Public Works and Government Services Canada
Mechanical and Maintenance Engineering
Real Property Branch

MD 15116 — 2006

Computer Room Air-conditioning Systems

Guidelines for Building Owners, Design Professionals, and Maintenance Personnel

Public Works and Government Services Canada
Travaux publics et Services gouvernementaux Canada

Canada

PWGSC

Mechanical Design Guidelines

MD 15116 — 2006

Computer Room Air-conditioning Systems

Guidelines for Building Owners, Design Professionals, and Maintenance Personnel

Mechanical and Maintenance Engineering

Professional and Technical Programs
Architectural and Engineering Resources Directorate
Real Property Branch
Public Works and Government Services Canada
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Public Information

Public Works and Government Services, Canada is pleased to present the Mechanical Design Guideline MD 15116 - 2006 "*Computer Room Air Conditioning Systems*".

Computer rooms form an integral part of most federal buildings, and very often, they perform "mission critical" function, handling sensitive data on a 24/7 basis. As a result computer room air conditioning systems differ from general office air-conditioning systems in many significant ways. The cooling load is much higher and the requirements for temperature and humidity control are much stricter than for general purpose office buildings. The air conditioning systems requires a much higher level of reliability, as a breakdown in computer room air conditioning systems could lead to disruption of essential services and major economic losses. In addition, computer room air conditioning systems require greater flexibility to accommodate future changes. In most cases, control of computer room operation is independent of the rest of the building.

The objective of this document is to provide general guidance for the design and operation of mechanical systems for computer rooms, server rooms, LAN rooms, telecom equipment rooms and data centers. It provides guidance for the design requirements, estimation of cooling loads, selection of computer room mechanical equipment, and, the proper commissioning of the mechanical systems. This guideline is intended for

Travaux publics et Services gouvernementaux Canada a le plaisir de vous présenter les Lignes directrices d'ingénierie mécanique IM 15116 - 2006 « *Systèmes de conditionnement d'air des salles d'ordinateurs* ».

Les salles d'ordinateurs font partie intégrante de la plupart des immeubles fédéraux, et elles remplissent très souvent une fonction « essentielle à la mission » en permettant de traiter des données confidentielles 24 heures sur 24. C'est pourquoi les systèmes de conditionnement d'air des salles d'ordinateurs diffèrent largement de ceux des locaux à bureaux généraux. La charge de refroidissement est beaucoup plus élevée et les exigences de température et d'humidité sont beaucoup plus strictes que celles des immeubles à bureaux à vocation générale. Les systèmes de conditionnement d'air des salles d'ordinateurs exigent un niveau de fiabilité beaucoup plus élevé, puisqu'une défaillance risque d'entraîner une perturbation des services essentiels et d'importantes pertes financières. Ces systèmes ont besoin en outre d'une plus grande souplesse pour tenir compte des modifications éventuelles. Dans la plupart des cas, les commandes de la salle d'ordinateurs fonctionnent indépendamment de celles du reste de l'immeuble.

L'objectif du présent document est d'offrir des conseils généraux sur la conception et l'exploitation des systèmes techniques des salles d'ordinateurs, des salles de serveurs, des salles de réseau local, des salles de télécommunications et des centres de données. Il contient des renseignements use in new projects as well as for the retrofits of existing buildings.

This document has been developed by the Mechanical and Maintenance Engineering group, NCA, in consultation with specialists and engineering professionals from throughout the regions. A previous version of this guideline was published in the 1980's but it is now obsolete due to rapid evolution of computer technology and an exponential increase in computer room equipment density. Many of the design techniques that were prevalent in the 80s are no longer applicable today.

One problem with many computer room air conditioning systems is simultaneous humidification and dehumidification, due to condensation in the cooling coils. This imposes an energy penalty on the cooling system. The present guideline addresses this issue, and suggests using only "dry coil" operation for maximum energy savings. Application of these guidelines will also improve equipment reliability, and minimize computer system failures.

It is important that clients, property managers, engineers, and, maintenance personnel be familiar with the contents of this document, so that they can apply the guidelines in a consistent manner for PWGSC projects throughout Canada.

We encourage you to use this guideline whenever Computer Room Air Conditioning Systems are being planned, or where existing facilities require upgrades. This document is available in either hard copy or electronic format

sur les exigences de calcul, l'estimation des charges de refroidissement, le choix de l'équipement technique des salles d'ordinateurs et la mise en service adéquate des systèmes mécaniques. Ces lignes directrices s'appliquent aux nouvelles constructions aussi bien qu'à l'aménagement des bâtiments existants.

Le présent document a été élaboré par le groupe du Génie mécanique et d'entretien du SCN avec la collaboration des spécialistes et des ingénieurs de l'ensemble des régions. Une première version de ces lignes directrices a été publiée dans les années 80, mais elle est devenue désuète en raison de l'évolution rapide de la technologie informatique et d'une croissance exponentielle de la densité de l'équipement des salles d'ordinateurs. Bon nombre de techniques de conception qui étaient courantes dans les années 80 ne sont plus applicables aujourd'hui.

L'un des problèmes qui se posent dans les systèmes de conditionnement d'air des salles d'ordinateurs, c'est le processus d'humidification et de déshumidification simultané dû à la condensation des serpentins de refroidissement. Ce processus impose une pénalité énergétique au système de refroidissement. Les présentes lignes directrices traitent de cette question et proposent de fonctionner uniquement avec batterie de refroidissement sèche en vue d'une économie maximale d'énergie. L'application de ces lignes directrices permettra également d'améliorer la fiabilité de l'équipement et réduire les défaillances du système informatique.

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Il est important que les clients, les gestionnaires immobiliers, les ingénieurs et le personnel d'entretien se familiarisent avec le contenu de ce document afin qu'ils puissent appliquer les lignes directrices d'une façon uniforme dans les projets de TPSGC partout au Canada.

Nous vous encourageons à utiliser les présentes lignes directrices toutes les fois que des systèmes de conditionnement d'air de salles d'ordinateurs sont en cours de planification ou que des installations existantes ont besoin d'être modernisées. Vous trouverez ce document soit en copie papier ou en version électronique au Centre de documentation de TPSGC à l'adresse doc.centre@pwgsc.gc.ca.

Pour obtenir plus de renseignements concernant les présentes lignes directrices, veuillez communiquer avec :

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Introduction

General

This document has been developed by the Mechanical and Maintenance Engineering group of Professional and Technical Programs, Architectural and Engineering Resources Directorate, Real Property Branch, Public Works and Government Services Canada.

Feedback

Corrections, recommendations, suggestions for modifications or additional information and instructions that will improve this document are invited. For this purpose the attached form entitled “Request for change to this manual” may be used and mailed or faxed to the address shown. E-mail or other forms of electronic transmission may also be used for this purpose.

Conflicts

Any area of conflict between this document and the Project Brief/RFP shall be brought to the attention of the Project Manager as soon as it is noted.

MD15116 - 2006 Computer Room Air Conditioning REQUEST FOR CHANGES	
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Type of change suggested:

☐ Correction of information
☐ Deletion of information
☐ Addition of Information

Details of suggested changes:

If necessary, photocopy relevant page(s) of this manual and attach to this sheet.

Page: Chapter: Paragraph no.:

Details of suggested changes:

(Use additional sheets if necessary)

Signature: ________________ Phone No:._______________ Date: ______________

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Chapter 1 Introduction

1.1 Purpose

This document has been developed to provide general guidance in the design of mechanical systems for Computer Rooms, Server Rooms, Telecom Rooms, and, Data Centres as used in PWGSC buildings.

These guidelines should not be construed as a rigid set of standards to be followed at the expense of innovative design, but rather, as benchmarks of design excellence against which design decisions may be compared.

Please refer to *Appendix A: Supplementary Material* for additional details about the HVAC Systems mentioned in the main body of this document.

Also, refer to *Appendix B: Fire Protection Systems*, for additional information about Fire Protection.

1.2 Scope

The document applies only to commercial properties such as office buildings, laboratories, and, industrial buildings. It is not intended for application to hotels, hospitals, health care facilities, or residential properties.

The target audience for this document is property managers, engineers, designers, installers, maintenance contractors, and, property owners. It is intended to apply both to new buildings as well as to retrofits of existing buildings.

This guideline supports the Project Brief and/or the RFP, which remain the prime reference documents for each project.

1.3 History of this Document

The document was first developed by the Building Consulting Section of the Mechanical Engineering division at Public Works Canada, in co-operation with Regional Mechanical Engineers, and published in October 1985 under the title “MD 15116: Mechanical Design Standards for Computer Room Air Conditioning”. In view of the rapid growth of the computer industry, this document has long been overdue for revision. Technology has evolved considerably since 1985, and many of the design techniques that were prevalent in those times are no longer applicable.

The document has now been revised in view of the findings of current research in this field, and the publication of several new guidelines and standards, including *ASHRAE "Thermal Guidelines for Data Processing Environments",* 2004.

Chapter 2 Design Requirements

2.1 General

Computer room air-conditioning systems differ from general office air-conditioning systems in many significant ways:

- Computer rooms have very sensitive electronic equipment.
- The cooling load is much higher, due to a higher density of heat generating equipment.
- Temperature and humidity conditions are required to be maintained at the same levels throughout the year; there are no seasonal variations.
- Most computer rooms require very tight humidity and temperature control, to meet the equipment manufacturers' requirements.
- There is little moisture addition so that the load consists almost entirely of sensible heat.
- Ventilation requirements are much lower than for office spaces in the absence of human occupancy.
- In office buildings, a breakdown in the A/C equipment may cause some discomfort but in a computer room, a breakdown could lead to disruption of essential services.
- In office buildings, small changes in temperature distribution are tolerable; however, in computer rooms a single localized “hot spot” can lead to equipment failure.
- Computer room equipment is more expensive than general office equipment.
- Rate of change in computer technology is very rapid. This will, in general, lead to increasing equipment density, and higher cooling loads during the life cycle of the computer room.
- Rapid changes in technology in computer rooms can lead to frequent changes in computer room layout.

The computer room air-conditioning system should also provide sufficient flexibility in air distribution to respond to localize hot spots, and to non-uniform distribution of supply air.

Hence, Computer room air-conditioning systems must be independent of all other air-conditioning systems within the building. Also, the system must be capable of adjusting to the frequent changes in layout and computer equipment installed therein, and also capable of operating while changes in layout and equipment are being made. Redundancy must also be provided for mission critical computer applications.

2.2 Design Requirements for Cooling Equipment

The operating characteristics and the environmental conditions required for satisfactory operation of computer equipment will differ with each computer equipment manufacturer.

All characteristics and required conditions shall be considered during the design. These shall include, but not be limited to, the following:

1. Heat generated by each piece of equipment.

2. Range of temperature and humidity levels, in accordance with the manufacturers' requirements.

3. Some components are designed to be cooled by air delivered directly to the racks from below the raised floor, while others may require cooling air at other points. The design should be in accordance with the manufacturers' requirements.

4. Required environmental conditions at the rack inlet.

5. The possibility of short-circuiting of hot air from rack outlet with the cold air at the rack inlet.

6. The possibility of short circuiting between and supply and return air.

2.3 Room Environmental Conditions

2.3.1 Dry Bulb Temperature

1. For computer rooms at elevations up to 900 metres above sea level, the dry bulb temperature shall be 21plus or minus 2 deg.C, or, as recommended by the manufacturer.

2. For computer rooms at higher elevations, the effect of altitude on air density should be considered. When air density is reduced due to higher altitude, the heat transfer rate from the equipment to the surroundings is reduced, for the same temperature differential. Hence, in order to maintain the same heat transfer rate, it is necessary to increase the temperature differential, by reducing the ambient air temperature. To accomplish this, the dry bulb temperature should

be reduced by 1 deg. C for every 300 metres above 900 metres altitude over sea level. As an example, consider a city located at an altitude of 1500 metres above sea level. Applying this rule, the dry bulb temperature would be reduced by 2 deg. C. Hence, the allowable dry bulb temperature is 19+-2 deg. C

The dry bulb temperature should be measured at the inlet to the computer equipment racks.

2.3.2 Relative Humidity

The Relative Humidity in the computer room shall be 45plus or minus 5% throughout the year, or, as recommended by the equipment manufacturer.

To maintain this humidity level, a vapour barrier should be provided for the computer room.

2.3.3 Ventilation Air

Ventilation air should be provided in accordance with *ASHRAE Standard 62.1* – latest version, based on the occupant density as well as the area of the computer room.

Computer rooms shall be under slight positive pressure relative to the outside and to the remainder of the building at all times.

2.3.4 Air Quality

All air entering the computer room shall be filtered to at least MERV 10 in accordance with *ASHRAE Standard 52.2* - 1999, Table E-1, corresponding to a dust spot efficiency of at least 50% with an arrestance exceeding 95%.

2.3.5 Vibration and Sound Control

The sound level in Computer Rooms shall meet the requirements of ASHRAE *Thermal Guidelines for Data Processing Environments* latest edition.

2.3.6 Sensible Heat Ratio

Latent heat gain in computer rooms will generally be very low. The primary sources of latent heat gain in building spaces are people, and, ventilation air. For computer rooms, both occupancy levels and ventilation levels are very low, and the marginal gain in latent heat is offset by the loss of latent heat to surrounding areas that are at lower humidity levels.

Hence the total heat gain is almost entirely sensible heat, and the sensible heat ratio is close to 1. As a result, dry cooling coil operation is required, without any condensation at the cooling coils.

Chapter 3 Design Cooling Loads

3.1 Heat Load due to IT Equipment

Heat gains from computer equipment are highly concentrated and non-uniform within the space.

The heat gains in computer rooms have increased rapidly with time, as computer hardware has become smaller and more powerful, resulting in higher equipment density. Data centres are also being designed for longer life spans of 15 years or more, and allowance has to be made for increases in cooling load of the facility during its life span. A minimum spare capacity of 25% should be provided to allow for future expansion.

Heat gains should *not* be based on nameplate values, as these are generally misleading and imply higher levels of power consumption and heat dissipation than will actually occur. The purpose of a nameplate rating is primarily to indicate the maximum power draw for safety and regulatory approval. Very often, manufacturers provide excess capacity in the power supplies to allow for future product enhancements and upgrades.

Heat loads should be based on manufacturers' data. We recommend obtaining a “Thermal Report” from the equipment manufacturers, in a standardized format. The report should include at least the following information:

1. Indication of several equipment configurations, for example a minimum configuration, a full configuration and, a typical configuration.
2. Description of each configuration.
3. Dimensions and weight for each configuration.
4. Steady state heat release, in watts, for each configuration, at an ambient temperature range of 20-25 deg.C.
5. Maximum airflow for each configuration, in cu.m./h at 35 deg.

An example of a thermal report is given below:

Table 1 Sample Thermal Report						
Company Name: **ABC Company** Product: **XYZ Server**						
Configuration	***Description***	***Dimensions***	***Typical***	***Nominal***	***Maximum***	***Weight***
		(WxDxH)	Heat release	Airflow	Airflow	kg
		mm	Watts	cu.m/h	cu.m/h	
Minimum	1 CPU-A, 1GB, 2I/	764x1016x1828	1765	680	1020	406
Maximum	8 CPU-B, 16GB, 64 I/	1549x1016x1828	10740	1275	1913	693
Typical	4 CPU-A, 8GB, 32 I/	764x1016x1828	5040	943	1415	472
Air flow pattern	Front to rear					

The equipment layout design team should decide which configuration shall be used, and determine the equipment heat load based on the thermal report from the manufacturer. In most cases, the “typical” configuration would be appropriate, but some designers may want to use the “maximum” configuration, depending upon the requirements for the project.

3.2 Lighting Loads

Lighting levels will generally be the same as for office spaces, as detailed in PWGSC Federal Office Building Standards. The actual lighting loads should be followed for design.

3.3 People Load

People load will be based on the occupancy requirements for the computer room. In general, the occupancy will be much lower than for office spaces. Heat generation per person should be calculated using *ASHRAE Fundamentals Handbook*.

3.4 Building Envelope Heat Gains

In general, computer rooms should be located in interior spaces, so that there is no heat transfer through the building envelope. However, large data centres may be housed in a separate facility, and heat gains from the building envelope should be considered in the design of the air-conditioning system.

3.5 UPS Systems

Heat gains from the UPS/Battery system should be considered, if it is served by the same air-conditioning system as the computer room. In addition, the ventilation requirements for the UPS/Battery system should be considered.

Chapter 4 Computer Room A/C Equipment

4.1 Selection of A/C equipment

The following types of A/C units are acceptable:

1. Refrigerant cooled units with either air-or liquid-cooled condensers. The units may be of the up-flow or the down-flow type.

   In the up-flow units, the supply air may be discharged directly into the computer room, or discharged into the ceiling space from which it will enter the computer room from ceiling diffusers.

   In the down-flow units, the supply air may be discharged into the space below the raised floor from which it will enter the computer room through perforated grilles or diffusers.

2. Chilled water/glycol units with remotely located air/liquid cooled chiller units. The units may be of the up-flow or the down-flow type as described above.

See *Appendix A Supplementary Material* for more details.

4.2 Functional Requirements for Air Distribution

1. Air may be returned directly to the A/C unit. Alternatively, the ceiling space may be used as a return air plenum with return grilles or small hoods located immediately over the heat-generating computer equipment.

2. Supply air distribution should be carefully designed to eliminate drafts and cold spots in the computer room.

3. When using under-floor plenums, adequate clearances should be provided within the raised floor cavity, to achieve uniform air flow.

4. If under-floor air distribution is employed, turbulence of supply air discharged into the space below the raised floor should be minimized by the use of turning vanes.

5. Floors and floor panels should be properly sealed. The walls under the raised floor should also be sealed properly.

6. Ducting serving other areas of the building should not pass through the computer room. If this is absolutely necessary, the ducts shall be completely enclosed in membrane having the same fire rating as the computer room enclosure.

4.3 Functional requirements for A/C units

1. The A/C units should be designed for dry coil operation i.e. there should be no condensation at the coil. Whenever condensation occurs, an energy penalty is imposed, due to the change of state of water vapour. See Appendix A for more details.

2. The A/C units shall be designed to prevent simultaneous humidification and dehumidification.

3. The A/C system should be designed for highest energy efficiency.

4. All cooling systems should incorporate capacity controls so that refrigeration load matches the cooling load.

5. Reheat shall be provided only in those cases where de-humidification is required. If operation is in the “dry coil” mode, then de-humidification would not normally be required.

6. The system should be designed for year-round cooling.

7. Computer room applications are often mission critical. For example, a computer room may process sensitive data for a number of Government departments, and any interruption, even for a few seconds, could lead to the loss of sensitive data. In such cases, standby air-conditioning systems should be provided. Standby equipment should be used on a regularly scheduled basis, to ensure operational readiness at all times.

8. Heat recovery from the computer room A.C. system should be considered, including the following options:

   - Free cooling
   - Heat recovery from condensers/ dry coolers, used for heating of domestic hot water
   - Recovery heat from condensers/dry coolers used for heating outside air

   However, the addition of heat recovery systems should not reduce the performance, or reliability, of the A/C equipment.

9. Liquid leak detectors should be installed in the space below the raised floor to detect any fluid leakage.

10. Hub or funnel drains should be installed adjacent to each A.C. unit complete with deep seal trap, and, trap primer connected to a suitable water source.

11. The computer room should be reasonably airtight to minimize the quantity of outside air required to maintain positive pressure within the space. Doors should be tight fitting and gasketted. If necessary, air locks shall be provided.

12. The computer room should be enveloped in a good vapor barrier to reduce moisture migration and structural damage. Computer rooms in areas where the winter outside design temperature is 0°C or lower should be located in the interior zone of the building and away from outside walls, roofs and floors. Cables and piping passing through the vapor barrier should be properly sealed and caulked.

13. Minimum clear space below raised floors should be 300 mm.

14. The A/C system shall be designed such that the airflow patterns match the equipment placement requirements. See *ASHRAE Thermal Guidelines for Data Processing Environments,* latest edition, for more details.

15. Temperature/humidity alarms should be provided within the computer room, and connected to the building automation system.

4.4 Fire Protection

1. Single-interlocked preaction fire suppression systems should be used for computer rooms.

2. A Fire-protection system using halon should not be used.

3. All fire protection systems should be constructed in compliance with applicable Codes and applicable Treasury Board and/or HRSDC guidelines.

Also, refer to *Appendix B: Fire Protection*, for more details.

4.5 Servicing Requirements

Provisions for servicing of computer room A/C units should be included during the design phase of the project. These provisions should include:

1. Selection of equipment with a view to durability, reliability and maintainability.

2. Easy access to all components requiring servicing.

3. Selection of the most efficient point of operation.

Servicing facilities should include:

1. Uninterrupted availability of service during the hours and days of the week specified in the project brief.

2. Local servicing facilities stocked with a complete range of computer room A/C unit components.

3. Local servicing personnel trained and qualified by the computer room A/C unit manufacturer.

4. Security classification clearance requirements that must be satisfied to gain access to the computer room.

Chapter 5 Measurements During Commissioning

5.1 General

Standard wall-mounted temperature and humidity sensors are generally inadequate for ensuring adequate cooling of computer rooms. This is because the electronic equipment performs correctly only when required environmental conditions are maintained at the inlet to the equipment. Simply maintaining the room temperature at the required value will not ensure proper cooling, especially in today's high-density computer racks.

For example, if the computer manufacturers require 21 deg.C at the inlet to the rack for proper operation, then a supply air temperature of 21 deg.C may lead to equipment failure, due to localized overheating. Localized humidity conditions may also cause problems, even if the wall sensor indicates the correct value. Hence, temperature and humidity measurements at various points in the computer room are required to ensure proper operation.

Three types of tests and measurements should be performed:

1. Facility health and audit tests.
2. Equipment installation verification tests.
3. Equipment troubleshooting tests.

The user should perform the appropriate type of test that best fits the application, following the recommended procedures in *ASHRAE Thermal Guidelines for Data Processing Environments*, latest edition.

5.2 Facility Health and Audit Tests

5.2.1 Objective

These tests are required to proactively determine the health of the facility, to prevent any potential equipment failures. They should be performed on a regular basis.

5.2.2 Measurement locations

Temperature and humidity measurement locations should be established on each aisle that has equipment air inlets, using the following guidelines:

1. Establish at least one measurement point for every 3-9m of aisle.

2. Locate measurement points midway along the aisle, centred between equipment rows.

3. The measurement points should be located at the appropriate height based on the type of electronic equipment, and the manufacturers' recommendations. A typical height may be 1.5 m.

4. Where hot aisle/cold aisle configuration is used, measurement points are required only in the cold aisle.

5.2.3 HVAC Operation

Record operating status of the HVAC unit (including fan status), fan speed, supply air temperature and humidity, return air temperature and humidity.

5.2.4 Evaluation of Results

Any temperatures and/or humidity levels outside the recommended operating range should be identified, documented, and, investigated. Possible corrective action should be taken including air balancing, or modification of the cooling system.

Temperature and humidity at the HVAC should be within the design range. If the return air temperature is significantly below the ambient temperature, possible short circuiting of the supply air should be investigated, and corrective action taken.

5.3 Equipment Installation Verification Tests

5.3.1 Objective

These tests are required to verify that the equipment is correctly installed, and that the bulk temperature and humidity conditions at the entrance to the equipment rack are within acceptable limits.

5.3.2 Measurement Locations

1. Locate measurement points at the geometric centres of the air intakes for the top, bottom, and, middle rack servers for each rack assembly, if there are three or more servers.

2. Locate measurement point at the geometric centre of top and bottom rack servers, if there are only two servers.

3. Ensure that the measurement points are 50 mm away from the racks.

5.3.3 Evaluation of Results

1. All temperature and humidity readings should be within the acceptable environmental limits prescribed in Section 2.

2. If any readings fall outside these limits, take corrective action such as air balancing, and/or changes to the cooling system.

3. If corrective action is not readily possible, evaluate the risks in consultation with the equipment manufacturer.

5.4 Equipment Trouble-shooting Tests

5.4.1 Objective

These tests are required after equipment failure has occurred, to determine whether the failure could have occurred due to inadequate environmental conditions, such as excessive temperature at the air inlets to the equipment.

5.4.2 Measurement Locations

1. Locate at least three measurement points across the entire air intake to the equipment, at a distance of 50 mm from the rack server.

2. Use a larger number of measurement points for larger servers, the objective being to cover the entire air intake.

5.4.3 Evaluation of Results

1. If all the measurements fall within the acceptable environmental limits, the failure is most likely not the result of inadequate HVAC system and consultations with the equipment manufacturer may be required to determine the cause of failure.

2. If some readings are outside the acceptable limits, then modifications to the HVAC system may be required.

Chapter 6 Glossary

Conditioned air

Air treated to control its temperature, humidity, purity, pressure, and, movement

Data centre

A building, or a portion of a building, whose primary function is to house a computer room and its support areas

Dew point temperature

The temperature at which water vapour has reached a saturation point

Dry bulb temperature

The temperature of air indicated by a thermometer

Enthalpy

The total heat content, the sum of the internal energy plus the pressure-volume work done on the system

Equipment

Refers to servers, storage products, workstations, personal computers

Equipment room

Data centre or telecom room that houses computer equipment

Latent heat

Change of enthalpy during a change of state, for example, during conversion of water to steam at a constant temperature

Rack

Frame for housing electronic equipment

Relative humidity

Ratio of mole fraction of water vapour in the air to the mole fraction of water vapour in fully saturated air, at the same temperature and barometric pressure conditions, expressed as a percentage

Sensible heat

Heat that causes a change in temperature

Wet bulb temperature

The temperature of air indicated by a wet-bulb thermometer leading to a fully saturated state

Supply air

Air entering a space from and air-conditioning, heating or ventilation system

Ventilation air

Outside air, or fresh air supplied to a space

Chapter 7 References

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Appendix A Supplementary Material

A1.0 Introduction

This appendix provides explanatory material that should be of assistance in using this guideline. It is intended to help explain the rationale behind some of the design requirements that are prescribed in this guideline.

This supplementary information may also describe alternative methods of meeting the design requirements, together with discussions of the advantages and disadvantages of each method.

A2.0 Air Distribution

A2.1 Supply Air

Raised floors may be used as distribution plenums and are particularly suited where computer equipment is to be supplied with cooling air directly.

Supply air that enters the computer equipment directly from below the raised floor has the advantage of reducing turbulence and air movement in the computer room and thus contributing to worker comfort.

However, the temperature and relative humidity of this supply air is critical.

A2.1.1 Supply Air Outlets in Raised Floor

1. Perforated floor panels – these have high induction rates and consequently may be located close to computer equipment without the danger of unmixed supply air entering the computer equipment air inlet, and with less discomfort to the operator.

   There is a wide divergence of opinion among raised floor manufacturers regarding free area of perforated floor panels.

   Some perforated floor panels may be equipped with volume control dampers.

2. Floor diffusers and floor registers – these have better directional control and longer throw and are normally equipped with volume control dampers, but may be too drafty for operators working nearby, and are also not mounted completely flush with the raised floor. For these reasons they are usually located away from cart traffic or occupied areas.

A2.2 Return Air

Using the ceiling space as a return air plenum has several advantages:

1. Return air grilles or small canopy hoods can be installed directly above heat-generating computer equipment and the heat generated can be captured almost directly into the return-air stream.

2. A portion of the heat generated by the lights can also be captured directly.

A3.0 The Necessity for "Dry" Coil Operation

A3.1 "Dry" Coil Operation

Due to the extreme Canadian climate, computer rooms are generally located in interior building spaces and equipped with vapour barriers to maintain high humidity levels throughout the year. Due to low occupancy, the ventilation requirements are minimal. Hence the latent heat gain is very low. Consequently the cooling load is almost 100% sensible heat and dehumidification is not normally required. It is, however, important that cooling coil capacity should provide "dry" cooling coil operation to prevent unnecessary dehumidification, and that simultaneous dehumidification and humidification should not occur.

The reasons for these requirements can be illustrated by reference to Example 1 below. See Figure A1.

Example 1: Dry and Wet Coil operation

<u>Assumptions</u>

Room temperature: 24°C

Room humidity: 50% RH

Supply air temperature: 16 deg.C

Bypass flow around cooling coil: 3.5%

Temperature rise between cooling coil discharge air and room supply air: 1.5deg.C

Sensible Heat Factor (SHF): 1.0 i.e. there are no latent heat gains or losses from the computer room to the surrounding rooms.

<u>Calculations</u>

Total dbt. Difference = ((24 - (16 - 1.5))/0.965= 9.85 °C.

Dbt. of supply air leaving cooling coil = 24 - 9.85 =14.15 °C.

Dry Coil Operation

Refer to the psychometric chart in Figure A1 that depicts “dry” coil operation. Air enters the cooling coil at condition R and leaves the coil at condition C. It mixes with bypass air at condition R to form a mixture at condition M. There is a temperature rise of 1.5 deg.C between the coil and the entry into the room, as the air picks up energy from the fan heat, the cables, and heat transfer through the floor slab. Hence it enters the room at condition S.

All of these processes occur at a constant Sensible Heat Ratio of 1.0, therefore the psychometric process follows a horizontal line R-S-M-C.

Wet Coil Operation

Consider the processes that occur if there is wet coil operation – i.e. if condensation occurs at the coil, as shown in Figure A2. Since there is condensation, the psychometric process no longer follows a horizontal line, and the air leaves the coil at condition C1. There is a change in enthalpy between conditions C and C1, depicted as LHc in Figure A2.

Air is now supplied at condition S1, and it has to return to condition R during the cooling process. Hence, the psychometric process follows the horizontal line (at constant SHF), and then an enthalpy change is required to return to condition R from R1. This is shown as LHh in the Figure A2.

Thus, it is seen that two enthalpy changes are required, LHc and LHh, so there is, in effect, a double penalty on the cooling system.

Operation of Cooling Coil with Moisture Loss from Computer Room

Because moisture is lost from a computer room when there is a breakdown in the vapour barrier, or when there is air infiltration into the space, the sensible heat factor becomes greater than 1.0, and the humidifier in the self-contained air-conditioning unit operates to replace this loss.

In order to maintain the computer room at design conditions under these circumstances, the moisture picked up by the return air must be removed by dehumidification as it passes through the cooling coil. This may necessitate some reheat.

Note that the cooling coil, although designed to operate as a “dry” coil will, under these circumstances, operate as a “wet” coil.

Consequently, operation of the reheat coil may be interpreted as a sign of excessive humidification. The visual alarm should alert the operating personnel of this condition.

A4.0 Types of Air-conditioning systems

A4.1 Self-contained Refrigerant A/C units

Multiple self-contained refrigeration units may be installed within the computer room. This type of system has the following advantages:

1. Excellent performance.

2. Inherent flexibility in matching cooling capacity to cooling load requirements.

3. If one unit breaks down, the other units can take over the cooling load, ensuring reliable, fail-safe operation

4. The A/C units may be located close to heat sources, resulting in higher cooling efficiency

5. Good security, as the equipment is located in a secure area.

A4.2 Split Refrigerant Cooled A/C unit (DX System)

In this type of system, the condensers are remotely located with refrigerant piping to the main air conditioning unit and the cooling coils. This type of system is useful when the distances between the elements of the air-conditioning system are not too large.

One advantage of this type of system is that a heat recovery device can be used to recover heat from the condenser.

A4.3 Split A/C System Using Glycol or Chilled Water

This system is used when the distances between condenser and compressor are too great for the use of refrigerant cooled unit. This system is relatively maintenance free, when compared to a DX system.

Chilled water may be used as the circulating fluid when freeze protection is not required. However, when there is exposure to freezing conditions, a glycol loop should be used. Heat recovery devices can readily be incorporated into these systems.

Since cooling loads are primarily sensible heat, the chilled fluid temperature should be maintained as high as possible without compromising the performance of the system.

Fig. A3 shows one possible arrangement, with a heat recovery device. The dry cooler heat exchanger is provided for free cooling and energy conservation. The cooling coil controls should include 3-way valves to ensure adequate flow through the chiller at all times.

A4.4 Chilled Water-cooled Computer Room A/C Unit

Water-cooled A/C units may also be used, using chilled water from a central chiller plant. System should be closed system, use distilled water (or other water treatment – usually as specified by the computer equipment manufacturer), water/water heat exchanger and be designed to operate all year round, 24 hours per day. The use of City water for cooling is not recommended.

A5.0 Heat Recovery Methods

A5.1 General

Several methods of heat recovery are possible, depending upon the type of building and the potential for using the recovered heat. Some of the possibilities are illustrated below.

A5.2 Arrangement #1: Heat Recovery for Domestic Water

With this arrangement, the recovered heat is utilized for heating domestic water. See Fig.A4.

A5.3 Arrangement #2: Economizer/Free Cooling

Another possibility for energy conservation for use with glycol or chilled water chillers is shown in Fig.A3, which illustrates the use of an additional dry cooler heat exchanger for periods when free cooling by outside air is possible.

A5.4 Arrangement #3: Using Additional Cooling Coil

Another possibility is to divert the condenser fluid from the refrigerant condenser to an additional cooling coil in the A/C unit. This is illustrated in Fig. A5.

Fig. A1

Psychrometric Process for Computer Room A/C Units with Dry Coil Operation, Appendix A, Section A3.1

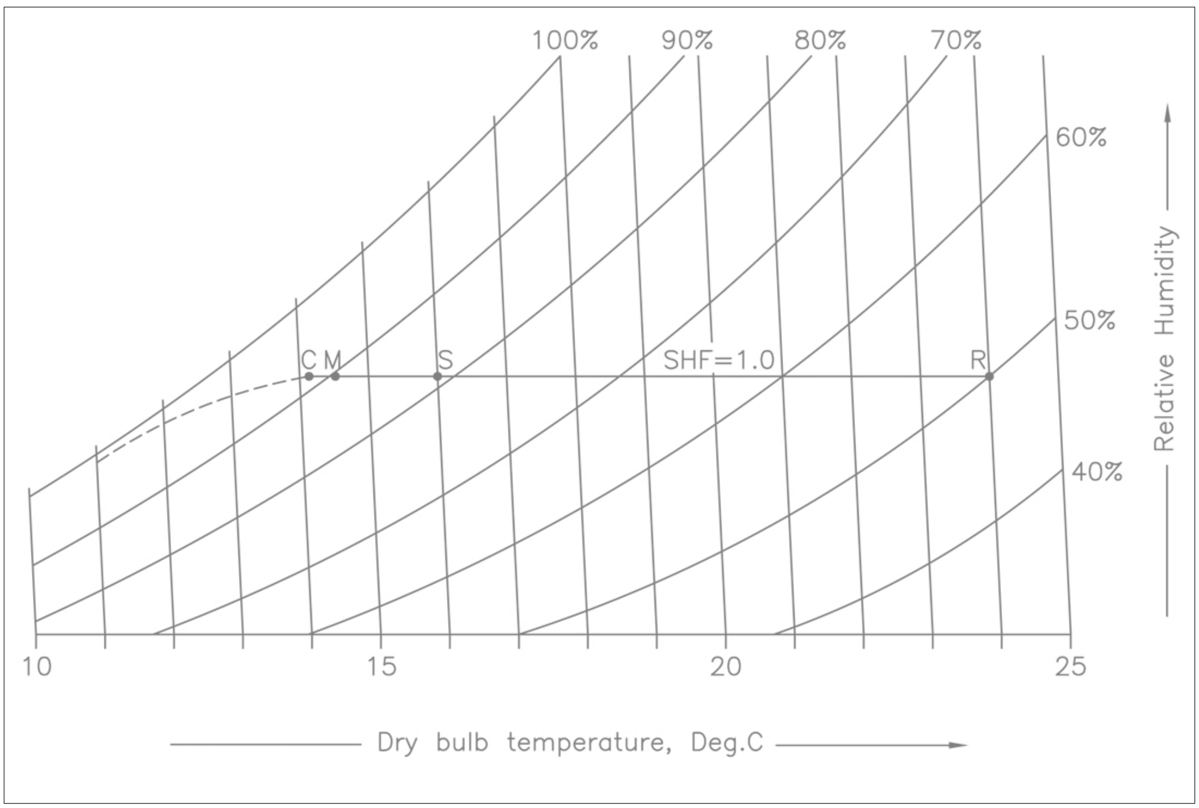


Fig. A2 **Psychrometric Process for Computer Room A/C Unit with Wet Coil Operation, Appendix A, Section A3.1**

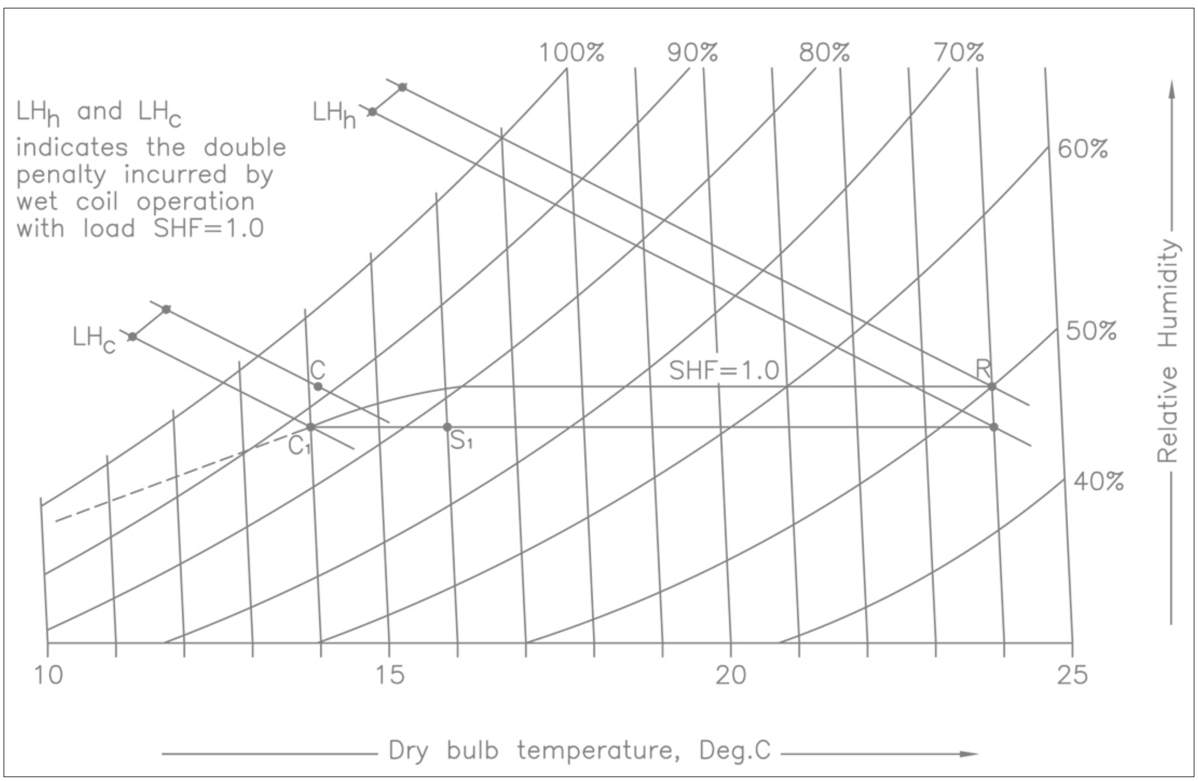
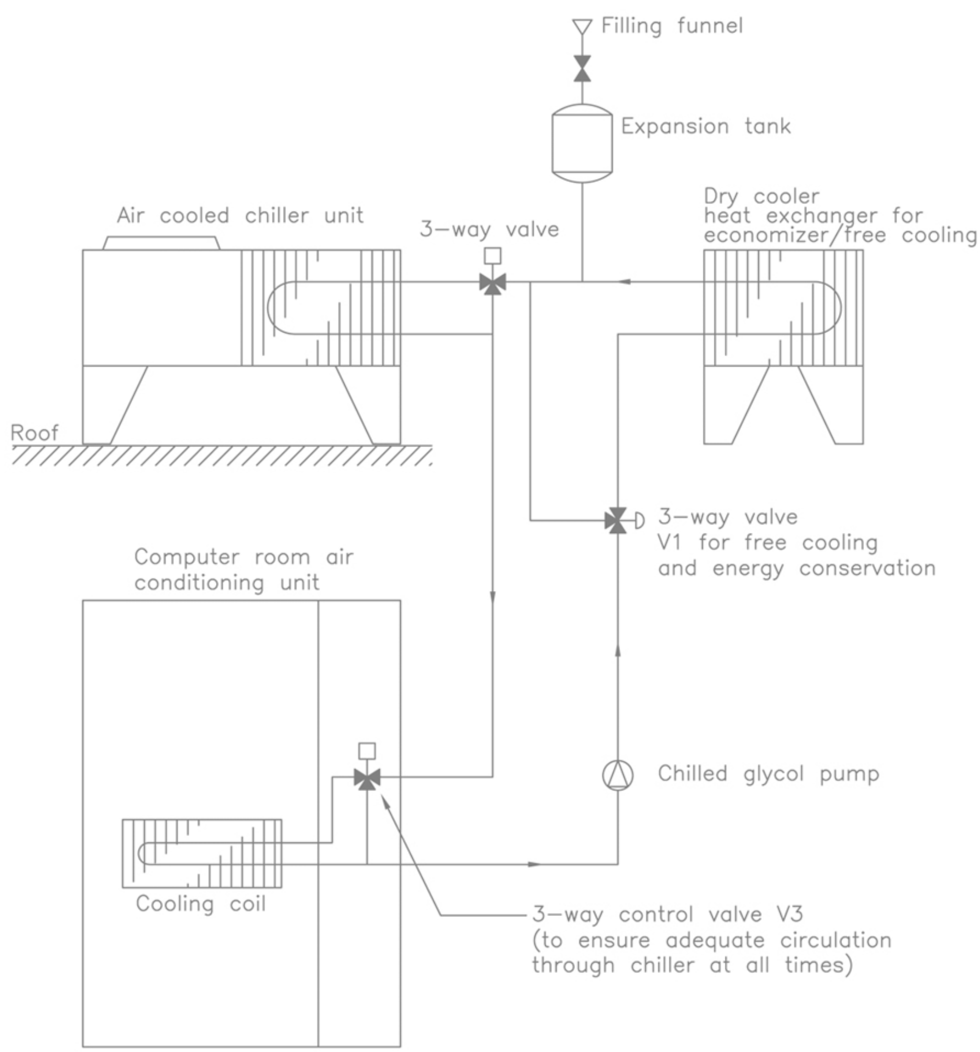


Fig. A3

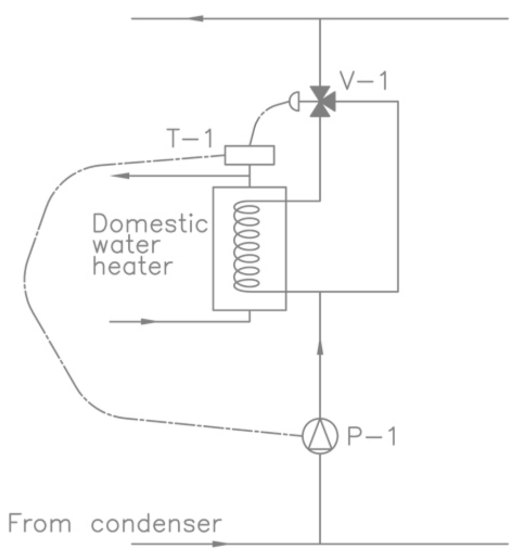
Chilled Water or Glycol-cooled Computer Room A/C Units, Appendix A, Section A.4.3



Notes :

1. Note connection to dry cooler heat exchanger for free cooling and energy conservation.

Fig. A4 Heat Recovery System for use with Glycol-cooled Condensers,Appendix A Section A5.0

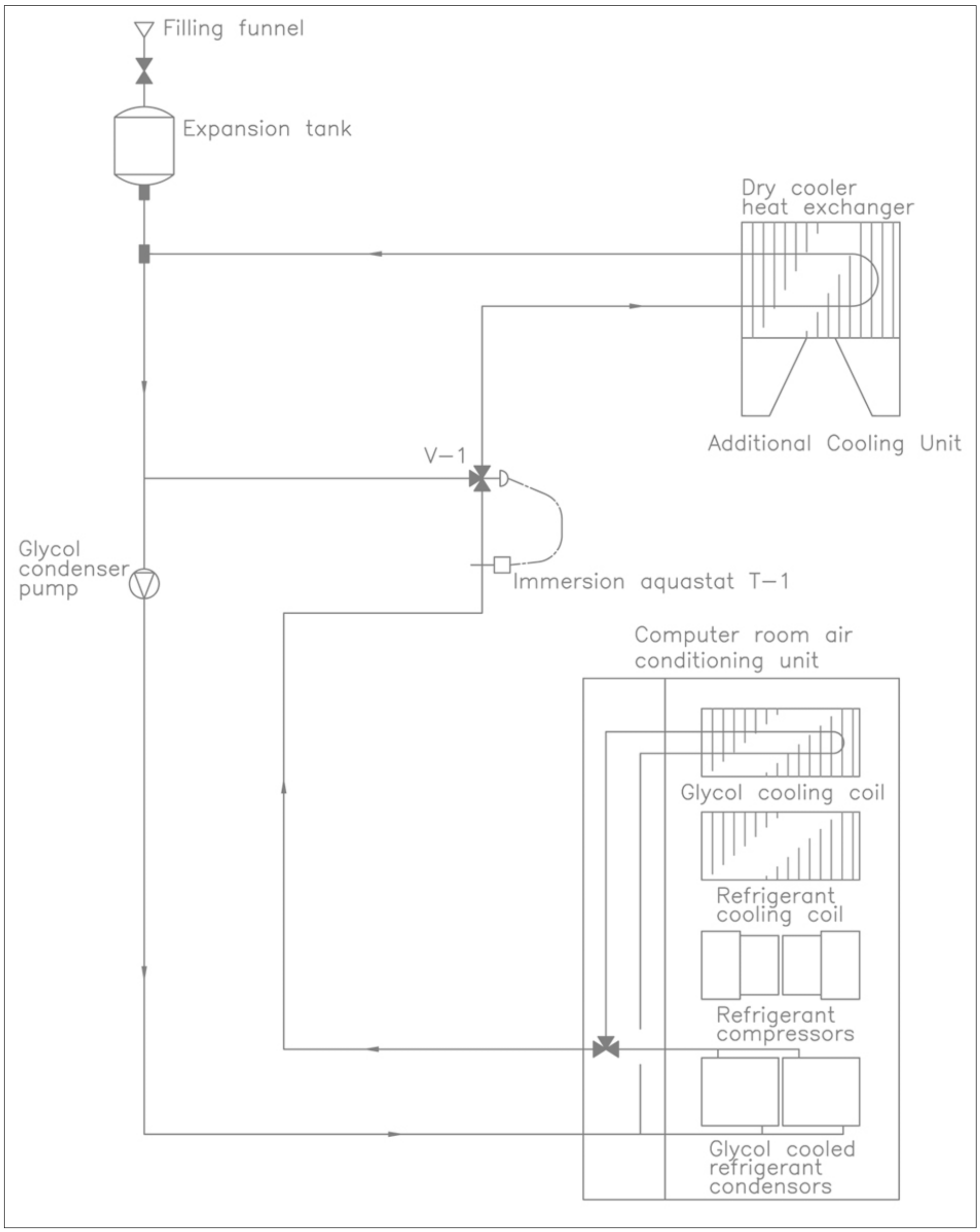


Notes :

1. When T–1 calls for heat, circulating pump P–1 starts and draws glycol through heat recovery loop(s). Valve V–1 modulates to vary flow through bypass.

Fig. A5

Energy Conservation – Additional Cooling Coil to Utilize Condenser Fluid, Appendix A, Section A 5.4



Appendix B Fire Protection Systems

B1.0 Type of Fire-suppression System

Based on fire risk analysis, the installation of a single-interlocked preaction fire-suppression system is recommended for all Level III EDP rooms. The installation of a gas-fired suppression system is not recommended.

B2.0 Background

The fire-protection systems in EDP rooms are governed mainly by three regulations: *the National Building Code, the National Fire Code and the Occupational Safety and Health Manual* as issued by Treasury Board Secretariat (Chapter 3-3 Fire Protection Standard for Electronic Data Processing Equipment).

The National Building Code's main focus is with life safety, and it refers to NFPA Standards for further details. In the case of fully sprinkler red buildings, NFPA Standard 13 requires the installation of a wet pipe sprinkler system throughout the entire building including the EDP rooms (NFPA 13 Appendix A-4-2: “A dry pipe system should be installed only where heat is not adequate to prevent freezing of water in all parts of, or in sections of the system”).

The Treasure Board Regulation's main focus is property protection and therefore, the requirements for Level III installations are as follows: “A halon 1301 system or other acceptable gaseous fire-suppression system shall be installed in the computer room where a fire-risk analysis concludes that, in addition to sprinkler protection, a gaseous fire-suppression system is necessary to minimize potential fire damage to the EDP equipment”.

The use of any halon product, including Halon 1301 has been effectively banned under the Montreal Protocol; therefore, to conform to the federal governments sustainability policy, the use of any fire suppression system using halon is not permissible. In order to comply with the Treasure Board requirements to protect the EDP equipment on large computer room projects, the COE commissioned several fire code consultants to review all the relevant regulations and provide recommendations. Based on the reports findings and recommendations, the COE recommends installation of strictly single-interlocked preaction fire-suppression systems for all the Level III EDP rooms.

B3.0 Justification

Fires originating within the computer room are expected to yield products of combustion, which will be corrosive and damaging to live electrical equipment. The quantity of smoke necessary to result in permanent damage depends on the properties of the combustible materials exposed to elevated temperatures. As large quantities of smoke can be produced in advance of visible flame or the subsequent sprinkler activation, it is generally accepted that the principle risk to sensitive computer equipment is from the corrosive, hot, smoke particles.

In order to protect the computer equipment from exposure to excessive quantities of smoke, early warning smoke detection should be installed in order that building occupants, supervisory staff and security staff can take appropriate action to suppress a small fire and implement smoke venting. This action may be sufficient to negate the operation of any further automatic fire suppression, whether sprinklers or gaseous suppression system. In the event that a fire is found to be too large to be suppressed by manual intervention, the manual release lever for the preaction valve can be activated in order to fill the sprinkler piping with water and await operation of the sprinklers. By this time, the quantity of smoke is expected to be so great as to result in widespread damage to the computer equipment within the room. It is to be noted that even small quantities of smoke can cause sensitive computer equipment to become unreliable. In these cases, the damage is done in advance of any activation of gaseous suppression or sprinkler systems.

Sprinkler operation within the computer room is expected only after the temperatures have risen to above 74 dec.C. The preaction valve will prevent sprinkler operation without the operation of at least two smoke detectors, thereby protecting the room and equipment from water damage in the event of physical damage to the sprinkler or accidental activation of a sprinkler. Otherwise, the sprinklers are extremely reliable fire-suppression systems with proven suppression capabilities.

The provision of a supplementary gaseous-suppression system could be an added value; however, there are limitations.

The discharge of gaseous-suppression systems (such as FM 2000 or Inergen) must occur within a short period of time to achieve good mixing with the air;

therefore, the gas is discharged with great force. Anything in the room that is not fixed may be picked up and tossed about. Any dust in the room will become airborne which will reduce visibility. Visibility will be further reduced by the creation of a fog. Expanding gases discharging from the nozzles cause considerable cooling of the air to the point where the humidity contained within the room air condenses and creates the fog. The high gases discharge noise coupled with the fire alarm add to the overall confusion.

The gases utilized for fire suppression do not cause adverse reactions on skin contact, and are generally non-toxic in prescribed concentrations and durations of exposure. However, the gases are heavier than the air; therefore, a room filled with the gas will very soon, after discharge, have a heavy concentration of gas near the floor and virtually no gas at the higher levels. This may create two problems:

1. Should anyone be trapped in a room after a gas discharge, there is a possibility of asphyxiation if anyone should fall and lie on the floor, as the gas will collect at the floor level.

2. Fires located at higher levels above the floor may re-ignite within minutes after the gas discharges and the gas pools at the floor level.

B4.0 Conclusion

The early warning smoke detection and preaction sprinkler protection systems are generally considered sufficient for the protection of computer and communications facilities when the rooms are occupied.

Suitable protocols must be developed and appropriate training is required for all computer room staff, supervisory staff, building maintenance personnel and security staff with respect to a response to alarm conditions. The implementation of appropriate procedures and training in combination with early warning smoke detection are expected to provide appropriate protection for the computer room and its equipment.

As such, the value added by implementation of a supplementary gaseous-suppression system is not considered to be sufficient to offset the added system maintenance costs, the potential system complications and the risks to room occupants in the event of activation