Tehran Urban & Suburban Railway Operation Company

Metro Cars Propulsion Design & Production Project

MCM Type Test procedure

JDEVS-MPDP-MC-PD-210-00

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October 2021

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INTERCERT ISO 9001:2015 Certificate Nr. 17-Q-1002669-TIC

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1. Introduction

This document describes the test procedure for the motor converter module (MCM) in the Propulsion System.

2. Applicable standards

The following standards are applied to this system.

Table 1- Applicable standards

Doc. & Drwg. #	Title or description	Remarks
IEC 61287-1	Power converters installed on board rolling stock	Railway applications
EN 50207	Electronic power converters for rolling stock	Railway applications
IEC 60850	Supply voltages of traction systems	Railway applications
IEC 61377-1	Determination of sound levels	Power transformers
IEC 62236-3-2	Electromagnetic compatibility	Railway applications

3- Test equipment required

The combined test is performed using the following equipment.

Table 2- Required Test Equipment (plan)

Instrument	**Manufacturer**	**Model / Serial No.**	**calibration expiration date**
Weight Measurement	PAND industries	203261	
Wind Intensity Measurement	PROVA	10180508	2023/08/14
Power and Quality Analiser	CHAUVIN ARNOUX	C.A 8336	2023/05/12
Infrared Thermometer	CHAUVIN ARNOUX	C.A1862	2023/04/25
Current Clamp	CHAUVIN ARNOUX	F203	
Digital Multimeter	VICTOR	VC97	2023/04/21
Sound Level Meter	BENETECH	GM1356	2023/04/05
Handheld Digital Oscilloscope	GPS LTD	GPS-810i	2023/04/25
Current Sensor	LEM	LA 305-S/SP19	

4- Routine test sequence

Routine test sequence is indicated in the following table.

Table 3- list of tests

NO	Type test	Subclause
1	Visual inspection	4.5.3.1
2	Marking inspection	4.5.3.4
3	Leakage test	4.5.3.5.4
4	Dielectric test	4.5.3.7
5	Insulation resistance test	4.5.3.8
6	Tests of mechanical and electrical protection and measuring equipment	4.5.3.9
7	Light load test	4.5.3.10

4-1- MCM routine test procedure

This section describes the steps and how to perform the routine tests of the MCM.

4-1-1- Visual inspection

The object of the visual inspection is to prove that the converter is free from physical defects and that surface treatments have been duly carried out.

This test includes checking these components:

1. All internal and interface electrical and mechanical components.
2. All internal and interface electrical and mechanical connections.
3. Electrical and mechanical connectors have been assembled correctly.
4. Connections between components follow the specified routes.

4-1-2- Marking inspection

The converter shall be provided with a nameplate which shall be readable during the useful life of the converter and on which at least the following is inscribed:

1. Manufacturer's mark
2. Title
3. Serial number
4. Mass
5. Specified input and output value

4-1-3- Leakage test

Where closed-circuit fluid cooling is employed, a leakage test shall be performed to prove that no leakage occurs in the complete cooling system.

4-1-3-1- How and steps to perform the test

By rotating the anemometer around the outside of the MCM box, no air leakage should be observed other than the outlet wind from the outlet valve of the MCM box.

4-1-4- Dielectric test

Dielectric tests are carried out to verify the correct state of a completely assembled converter.
They are not carried out to verify the insulation of elementary components or clearances and creepage distances.

4-1-4-1- How and steps to perform the test

This test is performed by equipping a digital resistive voltage test.

Steps to perform the test:

1. AC and DC terminals of the converter shall be connected to each other.
2. No circuit part of the converter shall be left floating during the test.
3. Motors or fans shall be grounded during the dielectric test.
4. Detach the control board and gate drive units for extra caution.
5. Gate-emitter of all IGBTs shall be connected to each other.
6. If any component or subassembly is not submitted to the dielectric test of the converter, its terminals shall be grounded.
7. Y-capacitors in EMC filters shall be disconnected.
8. According to IEC 62497-1:2010, First, a DC voltage of 1.9 kV is applied between the terminals and the body. After that, an AC voltage with a 1.9 kV peak is applied between the terminals and the body.
9. In order to prevent pre-damages of increasingly used solid insulation, the test voltage should be applied for only 10 s.
10. If the chosen test method is power frequency and if the test has to be repeated, the test voltage shall be reduced to 80 % of the initial test voltage.
11. The test is declared successful if no dielectric fault occurs.

4-1-5- Insulation resistance test

One minute after the dielectric test, the insulation resistance shall be measured by applying a DC voltage.

4-1-5-1- How and steps to perform the test

Steps to perform the test:

1. AC and DC terminals of the converter shall be connected to each other.
2. No circuit part of the converter shall be left floating during the test.
3. Motors or fans shall be grounded during the dielectric test.
4. Detach the control board and gate drive units for extra caution.
5. Gate emitter of all IGBTs shall be connected to each other.
6. If any component or subassembly is not submitted to the dielectric test of the converter, its terminals shall be grounded.
7. Y-capacitors in EMC filters shall be disconnected.
8. According to IEC 62497-1:2010, a DC voltage with 0.9 kV amplitude is applied between the terminals and the body.
9. The insulation resistance shall be not less than 1 MΩ for rated insulation voltages not exceeding 1 kV.

4-1-6- Tests of mechanical and electrical protection and measuring equipment

4-1-6-1- steps to perform the Tests of mechanical and electrical protection and measuring equipment

1. Connect the MCM to the 750 v DC line.
2. Examine function of the current and voltage sensor of the MCM.
3. Examine protections of the MCM for example up limit and low limit in voltage, current and temperature.

4-1-7- Light load test

This test is to verify that the power circuits of the converter function properly. During the test the complete converter is supplied according to the nominal input voltage and is operated with an output current with different sizes. All signal and power outputs of the converter shall be checked. This test is a short-time test at less than rated output power and is not intended for temperature rise.

4-1-7-1- How and steps to perform the test

1. Connect the MCM to the 750 v DC line.
2. Apply a 45 KW load and register value of the input voltage, input current, input power, output voltage, output current and output power.
3. Apply a 90 KW load and register value of the input voltage, input current, input power, output voltage, output current and output power.
4. Apply a 230 KW load and register value of the input voltage, input current, input power, output voltage, output current and output power.

5-Type test sequence

The test sequence is indicated in the following table.

Table 4- list of tests

NO	Type test	Subclause
1	Verification of dimensions and tolerances	4.5.3.2
2	Weighing	4.5.3.3
3	Cooling system performance tests	4.5.3.5
4	Commutation test	4.5.3.11
5	Acoustic noise measurement	4.5.3.12
6	Temperature-rise test	4.5.3.13
7	Power loss determination	4.5.3.14
8	Supply overvoltage and transient energy test	4.5.3.15
9	Sudden variations of load	4.5.3.16
10	Short-time supply interruption test	4.5.3.21
11	Tests of mechanical and electrical protection and measuring equipment	4.5.3.9
12	Step change of line voltage test	4.5.3.20
13	Safety requirements inspection	4.5.3.17

5-1- Type test procedure

This section describes the steps and how to perform the type tests of the MCM.

5-1-1- Verification of dimensions and tolerances

Dimensions and their tolerances shall be checked.

5-1-1-1- steps to perform the test

Check all the dimensions of the MCM box provided in Document JDEVS-MPDP-AC-PD-209-00 in Section 5-1 with the metering tool. Measured value should be written on the prepared diagram of the MCM box with a blue pen.

5-1-2- Weighing

Weight is specified in the contract, so the converter shall be weighed.

5-1-2-1- steps to perform the test

1. All MCM connections must be opened.
2. Attach the scales to the overhead crane.
3. Attach the converter to the scale with the help of the load belt and read its weight.
4. Read weight of the MCM.

5-1-3- Cooling system performance tests

This test may be performed either on a complete converter or on a partially finished converter which is representative of a finished converter. The object of this test is to measure the flow of the cooling medium passing through the various components concerned and to verify whether it complies with the specified flow.

5-1-3-1- steps to perform the test

1. The average air velocity passing through the heat sinks should be measure at 9 points.
2. Calculate the level of air passage through heatsink.
3. Calculate the flow rate of air passing through heatsink.
4. Estimate the space around heatsink for air passage.
5. Calculation of the average speed of air passing around the target equipment.

5-1-4- Commutation test

This test is carried out to verify that the converter will commutate the specified maximum instantaneous current.

5-1-4-1- steps to perform the test

1. Connect the converter to the 900 V DC.
2. Connect the three-phase AC load to the AC output of the converter.
3. After starting the converter, increase the AC output load in steps and bring it to the value above 400 kW.
4. Measure and record the values of the output current.

5-1-5- Acoustic noise measurement

During the test, the converter shall be in operation.

5-1-5-1- steps to perform the test

1. Due to the test performed in the workshop environment, the converter must be placed in the appropriate place.
2. Connect the converter to the 750 V DC line.
3. Connect the three-phase AC load to the AC output of the converter.
4. Before turning on the converter, calculate the average background noise at least 10 predetermined points at a distance of one meter from the converter ($\bar{L}_{bgA}$).
5. Turn on the converter and regulate the output AC load in nominal value.
6. The device fan should be set to slow speed and the average sound of the converter calculated at the same 10 points as before ($\bar{L}_{pA0-L}$).
7. The device fan should be set to high speed and the average sound of the converter calculated at the same 10 points as before ($\bar{L}_{pA0\_H}$).
8. The value of the converter sound is calculated by removing the background noise and should be compared with the set value ($\bar{L}_{pA}$).
9. Calculate the pressure of the devise sound (Lw).

5-1-6- Temperature-rise test

The temperature, of listed components shall be measured when the converter is subjected to the load profile or to equivalent conditions.

5-1-6-1- steps to perform the test

1. Connect the converter to the 750 V DC line.
2. AC output of the converter should be connected to the load.
3. Turn on the converter and set the output load on the nominal value (400 kw).
4. Should be created a partial list of the specified components and the temperature of these components should be measured every 10 minutes.
5. The duration of this test should be such that the temperature of the desired parts reaches a constant value and does not change.
6. Create a diagram or table of the recorded temperature and present it.

5-1-7- Power loss determination

This test is carried out to calculate the power efficiency.

5-1-7-1- steps to perform the test

1. Connect the converter to the 750 V DC line.
2. Connect the three-phase AC load to the AC output of the converter.
3. Set output load in nominal value.
4. Input voltage and current of the converter should be measured.
5. Calculate the input power of the converter.
6. Output power of the converter should be measured.
7. The efficiency of the converter calculated through input power and output power.

5-1-8- Supply overvoltage and transient energy test

It shall be confirmed that the converter is able to withstand overvoltage and transient energy surges. This test is performed in four zones. These zones show in below.

Zone A:	V-min block	500	VDC
Zone B:	V-min full performance	750	VDC
Zone C:	V-max full performance	900	VDC
Zone D:	V-high trip	1050	VDC

5-1-8-1- steps to perform the zone A test

1. Create a variable DC link voltage.
2. Change DC link voltage from 750 v to 500 v.
3. Converter shall be turn off in voltage 500 v DC link.

5-1-8-2- steps to perform the zone B test

1. Create a 750 v DC link.
2. Connect this link to input of the MCM.
3. Connect a 400 Kw load to output of the MCM.
4. Turn on the MCM and record output voltage and current of the MCM.
5. Converter shall be work without any difficulty.

5-1-8-3- steps to perform the zone C test

1. Create a 900 v DC link.
2. Connect this link to input of the MCM.
3. Connect a 400 Kw load to output of the MCM.
4. Turn on the MCM and record output voltage and current of the MCM.
5. Converter shall be work without any difficulty.

5-1-8-4- steps to perform the zone C test

1. Create a variable DC link voltage.
2. Apply a 1050 DC voltage to input of the MCM
3. Converter shall be turn off.

5-1-9- Sudden variations of load

Two kinds of test can be performed:

1. Short-circuit test
2. Load-break test

5-1-9-1- short-circuit test

A short circuit test shall be carried out for all short-circuit protected outputs.

5-1-9-1-1- steps to perform the output short-circuit test

1. Connect the MCM to the 750 v DC line.
2. Connect the three phase AC output to each other via a 60-amp fuse and put the switch on state off.
3. Turn on the converter.
4. After the output of the converter arrives to steady-state, by observing safety tips, turn the switch on the on state.
5. Record the three phase AC output voltage of the converter.

5-1-9-2- load-break test

This test is carried out to verify that the converter will not sustain any damage when the load is suddenly disconnected. The protection equipment shall be functioning.

5-1-9-2-2- steps to perform the output load break test

1. Prepare an AC load with a specified 70% of the rated output power of the converter.
2. Connect the AC load through a switch to the converter.
3. Start the converter and apply the AC load through the switch to the converter.
4. After the converter arrives at steady-state, disconnect the AC load suddenly through the switch.
5. See and record the output AC voltage and current.

5-1-10- Short-time supply interruption test

This test is provided to verify that a line voltage supply interruption of any duration does not damage the converter and the current consumption remains within the specified limits, independent of the load conditions of the converter.

5-1-10-1- steps to perform the Short-time supply interruption test

1. Connect the MCM to the 750 v DC line.
2. Turn on the converter.
3. Connect an AC load with 20 percent of the nominal value to output of the MCM.
4. Apply a one seconds interruption through an electromechanical switch on the DC link switchboard.
5. See and record the output AC voltage and current.

4-1-11- Tests of mechanical and electrical protection and measuring equipment

4-1-11-1- steps to perform the Tests of mechanical and electrical protection and measuring equipment

1. Connect the MCM to the 750 v DC line.
2. Examine function of the current, voltage and temperature sensor of the MCM.
3. Examine protections of the MCM for example up limit and low limit in voltage, current and temperature.

5-1-12- Safety requirements inspection test

The inspection is provided to check that the design of the converter meets the safety standards which are specified in the contract.

5-1-12-1- steps to perform the Safety requirements inspection test

1. Connect the MCM to the 750 v DC line.
2. Apply the pre-charge resistor of the system for 2 sec.
3. DC link capacitor voltage shall be equal to 750 v.
4. After arrive the converter to steady state, turn off the converter and see and record DC link voltage of the capacitor.
5. Voltage of the line capacitor after 5 minutes shall be lower than 50 v.

5-1-13- Step change of line voltage test

This test is provided to verify the agreed performance of the converter under sudden line voltage variations.

5-1-13-1- steps to perform the Step change of line voltage test

1. Provide a variable DC link voltage.
2. Connect the variable DC voltage to input of the MCM.
3. Change this DC voltage in form of the step from 900 v to 750 v.
4. Reverse the previous step, change the voltage from 750 v to 900 v.
5. The deviation of currents and voltages listed for checking.