

4 Paper Handling Equipment



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FORKLIFT TRUCKS

Alpha version for comment. Notes

1. Temporary drawings will be replaced in a uniform style
2. Photos marked with red bar need to be replaced with high resolution

IMPORTANT NOTICE!

A general guide cannot take into account the specificity of all products, procedures, laws and regulations. We therefore recommend that this guide be used only as a complement to information from suppliers, whose safety, operating and maintenance procedures along with applicable local legal regulations always take precedence over this guide. This guide is and is intended to be a presentation of the subject matter addressed. Although the authors have undertaken all measures to ensure the correctness of the material, it does not purport to list all risks or to indicate that other risks do not exist. The authors, contributors, the represented associations and participating companies do not give any guarantee thereof and no liability is assumed by reason of this guide as it is only advisory in nature and the final decisions must be made by the stakeholder. It shall not be applied to any specific circumstance, nor is it intended to be relied on as providing professional advice to any specific issue or situation.

⚠ Always check machine is in its specified safe position before working on any component (e.g. with compressed air, electrical power and gas disconnected). Only trained maintenance personnel adhering to safety regulations should perform maintenance work.



Best Practice



Poor Practice



Safety Issues



Environmental & Economic Impact


Choosing Handling Equipment


Throughout its long logistics chain paper may be handled up to 16 times. It is heavy, difficult to handle, prone to damage and has a high unit value: making the correct selection and maintenance of handling equipment essential.


Lift trucks are the most common handling method for paper rolls, palletised paper, pulp, and waste paper bales. When correctly equipped and operated they provide flexible, efficient and damage-free handling. Lift trucks and their clamping attachments need to be selected collectively to meet specific handling requirements.

Variable Paper Handling Needs Tools


Paper is manufactured in many grades, weights, densities and dimensions; handling equipment needs to suit the properties of the paper to be handled either as rolls or palletised sheets of paper. There are different ways to handle the same paper rolls. The most efficient and suitable tools should be used at each point in the logistics chain. For example, high volume stevedoring operations require different lift trucks and attachments than those used at a printer's warehouse.

 Do not oversize or undersize the attachments in relation to the actual needs.

 Any paper roll can be damaged by over-, or under-, clamping them.

 Set the clamping forces to the requirements of the paper roll — this is often indicated on the roll label. Use pressure selection valves or intelligent clamps to prevent damage to sensitive paper grades. Test the clamping forces regularly.

During clamp handling, the paper rolls are held by the friction force generated between the wrapper and clamp pads.

 Know the wrapper type and its handling properties. Select the contact pad friction surfaces to match the wrapper's requirements.

Typical tasks	Paper mills	Harbour	Transporter	Warehouse	Printer
Vertical roll pickup from the conveyor line	✓				
Horizontal roll pickup from the floor	✓				
Container unloading/loading	✓	✓			
Truck trailer unloading/loading	✓	✓	✓	✓	✓
Train wagon unloading/loading	✓	✓	✓	✓	✓
Printing/converting machine loading					✓
Stacking/unstacking in warehouse	✓	✓	✓	✓	✓
Ship unloading/loading		✓	✓		
- StoRo - sideport loading / unloading / stacking in berth			✓		
- RoRo trailer loading / unloading / stacking in ship's berth			✓		
- scissor lift loading, sling loading		✓			
Typical types of clamp trucks					
Rotating clamps	1-4 rolls	✓	1-4 rolls	1-4 rolls	1-4 rolls
	1-2 rolls	✓	1-2 rolls	1-2 rolls	1 roll
Tilting & Rotating clamps	1-4 rolls		1-4 rolls	1-4 rolls	1-2 rolls
	1-2 rolls	✓	1-2 rolls	1-2 rolls	1-2 rolls
Non-rotating clamps	1-4 rolls	✓	✓	✓	—
Non-rotating sliding arms clamps	✓	✓	✓	✓	—
Rotating sliding arms clamps	✓	✓	✓	✓	—

Summary of different handling needs in the logistics chain that help define the most appropriate clamp type for each operation.

Operational Checklist

The information is required to help determine the right equipment selection. Many of these points are elaborated on in the following pages.

Paper Properties: Units ☐ Metric, ☐ US/imperial

Single roll dimensions	Weight	Minimum Ø	Maximum Ø	Height/Width	Wrapped
Largest roll					yes/no
Smallest roll					yes/no
Average roll					yes/no
Heaviest roll					yes/no
Other important roll size					yes/no

Note: Roll height is roll standing on its end with core vertical (eye-to-sky) — this is the same dimension as roll width.

Paper type: ☐ Newsprint, ☐ LWC, ☐ SC, ☐ Carton board, ☐ Liner ☐ Kraft, ☐ Recycled Kraft > 70%, ☐ Tissue-Facial, ☐ Tissue-Soft Towelling, ☐ Tissue-Hard Towelling, ☐ Wax, ☐ Other

Wrapper type: ☐ Kraft paper, ☐ Plastic, ☐ Stretched Wrap, ☐ Banded, ☐ Unwrapped, ☐ Other (define)

Multiple rolls wrapped together: ☐ None, ☐ 2, ☐ 3, ☐ 4, ☐ 5 or more (define) _____

Flat spot on horizontal position (tissue only): ☐ Yes, ☐ No, or define _____

☐ Heavy rolls (near maximum weight) with diameters significantly below the maximum diameter. Is there enough clamping force for this application and paper type?

☐ Difficult to handle rolls (very soft/narrow/wide, etc.)?

☐ Any previous problems with out-of-roundness, telescoping, overloading or other damages?

Roll Handling

- ☐ Twin-pack double rolls, ☐ Single wrap single roll, ☐ Single wrap multiple rolls different Ø,
☐ Multiple rolls same Ø ☐ Two rolls clamped together ☐ Three or more rolls stacked singly,
☐ Four rolls clamped together

Stacking Pattern: ☐ Nested, ☐ Soldier

Maximum stacking height ____ Any operating height restriction on mast height ☐ no, ☐ yes

How many rolls with a single lift ____

Bilge/Lying (horizontal) handling

Operating Location

Construction: ☐ New, ☐ Existing

Operation type: ☐ Warehouse, ☐ Harbour, ☐ Stevedoring, ☐ Container, ☐ Railcars, ☐ Trucks,
☐ Printer/Converter, ☐ Feed machines, ☐ Unload machines

Environment: ☐ Indoors, ☐ Outdoors, ☐ Rough surfaces, ☐ Dusty, ☐ High temperature,
☐ Low temperature, ☐ High humidity, ☐ Low humidity, ☐ Ocean site

Clamping

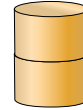
Type: ☐ Revolving, ☐ Non-revolving, ☐ Single roll handling, ☐ Multiple roll handling,
☐ Bilge/lying (horizontal) handling? If Bilge handling is needed then 5° forward tilt is required.
☐ Tilting, upending or extending

Clamp functions: Roll rotation ☐ no, ☐ yes — Rotation ☐ 90°, ☐ 180°, ☐ 190°, ☐ 360°

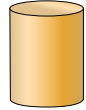
Mast functions: ☐ Forward tilt, ☐ Side shift, ☐ Tilt indicator, ☐ Mast chain slack prevention valve

Clamp pad preference: ☐ Bolt-on bonded rubber, ☐ Bonded urethane, ☐ Hinged pad,
☐ Ribbed cast, ☐ Spray metal, ☐ Standard cast; Tissue — ☐ Single radius,
☐ Double radius, ☐ Convex, ☐ Other ____; Contact pad size w ____ x h ____

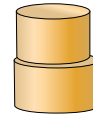
Total loaded axle weight (roll truck + attachment + load): ____ Any weight limits for containers, trucks, railcars? The forklift truck supplier has the complete responsibility to calculate capacity for application.



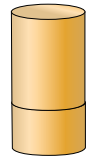
Twin-pack double rolls



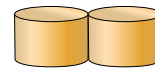
Single wrap single roll



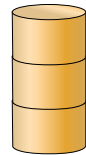
Single wrap multiple rolls different Ø



Multiple rolls same Ø



Two rolls clamped together



Three or more rolls stacked singly



Four rolls clamped together



Lift truck equipped for correct handling of two rolls with different diameters. Source: Cascade.

Lift Truck Specifications

Motorisation: ☐ electric, ☐ diesel, ☐ LPG

Required load capacity (clamp attachment + maximum roll weight) _____

Height of stowage _____

Lift mast max height _____

Lift mast forward tilt ☐

Hydraulic functions, pressure and flows adequate to the attachment(s) _____

Accumulator to reduce dynamic forces ☐

Cabin features

☐ Overhead guard to protect driver from falling rolls

☐ Signal lights and sound for reverse driving

☐ Rotating seat for reverse driving

☐ Headlights for top loading and driving

☐ Camera for top loading

☐ Signal lamps on roof for pressure valve adjustment

Pressure valves: ☐ manual (3 or 4 different level adjustments), ☐ intelligent system, ☐ scanner device

Motorisation

The engine should be selected to meet national regulations and intended use. Electrical drive, with no noise or air pollution, is preferred for working inside buildings. Diesel engines should use reduced sulphur fuel and be equipped with particle or KAT filtering systems. Lift trucks must be regularly maintained to the manufacturer's recommendation.

Generally, clamp and forklift trucks should be as small as possible to save space in the aisles. Large clamp trucks used for multiple roll handling or Super Jumbo rolls should have twin wheels for stability and better weight distribution.

Operator Ergonomics and Safety

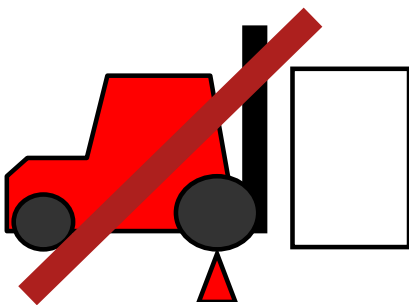
Good driver visibility is very important — appropriate mast construction helps. Transporting large rolls or two parallel stacks of rolls requires additional solutions. A rotating seat is recommended when driving backwards, or a camera with a video screen for the driver is an alternative but must comply with safety regulations. Each truck must be equipped with portable fire extinguishers.

Capacity

Lift truck basic capacity tables assume that the truck is operated with forks only. The rated capacity is given for a load with a centre of gravity at a given distance from the vertical face of the forks — this is the load centre. Loads with a centre of gravity further out reduce the truck's rated capacity. An attachment combined with the truck requires it to be re-rated. Attachments can reduce the lift truck's rated capacity if they push the load centre outward; load extenders and tilting attachments may move the load centre further.

The common rest capacity calculation used by attachment manufacturers is based on calculating the overall lift truck stability at low lifting heights. This does not take into account that several lift truck and attachment components may be overloaded — lift mast rollers, the lift mast and fork carriage all carry a heavier than normal burden when overloaded.

- ☒ Only the lift truck manufacturer should calculate the actual axle load including the specific attachment, paper load and lift height combination.



Standard mountings: ISO 2328 defines the main dimensions of fork arm mounting hooks and lift truck fork carriages. The standard divides fork mountings into five capacity classes, but classes 1 and 5 are rarely used on lift truck attachments. ISO 2328/ITA mounting hooks are available with a quick-change option. The lower mounting hooks can be opened without tools to enable fast mounting/demounting of attachments to the lift truck. Dual hook mounting allows the same hooks to be used with two different mounting classes — this requires that the clamp back plate has pre-positioned fastening holes for the different mounting sizes.

Mounting angle: Some rotating paper roll clamps can be built with forward tilted mounting. Typically all non-rotating clamps are built with 0° mounting angle. If a rotating paper roll clamp has a forward tilted mounting, the clamp can pick up horizontal paper rolls with less lift mast forward tilt. Alternatively, if the full mast tilt can be used, then clamp arms can be designed to be slightly shorter while retaining the same horizontal roll lifting ability

✓ Paper roll clamps for high stacking should have a 0° mounting to avoid damage (a forward tilted mounting has a severe negative effect when stacking). Correct operation with lying (horizontal paper) rolls requires the lift truck to have at least 5° forward tilt.

Integral mountings: These replace the original fork carriage and wheel brackets to reduce weight to increase capacity while giving better visibility. However, mounting is more difficult and the lift truck attachment cannot be easily detached.

Hydraulic Requirements

A correct hydraulic connection between the lift truck and its attachment is a key to high productivity. Inadequate oil supply from the truck to the attachment is responsible for about half of attachment service problems.

Hydraulic functions: Generally, lift trucks have two hydraulic functions available for attachment use — enough for fork positioners and paper roll clamps. Special attachments, and combinations, may require three or more hydraulic functions that have to be built onto the lift truck.

Hydraulic pressure: The hydraulic pressure available from the lift truck determines the operational force of the attachment. The attachment structure, seals/gaskets, hoses and other hydraulic components define the maximum hydraulic pressure. Hydraulic pressure is important for attachments generating clamping force because low pressure will reduce clamp lifting capacity. If the lift truck hydraulic pressure is too high, separate pressure relief valves must be installed into the hydraulic system of the lift truck or attachment.

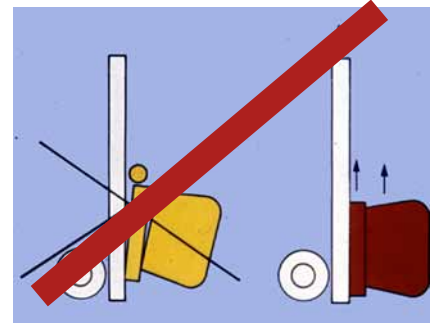
Oil flow to the attachment: This defines the operational speed of the attachment's forks or arms. Generally, the higher the oil flow, the faster the forks or arms will move. However, too high oil flow may lead to excessive oil heating, decreased component life and operation malfunctions. Too low oil flow may slow operation, cause problems with simultaneous arm movement with multiple arm clamps, and malfunctions. The attachment's oil flow and its operating speed may be affected by hydraulic hoses going over the lift mast, hose reels, swivel blocks and hose connectors.

Oil grade and quality: Normally, all attachments are compatible with standard, good quality petroleum-based hydraulic oils. Some seal and gasket types are not compatible with water-based or bio oils. Correct installation of the attachment onto the truck requires hose sizes and fittings that match hydraulic flow requirements — undersized fittings or hoses can cause heat build-up, reducing seal life and fuel economy.

✓ Oil purity has major influence on operation uptime. Frequent oil and oil filter changes are highly recommended.

Reduce Dynamic Force

Different floor surfaces can create dynamic forces if the clamp and roll bounce during lift truck travel. These can momentarily double the effective weight of the paper roll with a risk of it dropping out of the clamps, which can cause serious injury and damage. Dynamic forces can be reduced by equipping trucks with pneumatic tyres or an accumulator — [see page 16](#).



Forward tilted mounting. 0-degree mounting.
Source: Bolzoni Auramo, drawing p 86.



An attachment combination requires four hydraulic functions:
1. clamping, 2. rotation, 3. tilting, 4. extension.
Source: Bolzoni Auramo, photo p 89.

Lift Mast Height and Tilt

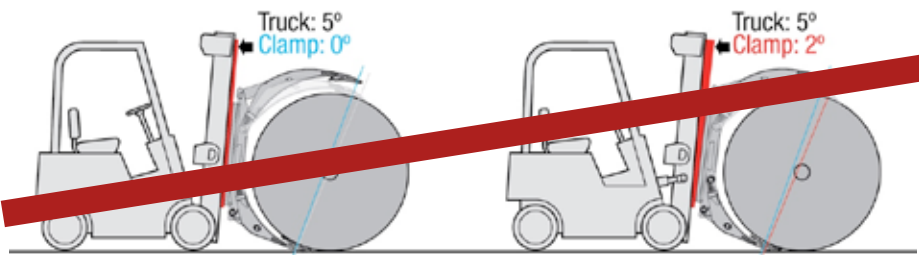
Lift mast height: The lifting height, mast type and need for free-lift depend on the user's requirements. When selecting the mast for attachment use, its lifting height requirements may differ considerably from those of a standard lift truck equipped with forks only. Check that the lifting height is sufficient in relation to the desired stacking height; and that the height of the mast does not restrict driving through doors or into a container or railcar.

Lift mast tilt: Most rotating paper roll clamps are built to use the lift mast forward tilt when lifting a horizontal roll to minimise overall clamp dimensions and arm length. Generally, lift masts have a standard 5° forward tilt. Clamps are also available for lift trucks without forward tilt — they are equipped with 0° roll arms, longer long arms and shorter short arms.

The mast is tilted backward for stability over longer distance travel. However, the mast must be in a vertical position to avoid paper damage paper when the roll is put down. If it is tilted too far backward during clamping it can cause local deformations on the roll surface under the pad corners and there is a risk of dropping the roll from incorrect clamping. A tilt indicator helps reduce these risks.



A 5° forward tilt ensures that the short arm pad is under the paper roll and the long arm pad is over the top.



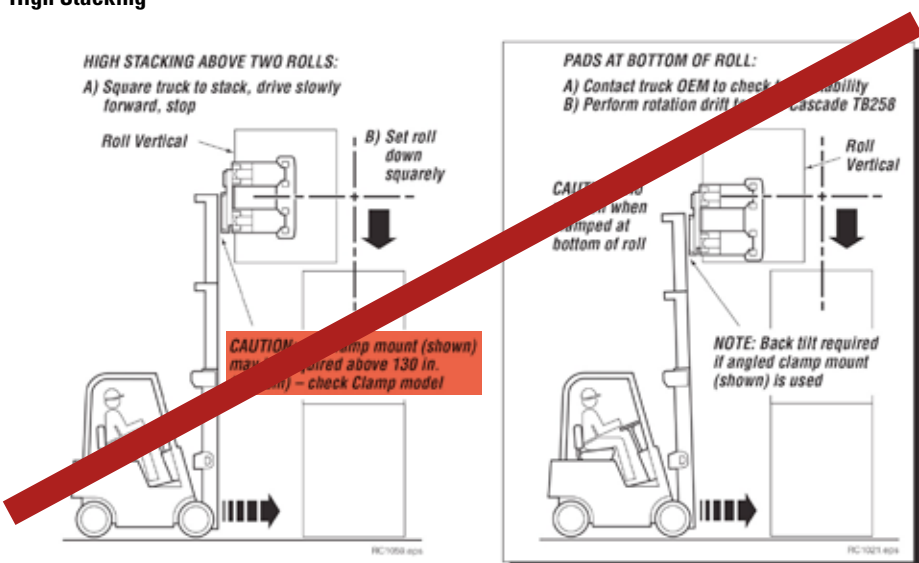
Clamps for bilge handling (paper rolls lying on the ground) require a 5° forward tilt to ensure that the short arm pad is under the paper roll and the long arm pad is over the top. This can be accomplished with 5° tilt on the truck and 0° on the attachment. Some users prefer 7° tilt for easier bilge handling, particularly with rubber pads on short arm. Source: Cascade.

High Stacking

- Square truck to stack, drive forward slowly, stop
- Set vertical roll down squarely
- 0° clamp shown

Clamp pads at bottom of roll

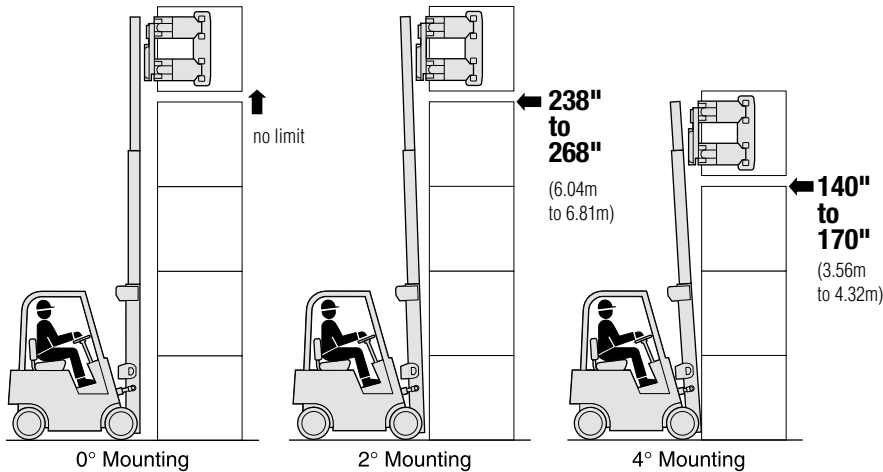
- Contact truck supplier to check stability
- Make a rotation drift test
- Do not rotate when roll clamped at bottom
- Back tilt required if angle clamp is used.



- ⚠ If rubber pads are used (to improve friction) with a 0° mounting (driver uses the mast to check the pads are parallel to the roll) then maintaining friction is assisted by using a non-rubber short arm pad and a rubber pad on the long arm.

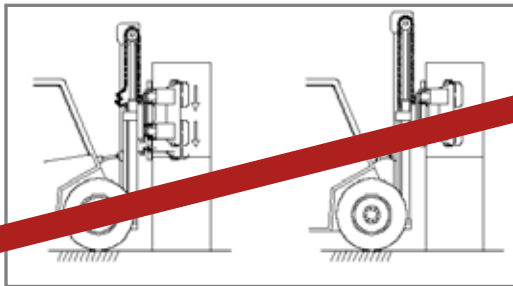
High Stacking and Mast Tilt

A forward tilted mounting has a severe negative effect when stacking paper rolls. When the mast is tilted backwards during stacking, the lift truck cannot reach the correct position on the side of the roll stack and in some situations will prevent stacking altogether. For this reason, all paper roll clamps used for high stacking should be delivered with 0° degree, or near, mounting.



Several types of mast position indicators are available to ensure operators clamp at 0°.
Sources: (left) Cascade, (right) Bolzoni Auramo

Mast chain slack prevention valve: If the mast lifting chains are slack when the roll is released there is a risk of damage to the paper roll, the truck's steering axle, mast and chains. A chain slack prevention valve inhibits chain slack by stopping the mast's downward movement immediately after the load is taken off the lift cylinder.

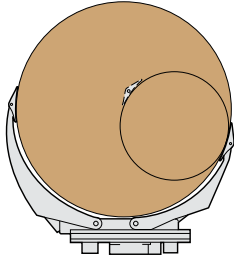


A mast chain slack prevention valve is recommended when stacking rolls. Source: Bolzoni Auramo.



⚠ Paper roll clamps for high stacking should have 0° mounting because a forward tilted mounting has a severe negative effect when stacking.
Source: Cascade.

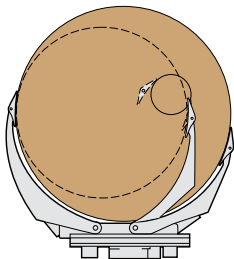
Roll Clamps



Fixed Frame - Fixed Short Arm

Double hydraulic function

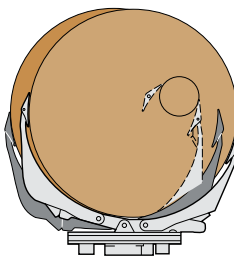
- Good arm profile when handling rolls near maximum diameter
- Continuous 360° rotation



Fixed Frame - Positioned Short Arm

Double hydraulic function

- Positioned Short Arm permits improved long arm profile over wide range of roll diameters
- Continuous 360° rotation



Swing Frame - Positioned Short Arm

Triple hydraulic function

- Improves handling in tight stacking locations
- Allows easy lateral positioning
- Continuous 360° rotation

Source: Cascade.

Selecting the correct clamp type is a key factor in operating efficiency and avoiding damage.

Pivot arm clamps: The dominant paper handling attachment allows the clamping arms to make a swinging motion around fixed pivot shafts. They can combine several paper handling needs into a single attachment. Clamps may be non-rotating, rotating or tilting and may be equipped with several pairs of arms to handle multiple rolls. The clamping arms can be short and long, or of equal length, and slim pivot arm clamps permit tight roll stacking. These clamps have a simple design, low weight, narrow frame, a wide roll range, good visibility, and self-limiting clamping force when the paper roll diameter decreases.



Different pivot arm clamp models. Sources: (left) Bolzoni Auramo, (figure p 40), (right) Cascade.

Non-rotating single paper roll clamps: Typically used in warehouses and port terminals for Sto-Ro ships where the rolls are taken on board on trailers and stowed in the ship's hold by clamp trucks.

Non-rotating multiple paper roll clamps: A good solution for paper transport in terminals and to load side port vessels. Multi-roll clamps can be configured as single or double width stack, with or without extendable upper arms.



Non-rotating multiple paper roll clamps: Sources: (left) Bolzoni Auramo, (right) Cascade.

The extendable upper arm optimises the position of the upper pads to stabilise the top rolls. In addition, clamps can be equipped with positionable centre arms to increase the range of roll diameters that can be handled. Hydraulically adjustable centre arms prevent the long arm from pushing rolls on the ground.



Rotating clamps: Allow the placement and handling of a roll in both vertical and horizontal positions in a wide range of applications at paper mills, warehouses, ports, printers and paper converters. A rotation system assists tight stacking in confined spaces as the short arm can be turned against the wall, or nearest paper roll, to save space and allow side-by-side roll stacking. Clamps with 180° rotation facilitate returning the roll automatically to the 90° position, they can also provide a hydraulic cushion at the end of rotation. A 360° system allows rotation in either direction; it can have a 90° bilge (lying roll) position stop, and allows for easy placement of the roll on a surface that is not aligned with the lift truck (such as when operating on a railcar bridge or uneven surface).



Rotating clamps for handling either jumbo rolls or up to three rolls for loading and unloading ships, rail wagons or trucks. Sources: (left) Bolzoni Auramo, (right) Cascade.

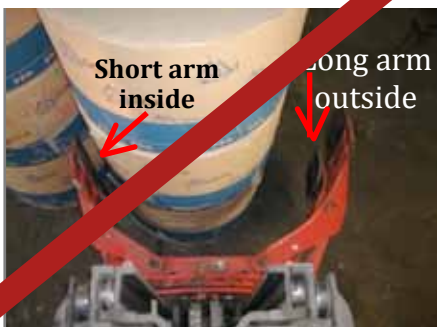
⚠ Paper roll clamps with automatic 180° rotation stop or 360° with 90° option reduce the risk of roll damage.

Swing frame clamp: This is a standard rotating pivot arm clamp with a secondary pivoting frame that allows the roll to be 'swung' or side-shifted in tight stacking spaces, enabling the driver to precisely position the roll without the need to reposition the lift truck. The swing frame also allows the clamp to be operated as an equal arm clamp.

Short and long arms: Rotating roll clamps normally have short and long clamping arms to enable lying (horizontal or bilge) roll handling. This design also makes vertical roll handling faster and safer in confined spaces such as containers and railcars. Tighter stacking with less lift truck manoeuvring is possible if the short arm side is turned towards the wall with the long arm making the clamping movement. The short arm can be either fixed or positioned to increase the roll range in the low end, and to centre rolls to the clamp. Non-rotating clamps normally have equal length arms to reduce its dimensions.



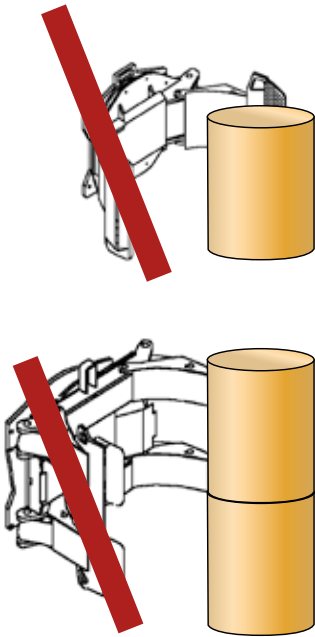
Swing frame. Source: Cascade.



Short arm makes handling in tight spaces easier and minimises the roll damage risk. Source: Bolzoni Auramo.



Short arm should be against the floor when lifting a roll from the ground. Source: Bolzoni Auramo.



Sliding arm paper roll clamps.
Source Bolzoni Auramo. Figure p 41



Sliding arm paper roll clamp without a centre arm.
Source: Cascade.

Multiple split arms reduce roll edge damage and the risk of dropping rolls from incorrect clamping. Damage will occur if rolls are clamped over their edges.
Sources: (left) Bolzoni Auramo, (right) Cascade.

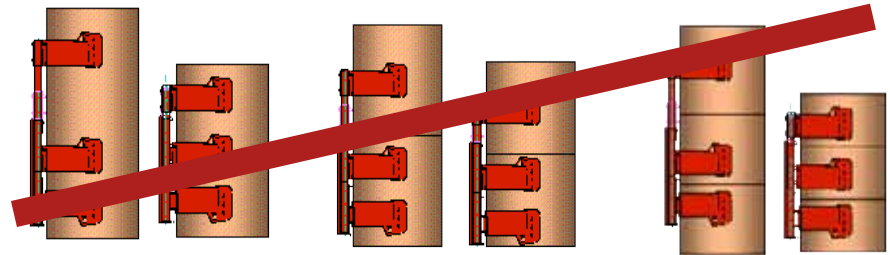
Sliding arm clamps: A slide system in the frame allows the arms to make a horizontal movement. They are mainly used in paper terminals and ports. They are heavier, wider and have a more limited roll range than pivot arm clamps.

There are two types: with or without a centre arm. Both can be used for side-by-side roll handling but only the non-centre arm type is suitable for carrying one roll on the centre line of the truck. Each type has advantages and disadvantages. The centre arm model allows for reduced pad pressure on the inside of the rolls, while the non-centre arm model can handle 2 rolls wide while retaining the ability to handle one roll with a narrow frame to work in a narrow aisle. The model without the centre arm has relatively high surface pressure when the rolls touch each other with only line contact of roll-to-roll — this is the compromise for being able to handle 1 or 2 rolls with a narrow frame.

⚠ Each roll being lifted must be clamped — “free riders” are very dangerous.

✓ Middle arms should be used when handling rolls side-by-side.

Fixed or split arms: Clamps handling more than one roll at time should always have a split clamping arm. This enables safe and damage-free handling of two (or more) paper rolls as well as a single roll. Split arms reduce roll edge damage and the risk of rolls dropping from incorrect clamping.



Source: Bolzoni Auramo.

Split arm clamps benefit from dividing the clamping force on each paper roll to provide a safer grip with less risk for out-of-roundness. Correct clamps are extremely important to avoid damage. The number of clamp pads determines the possible number of rolls that can be handled — each roll must be clamped by a minimum of one pair of pads.

Jumbo rolls (> 3 m wide) and/or super jumbo rolls (> 3,88 m wide) are best handled with a clamp of 2, 3 or 4 pads with adequate surface area. Each type has advantages and disadvantages. The two-clamp arm design reduces weight and cost, while 3 and 4 arm models improve surface distribution. The material and surface of the pads must be chosen to meet safe transportation requirements.

Multiple split arms: 2, 3 or 4 arms enable safe and damage-free handling of rolls of unequal diameters. Each roll is carried by its own clamping force and clamped in the optimal position. Clamping force is divided between all rolls.



Tissue paper clamps: These are designed to handle a wide variety of tissue papers that generally have large diameters and widths, requiring correspondingly larger clamp pads. Many paper types are used for different types of tissue, ranging from relatively dense service paper to very low density TAD (through air dried) tissue. Each requires a different pad to correctly handle each density. Ultra low density TAD paper is particularly sensitive. One system uses re-clamping to avoid over-clamping at the beginning of the clamp cycle to allow for the relaxation of the roll — a patented technology to preserve the original tissue fibre structure to improve runability.

Recycled paper (RCP) & pulp bales: RCP is loaded in wired units similar to pulp and handled with the same bale clamps. Special arms with compact dimensions are used to minimise contact with adjacent bales.



Bale clamp. Source: KAUP.



Special clamps are used to handle large diameter tissue rolls.
Sources: Cascade.



Special clamps are used to handle large diameter tissue rolls. Sources: Bolzoni Auramo.



Recycling bale clamp.
Source: Cascade.



Clamps can be equipped with load extenders to facilitate loading. Source: Cascade.

Clamp Contact Pads

Pads are the only parts of the clamp in contact with the paper roll and are a key to safe and damage-free handling. The material and surface of the pads must be chosen to meet the requirements for safe transportation. Desirable characteristics include: pad radius suitable for the roll diameter and a protected hinge system; a thin pad with good contact properties when handling tightly stacked rolls; smooth rounded profile without protruding parts or edges to damage the paper; front edge steering that guides the pads around the roll; smooth wear strips on short arm side to provide a margin against wear from floor contact; and positioning features that align pads to the roll and stop them from turning to avoid paper damage.

Contact pads are available with a wide variety of friction surfaces that are defined by the paper and wrapper type and other application requirements. Certain types of paper may require increased friction to be handled with an appropriate sized roll clamp. However, the increase of clamp size and force is not always the best option due to potential roll damage risk. High friction pads using rubber are not always suitable in applications where there is a risk of tearing the paper.

			Paper type				
	Contact pads	All round	Soft paper	Medium-Hard	Tissue	Durability	Maintenance
1	Cast or ribbed	✓	✓	x		High	Low
2	Rubber faced	✓	✓	✓		Moderate	Low
3	Steel-sprayed	✓	✓	✓		Moderate	Low-Moderate
4	Polyurethane faced	✓	✓	x		Moderate	Low-Moderate
5	Grooved rubber faced	✓	✓	✓	✓	Moderate	Low-Moderate
6	Flexible pads with rubber band		✓				
7	Oversized rubber faced for tissue				✓		

- 1: Cast or ribbed pad is a high friction option often used for handling kraft because it adds 5-10% inner layer friction.
- 2: High friction pads using rubber are not always suitable in applications where there is a risk of tearing the paper.
- 3: Steel sprayed pads have very high friction and are good for icy environments but are not recommended for plastic wrappers.
- 4: Polyurethane faced pads with a non-marking surface have relatively good friction properties.
- 5: Rubber faced pads with a grooved pattern "stick" less to the wrapper.
- 6: Flexible pads with a rubber band that adjusts to different roll diameters help minimise surface pressure and are primarily used for newsprint.
- 7: Tissue paper uses oversized rubber faced pad.



1 2 3 4 5 6 7

Using the right contact pad is a key to safe and damage-free handling.
Sources: (upper) Bolzoni Auramo, (lower) Cascade.



X Worn pads may require a clamping force up to three times higher than those in good condition.

Methods to Adjust Clamping Force

Coloured indicator lights on the top of the truck signal if the roll is clamped with the correct pressure. Clamping force can be adjusted by valve in the lift truck or paper roll clamp. The three types of system to adjust clamping are:

1. Manually

Manually with a four-stage pressure relief valve.
Source: Bolzoni Auramo.



2. Hydraulically

Hydraulically controlled clamp force system that changes clamp force in proportion to load weight.



HFC – Source: Cascade.



Force-Matic - Source: Bolzoni Auramo.

3. Automatically

Automatically with an intelligent paper roll clamp.
Source: Bolzoni Auramo.



AFC a computer controlled clamping system. Source: Cascade.



Intelligent paper roll clamps:

Automates clamping force control of the variables of paper grades, roll widths, weights and diameters. The system uses the lowest possible clamping force to prevent the roll from slipping from the clamp's grip while providing optimal handling performance. Automation can drastically reduce out-of-roundness damage. Some systems can also collect data handling in a history file. Automatic hydraulic valves that adjust the clamping force to a preset clamping factor multiplied by paper roll weight are also available. As a result, even the most difficult to handle paper rolls remain perfectly round in all handling conditions and situations. Some paper companies are using AGVs or other driverless systems to minimise costs and damage.



Electronic slip sensors are mounted on the long arm contact pads to measure the paper roll movement in relation to the contact pads.
Source: Bolzoni Auramo, photo p 55.

Clamping Principles and Terms

Six interrelated factors affect how a clamp picks up a roll:

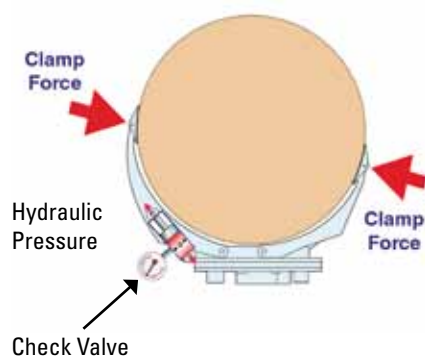
- 1: Hydraulic pressure
- 2: Clamp force
- 3: Contact pad surface pressure
- 4: Friction Handling and clamp set-up -
- 5: Dynamic forces
- 6: Clamping Factor

These elements work together to make operate a roll clamp. The hydraulic pressure from the lift truck to the roll clamp cylinder closes the clamp arms around the roll. This creates clamp force that is applied to the roll by the contact pads — a larger pad decreases contact pad surface pressure while a smaller pad increases pressure. The friction between the pad and the roll surface allows the roll to be lifted — the friction force must be greater than the roll weight or the roll will drop. These factors determine the Clamping Factor to securely hold the roll. An estimate of how much clamp force is needed to securely handle the roll can be determined from the roll weight, paper type, pad type and environmental conditions. The operator can then set the hydraulic pressure on the lift truck to ensure that the clamp applies the correct amount of clamp force.

The fundamental steps are:

1. Establish the initial hydraulic pressure
2. Verify that the hydraulic pressure is adequate. Fine tune the amount of pressure
3. Perform daily checks.

Hydraulic pressure: Is the amount of internal hose and cylinder pressure supplied by the lift truck to the clamp. It is measured as psi or bar (1 psi = 0,06895 bar; 1 bar = 14,5 psi). Hydraulic pressure causes the cylinders to move the clamp arms and pads against the paper roll — this is termed clamp force. (Note: It is incorrect to use the term pressure when referring to clamp force. In this guide pressure is divided into two types: hydraulic pressure, as described here, and contact pad surface pressure.)



*Clamp force is the result of hydraulic pressure moving the clamp arms and pads against the paper roll.
Source: Cascade.*

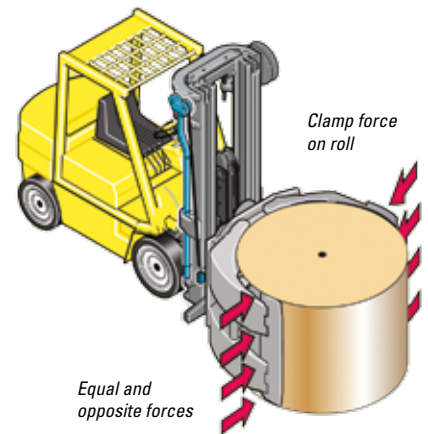


Clamp Force Indicator. Source: Cascade.

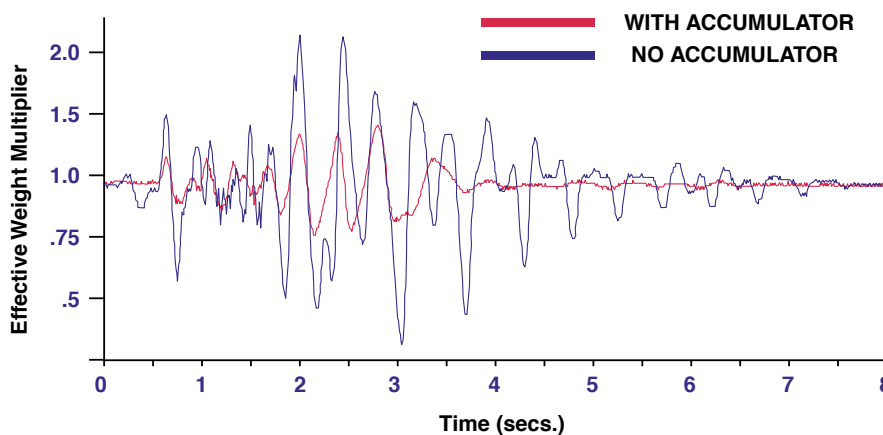
Clamp Force: The total amount of lateral force applied by the clamp pads to the paper roll. Measured as kN or Lbf and (1 kN = 224,81 Lbf; 1 Lbf = 0,004448 kN). Clamp force is generated mechanically and transmitted from the cylinder to the arms and then the pads that squeeze against the paper roll. The amount of clamp force applied to the roll depends on:

- The size of the hydraulic cylinders
- The amount of hydraulic pressure being applied to the cylinders
- The configuration of the arms and frame
- The diameter of the roll being handled. An exception is a Sliding Arm Clamp, where the clamp force is fairly consistent through the range of the clamp, but decreases as the arms extend past the frame.

▲ Dynamic Forces: Lift trucks operate on different floor surfaces that can create dynamic forces as the clamp and roll bounce during lift truck travel. Commonly known as G-Force (because of its association with gravity force), dynamic force momentarily increases the effective weight of the paper roll by as much as 100% and may lead to a risk of it dropping out of the clamps with a consequent high risk of serious injury and damage. These forces are caused by the simple travel of the lift truck through a warehouse, or by more severe conditions such as driving over rough surfaces or dock boards. Dynamic forces need to be managed and methods include an increase of clamping force, or reducing the dynamic forces by using trucks with pneumatic tires or using an accumulator to reduce the dynamic forces and the required clamp force and risk of over-clamping.

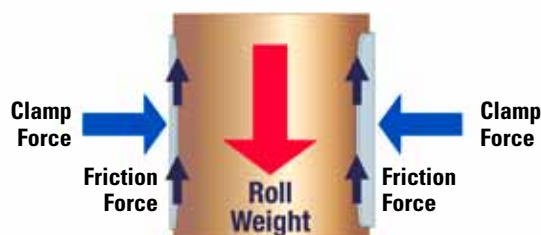


Source: Cascade.



This chart shows roll clamp bounce with and without accumulator. The hoist system fitted with an accumulator significantly reduces the number and magnitude of dynamic forces and its dampening reaction time when compared to a truck without an accumulator. Source: Cascade.

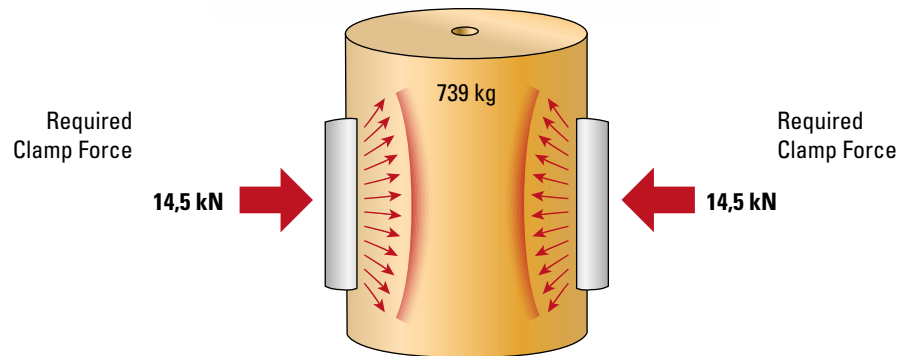
Friction: The resistance to movement of one surface against another. One of the most important factors in paper handling is the amount of friction between the paper roll and the contact pad. Friction force is the primary force used to lift the roll. Understanding friction and its effect on roll slippage is important in determining the right amount of clamp force and selecting the correct contact pads. The formula is Friction Force = $\mu \times \text{Weight}$ where μ is the coefficient of friction. Measured as Coefficient of Friction - no units.



Friction force must equal or exceed the roll weight or the roll will drop. The greater the clamp force, the greater the friction force. Source: Cascade.

Clamping Force

The metric equation is Clamping Force (kN)
 = Clamping Force Factor x Mass x Acceleration
 (acceleration due to gravity is 9,8 m/s² —
 this gravitational constant is incorporated in the
 definition of Lbf and is therefore not required in the
 imperial equation). Example with a clamp factor
 of 2,0 and roll mass of 739 kg. Source: Cascade.



- Clamping force can be adjusted manually, electrically or by hydraulically operated pressure selection valves.
- Clamping force measurement is kN (kiloNewton); 100 kP (kiloPascals) = 1 kN

Pivot arm clamps: Force is generated with hydraulic cylinders directed to the paper roll with a pushing motion through a linkage mechanism formed by the arms and frame. Clamping force normally increases in a non-linear manner when the arm opens. Changing the short arm position changes the dimensions of the mechanism and the clamp will produce different clamping forces.

Sliding arm clamps: The hydraulic clamping force is directed to the arms with a pulling motion. The force is relatively constant regardless of the arm opening position.

Clamping force diagram: The clamping force diagram is unique for each clamp model. It shows how the clamping force of a pivot arm clamp changes when the arm opening changes. If the roll range or lifting capacity changes, so does the form of the diagram.

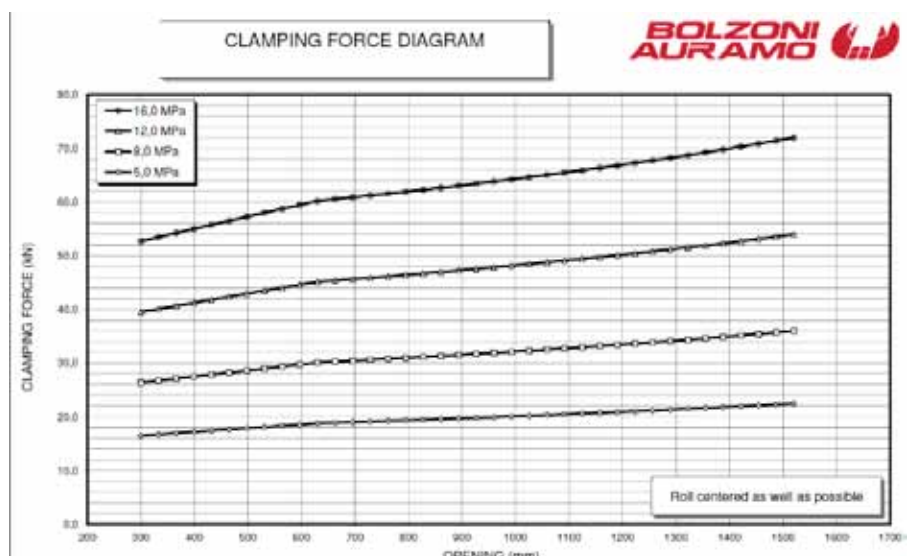


Pivot arm clamps. Source: Bolzoni Auramo, photo p 47.



Sliding arm clamps. Source: Cascade.

Source: Bolzoni Auramo.



The clamping force curve changes with different short arm positions. The main diagram shows separate curves for clamping force with short arm in closed and open positions. Some diagrams may show a third curve for a short arm position optimised to the roll diameter. Clamping force diagrams are not necessary for sliding arm clamps because their force is relatively constant with all arm opening positions.

Use the diagram if you have a fixed length clamping force testing device and need to know the actual clamping force with some other opening range (= test cylinder or test stand). Check the test device reading and use the diagram to determine the clamping force for the actual paper roll diameter. You need the diagram if you do not have a pressure gauge and you want to check that your four-stage pressure relief valve is working properly and is correctly adjusted.

Clamping Factor

(also known as Clamp Force Factor)

The clamping factor is a relation between clamping force and load force (gravity force). It is used to compensate the changes in friction and roll properties and the dynamic changes during handling. It combines the static and dynamic clamping force needed in all possible handling situations and with all paper rolls. The clamping factor can be used to define a rough initial value for the clamping force with varying paper grades and roll weight, e.g. paper weight 2000 kg x 1,3 clamp factor = 26kN total pressure.

Cfc = Freal / G which is the same as Freal = Cfc x G
Freal = Clamping force in the clamp
Cfc = Clamping factor
G = Theoretical smallest possible clamping force, in practise = the load force (weight x gravity). For example, for a 2000 kg paper roll, the G = 20 kN

Example: A newspaper roll, assumed clamping factor 1,5; paper roll weight 1500 kg.

The clamp can be adjusted to produce a 1,5 x 15 kN = 22,5 kN clamping force for this roll and roll diameter. Clamping force is usually measured in kN (kiloNewton)

1 kN (1000 N) = 100 kp (kilo Pascals) and corresponds to a weight of 100 kg on the paper roll.

Paper Grade	Clamping factor
Newsprint	1,5 - 1,6
Directory	1,3 - 1,7
Kraftliner	1,5 - 2,3
SC paper	1,6 - 2,4
LWC paper	1,7 - 2,4
Tissue/Fluff	1,4 - 1,6

The table shows some values for the clamping factor with different paper grades. They should be considered as a guideline only and may not be appropriate for all paper grades and handling situations. The clamping values are based on normal handling conditions using rubber-faced pads in good condition. Out-of-round measurements can be used to verify that clamping force settings are correct.

No single clamping method

Manufacturers use different methods to set clamp pressure and their setting instructions need to be referred to for each model. This is particularly important for pivot arm clamps where manufacturers provide a unique clamping force diagram/table for each model. If the roll range or lifting capacity changes, so does the form of the diagram/table; the clamping force curve is different with different short arm positions. The diagram/table is valid only for the hydraulic pressure indicated — if the hydraulic pressure changes, then the curve changes position. This clamping force data is needed for a fixed length clamping force testing device to know the actual clamping force with some other opening range (= test cylinder or test stand). Check the test device reading and use the diagram to see the clamping force for the actual roll diameter. Sliding arm clamps have a relatively constant clamping force with all arm opening positions and a clamping force diagram/table is not needed.

Setting Clamping Force and Testing see Module 5

Forklift Trucks

Printing and office papers are often transported as sheets stacked on pallets. Non-standard pallet sizes are common as paper sheet sizes vary a lot. Paper rolls are sometimes also transported on pallets. The cargo units are picked up and transported with lift trucks equipped with forks. One or more cargo units can be transported depending on the type of construction.

From the handling perspective, transporting palletised paper does not differ from normal pallet handling. The only major difference with these loads is their high vulnerability to external damage.

Depending on customer requirements and packing machine, the pallet loads are often wrapped with plastic or paper cover. Plastic or steel straps are used to keep the load tied securely to the pallet. Sometimes a strong wooden top lid is used to protect the upper side of the pallet, especially when several pallets are to be stacked on top of each other.

The fork used should always take into account its prescribed use and loading capacity limits. Hand-drawn pallet trucks are often used in printing plants.

Pallets should be handled with adjustable width forks or purpose built pallet forks. The length of the forks should be less than the width of the pallets/packs to be lifted.

Several pallets arranged one behind the other can be transported with long forks (e.g. truck unloading from the side). The 4-fork arm lift truck can pick up two side-by-side pallets. Multiple pallet handler systems are combined with telescopic forks.

The length of the forks should be less than the width of the pallets/packs to be lifted. Operators must ensure that the length of the forks used does not lead to impact or damage to adjoining pallets.

✗ Overlength forks and careless handling are the most common reasons for pallet damage.

✓ It is recommended to paint markings on the forks to help the driver determine the correct distance and avoid penetrating and damaging adjoining pallets. The thickness of forks must not exceed the free space in the pallet base where the forks enter.

Some Forklift Configurations

Fork positioners and double pallet handlers are commonly used for handling palletised paper goods due to the high variety of pallet sizes and high volumes involved in this particular transport. Some users prefer load-turning clamps because of the good load support they offer.



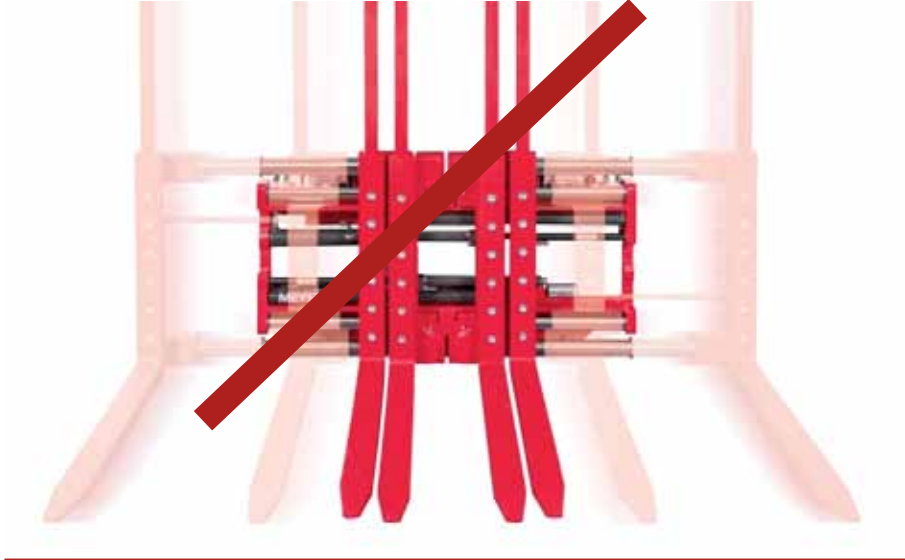
Fork positioners are the most suitable solution to handle pallets of sheet paper because they can be adapted easily to different pallet sizes. Source: KAUP.



Single-Double used to handle corrugated sheets.



Load turning clamp.



Multiple pallet system can handle up to four pallets with the same clamp. Source: Bolzoni Auramo.



Side-by-side double pallet handler for efficient internal logistics. Source: KAUP.



Dual forks used to handle two pallets together. Source: Ecograf.



Turnload are often used in recycling operations. Source: Cascade.