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PART 1	ENERGY MANAGEMENT SYSTEM (EMS) REQUIREMENTS

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PROOF OF COMPLIANCE TO MS 1525: 2007 (CODE OF PRACTISE ON ENERGY EFFICIENCY AND USE OF RENEWABLE ENERGY FOR NON-RESIDENTIAL BUILDINGS)

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SECTION 1: AIR-CONDITIONING AND MECHANICAL VENTILATION SYSTEM

PART 1	LOAD CALCULATIONS	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S1-1-1	The ACMV system equipment sizing is determined according to latest edition of the ASHRAE handbook or other equivalent publication e.g CIBSE	Heat load calculation shall be performed for each air side system (minimum) or if using computerised heat load calculation, each space shall be calculated independantly. Rule of Thumb method of using btu/hr.sq.ft is not acceptable	
S1-1-2	Indoor design conditions of an air-cond space for comfort cooling should be as follows: *i). Recommended design dry bulb temperature; 23ºC - 26ºC* *ii). Minimum dry bulb temperature; 22ºC* *iii). Recommended design relative humidity; 55% - 70%* *iv). Recommended air movement; 0.15 m/s - 0.5 m/s (Max 0.7 m/s)*	Design temp: 24ºC Design RH: 55%	
S1-1-3	The recommended outdoor design conditions shall be as follows: *i). Dry bulb temperature; 33.3ºC* *ii). Wet bulb temperature; 27.2ºC*	-Only required if using peak load calculation method (spreadsheet) - For computerised heat load calculation (hourly analysis) , hourly weather data shall be used	
S1-1-4	Outdoor air-ventilation rates should comply with Third Schedule (By Law 41) Article 12(1) of Uniform Building by Laws, 1984. Exception: Outdoor air quantites may exceed those shown, if required due to special occupancy or process requirements or source control of air contamination or indoor air quality consideration.	Self explainatory	
PART 2	**SYSTEMS AND EQUIPMENT SIZING**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-2-1	ACMV system and equipment sizing is sized to provide no more than the space and loads calculated.	Oversizing will result in drop in efficiency and shall be avoided.	
S1-2-2	Redundancy in capacity of equipment, **if incorporated into the sizing of duty equipment** should include efficiency devices such as variable speed drive, high efficiency motor,efficient unloading devices, multi compressors etc so as not to diminish the equipment/system efficiency when operaring at varying loads.	Say if 1000 TR chillers are selected to serve 800TR building cooling load, multi compressors shall be provided. Another example is chiller serving day and night load.	
S1-2-3	**For chiller design load (plant capacity) greater than 1000 kWr (280 RT)**, a minimum of two(2) chillers or a single multi-compressor chiller shall be provided to meet the required load.	Self explainatory	

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S1-2-4	Multiple unit of the same equipment type, such as multiple chillers, **with combined capacities exceeding the design load** shall be specified to operate concurrently only if controls are provided which sequence or otherwise optimally control the operation of each unit based on the required cooling load (Energy Management Control System)	Energy Management Control System shall be provided for air conditioning system serving area greater than 4000m².	
S1-2-5	Individual air-cooled or water cooled Direct Expansion (DX) units greater than 35 kWr (10 RT) (reciprocating compressor) or 65 kWr (18 RT) (scroll compressor) should consists of either multi compressors or single compressor with step/variable unloaders.	Self explainatory	
PART 3	**SEPARATE AIR DISTRIBUTION SYSTEMS**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-3-1	Zones which are expected to operate non-simultaneously for more than 750 hrs per year should be served by separate air distribution systems. (e.g 24/7 space and 8/5 space). Alternatively off-hour controls should be provided (see 1-4-7)	Self explainatory	
S1-3-2	Zones with special process temperature and/or humidity requirements should be served by separate air distribution system/s from those serving zones requiring only comfort cooling or should include supplementary provisions so that primary system/s may be specifically controlled for comfort purposes only. Exception is for zones requiring comfort only which are served by a system primarily used for process temperature and humidity control, need not be served by a separate system if the total supply air to these zones is no more than 25% of the total system supply air, or the total air conditioned floor area of the zones is less than 100 m^2.	Separate system required for comfort cooling and process cooling.	
S1-3-3	Separate air distribution systems should be considered for areas of the building having substantially different cooling charateristics, such as perimeter zones (3m room depth) in contrast to the interior zones.	Perimeter zone has higher Sensible Heat Factor (SHF) thus requires more air flow with higher supply air temperature. Interior zone has lower SHF and requires lower air flow with lower supply air temperature.	
S1-3-4	For air conditioned space requiring exhaust air volume in excess of 3400 m^3/h (2000 cfm), not less than 85% of non conditioned make-up air should be introduced directly into the space concerned unless the exhausted conditioned air is utilised for secondary cooling purposes. Altenatively,heat recovery devices should be provided.	Self explainatory	
PART 4	**CONTROLS**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-4-1	Each system should be provided with at least one (1) thermostat. Each thermostat should be capable to set between 22ºC to 27ºC. Multi stage thermostat should be provided for equipment exceeding 35/65 kWr (multicompressors).	No specific requirement to have thermostat control for each circuit (compressors). It is suggested that at least load modulation up to 50%. E.g for 4 nos of compressors, 2 compressors should be provided with multistage thermostate.	

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S1-4-2	At least one thermostate for regulation of space temperature shall be provided each separate zone (as stipulated in Section 1-Part 3) and system. As a minimum, each floor of a building should be considered as a separate zone. On a multistorey building where the perimeter system offsets only the transmission gains of the exterior wall, an entire side of uniform exposure may be zones separately. A readily accesible manual or automatic means should be provided to partially restrict or shut off the cooling input (for the exposure) to each floor.	Self explainatory	
S1-4-3	Each system should be equipped with a readily accesible means of shutting off or reducing the energy used during the periods on non-use or alternate uses of the building spaces or zones served by the system via either manually adjustable automatic timing devices, manual devices for use by operating personnel or automatic control system.	Self explainatory	
S1-4-4	For multi zone system, other than those employing the variable air volume for temperature control, should be provided with controls that will automatically reset the off-coil supply to the highest temperature that will satisfy the zone requiring the coolest air.	Thermostat shall be located within zone with substantially highest cooling load requirements.	
S1-4-5	In a system requiring moisture removal to maintain specific selected relative humidity in spaces or zones, no new source of energy such as electric reheat should be used to produce a space relative humidity below 70% for comfort cooling purpose.	Alternatives system including using heat pipes, condenser water, desuperheaeter heat reclaim, heat recovery wheel etc. No restriction for process cooling.	
S1-4-6	Systems employing reheat where permitted in S-1-4-5 and serving multiple zones, other than those employing variable air volume for temperature control, should be provided with controls that will automatically reset the system cold air supply to the highest temperature level that will satisfy the zone requiring the coolest air. single zone reheat systems should be controlled to sequence reheat and cooling.	Thermostat shall be located within zone with highest cooling load requirements.	
S-1-4-7	It is recommended that consideration be given to the use of recovery systems which will conserve energy (provided the amount expended is less than the amount recovered) when the energy transfer potential and the operating hours are considered. Recovered energy in the excess of the new source of energy expended in the recovery process may be used for control of temperature and humidity. Examples include the use of condenser water for reheat, desuperheater heaet reclaim, heat recovery wheel, heat pipe or any other energy recovery technology.	Self explainatory	
S1-4-8	For off-hour control, ACMV system should be equipped with automatic conrtrol to reduce the energy-use when equipment shutdown during period of non-use. Eg: timer, scheduler. Exception:- a). System serving area which are expected to operate continuously. b). Equipment with connected load less than 2kWe may be controlled by manual off-hour control.	E.g: All system above 2kWe shall be provided with at least timer or remote controller.	

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SECTION 1: AIR-CONDITIONING AND MECHANICAL VENTILATION SYSTEM

S1-4-9	Outdoor air supply and exhaust system should be provided with motorised or gravity dampers or other means to automatic shut-off during period of non-use.Exception: a). System serving areas which are expected to operate continuously. b). System which have design air flow rate of 1800cu.m/h or less. c). Gravity and other non-electrical ventilation which can be controlled by readily accessible manual dampers control.. d) where restricted by process requirements such as combustion air intakes	Motorised damper provides less resistance to air flow compared to gravity dampers. It should be interlocked with AHU operation.	
S1-4-10	Systems that serve zones which can be expected to operate non-simultaneously for more than 750 hours per year should include isolation devices and controls to shut off the supply of cooling to each zone independently. Isolation is not required for zones expected to operate continuously.	Self explainatory	
S1-4-11	For buildings where occupancy patterns are not known at time of system design, isolation areas should be pre-designed.	Self explainatory	
S1-4-12	Zones may be grouped into a single isolation area provided the total conditioned floor area does not exceed 250 sq.m per group nor include more than one floor unless variable air volume or equivalent devices are incorporated. Use of outside economy air cycle design where feasible should be considered.	For central systems and plants, controls and devices shall be provided to allow stable system and equipment operation for any length of time while serving only the smallest isolation areas served by the system or plant.	
S1-4-13	Each mechanical ventilation system (supply and/or exhaust) should be equipped with a readily accessible switch or other means for shut-off or volume reduction when ventilation is not required. Examples of such devices would include timer switch control, thermostat control, duty cycle programming and CO/CO2 sensor control.	E.g lift motor room ventilation system-thermostat,	
S1-4-14	For fan system with air-flow rate exceeding 17000 m^3/hr and operating more than 750 hours a year, the power required by the motor for entire fan system should not exceed 0.45 W per m^3/hr of air flow rate.	Self explainatory	
PART 5	**PIPING INSULATION**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-5-1	All piping installed to serve buildings and within buildings should be adequately insulated to prevent excessive energy losses. Additional insulation with vapour barriers may be required to prevent condensation under some conditions. Refer JKR specification.	Self explainatory	

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SECTION 1: AIR-CONDITIONING AND MECHANICAL VENTILATION SYSTEM

PART 6	AIR HANDLING DUCT SYSTEM INSULATION	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S1-6-1	All ducts, plenums and enclosures installed in or on buildings should be adequately insulated to prevent excessive energy losses. Additional insulation with vapour barriers may be required to prevent condensation under some conditions. Exceptions: Duct insulation is not required in the following cases:- a). Where the design temperature differential between the air in the duct and the surrounding air is 8ºC or less provided that the duct is within the air-conditioned space. b). When the heat gain or loss of the ducts, without insulation, will not increase the energy requirements of the buildings. c). Within ACMV equipment. d). Exhaust air ducts subject to qualification as in (a) above.	Self explainatory	
PART 7	**DUCT CONSTRUCTION**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-7-1	All ductwork was constructed and erected in accordance with ANSI/SMACNA 006-2006 HVAC Duct Construction Standards-Metal and Flexible published by SMACNA or other equivalent duct construction standards.	Self explainatory	
S1-7-2	All AHU & FCU shall have minimum straight duct length of 2 1/2 times duct diameter or longest side for rectrangular duct after the fan outlet before any bend.	SMACNA recommendation	
S1-7-3	High pressure and medium pressure ducts should be leak tested in accordance with HVAC Air Duct Leakage Test Manual published by SMACNA or any other equivalent standards, with the rate of leakage not to exceed the maximum rate specified.	Self explainatory	
S1-7-4	When low pressure supply air ducts are located outside of the conditioned space (except return air plenums), all transverse joints should be sealed using mastic plus tape or equivalent material. For fibrous glass ductwork, pressure sensitive tape is acceptable.	Self explainatory	
S1-7-5	Automatic or manual dampers installed for the purpose of shutting off outside air intake for ventilation air should be designed with tight shut-off characteristics to minimise air leakage.	Self explainatory	
PART 8	**BALANCING**	**EXPLAINATORY NOTES**	**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S1-8-1	The system design should provide means for balancing the air and water system such as but limited to dampers, temperature and pressure test connections and balancing valve.	Self explainatory	

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SECTION 1: AIR-CONDITIONING AND MECHANICAL VENTILATION SYSTEM

PART 9	ACMV SYSTEM	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S1-9-1	ACMV components standard rating temperature and minimum COP to comply with MS1525 Table 18, Table 19, Table 20, Table 21, table 22 and table 23.	Self explainatory	
S1-9-2	ACMV control system shoud be tested (T&C) to assure that control elements are calibrated and in proper working condition.	Self explainatory	
S1-9-3	An operation and maintenance manual (OMM) and as-built drawing should be provided to the owner. The manual should include basic data relating to the operation and maintenance of ACMV systems and equipment. Required routine maintenance action should be clearly identified. Where applicable, ACMV controls information such as diagrams, schematics, control sequence descriptions and maintenance and calibration information should be included.	Self explainatory	

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SECTION 2: AIR LEAKAGE

PART 1	AIR LEAKAGE	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S2-1-1	Provide advisory label for all openable fenestrations and doors between conditioned space and non conditioned space.	Architects to be advised	
S2-1-2	Any duct connection between air conditioned space to outside air should have motorised damper in between to prevent air leakages into air conditioned space when the duct is not in operation.	Self explainatory	
S2-1-3	If false ceiling is used as return air plenum to the AHU, partition to be provided in the false ceiling space between air conditioned space and naturally ventilated space to prevent air leakage.	Self explainatory	
S2-1-4	Door that separates conditioned space from exterior should be protected by an enclosed vestibule, with all doors opening into and out of the vestibules equipped with slef closing devices. Vestibules shall should be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time. Interior and exterior doors should have a minimum distance between them of not less than 2.5 meters when in closed position. *i. Doors in buildings less than four storeys above ground* *ii. Door not intended to be used as a building entrance door, such as mechanical or electrical equipment rooms.* *iii. Doors opening directly from a residential unit.* *iv. Doors that open directly from a space less than 300 sq.meter in area.* *v. Doors in building entrances with revolving doors* *vi. Doors used in primarily to facilitate vehicular movement or material handling and adjacent personnel doors.*	Self explainatory	

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SECTION 3: ELECTRIC POWER AND DISTRIBUTION

PART 1	ALTERNATIVE CURRENT (A.C) ELECTRIC MOTORS	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S3-1-1	Motors used more than 2000 hours per years shall be EFF1. All other motor operating less than 2000 hours shall be EFF2 (excluding motor used for fire protection system or any other emergency system). Refer to Table 15 and Table 16 of MS 1525 for EFF 1 and EFF 2 efficiency classification.	Self explainatory	
S3-1-2	If specific circumstances apply , motor continuous rating should not normally exceed 30 % of its estimated maximum load .	Self explainatory	
S3-1-3	Power factor for motors shall be corrected to better than 0.85 when operating at duty point.	Self explainatory	
S3-1-4	Where applicable , inverter controlled motor drives shall be used to control the speed of the motor for variable load. Soft starters shall be specified for motors exceeding 7.5 h.p/ 5.0 kW.	Variable speed drive should only be considered for highly variable and high loads.	
PART 2	**CABLING**		**SUPPORTING EVIDENCE (to be attached together with the checklist)**
S3-2-1	The cross section of cable and wires should comply with the provisions of MS IEC 60364 on Electrical Installations of Buildings.	Self explainatory	
S3-1-2	All inverters or devices with electronic switching gates shall be of at least the 12-pulse type. The 24-pulse type is recommended to minimise harmonic currents.	Self explainatory	

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SECTION 4: ENERGY MANAGEMENT SYSTEM

PART 1	ENERGY MANAGEMENT SYSTEM (EMS) REQUIREMENTS (ONLY APPLICABLE FOR BUILDINGS WITH AIR CONDITIONED AREA EXCEEDING 4000m^2)	EXPLAINATORY NOTES	SUPPORTING EVIDENCE (to be attached together with the checklist)
S4-1-1	The EMS should be supplied with full complement of energy management features including but not limited to:- i). Direct digital control algorithms. ii). Starting and stopping of equipment based on a time schedule. iii). Temporary override of the time schedules to accommodate changes in usage. iv). Chilled water leaving and entering temperature reset v).Control loop set point reset algorithm. vi).Chiller sequencing and optimisation algorithm. vii).Demand limiting algorithm. viii).Duty cycle algorithm. viv). HVAC Energy (Electrical & Thermal) tracking and reporting (Historical data) i.e Refrigeration Plant, pumps, cooling tower, AHU/FCU (Note: High level interfacing is required for Item iv -viii. Alternatively, they can also be executed by chiller control panel/multiple chiller controller.	Can be achieved via Building Automation System and Chiller Multiple Control System	