General information about axle load calculations

All types of transportation work using trucks require the truck chassis to be supplemented by some form of bodywork.

The aim of axle load calculations is to optimise the chassis and bodywork location.

It is important to be able to transport the maximum payload without exceeding the maximum permitted axle and bogie weight, taking into account the legal requirements and technical limitations.

In order to carry out load optimisation, information concerning the chassis weights and measurements is required.

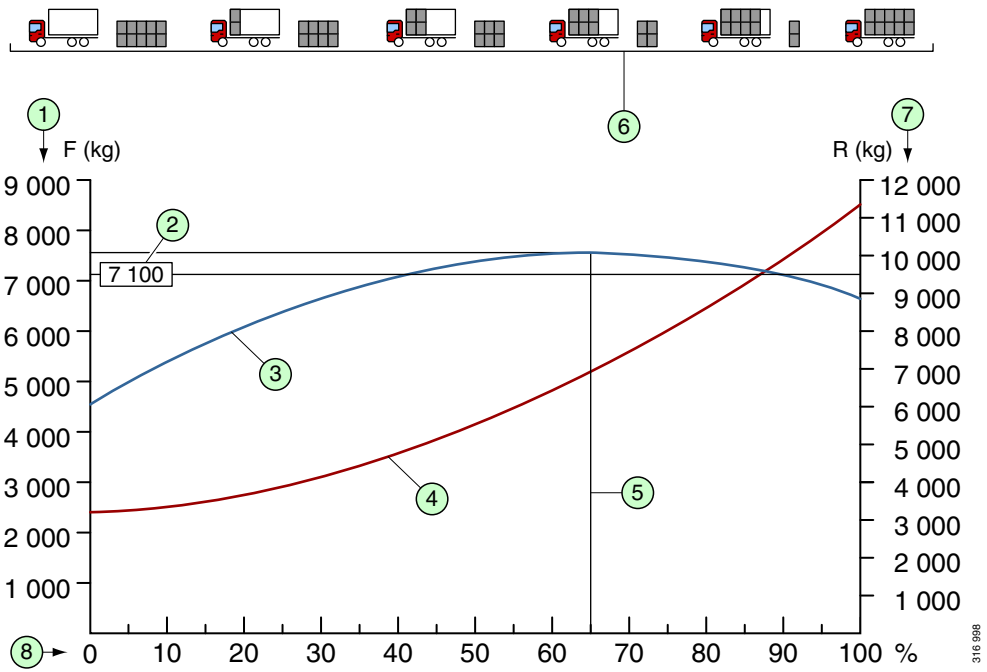
- The difference between the right-hand and left-hand wheel loads on an axle must not exceed 3 % of the total axle load. An uneven load will cause the vehicle to lean to one side.
- To ensure that the vehicle has good traction, at least 20 % of the vehicle weight must fall on the steered axles. Local regulations may, however, specify a different distribution.

Example

In some cases higher axle weights occur when a truck is partially laden than when it is fully laden. The figure shows that maximum front axle weight is attained when the truck is laden to about 65%.

In this case the maximum front axle weight is higher than permitted at 65 % load, despite being less at full load.

When calculating for refuse vehicles, for example, the conditions are reversed. Because they are loaded from the rear a higher rear axle weight can occur for loads less than full load.



1. Load on the front axle (kg)
2. Maximum front axle weight
3. Load curve for the front axle
4. Load curve for the rear axle
5. Highest load on front axle when unloading
6. Show how the vehicle is unloaded from the rear
7. Load on the rear axle (kg)
8. The size of the load as a percentage of the maximum load

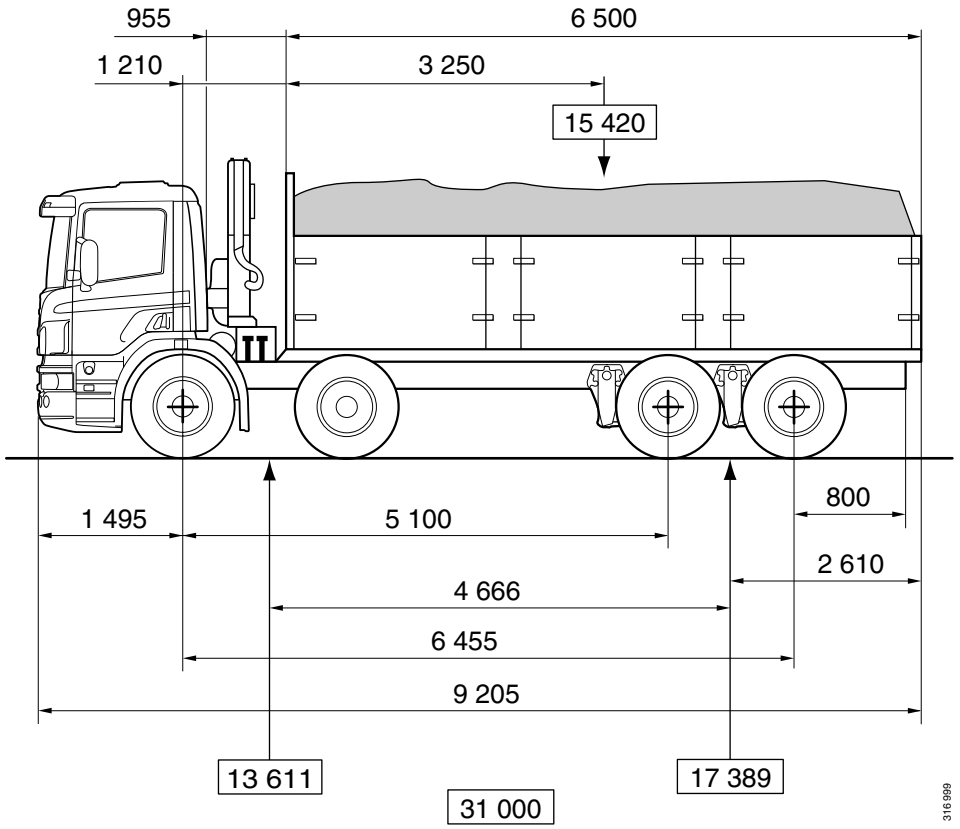
Axle load calculations

Scania distributors and dealers have a computer-based calculation program for load optimisation, which is an aid to axle weight calculations.

Example of result from an axle weight calculation:

	Front	Rear	Total
Chassis weight	6 445	2 585	9 030
Extra weight	0	0	0
Bodywork weight	1 146	3 404	4 550
Weight 1-4	0	0	0
Bodywork equipment	2 135	-135	2 000
Kerb weight	9 726	5 854	15 580
Load 0	3 885	11 535	15 420
Load 1–4	0	0	0
Cargo weight	3 885	11 535	15 420
Empty weight	9 756	5 854	15 580
Cargo weight	3 885	11 535	15 420
Gross laden weight	13 611	17 389	31 000
Maximum weight	14 200	19 000	32 000
Marginal weight	589	1 611	1 000

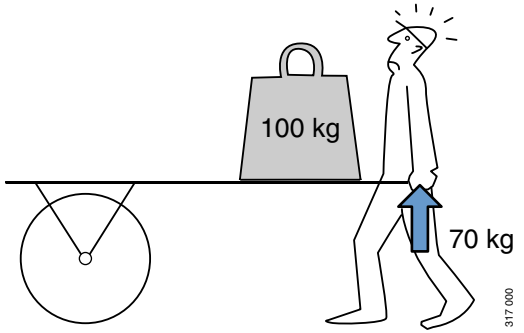
Weight on steered axles	66 %
On steered front axles	43 %
Skid limit, Asphalt	31 %
Skid limit, Gravel road	18 %



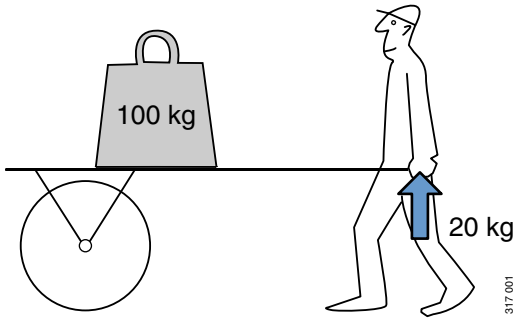
The lever principle

The lever principle can be described with the following example (the trolley in the example is assumed to be weightless).

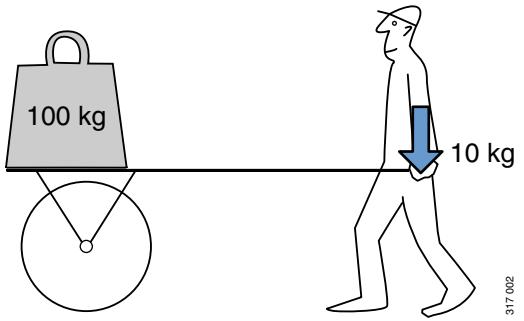
The trolley's two ground supports consist of a wheel at one end and a person who lifts the other end of the trolley. When a load is placed near the person he must bear a large part of the load, while the wheel bears a lighter part.



By moving the load nearer to the wheel, the loading on the wheel increases and the person only has to bear a lighter load.



If the weight is placed in front of the centre of the wheel, the person must press down on the trolley handle to prevent the trolley tipping forward.



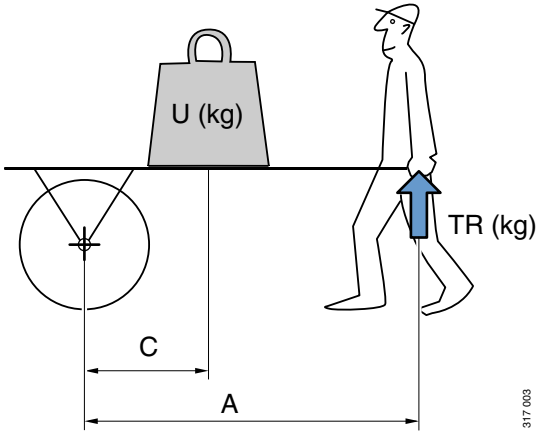
The load for the person varies in relation to the position of the load on the trolley.

When the system is not moving, the sum of all forces and torques equals 0. When there is a torque equilibrium around the centre of the wheel, the following equation will apply.

U = The load
TR = The load (the load's reacting force on the person)
C = The distance from the centre of the wheel to the load's centre of gravity
A = The distance between the ground supports (centre of wheel and the person)

$$U \cdot C = TR \cdot A$$

The load · its lever = the load· its lever



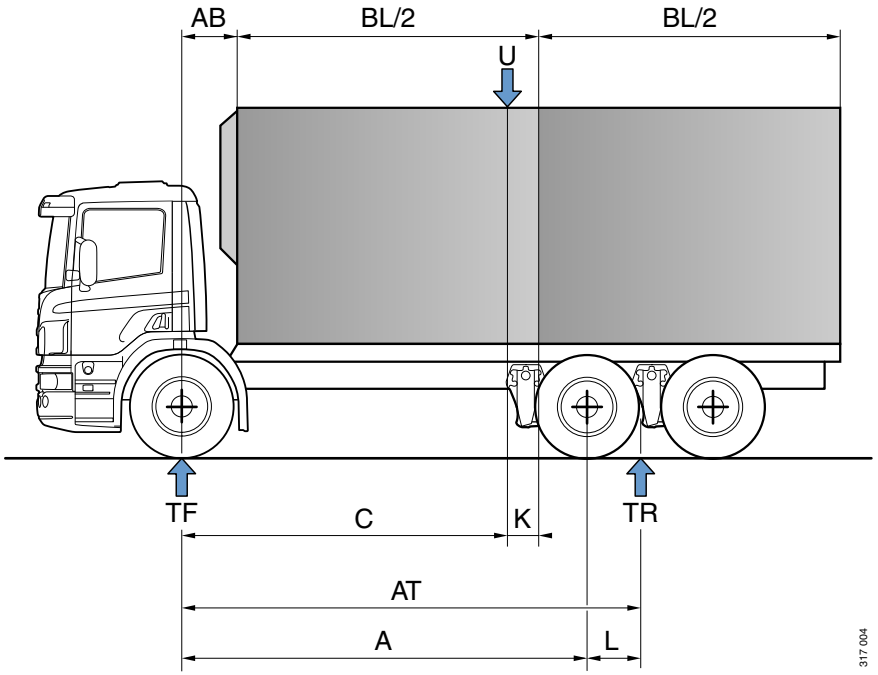
Concept and calculations

Axle weight and bodywork calculations are based on static equilibrium,

- The sum of the downward forces is equal to the sum of the upward forces. This means that the sum of the weight of all the truck's components and its load is as great as the truck's axle weights.
- The sum of the torques exerted by the forces of gravity around a point is the same as the sum of the torques exerted by the reaction forces around the same point. This is described by the lever principle in the previous section. The wheels in the previous example can be replaced by the truck's front wheels and the person by the rear wheels.

Measurements

Scania	BEP	Explanation
A	L011	Distance between the first front axle and the first driving axle
AB	L002	Distance from front axle to bodywork
Q	L012.1	Distance between front axles
LL	-	Distance between the first front axle and theoretical load centre for both front axles
L	L014	Distance between the first driving rear axle and the theoretical load centre for the bogie
AT	L015	Theoretical axle distance, distance between front and rear theoretical load centre
BL	-	External length of the load carrier
K	-	Distance between the centre point of the load bearer and the centre of gravity for load and bodywork
C	-	Distance between front load centre and centre of gravity of load and bodywork or extra weight



Weights and formulae

Type of weight:			Distributed weight	
			Front	Rear
T	=	Total weight of laden vehicle	TF	TR
W	=	Chassis weight	WF	WR
N	=	Extra weight, for example crane	NF	NR
U	=	Load and weight of bodywork	UF	UR

Use the following formulae:

$$T = W + N + U$$

$$C \cdot U = AT \cdot UR$$

Or in written form:

$$C = \frac{AT \cdot UR}{U}$$

$$U = UF + UR$$

In order to obtain an equilibrium, the total weight of the load and bodywork U multiplied by its lever C should give the same result as the proportion of U which lies over the centre of gravity of the rear axle, UR, multiplied by the theoretical axle distance, AT.

Calculate C so that you can then calculate the load surface BL. The location of load surface, BL, is generally determined by the deviation, K, having to be as close to 0 as possible.

Obtain the following information:

- Permitted axle weight
- Truck weights and axle distance
- Weight of bodywork and of any additional equipment

Calculation	Front weight (kg)		Rear weight (kg)		Total weight (kg)	
Total weight of laden vehicle		TF		TR		T
Chassis weight	-	WF	-	WR	-	W
Extra weight	-	NF	-	NR	-	N
Load + bodywork	=	UF	=	UR	=	U

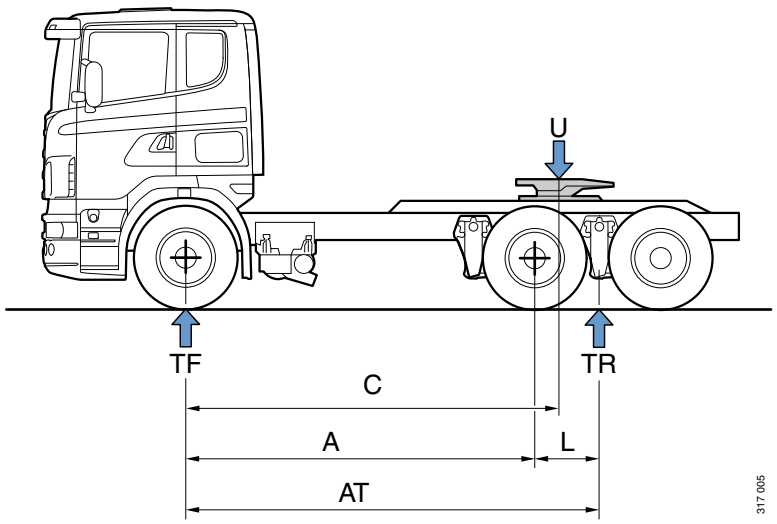
Here are five calculation examples.

Example 1: Tractor with wheel configuration 6x4

The aim of the calculation is to find out where the fifth wheel (C) must be located, to obtain the optimum axle weight.

Start the calculation by obtaining the following facts:

- Maximum permitted axle weight
- Truck weights and axle distance



A = 4,300 mm

L = 677.5 mm

AT = A + L = 4,977.5 mm

Calculation	Front weight (kg)	Rear weight (kg)	Total weight (kg)
Total weight[a]	TF = 7,000	TR = 19,000	T = 26,000
Chassis weight	- WF = 4,790	- WR = 3,350	- W = 8,140
Load + fifth wheel	= UF = 2,210	= UR = 15,650	= U = 17,860

a. Laden vehicle

Calculate C using the following calculation:

$$C = \frac{AT \cdot UR}{U} = \frac{4\,977{,}5 \cdot 15\,650}{17\,860} = 4{,}362 \text{ mm}$$

In order to utilise the maximum permitted axle weights, the fifth wheel should be positioned 4,350 mm behind the front axle, K is then 0.

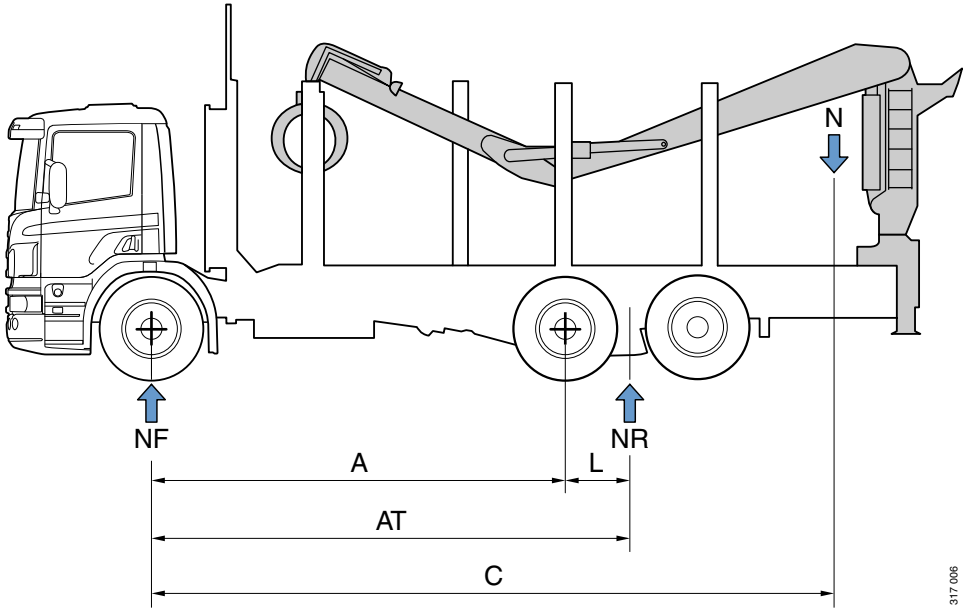
Example 2: Truck with rear mounted crane and wheel configuration 6x2

The purpose of the calculation is to determine the weight distribution of the crane on the front and rear axles respectively.

Start the calculation by obtaining the following facts:

- Maximum permitted axle weight
- Truck weights and axle distance
- Weight and centre of gravity of crane

A = 4,600 mm
L = 612 mm (6x2)
AT = A + L = 4,600 + 612 = 5,212 mm
C = 7,400 mm
N = 2,500 kg



By using the lever principle the following calculation can be made:

$$NR = \frac{N \cdot C}{AT} = \frac{2\,500 \cdot 7\,400}{5\,212} = 3{,}550 \text{ kg}$$

NR = 3,550 kg on condition that:

NF = N - NR = 2,500 - 3 350 = -1,050 kg

NF = - 1,050 kg

Note that the weight on the front axle is negative, in other words the weight on the front axle reduces.

For calculations on the entire vehicle, NF and NR are inserted in the relevant centres of gravity in the continued calculation.

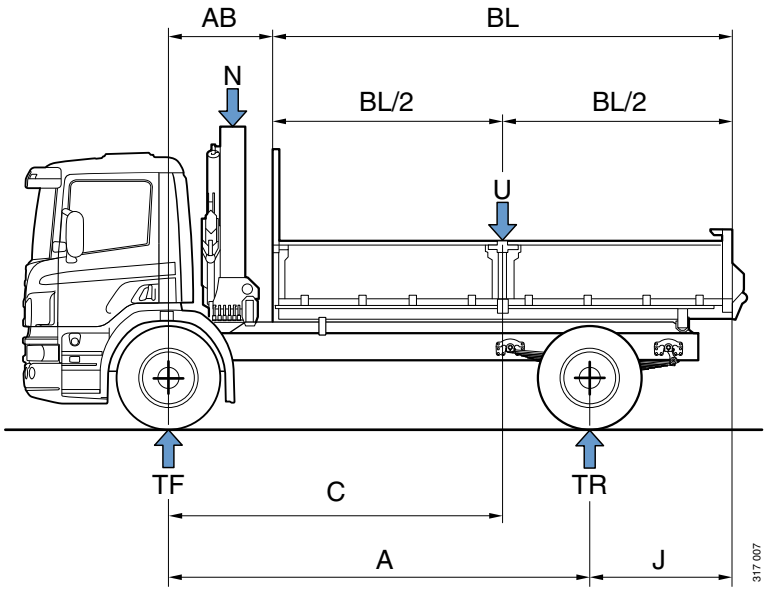
Example 3: Truck with crane behind cab and wheel configuration 4x2

The purpose of the calculation is to determine the weight distribution of the crane on the front and rear axles respectively and a suitable platform length for the bodywork.

Start the calculation by obtaining the following facts:

- Maximum permitted axle weight
- Truck weights and axle distance
- Weight and centre of gravity of crane

See example 2 for the calculation of the weight distribution of the crane on the axles.



A	=	AT = 4,300 mm
AB	=	At least 1,100 mm according to crane description and calculation
WF	=	4,260 kg
WR	=	1,848 kg
N	=	1,950 kg

Calculation	Front weight (kg)	Rear weight (kg)	Total weight (kg)
Total weight[a]	TF = 7,500	TR = 11,000	T = 18,500
Chassis weight	- WF = 4,260	- WR = 1,848	- W = 6,108
Equipment, crane	- NF = 1,586	- NR = 364	- N = 1,950
Load + bodywork	= UF = 1,654	= UR = 8,788	= U = 10,442

a. Laden vehicle

Calculate C using the following calculation:

$$C = \frac{AT \cdot UR}{U} \qquad C = \frac{4\,300 \cdot 8\,788}{10\,442} = 3{,}619 \text{ mm}$$

Enter the shortest possible AB measurement to obtain the longest load surface (BL) possible with optimum axle weight distribution.

$$C = AB + BL/2 \qquad 3\,619 = 1\,100 + BL/2 \qquad BL/2 = 2\,519 \text{ mm}$$

The longest possible load surface (BL) with optimum axle weight distribution is 5,038 mm. Use the tipper body that has a standard length of 4,400 mm. The previous calculation shows that the tipper body has space behind the crane.

Calculate the AB dimension to be able to select the tipper body with the optimal length and acceptable rear overhang.

$C = AB + BL/2$ 3 619 = AB + 2,200 AB = 1,419 mm

The rearmost point of the tipper body from the front axle is:

C + BL/2 = 3,619 + 2,200 = 5,819 mm

The overhang (J) behind the rear axle is then as follows:

(C + BL/2) - A = 5,819 - 4,300 = 1,519 mm

If the tipping axle is 1,000 mm behind the rear axle there is an overhang of 519 mm behind the tipping axle. This is an acceptable value and the choice of a tipper body with a length of 4,400 mm does not need to be changed.

Example 4: Tipper truck with wheel configuration 8x4*4

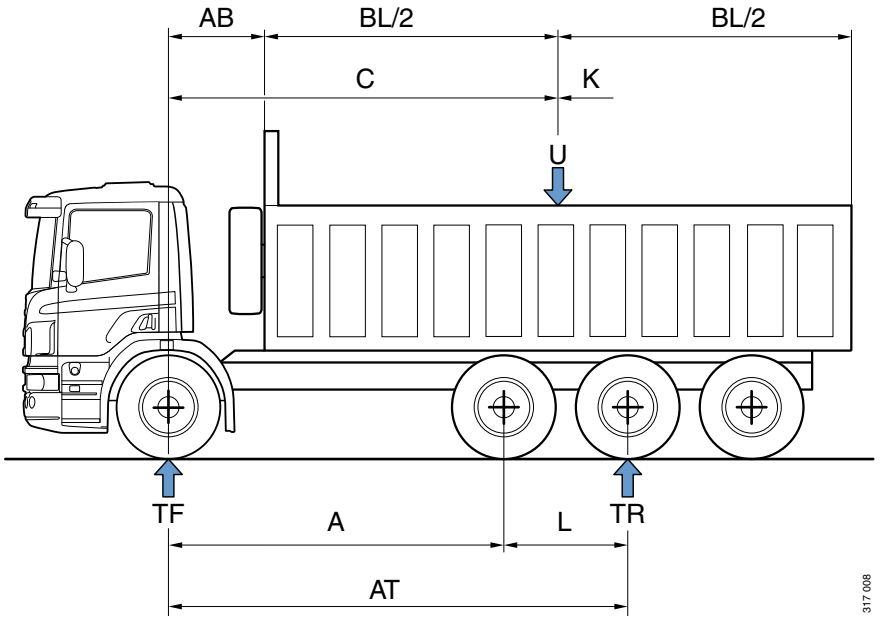
The aim of the calculation is to obtain a suitable length for the load area (BL) and location without exceeding the maximum permitted axle weight. The chosen length should also provide a suitable overhang in order to achieve good tipping stability in this case.

Start the calculation by obtaining the following facts:

- Maximum permitted axle weight
- Truck weights and axle distance
- Weight of bodywork and of additional equipment

In this example with a tipper truck the calculation is made with an evenly distributed load

The measurement (AB) is generally sought between the front axle and the front part of the bodywork. The minimum permitted AB measurement is indicated for different cab lengths. The minimum AB measurement for the 14 cab is indicated as 320 mm.



A = 3,350 mm
K = 0
L = 1,256 mm
AT = A + L = 4,606 mm (according to ICD)

Calculation	Front weight (kg)	Rear weight (kg)	Total weight (kg)
Total weight[a]	TF = 7,100	TR = 24,000	T = 31,100
Chassis weight	- WF = 4,870	- WR = 4,585	- W = 9,455
Load + bodywork	= UF = 2,230	= UR = 19,415	= U = 21,645

a. Laden vehicle

Use the following formula for the calculation of C:

$$C = \frac{AT \cdot UR}{U} \qquad C = \frac{4\,606 \cdot 19\,415}{21\,645} = 4\,131$$

Use the following formula to calculate how long the longest bodywork (BL) can be with optimum axle weight distribution:

$$C + K = AB + BL/2 \qquad 4{,}131 = 320 + BL/2 \qquad BL = 7{,}622 \text{ mm}$$

The longest bodywork with optimum axle weight distribution is 7,622 mm.

Use the tipper body that has a standard length of 6,200 mm. The following calculation shows that the tipper body selected has space. Calculate the AB measurement to see which platform length gives an acceptable rear overhang.

C = AB + BL/2 4 131 = AB + 6,200/2 AB = 1,031 mm

For a tipper platform with a load surface (BL) of 6,200 mm the tipper platform's rearmost point from the front axle is as follows:

C + BL/2 4,131 + 3,100 = 7,231 mm

The axle distance for the bogie is 1,355 + 1,305, which is shown on the vehicle's ICD.

The overhang behind the last axle is:

(C + BL/2) - (A + 1,355 + 1,305) = (4,131 + 3,100) - (3,350 + 1,355 + 1,305) = 7,231 - 6,100 = 1,221 mm

If the tipping axle is located 550 mm behind the last rear axle, an overhang of 1 221 - 550 = 657 mm is obtained behind the tipping axle. This is an acceptable value and the choice of a tipper body with a length of 6,200 mm does not need to be changed.

Example 5: Concrete mixer truck with wheel configuration 8x4

The purpose of the calculation is to obtain the optimum location of the concrete mixer at the highest permitted axle weight.

Start the calculation by obtaining the following facts:

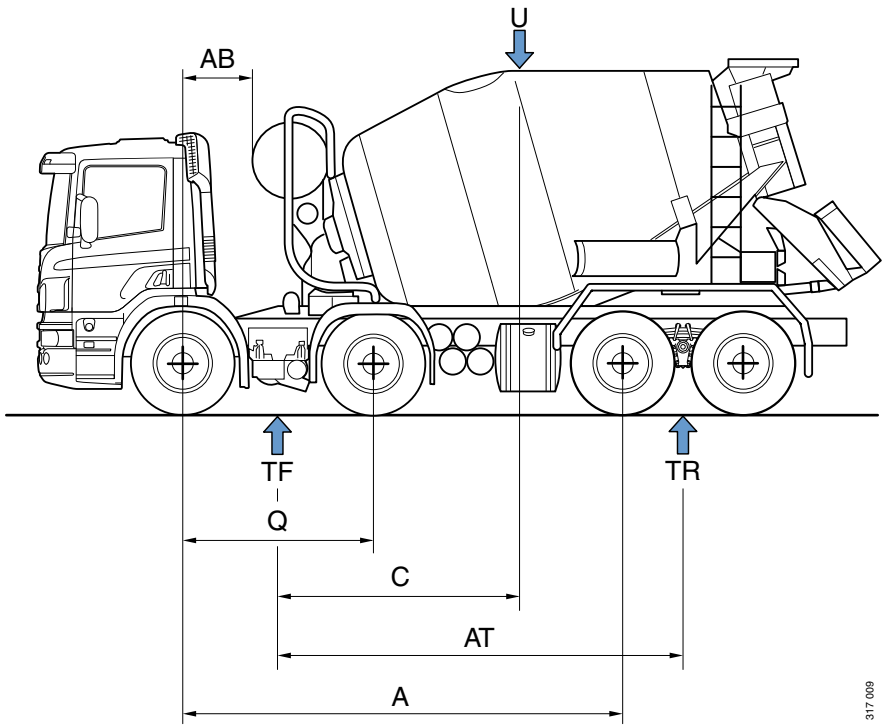
- Maximum permitted axle weight
- Truck chassis weight and axle distance
- Weight of bodywork and additional equipment and their respective centres of gravity (CG).

AT = 4,005 mm

CG = 2,941 mm, measurement from the front edge of the bodywork

Calculation	Front weight (kg)	Rear weight (kg)	Total weight (kg)
Total weight[a]	TF = 13,000	TR = 19,000	T = 32,000
Chassis weight	- WF = 6,385	- WR = 2,720	- W = 9,105
Load + bodywork	= UF = 6,615	= UR = 16,280	= U = 22,895

a. Laden vehicle



Calculate C to find out where the centre of gravity should be located in relation to the front load centre.

$$C = \frac{AT \cdot UR}{U} = \frac{4\,005 \cdot 16\,280}{22\,895} = 2{,}848 \text{ mm}$$

To determine the location of the concrete mixer in relation to the first front axle the AB measurement is calculated. Since C starts from the front load centre, half the front axle distance, in this case 1 940/2 = 970 mm, is used.

AB = C - CG + half front axle distance = 2,848 - 2,941 + 970 = 877 mm

Locate the concrete mixer 877 mm behind the first front axle.