



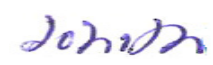
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BMRCL 5RSDM

Technical Specification

for HVAC Vehicle Level Test

in Climatic Chamber

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1. Introduction

1.1. General

This Technical specification document specifies the requirements of climatic chamber tests to be conducted on Metro car fitted with Heating Ventilation and Air Conditioning (HVAC) units, to validate the cooling performance and to measure Specific Energy Consumption of HVAC system, for Bangalore Metro Rail Corporation Limited (hereafter BMRCL) 5RSDM project.

BEML will carry out all required works and activities as Contractor to the Employer for BMRCL 5RSDM project, while the subcontractor shall be responsible for all works specified in this PTS document with regard to climatic chamber tests and shall be responsible for supporting the BEML activities as contractor for BMRCL 5RSDM project.

One M-car will be subjected to the climatic chamber tests. The scope of work includes all activities required to perform the car level type tests of HVAC system specified in the document meeting the best international practices even if not specifically mentioned in this PTS.

1.2. Train Composition

The rake formation shall generally be as follows:

6 Car Train formation: DM –T–M – M – T – DM

where,

DM : Driving Motor Car

T : Trailer Car with pantograph

M : Non -Driving Motor Car

1.3. Climatic & Environmental Conditions

The car shall operate reliably and safely under the climatic and environmental conditions specified at ERTS clause 2.1. Accordingly, the HVAC system shall be designed to operate with satisfactory performance under the following conditions as per ERTS clause 2.1.


Description	Limiting Values
Maximum ambient temperature (see note below)	42 °C
Minimum temperature	8 °C
Humidity	92% saturation during rainy season

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Rainfall	Rain occurs generally from May to October. Average annual rainfall is approximately 1065 mm. Maximum rainfall in any 24h period is 178 mm.
Atmosphere during hot season	Extremely dusty including bird feathers
Maximum wind load	125 Km/h
SO ₂ level in atmosphere	6.7 – 80 micro g/m ³
NO _x level in atmosphere	16 – 80 micro g/m ³
Respirator Suspended Particles Matter in atmosphere (RSPM)	49 – 120 micro g/m ³
Total Suspended particulate matter in atmosphere (TSPM)	111 – 360 micro g/m ³
Altitude	1000 m
Conditions in Stations	All underground stations will be fully air conditioned. Above ground stations will have air-conditioning for certain designated rooms only.
Flood Proofing	The traction sub-systems mounted on the under-frame will be designed to permit propulsion of the train at 10 kmph through water up to a depth of 75mm above rail level. Traction sub-systems shall be made splash proof in accordance with International Standards
Life	The Metro car is designed for min.35 year of life. Accordingly, the subject items & accessories shall also not deteriorate in their performance for 35 years

Note:

- 1) The temperature inside of an “inactive” metro train parked in the sun can easily exceed +60 °C.
- 2) The maximum design temperature inside the tunnel is expected to be 46°C under normal as well as congested conditions
- 3) Adequate margin shall specially be built into the design particularly to take care of the higher ambient temperatures, high humidity, dusty and corrosive conditions, etc. prevailing in Bangalore area.
- 4) The Subcontractor shall confirm from ASHRAE, outside design data conditions for Bangalore for the capacity calculation of HVAC.

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1.4. Vehicle Performance Requirements

The vehicle performance requirements with fully loaded train and tangent track are as per the following table.

Item	All Corridors
Maximum permissive speed (Design) on tangent and level track	90 kmph
Maximum permissive speed in operation on tangent and level track	80 kmph
Minimum Commercial speed with fully loaded (AW4 condition) train (excluding reverse time in terminal station) under normal condition	34 kmph
Average Acceleration rate from 0 kmph to 30 kmph for fully loaded (AW4) train on tangent & level track	1.0 m/s ² ± 5%
Average service deceleration from 80 kmph to 0 kmph.	0.95 m/s ² ± 5%
Instantaneous full-service deceleration	1.1 m/s ²
Maximum Jerk rate	0.7 m/s ³ ± 0.05
Maximumu adhesion limit in tunnel	18 %
Minmum average emergency deceleration	1.3 m/s ²
Annual running distance of one train	150,000 km

1.5. Track structure Parameters

The BMRCL 5RS-DM cars will operate with the track parameters as specified in the following table

Description	Elevated and At-grade Corridor		Tunnel Sections
	Ballasted	Ballast less (DFF)	Ballast less (DFF)
Track Laying Gauge	1435 mm		
Rail Type			
Main Line	UIC 60 Head hardened (1080)		
Depot	UIC 60 (880)		

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Rail Profile	60E1 (UIC 60) 880 grade	60E1 (UIC 60) 1080 grade HH	60E1 (UIC 60) 1080 grade HH
Inclination Of Rail	1 / 20		
Rail Seat Spacing, Main line	650 mm±10 mm	650 mm±10 mm	700 mm±10 mm
Sleeper Spacing, Depot	650 ± 20mm		
Ballast Cushion			
Main line	300mm		
Depot	250mm		
Standard Rail Length	13m and 18m		
Rail Panel Lengths	Long welded rails		
Minimum Radius of Curvature	Depot -100m	120m- with grade compensation	200m- with grade compensation
Minimum Turn Out Depot	1 in 7, R-140		
Minimum Turn Out Main line	1 in 7, R-140		
Maximum Cant Permissible in curves	125 mm		
Maximum Cant Deficiency Permissible	100mm		
Maximum Permissible Cant Gradient	1 in 440		
Turn-out Speed: Turn-out (Main line) 1 in 9, R-300	45 km/h		
Turn-out Speed: Turn-out (Main line) 1 in 7, R-140	25 km/h		
Turn-out Speed : Scissors (Main line)	20 km/h		
Turn-out Speed : In Depots	25 km/h		
Maximum Gradient (Main Line)	4% (compensated)		
Minimum vertical curve radius crest	1500m		
Maximum track axle load (AW4)	15.0 tonnes		
Widening of track Gauge on curves	Up to 9 mm for curves sharper than 500m radius		

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1.6. Current Collection System

System Particulars	For all sections and depot
Supply voltage system	750 V DC
Type of Current Collection	Through Third Rail (Inverted Rail) in all sections.
Current Collection	Through current collector shoes mounted on driving motor cars and motors cars

1.7. Power Supply Details for HVAC system

Power supply	Limiting Values
AC Input power supply (APS Output)	3-phase, AC 415 V \pm 5 %, 50 Hz \pm 1 %
DC Control power supply	110V DC, -30%, +25%,

1.8. Platform Interface

The principal details of the Platform Interfaces are set out in the following table.

Particulars		Measurements
Length of Platform		135m (6 coaches)
Width: Island type		8.0 to 12.0m
Width: Side type		4.0 to 6.0m
Height above rail level	Ballasted Track	1090mm \pm 5mm
	Ballast-less Track (DFF)	1080mm \pm 5mm
Maximum horizontal distance from centre of the track to face of passenger platform coping		As per para, 2.2.1 of SOD (December 2015)
Minimum horizontal distance from centre of the track to face of passenger platform coping		As per para, 2.2.2 of SOD (December 2015)
Minimum horizontal curvature at platform		1000m
Structural gauge and passing clearance in platform		Refer to Appendix E of ERTS

1.9. Signalling System (ERTS Clause 2.6)

Item	Description
Train Control System	CBTC based On board Continuous Automatic Train Control system (CATC) consisting of i) Automatic Train Protection ii) Automatic Train Operation (ATO) iii) Automatic Train Super-vision (ATS)

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	iv) Automatic Turn Back (ATB) v) Attended/Unattended train operation (GoA2/GoA3/GoA4)
Train Control mode	(i) Automatic mode (ii) Coded Manual modes (iii) Restricted Manual Forward mode (iv) Standby (v) Restricted Manual Reverse mode (vi) Run on Sight mode (vii) Cut-out mode (viii) UTO (ix) OFF mode

1.10. Principal Notional Vehicle Dimensions/ Leading Particulars

Description		Dimension
Maximum Length over body (including end-fairings)	DM car	21,050 mm
	T and M cars	20,800 mm
Maximum Length over couplers for all cars	DM car	21,750 mm
	T and M cars	21,700 mm
Maximum Width over Body		2,880mm
Minimum Passenger Saloon Headroom		2,050 mm
Maximum Floor height above rail level of any unloaded vehicle		1,130 mm
Minimum Floor height above rail level of fully loaded vehicle		1,100 mm
Maximum height of coupler above rail level for unloaded vehicle		815 mm
Maximum height of coupler above rail level for fully loaded vehicle		740 mm
Bogie Wheel Base	Maximum	2400 mm
	Minimum	2200 mm
Distance between bogie centres	Maximum	14,950 mm
	Minimum	14,450 mm
Wheel diameters	New	860 mm
	Half worn	820 mm
	Fully worn	780 mm

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1.11. Passenger Capacity

	Seating	Standing	Total (Seating +Standing)
		Fully Loaded/Dense Crush loaded (AW4)	Fully Loaded/Dense Crush loaded (AW4)
'DM' Car	43(each 'DM' car)	274	317
'T' Car	50 (each 'T' car)	290	340
'M' Car	50 (each 'M' car)	290	340
Total	248	1708	1994

1.12. Test schedule

All the tests shall be conducted during Aug/Sep- 2025. Subcontractor shall submit the available test slot during this period in the technical proposal. Exact test date and schedule may be mutually discussed and finalized.

2. Definitions and Abbreviations

2.1. Definitions


- **“Employer”** means Bangalore Metro Rail Corporation Limited (BMRCL), its legal successors and assignees.
- **"Subcontractor"** means the Supplier who supplies the required HVAC system to BEML for BMRCL 5RS-DM project. Subcontractor shall carry out the works in accordance with ERTS and ERGS with regard to HVAC system.
- **"Contractor"** means the persons or person appointed by the Employer to undertake the execution of the works for BMRCL 5RS-DM project. In order to avoid misunderstanding of the roles of the Contractor in ERTS and ERGS, the term “Contractor” shall be read as “Subcontractor” in ERTS/ERGS for those ERTS/ERGS Clauses referred to in this PTS.
- **"Contract"** means the contract between Subcontractor and BEML in relation to the supply of HVAC system for BMRCL 5RS-DM project.
- **“Engineer”** means any person nominated or appointed from time to time by the Employer to act as the Engineer for the purposes of the Contract and notified as such in writing to the Contractor.

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- **"Engineer's Representative"** means any Assistant of the Engineer appointed from time to time by the Engineer.
- **"GTC"** means "General Terms and Conditions for Supply of HVAC system for BMRCL 5RS-DM Project" issued by BEML.
- **"BEML"** means the Contractor to procure the HVAC system for BMRCL 5RS-DM project cars.
- **"ERGS"** means Employer's requirements General Specification for BMRCL 5RS-DM contract.
- **"ERTS"** means Employer's requirements Technical Specification for BMRCL 5RS-D M contract
- **"PTS"** means BEML's Procurement Technical Specification.

2.2. Abbreviations

ATC	:	Automatic Train Control
ATP	:	Automatic Train Protection
ATO	:	Automatic Train Operation
GOA	:	Grade of Automation
UTO	:	Unattended Train Operation
EMC	:	Electro-Magnetic Compatibility
EMI	:	Electro-Magnetic Interference
HVAC	:	Heating Ventilation and Air Conditioning
FAI	:	First Article Inspection
ISO	:	International Standards Organization
ITP	:	Inspection Test Plan
SOD	:	Schedule of Dimension
TCMS	:	Train Control Management System
SEC	:	Specific Energy Consumption
EN	:	European Standard
DSSP	:	Declared Scheduled Speed

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3. Qualification criteria

- I. Subcontractor shall have in-house climatic chamber to accommodate 25m long metro car with all facilities required for performing climatic chamber test and specific energy consumption (SEC) measurement.
- II. Subcontractor shall have adequate experience in performing vehicle level type test for HVAC system. The testing firm should have carried out the car level HVAC validation tests (thermal comfort and SEC tests) of Metro rolling stock on at least three mass rapid transit systems (MRTS).
- III. The subcontractor shall submit all the documents in support of meeting above requirements along with technical offer.

4. Standards

The testing of the vehicle level HVAC test shall conform to the latest editions of EN14750-1 and EN14750-2

5. Technical specifications

5.1.HVAC Technical specifications

Item	Unit Specifications	
Cooling capacity	37 kW	
Heating capacity	3 kW - For dehumidification	
Supply air	~4500 m ³ /h	
	External conditions	Internal conditions
Summer conditions	DB 35.2°C WB 19.6°C	25°C, <60% RH
Monsoon conditions	DB 27.3°C WB 23°C	25°C, <60% RH
Passenger Capacity (M-Car)	340	
Refrigerant	R-407C	
Maximum operating temperature	Full load operation up to 45 °C and at 50% at temperature between 45 °C and 52 °C.	
Fresh air flow	Adjustable with motor operated dampers ○ Closed (smoke in ambient air)	

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	<ul style="list-style-type: none"> ○ AW1, AW2, AW3, AW4 flow (normal operation) as a function of the passenger load <ul style="list-style-type: none"> ○ AW4: 1350 m³/h per AC ○ AW3: 1010 m³/h per AC ○ AW2: 675 m³/h per AC ○ AW1: 340 m³/h per AC ○ Emergency ventilation via emergency inverter installed in the saloon: 2050 m³/h with closed return air damper
Return air damper (installed in the return air duct)	Motor-operated The damper has two positions: <ul style="list-style-type: none"> ○ Open (normal operation) ○ Closed (emergency ventilation)
Electrical Power	415V AC / 3Phase / 50Hz (Main power supply-Normal operation) and 110VDC (Control power supply and Emergency Ventilation)
Weight	850 Kg approx
Max Dimension	4000 L x 1924 W x 380 H Approx.

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Modes of operation	<p>Normal operation</p> <ul style="list-style-type: none"> ○ Fresh air ventilation (fresh air flow varies as per passenger load) ○ 50 % cooling ○ 100 % cooling ○ Dehumidification (1 cooling circuit operates together with the heater) <p>Pre-cooling</p> <ul style="list-style-type: none"> ○ Full load cooling with AW0 passengers and closed fresh air dampers to bring down the indoor temperature to the specified target <p>Emergency ventilation</p> <ul style="list-style-type: none"> ○ Supply fan motor is supplied through the emergency inverter <p>Ambient air smoke</p> <ul style="list-style-type: none"> ○ Fresh air dampers close. Saloon air is recirculated and cooled / dehumidified as required to maintain the specified target temperatures <p>Indoor smoke</p> <ul style="list-style-type: none"> ○ HVAC shutdown
Temperature controls	<ul style="list-style-type: none"> ○ Return air temperature sensor - To control the cooling power and saloon temperature ○ 1 fresh air temperature sensor - To control pre-cooling operation and high temperature unloading of the refrigerant circuits ○ 1 supply air temperature sensor - To monitor air flow through the cooling coil
Humidity control	<p>1 solid-stated relative humidity sensor - 1 solid-stated relative humidity sensor</p>

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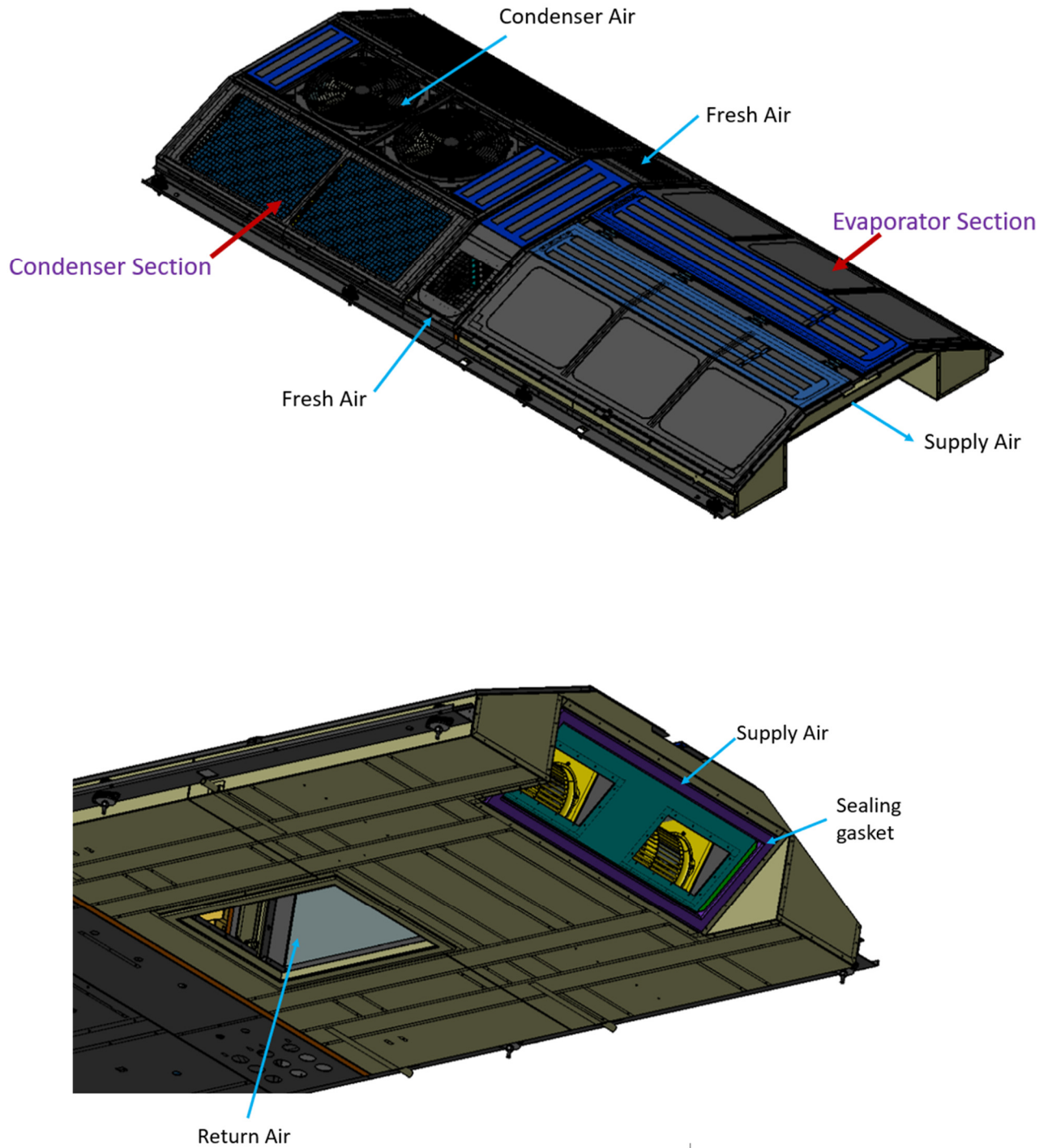


Figure 1:HVAC unit

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5.2. Estimated heat load

The estimated heat load under various passenger load conditions for summer and monsoon climatic conditions are tabulated below

Ambient condition		Summer	Monsoon
Passenger load condition		AW4	AW4
Number of passengers		340	340
Solar Gain (kW)		8.97	8.97
Transmission gain (kW)		5.08	1.14
Internal electrical load (kW)		2	2
Passenger load (kW)	Sensible heat	24.82	24.82
	Latent heat	15.3	15.3
Ventilation gain (kW)	Sensible heat	7.94	1.8
	Latent heat	0.18	10.63
Total heat load (kW)		64.29	64.66
Heat due to ingress of air during door opening		1.63	1.7
Total heat load per car		65.9	66.36

Note: Heat loads specified in the table above are based on estimation and actual values may change marginally during testing

5.3. Mounting and airflow arrangement

This HVAC system suffice the requirement of only Ventilation and air-conditioning and heaters are provided for dehumidification purpose only. Two identical units are suitably mounted on roof to achieve the required saloon interior conditions. General arrangement of M-car is attached.

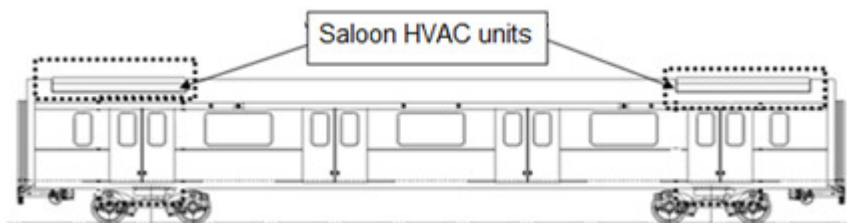


Figure 2: HVAC unit Arrangement on M-car

Conditioned air from each unit is directly introduced into a duct running full length of the car and further uniformly distributed in the saloon through diffusers. The supply air duct is

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diagonally split for each HVAC unit to feeds one side of the car, so that even in case of failure of one HVAC, the other working HVAC will be able to cool the saloon passenger area uniformly. The duct is fully lagged with non-combustible insulation material to prevent the formation of condensation. Two rows of air diffusers are mounted on each side of ceiling panel, for supply of conditioned air to saloon. Exhaust openings are provided at each end wall of the car

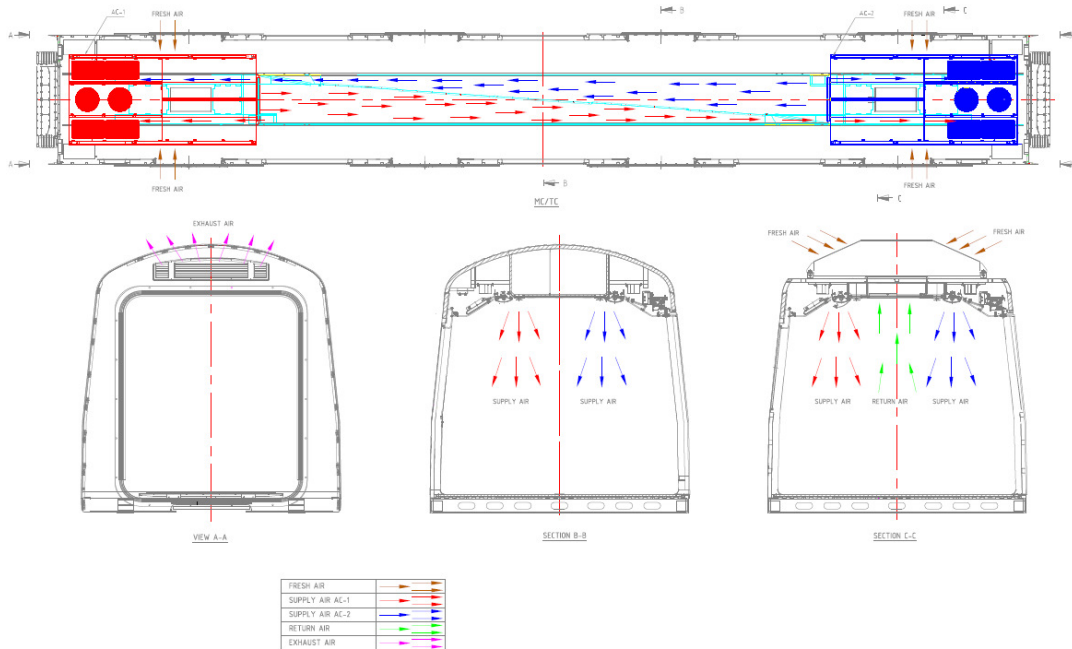


Figure 3: Air flow path

6. Test Details

One M-car equipped with all interior finish and all under-frame mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car. Car will be subjected to following tests

1. Air flow measurement
2. Cooling performance test
3. Specific Energy Consumption test

Air flow measurements shall be made in preparation chamber while cooling performance test and specific energy consumption tests shall be conducted in a climatic chamber

7. Air flow measurement

Detailed air velocity and air flow measurement tests will be conducted by BEML at BEML test track on the M-car which will undergo climatic chamber test, before dispatching the car for climatic chamber. However basic airflow measurements shall be made in preparation room at climatic chamber test facility before conducting the climatic chamber tests, to confirm the

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airflow rates meets the contract requirement. Following flow rates will be measured.

1. Return air flow
2. Fresh air

Brief test procedure for above tests is described below. Subcontractor shall prepare the detailed test procedure and submit to BEML for approval before conducting the tests. Subcontractor may propose better methods of flow measurements. Acceptance of same will be subjected to approval from BEML.

7.1. Return air flow measurement

Return air shall be measure using measuring duct/ hood. Details of return air measuring duct (if hood is not used) and measuring points is shown in the figure below.

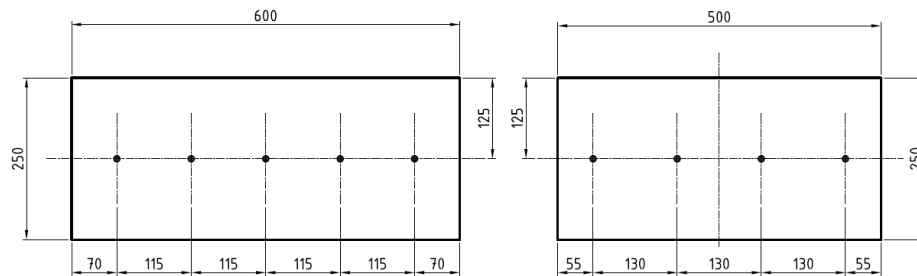


Figure 4: Return air measurement duct

Velocity will be recorded at all measurement points shown in the picture above. Average velocity shall be multiplied with the measuring duct inlet area to obtain the return air flow rate. This procedure shall be done at both return air openings located towards either end of the car.

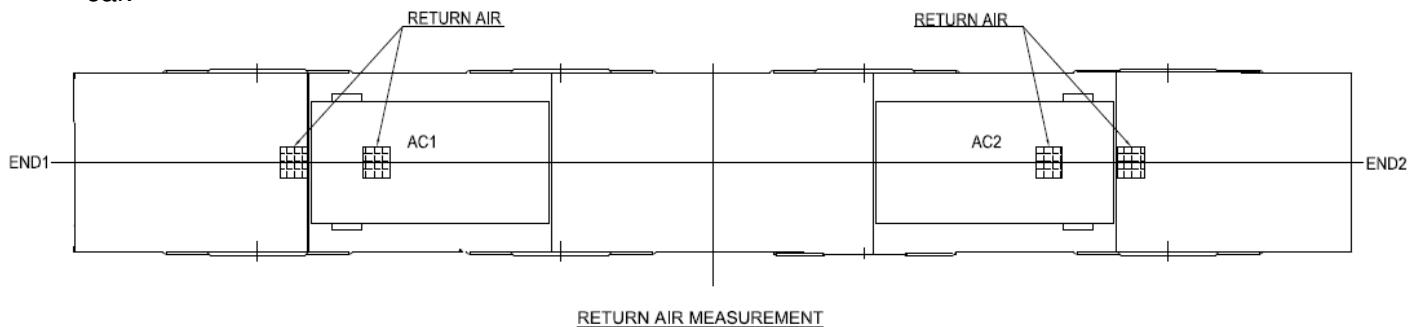


Figure 5: Return air inlet locations in car

7.2. Fresh air flow measurement

Fresh air flow shall be measured at the fresh air openings of HVAC unit mounted on the car. Fresh air shall be measured using measuring duct/hood. Measuring duct (if hood is not used)

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shall be mounted on HVAC unit. Details of fresh air measuring duct and measuring points is shown in the figure below.

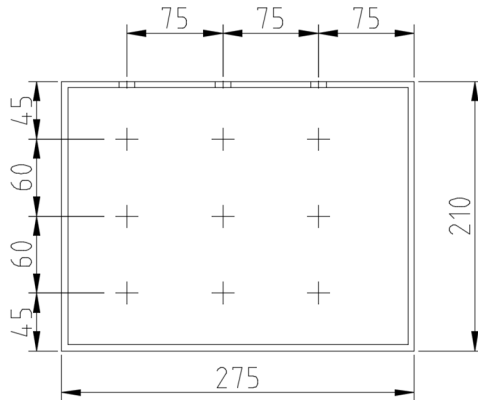


Figure 6: Fresh air measurement duct

Velocity will be recorded at all measurement points shown in the picture above. Average velocity shall be multiplied with the measuring duct outlet area to obtain the fresh air flow rate of each ventilator.

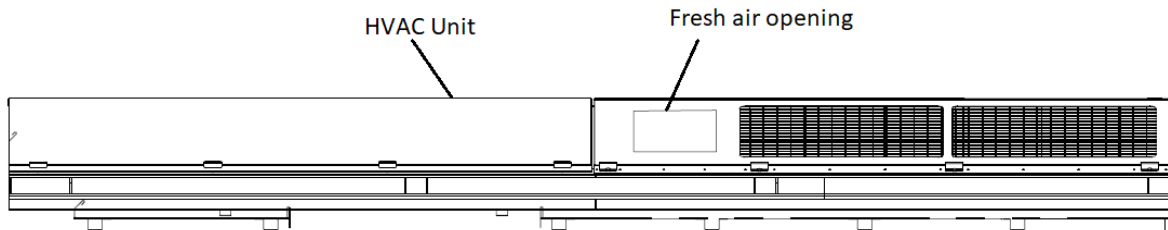


Figure 7: Fresh air inlet locations on HVAC

7.3. Test procedure - Return air and fresh airflow measurement

Brief test procedure for air flow measurement tests is described below. Sub-contractor shall prepare the detailed test procedure along with data record sheet and submit to BEML for approval before conducting the tests. Return and fresh airflow rates shall be measure with clean filters under normal ventilation mode

a) Test conditions:

1. Only blower fans "on" (all other equipment "off")
2. Keep all saloon doors closed
3. Fresh air dampers opening – at AW1, AW2, AW3 and AW4 conditions
4. Return air dampers open
5. Air filters clean

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b) Test procedure

Following measurements shall be recorded

1. Return airflow rates at 100% Fresh air dampers opening
2. Fresh airflow rates at 100% Fresh air dampers opening

Flow rate is equal to the product of average flow velocity and cross-sectional area of measurement duct. Flow velocity shall be measured by suitable flow velocity apparatus. Length and width of measurement duct shall be measured by measuring tape.

8. Cooling performance test

Purpose of these tests is to ensure that HVAC performance is as per contract / EN 14750-1 & 2 requirements.

8.1. Test conditions

Test Conditions	External Conditions	Internal conditions
Summer	Dry Bulb Temp 35.2°C Wet bulb 19.6°C	Dry Bulb Temp 25°C ≤60% RH
Monsoon	Dry Bulb Temp 27.3°C Wet bulb 23°C	Dry Bulb Temp 25°C ≤60% RH

8.2. Test details

These tests shall be conducted inside a Climate Chamber for judging the cooling performances of the HVAC system. Heating and humidifying equipment and all measurement equipment's shall be provided in the car for test purposes. Following tests shall be carried out

- a) Cooling Tests in Summer (35.2°C DBT & 19.6°C WBT ambient condition)
 - 1) Pre-cooling in AW0, with FAD closed, as per EN 14750-2
 - 2) Regulation for AW4, for 1 hour or 3 cycles, as per EN 14750-2
 - 3) Doors open for 30 sec close for 2 min, for 10 cycles, as per EN 14750-2
 - 4) Measurement of Cooling Capacity in Summer as per EN 14750-2
- b) Cooling Tests in Monsoon (27.3°C DBT & 23°C WBT ambient condition)
 - 1) Pre-cooling in AW0, with FAD closed, as per EN 14750-2
 - 2) Regulation for AW4, for 1 hour or 3 cycles, as per EN 14750-2
 - 3) Doors open for 30 sec close for 2 min, for 10 cycles, as per EN 14750-2
 - 4) Measurement of Cooling Capacity in Monsoon, as per EN 14750-2

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c) High Ambient Temperature Cooling Tests

- 1) Testing at 450C ambient temperature, as per ERTS 20.22.1(v)
- 2) Testing at 520C ambient temperature, as per ERTS 20.22.1(v)

8.3. Equipment's

Minimum following equipment's shall be required for conducting above tests

1. Data acquisition system
2. Sensible and latest heat load simulators
3. Measurement instruments for Voltage and current etc.
4. Temperature measuring instruments (air and surface (interior and exterior))
5. Humidity measuring instruments
6. Air flow measuring ducts and hood
7. Energy measurement devices

8.4. Test procedure

Brief test procedure for cooling performance tests is described below. Sub-contractor shall prepare the detailed test procedure and submit to BEML for approval before conducting the tests.

8.4.1. Pre-cooling


Pre-cooling test is performed to determine the time taken by HVACs to bring car interior temperature to set-temperature. Test shall be conducted for both summer and monsoon conditions

a) Test conditions

1. Before conducting pre-cooling tests, the test car shall be soaked in the specified ambient temperature and RH of the climate chamber with HVACs switched off.
2. Before the start of the pre-cooling test, the interior air and surface temperatures shall be stabilised within ± 1 K of the exterior air temperature.
3. Feed the set temperature in HVAC system
4. Doors closed
5. Air filters clean
6. Solar load 100%, passenger load AW0 and fresh air dampers shall fully close.

b) Test procedure

1. Start HVACs.
2. Record the interior conditions at every interval of time
3. Record the time required to bring car interior temperature to set-temperature

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c) Acceptance criteria

1. Mean interior temp. (Tim) $\leq 25 \pm 2$ °C
2. RH $\leq 60\%$
3. HVACs should not trip

8.4.2. Regulation test

Regulation test is performed to check stability of temperature achieved in the comfort zone. Test shall be conducted for both summer and monsoon conditions

a) Test conditions

1. Feed the set temperature to HVAC
2. Doors closed
3. Air filters clean
4. Solar load 100% & passenger load AW4

b) Test procedure

1. Keep the HVACs running for 1h or 3 cycles
2. Record the temperatures, humidity and total energy consumption

c) Acceptance criteria

1. Temperature at 1.1m within 8°C range
2. Temperature at any vertical to be within 8°C range
3. Tim $\leq 25 \pm 2$ °C and RH $\leq 60\%$
4. Temp. ≤ 70 °C inside all electrical cubicles
5. HVACs should not trip

8.4.3. Doors open close test

Door open-close test is performed to check stability of temperature achieved in the comfort zone with AW4 passenger load. Test shall be conducted for both summer and monsoon conditions

a) Test conditions

1. Feed the set temperature to HVAC
2. Air filters clean
3. Doors open/close

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4. Solar load 100% & passenger load AW4

b) Test procedure

1. Keep the HVACs running
2. Door open 30 sec – close 2 min on one side of the vehicle, 10 operational cycles
3. Record interior temperatures, humidity

c) Acceptance criteria

1. $T_{im} \leq 25 \pm 2 \text{ }^{\circ}\text{C}$ and $RH \leq 60\%$ at the end of each cycle
2. HVACs should not trip

8.4.4. Cooling Capacity

Cooling capacity test is performed to check cooling capacity of HVAC unit. Test shall be conducted for both summer and monsoon conditions

a) Test conditions

1. All HVAC run at full cooling capacity during the full test period
2. Air filters clean
3. Fresh air damper closed
4. Return air damper open
5. Doors closed
6. Variable heat load
7. Outside air velocity 0-15 kmph

b) Test procedure

1. Keep the interior condition $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, $60\% \pm 5\% RH$ by adjusting the number of heaters and steam generators.
2. Monitor supply and return air temp and RH.
3. After stabilization of parameters, HVACs shall keep running for 2 hours and 9 readings of all relevant temperature, humidity and power consumption values shall be taken at 15 minute intervals
4. Measure return air flow 3 times: one just before the test (after temperature

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stabilization is achieved), one during the test and one just after the test is completed.

c) Acceptance criteria

1. HVACs should not trip
2. Cooling capacity $\geq 74\text{kW}$

8.4.5. Regulation at 45°C ambient,

This test is performed to check the operation of HVAC units at high temperature

a) Test conditions

1. Car shall be soaked in ambient temperature of 45°C for 2 hours, with doors open, before starting the 45°C tests
2. Feed the set temperature to HVAC
3. Doors closed
4. Air filters clean
5. Solar load 100% & passenger load AW4
6. Outside air velocity 0-15 kmph
7. Outside temperature 45°C(-2~+0°C)

b) Test procedure

1. Keep the HVACs running for 1 h
2. Record the temperature, humidity and total energy consumption

c) Acceptance criteria

HVAC unit should not trip.

8.4.6. Regulation at 52°C ambient

This test is conducted to check the operation of HVAC units at extreme temperature

a) Test conditions

1. Car shall be soaked in ambient temperature of 52°C for 2 hours, with doors open,

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before starting the 52 °C tests.

2. Feed the set temperature to HVAC
3. Doors closed
4. Air filters clean
5. Solar load 100% & passenger load AW3
6. Outside air velocity 0-15 kmph
7. Outside temperature 52 °C (-2~+0 °C)

b) Test procedure

1. Keep the HVACs running for 1 h
2. Record the temperature, humidity and total energy consumption

c) Acceptance criteria

HVAC unit should not trip

9. Specific Energy Consumption test

a) Test details

SEC test shall be conducted under following conditions:

- i. Specific Energy Consumption of HVAC system shall be determined by conducting test on one M-car in climatic chamber
- ii. Round Trip time and run time between stations shall be corresponding to scheduled speed from Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport (RTT R6 or RTTORR or RTTALM) shall be considered as per Annexure-C
- iii. Round Trip Time corresponding to Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport (RTT R6 or RTTORR or RTTALM) shall be considered
 - i. Dwell time for each intermediate station shall be 30 seconds including doors opening and closing. At terminal station, door opening and closing shall be considered twice, one on arrival and second before leaving the terminal. Total Turnaround time at Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport stations shall be 4 minutes (i.e., 2 minutes at each terminal station).
 - ii. Inside car temperature to be maintained at 25°C. The car inside temperature

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before opening of the saloon doors at each station shall be within 25° C.

- iii. Ambient summer conditions shall be maintained outside the car. Ambient temperature, humidity and air speed of outside car shall be monitored as per EN 14750-2. Energy Consumption test shall be conducted at an air speed of 0-15 kmph.
- iv. Loading Condition: Heat load of AW4 numbers of persons (340 passengers), throughout the round trip including the terminal turnaround time. Fresh air corresponding to AW4 numbers of persons shall be applicable.
- v. Door opening and closing as per schedule to and fro run on the route
- vi. The energy measured on one car (M Car) in the climatic chamber will be multiplied by six (6) to determine the energy consumption by HVACs of a 6-car train in climatic chamber (SEC_{H-CC}). BEML will provide Cable losses between Auxiliary Converter-Inverter and HVAC, Efficiency curve of Auxiliary Converter-Inverter, Cable loss between Auxiliary Converter-Inverter and main transformer and Efficiency curves of Main Transformer during run, turnaround and during dwell time. Energy loss on account of these items shall then be added to the measured value above (SEC_{H-CC}) to determine the value of SEC_H .

The objective of this test is to check if the HVAC system meets the requirements of declared Specific Energy Consumption (SEC) for the HVAC system for to-and-fro run on scheduled speed from Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport AW4 passenger load. Brief test procedure for Specific Energy Consumption tests is described below. Sub-contractor shall prepare the detailed test procedure and submit to BEML for approval before conducting the tests.

b) Test conditions

1. Climate chamber temperature to be 35.2 °C and humidity corresponding to WB 19.6 °C
2. Feed the set temperature to HVAC
3. Air filters clean
4. All lights “on” and equipment load maximum
5. Solar load 100% and passenger load AW4
6. Outside car air velocity 0-15 km/h
7. One side doors to be opened and closed as per route running timings (for to-and-fro run on scheduled speed from Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport)

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c) Test procedure

1. M car to be soaked in summer ambient condition.
2. All doors to be close and vestibule opening to be temporarily blocked and sealed.
3. Feed the set temperature to HVAC.
4. HVACs to be started. Data recording to be started.
5. Pre-cooling to be done without any solar, passenger or equipment heat loads. After reaching stabilised conditions, let the HVACs keep running for 1 hour with doors closed.

Note: “Stabilised condition” means that the average interior temperature at 1.1 m (Tim) remains almost constant within the tolerance limit of $\pm 2^{\circ}\text{C}$ with respect to the interior temperature setting while the HVACs function under the nominal performance.

6. Add heats of solar load, AW4 passenger load and equipment load. Also switch “on” all the lights. Doors will remain closed.
7. Let the air conditioning system be operated until conditions interior temperatures stabilise (as explained in Note at SN 5 above). Then the HVACs should be kept running under stabilised condition for another 1 hour.
8. After 1 hour of stabilised operation, the testing for SEC will start. Starting time of the test will be marked and recorded.
9. The doors open/close operations to be sequenced as per the run time schedule specified for round trip of the earmarked section.
10. 4 minutes of turn back operation at last station will be simulated
11. Time of completion of doors open/close cycles for simulated round trip of Kalena Agrahara - Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport (recorded).

d) Data recording

1. Energy consumption (kWh) by energy meter (at 15 seconds sampling rate)
2. Data recording by data logger

e) Acceptance criteria

1. $T_{im} \leq 25 \pm 2^{\circ}\text{C}$ and $RH \leq 60\%$ under stabilised conditions and before every door opening in the doors open/close cycles for the simulated round-trip run
2. Temperatures at 1.1m from floor to be within 8°C range during the entire test.

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3. Temperatures at all three vertical planes to be within 8 °C range during the entire test.
4. HVACs should not trip during the entire test.

10. Scope of work

10.1. General

1. One M-car will be subjected to the climatic chamber tests. BEML will transport one M-car car from BEML unit to the test facility. BEML team along with HVAC supplier reps will participate in the tests. All tests will be witnessed by customer technical team.
2. Sub contractor shall co-ordinate with transporter to shift the car from the port to the test facility, assist in arranging the required facilities for loading and unloading the car at port and assist in any issues during local transportation of car
3. Unload the car at their test facility
4. All the facilities required for in-house (within sub contractor premises) movement of car, all material / consumables required for tests, electrical power supply, sensors and measuring instruments, data loggers, heating elements, humidifiers and any material / facility required for testing shall be in sub contractor's scope
5. Manpower required for all activities listed in scope of work shall be in sub contractor's scope.
6. Sub contractor shall be responsible for conducting all the tests specified in clause no. 7, 8 and 9 of this document.
7. Cooling performance tests (pre-cooling, regulation, cooling capacity tests and specific heat measurement tests) under summer conditions specified at clause no 8 and 9 shall be checked and verified by BEML before calling the customer for witnessing the tests.
8. All tests specified at clause no 7, 8 and 9 shall be conducted in presence of customer (tests done at clause no 10.1.7 above shall be repeated)

10.2. Testing

10.2.1. Test procedure

Brief test procedure for each test is described above. The Subcontractor shall prepare the

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detailed test procedure for all the tests and submit to BEML for approval. Test procedure shall be mutually discussed and agreed upon. Test procedure shall include following as minimum

- Details of test facility to be used
- Test schedule
- All the data required from car builder and HVAC supplier
- Standards to be followed
- Test equipments and sensors specifications
- Sensor calibration certificates
- Calibration procedures
- Test methodology
- Sensor mounting arrangement at all specified locations
- Heat load simulation details
- Humidity simulation details
- Energy consumption calculations

10.2.2. Air flow measurement

Air flow measurement test include but not limited to following activities

1. Preparation of test plan
2. Preparation of car for the test - closing the gangway openings to make it airtight, electrical power connection to HVAC and control system, preparation of test setup
3. Perform all the air flow measurement tests specified in clause no 7 of this document.
4. If the measured values are not meeting the contract requirement, BEML / HVAC supplier will take up the required modification on HVAC unit and air distributing ducts to adjust the air flow parameters. Subcontractor shall repeat the air flow measurement test after modification

10.2.3. Cooling performance test

Cooling performance test include but not limited to following activities

1. Preparation of test plan
2. Preparation of car for the test - closing the gangway openings to make it

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airtight, electrical power connection to HVAC and control system, preparation of test setup, installation of sensors, installation of data logging system, preparation of heat loads & humidifiers and all other aspect related to testing

3. Perform all the cooling performance tests specified in clause no 8 of this document. All tests shall be as per EN 14750.
4. If the measured values are not meeting the contract requirement, BEML / HVAC supplier will take up the required modification on HVAC unit and air distributing ducts to adjust the cooling parameters. Sub contractor shall repeat the Cooling performance test after modification

10.2.4. Specific Energy Consumption test

Specific Energy Consumption test shall include but not limited to following activities

1. Preparation of car for the test - preparation of test plan to simulate round trip run, preparation of test setup, installation of sensors& energy measurement instruments, installation of data logging system, preparation of heat loads & humidifiers and all other aspect related to testing
2. Pre cooling the car till stabilized conditions achieved inside saloon
3. Perform the Specific Energy Consumption test specified in clause no 9 of this document. All tests shall be as per EN 14750. The doors open/close operations and climatic chamber air speed to be sequenced as per the run time schedule specified for round trip

10.2.5. Test report

1. All test reports shall be prepared by the subcontractor and submitted to BEML/BMRCL. Reports shall be in English language. The Test reports shall include, but not be limited to, the followings:
 - i. The reference to the corresponding Test Procedure
 - ii. The date of the test was executed
 - iii. Description of any test conditions, input data, or tester actions
 - iv. Details of test instruments used (Make, Model) along with calibration certificate.
 - v. The test results for each test including a Passed / Failed indication
2. Test reports of all tests performed shall be submitted within 2 weeks of test performance to BEML/BMRCL for acceptance.

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3. BEML will review the test report and offer comments. Sub-contractor shall modify the test report as per BEML comments as required.

11. List of test and duration

The tentative test list and duration of tests to be conducted in the climatic chamber is listed below. Same may subjected to change based on the requirements of BEML and GC/BMRCL.

SN	Test description	Internal / Official	Duration / Days
1	Airflow measurements	Internal	2 days
2	Cooling tests in Summer Conditions	Internal	1 days
3	Cooling tests in Monsoon Conditions	Internal	1 days
4	High Ambient Temperature Cooling Tests at 45°C ambient temperature	Internal	0.5 days
5	High Ambient Temperature Cooling Tests at 52°C ambient temperature	Internal	0.5 days
6	Specific Energy consumption test	Internal	2 days
7	Measurements of thermal conductivity (K factor)	Internal	1 days
8	Airflow measurements	External	2 days
9	Cooling tests in Summer Conditions	External	1 days
10	Cooling tests in Monsoon Conditions	External	1 days
11	High Ambient Temperature Cooling Tests at 45°C ambient temperature	External	0.5 days
12	High Ambient Temperature Cooling Tests at 52°C ambient temperature	External	0.5 days
13	Specific Energy consumption test	External	2 days
14	Measurements of thermal conductivity (K factor)	External	1 days

** Test duration /days are may change during the design and test protocol finalization stage.

12. Annexure

1. Annexure - A: General Arrangement Drawing of M-Car
2. Annexure - B: Declared schedule speed

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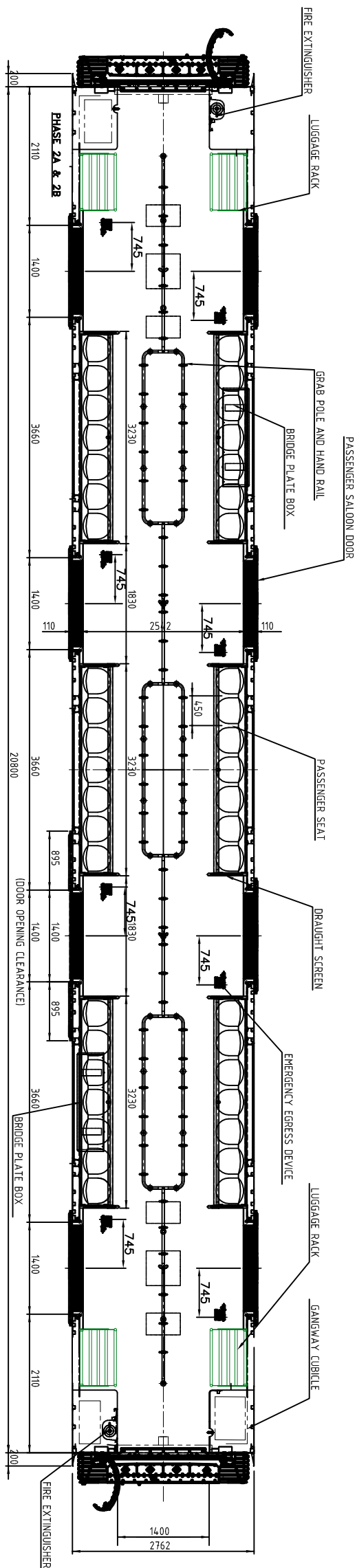
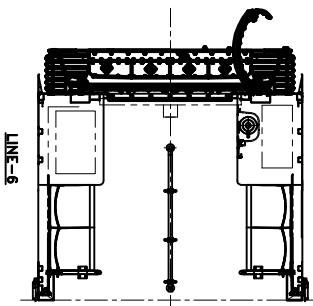
3. Annexure - C: Submittals Check Sheet

13. Submittals with Technical Offer

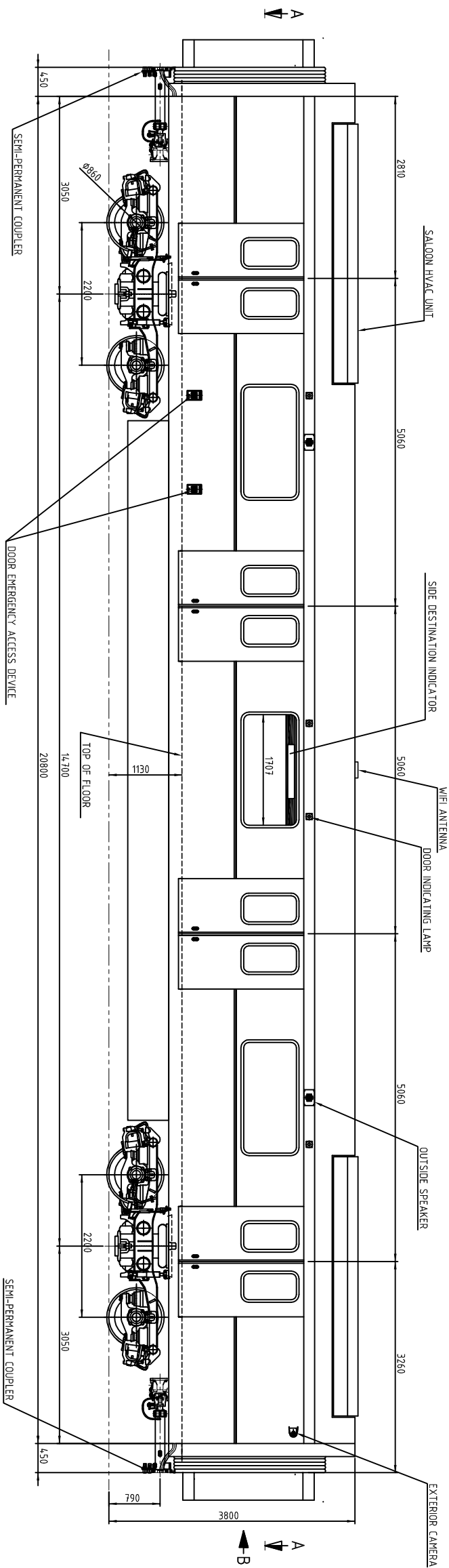
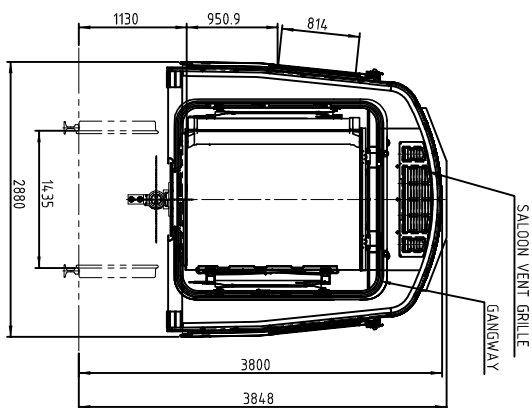
The subcontractor shall provide as a minimum, the following along with their proposal.

1. Following details about test facility
 - i) Details of the climatic chamber including size of climatic chamber and preparation hall.
 - ii) Available test facilities.
 - iii) Details of instruments like data acquisition system, temperature sensors, humidity sensors.
 - iv) Heat load simulation devices
2. Supporting documents for Qualification Criteria compliance. (Clause 3)
3. Clause-wise comments against the PTS Doc.
4. Brief test procedure.
5. Details of earliest available test slots and tentative test schedule.

Annexure -A




VIEW A-A



MODE		NON-UTO (GOA2)		UTO (GOA4)	
PHASE/LINE		PHASE 2A & 2B	LINE-6	PHASE 2A & 2B	LINE-6
PASSENGER CAPACITY	SEATED	42	50	42	50
	STANDEES (8 PASSENGER/m ²)	295	290	295	290
	TOTAL	337	340	337	340
MAXIMUM DESIGN SPEED		90 KM/H			
MAXIMUM OPERATIONAL SPEED		80 KM/H			
NOMINAL VOLTAGE		750 V DC			

Annexure - B

Line	Running Section	Distance (km)	Time (min)			Average speed (km/h)
			Run	Dwell	Total	
Phase-2A Line	Central Silk Board Junction → K.R Puram	16.72	18.82	5.50	24.32	41.25
	K.R Puram → Central Silk Board Junction	16.72	18.75	5.50	24.25	41.37
	Round Trip	33.44	37.57	12.00	49.57	40.47
Phase-2B Line	K R Puram → KIA Terminals	37.56	38.70	8.00	46.70	48.26
	KIA Terminals → K R Puram	37.56	38.69	8.00	46.69	48.27
	Round Trip	75.12	77.39	16.00	94.39	47.75
Reach-6	Kalena Agrahara → Nagawara	20.21	23.14	7.50	30.64	39.57
	Nagawara → Kalena Agrahara	20.21	23.45	7.50	30.95	39.17
	Round Trip	40.41	46.59	15.00	62.59	38.74

	TECHNICAL OFFER SUBMITTALS CHECK SHEET	Project BMRCL 5RSDM	
Aggregate :	SALOON HVAC SYSTEM	PTS DOC No.: GR/TD/7965	
BEML Enquiry/ RFQ Reference :			
SL.NO.	DETAILS	SUBMITTED	NOT SUBMITTED
1	Details of the climatic chamber including size of climatic chamber and preparation hall, available test facilities, details of instruments and test setup to be used	<input type="checkbox"/>	<input type="checkbox"/>
2	Supporting documents for Pre-Qualification Criteria compliance	<input type="checkbox"/>	<input type="checkbox"/>
3	Clause-wise comments against the ERTS, ERGS & this PTS Doc	<input type="checkbox"/>	<input type="checkbox"/>
4	Brief test procedure	<input type="checkbox"/>	<input type="checkbox"/>
5	Details of earliest available test slots and tentative test schedule.	<input type="checkbox"/>	<input type="checkbox"/>

Note : Incomplete submissions are liable for Rejection.

Signature of the Bidder with Seal