

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

DESIGN AND ENGINEERING OF BUILDINGS

PTS 34.17.00.32

NOVEMBER 2010



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PTS Circular 2010 - 1	PETRONAS 
PTS No:	PTS 34.17.00.32
Publication Title:	Design and Engineering of Buildings
Base PTS Version:	Release 13

This revision of PTS **34.17.00.32 – Design and Engineering of Buildings** has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this PTS (Revision 1, September 2002) will be removed from PTS binder/ e-repository from herein onwards.

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Revision History

Date	Version	Description of Updates	Author
12/05/2010	0	To update and incorporate content of PTS 20.076	MFAR / EK / AH / MKH

PREFACE

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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	6
1.4	ABBREVIATIONS	6
1.5	CROSS REFERENCES	6
1.6	SUMMARY OF REVISIONS FROM PREVIOUS EDITION	7
2.	DESIGN AND ENGINEERING DRAWINGS.....	8
2.1	BASIC INFORMATION	8
2.2	PRELIMINARY DESIGN AND ENGINEERING DRAWINGS	8
2.3	FINAL DESIGN AND ENGINEERING AND DRAWINGS	9
2.4	STRUCTURAL DESIGN	9
3.	DESIGN LOADS	10
3.1	DEAD LOADS	10
3.2	LIVE LOADS.....	10
3.3	WIND LOAD, SNOW/SAND AND EARTHQUAKE LOADS, LOADS DURING ERECTION, DYNAMIC LOADS AND LOAD COMBINATIONS	10
3.4	CRANE LOADS.....	10
3.5	LOADS DUE TO EQUIPMENT, ETC.....	11
3.6	DESIGN REQUIREMENTS FOR BLAST RESILIENT AND BLAST RESISTANT BUILDINGS	11
4.	CLIMATIC ASPECTS, INSULATION AND NOISE	16
4.1	GENERAL	16
4.2	HEATING, VENTILATION AND AIR CONDITIONING OF PLANT BUILDINGS	17
4.3	HEATING, VENTILATION AND AIR-CONDITIONING OF NON-PLANT BUILDINGS	18
4.4	COVERED WALKWAYS AND PARKING BAYS	22
4.5	INSULATION	23
4.6	NOISE ABATEMENT/VIBRATION	24
5.	DIMENSIONS	26
5.1	OFFICE BUILDINGS	26
5.2	MESS ROOMS.....	26
5.3	SANITARY BUILDINGS	26
5.4	WORKSHOP AND WAREHOUSE BUILDINGS	26
5.5	ELECTRICAL STATIONS AND ANALYSER HOUSES	26
5.6	CEILING HEIGHTS	27
6.	BUILDING ELEMENTS/COMPONENTS	28
6.1	GENERAL	28
6.2	WALLS	29
6.3	ROOFS.....	31
6.4	CEILINGS.....	32
6.5	FLOORS.....	33
6.6	DOORS	35
6.7	WINDOWS	38
6.8	SPECIAL REQUIREMENTS FOR PLANTS HANDLING VERY TOXIC PRODUCTS	41
6.9	STAIRCASES.....	42
7.	UTILITIES.....	43
7.1	DRAINAGE AND SEWERAGE.....	43
7.2	WATER SUPPLY AND RELATED PLUMBING	44
7.3	TELECOMMUNICATIONS AND INSTRUMENTATION.....	47
7.4	ELECTRICAL	47
7.5	LIGHTING.....	47
7.6	INSTRUMENT AND TOOL AIR, GAS, WATER AND STEAM LINES IN WORKSHOPS AND KITCHENS	47

8.	FIRE PROTECTION	48
8.1	GENERAL	48
8.2	SURFACE SPREAD OF FLAME	48
8.3	FIRE RESISTANCE.....	48
8.4	EXTERNAL FIRE EXPOSURE.....	49
8.5	FIRE-FIGHTING EQUIPMENT/SYSTEMS	49
9.	SECURITY	50
9.1	GENERAL	50
9.2	ENTRANCE GATES.....	50
10.	SURFACE PROTECTION	51
10.1	PAINTING AND COLOUR SCHEMES	51
10.2	GALVANISING AND ZINC SPRAYING	51
11.	SITE PREPARATION AND FINISHING	52
11.1	SITE PREPARATION	52
11.2	LANDSCAPING AND SITE FINISHING.....	52
11.3	MATERIAL STORAGE YARD	52
12.	MISCELLANEOUS	53
12.1	ROOM NUMBERPLATES AND NAMEPLATES	53
12.2	EMBLEMS AND LETTERING.....	53
12.3	PROVISIONS FOR EXTERNAL CLEANING	53
12.4	ACCESS TO UTILITY PIPING, ETC.....	53
12.5	FURNITURE AND FURNISHINGS	53
12.6	FLAGPOLES	53
13.	REFERENCES	55

APPENDICES

APPENDIX 1	FINISHES OF FLOORS, CEILINGS, AND WALLS	58
APPENDIX 2	TYPICAL WINDOW DETAIL	61
APPENDIX 3	CLIMATIC CONDITIONS FOR ROOMS IN NON-PLANT BUILDINGS	62

1.1 SCOPE

This PTS is a revision of an earlier PTS of the same number, dated September 1992. A summary of changes from the previous edition is given in (1.6).

-	Analyser houses	PTS 32.31.50.13 Standard Drawing S 17.001 Standard Drawing S 17.002
-	Fire stations	PTS 80.47.10.33
-	Laboratories	PTS 34.17.10.31
-	Substations and switch houses	PTS 33.64.10.10 Standard Drawing S 68.040
-	Blast Resilient and Blast Resistant Control Buildings/Field Auxiliary Rooms	PTS 34.17.10.30
-	Workshops	PTS 70.08.10.11 PTS 70.08.10.13
-	<i>Guide to the Warehousing of Chemicals</i>	<i>PTS 30.06.10.46</i>

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If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Blast resilient - Structures or their components that have already a certain elasticity/flexibility in their conventional design to receive some low (limited) blast loads; or structures or their components that are designed with an improved conventional (enhanced resilient) design to receive limited blast loads.

Blast resistant - Structures or their components that are designed to receive blast loads.

Peak side-on over-pressure - Initial peak pressure rise, above ambient, produced by a shock wave or pressure wave as felt by a flat surface oriented parallel to the direction of wave propagation.

Duration - The time from initial change in pressure to return to ambient pressure.

Plant Building - *Generic* term for control building (including plant laboratory), field auxiliary room, analyser house, electrical substation, compressor building or other related buildings for plant process operating activities.

Non-Plant Building - *Generic* term for buildings not related to plant process operating activities, e.g., administration building/office, training centre, canteen, warehouse, workshop, chemical store, laboratory, gate/guard house, security office or fire station.

1.4 ABBREVIATIONS

CFR - Combustion Fuel Reference

FAR - Field Auxiliary Room

1.5 CROSS REFERENCES

Where cross references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (13).

1.6 SUMMARY OF REVISIONS FROM PREVIOUS EDITION

The previous edition of this PTS was dated September 1992. Other than editorial revisions, the following are the main changes to that edition:

Old section	New Section	Change
1.1	1.1	Reference added
1.3.2	1.3.2	Definitions added.
4.1	4.1	Sentence added.
6.2.1	6.2.1	Should replaced by shall
6.3.1	6.3.1	PVC replaced by UPVC
6.3.2	6.3.2	Types of roof amended
-	12.7	Section added

2. DESIGN AND ENGINEERING DRAWINGS

2.1 BASIC INFORMATION

The Principal shall indicate the scope of work to the Contractor in the form of a project specification. This project specification will generally include one or more basic instruction drawings, showing the essential data and information on the buildings and their relationships with adjoining buildings and/or constructions.

If no basic instruction drawings are given, the Contractor shall use his own judgement in arriving at sound designs based on all other information given. This other information may be in the form of a list of requirements, possibly accompanied by one or more 'typical' drawings.

With the approval of the Principal, the Contractor may make alterations in the arrangement and orientation, if such alterations are considered necessary in view of local climatic conditions, improvement to landscape, or other reasons.

The Contractor shall adhere to modern building practices with regard to codes, material specifications, safety, ease of maintenance, etc. An architect shall be contracted to design the buildings and co-ordinate their installations. The selection of the architect shall be subject to approval by the Principal.

The layout and design of buildings (including drain systems, utility piping, cabling, etc.) shall be such as to allow future horizontal extension, unless this requirement is explicitly excluded in the project specification.

The ergonomic design requirements, as defined in PTS 30.00.60.15, shall be adopted. The appearance of buildings shall be plain, yet in accordance with local customs and existing buildings (if applicable).

2.2 PRELIMINARY DESIGN AND ENGINEERING DRAWINGS

A preliminary design shall be made for each building. This design shall consist of the following:

- a layout plan, showing the position of the buildings on site, including plant and true north and prevailing wind direction(s);
- a plan of every floor, indicating positions, dimensions and levels, including intended use of the rooms in the building;
- a schematic drawing of essential elevations and typical cross sections. The appearance of the administration buildings, e.g., canteen, training centre, engineering and office buildings, shall be in harmony with the local architecture;
- for buildings with basements, the highest ground water level shall be indicated;
- schedule of basic structural materials proposed to be used. Locally available materials shall be specified as much as possible provided they are technically acceptable;
- typical structural design calculations, as defined in PTS 34.00.01.30;
- a description of the mode of temperature and humidity control, ventilation and lighting facilities, stating approximate temperature and humidity ranges, air changes, and light intensities expected in the buildings;
- preliminary calculations for insulation against sun-load and proposed devices to be used for protection;
- a description, including material specifications, of other installations such as lifts, plumbing, drainage, sewage disposal, etc.

2.3 FINAL DESIGN AND ENGINEERING AND DRAWINGS

The final design shall comprise:

- a layout plan, showing the locations and orientation of the building;
- drawings showing the structural design of the main elements of the building and its foundation;
- plans of every floor and roof, cross-sections through individual floors, and essential elevations of the building. These drawings shall show the position, form, dimensions and materials of the various parts of the building;
- collected design data and calculations for climatic consideration, logically leading to the conditions expected to prevail in the building. Calculations and material and equipment data shall be provided as means to substantiate that the criteria of comfort will be satisfied;
- specifications of the works, in sufficient detail to invite competitive bids from erection Contractors and drafted so as to provide the minimum possible disparity between the interpretations of such Contractors. These specifications shall also include a programme of erection, the final material specifications, and working details;
- preparation of such additional detailed designs, specifications and drawings in order to define fully all details of the building and to ensure an effective and smooth completion of the erection work.

Drawings and related documents shall be made in accordance with PTS 34.00.01.30.

The scales to be used for various drawings shall be as defined below:

Plot plan	1:500
Plans, sections and elevations (for preliminary design)	1:200 or 1:100
Plans, sections and elevations (for final design)	1:100 or 1:50
Details, as required for erection Contractors	1:20, 1:10, 1:15, 1:2 or 1:1

2.4 STRUCTURAL DESIGN

For the structural design of buildings, reference is made to:

PTS 34.00.01.30;
PTS 34.28.00.31;
PTS 34.11.00.12;
PTS 34.19.20.31

3. DESIGN LOADS

3.1 DEAD LOADS

The dead weight of the various building elements comprising the structure shall be calculated, and used in the design.

3.2 LIVE LOADS

The following minimum live loads shall be used. If equipment weight to be supported exceeds the loads shown below, then the affected area shall be designed for the heavier load.

Type of building/room	Loads in kN/m ²
Offices, first-aid buildings, guard houses, toilets, wash and locker rooms, analyser houses, control room, computer room, instrument auxiliary room, electrical equipment room, laboratory room	3
Canteens, lunchrooms, training centres, corridors, stairs, halls	4
Library, filing rooms	5
Battery rooms, simulator room in training centre	10
<i>Workshop building (inclusive of covered area), workshop area in training centre, consumable store</i>	20
<i>Warehouse, chemical store and catalyst store</i>	20
Bulk storage	40

- NOTES:
1. For structural calculations, local codes/regulations and the actual loading situation shall be adhered to if these are more stringent.
 2. For garages and fire stations, the maximum weight of trucks and/or fire-fighting equipment shall be added to the above live loads.
 3. For warehouse, workshop and chemical store, the maximum loads of fork lift trucks shall be added to the above live loads.

3.3 WIND LOAD, SNOW/SAND AND EARTHQUAKE LOADS, LOADS DURING ERECTION, DYNAMIC LOADS AND LOAD COMBINATIONS

See PTS 34.00.01.30

3.4 CRANE LOADS

3.4.1 General

Crane loads shall be assumed at their maximum values, including the lifting capacity as well as the maximum horizontal loads caused by braking or acceleration, producing worst conditions, but not acting simultaneously with maximum wind forces. In general, the crane loads shall comply with ISO 8686 - Parts 1 and 5.

3.4.2 Workshop buildings

Unless otherwise stated in the project specification, the following cranes shall be installed:

- In the workshop building, two electrically operated overhead travelling cranes shall be installed to serve the mechanical and electrical workshops;

These overhead-travelling cranes shall meet the requirements for handling the heaviest equipment piece to be serviced, e.g., tube bundles or parts of stripped rotating equipment, etc. In any case the minimum capacity shall be:

Hoisting capacity	10 tonnes
Speed data shall be as follows:	
Normal hoisting speed	6 m/min
Slow hoisting speed	0.75 m/min
Crab travelling speed	18 m/min
Crane travelling speed	18 m/min

The minimum distance between the two cranes shall be 1000 mm. Spacers fixed to the crane shall guarantee this distance.

- In the welding area of the mechanical workshop a separate electrically or pneumatically operated overhead crane shall be installed;

Hoisting capacity: 5 tonnes
Same speeds as above

- A closed trolley system with protected power tracks shall be used for the electric power supply of these travelling cranes;
- A trolley beam with a hand-operated hoist, with a capacity of 1 tonne, shall be installed in the safety relief valve test area of the mechanical workshop;
- A 2-tonne jib crane with an arm of 3000 mm shall be installed on one of the steel columns of the mechanical workshop building. As the exact location is to be decided later on, all columns of the building shall be designed for this additional load;
- A trolley beam with a hand-operated hoist, capacity 2 tonnes, shall be provided in the instrument workshop. The beam shall extend 1500 mm outside the building.

3.4.3 Other buildings

- In the control building, a trolley beam with a hand-operated hoist, capacity 2 tonnes, shall be installed as defined in PTS 34.17.10.30
- In the CFR engine room of the main laboratory, a trolley beam including a hand-operated hoist with a capacity of 2 tonnes shall be installed above the test engines, extending to the external door.
- In electrical stations the building structure shall be capable of supporting a trolley beam including a hoist with a capacity of 2 tonnes. The requirement for the actual installation of this beam and hand-operated hoist shall be verified with the Principal.
- In other buildings, housings, e.g. for chilled water plants, compressors, gas turbine generators, etc., trolley beams with hand-operated hoists shall be installed for maintenance purposes. The hoisting capacity depends on the type of equipment to be hoisted and shall be approved by the Principal.

3.5 LOADS DUE TO EQUIPMENT, ETC.

If equipment and machinery are to be installed, e.g., in workshops, the loads shall be taken from Manufacturer's data.

3.6 DESIGN REQUIREMENTS FOR BLAST RESILIENT AND BLAST RESISTANT BUILDINGS

3.6.1 General

Control buildings and Field Auxiliary Rooms (FARs), located in a major hazard area, see (3.6.2), shall be blast resistant designed, so that after an explosion and fire, no fatalities of occupants shall occur and the building's instruments and equipment shall function safely during plant shutdown. Other buildings located in a major hazard area, e.g., analyser houses, substations, switch houses, etc., shall be blast resilient designed in accordance with (3.6.3) and the PTSs and Drawings referenced in (1.1).

The distance between buildings and process equipment, and the potential blast loads, will determine the design requirements of the buildings. Hazardous events, e.g., explosion, fire, etc., that generate blast loads and thermal radiation and which may occur around the chosen location, shall be identified or specified by the Principal. In order to determine whether an area shall be classified as a major hazard area, the following criteria shall be considered:

- the peak side-on over-pressure in kPa;
- the duration in sec.;
- the decay of the side-on over-pressure, duration and the related distances in metres;
- the thermal radiation (if applicable) and the decay related to the distance in kW/m^2 .

The above information shall be used for:

- location and design of new buildings;
- reviewing of existing buildings.

An experienced consultant with a track record in the design of blast resilient/resistant buildings should be engaged for this purpose.

The distance between a building and a hazardous source will determine the design principles and general design rules to be applied, as defined in (3.6.2) and (3.6.3). In (3.6.2), the major hazard areas are described. Response ranges for buildings within major hazard areas are listed in (3.6.4).

3.6.2 Major hazard areas

A major hazard area is an area that will be affected by explosion and/or external fire, thermal radiation or very toxic release. The severity will depend upon the distance between the building location and the source of the major hazard(s). A layout drawing with the plotted contours, i.e., over-pressures produced by the hazard(s), should be produced.

In the event of an explosion, external fire, thermal radiation, or very toxic release, a building shall be considered to be in a major hazard area if any of the following applies:

Major hazard description	Buildings	Threshold value	
Explosion	All buildings	Pressure ¹⁾	5 kPa
External fire - thermal radiation ²⁾	Control Rooms, FAR's, Workshops, Laboratories, Warehouses, Analyser Houses and Electrical Substations	Thermal radiation (long duration)	8 kW/m ²
	All other buildings	Thermal radiation (access for people, short duration)	5 kW/m ²
Very Toxic	All buildings	Distance	As specified by local regulations

NOTES: 1. For additional details of the pressure threshold values, see (3.6.3).

2. Classification is based on EN 1473.

If the threshold values will not be exceeded, the area shall be classified as a non-major hazard area and the appropriate design requirements shall be taken into account.

3.6.3 General design guidelines for all buildings in major hazard areas

The following safety requirements shall be adopted:

- Buildings normally occupied by personnel, such as main offices, laboratories, work shops, training centres, canteens, etc., and buildings needed during emergency situations (telephone building, first aid, fire-fighting garage, main guard house, emergency control centre, etc.), shall be built preferably in non-major hazard areas. If any of these buildings are located in a major hazard area, they shall be constructed so that the occupants are protected against partial or total collapse of the building and its components, including fragment impact and glass fragments. Such buildings shall therefore satisfy the enhanced blast resilience or resistance requirements defined in PTS 34.17.10.30. The Principal shall be consulted for approval in such instances;
- Control buildings and FARs should be located in the main administration area, which itself shall be located in a non-major hazard area. If this is not feasible, control buildings may be located in close proximity to a plant and shall meet the design requirements of this section and PTS 34.17.10.30.

NOTE: Even when incorporated within the main office block, control rooms and other 'plant buildings' shall have HVAC systems in accordance with PTS 31.76.10.10 .; see (4.2).

The following requirements shall apply if the building is located within a major hazard area:

Peak side-on over-pressure¹⁾ (“blast pressure”)	Special requirements for buildings within major hazard area		
	Building general	Doors	Windows
< 1 kPa	None	No special requirements other than local requirements.	No special requirements other than local requirements.
≥ 1 kPa and < 5 kPa	None, other than basic resilience	Glazing, if any, shall be laminated. No further special requirements other than local requirements.	Laminated glass with surface area < 1m ²
≥ 5 kPa	Blast resilience/resistance in accordance with PTS 34.17.10.30.		

NOTE 1: The duration related to the over-pressure will be in the range of 50 ms and 150 ms.

In addition, the following requirements govern the design of blast resilient or resistant buildings and their components. Specific blast resilience or resistance requirements are given in PTS 34.17.10.30 and will depend on the blast load caused by the explosion.

- Buildings shall be supported by a steel or reinforced concrete frame with such structural details that plastic deformation can occur without a total collapse;
- The joints shall ensure the ductile behaviour of the completed element. The supports shall be large enough to allow horizontal movements;
- Materials with a brittle behaviour, such as masonry, shall not be used in such a way that they have a strength function;
- The buildings shall have reinforced brick or reinforced masonry infill walls and/or steel frames with cladding, or shall be constructed as prefabricated or in-situ reinforced concrete modules or walls;
- Reinforced brick or masonry in-fill wall constructions shall be provided with sufficient reinforcement to withstand blast loads up to 20 kPa side-on overpressure.
- In blast resistant steel structures, more closely spaced structural steel bracing shall be provided in roofs and walls;
- Roofs and ceilings, electrical fittings, etc., shall be installed so that they cannot easily collapse during an explosion in the plant. All roofs shall be made of monolithic reinforced concrete or galvanised steel sheeting (box rib). Loose lightweight concrete roof slabs shall not be used. Gravel, as a protection or roof finish, or loose tiles for walkways on top of the roof finish, shall not be used;
- All windows in outer walls of all buildings shall have laminated safety glass.

3.6.4 Response (deformation) ranges for buildings within major hazard areas

The following table gives guidance for determination of response criteria:

Response	Description	Buildings
Low	Localised building/component damage. Building can be used; however repairs are required to restore integrity of the structural envelope. Total cost of repairs is moderate.	Control Rooms, Field Auxiliary Rooms and buildings which are occupied
Medium	Widespread building/component damage. Building cannot be used until repaired. Total cost of repairs is significant.	Substations and Analyser houses
High	Building/component has lost structural integrity and may collapse due to environmental conditions, e.g., wind, snow, or rain. Total cost of repairs approach replacement cost of building.	Sheds and compressor houses

The Principal shall give the required response criteria.

3.6.5 General design guidelines for all buildings in non-major hazard areas

Buildings located in non-major hazard areas do not require special provisions with regard to explosion (blast loads) and/or external fire and thermal radiation. The local building regulations shall be followed.

4. CLIMATIC ASPECTS, INSULATION AND NOISE

4.1 GENERAL

Buildings may require climatic conditioning, i.e., heating, ventilation and air conditioning (HVAC), to maintain the temperature, relative humidity and air quality within defined limits in order to provide reliable operation of electronic equipment and acceptable human working conditions.

Careful attention shall be paid to the prevailing climatic conditions in various seasons. Records of all local climatic design data such as air temperature, temperature differences, saline atmosphere, sand and dust storms, infiltration of sand in buildings, humidity, solar influence, wind, micro-climatic variations, etc., shall be used to arrive at a satisfactory design which ensures good conditions for equipment and personnel. In addition, the location and orientation of the building shall be taken into account.

The Contractor shall collect the meteorological data required for the design of the air conditioning if not specified by the Principal in the project specification. For various geographical locations, climatic data such as temperatures, humidity, wind, saline content of the atmosphere, chances of sand and dust storms, micro-climatic variations, altitude, etc. can be found in handbooks issued by, for example, the Meteorological Office in London.

Specialised manufacturers generally supply HVAC systems as package units or as single components. Standard HVAC equipment, suitable for the prevailing conditions, shall be applied as far as possible. The refrigerants shall comply with the "Montreal Protocol on Substances that Deplete the Ozone Layer", including amendments. *All refrigerant plants used to be provided ozone friendly cooling type for the air conditioning system. The system shall not make use of CFC refrigerants (R11, R12, R500, etc)*

Sufficient space shall be reserved for positioning and maintenance of the HVAC equipment and ducting. For a central HVAC system for buildings in a residential area, a separate HVAC space or room is preferred.

4.2 HEATING, VENTILATION AND AIR CONDITIONING OF PLANT BUILDINGS

Requirements and information regarding HVAC of plant buildings are defined in PTS 31.76.10.10.

4.3 HEATING, VENTILATION AND AIR-CONDITIONING OF NON-PLANT BUILDINGS

4.3.1 General

The category of non-plant buildings includes:

- administration buildings;
- laboratories (non-plant);
- training centres;
- workshops;
- warehouses;
- fire-stations;
- guard-houses/gate-houses/security buildings;
- residential buildings.

In temperate climates, air conditioning is usually not considered for this category of buildings unless required for the proper operation of equipment. In that case, air conditioning shall be limited to the rooms concerned.

4.3.2 Human comfort

ASHRAE 55/55a) stipulates that air-conditioned rooms that are continuously occupied by people shall have the following conditions:

Temperature: between 20 °C and 26 °C;
Relative humidity: between 30 % and 70 %.

The advised climatic conditions for various rooms are further specified in (Appendix 3).

4.3.3 Heating

Heating may be required to raise the temperature inside a building to the required level. The dissipated heat from personnel, lighting and electronic equipment etc., shall not be taken into account for heating capacity calculations. Heat losses through walls, floors and roofs shall be taken into account.

The Contractor shall submit the "heating load" calculations to the Principal. The calculations shall be based on ASHRAE Handbook Fundamentals.

4.3.4 Cooling

Cooling may be required to lower the temperature and/or humidity inside a building to the required level.

Cooling capacity calculations shall be based on heat generation from heat sources such as:

- personnel;
- electronic equipment;
- lighting;
- (fresh) air intake;
- solar radiation through transparent surfaces such as windows;
- heat transmission through walls, roofs/ceilings, floors, etc.

Cooling load calculations shall be based on the method of calculation in ASHRAE Handbook Fundamentals.

The Contractor shall submit the cooling load calculations to the Principal.

Condensation on air ducting, chilled water piping etc. shall be avoided under all climatic conditions specified, see (Appendix 3).

4.3.5 Humidification

Humidification may be required to increase the relative humidity inside a building to the required level. The Contractor shall submit the humidity calculations to the Principal. If humidification is required, steam humidification shall be employed and the humidifiers should be connected to the drinking water system. The water quality shall be checked with respect to the humidifiers applied. Precautions shall be taken to avoid excessive fouling of humidifiers.