

ALCOA® ALUMINUM WHEEL / Alcoa® Dura-Stream® wheel comparative test

SUMMARY

Fuel Savings: 0,61 l/100km (3,3 %)

cd*A Reduction: 0,14 m² (2,8 %)

Constant Speed test runs (CST) with a heavy-duty semi-trailer combination, based on Annex VIII of Commission Regulation (EU) 2017/2400 and additional energy consumption test results.



**DEKRA Standard
Fuel Savings in Aerodynamics**
• Based on Commission Regulation
(EU) 2017/2400 Annex VIII
• Verified improved air drag data
and reduced fuel consumption

Valid date: 08/2030
Cert. ID: 2024502947-6.1.2
www.dekra-siegel.de

Applicant : Howmet-Köfém Kft., 8000 Székesfehérvár, Hungary
Purpose : Aerodynamic track measurement of wheel configurations
Test Vehicle : VOLVO FH500 Aero XL / Schmitz Cargobull S3B / Payload
VIN : YV2RT40A7SB512916 / WSM00000005238560

Technical Measurement Report

Execution of Constant Speed test runs (CST) with a heavy-duty semi-trailer combination, based on Annex VIII of Commission Regulation (EU) 2017/2400 and additional fuel consumption tests, in order to evaluate the impact on air drag resistance and fuel consumption between aluminum and Alcoa® Dura-Stream® wheels, also in combination with multiple cover and rim designs.

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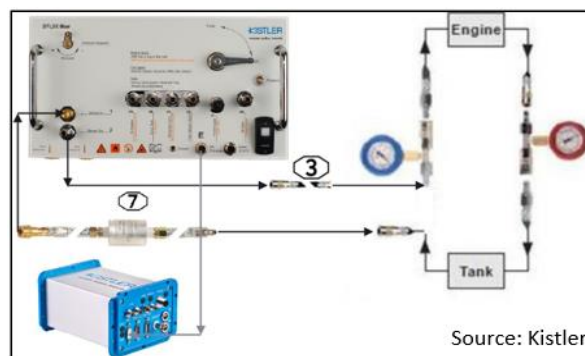
1. Methodology for testing

1.1. Core values and measurements

1.1.1. Diesel engine fuel consumption : Result in unit [l/100 km]

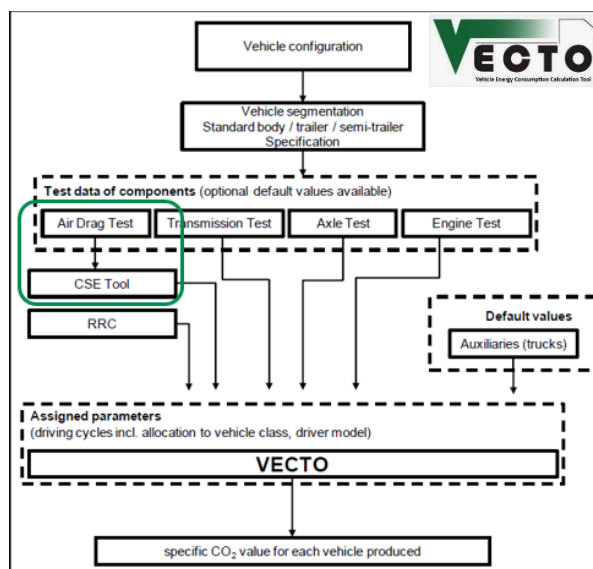
Kistler fuel flow meter DFL3x-5bar implemented into diesel engine fuel circuit. It contains 2 temperature sensors, a heat exchanger and is installed in between feed line to the engine and return line to the tank. Diesel flow rate measured in [l/h].

The fuel consumption runs consist of every Highspeed portion in the CST, at a constant speed of 88 km/h, measured for 10 rounds (10 x 5,8 km) continuously.

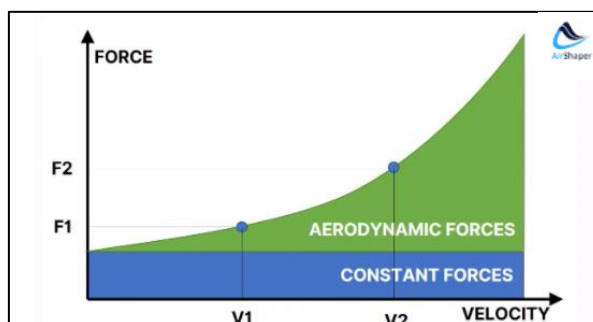


1.1.2. Aerodynamic resistance coefficient $c_d \cdot A$: Result in unit [m²]

Equals the product of air drag coefficient c_d and frontal surface area A of the vehicle. It's calculated in VECTO Airdrag, which is a sub tool of the European VECTO tool, according to Annex VIII of Commission Regulation (EU) 2017/2400, to calculate CO₂ emissions and energy consumption.



Two forces F_1 and F_2 to be measured during Constant Speed Test (CST), operating at low speed ($v_1=15\text{km/h}$) and high speed ($v_2=90\text{km/h}$).



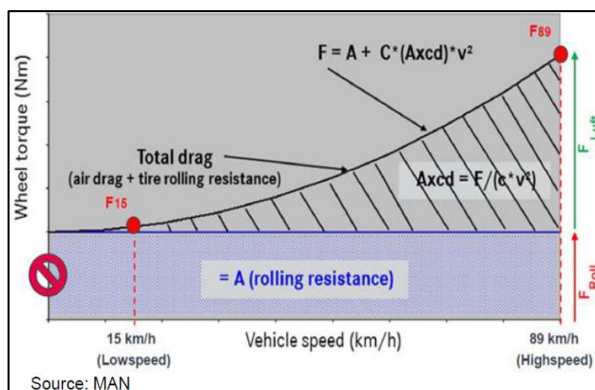
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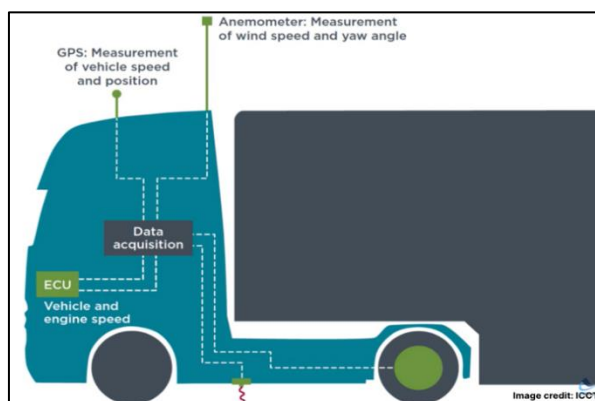
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Rolling resistance are constant forces. Airdrag force follows a square interpolation over vehicle velocity. Evaluation of the 2 points of interest within the measurement.



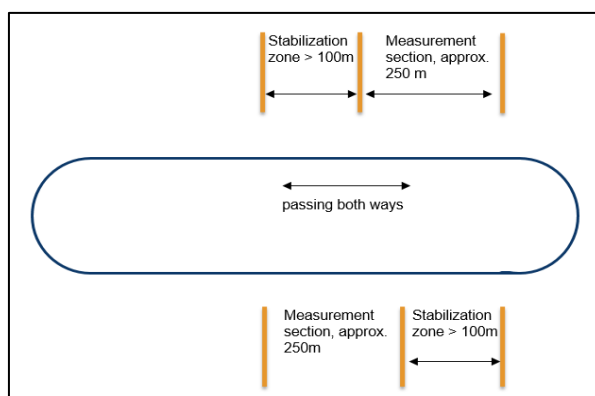
Recorded parameters:

DGPS: speed and position
 Anemometer: wind speed, yaw angle
 ECU: vehicle speed, engine speed, numerous CAN parameters for vehicle/engine operating modes
 Drive axle torque wheels
 Infrared ground temperature sensor
 Temperature sensor at anemometer
 Test track weather station



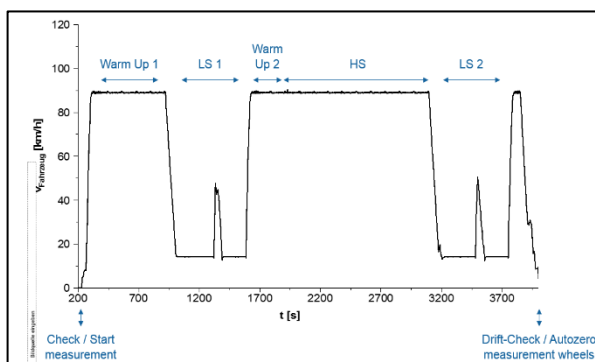
Test track criteria's:

Passing in both driving directions required. At least 3x 250m recording sections with 100m stabilization zone. At DEKRA Test Track facilities all EU Annex given test track requirements are fulfilled.



Driving cycle specifications:

90min Warm Up (45min each direction, 88km/h)
 Auto Zero: Lift drive wheels off the ground.
 Standstill time < 10 min
 Warm Up 1: 10 – 20 min
 LS1: Drive through all measurement section at low speed (one direction). Maximum of 20min
 Warm Up 2: minimum of 5min
 HS: 10 valid passing's per heading at high speed
 LS2: directly after HS
 Drift-Check / Autozero



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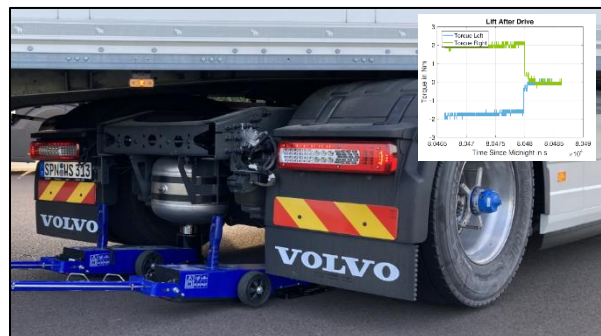
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Vehicle conditioning:

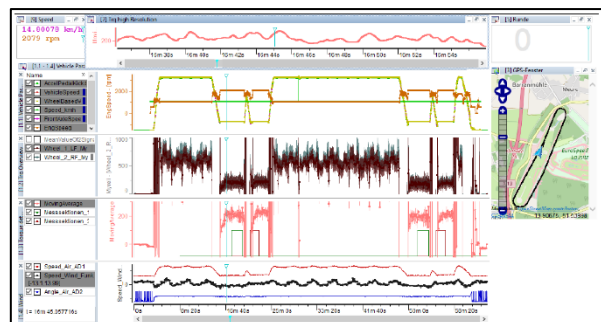
Installation of measurement equipment, review all calibration protocols
 Vehicle preparation (tire pressure, mount / demount of aerodynamic devices)
 Determine Vehicle Data (Vehicle Height, Anemometer Height, Vehicle Mass)
 Fill in Checklist Vehicle Preparation
 Verifying all requirements according to Annex
 Checking for measurement data
 Fill in Vehicle Data of Air Drag Input Tool

Checkliste Vehicle Preparation		A	B	C
extensive modification small modification (Variant) "cleaning windcreens"	Vehicle Number / Variant	Vehicle Data		
	Date:	1		
	Auditor / Tester:	2		
	FIN:	3	classCode	3 [-]
	Trailer: FIN / IAV ST1	4	configuration with trailer	no
	Total mass:	5	GVMMax	15000 [kg]
	Version V 1.0.16	6	vVehMax	90 [km/h]
		7	vehHeight	3,799 [m]
		8	anemometerHeight	5,116 [m]
		9	testMass	7405 [kg]
		10	gearRatio_low	9.300 [-]
		11	gearRatio_high	0.790 [-]
		12	axleRatio	3.583 [-]
		13	gearBox_type	AMT
	Inside / Blue measurement			
X	measuring package used			
X	wires plugged in as labeled			
X	visible damages on			
X	check if connection			
	PT – Mini module allocated to PT and AD modules shc			
	Set 1 only if something was changed			
X	PT Modul: 15342-PTMM / Sensor BP 15 10 A 278, TM-P100-AA-3.0 100-4000STB 3711431			
X	AD Modul 15917-ADMM			
	Set 2 only if something was changed			
X	PT Modul: 15962-PTMM / Sensor BP 15 10 A 277, TM-P100-AA-3.0 100-4000STB			

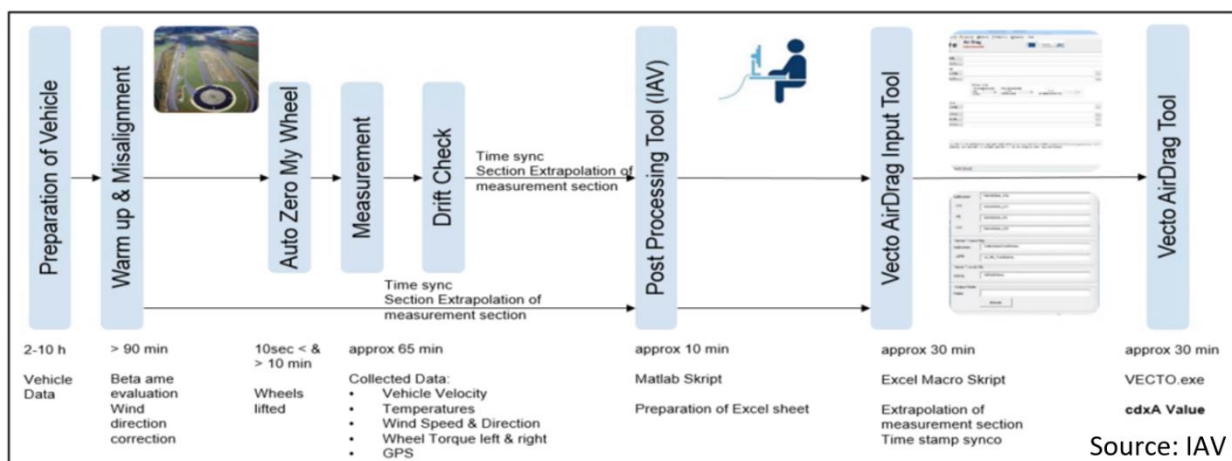
Torque wheel drift check and zeroing:
 Driving axle to be lifted, engine off.



Data review CANape.
 Post Processing in Matlab Script.
 VECTO AirDrag Tool calculation.



Overview of entire CST process:

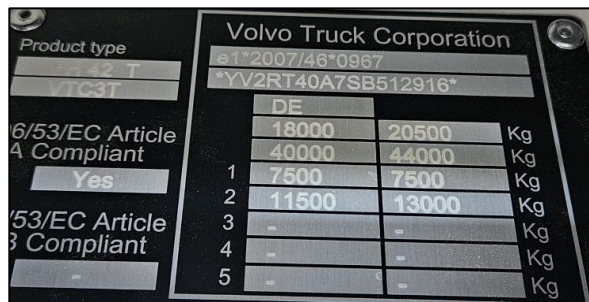


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2. Test vehicle specification

2.1. Test vehicle - Tractor

2.1.1. Type : FH 42 T, VTC3T, FH500 Globetrotter XL Aero
2.1.2. Make (trade name of manufacturer) : Volvo
2.1.3. Manufacturer's name and address: : Volvo Truck Corporation
Herkulesgatan 75. SE-405 08 Göteborg,
Sweden
2.1.4. Vehicle identification number : YV2RT40A7SB512916
2.1.5. Registration / license plate number : SPN – WS 313
2.1.6. Factory sign :



Volvo Truck Corporation		
s1*2007/46*0967		
YV2RT40A7SB512916		
	DE	
	18000	20500 Kg
	40000	44000 Kg
1	7500	7500 Kg
2	11500	13000 Kg
3	-	- Kg
4	-	- Kg
5	-	- Kg

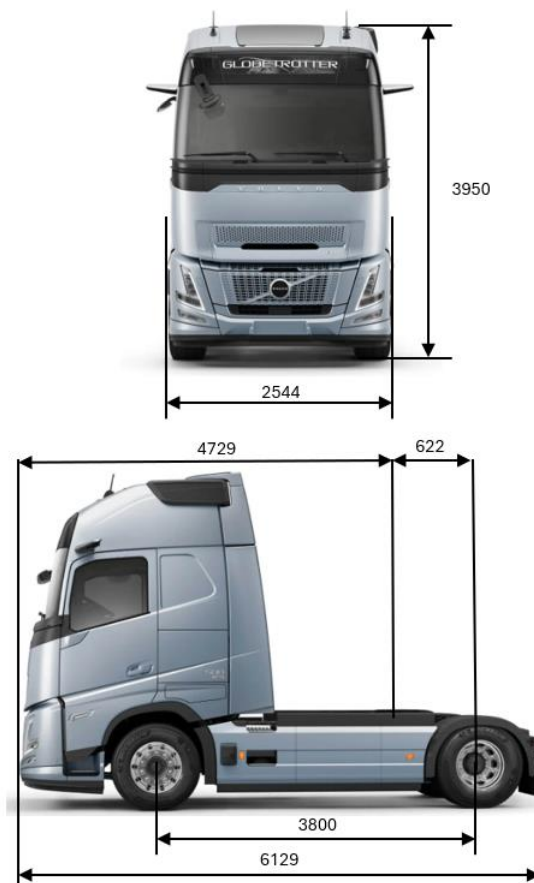
2.1.7. Vehicle photo



2.1.8. Axle : 4 x 2, RWD
2.1.9. Model year : 2025
2.1.10. Vehicle mileage : SOT 1165 km / EOT 6146 km

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- 2.1.11. Engine : Volvo DT13K500, 12.8 l, 375 kW, EU6
- 2.1.12. Transmission : Volvo AT2812 TRAG-G (Automatic, 12 gears)
Gear 2 ratio (CST-Lowspeed): 11.73
Gear 12 ratio (CST-Highspeed): 1.0
- 2.1.13. Axle Drive Ratio : 2.31
- 2.1.14. Tire dimension & tire pressure : Front 1: 315/70 R 22.5 at 130.5 PSI
Rear: 315/70 R 22.5 (dual) at 130.5 PSI
- 2.1.15. Vehicle Weight [kg] : 8611 kg (ready for test, tractor only)
GVW 20500 kg
GVCW 44000 kg
- 2.1.16. Vehicle class according (EU) 2017/2400 : 5 (4x2 tractor > 16t)
- 2.1.17. Vehicle dimensions :



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2.1.18. Aerodynamic effecting components : Cab Globetrotter XL Aero, sunscreen, cabin roof and side visors, chassis side covers, Camera Monitor System (only front windscreen view mirror), 5th wheel height 1100mm

2.2. Test vehicle - Trailer

2.2.1. Type : ST1

2.2.2. Make (trade name of manufacturer) : SCB*S3B

2.2.3. Manufacturer's name and address: : Schmitz Cargobull AG
48612 Horstmar, Germany

2.2.4. Vehicle identification number : WSM00000005238560

2.2.5. Registration / license plate number : B – X 3393

2.2.6. Factory sign :

Typ		SCHMITZ CARGOBULL The Trailer Company Schmitz Cargobull AG		IN COMPLIANCE WITH DIRECTIVE 96 / 53 / EC in Übereinstimmung mit Richtlinie 96 / 53 / EG	
SCB*S3B		e4*2007/46*0152		LENGTH Länge	13,9 m
APPROVAL NO. Genehmigungs-Nr.		WSM00000005238560		WIDTH Breite	2,55 m
VEHICLE ID. NO. Fahrzeug-Ident.-Nr.		DE			
COUNTRY CODE Länder Code				to min.	0 m
MAX. GROSS WEIGHT Zul. Gesamtgewicht		36000	39000	to max.	12 m
MAX. COUPLING POINT LOAD Zul. Last Kupplungsstelle		0	12000		
MAX. AXLE LOAD Zul. Achslast		1	8000 T		
MAX. AXLE LOAD Zul. Achslast		2	8000 T		
MAX. AXLE LOAD Zul. Achslast		3	8000 T		
		kg		kg	

2.2.7. Vehicle photo :



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2.2.8. Axle : 3 / first axle lifting capability blocked

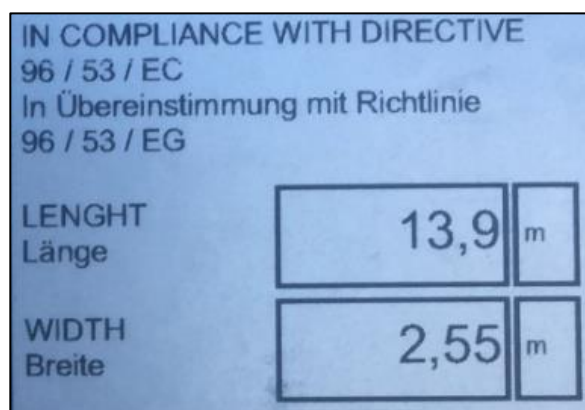
2.2.9. Model year : 2020

2.2.10. Tire dimension & tire pressure : 385/65 R 22.5 at 130.5 [PSI]

2.2.11. Track width : 2050 [mm]

2.2.12. Vehicle Weight [kg] : 15700 kg (ready for test, trailer only incl. payload)
GVW 39000 [kg]

2.2.13. Vehicle dimensions :



2.2.14. Aerodynamic effecting components : side guards, rear guard, 2 back doors, 2 spare wheels, 1 storage case (left rear), solid side walls and roof

2.2.15. Payload documentation :



Payload located in trailer above connecting pin location and above rear trailer axles
Payload weight: 8400 [kg]

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3. Test vehicle instrumentation

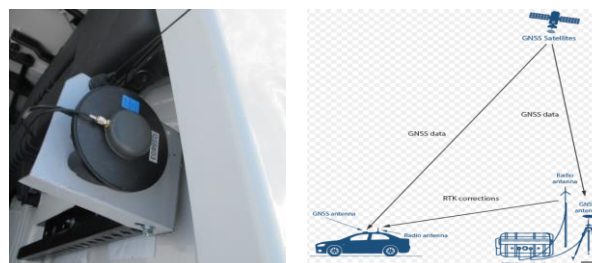
3.1. Constant Speed Test (CST)

3.1.1. Sensors

3.1.1.1. Inertial Measurement Unit : GNSS, Roll Rate, Pitch Rate, Yaw Rate
 Racelogic VBOX IMU04 X Acceleration, Y Acceleration, Z Acceleration



3.1.1.2. Racelogic radio antenna (RTK) : (D)GPS position + RTK correction, velocity



Location of mounting : Cabin roof: RTK antenna & GNSS IMU
 proving ground: GNSS, RTK antenna, base stat.

3.1.1.3. Temperature sensor, PT100 : Ambient temperature

Location of mounting : Above vehicle roof, at wind sensor

3.1.1.4. Temperature sensor, infrared : Ground temperature at track

Location of mounting : Below vehicle, 300 mm from ground

3.1.1.5. PDS Gill Ultrasonic Wind Sensor : Anemometer, Wind speed and direction

Location of mounting : Above trailer front, at post



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3.1.1.6. Kistler P1HT : Wheel torque measuring system

Location of mounting : Drive axle



3.1.1.7. Vehicle data : OBD, Powertrain CAN Bus

3.2. Fuel consumption

3.2.1. Kistler CDS-DFL-3X / DFLX-Proc. : Diesel fuel consumption measuring system

Location of mounting : connected to engine HPFP, mounted above gearbox



3.3. Data acquisition and validation

3.3.1. Racelogic VBOX3i-V5 : Signal conditioning, 100 Hz data logger

Location of mounting : inside cabin



3.3.2. Vector CANape : data acquisition software

MathWorks Matlab : data validation software

VECTO Air Drag : vers. 3.2.1.0, Sub tool of (EU) Vehicle Emission Calculation Tool (VECTO), calculation of $cd \cdot A$

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3.4. Additional

- 3.4.1. Vaisala/Fin. WXTPTU : Proving ground weather station
3.4.2. Vaisala/Fin. WMT701 : Proving ground wind sensor
3.4.3. Racelogic DGNSS Base Station : Proving ground GNSS for (D)GPS on base station with RTK correction
3.4.4. Dini Argeo WWSE10TRF-3 : 10x 10.000 kg wireless wheel scale system with terminal



- 3.4.5. Vehicle tires : Thread depth modified for < 10 mm
Best eco level
Tractor : Bridgestone ECOPIA H-Steer 002 (2x) / ECOPIA H-Drive 002 (4x)
Trailer : Goodyear Fuelmax T HL (6x)

4. Testing agenda and trial variants

4.1. General information

- 4.1.1. Testing location : High Speed Oval
DEKRA Automobil GmbH
Technology Center
Lausitzallee 1
01998 Klettwitz, Germany
4.1.2. Testing period : 20/05/2025 – 18/06/2025



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4.2. Trial variants

Location of mounting : steer axle drive axle trailer axles

4.2.1. Variant 3 Aluminum 9" baseline

Steer: 22.5" x 9" OS 176 Alcoa® Ultra One®
89U510 Al rim with Volvo series bolt cover
Drive: 22.5" x 9" dual Al torque wheels Kistler
RoaDyn P1HT
Trailer: 22.5" x 11.75" OS 120 Alcoa® Ultra
One® Lvl One 81U527 Al rim



4.2.2. Variant 11.2 Dura Stream baseline

Steer: 22.5" x 9" OS 177.2 Alcoa® Dura-
Stream® Al rim with Dura-Stream® cover (5 bolt
mounted)
Drive: 22.5" x 9" dual Al torque wheels Kistler
RoaDyn P1HT
Trailer: 22.5" x 11.75" OS 120 Alcoa® Ultra
One® Lvl One® 81U527 Al rim



Tire information: : Tires reused inbetween wheel changes. Further
installed in the same position and moving
direction at tractor and trailer.

Steer axle (9") : Bridgestone ECOPIA H-Steer 002

Drive axle : Bridgestone ECOPIA H-Drive 002

Trailer axles : Goodyear FUELMAX T HL

4.3. Testing Agenda

4.3.1. Fuel consumption run : Every constant highspeed portion of a CST

4.3.2. Constant Speed Test : 3x CST for each variant
2x variants total

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5. Trial protocols and results

5.1. Testing protocol at every Start of Test

1. Date of test / Vehicle mileage SOT [km] : 20/5/2025 / 1165
2. VIN : YV2RT40A7SB512916
3. Vehicle configuration as per request : confirmed by Howmet & DEKRA engineer
4. Vehicle settings : head light on; DPF regeneration off; shifter in normal driving mode; air suspension in driving level at tractor and trailer, air conditioning off; gears: 2nd for low speed, 12th for high speed
5. Vehicle fault code / MIL status : None / off
6. Vehicle conditions : ready
7. Measurement system online : all channels are reading plausible values
8. Track conditions : dry
9. Tire pressure [psi], thread depth, cond. : 130.5, < 10 [mm], no damages
10. Vehicle weight [kg] : 24210 - 24285
11. Vehicle dimensions – tractor [mm] :

Front left to ground	213
Front right to ground	223
Chassis to cabin gap front	100
Cabin rear to trailer front	542
Door front edge to ground left	524
Door front edge to ground right	545
Side cover to ground left	147
Side cover to ground right	153
Frame end to ground left	672
Frame end to ground right	670
12. Vehicle dimensions - trailer :

Height front left to ground:	3959
Height front right to ground:	3966
Height rear left to ground:	3940
Height rear right to ground:	3962
13. Anemometer height [mm] : 5358
14. Vehicle photo documentation at track : done
15. Vehicle mileage EOT [km] : 18/06/2025 / 6146

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5.2.1. Trial results for Variant 3 – Aluminum 9" baseline

Date of trial : 20/05/2025
VIN : YV2RT40A7SB512916
Vehicle mileage SOT / EOT / Total [km] : 1165 1691 526
Vehicle wheel configuration:
Steer: 9" Alcoa® 89U510, series bolt cov.
Drive: 9" dual aluminum torque wheels
Trailer: 11.75" Alcoa® 81U527 rim
Vehicle CGVW [kg] : 24250
Result fuel consumption run [l/100km] : **18,37**
Result aerodynamic drag / cd*A [m²] : **5,09**



VAR03	f-cons. [l / 100km]	cdxA [m²]	T_Amb [°C]	T_wheel_FL [°C]	T_wheel_FR [°C]	T_wheel_RL [°C]	T_wheel_RR [°C]	T_ground [°C]	LS_Speed [km/h]	HS_Speed [km/h]
CST 1	18,28	-	20,98	34,81	39,62	32,70	32,74	26,26	13,09	87,71
CST 2	18,26	5,03	17,70	29,93	34,08	28,18	28,82	21,62	13,09	87,68
CST 3	18,41	5,10	15,23	26,83	30,96	25,40	26,26	18,93	13,09	87,68
CST 4	18,53	5,15	13,87	25,41	29,22	23,82	24,75	17,27	13,09	87,67
Avg	18,37	5,09	16,94	29,25	33,47	27,52	28,14	21,02	13,09	87,69



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5.2.2. Trial results for Variant 11.2 – 9" Alcoa® Dura-Stream® Aluminum baseline

Date of trial : 18/06/2025
 VIN : YV2RT40A7SB512916
 Vehicle mileage SOT / EOT / Total [km] : 5682 6146 464
Vehicle wheel configuration:
 Steer: 9" Alcoa® Dura-Stream®
 Drive: 9" dual aluminum torque wheels
 Trailer: 11.75" Alcoa® 81U527
 Vehicle CGVW [kg] : 24210
 Result fuel consumption run [l/100km] : **17,77**
 Result aerodynamic drag / cd*A [m²] : **4,95**



VAR11.2	f-cons. [l / 100km]	cdxA [m²]	T_Amb [°C]	T_wheel _FL [°C]	T_wheel _FR [°C]	T_wheel _RL [°C]	T_wheel _RR [°C]	T_ ground [°C]	LS_ Speed [km/h]	HS_ Speed [km/h]
CST 1	17,58	4,91	22,80	36,60	41,46	32,67	-	28,26	13,10	87,73
CST 2	17,76	4,95	20,20	33,26	37,81	29,64	-	25,62	13,10	87,72
CST 3	17,95	5,00	17,94	31,26	35,08	27,34	-	23,34	13,09	87,70
Avg	17,77	4,95	20,31	33,71	38,12	29,89	-	25,74	13,10	87,72



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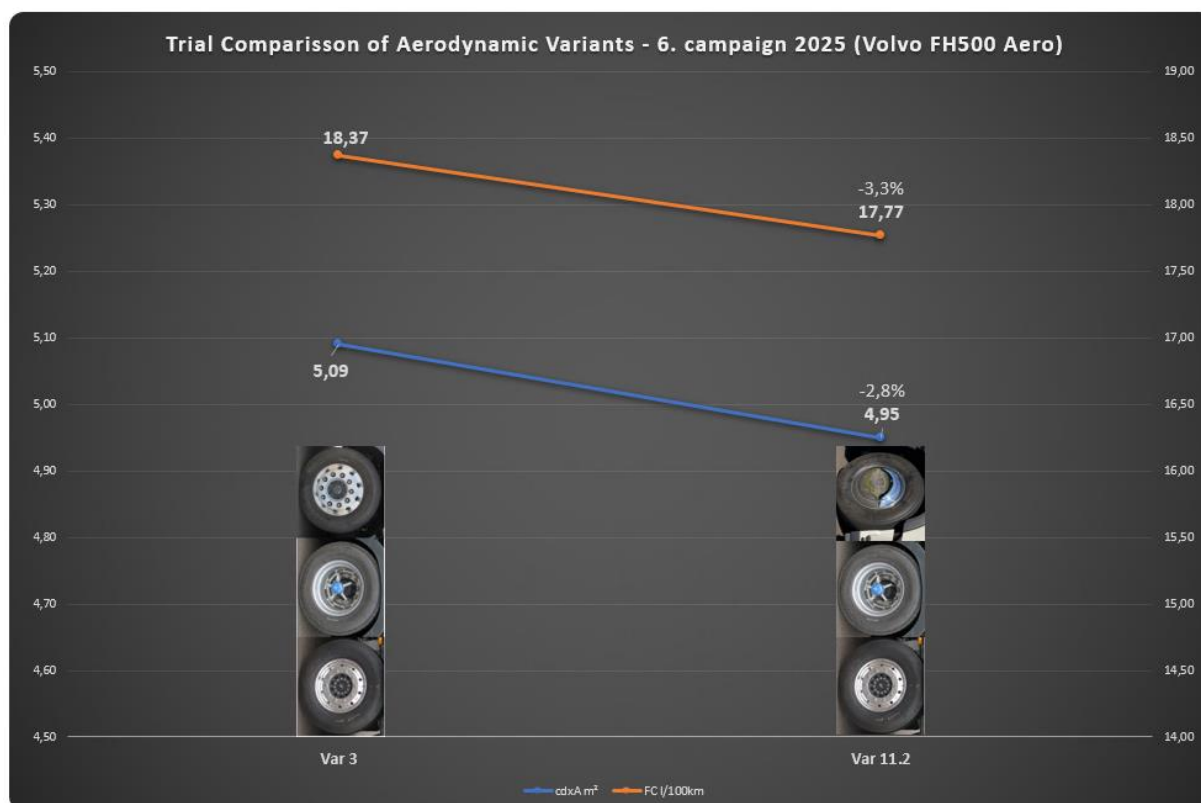
6.1. General

DEKRA Automobil GmbH Klettwitz is an accredited laboratory to perform the Constant Speed Test, based on the Annex VIII of Commission Regulation (EU) 2017/2400. As an exception, based on customer request, payload was added to the trailer and a fuel consumption unit installed. Testing was not related to homologation purpose, but it was a mandatory target to create a scenario close to realistic customer conditions.

DEKRA confirms to have successfully completed 2 aerodynamic configurations of the described vehicle. The target of 3 valid Constant Speed Tests per aerodynamic configuration was met.

6.2. Results overview

As per the completed testing protocol, the tested series production semi-trailer truck combination, showed an amount of 0.61 l/100km in fuel savings or 3.3% less fuel consumption, when replacing the ALCOA® wheels with the aerodynamic design Alcoa® Dura-Stream® wheels at the tractor steer axle. Further these changes to the vehicle configuration reduced the aerodynamic drag in the Constant Speed Test by 0.14 m² or 2.8 % [cdxA value].



Applicant : Howmet-Köfém Kft., 8000 Székesfehérvár, Hungary
Purpose : Aerodynamic track measurement of wheel configurations
Test Vehicle : VOLVO FH500 Aero XL / Schmitz Cargobull S3B / Payload
VIN : YV2RT40A7SB512916 / WSM00000005238560

6.3. Associated Testing

The reader is directed to report #2022501866-1.2 which shows testing that demonstrates a fuel savings benefit upon replacing steel wheels with Aluminum wheels on a heavy-duty semi-trailer combination of up to 1.29%. This report can be found on the Howmet Wheels Systems website.