Measuring of fuel consumption on Dynapac-roller, monitored by VTI

Authors: Håkan Arvidsson and Henrik Bjurström

TEST REPORT

VTInr:22-002

Client	Dynapac Compaction Equipment AB Fredrik Åkesson Box 504, 371 23 Karlskrona
Commission	Surveillance of fuel consumption test
Test material	Unbound base material
Test date	-
Date of registration	2022-02-02
Test period	2022-02-08 – 2022-02-17
Marking of sample	-

Summary

Commission (short version)

VTI has performed surveillance of fuel consumption tests on a Dynapac roller of model CA 3500D. The roller was tested in three different settings in each test week. The second test week was a duplicate of the first test week. The roller was driven by personnel of Dynapac.

Summary of Results

Standard	**82 litres/day**
EcoMode	**68 litres/day**
EcoMode+Sesmic	**55 litres/day**

Content

2022-04-11

X

Test Report Performed by
Laboratory Coordinator
Signerat av: Håkan Arvidsson

2022-04-11

X

Test Report Performed by
Research engineer
Signerat av: Henrik Bjurström

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Commission

VTI[1] has performed surveillance of fuel consumption tests on a Dynapac roller of model CA 3500D. The roller was tested in three different settings in each out of two weeks. The two test weeks were identical regarding the test procedure, performing the tests twice with the intention of validating that similar test results were reached. The first week of testing was during February 8th to February 10th 2022 and the second week was during February 15th to February 17th 2022. The roller was driven by personnel of Dynapac.

Conditions

A roller from Dynapac of the model CA3500D was used. See appendix C for technical data.

Settings, Dynapac

You can use different kinds of settings on the roller:

- Standard mode – engine runs on high (full) RPM and the vibration frequency is 29 Hz in high amplitude and 33 Hz in low amplitude.
- Eco mode – engine runs on lower RPM that is automatically adjusted to the engine needs. Compaction frequency is the same as in standard mode.
- Eco mode + Seismic mode – lower RPM controlled by the Eco setting. The Seismic setting automatically adjusts the vibration frequency in order to maximize the compaction effect.

Driving schedule

Every morning started with a warmup of the engine, roller and electronics with the machine running at idle speed for 10 minutes.
Six cycles of driving were performed each day and one machine setting was used for each day of the week. Three cycles before lunch and three cycles in the afternoon. Every cycle had a duration of one hour (60 minutes) and consisted of:

Transport driving	9 minutes
Vibration, low amplitude	14 minutes
Vibration, high amplitude	7 minutes
Transport driving	9 minutes
Vibration, low amplitude	14 minutes
Vibration, high amplitude	7 minutes

The ratio between these driving modes corresponds to the typical use of rollers according to Dynapac.

Test area

The test area that was used for this compaction work is a harbor area on the Verkö island just outside Karlskrona.
The material being compacted had an approximated grading of 0/150 mm with quite a high content of fines and over size aggregates, see Figure 4 and Figure 5 in Appendix B, Photos (VTI)

[1] VTI = The Swedish National Road and Transport Research Institute

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Results

During the test days, VTI observed the driving of the roller all day and as far as we could observe, the decided schedules were kept. The refueling of diesel was only performed in the presence of VTI personnel. Every test day VTI and Dynapac personnel together made sure that the fuel tank of the roller was full in the morning and that it was filled up again before leaving the work site. The amount of diesel being refueled was noted, see Table 1.

Table 1. Results of fuel consumptions, liters per day

Setting	Average	Reduction[2]	Test week 1	Test week 2
Standard	**81,6**	-	85,9 liters	77,3 liters
EcoMode	**67,6**	17 %	67,5 liters	67,7 liters
EcoMode+Seismic	**55,4**	32 %	55,4 liters	55,4 liters

The fuel consumption is very similar between test week 1 and 2, except for the Standard mode where the deviation is quite high. If we would add 3 more liters for day 1, week 2 (explanation and motivation for doing so is given under "Other observations" here below and in Appendix A) the average will be 83,1 liters and the reduction numbers will improve even further for Eco Mode and Eco Mode+Seismic,.

Then the reduction would be *EcoMode:* *19%*

EcoMode+Seismic: *33%*

Weather observations

Test week 1

Date	Setting	Weather
8 February -22	Standard	from +3°C to +7°C, Windy and mixed sky: rain and clear (sunny)
9 February -22	EcoMode	from +3°C to +6°C, Windy and mixed sky: clear (sunny) and rain
10 February -22	EcoMode+Seismic	from +3°C to +4°C, Windy and mixed sky: cloudy and clear (sunny)

Test week 2

Date	Setting	Weather
15 February -22	Standard	+5°C, cloudy, windy
16 February -22	EcoMode	From +4°C to +6°C, windy, cloudy and light rain
17 February -22	EcoMode+Seismic	+3°C, light rain.

[2] In comparison to Standard setting

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Other observations

The morning of day 2 in the first week an oil leakage from a drum bearing was discovered. The oil level has then regularly been checked and oil was refilled when needed. This leakage did probably not have any influence on the fuel consumption.

The roller has been at the mechanics during the weekend between week 1 and 2 due to the oil leakage. Therefore, the roller was refueled on the first day of week 2 before starting, to ensure that the work started from a full fuel tank.
The roller was refueled after the work was done every day. However, on the morning of the second day the second week, it was noticed that roller indicated a fuel level of 94%. This could be due to the fact that the roller was parked slightly different (lightly inclined backwards) when refueling the second week compared to the first week. Parking differently was to allow dumper trucks to pass. However, the roller was parked the same way all three days during the second week. Therefore, it is possible that the fuel reading on the first day became a bit low.
If the volumes of diesel being refueled are compared to the fuel consumption given by the software, it can be seen that the refueled volumes generally are slightly higher than what the software indicates. One exception is the first day of week 2 (Standard mode) when the actual refueled diesel volume was 5% lower than indicated by the software. All refueled volumes and all software fuel readings are shown in Table 2.

Table 2. Refueled diesel volumes compared to daily fuel consumption given by the roller software.

	Test week 1			Test week 2		
Setting	Refueled	Software	Diff.	Refueled	Software	Diff.
Standard	85,9 l	84,5 l	+2%	77,3 l	81,0 l	-5%
EcoMode	67,5 l	64,5 l	+5%	67,7 l	63,5 l	+7%
EcoMode+Seismic	55,1 l	52,0 l	+6%	55,4 l	51,5 l	+8%

The difference between week one and two for the standard setting can depend on different placing of depot tank and the roller.

If the fuel consumptions for all three settings are plotted in the same figure (Figure 1), the differences become clear.

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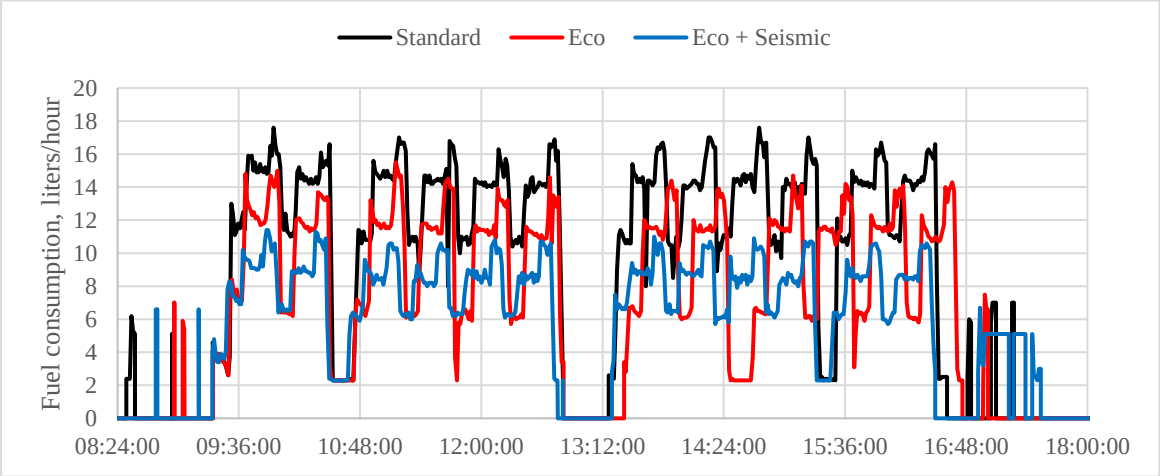

Figure 1. Fuel consumption for the three test days (different driving and compaction modes) during the first week.

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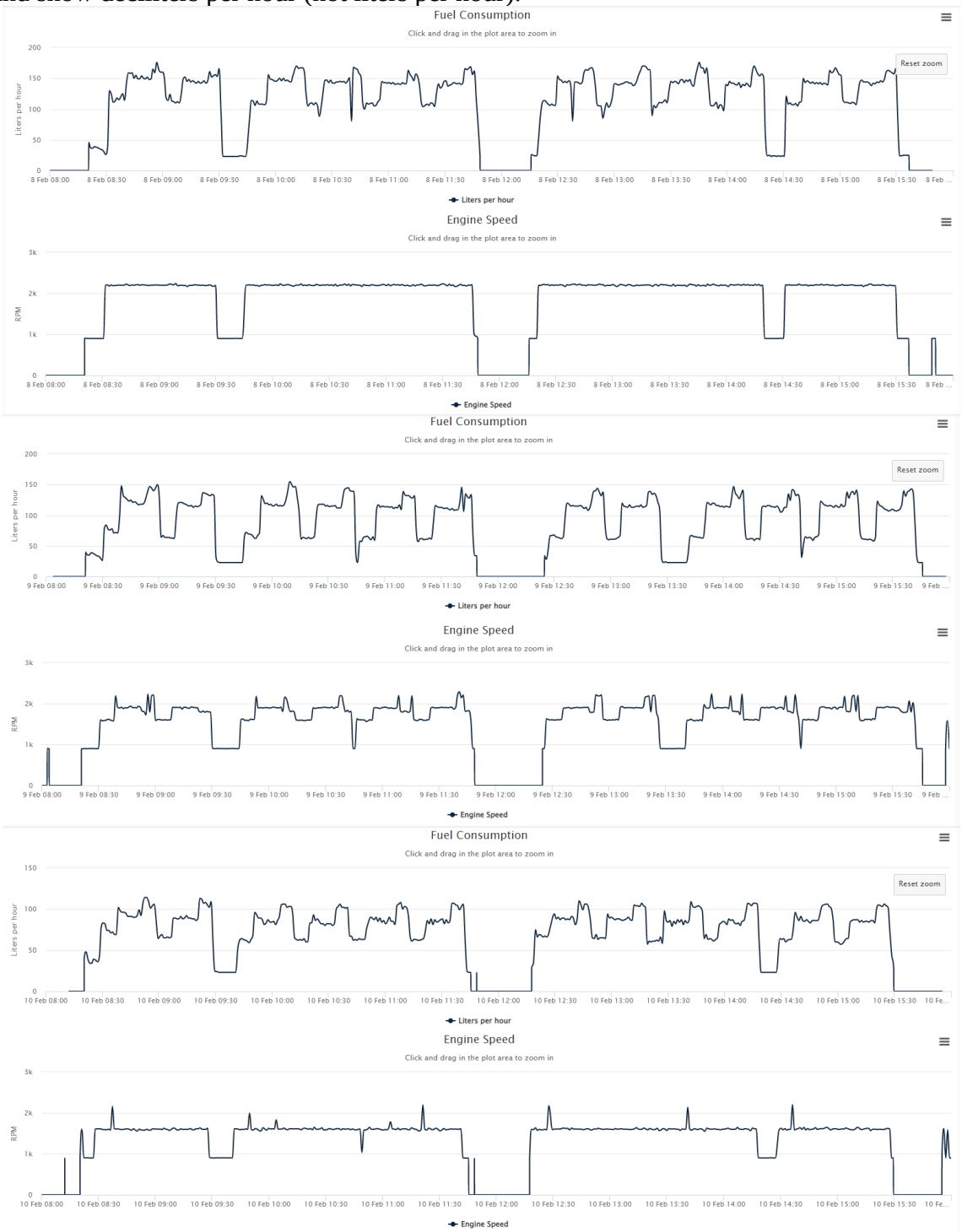
Appendix A - Data provided by Dynapac

The data provided below show fuel consumption and engine speed (RPM) for the three test days during the first week. Note that the y-axes in the fuel consumption diagrams are wrong and show deciliters per hour (not liters per hour).



Figur 1. Fuel consumption and engine speed (RPM) for the first test week.

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Explanation to fuel deviation, given by Dynapac

Since the machine was loaded for transport to the workshop and was driven in connection with repair and then back to Verkö, we needed to replenish fuel before the tests started on Tuesday morning 15/2. Your pictures show that we filled in six liters.
The machine has only consumed three liters during transport and repair. See total fuel used 15/2 and 10/2 given by the machine's software, 3006 and 3003 liters respectively. It means that we had three liters more in the tank in the morning of 15/2 than in the evening of 10/2.

If you add these three liters to the refueled 77.3 litres for Tuesday 15/2, the total consumption will be 80.3 liters. Measured by the ECU of the machine is 81 liters. That difference is within tolerance and would provide a better consistency with the expected savings.
Please see the pictures (
Figur 2. Refueled volumen in the evening 10 Feb., 55.5 liters. The total reading is approximately 110511 liters.
and
Figure 2) below for the explanation. See both the total volume and the current one for refueling:

Figur 2. Refueled volumen in the evening 10 Feb., 55.5 liters. The total reading is approximately 110511 liters.

Figure 2. Meter not reset in the morning of 15 Feb., 55.5 l from Thu 10/2 + 6.2 liters from the morning of 15 Feb. after the weekend transport and repair gives 61.7 liters. Compare total fuel used from Thursday 10 Feb. to Tuesday 15 Feb., 3003 to 3006 liters. Only 3 liters. Total volume here is about 110517 liters.

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Appendix B, Photos (VTI)

All photos: Håkan Arvidsson and Henrik Bjurström, VTI

Figure 3. Tuesday morning, February 8, 2022. The testing has just begun.

Figure 4. Picture of the material. The ruler is 1 m (1000 mm).

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Figure 5. To the left: lose material. To the right: The roller on wet material with high fine content.

Figure 6. Material handling with Caterpillar. The roller in the background.

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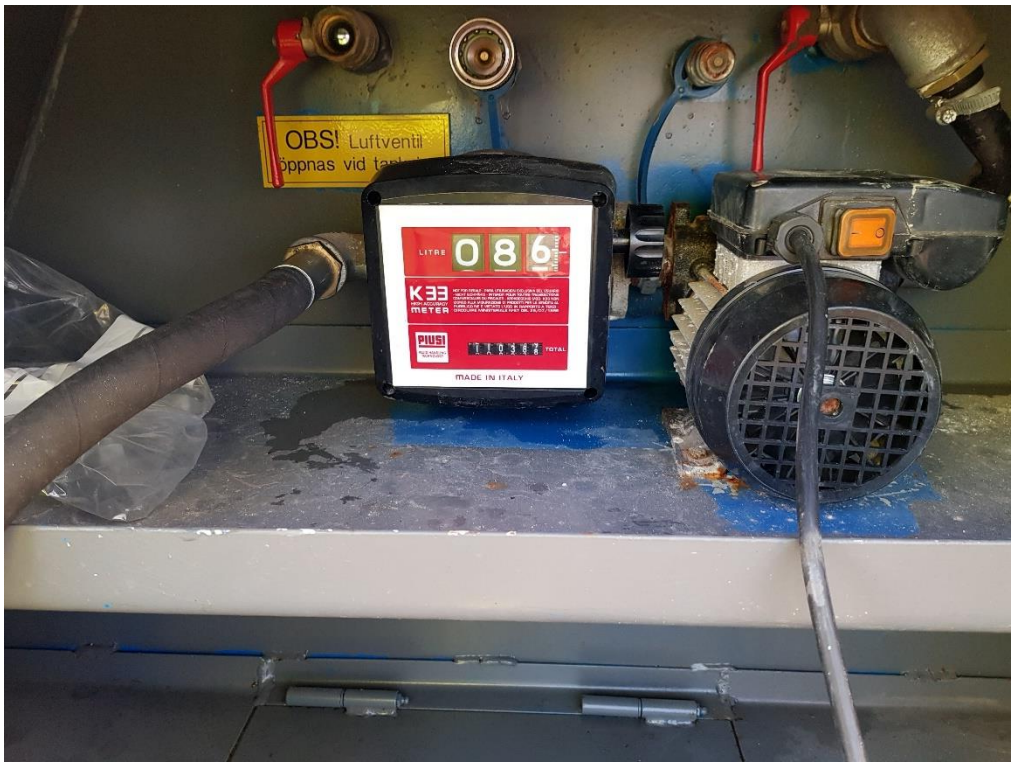

Figure 7. Reading on fuel meter after day 1, week 1. Standard mode with high frequency; 86,5 liters.

Figure 8. The roller in work day 2 with Eco mode.

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Figure 9. Filling of material in the exploitation area.

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Figure 10. A view over the test site with the ocean in the background.

Figure 11. Reading on fuel meter after day 2, week 1. Eco mode; 67,5 liters.

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Figure 12. The roller in work during day 3, Eco mode + Seismic.

Figure 13. Reading on fuel meter after day 3, week 1. Eco mode + Seismic; 55,4 liters.

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Figure 14. To the left; entering the roller for a new day a new week. To the right the roller in work: Standard mode.

Figure 15. Transport of material.

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Figure 16. A view of the working roller.

Figure 17. A scenic view of the roller close to the shore.

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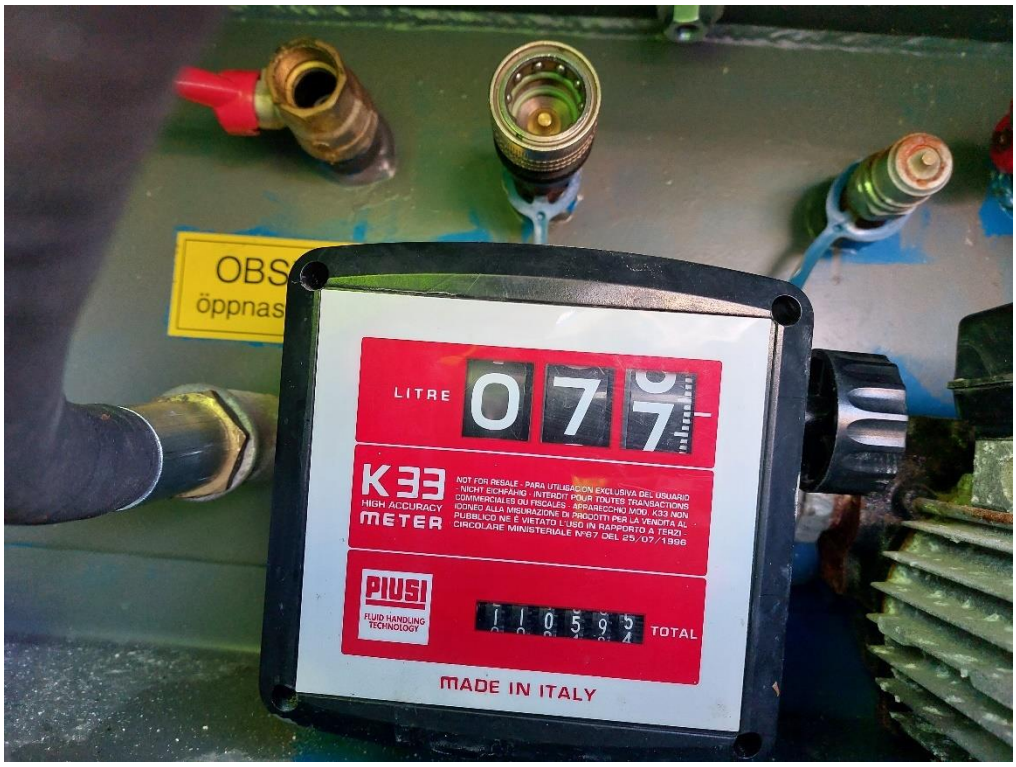

Figure 18. Reading on fuel meter after day 1, week 2. Standard mode with high frequency; 77,3 liters. (Three liters are to little?)

Figure 19. A view over the working site. The roller is to the left just below the horizon (below the arrow)**.**

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Figure 20. Reading on fuel meter after day 2, week 2. Eco mode; 67,7 liters.

Figure 21. Day three week two, Eco Mode + Seismic on a quite wet surface.

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Figure 22. The working roller.

Figure 23. Reading on fuel meter after day 3, week 2. Eco mode + Seismic; 55,4 liters.

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Figure 24. After work. The parked roller after the two weeks of testing at Verkö in Karlskrona, February 17, 2022.

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Appendix C, Dynapac CA3500D – Technical data

Dynapac CA3500D

Single drum vibratory rollers

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Technical data

Masses	
Operating mass (incl. ROPS)	11900 kg
Operating mass (incl. Cab)	12100 kg
Module mass (front/rear)	7600 kg/4500 kg
Max. operating mass	13800 kg

Dimensions	
Drum width	2130 mm

Traction	
Speed range (Dual/TC/AS)	4/6/7/12 km/h
Vertical oscillation	±9°
Tyre size (8 ply)	23.1 x 26 AW
Max. theoretical gradeability	55 %

Compaction	
Static linear load	36 kg/cm
Nominal amplitude (high/low)	1.9 mm/0.9 mm
Centrifugal force (high/low amplitude)	280 kN/170 kN
Vibration frequency (high/low amplitude) SEISMIC available (values for manual mode)	31 Hz /34 Hz

Engine	
Manufacturer/Model	Cummins QSF3.8 (IV/T4final)
Type	Water cooled turbo Diesel
Rated power, SAE J1995	97 kW (130 hp) @ 2200 rpm
Fuel tank capacity	255 l
DEF tank capacity	20 l

Engine	
Manufacturer/Model	Cummins F3.8 (V)
Type	Water cooled turbo Diesel
Rated power, SAE J1995	100 kW (135 hp) @ 2,200 rpm

Engine	
Manufacturer/Model	Cummins QSB4.5 (IIIA/3)
Type	Water cooled turbo Diesel
Rated power, SAE J1995	97 kW (130 hp) @ 2200 rpm

Hydraulic system	
Driving	Hydrostatic
Vibration	Hydrostatic
Steering	Hydrostatic
Service brake	Hydrostatic in forward and reverse lever.
Parking/ Emergency brake	Failsafe multidisc brake in drum gear box and in rear axle.

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Dynapac CA3500D

Single drum vibratory rollers

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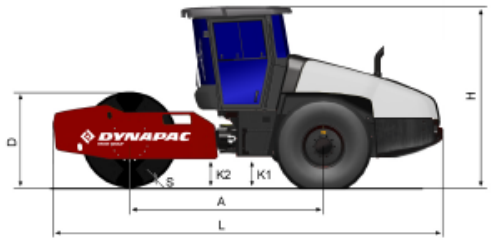
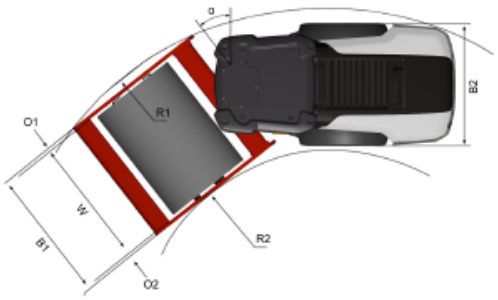
Technical data





Dimensions	
A. Wheelbase	2990 mm
B1. Width, front	2304 mm
B2. Width, rear	2130 mm
D. Drum diameter	1520 mm
H1. Height, with ROPS/cab	2880 mm
H2. Height, w/o ROPS/cab	2130 mm
K1. Ground clearance	450 mm
K2. Curb clearance	450 mm
L. Length	5990 mm
O1. Overhang, right	87 mm
O2. Overhang, left	87 mm
R1. Turning radius, outside	5450 mm
R2. Turning radius, inside	3300 mm
S. Drum shell thickness	35 mm
W. Drum width	2130 mm
α. Steering angle	±38°

Optional equipment

Air Conditioning /Automatic Climate Control (ACC) (Optional)

- The system contains fluorinated greenhouse gases.
- Coolant designation: HFC-134a
- Coolant weight when full: 1,35 kg
- CO_2-equivalent: 1930 ton
- GWP: 1430

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