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## FEFPEB GUIDELINE for Industrial Packaging:



Version n. 1.0

## STABILITY AND SAFETY REQUIREMENTS

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## FIELD OF APPLICATION AND AIM OF THE GUIDELINE

The guideline "Stability and Safety Requirements" is the result of the work of the Section "Industrial Packaging" of FEFPEB and it aims at including a (non - exhaustive) list and description of the main minimum requirements for designing and manufacturing the wooden industrial packaging with a focus on the issues of Stability and Safety: therefore, the requirements included in this guidelines are lower than the requirements included in the national standards and national guidelines for wooden industrial packaging manufacturers. As ""wooden industrial packaging" it is meant the packaging and shipment of machinery, plants, materials and manufactured goods in general, of small and large dimensions.

## OVERVIEW OF THE MAIN CATEGORIES OF WOODEN INDUSTRIAL PACKAGINGS

To export a wide sortiment of industrial products, especially for far destinations, there are very often used wood packagings to ensure high level of mechanical protection.

Wooden cases, wooden crates, osb and plywood cases and boxes allow safety handling and stacking the goods within the whole logistic chain.


Pic. n. 01 - Wooden (timber) case


Pic. n. 02 - Wooden (OSB) case


Pic. n. 03 - Wooden (plywood) case


Pic. n. 04 - Wooden crate


Pic. n. 05 - Wooden (plywood) "foldable" box
Stability and Safety Requirements - FEFPEB - Industrial Packaging


Pic. n. 06 - Wooden (skidded, OSB) case
1 - lid
2 - side
3 - head
4 - floor


Pic. n. 07 - Wooden (skidded, timber) case
1 - lid
2 - side
3 - head
4-floor

SAFETY

## 1. Static and dynamic safety

The packaging should not reveal partial and/or total collapse or the detachment of parts under the effect of the weight of the contents and of external loads (static and dynamic) such as to jeopardize the protective effect thereof of the contents or the safety of the operators.

## 2. Safety upon impact, rolling, vibrations

The safety and stability of the packaging must be ensured even in the packaging of impact, rolling and vibrations deriving from:

- Handling
- Loading, unloading and stacking
- Transport:

| $\circ$ | on road |
| :--- | :--- |
| $\circ$ | rail |
| $\circ$ | sea |
| $\circ$ | air |

## 3. Safety of operators ensuing from morphology.

During use in the conditions of use provided for in the draft design the packaging should not present, compatibly with the content, irregularities of shape and/or surface such as to jeopardize operator safety.

## 4. Balancing

Ensure the contents are stable for the entire duration of use:

- design providing for the correct shape of the packaging, the correct distribution of loads within it and correct positioning of the slinging points;


Pic n. 08 - the importance of balancing

- perfect stability of the load, achieved with the necessary blocking devices.


Pic. n. 09 - Example of blocking devices

## DRAFT DESIGN

Draft design: the set of requirements, requisites and services which must be known in order to proceed with the design, manufacture and completion of industrial packaging.

1) The stresses related to the logistics environment such as the conditions of :

- Handling and logistics
- Transport
- Transshipment and storage
- Maintenance
- Climatic conditions

2) Characteristics of the product to be packaged:

- Nature
- Centre of gravity and restraints

3) Packaging characteristics:

- List of requirements set by the Client
- Definition of the type of packaging
- Reference standard or specification
- Allowable wood stresses
- Type of fasteners
- Type of lid

4) Country of destination

- Special requirements
- Any prohibition of use of specific materials


## CALCULATION OF THE CONSTRUCTION ELEMENTS

The main phases of calculating the construction elements are:

- Assessment of the stresses deriving from the draft design previously defined (definition of the ACTION);
- Sizing and testing of the packaging elements (definition of the STRENGTH)


## Action < STRENGTH

It is the Project engineer's duty to correctly size the packaging so as to ensure that the size of the construction elements, the arrangement and fastening of the same ensure sufficient strength and rigidity.


Pic. n. 10 - Action and strength


Pic. n. 11 - Action and strength

DESIGN LOADS

In order to correctly design the packagings, the type of load to which they may be subjected throughout all phases of use and which may also regard storage, handling and transport must be correctly assessed.

- STACKING load*
- CONCENTRATED load
- DYNAMIC actions


Pic. n. 12 - Design loads
*Some standards and/ or guidelines make a distinction between Stacking load and Superimposition load, as for example, the Italian standard UNI 9151-3.

## STACKING LOAD

Evenly distributed load which must be entirely supported by the SIDES, deriving from stacking one packaging on the other.

The weight-bearing elements in the packaging of stacking are therefore the sides in their entirety (frame and covering). The cross-section of the structural elements constituting the frame must be calculated on the basis of the parameters required by the draft design and in the manner provided for in the reference standards.


Pics. n. 13 and n. 14 - Example of stacking load
The weight of the upper packaging is transferred directly to the sides of the packaging below (in the packaging they are with the same width; otherwise it's necessary to put some beams). The uprights of the frame must therefore have a cross-section such as to withstand the compression load.


Pic. n. 15 - Example of stacking load
The support capacity Cma [kg], that is the stackable limit, is calculated as the product of the stacking parameter $\mathrm{Ca}[\mathrm{kg} / \mathrm{m} 2]$ by the surface area Sa 1 of the packaging receiving the load [m2].
(m2 = square meter)

## $\mathrm{Cm}_{\mathrm{a}}=\mathrm{Sa} 1 \times \mathrm{C}_{\mathrm{a}}$



Pic. n. 16-Example of stacking load (the surface area Sa1 is marked with red colour)
The surface area Sa1 is calculated as the product of the length by the width of the packaging receiving the load (lower). The stacking parameter $\mathrm{C}_{\mathrm{a}}$ (distributed load) is defined by the draft design in relation to the conditions of transport.
In the event that the upper packaging does not use all the length of the sides of the packaging receiving the load the maximum weight $\mathrm{Pca}[\mathrm{kg}]$ of the upper packaging is calculated as the product of the stacking parameter $\mathrm{C}_{a}[\mathrm{~kg} / \mathrm{m} 2]$ by the surface area Sa 2 [m2].

## $\mathrm{Pca} \leq \mathrm{Sa} 2 \times \mathrm{Ca}$

The surface area Sa 2 is calculated as the product of the length of the upper packaging by the width of the lower packaging.

It's known that the pictorial marking of the packagings is ruled by Standard UNI EN ISO 780. In particular, the following two symbols included in the ISO 870, about "stacking load", are important:

- Symbol n. 13 - "Stacking limit by mass", which specifies the "Stacking Load Limit" in kilos, on each packaging
- Symbol n. 15 - "Do not stack"


Pic.n. 17 - symbols n13 and n15 of ISO 780
The presence of the symbol $n .13$ on the packaging is a guarantee for the manufacturer, especially in packagings of stacking limits imposed by the ordering client, because it allows him to distance himself from limits that are too low, and at the same time, he can safeguard himself from incorrect handling performed along the transport chain.

Equally important is symbol No. 15, to be used for packagings that are used only to contain products whose shipping and storage requirements do not allow superimpositions and stackings of any kind.

## EXAMPLES OF CALCULATION OF STACKING LOAD

## EXAMPLE n. 1

It's necessary to calculate the stackable limit Cma of a packaging with the following dimensions : width of 2 m and length of 6 m .
We consider the stacking parameter Ca (evenly distributed load) equal to W.
The Surface area Sa1 is calculated as Sa1 = $6 \mathrm{~m} \times 2 \mathrm{~m}=12 \mathrm{~m} 2$ (the surface area Sa1 is calculated as the multiplication of the length and the width of the packaging that receives the load).
$\mathrm{Ca}=\mathrm{W}(\mathrm{Kg} / \mathrm{m} 2)$
Since the stacking load is calculated according to the formula $\mathrm{Cma}=\mathrm{Sa} 1 \times \mathrm{Ca}$
Then $\mathrm{Cma}=\mathrm{Sa} 1 \times \mathrm{Ca}=12(\mathrm{~m} 2) \times \mathrm{W}(\mathrm{Kg} / \mathrm{m} 2)=12 \times \mathrm{W}(\mathrm{Kg})$


EXAMPLE n.2: Length and Width of the upper packaging are the same of the lower packaging


Length of Upper packaging $=6 \mathrm{~m}$; Width of Upper packaging $=2 \mathrm{~m}$
Length of Lower packaging $=6 \mathrm{~m}$; Width of Upper packaging $=2 \mathrm{~m}$
We have to calculate the load the maximum weight Pca $[\mathrm{kg}]$ of the upper packaging.
We know that Pca has to be $\leq \mathrm{Sa} 2 \times \mathrm{Ca}$
The surface area Sa2 will be $6 \mathrm{~m} \times 2 \mathrm{~m}=12 \mathrm{~m} 2$
$\mathrm{Ca}=\mathrm{W}(\mathrm{Kg} / \mathrm{m} 2)$
Then the load of the maximum weight $\mathrm{Pca} \leq \mathrm{Sa} 2 \times \mathrm{Ca}=12 \times \mathrm{W}(\mathrm{Kg})$
The surface Sa 2 is calculated as the multiplication of the length of the upper packaging and the width of the lower packaging

EXAMPLE n. 3 - Same length for both upper and lower packagings, width of upper packaging is lower than width of lower packaging


Since

- Upper packaging (Length 6m; Width 1 m )
- Lower packaging (Length 6m; Width 2 m)

In this packaging, to get the stacking load, the manufacturer will have to put some "mobile" beams under the upper packaging: in this way the loads will "go" on the sides


About the stacking load in this packaging, the maximum weight Pca [kg] of the upper packaging has to be $\mathrm{Pca} \leq \mathrm{Sa} 2 \times \mathrm{Ca}$


Since the surface area $\mathrm{Sa} 2=$ length of upper packaging x width of lower packaging $=6 \mathrm{~m}$ $x 2 m=12 m 2$

Since $\mathrm{Ca}=\mathrm{W} \mathrm{kg} / \mathrm{m} 2 ; \mathrm{Pca} \leq \mathrm{Sa} 2 \times \mathrm{Ca}=12 \times \mathrm{W}(\mathrm{Kg})$ (it's the same of the example n .2 )

EXAMPLE n. 4 - Same Width for both upper and lower packaging, but the length of upper packaging is lower than the length of lower packaging


Since

- Upper packaging (Length 4 m ; Width 2 m )
- Lower packaging (Length 6 m ; Width 2 m )

About the stacking load in this packaging, the maximum weight Pca [kg] of the upper packaging has to be $\mathrm{Pca} \leq \mathrm{Sa} 2 \times \mathrm{Ca}$

Since the surface area Sa2 = length of upper packaging x width of lower packaging $=4 \mathrm{~m}$ x $2 \mathrm{~m}=8 \mathrm{~m} 2$

Since $\mathrm{Ca}=\mathrm{W}(\mathrm{Kg} / \mathrm{m} 2)$
Pca $\leq \mathbf{S a} \mathbf{x} \mathbf{~ C a = 8 \times W ( K g ) ( i t ' s ~ l o w e r ~ t h a n ~ t h e ~ p r e v i o u s ~ e x a m p l e ! ) ~}$


In the packaging the length of upper packaging is lower than the length of lower packaging, the manufacture may choose to use two beams to subdivide the load on the whole length of sides.


## THE CONCENTRATED LOAD

The concentrated load is important because the lid has to bear high loads on a small surface, as, for example, a footprint (see Pics. n. 18 and n.19).


Pics n. 18 and n. 19 - Examples of concentrated load

The calculation of the concentrated load is necessary to design the load - bearing elements of the lid and it has to be applied in the most unfavourable point (see Pic. n. 20).


Pic. n. 20 - concentrated load and design of load - bearing elements

## THE DYNAMIC LOAD

Load acting on the packaging and its contents arising during handling and transport.
The value of the dynamic load $C_{d}$ acting on the packaging is equal to the product of the weight $\mathrm{P}[\mathrm{kg}]$ and the acceleration.

$$
C_{d}=P \times a
$$

- LONGITUDINAL (braking or acceleration of the means of transport)
- TRANSVERSAL (acceleration by effect of a curvilinear trajectory of the means of transport)
- VERTICAL


## DYNAMIC ACTIONS

The acceleration values used to calculate the dynamic load may derive from the design hypotesys or from a national technical standard. The CTU Code indicates the values in the table n.1.

| Means of <br> transportation | Value of <br> acceleration <br> forward | Values of <br> Acceleration <br> backward | Values of lateral <br> Acceleration |
| :---: | :---: | :---: | :---: |
| BY ROAD | $1,0 \mathrm{~g}$ | $0,5 \mathrm{~g}$ | $0,5 \mathrm{~g}$ |
| BY RAIL (shunting <br> traffic) | $4,0 \mathrm{~g}$ | $4,0 \mathrm{~g}$ | $0,5 \mathrm{~g} \mathrm{(a)}$ |
| BY RAIL <br> (Combined <br> traffic)* | $1,0 \mathrm{~g}$ | $1,0 \mathrm{~g}$ | $0,5 \mathrm{~g} \mathrm{(a)}$ |
| BY SEE (Baltic <br> sea) | $0,3 \mathrm{~g} \mathrm{(b)}$ | $0,3 \mathrm{~g} \mathrm{(b)}$ | $0,5 \mathrm{~g}$ |
| BY SEE (North <br> sea) | $0,3 \mathrm{~g} \mathrm{(c)}$ | $0,3 \mathrm{~g} \mathrm{(c)}$ | $0,7 \mathrm{~g}$ |
| BY SEE <br> (Worldwide travel) | $0,4 \mathrm{~g} \mathrm{(d)}$ | $0,4 \mathrm{~g} \mathrm{(d)}$ | $0,8 \mathrm{~g}$ |
| BY AIR | $1,5 \mathrm{~g}$ | $1,5 \mathrm{~g}$ | Vertical $\pm 3,0 \mathrm{~g}$ |

Table n. 1 - Example of values of acceleration taken from a IMO/ILO/UNECE Code of practice for packing of cargo transport units (CTU CODE)

The above values shall be combined with vertical gravitational forces of 1 g and dynamic fluctuations, also vertical:

$$
\text { (a) }= \pm 0,3 \mathrm{~g}(\mathrm{~b})= \pm 0,5 \mathrm{~g}(\mathrm{c})= \pm 0,7 \mathrm{~g}(\mathrm{~d})= \pm 0,8 \mathrm{~g}
$$

*railway wagons with packagings, swaps, trucks, lorries and complete trains type UIC and RIV.

Considering the physical characteristics of the product or manufactured item to be packaged and the entity of the dynamic load applying, the stability of the material and/or item inside the packaging must be ensured by suitable fastening to the base, which may consist of:

- Fastening elements able to prevent longitudinal and transversal shifts;
- Tie-rods, bolts or struts, able to perform anchorage and prevent tipping.

Example of calculation of dynamic load
Since a weight of the packaging including the content equal to $12500 \mathrm{~kg}(=\mathrm{P})$, we want to calculate the value of the dynamic load in the longitudinal direction.

We consider an acceleration value of $1,0 \mathrm{~g}(=\mathrm{a})$.
Since the formula of dynamic load is $\mathrm{Cd}=\mathrm{P} \times \mathrm{a}$
$C d=P \times a=12500(K G) \times 1,0 \mathrm{~g}=12500$

## CENTRE OF GRAVITY

Where goods are packaged individually and the marking of the centre of gravity is necessary, it is the duty of the customer/manufacturer to establish its position and indicate this to the packer. The centre of gravity must be marked according to a national Standard (es. DIN 55402 ) or to EN ISO 780 or according to the regulations of the country of destination.

The centre of gravity is the point where all the weight of a body is applied.


Pic. n. 21 - image of "centre of gravity" taken from ISO 780


Pics. n 22 and n. 23- examples of centre of gravity in a wooden packaging

It may happen to have an eccentric centre of gravity: in this packaging there is an eccentricity between the straight line passing by the centre of gravity and the hook


Pics. n. 24 and n. 25 - eccentric centre of gravity

In this packaging It will be important to limit the eccentricity of the centre of gravity during the lifting (see pics below)


Pics. n. 26 and n. 27 - lifting in the packaging of eccentric centre of gravity

## Example of calculation of the centre of gravity

It's possible to calculate the centre of gravity by means of the following steps
STEP1: First of all it's necessary to estabilish a Cartesian coordinate and to divide the shape in elementary shapes


Pic. n. 28 - Cartesian coordinate and dividing in basic shapes

STEP 2: Then it's possible to calculate the coordinates of the centre of gravity of each elementary shape


$$
x_{61}=1,5 \mathrm{~m}
$$

Pic. n. 29 - coordinates of the centre of gravity of each elementary shape

STEP 3: It's possible to calculate the centre of gravity of the complex shape according to the cartesian coordinate that has been set

$x_{G 1}=1,5 \mathrm{~m}$

$$
x_{G}=\frac{\sum m_{i} \cdot x_{G i}}{\sum m_{i}} \quad \Longrightarrow \quad x_{G}=\frac{10000 \mathrm{~kg} \cdot 1,5 \mathrm{~m}+5000 \mathrm{~kg} \cdot 3,5 \mathrm{~m}}{15000 \mathrm{~kg}}=2,16 \mathrm{~m}
$$

$$
y_{G}=\frac{\sum m_{i} \cdot y_{G i}}{\sum m_{i}} \quad \not \quad y_{G}=1 \mathrm{~m}
$$

Pic. n. 30-calculation of the centre of gravity of the complex shape


Pic. n. 31 - calculation of the centre of gravity of the complex shape
N.B. If the Cartesian coordinate has only one axis of symmetry, then the centre of gravity belongs to this axis
N.B. If the Cartesian coordinate has two axis of symmetry, then the centre of gravity is located in their intersection

## ANCHORAGE OF THE CONTENTS

Anchoring the contents is necessary mainly to satisfy the requirements for the stability and safety of the package as a whole. The stability of the contents, for the duration of the use of the packages in the conditions specified in the Draft design, depends primarily and indispensably on guaranteeing these requirements.

Considering the physical characteristics of the product to be packaged and the stresses it will be subjected to, the stability must be ensured of the material and/or the product inside the packaging by providing appropriate preventive and executive measures.

The stability and protection can be achieved:

- by a design that plans for the correct distribution of the loads inside the packaging;
- by the perfect stability of the load, obtained with blocks and suitable supports that will prevent the contents from shifting longitudinally or transversally.

The packaging contents must be anchored, then, to the base and/or to the packaging elements suitable for the purpose, with bolts, steel cables, straps, double-screw tie-rods or other systems that will prevent shifting and avoid overturning.

In the pictures below, the dynamic actions to be sized up with the aim of

[^0]

Pic. n. 32 - example of sizing up dynamic actions


Pics. n. 33 and n. 34 - example of stability achieved by means of suitable elements

## MATERIALS AND CALCULATION METHODS

## WOOD

Most of wood species can be used to manufacture wood packaging. Wood should guarantee a suitable durability (natural durability or with a level of durability obtained by means of preserving treatments) in compliance with the end use terms, as agreed in the contract.

The mechanical properties of wood changes also according to its moisture, as shown in the figure below:


Pic.n. 35 - Connection of wood moisture and its mechanical properties ( $a=$ resistance to tension parallel to grain; $b=$ resistance to bending MoR; $c=$ resistance to compression parallel to the grain; $d=$ resistance to compression perpendicular to the grain; $e=$ resistance to tension perpendicular to the grain).

If glued wood products are used to manufacture wood crates, the adhesive contained in these wood products must be resistant and durable with the aim of guaranteeing the preservation of the entirety of gluing, even in the packaging of high humidity level.

## CALCULATION METHODS

Regard the use of wood for "structural use", it's possible to choose between the two following methods:

- calculation method of the ALLOWABLE STRESSES
- calculation method of the LIMIT STATES

BASE: CALCULATION, SIZING AND CONSTRUCION CRITERIA
The Base is a complex horizontal and lower element of the packaging, intended to bear the content and usually made by the following elements:

- Longitudinal base beams
- Underbeams (which can be longitudinal or transversal)
- Head Beams
- Floor
- Transversal reinforcements / Load bearing cross - beams


## LONGITUDINAL BASE BEAMS

The size of longitudinal base beams depends on the weight and the arrangement of the contents, on the internal length of the packaging and on the distance between the centres of fork-lifting and the distance between the points of lashing of ropes and chains.


Pic. n. 36.- Examples of LONGITUDINAL BASE BEAMS with LONGITUDINAL underbeams (upper drawing) and TRANSVERSAL underbeams (lower drawing) - (1=transversal reinforcement; 2= floor; 3= Head beam; 4= LONGITUDINAL BASE BEAMS; 5 = Longitudinal or transversal underbeams)

Depending on the stresses calculated, the project engineer must size the cross-section and the number of longitudinal beams so as to prevent structural collapse of the packaging:


Pic. n. 37 - Diagram of the bending moment

## LONGITUDINAL UNDERBEAMS

The longitudinal underbeams are important for the movement of the packaging (fork lifting, lashing, lifting), as shown in the drawings and pic below.


Pics n. 38 and n. 39 - centres of fork-lifting (blue arrows) and points of lashing of ropes and chains (red arrows)


Pic. n. 40-centres of fork-lifting (blue arrows) and points of lashing of ropes and chains (red arrows)

TRANSVERSAL UNDERBEAMS

Their "contact surface" (=it refers to the surface made by the point of contact between the longitudinal base beams and the transversal underbeams) with the longitudinal base beams should be able to guarantee that the maximum allowable compression value in a direction orthogonal to the grain is not exceeded.


Pic. n. 41 - Transversal underbeams (marked with red colour)
When used, the transversal underbeams may give some advantages and disavantages:

- Advantage of cooperation with transversal reinforcements in "absorbing" the bendings in the trasversal direction ;
- Disavantages of
- Uncertainity about the points of fork-liftings;
- Concentration of the crushing tensions (in the wood, in the support surface, in packaging of stacking);
- Fair supports for longitudinal beams.


Pic. N. 42 - example of how the transversal underbeams contribute to "absorb" the thrusts of ropes


Pics. n. 43 and n. 44 - example of how the transversal underbeams contribute to "absorb" the thrusts of ropes


Pic. n. 45- transversal underbeams and points of fork lifting


Pic. n. 46 - tranversal underbeams

## HEAD BEAMS / HEADER

The manufacturer will have to choose, according also to the thickness of the cross-section of the head beams, the right type of connection of the same to the longitudinal beams: for example by means of bolting or nailing. In the recent years the option of using self-tapping screws has been added.


Pic. n. 47-head beams / header (marked with red colour)


Pic. n. 48 - head beams / header in a slightly back position - with the aims of a good fixing of the lower trasversal beams of the sides, head beams can be positioned sightly back compared to the external parts of the longitudinal base beams

The head beams are important because

- They give to the packaging a "box effect" : they are a "closing element", cooperate to "absorb" external strikes, etc.
- Thery cooperate to absorb the bending of the packaging in the transversal direction
- They cooperate in "blocking" the content.


Pic. n. 49 - head beams also cooperate in blocking the content

FLOOR

Composite element generally composed of boards arranged in a transversal direction or wood-based panels, connected to the longitudinal base beams.

It can be LOAD-BEARING or NON LOAD-BEARING depending on whether or not it has to bear the weight of the material contained in the package.


Pic. n. 50 - Floor (marked with red colour)

## LOAD - BEARING FLOOR

The thickness of weight-bearing floors depends on: the WEIGHT of the contents, the distance between the axes of the longitudinal base beams it is attached to, the allowable stresses and modulus of elasticity in relation to the wood species and class of the boards, the type and quality of the panels to be used.


Pic. n. 51 - Take care of the centre of gravity and of the distribution of the load


Pic. n. 52 - example of a load bearing floor, able to receive an evenly distributed load made by different elements and subdivided with homogeneity on all the surface

## NON LOAD-BEARING FLOOR

- Filling of a base provided with transversal reinforcements
- Independent element in the packaging of "rigid" load with support base affecting the entire surface area of the base (e.g. machinery)


Pic. n. 54 - example of non - load bearing floor

## TRANSVERSAL REINFORCEMENTS <br> / LOAD BEARING CROSS BEAMS

The load bearing cross beams are wood elements destined to support the loads of the contents (especially concentrated contents) and transmit them to the longitudinal base beams to which they are bolted or nailed. The transversal reinforcements may also have a function of countering the compression effect due to the transversal tightening caused by ropes or chains.


Pic. n. 55 - Transversal reinforcements (marked with red colour)

The cross-section of the load bearing cross beams depends on the type, position and entity of the loads imposed on them, the distance between the axes of the longitudinal base beams, the allowable stresses and modulus of elasticity in relation to the wood species and class to be used. Their function is in fact that of transferring the load of the contents to the longitudinal beams.



Pic .n. 57-Beam on a number of supports with distributed load


Pic. n. 58 -Deformed


Pic. n. 59 - Diagram of the bending moment


Pic. n. 60 - Rigid load with supports affecting the two ends

When the packaging is stationary, the transversal reinforcements lay on longitudinal beams, with a "statical scheme" of a beam with different supports:


Pic n. 61 - statical scheme of transversal reinforcement when the packaging is stationary

In the stage of lifting, it's important to reduce the eccentricity between the support of the content and point of lifting


Pic . n. 62 - importance of reducing eccentricity between the support of the content and the point of lifting

The transversal reinforcements may also have the function of contrasting the compression action made by the transversal clamping caused by ropes or chains


Pic. n. 63 - contrasting the compression action caused by ropes or chains


Pic. n. 64 - example of a base made with a mixed structure (longitudinal beams made with solid wood and transversal reinforcements made of steel)

## SIDES

The sides or side walls are taken to mean those complex vertical lateral components of the packaging, applied to the external longitudinal base beams, consisting of a frame and of covering. The sides must be sized with the aim of withstanding the stacking load.


Pic. n. 65 - the importance of withstanding the stacking load

HEADS
The head is taken to mean a complex vertical component of the packaging, applied perpendicular to the longitudinal base beams, consisting of a frame and of a covering. The heads, also called head walls, must be attached to the head beams which they work in conjunction with to withstand external actions to stiffen the sides and to ensure that the packaging is not deformed in a transversal direction. The heads do not contribute to sustaining the stacking loads.


Pic. n. 66 - Difference between head and side

## SIDE WALL FRAMES

The side wall frame is taken to mean a composite element consisting of the set of elements defined below: diagonal, upright, corner upright, intermediate upright, auxiliary upright, crossbeam, lower crossbeam, upper crossbeam, intermediate crossbeam, auxiliary crossbeam, auxiliary segment.

- Ensure that the sides support the stacking load (see pic. n. 67);
- also support any possible horizontal loads (see pics n. 68 and n. 69)

Appropriate bracing elements should therefore be provided. Such elements are generally composed of diagonals (see pic. n. 70) or of wood-based panels (see pic. n. 71)


Pic. n. 67-Vertical load


Pic. n. 68 - Horizontal load: no bracing (before stress)
$\longrightarrow$


Pic. n. 69 - Horizontal load: no bracing (during stress)


Pic. n. 70 - Horizontal load: bracing with diagonals


Pic. n. 71 - Horizontal load: bracing with panels

## UPRIGHTS / STRUT

The intermediate strut and any auxiliary uprights have the function of supporting the loads transmitted to them by the lid.


Pic. n. 72 - Uprights(red)
The value of rigidity of the lid must be enough to avoid the deformation of the struts and then of the side

LID
Complex horizontal component for closing the top of the packaging. The set composed of the lid and of the lid supports (or supplementary lid structure) should be sized to withstand the superimposition load.


Pic. n. 73 - Lid and lid supports (1 = Lid; 2 = Lid supports)

## SUPPLEMENTARY LID STRUCTURE

The lid supports may be placed as free-standing elements.


Pic. n. 74- Supplementary lid structure (1= lid support)

The lid supports should be sized to:

- withstand the upper loads imposed on the lid and to transmit them to the uprights (BENDING ACTIONS);
- withstand the external lateral actions exercised on the packaging, particularly those caused by the action of ropes or chains on the upper lateral edges during hoisting operations ( COMPRESSION ACTIONS).


Pic. n. 75 - The size of lid supports should take care of actions

## HANDLING WITH ROPES OR CHAINS

Key:
$\mathrm{Q}=$ crane hook
La =Width of lid of packaging to be handled
$\mathrm{Hf}=$ Distance of hook from lid

When moving with ropes or chains, the angle created in the point of encounter of the ropes, starting from the crane hook $(Q)$, should be $\leq 60^{\circ}$. The more the angle is below $60^{\circ}$ the weaker the external lateral action exercised by the ropes on the packaging is.

Being an equilateral triangle, it is possible to check the suitability of the arrangement by making sure that the distance of the hook from the lid (Hf) is equal to or greater than ( $\geq$ ) the result of the following formula:
$\mathrm{Hf}=\sqrt{ }(\mathrm{La} 2-(\mathrm{La} / 2) 2)$
so if $\mathrm{La}=100 \mathrm{Hf}=\sqrt{ }(1002-502)=86,6$
Therefore, the distance (Hf) corresponds, in any case, to 86,6 \% of the width (La) of the lid of the packaging.

For guaranteeing the movement, it's, therefore, enough to verify if distance (Hf) is $\geq 86,6 \%$ of the width of the lid.

After this premise, for convenience the coeffi cient 0,9 is used as ratio of La and Hf
$\mathrm{Hf}=0,9 \times \mathrm{La}$


Pic. n. 76 - Handling with ropes or chains

Environmental and logistics situations often will not allow operators of the handling chain to satisfy the needs illustrated above, because ropes or chains may not be available or adequate, or because environments or equipment do not allow the crane hook to operate at optimum levels. In these packagings, a balance beam lifter should be used.


Pic. n. 77-Packaging to be handled by means of lifting device
N.B. Generally, during the stage of lifting,

- the ropes produce some horizontal thrusts
- for every deviation, each rope produces a force on the packaging
- these deviation forces re-estabilish the balance


Pics n. 78 - horizontal thrusts and deviation forces

About the horizontal thrusts, there can be three types of configurations as shown in the pics below.
configuration of type 1 - in this case the pull Tver of each vertical rope is the $1 / 4$ of the lifting load $P$ (which will include also the dynamic effects). The rope will pass under the packaging with a deviation of $90^{\circ}$. Therefore the horizontal thrust from the base $S_{B}$ will be equal to Tver $=P / 4$


Pics n. 79 and n. 80 - Configuration of type 1

Configuration of type 2 - In this case each rope, along the sides of the packaging, does not receive any deviation. Since the vertical pull of each rope Tver $=P / 2$, then Tver $=P / 4$. The rope will pass under the packaging with a deviation of $90^{\circ}$. Therefore the horizontal thrust from the base $S B$ will be equal to Tver $=P / 4$. In the intersection with the lid, an horizontal thrust will be produced (Sc and Ta).


Pics n. 81 and n. 82 - Configuration of type 2

Configuration of type 3-In this case, each rope, in the intersection with the longitudinal base beams diverts either in the transversal plane or in the longitudinal plane. Two deviations cause two horizontal thrusts ( $\mathrm{S}_{\mathrm{B}}$ and $\mathrm{S}_{\mathrm{L}}$ ). In the intersection with the lid, there is only a deviation: the rope diverts only in the transversal plane.


Pics n. 83, n. 84, n. 85 - Configuration of type 3

LID COVERING

In the following pictures there are some possible types of manufacturing lid covering


Pic. n. 86 - Single layer covering with wood based panels (1=OSB or Plywood; 2= waterproof material)


Pic. n. 88 - Double layer covering with wood based panels ( $1=$ OSB or Plywood; 2= waterproof material)


Pic. n. 87-Single layer covering with boards (1 = Boards; 2= waterproof material)


Pic. n. 89 - Double layer covering with boards + wood based panels (1= Osb or Plywood; 2= waterproof material; 3= boards)

## FASTENING

Wooden and / or Metal elements for fastening may be used by the manufacturer with the aims of joining, securing, blocking wooden elements and contents.

## METAL FASTENING ELEMENTS

The metal fastening elements may be used to connect together the parts of the packaging and also to join the wooden elements used to secure the contents.
The manufacturer should be very careful in the selection of the type of fastening elements used, and also their layout.
Depending on the use of the packagings, the various wooden elements can be connected with nails, staples and other fastening elements.

## NAILS

The choice of nails in the manufacture of packagings depends on the type of wood used, on its humidity, on the thickness of the sawn pieces, on the desired tear resistance and on the chemical or climatic environment of destination.
The most frequently used nails are the threaded ones, that is part of the stem is shaped so that it adheres and better resists extraction.


Pics n. 90 and n. 91 - Nails

## STAPLES

Staples are u-shaped fastening elements made with round or square-section wire; they have two stems, usually of the same length and generally with sharp points. In making industrial packaging, their use follows the same rules applied to nails.


Pic n. 92 - Staples

## SCREWS

Screws, compared to nails, have the advantage that they can be disassembled and reassembled without losing their efficacy, except through weakening, which to some degree occurs every time they are tightened, but normally this is not a problem.


Pics n. 93 and n. 94 - Screws

Recently, due to the technical development of building sector, too self-drilling screws are available for the manufacturers (see Pics below).


## BOLTS

When using this fastening element, a washer needs to be placed between the wood and the nut to prevent the two surfaces from coming into direct contact.
The holes drilled in the objects to be joined must not be threaded, they must allow the free passage of the bolts.
The threads of the bolt do not necessarily have to extend the entire length of the stem, as the threads that remain inside the wood are not necessary.
A variant is a totally threaded bar, cut to the right length, with a nut and washer at both ends.


Pics n. 97 and n. 98 - Bolts
Stability and Safety Requirements - FEFPEB - Industrial Packaging

## ROPES

Ropes or cables are lines made of metal wires or hemp or synthetic threads tightly intertwined.
The various types of lines depend on the use they are destined to. A wide variety of ropes and cables exist that can satisfy all requirements for use.

## TIE - RODS

Tie-rods are structural elements made of metal used to contrast side pressing forces due to weight. In industrial packaging, tie-rods are used to give the necessary tension to two cables or ropes to two pieces of opposed cable or rope in order to anchor and to secure the container contents. If bolts or similar fasteners are not used, tie-rods are indispensable to oppose longitudinal, transversal and vertical accelerations. Ties are usually used together with brackets and clamps.


Pic. n. 99 - Tie - rods

## METAL ANGLE BARS

In packaging production, metal angle irons can also be useful, especially for the construction of containers that will be disassembled and re-used a number of times, as for exhibitions or for shipping returnable samples.

WOODEN ELEMENTS FOR FASTENING THE CONTENTS

## TIES

Ties are a set of elements that make up a rigid structure that can block the contents to the packaging.
They enable the contained material to be made solid with the packaging, to be isolated from it and to satisfy the stability and safety requirements of the packaging, seen as a whole, but specifically they must ensure:

- Static and dynamic safety,
- Safety against shocks, rolling and vibrations,
- Equilibrium.

Their use, then, is connected to the stability of the contents inside the packaging for the duration of the use of the packaging in the conditions planned in the Draft design; they are elements that must safeguard against dynamic longitudinal and transversal stresses to which the entire package may be subjected.
To satisfy this need for stability and to avoid overturning, where possible it is necessary to tie down the material with wooden elements positioned transversally and also longitudinally to the container, fastened respectively to the frame of the sides and of the heads, and also one to the other depending on the characteristics of the product.
Depending on the various conditions of use, the structural elements that form the tie can be:

- Connected one to the other, at the intersection points, to obtain greater rigidity of the whole.
- Not connected one to the other, to give the contents a minimum degree of flexibility in case of shock or acceleration.
The ties should be arranged outside the barrier bag.
In case this is not possible, sealing material, rubber or other, must be put between the contact surfaces of the clamp elements and the barrier bag where the parts are fastened together; this is to ensure the moisture proofing of the cover. The points where the wooden elements come in contact with the contents should be protected from rubbing with suitable materials, to ensure that the parts under pressure are not damaged.


Pic. n. 100 - Tie
In the example in the pic below, the absence of an appropriate fastening (i.e. a tie or other systems) has caused, following an acceleration, a damage on the pillars. This example reminds us of the importance of the anchorage of the content.


Pics n. 101 and n. 102 - example of damage caused by the absence of an appropriate fastening

## WEDGES AND STOCKS

Wedges and stocks are wooden elements used to block and anchor packaged materials and their purpose is to prevent the contents from shifting, especially at the contact points with the container base.
At the points where these elements touch the contents, the contents should be protected from rubbing with suitable materials, also to guarantee that the parts subjected to pressure are not damaged.
The use of these elements should be supported by appropriate fastening systems that should be suitable for the purpose to which they are destined, ensuring that the connections are sufficient to preclude risks for the safety of the material and for the shipment in general.

## NON - EXHAUSTIVE ACRONYM LIST

$\mathbf{a}=$ [g], acceleration
$\mathbf{C a}=[\mathrm{kg} / \mathrm{m} 2]$, is the stacking parameter
$\mathbf{C d}=[\mathrm{kg}]$, dynamic load acting on the packaging
Cma $=[\mathrm{kg}]$, is the stackable limit
CTU = acronym of "IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units"

Hf = Distance of hook from lid
$\mathbf{L a}=$ Width of lid of packaging to be handled
P or W = [kg], weight
Pca $=[\mathrm{kg}]$, is the maximum weight of the upper packaging
Q= crane hook
Sa1 $=[\mathrm{m} 2]$, is the surface area of the packaging receiving the load. It is calculated as the product of the length by the width of the packaging receiving the load (lower).

Sa2 $=$ [m2], surface area that is calculated as the product of the length of the upper packaging by the width of the lower packaging.

Tver = the pull of each vertical rope


[^0]:    $\Rightarrow$ prevent slipping
    $\Rightarrow$ prevent tipping

