

Validation 1 results of Indian Vehicles on LPVC Version 1.4 and Issues pertaining to WLTC Version 5

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**13th DHC Informal Group Meeting
64th GRPE Session, June 2012**

Geneva

Validation 1 Test on Low Powered Vehicles and Issues pertaining to WLTC Version 5

Contents:

- ☐ **Validation 1 results of Indian Vehicles on LPVC Version 1.4**
- ☐ **Issues pertaining to WLTC Version 5 based on India Validation 1b results**

Validation 1 results of Indian Vehicles on LPVC Version 1.4

Contents:

- Introduction
- Vehicle Models Tested
- Test Matrix
- Test Results
- Observations and Recommendations on LPVC

Introduction

- Test Cycle - Low Power Vehicle Cycle (LPVC) version 1.4
- Steven 3 Gear shift methodology for Gear Shift Calculation
- Total 8 low powered vehicles $\text{PMR} < 34 \text{ kW/t}$ tested

	Power Range kW	PMR Range kW/t (on Kerb weight)
Diesel	6.5 to 46.3	10.1 to 27.7
CNG	15.5	14.09

- All vehicles are Manual Transmission
- Speed Tolerance +/- 2 km/h

Vehicle Models Tested

Sr. N o.	Make	Model	Vehicle Category	Fuel Type	Kerb Weight kg	Test Mass kg *	Engine CC	Max. Power kW	PMR kW/t	Max. vehicle speed in km/h	Phases Followed based on vehicle classification
1	Mahindra	Gio	M1	Diesel	670	842	441.5	6.8	10.1	55	L+L+L
2	Piaggio	Ape Mini	N1	Diesel	597	838	441	6.5	10.88	59	L+L+L
3	Tata Motors	Magic Iris	M1	Diesel	685	833	611	8	11.67	55	L+L+L
4	Tata Motors	Magic CNG	N1	CNG	1100	1275	701	15.5	14.09	77	L+M+L
5	Piaggio	Ape Truck Plus	N1	Diesel	800	1218	871	12.5	15.63	74	L+M+L
6	Mahindra	Maxximo	N1	Diesel	950	1313	909	18	18.95	70	L+M+L
7	Mahindra	Bolero Camper SC	N1	Diesel	1725	2149	2523	46.3	26.84	100	L+M+H
8	Mahindra	Bolero SLX	M1	Diesel	1670	1854	2523	46.3	27.7	100	L+M+H

*Note:

Test mass = Kerb mass + 100 + Optional mass.

Optional mass = 15% of the (GVW - Kerb mass – 100) for Passenger vehicles and,
35% of the (GVW - Kerb mass – 100) for Commercial vehicles

Test Matrix

Sr. No.	Make	Model	Fuel Type	No of Tests Steven 3 Gear Shift		Total Tests per vehicle
				Cold	Hot	
1	Mahindra	Gio	Diesel	2	-	2
2		Maxximo	Diesel	2	-	2
3		Bolero SLX	Diesel	2	-	2
4		Bolero Camper	Diesel	2	-	2
5	Tata Motors	Iris	Diesel	2	-	2
6		Ace Magic	CNG	3	-	3
7	Piaggio Vehicles	Ape Truk Plus	Diesel	1	2	3
8		Ape Mini	Diesel	1	2	3
Total Tests				15	4	19

Test Results

- Actual cycle traced by the test vehicle as per LPVC Version 1.4
- Inset shows the details of the Test Vehicle including the Power, Kerb Mass, PMR in kW/t. (Power/Kerb Mass), Engine cc, Test Mass
- Tested as per GTR test mass

Test mass = Kerb mass + 100 + Optional mass.

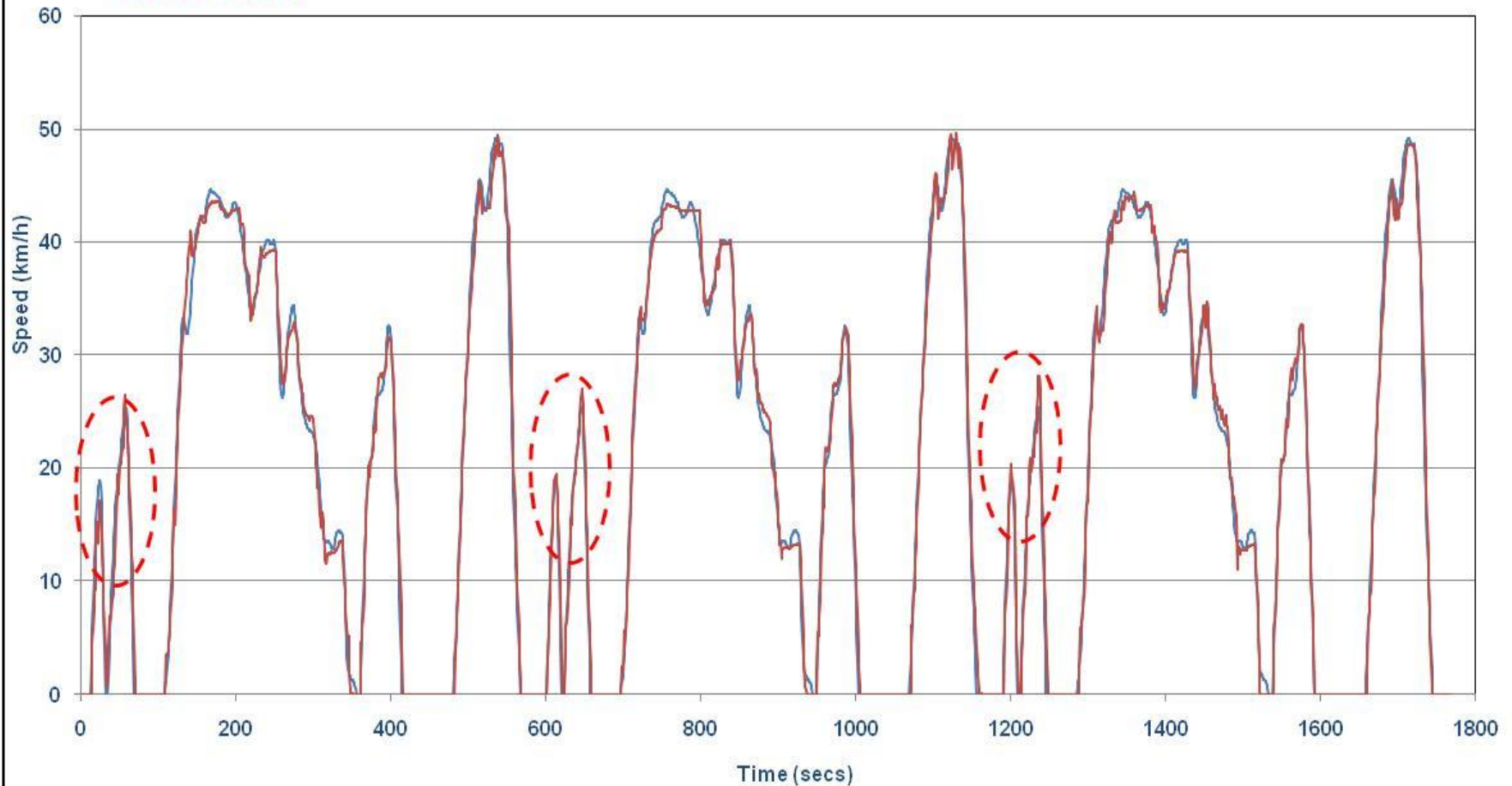
Optional mass = 15% of the (GVW - Kerb mass – 100) for PC and,
35% of the (GVW - Kerb mass – 100) for LDCV

Test Results

Mahindra GIO_LPVC v1.4 Class 1_L+L+L Phase_Steven Gear Shift_Test 1

Max. Power= 6.8 kW@3600 rpm
PMR=10.15 kW/t (Unladen)
Engine CC =441.5 cc
Unladen Wt.= 670 kg
Ref. mass (GTR)= 842 kg
Inertia Class= 840 kg

— Target Speed
— Vehicle Speed

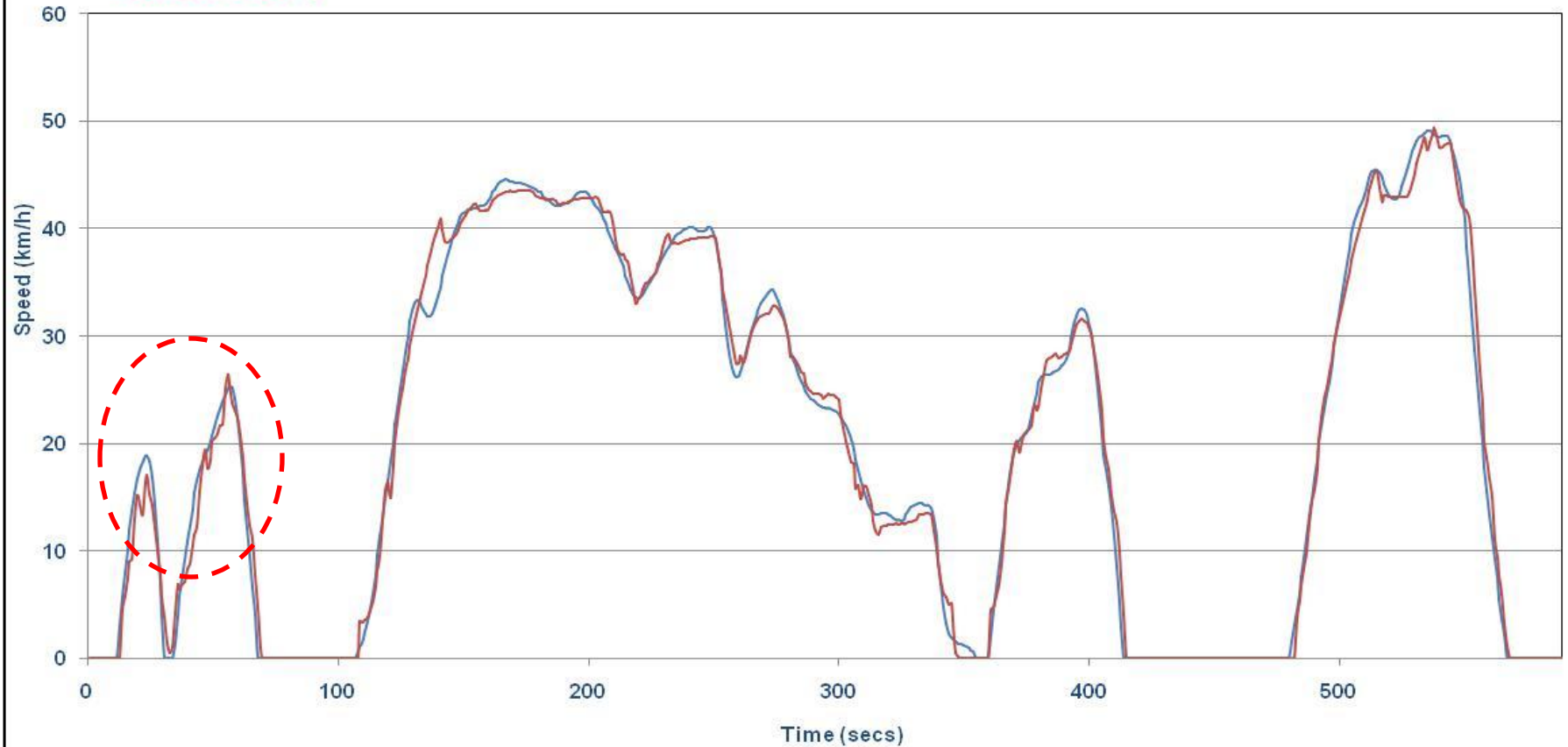


Test Results

Mahindra GIO_LPVC v1.4 Class 1_Low Phase_Sтивен 3 Gear Shift_Test 1

Max. Power= 6.8 kW@3600 rpm
PMR= 10.15 kW/t (Unladen)
Engine CC =441.5 cc
Unladen Wt.= 670 kg
Ref. mass (GTR)= 842 kg
Inertia Class= 840 kg

— Target Speed
— Vehicle Speed



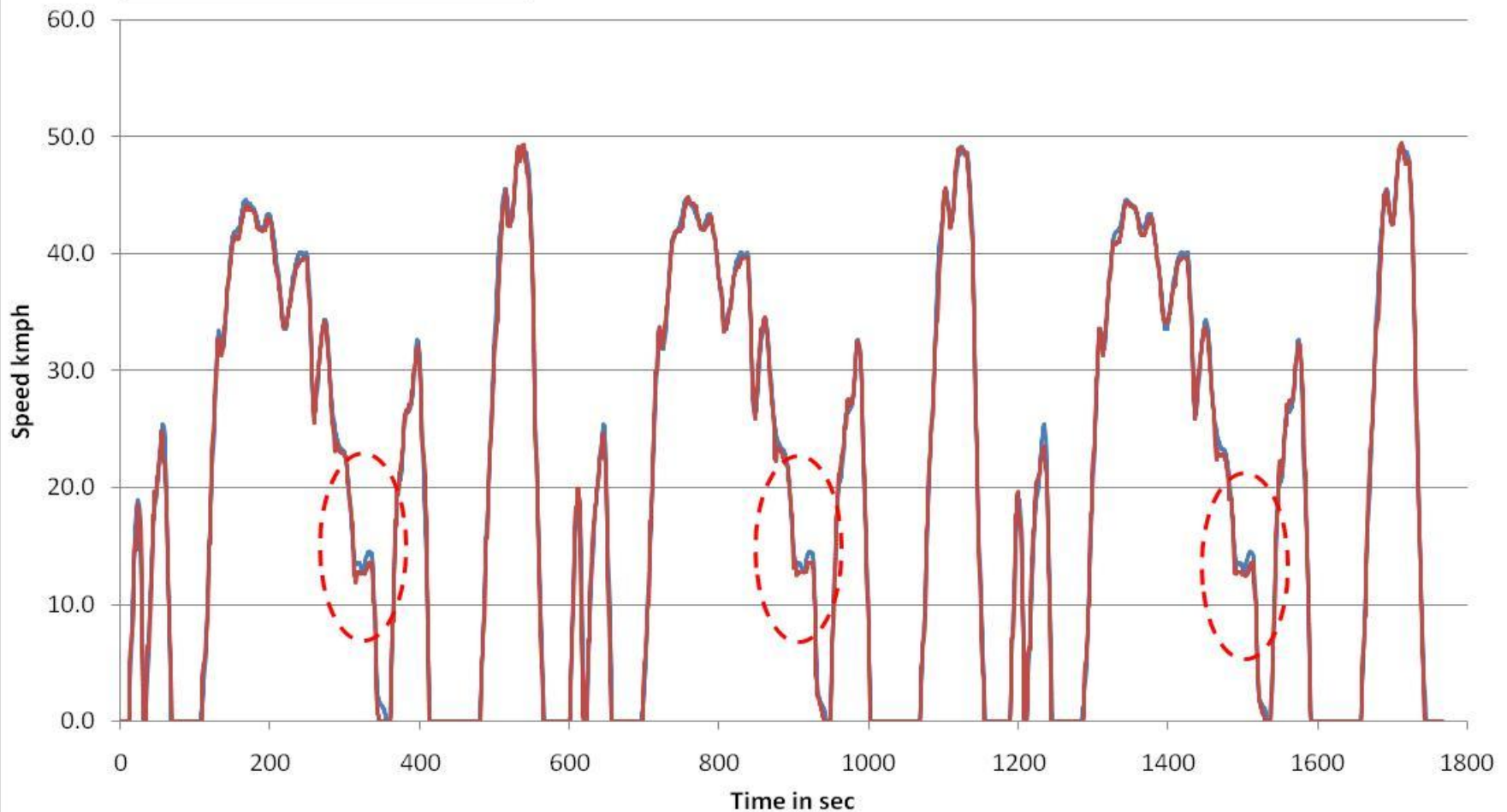
Test Results

Piaggio Ape Mini Truk_LPVC v1.4 Class 1_(L + L + L)_ Steven 3 Gear Shift_Test 1

Max Power = 6.5kW @3600 rpm
PMR = 10.88 (Unladen)
Engine cc= 441cc
Ref. Mass (GTR) = 838kg
Inertia Class= 840kg

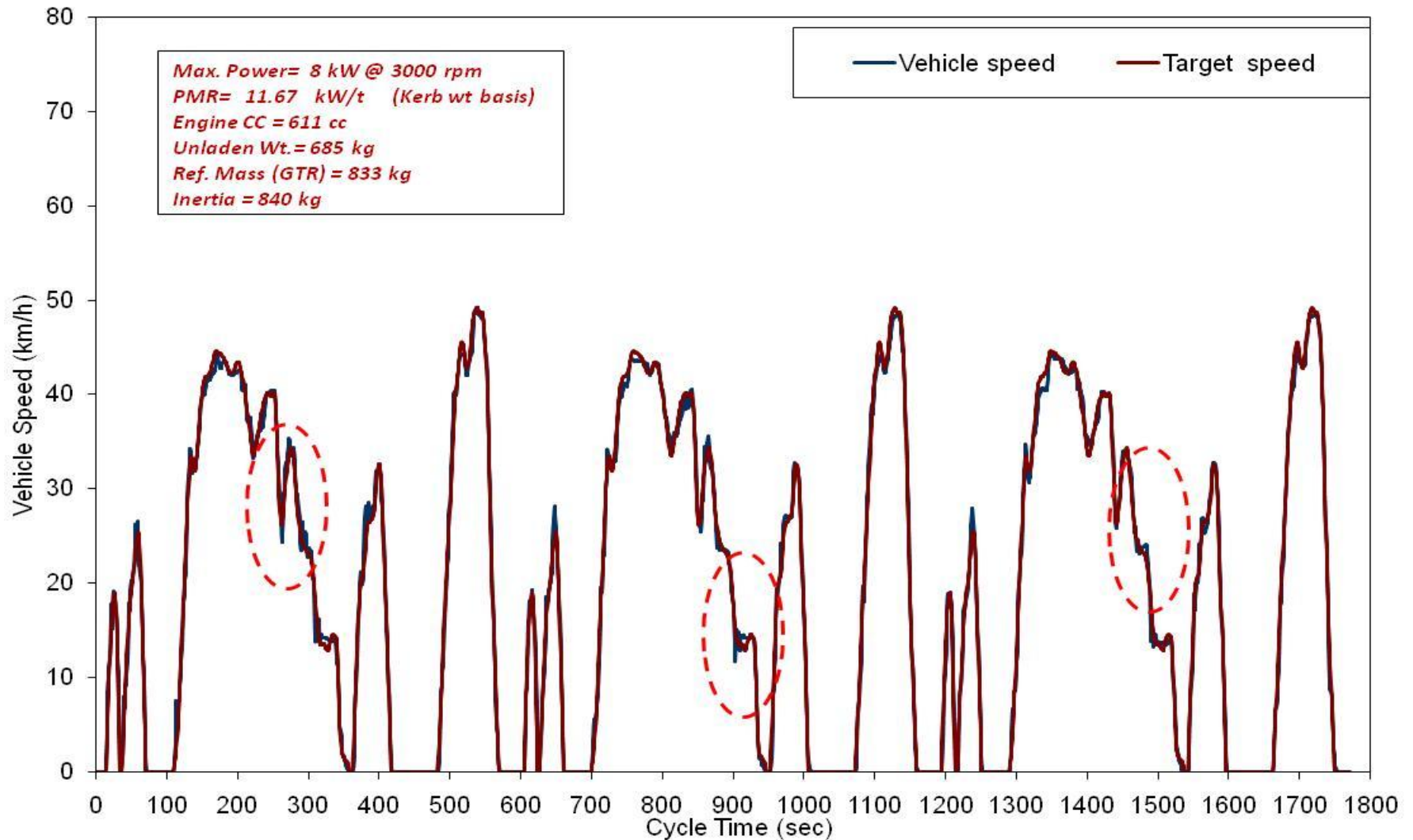
Cold Start

— Target Speed
— Vehicle Speed



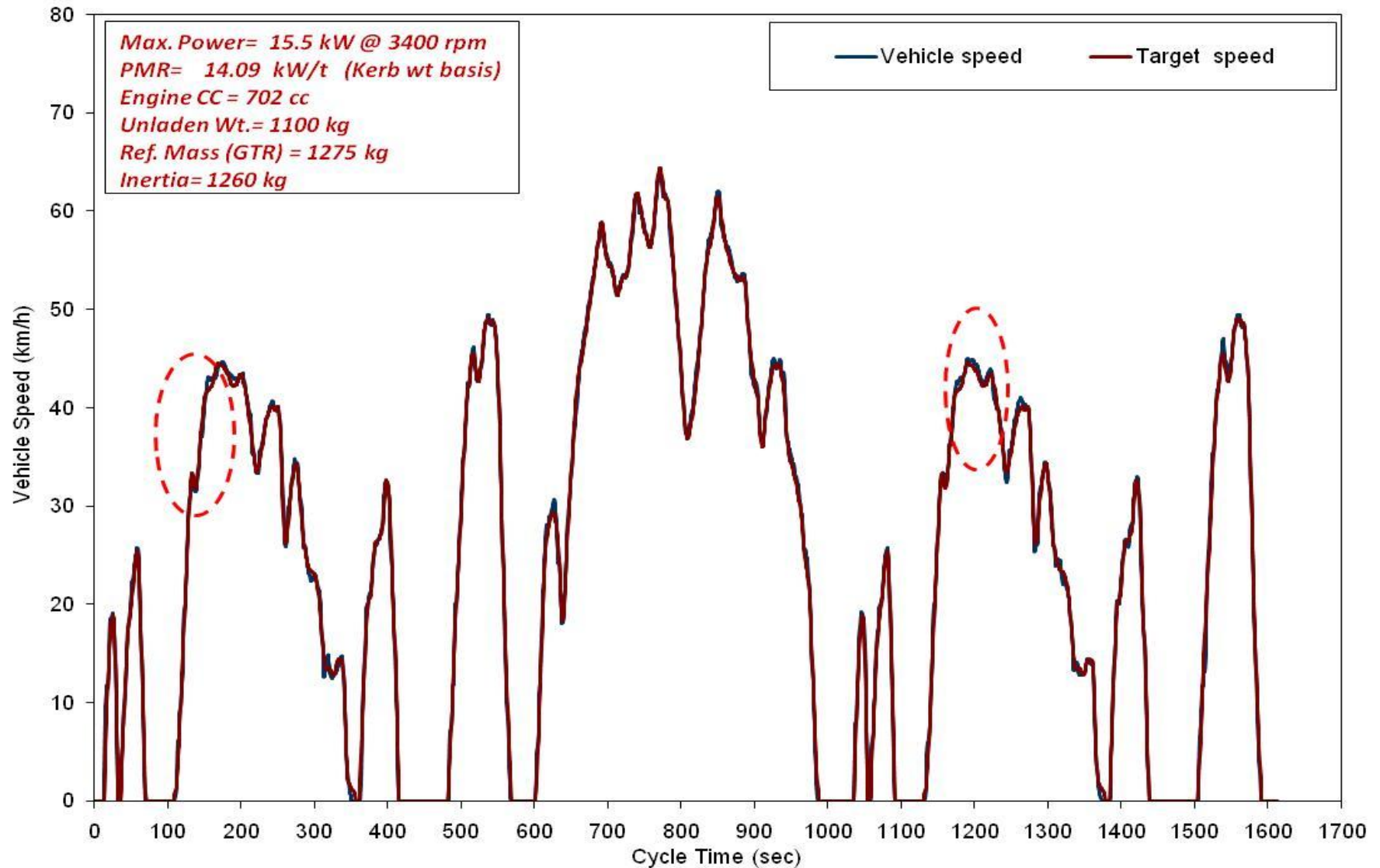
Test Results

Tata Magic Iris Diesel_LPVC v1.4 Class 1_L+L+L_Steven 3 Gear Shift



Test Results

Tata Magic CNG_LPVC v1.4 Class 1_L+M+L_Steven 3 Gear Shift



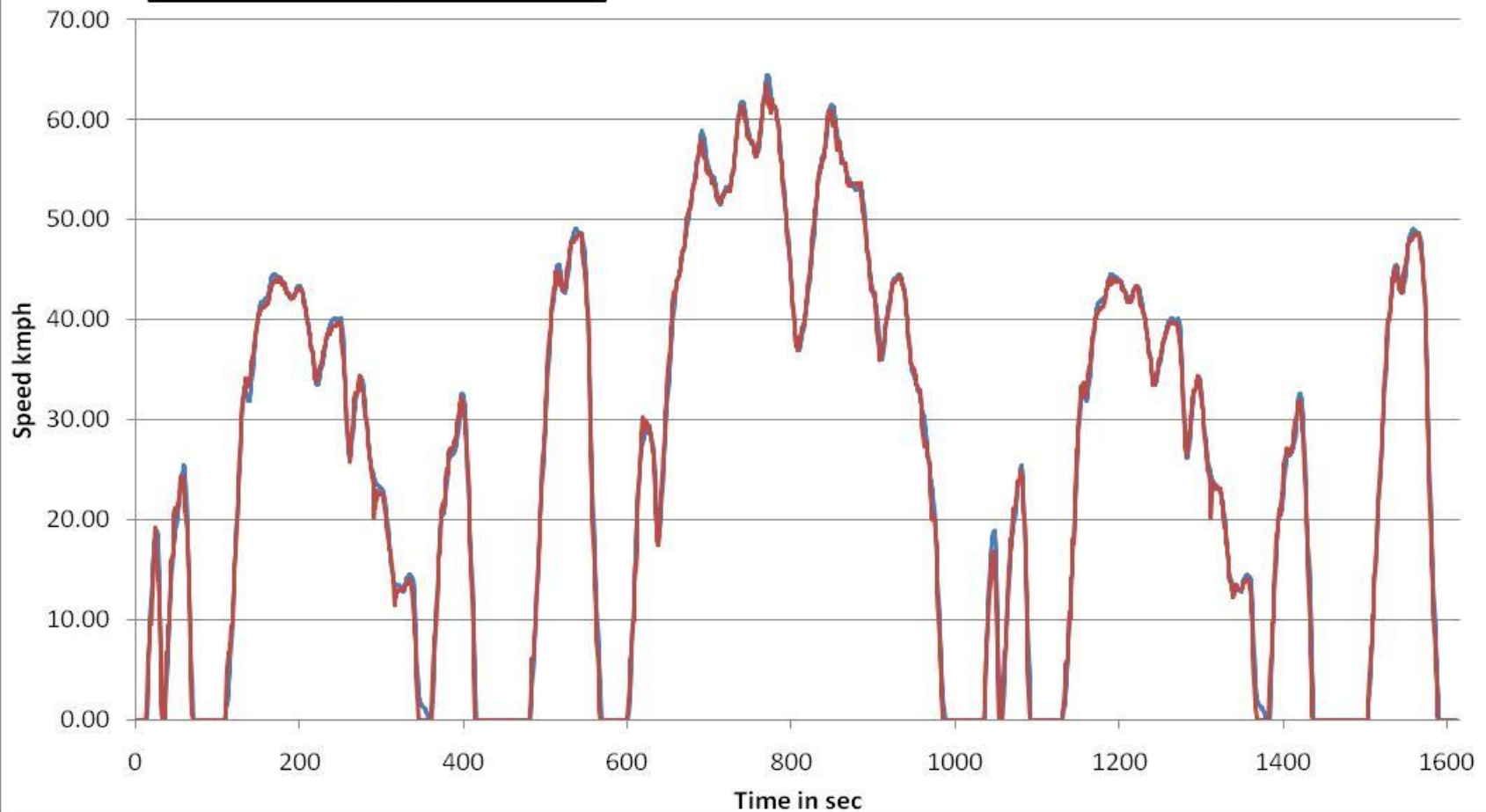
Test Results

Piaggio Ape Truk Plus_LPVC v1.4 Class 1_(L + M + L)_ Steven 3 Gear Shift_Test 3

Hot Start

Max Power = 12.5kW @3000 rpm
PMR = 15.62 (Unladen)
Engine cc= 871cc
Ref. Mass (GTR) = 1218kg
Inertia Class= 1200kg

— Target Speed
— Vehicle Speed



Test Results

Mahindra Maxximo _LPVC ver.1.4 Class 1_L+M+L Phase_Steven Gear Shift_Test 1

Max. Power= 18 kW@4000 rpm

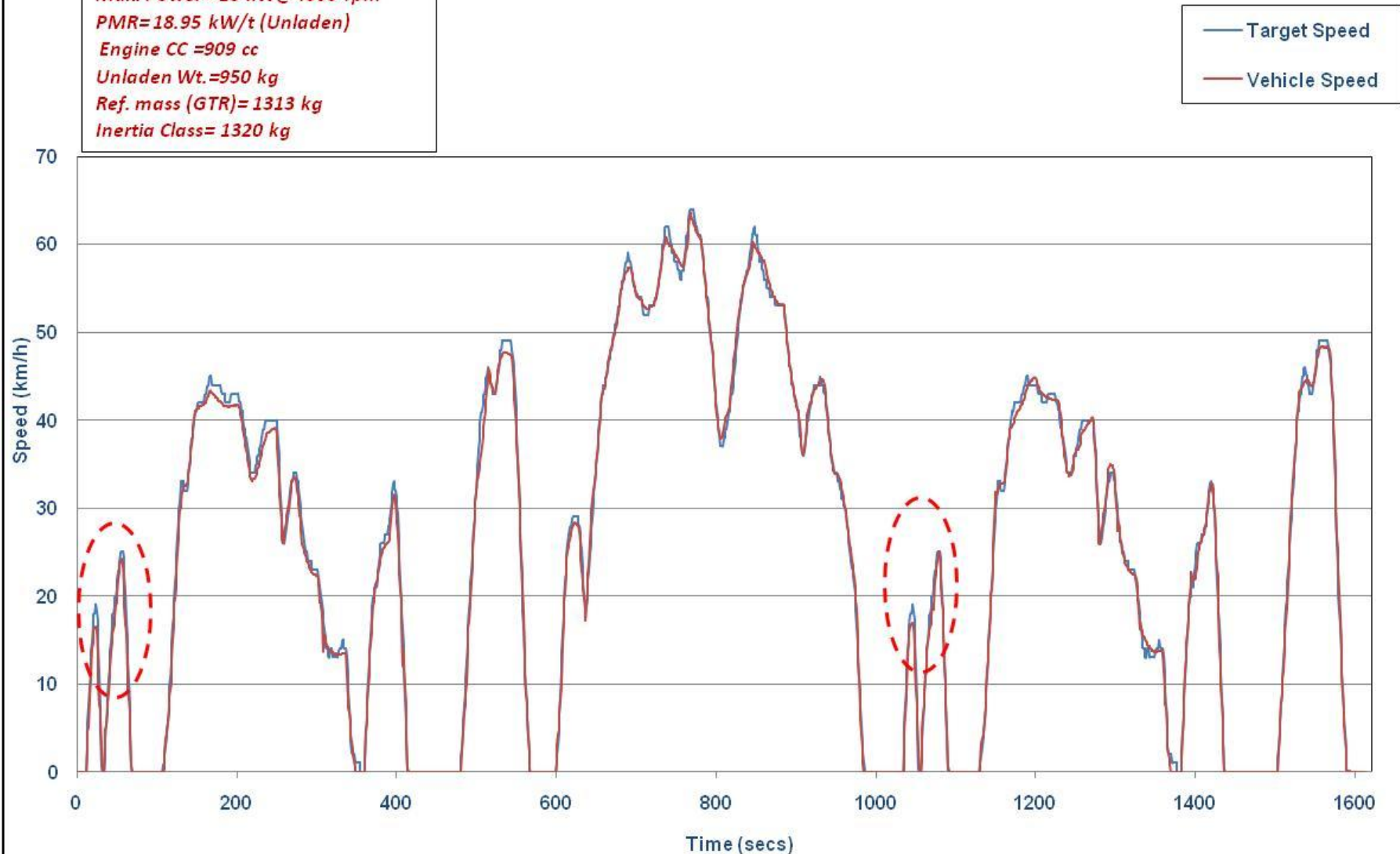
PMR=18.95 kW/t (Unladen)

Engine CC =909 cc

Unladen Wt.=950 kg

Ref. mass (GTR)= 1313 kg

Inertia Class= 1320 kg



Test Results

Mahindra Bolero SLX_LPVC ver.1.4 Class 2_L+M+H Phase_Steven 3 Gear Shift_Test 2

Max. Power= 46.3 kW@ 3200rpm

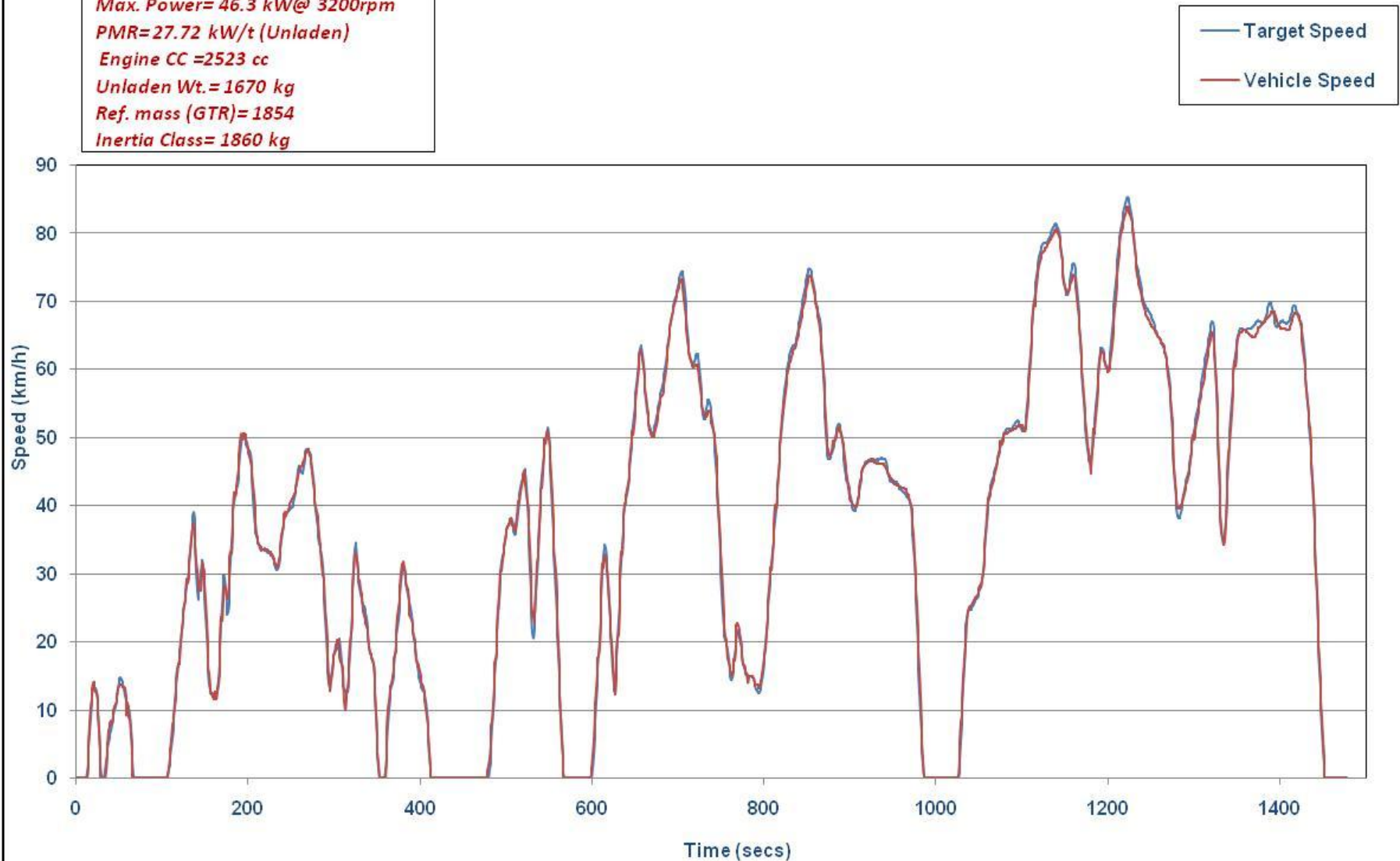
PMR=27.72 kW/t (Unladen)

Engine CC =2523 cc

Unladen Wt.= 1670 kg

Ref. mass (GTR)= 1854

Inertia Class= 1860 kg

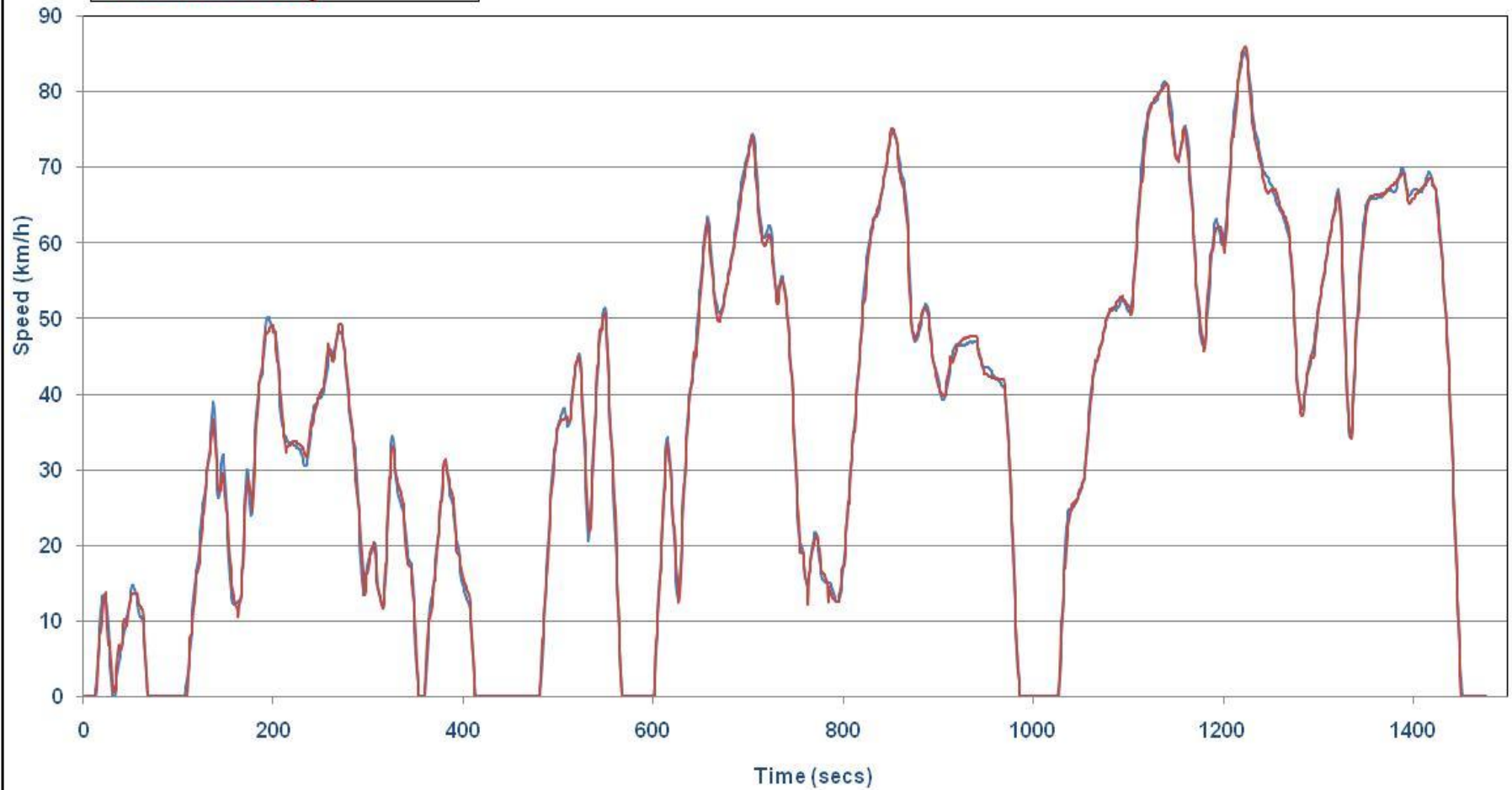


Test Results

Mahindra Bolero Camper_LPVC ver 1.4 Class 2_L+M+H Phase_Steven 3 Gear Shift_Test 1

Max. Power= 46.3 kW@ 3200rpm
PMR=26.84 kW/t (Unladen)
Engine CC =2523 cc
Unladen Wt.= 1725 kg
Ref. mass (GTR)= 2149
Inertia Class= 2160 kg

— Target Speed
— Vehicle Speed



Observations and Recommendations

Gear Shift

- The low powered vehicles have a very deep first gear which is necessary to achieve the required gradeability. There is a big difference between the 1st to 2nd gear. This is reflected in N/V ratio also.
- The Low powered vehicles show a deviation at the beginning of the cycle ~ 10-20 sec, where there is a shift at ~ 12 km/h and just thereafter. This phenomenon is observed on three test vehicles & it repeats at every 1st to 2nd gear transition.
- We suggest to lower the gear shift point to ~ 10 km/h. Alternatively, the vehicles may be started in second gear without using the first gear.
- In current regulation, fixed gear shift points are specified. A steady speed step of ~ 2 seconds is provided to account for the time required for gear change. However, with the Steven gear shift procedure, the gear shift points would be different depending on vehicle characteristics. Provision of steady speed step of ~ 2 s is necessary in WLTC driving cycle. Some thought needs to be given to address this issue.

Observations and Recommendations

Cycle smoothening

- In case of many vehicles, the cycle deviation & the tendency for the same is observed at the beginning of the cycle between 10 – 20 sec which involves a gear change at ~ 12 km/h speed.
- This deviation is on account of transient nature of the cycle & gear change from 1st to 2nd. We recommend to smoothen this part of the cycle.
- Vehicles up to PMR 22 kW/t have single / two cylinder engines – engine response to speed change is sluggish.
- Too many fluctuations in the driving cycles lead to violations. Hence, smoothening to extent possible is desirable.

Issues Post Validation 1b pertaining to WLTC Version 5

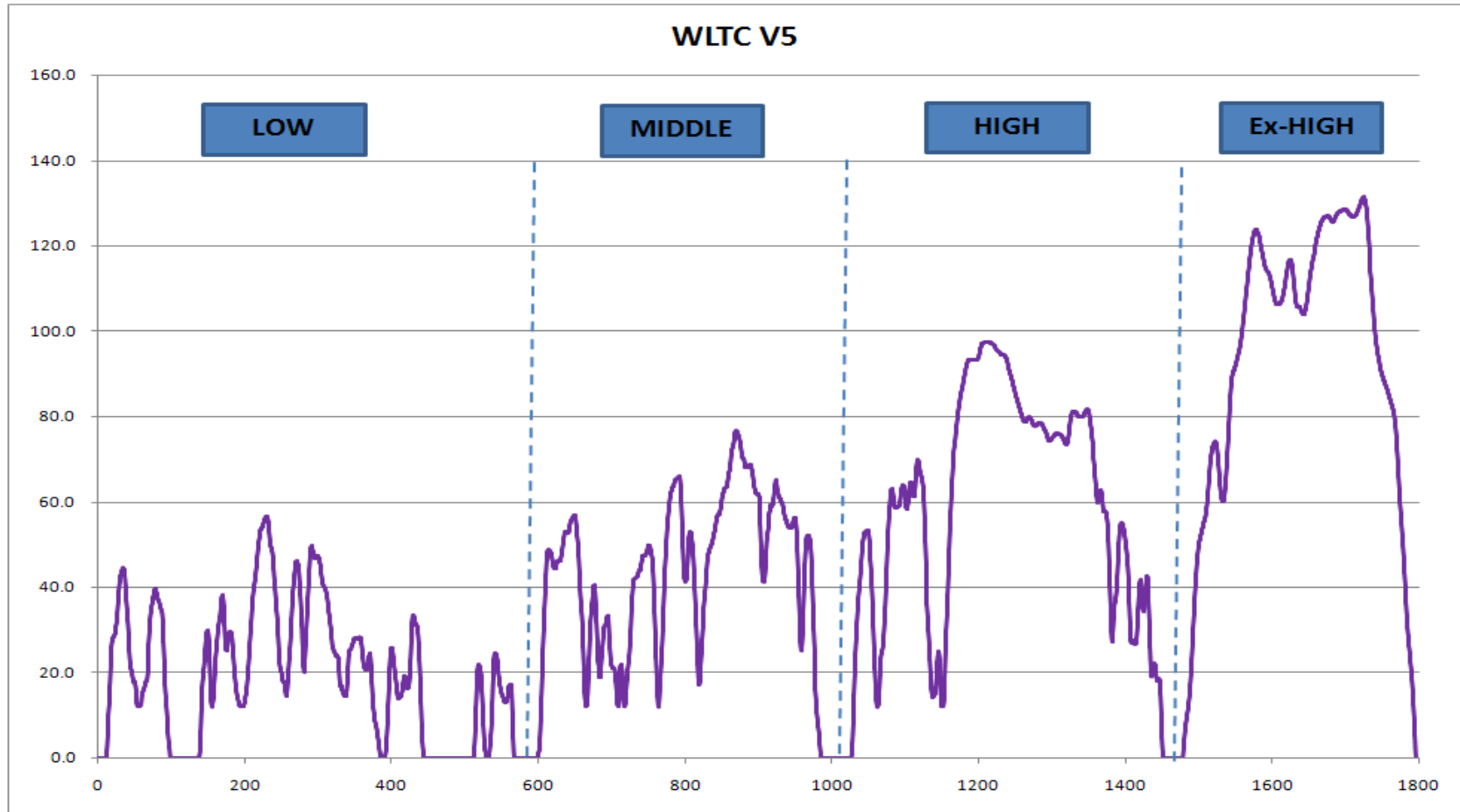
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Overview

- The Present WLTC V5.0
- Compact & Sub Compact Car Segment
- Concerns Highlighted by India during 12th DHC (ISPRA)
- Concerns and Issues
- The Way Forward

The Present: WLTC V5.0



	Low	Middle	High	Ex-High	Total L/M/H	Total L/M/H/Ex H
Time in s	589	433	455	323	1477	1800
Distance, km	3	5	7	7.7	15	22.7
Max Speed, km/h	56.5	76.6	97.4	131.3	97.4	131.3

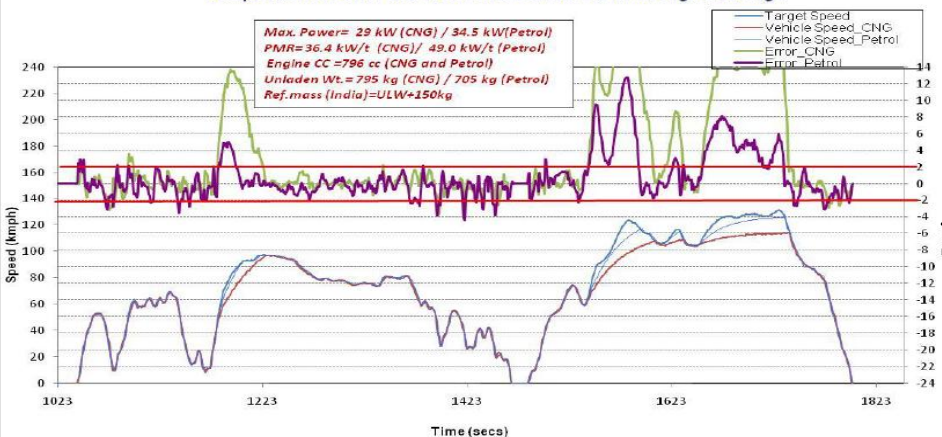
Indian Compact & Sub Compact Car Segment

- Compact & Sub Compact Car segment is relevant to global economy, specially for developing and under-developed countries.
- Such vehicles help the world in fuel & energy conservation, lower CO₂ emissions, etc.
- Produced in high volumes in Asia and exported throughout the world
- Potential customers are first time buyers
- Preferred by smaller families with second car usage.

Main Concerns & Issues: H & Ex-H Phases

Comparison of Petrol and CNG Vehicle Sr No. 5 & 11 on High & Ex-High

Max. Power= 29 kW (CNG) / 34.5 kW (Petrol)
 PMR=36.4 kW/t (CNG) / 49.0 kW/t (Petrol)
 Engine CC =796 cc (CNG and Petrol)
 Unladen Wt.= 795 kg (CNG) / 705 kg (Petrol)
 Ref.mass (India)=ULW+150kg



During 12th DHC India had presented Validation data. Most of Indian Compact Cars cannot follow the target speed with large deviations in driving High and Ex-High Phases as shown. (WLTP-DHC-12-02).

WLTC V5.0 finalized at ISPRA meeting has not addressed concerns of steep accelerations of High and Ex-High Phase.(WLTP-DHC-12-08) and these points are still open for investigation/finalisation.

No.	Time	Comments	by	Action
1	24 - 28	Need to be smoothness	Japan	Smoothing
2	48 - 67	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
3	140 - 160	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
4	185 - 210	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
5	250 - 270	Need to be smoothness	India/Japan	Smoothing
6	275 - 295	Need to be smoothness	India/Japan	Smoothing
7	545 - 560	Need to be smoothness	Japan	Smoothing
8	600 - 615	Require close to W.O.T. operation	Japan	Evaluated during validation2
9	660 - 670	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h & Smoothing
10	709	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
11	715 - 718	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
12	720 - 730	Require close to W.O.T. operation	Japan	Evaluated during validation2
13	760 - 770	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
14	770 - 785	Require close to W.O.T. operation	Japan	Evaluated during validation2
15	780 - 804	Difficult to drive (PMR concern)	India	Evaluated during validation2
16	800 - 810	Require close to W.O.T. operation	Japan	Evaluated during validation2

No.	Time	Comments	by	Action
17	815 - 830	Need to be smoothness	India/Japan	Smoothing
18	860 - 870	Require close to W.O.T. operation	Japan	Evaluated during validation2
19	910 - 925	Require close to W.O.T. operation	Japan	Evaluated during validation2
20	950 - 980	Require close to W.O.T. operation	Japan	Evaluated during validation2
21	1060 - 1065	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
22	1070 - 1125	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
23	1140 - 1155	Difficult to drive the low speed parts	JRC/India/Japan	Minimum speed to 12 km/h
24	1155 - 1250	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
25	1310 - 1325	Require close to W.O.T. operation	Japan	Evaluated during validation2
26	1375 - 1385	Difficult to follow the target speed Require close to W.O.T. operation	India/Japan	Evaluated during validation2
27	1420 - 1450	Difficult to follow the target speed	India	Evaluated during validation2
28	1530 - 1585	Difficult to follow the target speed	India/Japan	Evaluated during validation2
29	1640 - 1675	Difficult to follow the target speed	India/Japan	Evaluated during validation2
30	1530 - 1740	Difficult to drive (PMR concern)	India	Evaluated during validation2
31	All	to be one decimal point (to XX.X km/h)	Japan	one decimal point

Results of Validation 1b

Vehicle	Engine CC	PMR, kW/Ton	V Max, kph	L	M	H	Ex	Class as per Steven
A	796	49.0	135	O / O	O / EP	X / EP	X / EP	Class3
E	814	53.1	137	O / O	O / EP	X / EP	X / EP	Class3
W	998	55.6	145	O / O	O / O	X / EP	X / EP	Class3
S	1197	64.6	160	O / O	O / O	O / EP	X / EP	Class3
B	1198	70.7	169	O / O	O / O	O / O	O / EP	Class3
AC	796	36.4	135	O / O	O / EP	X / EP	X / EP	Class3
W	1197	45.2	140	O / O	O / EP	X / EP	X / EP	Class3
SC	1586	50.2	160	O / O	O / O	X / EP	X / EP	Class3

Legend :

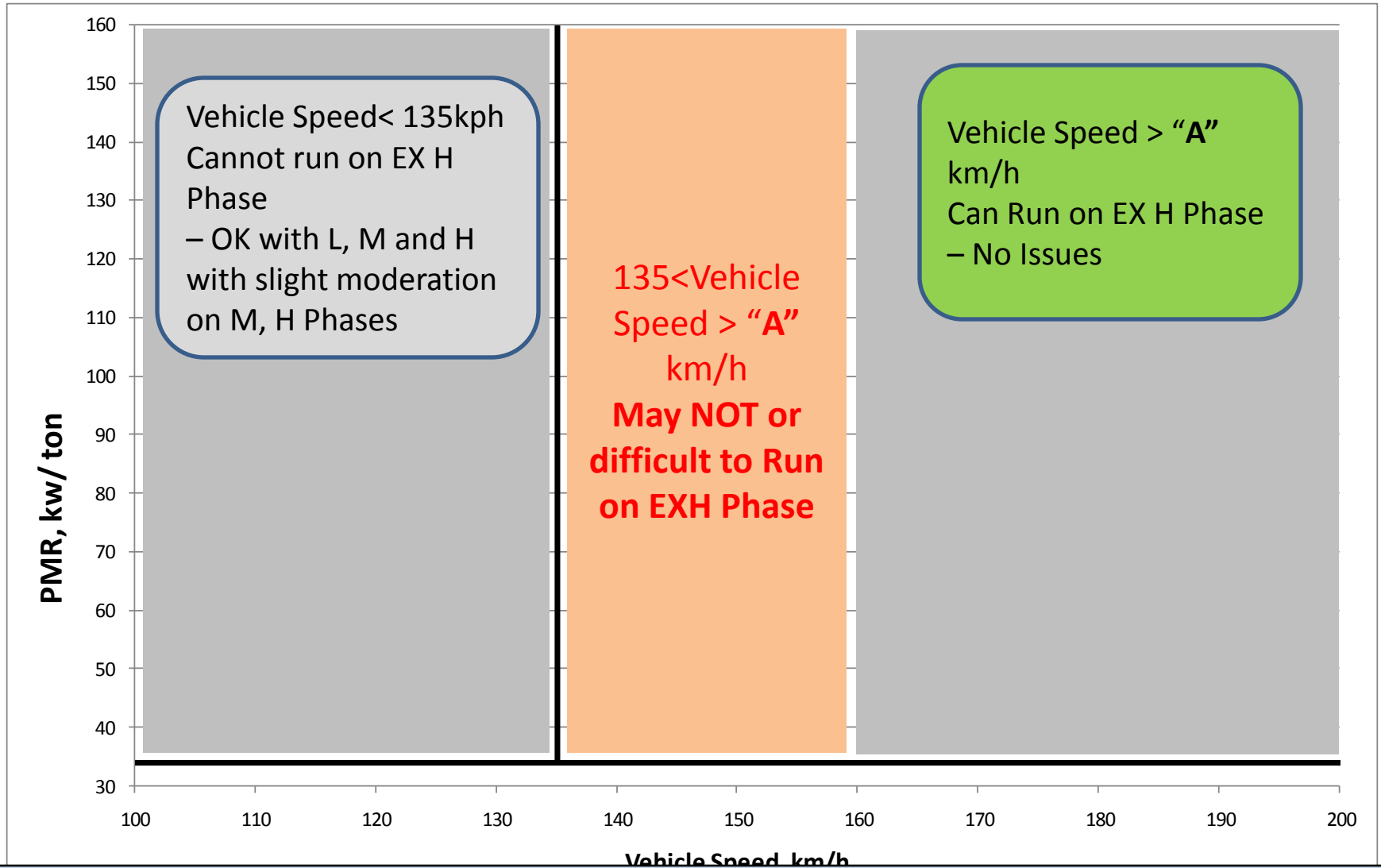
- O / O : OK for Drive Cycle Traceability and WOT (Engine Protection Mode) not activated
- O / EP: OK for Drive Cycle Traceability and WOT (Engine Protection Mode) activated
- X / EP: Not OK for Drive Cycle Traceability and WOT (Engine Protection Mode) Activated

•Most of Indian Compact Cars fall in Class 3 Category. Validation 1b Test Results, show that these vehicles cannot drive High and Ex-High Phases of the Current Version of WLTC.

•Class 3 cycle demands such cars to be driven in WOT (the Engine Protection Area) which is rarely used in actual driving situations.

•India has already cited these concerns related to drivability during 12th DHC Meet at ISPRA

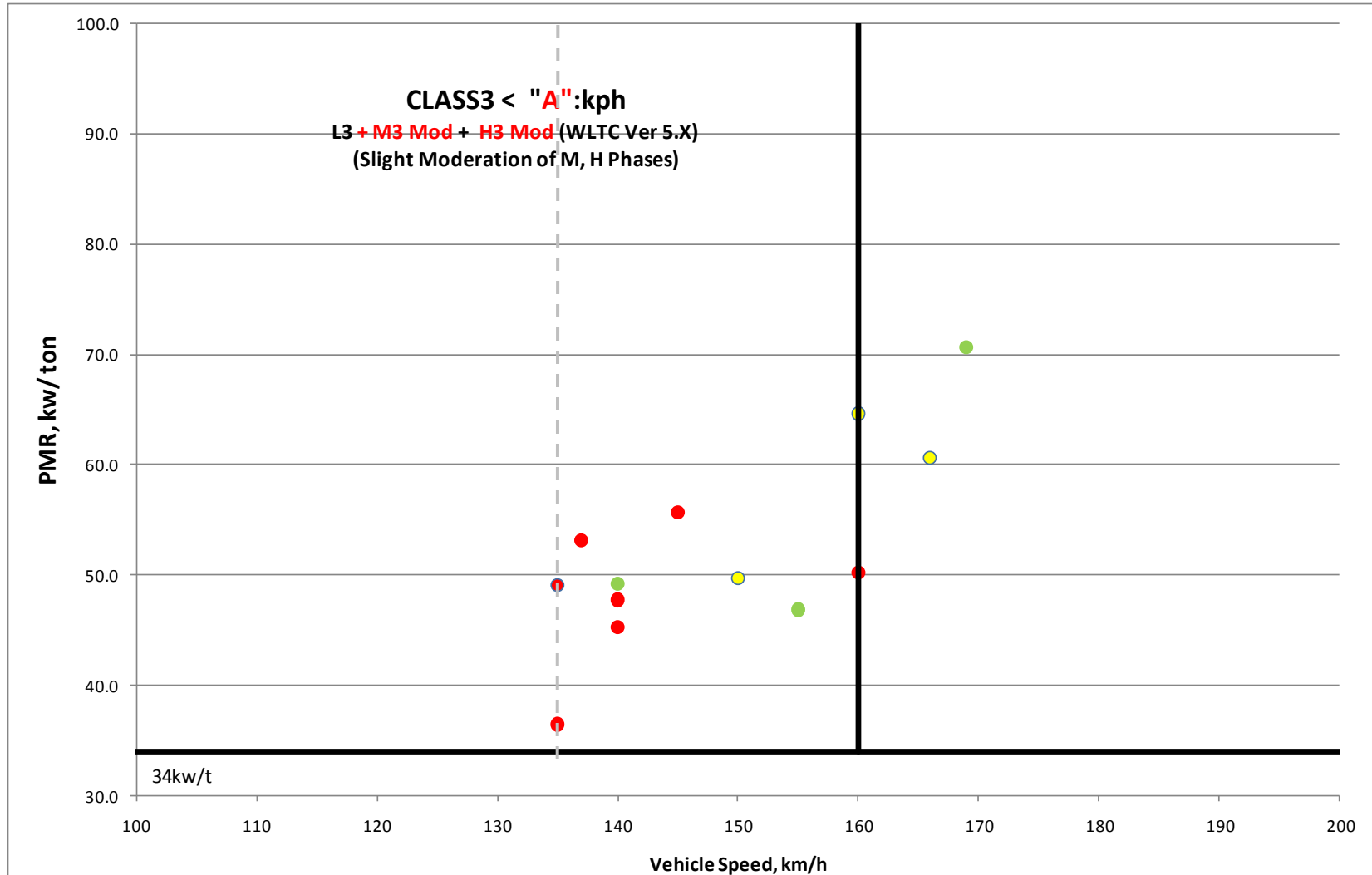
Cycle Class 3 Speed Threshold Change Proposal



Vehicles having max speed slightly > 135 km/h with lower PMR (power ~ 60 kW) will not be able to:

- 1. Trace the EX H Phase, and /or*
- 2. May trace but with engine in WOT (engine protection region)*

Cycle Class 3 Speed Threshold Change Proposal



*It is proposed to have the EX H Phase applicable for vehicles with Max speed around 155~160 km/h. Even with 160 km/h, some vehicles will have issues, however they are in the borderline areas. **This change along with the slight moderation for M and H Phases should make the cycle conducive for application in major areas of the world***

Issues pertaining to WLTC Version 5 based on India

Validation 1b results

The Way Forward

- Compact and sub compact vehicles with PMR >34 kW/t and power < 60 kW have issues in negotiating the class 3 WLTC cycle consisting of L+M+H+ExH. Such vehicles are generally Gasoline/CNG/LPG vehicles having low torque to mass ratio and maximum speed around 130-155 km/h. The ExH phase of driving cycle is difficult to be traversed.
- This has been presented at 12th DHC meeting at Ispra by India in Validation 1b test results
- We propose that vehicles with max. speed upto 155 – 160 km/h be subjected to Class 3 L+M+H phases only. This would allow 15 - 18% margin on declared maximum speed to take care of driveability problems.
- This change along with the slight moderation for M and H Phases should make the cycle conducive for application in major areas of the world

Thank You