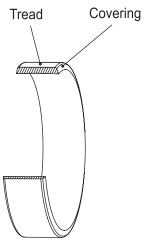
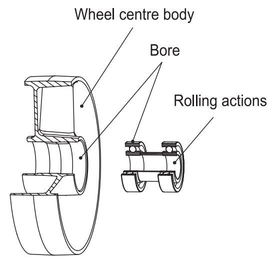
1. GENERAL INFORMATION





The wheel is a mechanical assembly in which sliding motion is replaced by rolling motion through rotation around an axis. The wheel consists of the following components:
the tread, the covering, the wheel centre body, the bore and the rolling action.

- **Tread**

The tread is the wheel's outer surface, i.e. the part that comes in contact with the ground. It can be smooth or engraved with raised patterns to increase its grip on the ground.

- **Covering**

The covering, or rolling strip, is the outer ring. It is made of different materials and characterises the wheel. The covering is fixed when joined with the wheel centre body as a single solid piece (using an adhesive or through a mechanical connection) or fitted when mechanically assembled on the wheel centre body.

- **Wheel centre body**

The wheel centre body is the wheel part that connects the covering to the bore. It comes in various shapes and is made of different materials; it can be a single piece or two or more parts joined together.

- **Bore and rolling actions**

The bore is the middle part of the wheel that houses the axle or the rolling actions that make rotation easier (ball bearings, roller bearings, plain bearings, etc.).
Depending on the construction methods and materials forming the covering, wheels can be divided into three families: rubber wheels, polyurethane wheels and monolithic (or hard tread) wheels.

1.1 Rubber wheels

A rubber wheel covering consists of an elastomer made from natural and/or synthesised rubber. The rubber used to build industrial wheels can be vulcanised or injection moulded.

- **Vulcanised rubber:** special mineral loads and vulcanising agents are added to the rubber that under goes a process called "vulcanising". During this process, the rubber's molecular structure changes significantly: the "pasty" material at the beginning of the process becomes a non-fusible product that acquires and, over time, maintains the form of the mould in which the reaction occurs. The ring obtained is mechanically assembled to the wheel centre body. Vulcanised rubber has enhanced elastic deformability properties within relatively broad ranges of applied traction and compression loads. The physical-mechanical characteristics of vulcanised rubber vary according to the quality of the natural and/or synthesised rubber used, the type and quantity of mineral loads added and the conditions under which the vulcanisation process takes place.

- **Injected rubber:** the rubber goes through a chemical synthesis process. The material obtained is injected into a mould in which the wheel centre body has already been inserted. The injected rubber maintains its fusibility even after moulding. Normally, the elastic properties of injected rubber are worse than those of the best quality vulcanised rubber, even though they are comparable to those of medium and low-quality vulcanised rubber. The following are some of the main physical-mechanical parameters relative to the quality of rubber (for the definition of each parameter see the standards indicated next to that parameter):

  - hardness UNI EN ISO 868:1999; ASTM D 2240-2004
  - specific density UNI 7092:1972; ISO 2781:1988
  - impact strength UNI 7716:2000; ISO 4662:1986
  - abrasion loss UNI 9185:1988; DIN 53516:1987
  - ultimate tensile strength UNI 6065:2001; ISO 37:1994; ASTM D 412c-1998
  - ultimate elongation UNI 6065:2001; ISO 37:1994; ASTM D 412c-1998
  - tearing resistance UNI 4914:1987; ASTM D 624b-2000
  - compression set UNI ISO 815:2001

These parameters are not independent; in other words, changing one of them usually leads to a change in other parameters (to varying degrees). Hardness is the easiest parameter to determine: in general, increased hardness reduces the elastic properties (impact strength, ultimate elongation, compression set) and lowers overall wheel performances. Instead, parameters such as tearing resistance and abrasion loss depend mainly on the composition of the vulcanised rubber and, to a lesser extent, on hardness.

1.2 Polyurethane wheel

A polyurethane wheel covering consists of an elastomer obtained exclusively from the synthesis of raw materials. Polyurethanes are chemical compounds obtained from a polymerisation reaction triggered by mixing two components, belonging to two different families of compounds (Di-Isocyanates and Polyalcohols), that were previously heated to temperatures that keep them in the liquid state with relatively low viscosity. In general, elastomer polyurethanes do not contain any additional mineral loads. The reactive mix is cast or injected into heated moulds containing the metal or plastic centres. Thanks to the temperature of the mould and of the wheel centre body, the polymerisation reaction can be completed inside the polyurethane, while the polyurethane is chemically linked to any adhesive that may be present on the surface of the wheel centre body.

- **Mould-on polyurethane** is no longer fusible, has good elasticity characteristics in addition to medium-high hardness and compression and traction strength.

- **Injected polyurethane** is fusible even after moulding; in general, it has inferior elasticity characteristics but superior hardness with respect to mould-on polyurethane.

- The following are some of the main physical-mechanical characteristics of polyurethane (for the definition of each characteristic see the standards indicated next to that parameter):

- hardness UNI EN ISO 868:1999; ASTM D 2240-2004
- specific density UNI 7092:1972; ISO 2781:1988
- impact strength UNI 7716:2000; ISO 4662:1986
- abrasion loss UNI 9185:1988; DIN 53516:1987
- ultimate tensile strength UNI 6065:2001; ISO 37:1994; ASTM D 412c-1998
- ultimate elongation UNI 6065:2001; ISO 37:1994; ASTM D 412c-1998
- tearing resistance UNI 4914:1987; ASTM D 624b-2000
- compression set UNI ISO 815:2001.

1.3 Monolithic (hard tread) wheels

In monolithic (hard tread) wheels, the wheel centre body and the covering are made with the same material. The physical-mechanical characteristics of the wheel will change depending on the material used.

2. BRACKETS

The bracket is the part that connects the wheel to the equipment. Normally, all wheels need a bracket to be applied to the equipment; an exception is made for wheels whose axle is built into the equipment. Brackets can be the swivel or the fixed type.
ELESA wheels are coupled to various types of bracket made out of zinc-plated steel sheet, AISI 304 stainless steel or electro-welded steel described in detail in the respective product data sheets.
The description of the brackets made out of steel sheet follows by way of example.

2.1 Swivel bracket

The swivel bracket rotates around its own vertical axis as the running direction changes. The wheel axis is misaligned with respect to the bracket axis so that it is easier to manoeuvre the equipment. "Manoeuvrability" is defined as the ability of the equipment to change direction, while "directionality" refers to the equipment's ability to maintain a trajectory along a specific direction. Excessive offset reduces equipment directionality due to "sliding" of the wheel (the "Swimmy" effect). Swivel brackets can also be equipped with brakes. The swivel bracket consists of a connecting plate, a fork, a ball race ring, swivel actions, a central pin and, if necessary, a dust seal.

- **Fitting plate**

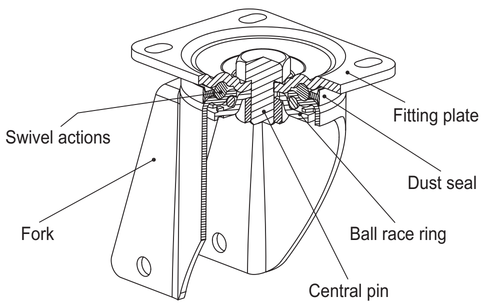
The fitting plate is used to connect the bracket to the equipment (four connection holes).

- **Wheel support fork**

The fork is the piece with the characteristic upside-down "U" shape that supports the wheel. Holes are drilled at the bottom to house the wheel's axle set, while the swivel actions are inserted in the top.

- **Ball race ring**

The ball race ring contains the castor's swivel actions.
In special cases, it can also be used only as a dust seal or a guard.



- **Swivel actions**

Swivel actions allow the plate to rotate on the fork. They consist of a ring of balls in contact between the plate and the fork (called "ball gyro") lubricated with grease to protect against dust, liquids and other aggressive agents. The bracket load capacity varies significantly according to the type of swivel action being used.

- **Central pin**

The central pin is the part that joins the plate and the ball race ring. Thanks to the central pin, the plate and the ball race ring form a single piece, while the fork is free to rotate around its own axis. The pin can:

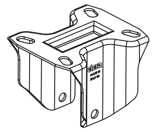
- be incorporated in the plate, through forming and riveting after assembling the parts;
- be incorporated in the plate, through hot forming on the plate and tightening with a self-locking nut;
- consist of a screw and a nut.

- **Dust seal**

The dust seal protects the swivel actions of the bracket against dust and solid and medium-grain aggressive agents.

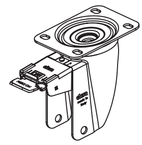
2.2 Fixed bracket

The fixed bracket is designed to keep the wheel moving in a specific direction; therefore, it guarantees equipment directionality. Instead, equipment manoeuvrability depends on the use of swivel brackets. In general, the fixed bracket consists of a single pressed steel plate shaped into an upside-down "U". Holes to house the wheel axle set are drilled at the bottom, while the equipment attachment holes are at the top.



2.3 Swivel bracket with brake

The brake is the device that allows the blocking of the rotation of the bracket around its axis, of the rotation of the wheel and of the rotation of the castor (wheel+bracket assembly).



3. AXLE SET

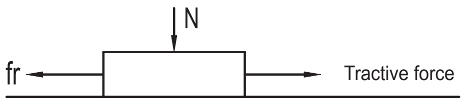
The axle set is the piece used to connect the wheel to the castor. Normally, it consists of a threaded pin with nut, washers, tube and, where necessary, spacers. For standard applications, the axle set can be riveted directly on the castor fork.

4. LOADS, FRICTION AND FORCES

Dissipative forces or friction occur along the contact surfaces between bodies and tend to oppose the movement.

4.1 Sliding friction

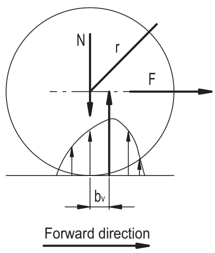
Sliding friction force opposes the movement between two contact surfaces that slide against each other. This force depends on the type of contact surfaces (materials and finishing level) and on the load applied in the direction perpendicular to the motion direction (Normal force).



In mathematical terms, the sliding friction force is defined as follows:
Fr=br x N where: **br** = sliding friction coefficient **N** = normal force (or load)

If two bodies are initially stationary, the resistance force is called the static friction force and represents the minimum force that must be applied to start moving the two bodies. When the two bodies are in relative motion, a force lower than the static friction force is sufficient to keep the speed constant: this is called the dynamic friction force. The friction coefficient is obtained experimentally for both static friction and dynamic friction.

4.2 Rolling friction



Rolling friction force is generated when two bodies roll on each other without sliding. Let's imagine a wheel with **radius r** subjected to a **load N**. As the wheel approaches the contact point, the material is compressed and afterwards, once the contact point has been surpassed, undergoes an elastic release. If the material used to manufacture the wheel is not perfectly elastic, some of the energy required for compression is lost in the subsequent return phase – dissipated in the form of heat to counteract internal frictional resistance of the material. If we think in terms of forces, instead of energies, we could say that the distribution of pressure in the contact is not symmetrical compared to the direction of force N. The diagram of pressure generates, therefore, a resultant equal to N but moved forward with respect to the wheel axis by a distance bv (arm of the rolling friction). The displacement of the resultant generates a moment of resistance. To keep the wheel turning evenly it is necessary to apply a motive moment identical to and opposite **Mr** or a **traction force F** parallel to the forward direction and such that.
From the previous formulas we obtained:

$$F = \frac{M_r}{r} = \frac{b_v \times N}{r} = f_v \times N$$

Where:

$$f_v = \frac{b_v}{r}$$

With **fv** known as the **rolling friction coefficient** which can be found with experimental tests.

4.3 Tractive force

Tractive force is the force needed to overcome the resistance caused by friction when two bodies slide or roll on each other. Compared to the resistance generated by friction, tractive force has the same intensity and the same sense, but the opposite direction. The lower the force needed to keep a equipment moving, the greater the smoothness of the wheel applied to the moving equipment. In the specific case of a wheel rolling on a flat surface, the tractive force must overcome the resistance caused by rolling friction - that arises when the wheel comes in contact with the surface - and by sliding friction - generated by the mechanical bore and axle set coupling.

5. CHOOSING THE RIGHT WHEEL

Any product that isn't used under the conditions for which it was designed may not satisfy the user's needs. It may also damage materials and cause injuries. Here are some examples in which wheels and castors are used incorrectly:

- using a wheel not suitable for the floor will deteriorate the wheel covering and damage the floor;
- choosing a fixed castor under operating conditions for which a equipment must be vey manoeuvrable will make it extremely difficult to move that equipment;
- applying a load that exceeds the wheel's rated load capacity will lead to wheel malfunctions and premature deterioration.

Therefore, a technical analysis of the operating conditions must be performed. The most economical solution should be chosen only after the product has been technically evaluated. The purpose of performing a technical analysis on a equipment moving solution is to define the operating conditions and any external factors that may affect equipment use. The following factors must be analysed in order to choose the right wheel:

- **nature and condition of the ground (5.1)**
- **environment (5.2)**
- **magnitude and nature of the load (5.3)**
- **speed and means of traction (5.4)**
- **manoeuvrability (5.5)**
- **diagrams (5.6)**

The process of choosing the right wheel to match the operating conditions can be divided into three steps: **step one:** identifying the correct type of wheel based on the floor and the characteristics of the operating environment; **step two:** calculating the dynamic capacity, static load and rolling resistance required by the specific application and, therefore, determining the wheel diameter; **step three:** identifying the correct bracket and checking the dynamic capacity of the castor (wheel+bracket assembly). If the evaluation of these various aspects generates different data with reference to the same wheel and/or castor characteristic, the final choice must be made based on the most conservative condition.

• Static load[N]

Static load is the maximum load that a motionless (stationary) wheel can support without generating any permanent deformations that may reduce its operating efficiency. A wheel mounted on a equipment that is seldom moved, and therefore almost always remains in the same position, is defined as being subjected to a static load.

• Dynamic carrying capacity

Dynamic carrying capacity of a wheel is defined as the value (expressed in N) of the maximum load that can be supported by that wheel in conformity with ISO 22883:2004 and UNI EN 12532:2001 that, for industrial wheels, require dynamic testing under the following conditions:

- constant speed of 1.1 m/s (4 km/h)
- overcoming 500 obstacles and 15,000 revolutions of the diameter;
- obstacles with width 100 mm and height 5% of the wheel diameter with an elastic rolling strip (hardness up to 90 Shore A) and 2.5% of the diameter for wheels with a rigid rolling strip (hardness greater than 90 Shore A);
- temperature 20 °C (tolerance ± 10 °C);
- non-continuous operation (3 minutes of operation and 1 minute stopped);
- smooth, hard and horizontal floor.

• Rolling resistance

Rolling resistance is the value (expressed in N) of the maximum load that can be supported by each single wheel at a constant speed of 4 km/h with application of a tractive force or thrust equal to 50N (excluding the initial pickup). This value is obtained by applying a tractive force of 200N to a 4-wheeled equipment and measuring the magnitude of the maximum transportable load per wheel during normal moving conditions. The applied tractive force of 200N complies with the international workplace standard for indoor moving and is universally recognised as the human fatigue limit that can be supported for extended periods of time.

5.1 Nature and condition of the ground

The nature and condition of the ground and the presence of any obstacles will havean influence on choosing the right wheel. They are also important factors affecting the performance of the moving equipment as well as the efficiency and the duration of the wheels and castors. Special attention is required for cases involving uneven floors or where obstacles are present. In this case, the impact of the wheel against an obstacle generates advancement resistance whose magnitude depends on the elasticity of the rolling strip material. In fact, the energy absorbed during an impact is greater in a wheel with an elastic rolling strip than in a rigid wheel, thus partially cancelling the braking effects caused by the obstacle. For floors that are uneven or on which obstacles are present, with load capacity being equal, a wheel with a greater diameter should be chosen in order to overcome the obstacle. The wheel must be chosen very carefully in all cases in which there are obstacles, chemical and/or organic substances and machining residues. The main types of flooring are: tiles, asphalt, cement-resin, not paved floor, expanded metal floor, floor with chips, obstacles etc.

The main floor-wheel covering combinations are listed in the following table.

Floor type	Suitable covering
Tiles	Polyurethane or rubber
Asphalt	Rubber
Cement-resin	Polyurethane or rubber
Not paved	Rubber
Expanded metal	Rubber
With chips/obstacles	Rubber

5.2 Environment

To choose the right wheel, it's also important to determine if the wheel materials are compatible with the chemical-environmental conditions, the temperature, the humidity and the inductive electrostatic phenomena that may affect wheel operation. The standard operating conditions are indicated in the manufacturer's catalogue for each type of wheel.

Chemical-environmental conditions

Because there are so many different types of aggressive chemical agents in work environments, it's difficult to provide a complete and exhaustive description.The main chemical substances that a wheel may come in contact with include: weak acids (e.g. boric acid, sulphurous acid), strong acids (e.g. hydrochloric acid, nitric acid), weak bases (e.g. alkaline solutions), strong bases (soda, caustic soda), chlorinated and aromatic solvents (e.g. acetone, turpentine), hydrocarbons (e.g. petrol, oil, diesel oil, mineral oils), alcohol (e.g. ethyl alcohol), fresh water, salt water, saturated steam. Therefore, when choosing a wheel, it's very important to check if the material forming the covering, the wheel centre body, the rolling actions and the bracket is compatible with the specific features of the operating environment. Caution is required in those sectors in which water, acids, bases, steam and other aggressive agents are often present. For example, a polyurethane wheel should be used instead of a tyred wheel in environments with a large quantity of oils, fats and hydrocarbons, while it is recommended to use stainless steel castors in humid environments and in the presence of high saline concentrations.

Temperature

If operating temperatures in an application differ from the standard range of values indicated by the manufacturer, check the resistance of the wheel materials. This not only applies to the rolling strip and the wheel centre body, but also to the type of lubricant used (it may be necessary to contact the manufacturer). The indicative percentages of carrying capacity variation as a function of temperature are shown in the following table.

Temperature range [°C]		Carrying capacity variation coefficient (1 = 100% of the carrying capacity)											
from	to	RE.FF	RE.F2	RE.F5	RE.F5-ESD	RE.F4	RE.F7	RE.F8	RE.G1	RE.E2	RE.E3	RE.G2	RE.G5
-40	-20	▲	▲	▲	▲	▲	0,50	0,50	▲	▲	0,40	0,40	▲
-20	0	1,00	1,00	1,00	1,00	1,00	1,00	1,00	0,80	1,00	1,00	1,00	1,00
0	+20	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
+20	+40	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
+40	+60	0,90	0,90	0,90	0,90	0,90	1,00	0,90	0,85	0,85	0,85	0,85	0,90
+60	+80	0,70	0,80	0,80	0,80	0,80	1,00	0,70	0,50	0,60	0,60	0,60	0,80
+80	+120	0,40	▲	0,40	0,40	0,40	1,00	0,60	▲	▲	▲	0,40	0,40
> 120 °C		▲	▲	▲	▲	▲	1,00	▲	▲	▲	▲	▲	▲

▲ not recommended

The above-mentioned variation values refer to the prolonged and continued use (over 30 minutes) of the wheels at the specified ambient temperatures.

5.3 Magnitude and nature of the load

The magnitude of the load is the value [N] obtained by adding the weight to be transported to the equipment weight (tare). The nature of the load, either a liquid or a solid, has a significant effect on the wheel load capacity calculation. The formula to determine the load capacity for each wheel is:

$$Q = \frac{P_U + P_C}{n}$$

where: **Q** = load capacity for each wheel **Pu** = weight to transport **Pc** = equipment tare (equipment weight) n = number of wheels in contact with the ground

SOLID LOAD

For a solid load, n=3 for a four-wheeled equipment (where three out of four wheels are considered to be in contact with the ground at all times).

LIQUID LOAD

For a liquid load n=2 for a four-wheeled equipment (where two out of four wheels are considered to be alternatively in contact with the ground). A thorough analysis is indispensable when the equipment is part of an automated or continuous cycle production unit. In this case, all the forces that act on the wheel must be taken into consideration; therefore, it is recommended to include allowances and safety factors.

5.4 Speed and means of traction

Equipment speed is an important factor when choosing a wheel. In fact, if the speed is 0, and thus the use is mainly static, it is enough to compare the load capacity for each wheel with the static load indicated in the manufacturers' catalogues. If the speed is other than 0, then the means of traction must be taken into consideration. The means of traction is the tool used to exert the force that moves the body. In industry, traction devices can be manual or mechanical. Manual moving refers to the situation in which the force is exerted by one or more persons, while mechanical refers to the situation in which such force is exerted by a mechanical device (on-board drives or by using towing devices).

• Manual moving

For manual moving, the speed is generally less than or equal to 4 km/h. Choosing a wheel that allows only one operator to move a load should be based on a wheel rolling resistance value determined by the following formula:

$$S = \frac{P_u + P_c}{n}$$

where: **S** = rolling resistance **Pu** = weight to transport **Pc** = equipment tare (equipment weight) n = number of equipment wheels (maximum 4). The value obtained should be compared to the wheel rolling resistance value indicated in the manufacturer's catalogue.

• Mechanical moving with towing devices

In case of towed mechanical moving, the wheel should be chosen based on the equipment's operating speed. The wheel rated dynamic load capacity normally refers to a speed of no more than 4 km/h (1.1 m/s). If the speed is higher than 4 km/h, a correction factor must be applied to the load capacity value since the materials forming the wheel undergo chemical-physical changes during which their performances decrease with an increase in operating speed. The indicative percentages of load capacity variation with an increase in speed for different types of wheels are shown in the following table.

Speed range [Km/h]		**Carrying capacity variation coefficient (1,00 = 100% of the carrying capacity)**											
min	MAX	RE.FF	RE.F2	RE.F5	RE.F5-ESD	RE.F4	RE.F7	FE.F8	RE.G1	RE.E2	RE.E3	RE.G2	RE.G5
0,00	4,00	1,00	1,00	1,00	1,00	1,00	1,0	1,00	1,00	1,00	1,00	1,00	1,00
4,00	6,00	▲	1,00	0,80	0,80	0,80	▲	▲	▲	▲	▲	0,80	0,80
6,00	10,00	▲	0,80	▲	▲	0,60	▲	▲	▲	▲	▲	0,60	0,65
10,00	16,00	▲	0,60	▲	▲	0,40	▲	▲	▲	▲	▲	0,40	0,50
> 16 Km/h		▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲

▲ not recommended

• On-board mechanical movement

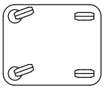
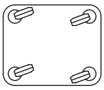
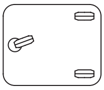
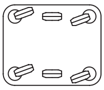
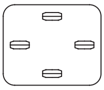
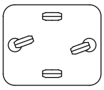
For equipments with an on-board drive (equipments with drive wheels – self-propelled equipments), the wheels are subjected to particular stress and strain. Besides supporting the load, the drive wheels must transmit the tangent stress that allows the wheel and therefore the equipment to advance. In addition, the drive wheel covering is subjected to even greater stress. In particular, when choosing wheels and castors for self-propelled equipments, the following factors must also be taken into consideration:

• type of plain or ball bearing applied in the bore;
• shaft/bore coupling tolerances;
• bore material in relation to shaft material;
• start and stopping frequency of the motion transmission part;
• direction reversals;
• presence of even temporary overloads.

Since many factors have to be evaluated, it is recommended to contact ELESA S.p.A. to choose the wheels and castors to apply to self-propelled equipments.

5.5 Manoeuvrability

Equipment manoeuvrability refers to the ability of a equipment to be moved more or less easily during use. The limited space available inside some production departments or particularly winding routes that sometimes connect a work unit to another may require special equipment manoeuvrability characteristics to make operator tasks easier. Swivel castors allow the equipment to rotate and the greater the castor offset (i.e. the distance between the bracket rotation axis and the wheel rotation axis), the easier the rotation. However, though it does guarantee excellent manoeuvrability, excessive offset may cause the castor to oscillate along straight routes (Swimmy effect). Fixed castors do not allow the equipment to change direction but do guarantee directionality. In any case, the fixed castors must be mounted so that they are perfectly parallel to each other. The most common wheel layouts along with the relative castors are shown in the following table.

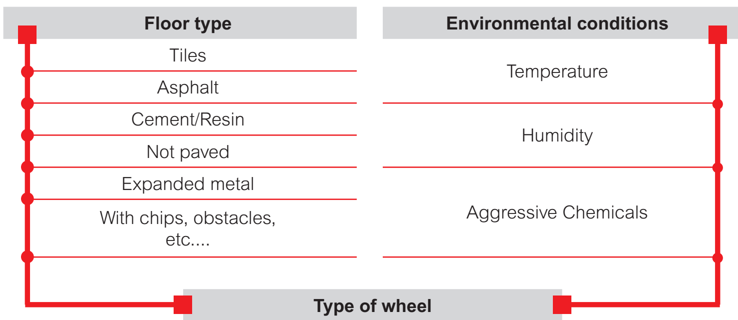
Diagram	Castor layout	Operating conditions	Application examples
	**Stable equipment** two swivel castors and two fixed castors.	Long and straight routes. Few direction changes.	Mechanical workshops, semi-automated warehouses, metallurgical workshops.
	**Stable equipment** four swivel castors.	Short routes. Frequent direction changes. Approach to machines or shelves.	Supermarkets, wood machining companies, small distribution centres.
	**Stable equipment** one swivel castor and two fixed castors	Long and straight routes. Few direction changes.	Small equipments Tool/object carriers Light loads.
	**Tipping equipment** two fixed castors and four swivel castors.	Long routes with mechanical towing. Few direction changes.	Moving in railway, postal, airport areas. Heavy loads.
	**Tipping equipment** four fixed castors.	Long and straight routes without direction changes.	Assembly or machining lines with round trip and head transfer device.
	**Tipping equipment** two fi xed castors and two swivel castors.	Long routes with manual or mechanical towing. Few direction changes.	Mechanical and metallurgical workshops, semi-automated warehouses.

5.6 Choosing the wheel

Each of the parameters and operating characteristics outlined in the previous paragraphs is used in one of the three steps involved in choosing the wheel.

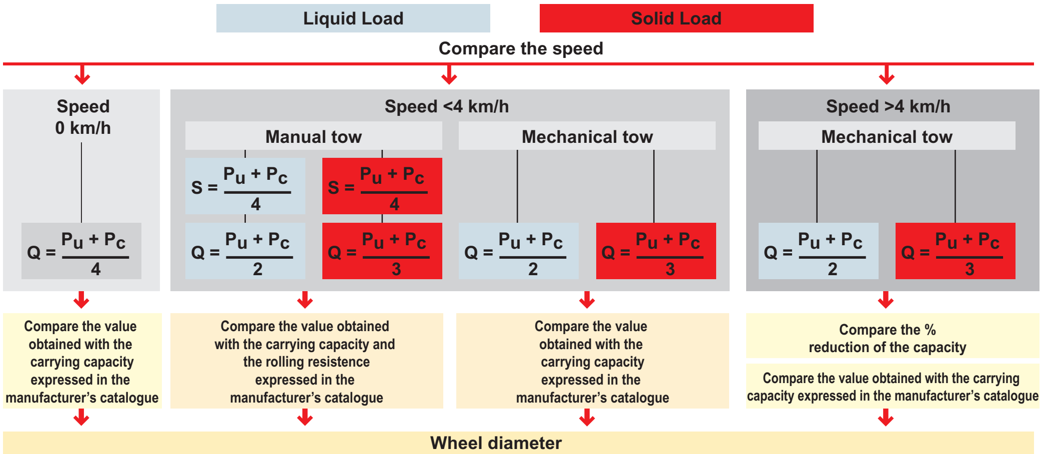
Step 1
The type of wheel suitable for the floor and operating environment is identified in step 1. The following graph summarizes the factors that influence the choosing of the type of wheel; “type of wheel” means:

- materials that form the covering and the wheel centre body;
- type of anchorage between covering and wheel centre body;
- rolling actions.



Step two

The load capacity, static load and smoothness values required by the specific application and needed to determine the wheel diameter are calculated in step two. One of the most important parts of this step is an analysis of the load that the wheel must support. The following diagram indicates what calculations to perform and what values to consider depending on the various operating conditions. These aspects must always be indicated (magnitude and nature of the load and speed), while ensuring that all the values determined are not higher than the rated values indicated in the manufacturer's catalogue. If the evaluation of various aspects generates different data with reference to the same wheel characteristic, the final choice must be made based on the most conservative condition.



S = rolling resistance **Q** = load capacity **Pu** = weight to transport **Pc** = equipement weight

Step three

The correct castor is chosen in the third step. The step can be divided into two separate parts:
1. Choosing fixed or swivel brackets, depending on manoeuvrability and directionality needs;
2. Checking the compatibility between dynamic load capacity and rated dynamic load capacity of the wheel and bracket.

The following table summarizes some general indications for choosing the right wheels according to the application's features.

● Reccommended ❐ Tolerated ▲ Not recommended

Selection parameters	Value range	RE.FF	RE.F2	RE.F5 RE.F5-ESD	RE.F4	RE.F7	RE.F8	RE.G1	RE.E2	RE.E3	RE.G2	RE.G5
Load capacity	Light load, up to 250 kg	●	●	●	●	●	●	●	●	●	●	●
	Medium load, up to 750 kg	●	●	●	●	▲	●	▲	▲	▲	●	●
	Heavy load, more than 750 kg	❐	●	●	●	▲	❐	▲	▲	▲	▲	❐
Rolling resistance	< 125 kg	●	●	●	●	●	●	●	●	●	●	●
	> 125 kg	❐	●	●	●	●	●	▲	▲	▲	●	●
Flooring	Tiles	●	●	●	●	●	●	●	●	●	●	●
	Asphalt	●	●	❐	❐	▲	❐	●	●	●	●	❐
	Cement - Resin	●	●	●	●	❐	❐	●	●	●	●	●
	Not paved	▲	●	❐	❐	▲	▲	▲	●	●	●	❐
	Expanded metal	❐	●	❐	❐	▲	▲	●	●	●	●	❐
	With chips, obstacles, etc.	▲	●	❐	❐	▲	▲	▲	▲	▲	●	❐
Environmental chemical conditions	No aggressive chemicals	●	●	●	●	●	●	●	●	●	●	●
	With aggressive chemicals	❐	▲	❐	❐	▲	●	●	▲	▲	❐	❐
Temperature	-40° / -20°	▲	▲	▲	▲	❐	●	▲	▲	❐	❐	▲
	-20° / +80°	●	●	●	●	●	●	●	●	●	●	●
	+80° / +120°	❐	▲	❐	❐	●	❐	▲	▲	▲	❐	❐
	> 120°	▲	▲	▲	▲	●	▲	▲	▲	▲	▲	▲
Means of traction	Manual (speed ≤ 4 Km/h)	●	●	●	●	●	●	●	●	●	●	●
	Mechanical (speed ≤ 16 Km/h)	▲	●	●	●	▲	▲	▲	▲	▲	❐	❐

Axle set
Connection through which the wheel is assembled to the castor. Normally, it consists of a threaded pin with nut, washers, tube and, where necessary, spacers.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Ball race ring
The part that encloses the castor rolling actions.

Bolt hole
Hole made in the top of the bracket and used to attach the castor to the equipment.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Bore
Central part of the wheel designed to house the axle set or the rolling actions that facilitate rotation (ball bearings, roller bearings, plain bearings...).
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Bracket
Connection part between wheel and equipment. Normally, all wheels must use a bracket to be applied to the equipment; an exception is made for wheels whose axle is built into the equipment. Swivel bracket: rotates around its vertical axis as the operating direction changes; it can be a swivel plate bracket, swivel bracket with through hole or swivel bracket with stem. The swivel bracket can be equipped with a brake. Fixed bracket: no rotation; it is designed to keep the wheel moving along a straight line.
Reference standards: UNI EN 12526:2001- ISO 22877:2004

Brake
A device that blocks the rotation of the bracket around its own axis, the wheel rotation or the rotation of the castor (wheel and bracket assembly). Front, rear brakes can be mounted on swivel castors.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Central pin
Swivel bracket part that joins the plate, fork and ball race ring; thanks to the central pin, the plate and fork form a single piece, while the ball race ring remains free to rotate around its own axis.

Wheel centre body
The wheel centre body is the wheel part that connects the covering to the bore. It comes in various shapes and is made of different materials; it can be a single piece or two or more parts joined together.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Covering
Outer ring of the wheel; it can be made of various materials and characterises the wheel. The covering is fixed when joined with the wheel centre body and is fitted when mechanically assembled on the wheel centre body.

Dynamic carrying capacity
Carrying capacity of a wheel is defined as the value (expressed in N) of the maximum load that can be supported by that wheel in conformity with European UNI EN 12532:2001 and International ISO 22883:2004 standards. Dynamic testing under constant speed (4 km/h, 1.1 m/s) requires overcoming 500 100mm-wide obstacles, with height equal to 5% of diameter for wheels with an elastic rolling strip (hardness up to 90 Shore A) and to 2.5% of the diameter for wheels with a rigid rolling strip (hardness greater than 90 Shore A), without permanent deformation of the wheel affecting its operating efficiency.

Directionality
Possibility of an object to continue moving along a predetermined direction.

Dust seal
The part of the swivel bracket that protects the rolling actions.

Fork
Fixed or swivel bracket part that supports the wheel; normally, it has an upside-down "U" shape. The holes to house the wheel axle set are made at the bottom ends of the fork; the swivel actions are installed in the top.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Hardness
Propensity of a material to be penetrated by another material. It is measured with empirical tests that are used to evaluate the magnitude of the penetration of a specific force in the material under specific conditions. The penetration hardness is inversely proportional to the penetration. Different tests can be performed to measure the hardness of a material. Shore A and Shore D durometers are used in some of the most widely used tests: durometer type A is used for the softer materials (elastomers), while type D is used for harder materials (thermoplastic material, polypropylene).
Reference standards: UNI EN ISO 868:1999 - ASTM D 2240-2004

Manoeuvrability
Possibility of an object to easily change its operating direction.

Plate
Top part of the bracket, with holes or slots used for the equipment connection. It can be made in different shapes: rectangular with four fitting holes, square with four fitting holes, triangular with three fitting holes, circular with a bolt hole, circular with a stem.
Reference standard: UNI EN 12526:2001 - ISO 22877:2004

Rolling resistance
Value (expressed in N) of maximum load, applicable for each single wheel that an operator can move, over level paths, even for long periods without fatigue.

Static load
Value (expressed in N) of the maximum load that a stationary wheel can withstand without generating any permanent changes to that wheel.
Reference standards: UNI EN 12527:2001 - ISO 22878:2004

Stem
Vertical end of the castor used to attach the castor into a hole in the equipment.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004

Tearing resistance
Capacity of a material to resist the propagation of a cut. It is measured through a test under the conditions defined in standards ASTM D 624b-2000 - UNI 4914:1987. During that test, a cut perpendicular to the tractive force is made on a test piece placed under traction.

Tread
Wheel external surface; the part of the wheel in contact with the ground. It can be smooth or sculpted with raised patterns to increase its grip on the ground.

Vulcanisation
Treatment with sulphur or sulphurous compounds applied to some substances, including rubber, to eliminate their plastic characteristics and to make them perfectly elastic.

Wheel
A circular mechanical assembly in which sliding motion is replaced by rolling motion through rotation around its own axis. The wheel consists of the following components: the tread, the covering, the wheel centre body, the bore and the rolling action. Depending on the different construction versions and materials used, wheels can be classified into four families: rubber, polyurethane, monolithic (hard tread) and pneumatic.
Reference standards: UNI EN 12526:2001 - ISO 22877:2004