






Hyundai Rotem Company

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| Ref No. | RM\1A-05-06-15\D0005\R02 |
| Doc. No. | REDD103886 |
| Rev. No. | 01 |
| DATE | Mar. 10. 2011 |
| Page | 1/12 |

Propulsion System

**Type Test Report for Mainline
Test of Propulsion System in
AW3 Load Condition**

| | | | |
|----------|---------------|-------------|---|
| Approved | Mar. 10. 2011 | J. S. HAN |  |
| Reviewed | Mar. 10. 2011 | E. S. CHUNG |  |
| Written | Mar. 10. 2011 | K. K. LEE |  |
| | Date | Name | Signature |



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| Ref No. | RM1A-05-06-15\D0005\R02 |
| Doc. No. | REDD103886 |
| Rev. No. | 01 |
| Date | Mar. 10. 2011 |
| Page | 2/12 |

REVISION HISTORY

| Rev. No. | Page | Details | | Date |
|----------|------|---|------|--------------|
| | | ~ From | ~ To | |
| 0 | All | First Issued | | Dec. 3. 2010 |
| 1 | 4 | Added the test schedule for Traction thermal capacity test and Journey time/Energy consumption test | | Mar.10.2011 |
| | 7, 8 | Amended the test result for journey time test and energy consumption test | | |
| | 11 | Added the test result for traction thermal capacity test in NIMT line | | |
| | 12 | Added the appendix 7 | | |
| | | | | |



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|---|--|----------|--------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM\1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 3/12 |

Table of Contents

| | |
|---------------------------|----|
| 1. GENERAL | 4 |
| 2. RELATIVE DATA..... | 4 |
| 3. TEST INFORMATION | 4 |
| 4. TEST RESULTS | 5 |
| 5. ATTACHEMENTS | 12 |

| | | | |
|---|--|----------|--------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM\1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 4/12 |

1. GENERAL

This document is to report the result of type test for mainline test of propulsion system in AW3 load condition. And the type test has been carried out according to 'Main Line Test Procedure for Propulsion System (RM\1A-05-06-15\D0003)'.

2. RELATIVE DATA

RM\1A-05-06-15\D0003

Main Line Test Procedure for Propulsion System

3. TEST INFORMATION

3.1. Schedule

- Traction Performance Test : 30th. Oct. 2010 ~ 8th.Nov.2010
: 11th. Jan.2011~21st. Jan.2011
(Journey time/Energy Consumption Test)
- Traction Thermal Capacity Test : 4th.Nov.2010 (Hut line)
: 18th.Jan.2011(NIMT line)

3.2. Venue

- Wellington EMU Mainline

3.3. Test Product Type

- Matangi 1st Unit, 2nd Unit

3.4. Tester


- R&D Center : Mr. K.K. Lee
- CS Team : Mr. B.I. Lee, Mr. D.H. Park, Mr. S.S. Ryu

3.5. Attendants

- Kiwirail : Mr. David. Hindson
- GWRL : Mr. Rigby Wason

3.6. Test Item

- 1) Traction Performance Test
 - Tractive Effort Test
 - Speed Characteristics Test
 - Journey Time/Energy Consumption Measurement
- 2) Electric Brake Test
- 3) Traction Thermal Capacity Test

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|---|--|----------|-------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 5/12 |

4. TEST RESULTS

4.1. Traction Performance Test

4.1.1. Tractive Effort Test

1) Powering Test

■ PASS □ FAIL

| No. | Test Item | | Criteria | Result | Chart No. |
|-----|------------------|-----------------------------|---|--------|--------------------|
| 1 | Powering Test | Min.P→20km/h→coasting→Min.B | Operated without abnormal motor current and any protection detection | Pass | NWMMF- 001, 002 |
| 2 | | Max.P→40km/h→coasting→Max.B | | Pass | NWMMF- 003, 004 |
| 3 | | Max.P→60km/h→coasting→Max.B | | Pass | NWMMF- 005, 006 |

2) Re-Powering Test


■ PASS □ FAIL

| No. | Test Item | | Criteria | Result | Chart No. |
|-----|-------------------------|---|---|--------|--------------------|
| 1 | Re- Powering Test | Min.P→10km/h→coasting→Min.P →20km/h→coasting→Max.B | Operated without abnormal motor current and any protection detection | Pass | NWMMF- 007, 008 |
| 2 | | Max.P→40km/h→coasting→Max.P →60km/h→coasting→Max.B | | Pass | NWMMF- 009, 010 |

3) Powering Test in Minimum Voltage Condition

■ PASS □ FAIL

| No. | Test Item | | Criteria | Result | Chart No. |
|-----|--|--|--|--------|--------------------|
| 1 | Max.P→60km/h→coasting→Max.B (OHV voltage App. 1,300V) | | Maximum traction performance is maintained | Pass | NWMMF- 011, 012 |

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|---|--|----------|-------------------------|
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| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 6/12 |

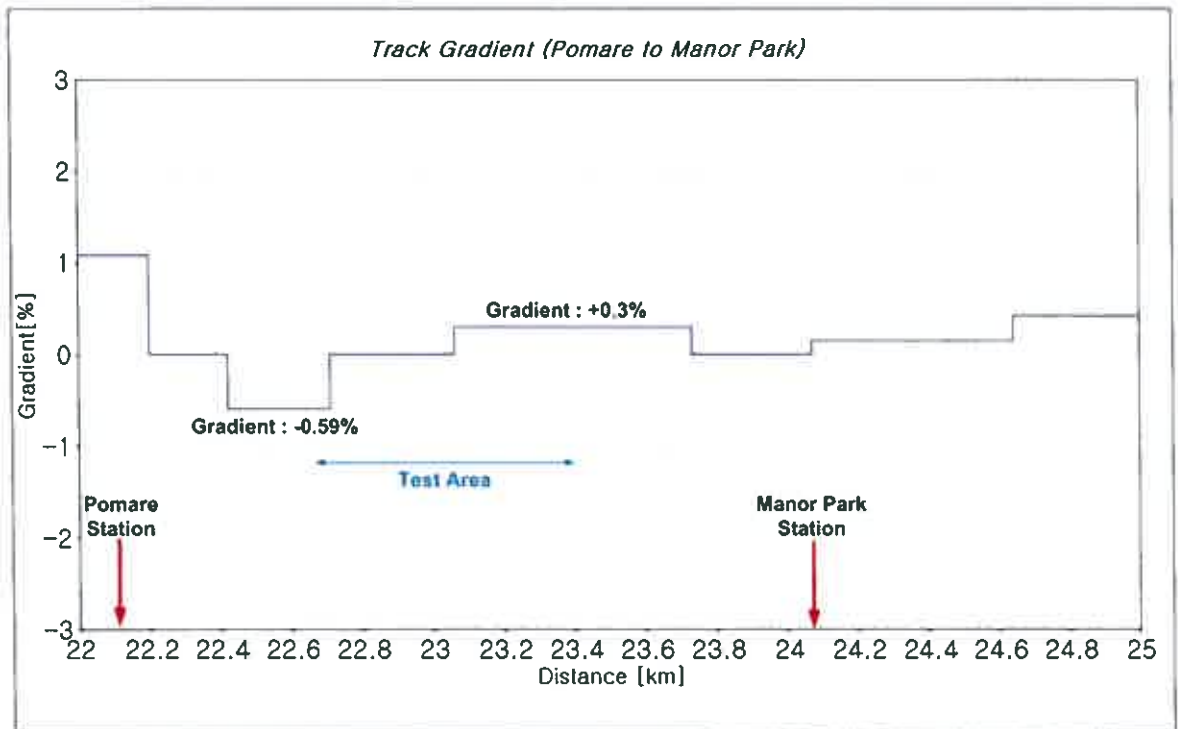
4) Acceleration/Jerk Test


■ PASS □ FAIL

| No. | Test Item | Criteria | Result | | Chart No. |
|-----|----------------------------------|------------------------------------|---|---|----------------|
| | | | MC direction | TC direction | |
| 1 | Max. Acceleration Rate | Less than 0.9m/s ² | 0.80 m/s ² | 0.85 m/s ² | NWMMF-013, 014 |
| 2 | Acceleration Rate (0 to 65km/h) | Not less than 0.69m/s ² | 0.71 m/s ² | 0.77 m/s ² | |
| 3 | Acceleration Rate (0 to 100km/h) | Not less than 0.34m/s ² | 0.38 m/s ² <small>Note)</small> | 0.46 m/s ² <small>Note)</small> | |
| 4 | Jerk Rate | Less than 0.75m/s ³ | 0.45 m/s ³ | 0.50 m/s ³ | |

Note) We have performed the acceleration test between 'Pomare station' and Manor park station'. This route has up gradient condition and down gradient condition according to direction of vehicle. In case of Mc direction, the acceleration rate in 0km/h to 100km/h decreases due to 0.3% up gradient track and in case of Tc direction, the acceleration rate in 0km/h to 100km/h increases due to 0.54% down gradient track.

The test area is shown in following figure.



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|---|--|----------|-------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 7/12 |

5) Slip/Slide Test

PASS FAIL

| No. | Test Item | Criteria | Result | Chart No. |
|-----|---|--|--------|----------------|
| 1 | Spray the water on track Max.P→60km/h→coasting→Max.B | Torque pattern can be controlled according to rail condition | Pass | NWMMF-015, 016 |

4.1.2. Speed Characteristics Test

1) Maximum Speed Test

PASS FAIL

| No. | Test Item | Criteria | Result | Chart No. |
|-----|---|--|--------|-----------|
| 1 | Max.P→121km/h→coasting→Max.B (Without over speed protection) | Inverter should operate correctly at the maximum speed | Pass | NWMMF-017 |
| 2 | Max.P→115km/h→coasting→Max.B (With over speed protection) | Confirm the over speed protection | Pass | NWMMF-018 |


4.1.3. Journey Time/Energy Consumption Measurement

1) Journey Time Measurement in Dry Track Condition

PASS FAIL

| No. | Route | Criteria | Result | Chart No. |
|-----|--|-----------------|---------------------------|-----------|
| 1 | Wellington station to Paraparaumu station | Within 00:54:08 | 00:53:50 | NWMMF-019 |
| 2 | Paraparaumu station Wellington station | Within 00:54:08 | 00:51:58 | NWMMF-020 |
| 3 | Wellington station to Upper Hutt station | Within 00:44:54 | 00:42:31 | NWMMF-021 |
| 4 | Upper Hutt station to Wellington station | Within 00:44:27 | 00:43:37 | NWMMF-022 |
| 5 | Wellington station to Johnsonville station | Within 00:21:02 | 00:24:23 ^{note)} | NWMMF-023 |
| 6 | Johnsonville station to Wellington station | Within 00:21:07 | 00:25:27 ^{note)} | NWMMF-024 |

Note) The test result for Johnsonville line does not meet the criteria due to restriction speed different between the simulation condition and current condition of restricted speed. So RM compares the measured result with simulation result in appendix 7.

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|---|--|----------|-------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 8/12 |

2) Journey Time Measurement in Wet Track Condition

PASS FAIL

| No. | Route | Criteria | Result | Chart No. |
|-----|--|-----------------|----------------------------------|------------------|
| 1 | Wellington station to Paraparaumu station | Within 00:54:08 | 00:53:47 | NWMMF-025 |
| 2 | Paraparaumu station Wellington station | Within 00:54:08 | 00:52:22 | NWMMF-026 |
| 3 | Wellington station to Upper Hutt station | Within 00:44:54 | 00:44:43 | NWMMF-027 |
| 4 | Upper Hutt station to Wellington station | Within 00:44:27 | 00:44:24 | NWMMF-028 |
| 5 | Wellington station to Johnsonville station | Within 00:21:02 | 00:24:20^(note) | NWMMF-029 |
| 6 | Johnsonville station to Wellington station | Within 00:21:07 | 00:24:34^(note) | NWMMF-030 |

Note) The test result for Johnsonville line does not meet the criteria due to restriction speed different between the simulation condition and current condition of restricted speed. So RM compares the measured result with simulation result in appendix 7.

3) Energy Consumption Measurement in Dry Track Condition


PASS FAIL

| No. | Route | Criteria | Result | Chart No. |
|-----|---|------------------|------------------|------------------|
| 1 | Wellington station to Paraparaumu station | Less than 237kWh | 211.4 kWh | NWMMF-019 |
| 2 | Paraparaumu station Wellington station | Less than 195kWh | 193.9 kWh | NWMMF-020 |
| 3 | Wellington station to Upper Hutt station | Less than 174kWh | 170.3 kWh | NWMMF-021 |
| 4 | Upper Hutt station to Wellington station | Less than 135kWh | 134.3 kWh | NWMMF-022 |

4) Energy Consumption Measurement in Wet Track Condition

PASS FAIL

| No. | Route | Criteria | Result | Chart No. |
|-----|---|------------------|------------------|------------------|
| 1 | Wellington station to Paraparaumu station | Less than 237kWh | 212.0 kWh | NWMMF-025 |
| 2 | Paraparaumu station Wellington station | Less than 195kWh | 193.4 kWh | NWMMF-026 |
| 3 | Wellington station to Upper Hutt station | Less than 174kWh | 160.0 kWh | NWMMF-027 |
| 4 | Upper Hutt station to Wellington station | Less than 135kWh | 134.8 kWh | NWMMF-028 |

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|---|--|----------|--------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM\1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 9/12 |

4.2. Electric Brake Test

PASS FAIL

| No. | Test Item | Result | Chart No. |
|-----|---|--------|----------------------------|
| 1 | The unit will maximise the use of regenerative braking and then rheostatic braking before using friction braking | Pass | NWMMT- 031, 032 |
| 2 | Electric braking will be provided as part of the normal service brake. The electric braking will comprise regenerative and rheostatic braking. | Pass | |
| 3 | On dry track the electric braking on the motor car must be maximised. | Pass | |
| 4 | For electric braking, regenerative braking will be maximised, subject to overhead receptivity. | Pass | |
| 5 | Rheostatic braking will be continuously rated for all braking duty cycle and can be used for the discharge of power from the traction circuit. | Pass | |
| 6 | The current of traction motor does not exceed the design value. | Pass | |
| 7 | There is no abnormal self-excitation of the traction motor. | Pass | |
| 8 | In the case of regenerative braking and in the event of loss of the power supply, external short circuit of the power supply, pantograph bounce, lack of receptivity of the power supply, line gap or neutral sections, transition takes place to friction brake. | Pass | |
| 9 | The electric braking builds up and releases steadily without significant jerk. | Pass | |

| | |
|----------|-------------------------|
| Ref No. | RM1A-05-06-15\D0005\R02 |
| Doc. No. | REDD103886 |
| Rev. No. | 01 |
| Date | Mar. 10. 2011 |
| Page | 10/12 |

4.3. Traction Thermal Capacity Test

4.3.1. Traction Thermal Capacity Test Result for Hutt Line

■ PASS □ FAIL

| No. | Measuring Position | Criteria for Rising Temperature | Measuring Value | | Result | Remark. |
|-----|---|---------------------------------|-----------------|------|--------|---------------|
| | | | Start | End | | |
| 1 | Environment temperature | - | 16.2 | 21.0 | - | Appendix 4 |
| 2 | Frame Temperature of traction motor | Less than 200℃ | 15.7 | 66.0 | Pass | |
| 3 | Bearing cap D.E. temperature of Traction motor | Less than 115℃ | 15.5 | 57.3 | Pass | |
| 4 | Between Speed sensor housing and Frame O.D.E. temperature of Traction motor | Less than 115℃ | 15.7 | 40.9 | Pass | |
| 5 | Outlet air temperature of Traction motor | - | 15.7 | 50.1 | - | |
| 6 | Inlet air temperature of Traction motor | - | 15.7 | 27.5 | - | |
| 7 | Coil temperature of Filter reactor | Less than 155℃ | 15.9 | 31.4 | Pass | |
| 8 | IGBT stack temperature of VVVF Inverter | Less than 100℃ | 15.4 | 35.6 | Pass | |
| 9 | Capacitor temperature of VVVF Inverter | Less than 70℃ | 16.3 | 20.9 | Pass | |
| 10 | Axle box temperature | Less than 80℃ | - | - | Pass | |



MC Car

TC Car

| | | | | | | | | | | |
|-------------|------|------|--|------|------|------|------|--|------|------|
| | 1 | 2 | | 3 | 4 | 5 | 6 | | 7 | 8 |
| Start Temp. | 15.7 | 15.6 | | 15.5 | 15.6 | 15.5 | 15.6 | | 15.5 | 15.6 |
| End Temp. | 39.6 | 36.8 | | 39.0 | 40.4 | 34.9 | 35.4 | | 33.4 | 36.4 |

| | | | | | | | | | | |
|-------------|------|------|--|------|------|------|------|--|------|------|
| | 1 | 2 | | 3 | 4 | 5 | 6 | | 7 | 8 |
| Start Temp. | 15.2 | 15.4 | | 15.6 | 15.5 | 15.5 | 15.5 | | 15.6 | 15.6 |
| End Temp. | 35.8 | 34.8 | | 39.4 | 36.9 | 36.9 | 34.0 | | 36.9 | 33.9 |

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|---|--|----------|-------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 11/12 |

4.3.2. Traction Thermal Capacity Test Result for NIMT Line

■ PASS □ FAIL

| No. | Measuring Position | Criteria for Rising Temperature | Measuring Value | | Result | Remark. |
|-----|---|---------------------------------|-----------------|------|--------|------------|
| | | | Start | End | | |
| 1 | Environment temperature | - | 21.5 | 28.4 | - | Appendix 4 |
| 2 | Frame Temperature of traction motor | Less than 200℃ | 22.7 | 78.5 | Pass | |
| 3 | Bearing cap D.E. temperature of Traction motor | Less than 115℃ | 22.6 | 57.7 | Pass | |
| 4 | Between Speed sensor housing and Frame O.D.E. temperature of Traction motor | Less than 115℃ | 22.5 | 46.5 | Pass | |
| 5 | Outlet air temperature of Traction motor | - | 22.1 | 49.2 | - | |
| 6 | Inlet air temperature of Traction motor | - | 22.6 | 36.0 | - | |
| 7 | Coil temperature of Filter reactor | Less than 155℃ | 21.7 | 41.2 | Pass | |
| 8 | IGBT stack temperature of VVVF Inverter | Less than 100℃ | 20.8 | 40.3 | Pass | |
| 9 | Capacitor temperature of VVVF Inverter | Less than 70℃ | 21.7 | 26.7 | Pass | |
| 10 | Axle box temperature | Less than 80℃ | | | Pass | |

MC Car


TC Car



| | | | | | | | | | | | | | |
|-------------|------|------|---|--|------|------|------|------|---|--|------|------|---|
| | 1 | 2 | ℃ | | 3 | 4 | 5 | 6 | ℃ | | 7 | 8 | ℃ |
| Start Temp. | 20.9 | 21.0 | ℃ | | 20.8 | 21.0 | 20.4 | 20.2 | ℃ | | 20.3 | 20.3 | ℃ |
| End Temp. | 36.3 | 38.5 | ℃ | | 38.1 | 39.2 | 40.1 | 39.0 | ℃ | | 39.5 | 36.7 | ℃ |



| | | | | | | | | | | | | | |
|-------------|------|------|---|--|------|------|------|------|---|--|------|------|---|
| | 1 | 2 | ℃ | | 3 | 4 | 5 | 6 | ℃ | | 7 | 8 | ℃ |
| Start Temp. | 20.9 | 20.7 | ℃ | | 20.7 | 20.7 | 20.4 | 20.3 | ℃ | | 20.4 | 20.5 | ℃ |
| End Temp. | 34.8 | 39.1 | ℃ | | 36.4 | 38.9 | 38.5 | 40.5 | ℃ | | 39.2 | 40.5 | ℃ |

| | | | |
|---|--|----------|--------------------------|
|  | Type Test Report for Mainline Test of Propulsion System in AW3 Load Condition | Ref No. | RM\1A-05-06-15\D0005\R02 |
| | | Doc. No. | REDD103886 |
| | | Rev. No. | 01 |
| | | Date | Mar. 10. 2011 |
| | | Page | 12/12 |

5. ATTACHEMENTS

- 1) Appendix 1 : Main Line Test Procedure for Propulsion System
- 2) Appendix 2 : Train Performance Curve for Matangi after Mainline Test
- 3) Appendix 3 : Test Chart for Propulsion System in mainline and AW3 load condition
- 4) Appendix 4 : Test Chart for Thermal Capacity Test
- 5) Appendix 5 : Journey Time/Energy Consumption Test Result
- 6) Appendix 6 : Test Chart for Journey Time and Energy Consumption Test
- 7) Appendix 7 : Review the Journey Time Test Result for Johnsonville Line with Current Restricted Speed