

TEST REPORT No 12043/COŚ

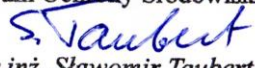
Measurements of fuel consumption in tests SORT 1 for the bus MAZ 203016
Report title

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THE TESTING TEAM

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1. THE AIM AND THE SCOPE OF WORK

The aim of this work was the measurement of the fuel consumption in SORT 1 test¹, performed for the MAZ type 203016 bus manufactured by MAZ.

2. OBJECT OF THE TESTS

For the purpose of conducting the tests, the manufacturer has provided the test object, whose basic data is given in Table 1. The tested object is shown on Fig. 1 to Fig. 2. Other bus data is presented in Annex 1.

During the tests, the vehicle was powered by diesel fuel supplied by the Applicant along with the tested object.

Table 1.

Basic technical data of MAZ 203016

Make	MAZ
Type	203016
VIN Number	Y3M203016L0000339
Engine manufacturer	Daimler Truck AG
Type of engine	OM926LA.V/3
Gearbox manufacturer	Allison
Type of gearbox	T375w/Ret
Software of gearbox	63CR07PC
Main transmission manufacturer	ZF, AV 133/80
Main transmission reduction ratio	6,19
ITS's identification number of the test object	185
Date of accepting the object for testing	12.08.2020

¹ "UITP Project 'SORT' Standardised On-Road Test Cycles". New Edition UITP 2014. International Association of Public Transport, 2014.



Fig. 1. The MAZ 203016 bus - front view



Fig. 2. The MAZ 203016 bus - rear view

3. MEASURING DEVICES USED IN THE TESTS

For the purposes of the tests there were used:

- fuel flowmeter KMA Mobile MessMod by AVL, serial number 166 with conditioning module KMA Mobile Cond by AVL, serial number 161
- the LABEL, type LB-701, M type thermo-hygro-barometer (serial number 1371) with a LB-702B display (serial number 1073),
- anemometer CFM Master, model 8901, serial number 8809870,

- optical head CORSYS-DATRON type L-400, serial number 41434, for measurement of vehicle speed,
- electronic, non-automatic balance type IT8000 MARS-STP by MASA Company, serial number 5231207-1.

4. THE COURSE AND RESULTS OF THE WORK

4.1. Preparing the object to testing

The mass in running order of the tested bus was measured using an non-automatic balance. This mass was 11126 kg.

Determination of the load mass C_L of the tested bus was carried out in accordance with section 1.3 of sheet 2 of Annex A to the SORT document. The mass of non-standard or optional equipment has been subtracted from the load mass C_L . The values of masses of this equipment were provided by the bus manufacturer. They are listed in Table 2.

Table 2.

Mass of optional equipment installed in tested bus [kg]

Air-conditioning	0
Ticketing equipment (excluding the supporting devices)	0
Automatic vehicle monitoring system (AVM)	0
Information equipment	0
Secured driver cabin	0
Overload due to double glazing	0
Lubrimatic equipment	0
Total weight of optional equipment	0

The calculated and measured vehicle mass for the test are given in the table 3.

Table 3.

Mass of the tested vehicle [kg]

No.	Parameter	Value
1.	Mass of the vehicle	11126
2.	Mass of load C_L	3200
3.	Mass of optional equipment (table 2)	0
4.	Correction factor C_S due to the number of seats	0
5.	Correction factor C_F due to the capacity of the fuel tank	8
6.	Calculated vehicle weight for the test (1 + 2 – 3 – 4 – 5)	14318
7.	Measured mass	14325

4.2. Test track

Fuel consumption measurements were carried out on the road from Nieborów to Leśnictwo Nieborów (Poland). The longitudinal gradient of the track was calculated from the altitude of the

start and end points of the track and the distance between them. The basic parameters of the track are given in Table 4.

Table 4.
Basic parameters of the measurement path

Parameter		Value
Condition of the track surface	[-]	dry
Maximum longitudinal gradient	[%]	0,31
Track altitude ²	[m]	100
Minimum radius	[m]	not applicable
Track length	[m]	1400

4.3. Weather conditions

Weather conditions during the testing are shown in Table 5.

Table 5.
Weather conditions prevailing during the measurements of fuel consumption

Parameter	Test start	End of test
date of the test	20.08.2020	20.08.2020
test start / end time	7:30	10:00
wind speed along the axis of the route [m/s]	0,04	0
ambient temperature [°C]	22,4	24,8
relative humidity [%]	61,5	55,3
ambient pressure [hPa]	1000,7	1001,4

4.4. Fuel

During the tests, the vehicle was powered by diesel fuel delivered in bus tank by the Applicant. Fuel density at 20°C was measured at ITS and was equal to:

$$\rho_{ON} = 0,825 \pm 0,001 \text{ [kg/dm}^3\text{]}$$

The value of the fuel density was used to calculate the volumetric fuel consumption.

4.5. Results of the measurements

The fuel consumption was calculated in accordance with the methodology set out in chapter VI, section C of the SORT standard.

Date of measurements: 2020-08-20.

² Height above sea level was determined on the basis of data from the website <http://www.wysokosc.mapa.info.pl>

Results of the measurement are showed in annex 2. The time and average speed for each measurement are presented in table 6. Moreover, in table 7 there are the results of the fuel consumption calculations.

Table 6.

Time and average speed measured in SORT 1 test

Test number	Direction K1 ³			Direction K2 ³		
	distance [m]	time [s]	average speed [km/h]	distance [m]	time [s]	average speed [km/h]
K1 ₅ K2 ₁	1131,52	310,66	13,09	1165,30	311,47	13,47
K1 ₂ K2 ₄	1138,29	310,54	13,19	1147,46	310,56	13,28
K1 ₁ K2 ₂	1131,98	310,82	13,12	1139,41	310,31	13,21

Table 7.

Fuel consumption in SORT 1 test [kg/100 km]

Test number	Direction K1	Direction K2	Average
K1 ₅ K2 ₁	42,32	40,04	
K1 ₂ K2 ₄	42,35	40,46	
K1 ₁ K2 ₂	42,40	40,56	
Average	42,36	40,35	41,36

Measured average mass fuel consumption according to the methodology of the SORT 1 test is:

$$FC_{SORT1} = 41,36 \text{ kg/100 km.}$$

Taking into account the density of diesel fuel equal to 0,825 kg/dm³ (see point 4.4 of this test report), the average fuel consumption in the SORT 1 test expressed in [dm³/100 km] is:

$$FC_{SORT1} = 50,13 \text{ dm}^3/100 \text{ km.}$$

Taking into account the lower heating value of diesel fuel equal to 10 kWh/dm³⁴, the average energy consumption in the SORT 1 test expressed in [kWh/km] is:

$$EC_{SORT1} = 5,013 \text{ kWh/km.}$$

The reproducibility of measurements were calculated using following equation:

$$p = \frac{FC_{\max} - FC_{\min}}{FC_{\min}} \cdot 100$$

where:

FC_{max} means maximum fuel consumption,

FC_{min} means minimum fuel consumption.

³ The K1 direction means driving on the test track in the south-west direction (SSW), while the K2 direction in the north-east one (NNE)

⁴ The value is given in the document UITP PROJECT SORT. „SORT calculation for gas vehicles”. D/2015/0105/4

The reproducibility of measurements is: $p_{K1} = 0,19\%$ for K1 direction and $p_{K2} = 1,31\%$ for K2 direction. These two values are lower than limit value of 2%.

5. CONCLUSIONS

Measured average value of the fuel consumption of the MAZ type 203016 bus, in the SORT 1 test, is 41,36 kg/100 km (50,13 dm³/100 km).

The uncertainty of the measurement is estimated as $\pm 0,22$ kg/100 km ($\pm 0,31$ dm³/100 km). This uncertainty is the expanded uncertainty with a confidence level of 95% and the expansion factor $k = 2$.

End of test report

ANNEX 1

Bus technical specifications and measurement data

SORT TEST: SHEET 3

Test protocole

Date of test	20-08-2020
Test start time	07:30
Test end time	10:00
Place of test	Nieborów
Establishment carrying out the measurement	Motor Transport Institute

A. Test external conditions (for information)

1. Street conditions

N°	Item	Value	Unit
1.1	State of track surface	dry	/
1.2	Max. longitudinal gradient	0.31	%
1.3	Track altitude	100.0	m.a.s.l.
1.4	Min. radius	0.0	m
1.5	Track length	1400	m

2. Weather conditions

N°	Item	Value		Unit
		Test start	Test end	
2.1	Wind speed (< 3 km/h) (1)	0.0	0.0	m/s
2.2	Temperature ([0°C;30°C])	22.4	24.8	°C
2.3	Humidity (< 95 %)	61.5	55.3	%
2.4	Atmospheric pressure	1.0007	1.0004	bar

B. Vehicle set-up

1. Vehicle characteristics

1.1. Type and dimensions

N°	Item	Value	Unit
1.1.1	Vehicle type	MAZ 203016	/
1.1.2	Length (L)	12	m
1.1.3	Width (W)	2.55	m
1.1.4	Height	3.28	m
1.1.5	Empty weight	11125.9	kg
1.1.6	Mileage	1100	km

1.2. Engine

N°	Item	Value	Unit	at (rpm)
1.2.1	Manufacturer and type	Daimler Truck AG, OM926LA.V/3	/	/
1.2.2	Engine capacity	7 201	cm³	/
1.2.3	Maximum power	240	kW	2 200
1.2.4	Maximum torque	1 300	Nm	1200-1600
1.2.5	Driving mode of the engine fan	Hydraulically driven fan controlled by an electronic control unit	/	/

1.3. Gearbox

N°	Item	Value
1.3.1	Manufacturer and type	Allison, T375w/Ret
1.3.2	Used software	63CR07PC

1.4. Tyres

N°	Item	Value	Unit
1.4.1	Manufacturer and type	Continental, Conti Urban HA3, 150/145J, 152/148E	/
1.4.2	Dimensions (front axle)	275/70 R 22,5	/
1.4.3	Dimensions (central axle)	n/a	/
1.4.4	Dimensions (rear axle)	275/70 R 22,5	/
1.4.5	Nominal pressure (front axle)	8,5±0,25	bar
1.4.6	Nominal pressure (central axle)	n/a	bar
1.4.7	Nominal pressure (rear axle)	8,5±0,25	bar
1.4.8	Pattern depth of new tyres	19	mm
1.4.9	Actual pattern depth measured (minimum 80 % depth of the new)	19	mm

1.5. Motor axle

N°	Item	Value
1.5.1	Manufacturer and type	ZF, AV 133/80
1.5.2	Reduction ratio	6.19

1.6. Engine lubricant

N°	Item	Value
1.6.1	Type	Mercedes-Benz NFZ-Motoroil MB 228.51
1.6.2	SAE Grade	10W40
1.6.3	Other features	x

1.7. Gearbox lubricant

N°	Item	Value
1.7.1	Type	Castrol TransSynd Tote 1000L 0.023
1.7.2	SAE Grade	Tes 295
1.7.3	Other features	x

1.8. Batteries

N°	Item	Value	Unit
1.8.1	Type	Таггстоун 220	
1.8.2	Number	2	Quantity
1.8.3	Nominal unit voltage	12x2	V
1.8.4	Unit weight	62,5x2	kg

1.9. Miscellaneous equipments

N°	Item	Value
1.9.1	Number of doors	6
1.9.2	Retarder	retarder integrated in the automatic transmission
1.9.3	Air conditioning	x
1.9.4	Other	x

1.10. Load calculation

N°	Item	Value	Unit
1.10.1	Vehicle length	12	m
1.10.1	Vehicle width	2.55	m
1.10.1	Load (CL)	3200	kg

1.11. Optional equipment

N°	Item	Weight to deduct from lump load
1.11.1	Air conditioning	x
1.11.2	Ticketing equipment (excluding the supporting devices)	x
1.11.3	Automatic vehicle monitoring system (AVM)	x
1.11.4	Information equipment	x
1.11.5	Secured driver cabin	x
1.11.6	Overload due to double glazing	x
1.11.7	Lubrimatic equipment	x
(1)	Total weight of optional equipment	0

1.12. Other factors to take into account

N°	Item	Actual weight (A) in kg	Reference weight (B) (kg)	Difference (A - B) in kg
1.12.1	CS : Seats (forfaitary load: 10 kg/seat)	300	300	0
1.12.2	CF : Fuel tank capacity (litres x 0.840)	176.4	168	8
1.12.3	On-board persons (Y) (excluding the driver)	x	Actual measured weight	x
1.12.4	Fuel measuring equipment	x	none	x
(2)	Total weight of other factors (kg)	8.4		

1.13. Final value of the load and the weight of the complete vehicle

N°	Item	Value	Unit
1.13.1	Lump load	11 126	kg
1.13.2	CL : Load	3 200	kg
1.13.3	Optional equipment (1)	0	kg
1.13.4	Other factors (2)	8	kg
1.13.5	Load = CL - (1) -(2)	3 192	kg
1.13.6	Total vehicle weight to reach	14 318	kg
	Total vehicle weight measured (Weighing ticket)	14 325	kg

2. Fuel

N°	Item	Value	Unit
2.1	EC standard	-	/
2.1.1	Fuel density at 20°C	8.825	kg/dm³
2.2	Sulfur rate	-	ppm
2.3	Fuel temperature at test start	-	°C
2.4	Fuel temperature at test end	-	°C
2.5	AdBlue volume at test start	-	litre
2.6	AdBlue volume at test end	-	litre
2.7	Difference	/	litre

ANNEX 2

Results of fuel consumption measurement

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.48	0	-	2	0.480	-	1131.98	42.40
Measurement 2	0.4821	0	-	2	0.482	-	1138.29	42.35
Measurement 3	0.4818	0	-	2	0.482	-	1125.66	42.80
Measurement 4	0.4934	0	-	2	0.493	-	1147.93	42.98
Measurement 5	0.4789	0	-	2	0.479	-	1131.52	42.32
Measurement 6	0.492	0	-	2	0.492	-	1130.09	43.54
Measurement 7	0.4946	0	-	2	0.495	-	1133.81	43.62
Measurement 8	-	0	-	2	#N/A	-	-	#N/A
Measurement 9	-	0	-	2	#N/A	-	-	#N/A
Measurement 10	-	0	-	2	#N/A	-	-	#N/A
Measurement 11	-	0	-	2	#N/A	-	-	#N/A
Measurement 12	-	0	-	2	#N/A	-	-	#N/A
Average SORT 1 :								42.36
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	-	-	-	1	#N/A	-	-	#N/A
Measurement 2	-	-	-	1	#N/A	-	-	#N/A
Measurement 3	-	-	-	1	#N/A	-	-	#N/A
Measurement 4	-	-	-	1	#N/A	-	-	#N/A
Measurement 5	-	-	-	1	#N/A	-	-	#N/A
Measurement 6	-	-	-	1	#N/A	-	-	#N/A
Measurement 7	-	-	-	1	#N/A	-	-	#N/A
Measurement 8	-	-	-	1	#N/A	-	-	#N/A
Measurement 9	-	-	-	1	#N/A	-	-	#N/A
Measurement 10	-	-	-	1	#N/A	-	-	#N/A
Measurement 11	-	-	-	1	#N/A	-	-	#N/A
Measurement 12	-	-	-	1	#N/A	-	-	#N/A
Average SORT 2 :								Insufficient number of measurements.
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	-	0	-	1	#N/A	-	-	#N/A
Measurement 2	-	0	-	1	#N/A	-	-	#N/A
Measurement 3	-	0	-	1	#N/A	-	-	#N/A
Measurement 4	-	0	-	1	#N/A	-	-	#N/A
Measurement 5	-	0	-	1	#N/A	-	-	#N/A
Measurement 6	-	0	-	1	#N/A	-	-	#N/A
Measurement 7	-	0	-	1	#N/A	-	-	#N/A
Measurement 8	-	0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 3 :								Insufficient number of measurements.

Consumption relative to the exploitation

Bench / serie of vehicles	Coefficient A	B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		I
					0.00		I

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.4666	0	-	2	0.467	-	1165.3	40.04
Measurement 2	0.4622	0	-	2	0.462	-	1139.41	40.56
Measurement 3	0.4699	0	-	2	0.470	-	1147.88	40.94
Measurement 4	0.4642	0	-	2	0.464	-	1147.46	40.45
Measurement 5	0.4705	0	-	2	0.471	-	1137.14	41.38
Measurement 6	0.4602	0	-	2	0.460	-	1117.46	41.18
Measurement 7	0.4623	0	-	2	0.462	-	1120.05	41.27
Measurement 8	-	0	-	2	#N/A	-	-	#N/A
Measurement 9	-	0	-	2	#N/A	-	-	#N/A
Measurement 10	-	0	-	2	#N/A	-	-	#N/A
Measurement 11	-	0	-	2	#N/A	-	-	#N/A
Measurement 12	-	0	-	2	#N/A	-	-	#N/A
Average SORT 1 :								40.35
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	-	-	-	1	#N/A	-	-	#N/A
Measurement 2	-	-	-	1	#N/A	-	-	#N/A
Measurement 3	-	-	-	1	#N/A	-	-	#N/A
Measurement 4	-	-	-	1	#N/A	-	-	#N/A
Measurement 5	-	-	-	1	#N/A	-	-	#N/A
Measurement 6	-	-	-	1	#N/A	-	-	#N/A
Measurement 7	-	-	-	1	#N/A	-	-	#N/A
Measurement 8	-	-	-	1	#N/A	-	-	#N/A
Measurement 9	-	-	-	1	#N/A	-	-	#N/A
Measurement 10	-	-	-	1	#N/A	-	-	#N/A
Measurement 11	-	-	-	1	#N/A	-	-	#N/A
Measurement 12	-	-	-	1	#N/A	-	-	#N/A
Average SORT 2 :								Insufficient number of measurements
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1		0	-	1	#N/A	-	-	#N/A
Measurement 2		0	-	1	#N/A	-	-	#N/A
Measurement 3		0	-	1	#N/A	-	-	#N/A
Measurement 4		0	-	1	#N/A	-	-	#N/A
Measurement 5		0	-	1	#N/A	-	-	#N/A
Measurement 6		0	-	1	#N/A	-	-	#N/A
Measurement 7		0	-	1	#N/A	-	-	#N/A
Measurement 8		0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 3 :								Insufficient number of measurements

Consumption relative to the exploitation

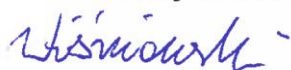
Bench / serie of vehicles	Coefficient A	B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		I
					0.00		I

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Applicant's Address: 22021 Minsk
REPUBLIC OF BELARUS
Nr zamówienia: 0738/COŚ/20
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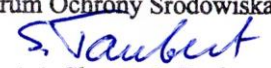
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Wyniki badań odnoszą się wyłącznie do badanych obiektów.

Test results relate solely to the object being tested.

Oszacowanie niepewności wyników pomiarów nie uwzględnia etapu pobierania próbek

Estimation of the measurement results uncertainty does not take into account the sampling stage.

Bez pisemnej zgody Instytutu Transportu Samochodowego sprawozdanie nie może być powielane inaczej niż w całości.

Without a written consent from the Motor Transport Institute, the report can not be duplicated other than in its complete form.

THE TESTING TEAM

<u>First name, surname</u>	<u>Scope of work</u>
Piotr Wiśniowski	project leader, fuel consumption measurement, compiling the test report
Sławomir Taubert	authorising the test report
Paulina Grzelak	compiling the test report
Maciej Gis	compiling the test report
Andrzej Wierzejski	speed and distance measurements
Marcin Przygucki	test driver
Marek Jakubowski	preparing the vehicle to the tests

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ANNEXES

1. Bus technical specifications and measurement data
2. Results of fuel consumption measurement

1. THE AIM AND THE SCOPE OF WORK

The aim of this work was the measurement of the fuel consumption in SORT 2 test¹, performed for the MAZ type 203016 bus manufactured by MAZ.

2. OBJECT OF THE TESTS

For the purpose of conducting the tests, the manufacturer has provided the test object, whose basic data is given in Table 1. The tested object is shown on Fig. 1 to Fig. 2. Other bus data is presented in Annex 1.

During the tests, the vehicle was powered by diesel fuel supplied by the Applicant along with the tested object.

Table 1.

Basic technical data of MAZ 203016

Make	MAZ
Type	203016
VIN Number	Y3M203016L0000339
Engine manufacturer	Daimler Truck AG
Type of engine	OM926LA.V/3
Gearbox manufacturer	Allison
Type of gearbox	T375w/Ret
Software of gearbox	63CR07PC
Main transmission manufacturer	ZF, AV 133/80
Main transmission reduction ratio	6,19
ITS's identification number of the test object	185
Date of accepting the object for testing	12.08.2020

¹ "UITP Project 'SORT' Standardised On-Road Test Cycles". New Edition UITP 2014. International Association of Public Transport, 2014.



Fig. 1. The MAZ 203016 bus - front view



Fig. 2. The MAZ 203016 bus - rear view

3. MEASURING DEVICES USED IN THE TESTS

For the purposes of the tests there were used:

- fuel flowmeter KMA Mobile MessMod by AVL, serial number 166 with conditioning module KMA Mobile Cond by AVL, serial number 161
- the LABEL, type LB-701, M type thermo-hygro-barometer (serial number 1371) with a LB-702B display (serial number 1073),
- anemometer CFM Master, model 8901, serial number 8809870,

- optical head CORSYS-DATRON type L-400, serial number 41434, for measurement of vehicle speed,
- electronic, non-automatic balance type IT8000 MARS-STP by MASA Company, serial number 5231207-1.

4. THE COURSE AND RESULTS OF THE WORK

4.1. Preparing the object to testing

The mass in running order of the tested bus was measured using an non-automatic balance. This mass was 11126 kg.

Determination of the load mass C_L of the tested bus was carried out in accordance with section 1.3 of sheet 2 of Annex A to the SORT document. The mass of non-standard or optional equipment has been subtracted from the load mass C_L . The values of masses of this equipment were provided by the bus manufacturer. They are listed in Table 2.

Table 2.

Mass of optional equipment installed in tested bus [kg]

Air-conditioning	0
Ticketing equipment (excluding the supporting devices)	0
Automatic vehicle monitoring system (AVM)	0
Information equipment	0
Secured driver cabin	0
Overload due to double glazing	0
Lubrimatic equipment	0
Total weight of optional equipment	0

The calculated and measured vehicle mass for the test are given in the table 3.

Table 3.

Mass of the tested vehicle [kg]

No.	Parameter	Value
1.	Mass of the vehicle	11126
2.	Mass of load C_L	3200
3.	Mass of optional equipment (table 2)	0
4.	Correction factor C_S due to the number of seats	0
5.	Correction factor C_F due to the capacity of the fuel tank	8
6.	Calculated vehicle weight for the test (1 + 2 – 3 – 4 – 5)	14318
7.	Measured mass	14325

4.2. Test track

Fuel consumption measurements were carried out on the road from Nieborów to Leśnictwo Nieborów (Poland). The longitudinal gradient of the track was calculated from the altitude of the

start and end points of the track and the distance between them. The basic parameters of the track are given in Table 4.

Table 4.

Basic parameters of the measurement path

Parameter		Value
Condition of the track surface	[-]	dry
Maximum longitudinal gradient	[%]	0,31
Track altitude ²	[m]	100
Minimum radius	[m]	not applicable
Track length	[m]	1400

4.3. Weather conditions

Weather conditions during the testing are shown in Table 5.

Table 5.

Weather conditions prevailing during the measurements of fuel consumption

Parameter	Test start	End of test
date of the test	20.08.2020	20.08.2020
test start / end time	10:00	13:00
wind speed along the axis of the route [m/s]	0	0,3
ambient temperature [°C]	24,8	28,20
relative humidity [%]	55,3	37,2
ambient pressure [hPa]	1001,4	1001,4

4.4. Fuel

During the tests, the vehicle was powered by diesel fuel delivered in bus tank by the Applicant. Fuel density at 20°C was measured at ITS and was equal to:

$$\rho_{ON} = 0,825 \pm 0,001 \text{ [kg/dm}^3\text{]}$$

The value of the fuel density was used to calculate the volumetric fuel consumption.

4.5. Results of the measurements

The fuel consumption was calculated in accordance with the methodology set out in chapter VI, section C of the SORT standard.

Date of measurements: 2020-08-20.

² Height above sea level was determined on the basis of data from the website <http://www.wysokosc.mapa.info.pl>

Results of the measurement are showed in annex 2. The time and average speed for each measurement are presented in table 6. Moreover, in table 7 there are the results of the fuel consumption calculations.

Table 6.

Time and average speed measured in SORT 2 test

Test number	Direction K1 ³			Direction K2 ³		
	distance [m]	time [s]	average speed [km/h]	distance [m]	time [s]	average speed [km/h]
K1 ₅ K2 ₇	973,882	184,41	18,94	968,270	184,53	18,82
K1 ₃ K2 ₅	958,487	184,25	18,67	968,861	184,28	18,86
K1 ₂ K2 ₃	961,110	184,60	18,69	950,360	184,25	18,52

Table 7.

Fuel consumption in SORT 2 test [kg/100 km]

Test number	Direction K1	Direction K2	Average
K1 ₅ K2 ₇	34,53	31,45	
K1 ₃ K2 ₅	34,83	31,66	
K1 ₂ K2 ₃	35,06	31,77	
Average	34,81	31,63	33,22

Measured average mass fuel consumption according to the methodology of the SORT 2 test is:

$$FC_{SORT2} = 33,22 \text{ kg/100 km.}$$

Taking into account the density of diesel fuel equal to 0,825 kg/dm³ (see point 4.4 of this test report), the average fuel consumption in the SORT 2 test expressed in [dm³/100 km] is:

$$FC_{SORT2} = 40,27 \text{ dm}^3/100 \text{ km.}$$

Taking into account the lower heating value of diesel fuel equal to 10 kWh/dm³ ⁴, the average energy consumption in the SORT 2 test expressed in [kWh/km] is:

$$EC_{SORT2} = 4,027 \text{ kWh/km.}$$

The reproducibility of measurements were calculated using following equation:

$$p = \frac{FC_{\max} - FC_{\min}}{FC_{\min}} \cdot 100$$

where:

FC_{max} means maximum fuel consumption,

FC_{min} means minimum fuel consumption.

The reproducibility of measurements is: p_{K1} = 1,54% for K1 direction and p_{K2} = 1,01% for K2 direction. These two values are lower than limit value of 2%.

³ The K1 direction means driving on the test track in the south-west direction (SSW), while the K2 direction in the north-east one (NNE)

⁴ The value is given in the document UITP PROJECT SORT. „SORT calculation for gas vehicles”. D/2015/0105/4

5. CONCLUSIONS

Measured average value of the fuel consumption of the MAZ type 203016 bus, in the SORT 2 test, is 33,22 kg/100 km (40,27 dm³/100 km).

The uncertainty of the measurement is estimated as ± 0.22 kg/100 km ($\pm 0,31$ dm³/100 km). This uncertainty is the expanded uncertainty with a confidence level of 95% and the expansion factor $k = 2$.

End of test report

ANNEX 1

Bus technical specifications and measurement data

SORT TEST: SHEET 3

Test protocole

Date of test	20-08-2020
Test start time	10:00
Test end time	13:00
Place of test	Nieborów
Establishment carrying out the measurement	Motor Transport Institute

A. Test external conditions (for information)

1. Street conditions

N°	Item	Value	Unit
1.1	State of track surface	dry	/
1.2	Max. longitudinal gradient	0.31	%
1.3	Track altitude	100	m.a.s.l.
1.4	Min. radius	0	m
1.5	Track length	1400	m

2. Weather conditions

N°	Item	Value		Unit
		Test start	Test end	
2.1	Wind speed (< 3 km/h) (1)	0.0	0.3	m/s
2.2	Temperature ([0°C;30°C])	24.8	28.2	°C
2.3	Humidity (< 95 %)	55.3	37.2	%
2.4	Atmospheric pressure	1.0014	1.0014	bar

B. Vehicle set-up

1. Vehicle characteristics

1.1. Type and dimensions

N°	Item	Value	Unit
1.1.1	Vehicle type	MAZ 203016	/
1.1.2	Length (L)	12	m
1.1.3	Width (W)	2.55	m
1.1.4	Height	3.28	m
1.1.5	Empty weight	11125.9	kg
1.1.6	Mileage	1100	km

1.2. Engine

N°	Item	Value	Unit	at (rpm)
1.2.1	Manufacturer and type	Daimler Truck AG, OM926LA.V/3	/	/
1.2.2	Engine capacity	7 201	cm³	/
1.2.3	Maximum power	240	kW	2 200
1.2.4	Maximum torque	1 300	Nm	1200-1600
1.2.5	Driving mode of the engine fan	Hydraulically driven fan controlled by an electronic control unit	/	/

1.3. Gearbox

N°	Item	Value
1.3.1	Manufacturer and type	Allison, T375w/Ret
1.3.2	Used software	63CR07PC

1.4. Tyres

N°	Item	Value	Unit
1.4.1	Manufacturer and type	Continental, Conti Urban HA3, 150/145J, 152/148E	/
1.4.2	Dimensions (front axle)	275/70 R 22,5	/
1.4.3	Dimensions (central axle)	n/a	/
1.4.4	Dimensions (rear axle)	275/70 R 22,5	/
1.4.5	Nominal pressure (front axle)	8,5±0,25	bar
1.4.6	Nominal pressure (central axle)	n/a	bar
1.4.7	Nominal pressure (rear axle)	8,5±0,25	bar
1.4.8	Pattern depth of new tyres	19	mm
1.4.9	Actual pattern depth measured (minimum 80 % depth of the new)	19	mm

1.5. Motor axle

N°	Item	Value
1.5.1	Manufacturer and type	ZF, AV 133/80
1.5.2	Reduction ratio	6.19

1.6. Engine lubricant

N°	Item	Value
1.6.1	Type	Mercedes-Benz NFZ-Motoroil MB 228.51
1.6.2	SAE Grade	10W40
1.6.3	Other features	x

1.7. Gearbox lubricant

N°	Item	Value
1.7.1	Type	Castrol TransSynd Tote 1000L 0.023
1.7.2	SAE Grade	Tes 295
1.7.3	Other features	x

1.8. Batteries

N°	Item	Value	Unit
1.8.1	Type	Таггстоун 220	
1.8.2	Number	2	Quantity
1.8.3	Nominal unit voltage	12x2	V
1.8.4	Unit weight	62,5x2	kg

1.9. Miscellaneous equipments

N°	Item	Value
1.9.1	Number of doors	6
1.9.2	Retarder	retarder integrated in the automatic transmission
1.9.3	Air conditioning	x
1.9.4	Other	x

1.10. Load calculation

N°	Item	Value	Unit
1.10.1	Vehicle length	12	m
1.10.1	Vehicle width	2.55	m
1.10.1	Load (CL)	3200	kg

1.11. Optional equipment

N°	Item	Weight to deduct from lump load
1.11.1	Air conditioning	x
1.11.2	Ticketing equipment (excluding the supporting devices)	x
1.11.3	Automatic vehicle monitoring system (AVM)	x
1.11.4	Information equipment	x
1.11.5	Secured driver cabin	x
1.11.6	Overload due to double glazing	x
1.11.7	Lubrimatic equipment	x
(1)	Total weight of optional equipment	0

1.12. Other factors to take into account

N°	Item	Actual weight (A) in kg	Reference weight (B) (kg)	Difference (A - B) in kg
1.12.1	CS : Seats (forfaitary load: 10 kg/seat)	300	300	0
1.12.2	CF : Fuel tank capacity (litres x 0.840)	176.4	168	8
1.12.3	On-board persons (Y) (excluding the driver)	x	Actual measured weight	x
1.12.4	Fuel measuring equipment	x	none	x
(2)	Total weight of other factors (kg)	8.4		

1.13. Final value of the load and the weight of the complete vehicle

N°	Item	Value	Unit
1.13.1	Lump load	11 126	kg
1.13.2	CL : Load	3 200	kg
1.13.3	Optional equipment (1)	0	kg
1.13.4	Other factors (2)	8	kg
1.13.5	Load = CL - (1) -(2)	3 192	kg
1.13.6	Total vehicle weight to reach	14 318	kg
	Total vehicle weight measured (Weighing ticket)	14 325	kg

2. Fuel

N°	Item	Value	Unit
2.1	EC standard	-	/
2.1.1	Fuel density at 20°C	8.825	kg/dm³
2.2	Sulfur rate	-	ppm
2.3	Fuel temperature at test start	-	°C
2.4	Fuel temperature at test end	-	°C
2.5	AdBlue volume at test start	-	litre
2.6	AdBlue volume at test end	-	litre
2.7	Difference	/	litre

ANNEX 2

Results of fuel consumption measurement

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1		0	-	2	#N/A	-		#N/A
Measurement 2		0	-	2	#N/A	-		#N/A
Measurement 3		0	-	2	#N/A	-		#N/A
Measurement 4		0	-	2	#N/A	-		#N/A
Measurement 5		0	-	2	#N/A	-		#N/A
Measurement 6		0	-	2	#N/A	-		#N/A
Measurement 7		0	-	2	#N/A	-		#N/A
Measurement 8		0	-	2	#N/A	-		#N/A
Measurement 9	-	0	-	2	#N/A	-		#N/A
Measurement 10	-	0	-	2	#N/A	-		#N/A
Measurement 11	-	0	-	2	#N/A	-		#N/A
Measurement 12	-	0	-	2	#N/A	-		#N/A
Average SORT 1 :								Insufficient number of measurements.
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.3107	0	-	1	0.311	-	949.211	32.73
Measurement 2	0.337	0	-	1	0.337	-	961.11	35.06
Measurement 3	0.3338	0	-	1	0.334	-	958.487	34.83
Measurement 4	0.3537	0	-	1	0.354	-	968.87	36.51
Measurement 5	0.3363	0	-	1	0.336	-	973.882	34.53
Measurement 6	0.3438	0	-	1	0.344	-	955.838	35.97
Measurement 7	0.3388	0	-	1	0.339	-	962.31	35.21
Measurement 8	0.3396	0	-	1	0.340	-	961.935	35.30
Measurement 9	0.3423	0	-	1	0.342	-	953.93	35.88
Measurement 10	0.3424	0	-	1	0.342	-	950.74	36.01
Measurement 11	0.3293	0	-	1	0.329	-	975.651	33.75
Measurement 12	0.341	0	-	1	0.341	-	959.374	35.54
Average SORT 2 :								34.81
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1		0	-	1	#N/A	-	-	#N/A
Measurement 2		0	-	1	#N/A	-	-	#N/A
Measurement 3		0	-	1	#N/A	-	-	#N/A
Measurement 4		0	-	1	#N/A	-	-	#N/A
Measurement 5		0	-	1	#N/A	-	-	#N/A
Measurement 6		0	-	1	#N/A	-	-	#N/A
Measurement 7		0	-	1	#N/A	-	-	#N/A
Measurement 8		0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 3 :								Insufficient number of measurements.

Consumption relative to the exploitation

Bench / serie of vehicles	Coefficient A	B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		/
					0.00		/

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1		0	-	2	#N/A	-		#N/A
Measurement 2		0	-	2	#N/A	-		#N/A
Measurement 3		0	-	2	#N/A	-		#N/A
Measurement 4		0	-	2	#N/A	-		#N/A
Measurement 5		0	-	2	#N/A	-		#N/A
Measurement 6		0	-	2	#N/A	-		#N/A
Measurement 7		0	-	2	#N/A	-		#N/A
Measurement 8	-	0	-	2	#N/A	-		#N/A
Measurement 9	-	0	-	2	#N/A	-		#N/A
Measurement 10	-	0	-	2	#N/A	-		#N/A
Measurement 11	-	0	-	2	#N/A	-		#N/A
Measurement 12	-	0	-	2	#N/A	-		#N/A
Average SORT 1 :								Insufficient number of measurements
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.3421	0	-	1	0.342	-	963.439	35.51
Measurement 2	0.3676	0	-	1	0.368	-	963.157	38.17
Measurement 3	0.3019	0	-	1	0.302	-	950.36	31.77
Measurement 4	0.3541	0	-	1	0.354	-	953.508	37.14
Measurement 5	0.3067	0	-	1	0.307	-	968.861	31.66
Measurement 6	0.3674	0	-	1	0.367	-	958.114	38.35
Measurement 7	0.3045	0	-	1	0.305	-	968.27	31.45
Measurement 8	0.3659	0	-	1	0.366	-	963.183	37.99
Measurement 9	0.365	0	-	1	0.365	-	963.797	37.87
Measurement 10	0.3683	0	-	1	0.368	-	976.642	37.71
Measurement 11	0.302	0	-	1	0.302	-	975.651	30.95
Measurement 12	0.3584	0	-	1	0.358	-	948.146	37.80
Average SORT 2 :								31.62
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1		0	-	1	#N/A	-	-	#N/A
Measurement 2		0	-	1	#N/A	-	-	#N/A
Measurement 3		0	-	1	#N/A	-	-	#N/A
Measurement 4		0	-	1	#N/A	-	-	#N/A
Measurement 5		0	-	1	#N/A	-	-	#N/A
Measurement 6		0	-	1	#N/A	-	-	#N/A
Measurement 7		0	-	1	#N/A	-	-	#N/A
Measurement 8		0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 3 :								Insufficient number of measurements

Consumption relative to the exploitation

Bench / serie of vehicles	Coefficient A	B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		/
					0.00		/



COŚ

TEST REPORT No 12045/COŚ

Measurements of fuel consumption in tests SORT 3 for the bus MAZ 203016
Report title

Nazwa Zleceniodawcy:	BELAVTOMAZ
Name of the Applicant:	
Adres Zleceniodawcy:	Sotsialisticheskaya St. 2
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Nr zamówienia:	0738/COŚ/20
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sporządził:
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Centrum Ochrony Środowiska

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THE TESTING TEAM

<u>First name, surname</u>	<u>Scope of work</u>
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Sławomir Taubert	authorising the test report
Paulina Grzelak	compiling the test report
Maciej Gis	compiling the test report
Andrzej Wierzejski	speed and distance measurements
Marcin Przygucki	test driver
Marek Jakubowski	preparing the vehicle to the tests

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ANNEXES

1. Bus technical specifications and measurement data
2. Results of fuel consumption measurement

1. THE AIM AND THE SCOPE OF WORK

The aim of this work was the measurement of the fuel consumption in SORT 3 test¹, performed for the MAZ type 203016 bus manufactured by MAZ.

2. OBJECT OF THE TESTS

For the purpose of conducting the tests, the manufacturer has provided the test object, whose basic data is given in Table 1. The tested object is shown on Fig. 1 to Fig. 2. Other bus data is presented in Annex 1.

During the tests, the vehicle was powered by diesel fuel supplied by the Applicant along with the tested object.

Table 1.

Basic technical data of MAZ 203016

Make	MAZ
Type	203016
VIN Number	Y3M203016L0000339
Engine manufacturer	Daimler Truck AG
Type of engine	OM926LA.V/3
Gearbox manufacturer	Allison
Type of gearbox	T375w/Ret
Software of gearbox	63CR07PC
Main transmission manufacturer	ZF, AV 133/80
Main transmission reduction ratio	6,19
ITS's identification number of the test object	185
Date of accepting the object for testing	12.08.2020

¹ "UITP Project 'SORT' Standardised On-Road Test Cycles". New Edition UITP 2014. International Association of Public Transport, 2014.



Fig. 1. The MAZ 203016 bus - front view



Fig. 2. The MAZ 203016 bus - rear view

3. MEASURING DEVICES USED IN THE TESTS

For the purposes of the tests there were used:

- fuel flowmeter KMA Mobile MessMod by AVL, serial number 166 with conditioning module KMA Mobile Cond by AVL, serial number 161
- the LABEL, type LB-701, M type thermo-hygro-barometer (serial number 1371) with a LB-702B display (serial number 1073),
- anemometer CFM Master, model 8901, serial number 8809870,

- optical head CORSYS-DATRON type L-400, serial number 41434, for measurement of vehicle speed,
- electronic, non-automatic balance type IT8000 MARS-STP by MASA Company, serial number 5231207-1.

4. THE COURSE AND RESULTS OF THE WORK

4.1. Preparing the object to testing

The mass in running order of the tested bus was measured using an non-automatic balance. This mass was 11126 kg.

Determination of the load mass C_L of the tested bus was carried out in accordance with section 1.3 of sheet 2 of Annex A to the SORT document. The mass of non-standard or optional equipment has been subtracted from the load mass C_L . The values of masses of this equipment were provided by the bus manufacturer. They are listed in Table 2.

Table 2.

Mass of optional equipment installed in tested bus [kg]

Air-conditioning	0
Ticketing equipment (excluding the supporting devices)	0
Automatic vehicle monitoring system (AVM)	0
Information equipment	0
Secured driver cabin	0
Overload due to double glazing	0
Lubrimatic equipment	0
Total weight of optional equipment	0

The calculated and measured vehicle mass for the test are given in the table 3.

Table 3.

Mass of the tested vehicle [kg]

No.	Parameter	Value
1.	Mass of the vehicle	11126
2.	Mass of load C_L	3200
3.	Mass of optional equipment (table 2)	0
4.	Correction factor C_S due to the number of seats	0
5.	Correction factor C_F due to the capacity of the fuel tank	8
6.	Calculated vehicle weight for the test (1 + 2 – 3 – 4 – 5)	14318
7.	Measured mass	14325

4.2. Test track

Fuel consumption measurements were carried out on the road from Nieborów to Leśnictwo Nieborów (Poland). The longitudinal gradient of the track was calculated from the altitude of the

start and end points of the track and the distance between them. The basic parameters of the track are given in Table 4.

Table 4.

Basic parameters of the measurement path

Parameter		Value
Condition of the track surface	[-]	dry
Maximum longitudinal gradient	[%]	0,31
Track altitude ²	[m]	100
Minimum radius	[m]	not applicable
Track length	[m]	1400

4.3. Weather conditions

Weather conditions during the testing are shown in Table 5.

Table 5.

Weather conditions prevailing during the measurements of fuel consumption

Parameter	Test start	End of test
date of the test	20.08.2020	20.08.2020
test start / end time	13:00	17:00
wind speed along the axis of the route [m/s]	0,3	0,5
ambient temperature [°C]	28,20	30,17
relative humidity [%]	37,2	31,6
ambient pressure [hPa]	1001,4	1001,3

4.4. Fuel

During the tests, the vehicle was powered by diesel fuel delivered in bus tank by the Applicant. Fuel density at 20°C was measured at ITS and was equal to:

$$\rho_{ON} = 0,825 \pm 0,001 \text{ [kg/dm}^3\text{]}$$

The value of the fuel density was used to calculate the volumetric fuel consumption.

4.5. Results of the measurements

The fuel consumption was calculated in accordance with the methodology set out in chapter VI, section C of the SORT standard.

Date of measurements: 2020-08-20.

² Height above sea level was determined on the basis of data from the website <http://www.wysokosc.mapa.info.pl>

Results of the measurement are showed in annex 2. The time and average speed for each measurement are presented in table 6. Moreover, in table 7 there are the results of the fuel consumption calculations.

Table 6.

Time and average speed measured in SORT 3 test

Test number	Direction K1 ³			Direction K2 ³		
	distance [m]	time [s]	average speed [km/h]	distance [m]	time [s]	average speed [km/h]
K1 ₅ K2 ₈	1555,22	207,43	26,86	1534,70	207,54	26,49
K1 ₂ K2 ₄	1543,16	207,51	26,67	1527,59	207,29	26,43
K1 ₇ K2 ₃	1529,78	207,71	26,39	1524,31	207,27	26,36

Table 7.

Fuel consumption in SORT 3 test [kg/100 km]

Test number	Direction K1	Direction K2	Average
K1 ₅ K2 ₈	31,73	28,25	
K1 ₂ K2 ₄	32,14	28,32	
K1 ₇ K2 ₃	32,23	28,38	
Average	32,03	28,32	30,18

Measured average mass fuel consumption according to the methodology of the SORT 3 test is:

$$FC_{SORT3} = 30,18 \text{ kg/100 km.}$$

Taking into account the density of diesel fuel equal to 0,825 kg/dm³ (see point 4.4 of this test report), the average fuel consumption in the SORT 3 test expressed in [dm³/100 km] is:

$$FC_{SORT3} = 36,58 \text{ dm}^3/100 \text{ km.}$$

Taking into account the lower heating value of diesel fuel equal to 10 kWh/dm³ ⁴, the average energy consumption in the SORT 3 test expressed in [kWh/km] is:

$$EC_{SORT3} = 3,658 \text{ kWh/km.}$$

The reproducibility of measurements were calculated using following equation:

$$p = \frac{FC_{\max} - FC_{\min}}{FC_{\min}} \cdot 100$$

where:

FC_{max} means maximum fuel consumption,

FC_{min} means minimum fuel consumption.

The reproducibility of measurements is: p_{K1} = 1,60% for K1 direction and p_{K2} = 0,45% for K2 direction. These two values are lower than limit value of 2%.

³ The K1 direction means driving on the test track in the south-west direction (SSW), while the K2 direction in the north-east one (NNE)

⁴ The value is given in the document UITP PROJECT SORT. „SORT calculation for gas vehicles”. D/2015/0105/4

5. CONCLUSIONS

Measured average value of the fuel consumption of the MAZ type 203016 bus, in the SORT 3 test, is 30,18 kg/100 km (36,58 dm³/100 km).

The uncertainty of the measurement is estimated as ± 0.22 kg/100 km ($\pm 0,31$ dm³/100 km). This uncertainty is the expanded uncertainty with a confidence level of 95% and the expansion factor $k = 2$.

End of test report

ANNEX 1

Bus technical specifications and measurement data

SORT TEST: SHEET 3

Test protocole

Date of test	20-08-202
Test start time	13:00
Test end time	17:00
Place of test	Nieborów
Establishment carrying out the measurement	Motor Transport Institute

A. Test external conditions (for information)

1. Street conditions

N°	Item	Value	Unit
1.1	State of track surface	dry	/
1.2	Max. longitudinal gradient	0.31	%
1.3	Track altitude	100	m.a.s.l.
1.4	Min. radius	0	m
1.5	Track length	1400	m

2. Weather conditions

N°	Item	Value		Unit
		Test start	Test end	
2.1	Wind speed (< 3 km/h) (1)	0.3	0.5	m/s
2.2	Temperature ([0°C;30°C])	28.2	30.2	°C
2.3	Humidity (< 95 %)	37.2	31.6	%
2.4	Atmospheric pressure	1.0014	1.0013	bar

B. Vehicle set-up

1. Vehicle characteristics

1.1. Type and dimensions

N°	Item	Value	Unit
1.1.1	Vehicle type	MAZ 203016	/
1.1.2	Length (L)	12	m
1.1.3	Width (W)	2.55	m
1.1.4	Height	3.28	m
1.1.5	Empty weight	11125.9	kg
1.1.6	Mileage	1100	km

1.2. Engine

N°	Item	Value	Unit	at (rpm)
1.2.1	Manufacturer and type	Daimler Truck AG, OM926LA.V/3	/	/
1.2.2	Engine capacity	7 201	cm³	/
1.2.3	Maximum power	240	kW	2 200
1.2.4	Maximum torque	1 300	Nm	1200-1600
1.2.5	Driving mode of the engine fan	Hydraulically driven fan controlled by an electronic control unit	/	/

1.3. Gearbox

N°	Item	Value
1.3.1	Manufacturer and type	Allison, T375w/Ret
1.3.2	Used software	63CR07PC

1.4. Tyres

N°	Item	Value	Unit
1.4.1	Manufacturer and type	Continental, Conti Urban HA3, 150/145J, 152/148E	/
1.4.2	Dimensions (front axle)	275/70 R 22,5	/
1.4.3	Dimensions (central axle)	n/a	/
1.4.4	Dimensions (rear axle)	275/70 R 22,5	/
1.4.5	Nominal pressure (front axle)	8,5±0,25	bar
1.4.6	Nominal pressure (central axle)	n/a	bar
1.4.7	Nominal pressure (rear axle)	8,5±0,25	bar
1.4.8	Pattern depth of new tyres	19	mm
1.4.9	Actual pattern depth measured (minimum 80 % depth of the new)	19	mm

1.5. Motor axle

N°	Item	Value
1.5.1	Manufacturer and type	ZF, AV 133/80
1.5.2	Reduction ratio	6.19

1.6. Engine lubricant

N°	Item	Value
1.6.1	Type	Mercedes-Benz NFZ-Motoroil MB 228.51
1.6.2	SAE Grade	10W40
1.6.3	Other features	x

1.7. Gearbox lubricant

N°	Item	Value
1.7.1	Type	Castrol TransSynd Tote 1000L 0.023
1.7.2	SAE Grade	Tes 295
1.7.3	Other features	x

1.8. Batteries

N°	Item	Value	Unit
1.8.1	Type	Таггстоун 220	
1.8.2	Number	2	Quantity
1.8.3	Nominal unit voltage	12x2	V
1.8.4	Unit weight	62,5x2	kg

1.9. Miscellaneous equipments

N°	Item	Value
1.9.1	Number of doors	6
1.9.2	Retarder	retarder integrated in the automatic transmission
1.9.3	Air conditioning	x
1.9.4	Other	x

1.10. Load calculation

N°	Item	Value	Unit
1.10.1	Vehicle length	12	m
1.10.1	Vehicle width	2.55	m
1.10.1	Load (CL)	3200	kg

1.11. Optional equipment

N°	Item	Weight to deduct from lump load
1.11.1	Air conditioning	x
1.11.2	Ticketing equipment (excluding the supporting devices)	x
1.11.3	Automatic vehicle monitoring system (AVM)	x
1.11.4	Information equipment	x
1.11.5	Secured driver cabin	x
1.11.6	Overload due to double glazing	x
1.11.7	Lubrimatic equipment	x
(1)	Total weight of optional equipment	0

1.12. Other factors to take into account

N°	Item	Actual weight (A) in kg	Reference weight (B) (kg)	Difference (A - B) in kg
1.12.1	CS : Seats (forfaitary load: 10 kg/seat)	300	300	0
1.12.2	CF : Fuel tank capacity (litres x 0.840)	176.4	168	8
1.12.3	On-board persons (Y) (excluding the driver)	x	Actual measured weight	x
1.12.4	Fuel measuring equipment	x	none	x
(2)	Total weight of other factors (kg)	8.4		

1.13. Final value of the load and the weight of the complete vehicle

N°	Item	Value	Unit
1.13.1	Lump load	11 126	kg
1.13.2	CL : Load	3 200	kg
1.13.3	Optional equipment (1)	0	kg
1.13.4	Other factors (2)	8	kg
1.13.5	Load = CL - (1) -(2)	3 192	kg
1.13.6	Total vehicle weight to reach	14 318	kg
	Total vehicle weight measured (Weighing ticket)	14 325	kg

2. Fuel

N°	Item	Value	Unit
2.1	EC standard	-	/
2.1.1	Fuel density at 20°C	8.825	kg/dm³
2.2	Sulfur rate	-	ppm
2.3	Fuel temperature at test start	-	°C
2.4	Fuel temperature at test end	-	°C
2.5	AdBlue volume at test start	-	litre
2.6	AdBlue volume at test end	-	litre
2.7	Difference	/	litre

ANNEX 2

Results of fuel consumption measurement

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1			-	2	#N/A	-		#N/A
Measurement 2			-	2	#N/A	-		#N/A
Measurement 3			-	2	#N/A	-		#N/A
Measurement 4			-	2	#N/A	-		#N/A
Measurement 5			-	2	#N/A	-		#N/A
Measurement 6			-	2	#N/A	-		#N/A
Measurement 7			-	2	#N/A	-		#N/A
Measurement 8			-	2	#N/A	-		#N/A
Measurement 9			-	2	#N/A	-		#N/A
Measurement 10			-	2	#N/A	-		#N/A
Measurement 11			-	2	#N/A	-		#N/A
Measurement 12			-	2	#N/A	-		#N/A
Average SORT 1 :								Insufficient number of measurements.
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1			-	1	#N/A	-		#N/A
Measurement 2			-	1	#N/A	-		#N/A
Measurement 3			-	1	#N/A	-		#N/A
Measurement 4			-	1	#N/A	-		#N/A
Measurement 5			-	1	#N/A	-		#N/A
Measurement 6			-	1	#N/A	-		#N/A
Measurement 7			-	1	#N/A	-		#N/A
Measurement 8			-	1	#N/A	-		#N/A
Measurement 9			-	1	#N/A	-		#N/A
Measurement 10			-	1	#N/A	-		#N/A
Measurement 11			-	1	#N/A	-		#N/A
Measurement 12			-	1	#N/A	-		#N/A
Average SORT 2 :								Insufficient number of measurements.
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.5142	0	-	1	0.514	0.411	1558.25	33.00
Measurement 2	0.4959	0	-	1	0.496	0.397	1543.16	32.14
Measurement 3	0.4983	0	-	1	0.498	0.399	1534.17	32.48
Measurement 4	0.4945	0	-	1	0.495	0.396	1525.26	32.42
Measurement 5	0.4934	0	-	1	0.493	0.395	1555.22	31.73
Measurement 6	0.4951	0	-	1	0.495	0.396	1507.68	32.84
Measurement 7	0.4931	0	-	1	0.493	0.394	1529.78	32.23
Measurement 8	0.5011	0	-	1	0.501	0.401	1536.51	32.61
Measurement 9	-	-	-	1	-	-	-	-
Measurement 10	-	-	-	1	-	-	-	-
Measurement 11	-	-	-	1	-	-	-	-
Measurement 12	-	-	-	1	-	-	-	-
Average SORT 3 :								32.03

Consumption relative to the exploitation

Bench / serie of vehicles	Coefficient A	^B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		I
					0.00		I

Calculation of consumption by massique measurements :

Item	Initial mass of fuel	Final mass of fuel	Electricity consumption	Number of cycles effectuated	Total mass of the used fuel	Volume of fuel used per cycle (T Ref = 20°C)	Distance operated per cycle	Measured fuel consumption (T reference : 20 °C)
SORT 1								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	-	0	-	1	#N/A	-	-	#N/A
Measurement 2	-	0	-	1	#N/A	-	-	#N/A
Measurement 3	-	0	-	1	#N/A	-	-	#N/A
Measurement 4	-	0	-	1	#N/A	-	-	#N/A
Measurement 5	-	0	-	1	#N/A	-	-	#N/A
Measurement 6	-	0	-	1	#N/A	-	-	#N/A
Measurement 7	-	0	-	1	#N/A	-	-	#N/A
Measurement 8	-	0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 1 :								Insufficient number of measurements
SORT 2								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	-	0	-	1	#N/A	-	-	#N/A
Measurement 2	-	0	-	1	#N/A	-	-	#N/A
Measurement 3	-	0	-	1	#N/A	-	-	#N/A
Measurement 4	-	0	-	1	#N/A	-	-	#N/A
Measurement 5	-	0	-	1	#N/A	-	-	#N/A
Measurement 6	-	0	-	1	#N/A	-	-	#N/A
Measurement 7	-	0	-	1	#N/A	-	-	#N/A
Measurement 8	-	0	-	1	#N/A	-	-	#N/A
Measurement 9	-	0	-	1	#N/A	-	-	#N/A
Measurement 10	-	0	-	1	#N/A	-	-	#N/A
Measurement 11	-	0	-	1	#N/A	-	-	#N/A
Measurement 12	-	0	-	1	#N/A	-	-	#N/A
Average SORT 2 :								Insufficient number of measurements
SORT 3								
Sign (unit)	Mi (kg)	Mf (kg)	D SOC (A.h)	N	M = Mi - Mf (kg)	V (l)	d (m)	C (kg/100 km)
Measurement 1	0.4418	0	-	1	0.442	-	1523.76	28.99
Measurement 2	0.4436	0	-	1	0.444	-	1553.34	28.56
Measurement 3	0.4326	0	-	1	0.433	-	1524.31	28.38
Measurement 4	0.4326	0	-	1	0.433	-	1527.59	28.32
Measurement 5	0.4369	0	-	1	0.437	-	1538.39	28.40
Measurement 6	0.4427	0	-	1	0.443	-	1534.02	28.86
Measurement 7	0.4426	0	-	1	0.443	-	1551.41	28.53
Measurement 8	0.4336	0	-	1	0.434	-	1534.70	28.25
Measurement 9	-	0	-	1	-	-	-	-
Measurement 10	-	0	-	1	-	-	-	-
Measurement 11	-	0	-	1	-	-	-	-
Measurement 12	-	0	-	1	-	-	-	-
Average SORT 3 :								28.32

Consumption relative to the exploitation

Bench / serie of vehicles	Coefficient A	B Coefficient	Coefficient B	Coefficient C	Measured consumption (l/100km)	Announced consumption (l/100 km)	Observed deviation (%)
					0.00		I
					0.00		I