of 0.35m/s and at working height, not less than 0.3m/s.

(b) Cross flow system: The minimum average velocity shall be 0.4m/s measured 1m from the filter or diffuser face.

6.5.4 The siting of the return air grilles shall not cause short circuiting of the supply air.

6.5.5 A minimum of 0.35 cu.m/s fresh air supply volume shall be maintained at all times during operation to ensure adequate purging of pollutants.

6.5.6 The control instrumentation shall include the indication of:

(a) Operating status, eg in use or not in use.

(b) Terminal filter pressure differential.

6.5.7 System Purging

Provision shall be made to enable the system to run at normal operating performance for a minimum period of five minutes before surgery is to take place.

7.0 ENERGY CONSERVATION

7.1 **Ambient Design Condition**

The following ambient summer and winter design conditions shall be used in all air-conditioning calculations for health care institutions throughout the State of Victoria. For institutions in towns not listed below, the design conditions applying to the nearest listed town should be used.

	SUMMER		WINTER	
TOTAL	DRY BULB	WET BULB	DRY BULB	
Ararat	35	21	4	
Bairnsdale	34	22	2	
Ballarat	33	20	2	
Benalla	38	21	2	
Bendigo	36	21	3	
Colac	33	22	3	
Geelong	34	22	4	
Hamilton	33	20	3	
Horsham	36	21	3	
Melbourne	35	22	4	
Mildura	39	22	4	
Morwell	34	22	2	
Sale	35	22	2	
Seymour	37	21	1	
Shepparton	38	22	3	
Wangaratta	38	21	3	
Warrnambool	32	21	5	

7.2 **Facility Design**

7.2.1 The designer should aim at producing an integrated design of building and air-conditioning system by analytical approach with the aid of suitable computer programs to effect the most economical combination of initial and operating cost.

7.2.2 At the design stage, the most suitable tariffs and fuel type should be established to suit the building operation and usage patterns.

7.2.3 The selected systems shall not be only economical to purchase and install but also demonstrate long term benefit in efficiency, operating costs, reliability, maintainability and flexibility.

7.3 **Computer Usage**

All computer programs used, should be the current versions. Where designs incorporate combined heating and cooling, or initial heating with possible future cooling, "CAMEL" should be used for all load calculation. "TEMPER" should be used for evaluating internal air temperature and "BUNYIP" for energy consumption analysis. Sufficient program runs should be carried out to ensure optimum system design.

For major projects, appropriate programs should be used for

(a) Analysing thermal behaviour of the building and predicting the effect on the heating and cooling loads of variation of the building components eg. glazing insulation, shading and wall/glass ratio.

(b) Energy analysis under simulated conditions of a building over a specified time to determine the energy consumed for the purpose of establishing the relative energy savings for various systems proposed.

7.4 Energy Management Design

Design should include consideration of recognised procedures such a variable Air Volume System and microprocessor energy management systems to facilitate Time Control, Cyclic Control, Load Shedding and utilisation of outside air for reduction of energy usage and its related cost.

7.5 Chiller Selection

7.5.1 Selection of chiller should be based on the configuration of thermal load demand of a building. The chiller capacity should match the thermal load as close as possible for maximum operating efficiency and consequent minimum energy consumption. In the cases where it is necessary to operate a chiller at light load for a significant portion of the operating hours, part load efficiency should be included in the selection analysis.

7.5.2 If a centrifugal chiller is to be adopted, it should not run at continuous sustained loads below 30% of its maximum rated capacity; if such a case is unavoidable, a separate reciprocating chiller suitably sized should be provided for light loads operation.

7.6 Mechanical Ventilation

Each mechanical ventilation system supply or exhaust should be equipped with a readily accessible means for either shut-off or volume reduction.

7.7 Energy Centre

The Energy Centre concept which offers advantages such as enhancing the ease of servicing, control for operation and energy optimisation should be encouraged.

7.8 Quantifiable Measure of Performance

Energy Targets expressed as an Energy Utilisation Indices (EUI) should be used for performance assessment. To establish a meaningful qualitative assessment yardstick, calculation of EUI should consider all the parameters that affect energy consumption. It is recommended the method of EUI calculation developed by BOMA (Building Owners & Managers Association of Australia) should be adopted.

7.9 Efficiency Monitoring

(a) All major equipment should be metered for their energy consumption.

(b) Monitoring systems, computerised or manual should be designed to provide indication of change in efficiency on a monthly basis.

8.0 DOCUMENTATION

8.1 Proposal Documents

The proposed documents for the air-conditioning system should consist of:

(a) Properly prepared plans and specification containing sufficient details for costing installation, commissioning, testing and servicing. The plans should be prepared following AS 1100 Technical Drawing Part 201-1984.

(b) A Functional Program describing space requirement, number of staff or other occupants of various spaces, types and sizes, including beds, equipment etc. in the air-conditioned space. The Program should also address the inter-relationships of various functions and spaces as well as the potential for future expansion.

(c) Complete design data, including summary of heat loss assumption and calculation, estimated hot water and chilled water consumption and electric power requirements as may be required for future alteration, addition, energy audit and retrofit for energy conservation.

8.2 Operating and Maintenance Manuals

On completion of an installation, the Contractor should provide the Proprietor with at least two sets of Operating and Maintenance Manuals. The Manuals should be organised in four parts as follows:

Part 1 - General

1.1 A set of record plans on which all work "as installed" is clearly defined including:

(a) Schematic Diagrams of air, water, gas and electricity supplies showing the manner in which they are designed to operate.

(b) Schedule of controls showing all normal settings and ranges.

(c) Electrical Wiring Diagram with component list and switchboard layout.

1.2 (a) Data on the installing contractors, and equipment supplier(s) including contact address and telephone numbers for normal and emergency calls.

(b) Copies of inspection certificates and commissioning reports.

Part 2 - Operating Instructions

The Instructions should set out procedures for start-up, shutdown, time switch control, bypass operation and general procedures for checking and rectification of faults.

Part 3 - Maintenance Instructions

The Instructions should set out all requirements for effective maintenance, periodic attention schedule, lubrication procedure, cleaning, adjustment and inspection requirements.

Part 4 - Water Treatment Program

The work of this Program should be coordinated with the work of cleaning degreasing and pre-treatment. It should include the work as recommended Guidelines for the Control of Legionnaire's Disease.

9.0 COMMISSIONING

9.1 Check List

It is desirable to use a "Check List" approach to ensure that the works involving multiple trades are done in a timely and proper manner. The Check List should include all the tasks required to change a static complex of ductwork, piping and equipment into a dynamic, operating environmental control system, ready to serve with a reasonable expectation of delivering performance within the design intent.

9.2 Testing and Adjustment

9.2.1 All flow, temperature, humidity and pressure controls should be tested and adjusted by personnel fully trained and experienced in the field who should preferably be employees of the control manufacturers.

9.2.2 The controls should be tested to ensure the installed system is capable of satisfying the specified requirement and operating correctly and safely. Adjustment, if necessary, should be made to provide stable optimum performance in all cases.

9.2.3 Testing for safety of major components, such as boiler and refrigeration plants, should be carried out according to relevant AS Codes.

9.2.4 Air Balancing

All air handling equipment and ducted systems should be balanced so that the air quantities at the outlets are as specified and the outlets operate without draughts and noise. The following tolerances should not be exceeded:

Fan Capacity $\pm$ 10% of the specified capacity.

Air Quantity

Register $\pm$ 10% of the specified quantity
Diffuser $\pm$ 10% of the specified quantity
Return or Exhaust air Grille $\pm$ 10% of the specified quantity.

Temperature $\pm$ 1^{o}C of the specified temperature
Pressure Reading $\pm$ 5% of the specified range
Adjustments if necessary, should be made to provide stable optimum performance in all cases.

10.0 INSPECTION AND TESTING

10.1 Procedures

Inspection and testing procedures should be established to maintain the necessarily high standards in respect of the required health and safety features of the air-conditioning systems to ensure availability of these features in an emergency. Records of inspection and testing should be maintained and kept in a proper Plant Register.

10.2 Performance Measurement

The methods used for the performance measurements of plant and equipment should be of an appropriately high standard of accuracy. They should:

(1) ensure reliable consistency of the results of measurement.

(2) Allows sound assessment of the measurement results for compliance with relevant health and safety criteria.

10.3 Testing of Control

Electric, electronic or pneumatic control should be tested for correct automatic operation and protection of air-conditioning plants and auxiliaries.

10.4 Chiller Plant

If a chiller plant has been selected in primary on savings to be made on energy charge, it is essential that a properly conducted Site Performance Test be carried out to determine:

(a) The measured capacity
(b) The measured specific power consumption

10.5 **Evaluation of UCA - System**

Three methods are recommended for evaluation of UCA systems, they are:

(1) Physical Method
(2) Bacteriological Method
(3) Smoke Visualisation Studies

10.5.1 Physical Method:

This method consists of 2 tests

(a) Air Filter Efficiency Test

This test is done by introducing small inert particles into the air before it reaches the filter and scanning the filter face and frame for leakage by means of a photometer or a DOP Generator.

(b) Test on ability of an UCA to remove dispensed bacteria by means of measuring a velocity at different positions inside the operating room. The "Velocity Profile" platted basing on air velocity readings should demonstrate that enough filtrated air is moving in the concept direction.

The air flow at 1m from the air filter face should have a minimum average velocity of 0.35 m/sec. and at no point should it drop below 0.3 m/sec.

10.5.2 Bacteriological Method

By means of air sampling using either a Casella Slip Sampler or a Biotest Reuter Centrifugal Sampler. Air samples should be taken in different positions inside the operating room at low level and in positions within 300mm of the wound. Sampling for microorganisms in air passing through the final air filter should be taken after initial installation or on replacement of the filter.

(a) Air leaving the diffuser or final filter shall contain not more than 0.5 BCP/cu.m of air.

(b) Air sampled within 300mm of the wound site during surgery shall, on average, contain less than 10 BCP/cu.m. In the event that special clothing is used eg. total body exhaust system, the count shall be less than 1 BCP/cu.m.

(c) Air sampled at the perimeter of the clean zone during surgery shall contain not more than 20 BCP/cu.m and less than 10 BCP/cu.m when using special clothing.

10.5.3 Smoke Visualisation Studies

These studies are generally done by using paraffin in an electrically heated smoke generator. When carrying out the study:

(a) Close all the doors of the operating room and open all exhaust vents.

(b) Observe and record by photographing (if necessary), the air flow -

(i) under and around the ventilating points

(ii) around the periphery of the final filter frame.