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1 BASIC INFORMATION ABOUT ROLL-BOND EVAPORATOR

Roll bond evaporator panel is used as heat exchanger in production of freezers and refrigerators industry.

1.1 ONE SIDE INFLATED EVAPORATOR – OSF, OSEF

OSF, OSEF evaporator is two-layered evaporator panel with channels on the one side.

It is produced from two Al strips (layers), same or different thickness of the layers. OSF, OSEF evaporator panel is made from Al 99,5% (AA 1050) for soft (channels side) layer and Al 99,0 % with Zr up to 0,20 % (AA 1230) for hard (flat side) layer.

The layers are rolled together according to Roll-Bond technology by the Expandal line. After the annealing process the panel is transformed by hydraulic press.

The channels on soft side of the panel are formed (expanded) by the high pressure of dry air, while hard side of the panel remains flat. Because of special advanced computer managed inflating process, all one side inflated panels are OSEF (extra flat) quality.

By the customers request OSF, OSEF evaporators are delivered:

- a) Rectangular evaporator cut panel on mechanical shears according to requested dimension or,
- b) Punched evaporator panel with all details to end dimensions (ready to completion process).

Max dimension of rectangle cut OSF, OSEF plate are: 2350 x 495 mm.

1.2 DOUBLE SIDE INFLATED EVAPORATOR - DSI

Double side inflated evaporator is two-layered evaporator panel with symmetrical channels on both sides.

It is produced from two Aluminium strips-Al 99,5% (AA1050). Two strips are rolled together according to Roll-Bond technology with Expandal line. After the annealing process the panel is transformed by hydraulic press. The channels are formed on both side of the panel with the high pressure of dry air.

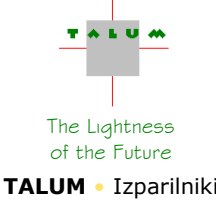
By the customers request DSI evaporators are delivered:

- a) Rectangular cut evaporator on mechanical shears according to requested dimension or,
- b) punched evaporator with all details to end dimensions (ready to completion process).

Max dimension of rectangle cut DSI plate are: 2350 x 505 mm.

Fulfil customer:

Note:	Approved from:
	Date:
	Signature: Responsible for specification

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2 REQUIRED DOCUMENTATION AND STANDARDS USED

2.1 DOCUMENTATION

Documentation includes:

- Technological documentation according to Expandal line.
- Drawing for each type of evaporator panel.
- Contract or order for supply of evaporators.
- Customers demands or his quality specification.
- Standards in use and regulations as reference documents.

2.2 REFERENCE DOCUMENTS

Reference document	Purpose
Purchase spec. KA35, KAA1050	Chemical composition – soft layer
Purchase spec. KA22	Chemical composition – hard layer
ISO 6507	Hardness according to VICKERS
DIN 8964-1	Volume of the channels system
DIN 8964-1	Internal humidity in the channels
DIN 8964-1	Insoluble impurity
DIN 8964-1	Soluble impurity
DIN 8964-1	Unblown residual (graphite)
DIN 15155	Dimension of returnable metal box

3 QUALITY CHARACTERISTICS

3.1 CHEMICAL COMPOSITION VALUE

3.1.1 ONE SIDE INFLATED evaporators – OSF, OSEF

Channels layer (Table 1): Al 99,5 % (AA1050)

The heavy metals contains should not exceed 100 ppm regarding EU directive 2002/95/EC (RoHS).

% max. % impurities										
Al	Si	Fe	Ti	Cu	Mg	Mn	Zn	Zr	separately	altogether
Min. 99,5	0,25	0,40	0,05	0,03	0,03	0,03	0,03	0,01	0,03	Max. 0,50

Table 1

Flat layer (Table 2): Al 99,0 % (AA 1230)

The heavy metals contains should not exceed 100 ppm regarding EU directive 2002/95/EC (RoHS).

% max. % impurities									
Zr	Si	Fe	Cu	Mg	Mn	Zn	Ti	separately	Al
0.15-	0.05 -	0.45 -	0.03	0.03	0.03	0.03	0.05	0.03	Min 99.00
0.20	0.10	0.60							Max. 99.35

Table 2

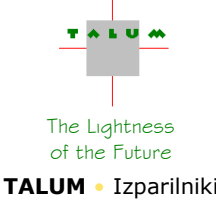
3.1.2 DOBLE SIDE INFLATED evaporators – DSI

Both layers (Table 3): Al 99,5 % (AA1050)

The heavy metals contains should not exceed 100 ppm regarding EU directive 2002/95/EC (RoHS).

% max. % impurities										
Al	Si	Fe	Ti	Cu	Mg	Mn	Zn	Zr	separately	altogether
Min. 99,5	0,25	0,40	0,05	0,03	0,03	0,03	0,03	0,01	0,03	Max. 0,50

Table 3

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3.2 MECHANICAL PROPERTYS

3.2.1 OSF, OSEF

Hardness are in range regarding to the production technology (hot rolling, annealing, channels inflation) and measured at the places out of the channels:

VICKERS HV 5 (ISO 6507)

hard layer (flat side)	30 - 44 HV
soft layer (channel side)	20 - 25 HV

3.2.2 DSI

The hardness of double side inflated panels are in range between **20 in 25 HV**, measured at the places out of the channels by Vickers (HV5). This should assure sufficiently ability to remodeling of evaporator panels during evaporators completion process.

3.3 DIMENSIONS OF EVAPORATOR PANEL (OSF, OSEF, DSI)

The evaporator panel dimensions are defined with the drawing for each type (code). If drawing not define necessary dimensions or their tolerances, needed for designing stage and production execution, the consensus about dimensions and tolerances with buyer should be reach. This agreement should customer confirm with written confirmation, fitted with necessary data which define type (code) of evaporator panel.

The samples are needed for establishing the suitability of evaporator panel for each and every code. The customer find out, if the samples are in accordance with as per agreement and this confirm with the final written confirmation.

The drawing is required in writing, 1 (ONE) copy.

In the early stages of inquiries or agreements, the CAD versions of drawing is suitable to quick response, but for designing stage is needed **only written or CAD dxf file of drawing**.

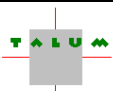
Cutting process could be made by rectangular cutting with mechanical shears or punching with punching tools.

Dimensions are divided on:

- Evaporator panel dimension – external** (width, length, thickness, channel system position on evaporator panel, etc).
- Dimensions of channels system – (channels designe)** on evaporator panel.
- Dimensions of channels cross-section.**

3.3.1 EXTERNAL DIMENSIONS OF EVAPORATOR PANEL (OSF, OSEF, DSI)

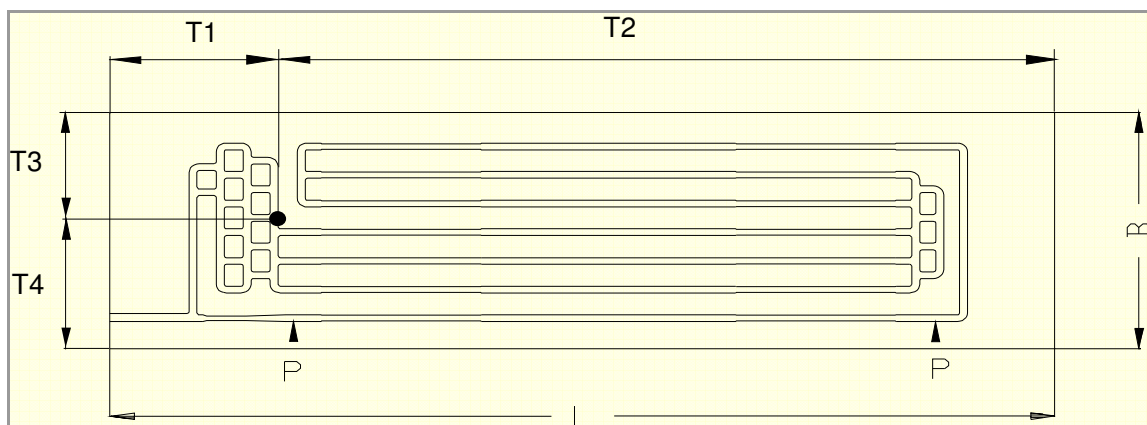
Each type of evaporator panel have an reference points according to the drawing and they are used for determination and control of the channels in proportion to external dimensions-edge of evaporator panel (*picture 1 and picture 2*).

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3.3.2 EXTERNAL DIMENSIONS of OSF, OSEF and DSI panels – RECTANG. CUT

The following quality characteristics with tolerances are allowed (*picture 1*):

- Panel Thickness: **$d \pm 0,1 \text{ mm}$**
- Panel Length: for $L \leq 1500 \text{ mm}$: **$L \pm 1 \text{ mm}$**
for $L \geq 1500 \text{ mm}$: **$L \pm 2 \text{ mm}$**
- Panel Width: **$B \pm 1 \text{ mm}$**
- Distance from the edge to the channel: **$P \pm 1 \text{ mm}$**
- Reference points within the channels: lengthwise: **$T1, T2 \pm 1 \text{ mm}$**
widthwise: **$T3, T4 \pm 1 \text{ mm}$**

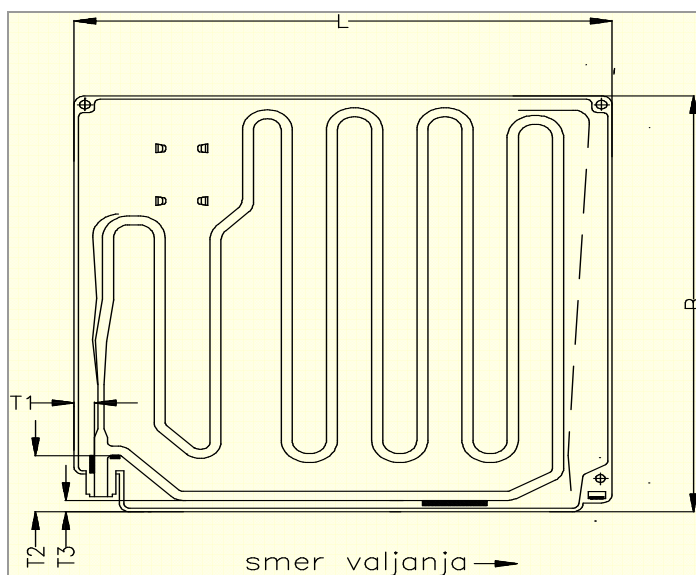


picture 1

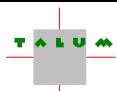
3.3.3 EXTERNAL DIMENSIONS for OSF, OSEF and DSI panels – PUNCHED

The following quality characteristics with tolerances are allowed (*picture 2*):

- thickness of the panel: **$d \pm 0,1 \text{ mm}$**
- length of the panel: for $L \leq 1300 \text{ mm}$: **$L - 1 \text{ mm}$**
for $L \geq 1300 \text{ mm}$: **$L - 2 \text{ mm}$**
- width: **$B - 1 \text{ mm}$**
- reference points: **$T1, T2, T3 \pm 1 \text{ mm}$** (light lines)

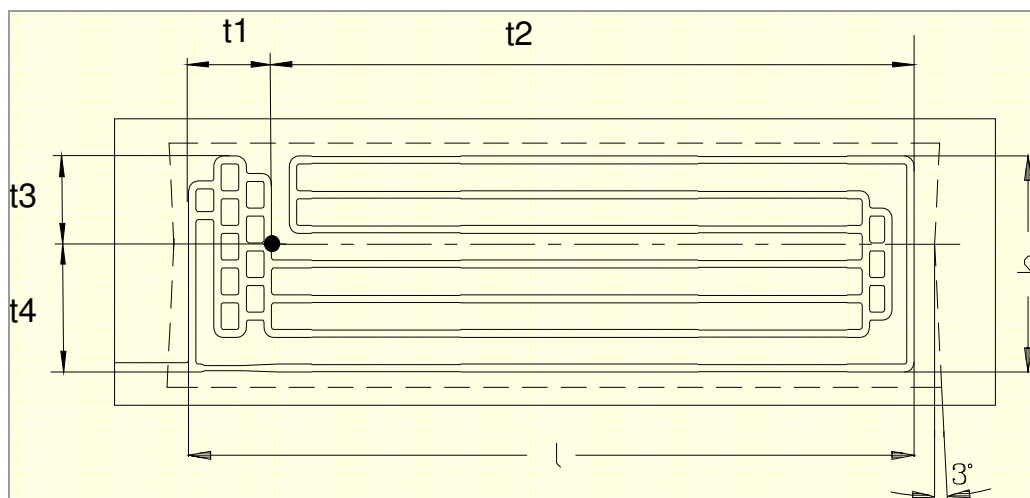


picture 2

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3.4 DIMENSIONS OF CHANNELS DESIGN – DSI, OSF, OSEF (picture 3)

- length of the channels (channels picture): $l \pm 2 \% * l$
- width of the channels (channels picture): $b \pm 1 \% * b$
- angle deviation (channels picture): $\alpha_{\max} = 3^\circ$
- channels lenght: $(l \pm 2 \% * l_i) + b_i * \operatorname{tg} 3^\circ$
(l_i , b_i = free dimension)
- reference point position within the channels picture in wiew of allowed expanding of width and length during the rolling **t1, t2, t3, t4**



picture 3

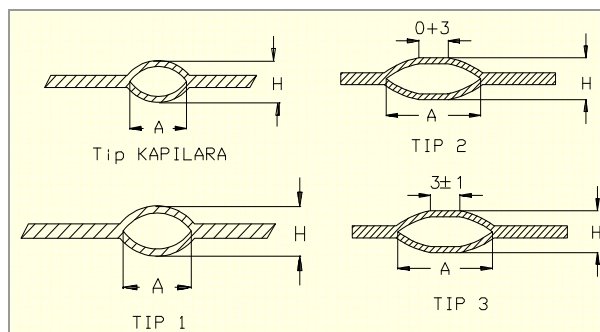
3.5 DIMENSIONS OF THE CHANNEL'S CROSS SECTIONS (OSF, OSEF, DSI)

3.5.1 Cross section of DSI channels – standardized (picture 4)

Picture 4 shows dimemenisons of cross section of DSI evaporator, which are standardized. Modifications must be agreed with a customer and defined by the drawing (or written agreement) for each type of the panel.

LEGEND:

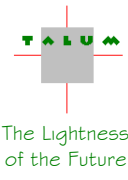
- A** = width of the channel or capillary
H = height of the channel or capillary
0⁺³ = width allowed on flat part of the channel
3^{±1} = width allowed on flat part of the channel



picture 4

3.5.1.1 WIDTH (A) of DSI channels – standardized (picture 4)

- capillary type: **A** = 5,0 - 6,3 mm $\pm 0,50$ mm
- type 1 (bending z.): **A** = 6,5 ; 7,0 ; 7,5 ; 8,0 mm $\pm 0,80$ mm
- type 2 and type 3: **A** = 8,5 ; 9,0 ; 9,5 ; 10,0 ; 10,5 ; 11,0 mm $\pm 1,0$ mm

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3.5.1.2 HEIGHT (H) of DSI channels - standardized (picture 4)

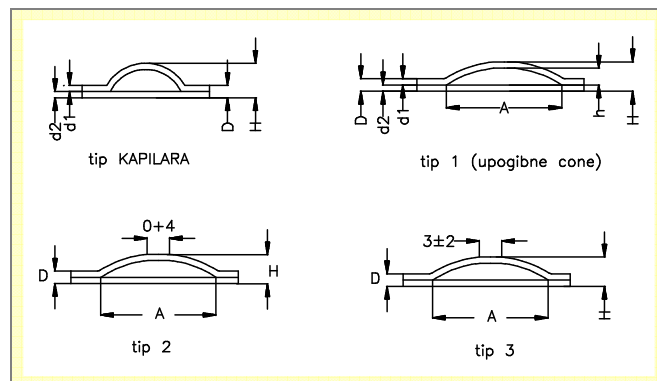
Thickness of the pannel $d \pm 0,1 \text{ mm}$	Capillary $H \pm 0,30 \text{ mm}$	TYPE 1 - bending zone $H \pm 0,30 \text{ mm}$	TYPE 2, TYPE 3 $H \pm 0,15 \text{ mm}$
1,20 mm	3,20 mm	4,30 mm	4,30 mm
1,40 mm	3,40 mm	4,50 mm	4,50 mm

Table 4

3.5.2 Cross section of OSF, OSEF channels –standardized (picture 5)

LEGEND:

- D** = thickness of the panel
H = height of channel, height of capillary
A = width of the channels, capillary
0^{±4} = width allowed on flat part of the channel
3^{±2} = width allowed on flat part of the channel



picture 5

3.5.2.1 WIDTH (A) of OSF, OSEF channels – standardized (picture 5)

- capillary type: **A** = 5,0 - 6,3 mm $\pm 0,50 \text{ mm}$
type 1 (bending z.): **A** = 6,5 ; 7,0 ; 7,5 ; 8,0 mm $\pm 0,80 \text{ mm}$
type 2 and type 3: **A** = 8,5 ; 9,0 ; 9,5 ; 10,0 ; 10,5 ; 11,0 mm $\pm 1,0 \text{ mm}$

3.5.2.2 HEIGHT (H)of OSF, OSEF channels – standardized (picture 5)

Table below shows standardized height of the channels and layers thickness,with tolerances to assure required quality characteristic-volume of the channels.

Soft layer	Hard layer	Thickness of the panel	capillary TYPE	TYPE 1 bending zone	TYPE 2, TYPE 3
d1	d2	$d \pm 0,1 \text{ mm}$	$H \pm 0,30 \text{ mm}$	$H \pm 0,30 \text{ mm}$	$H \pm 0,15 \text{ mm}$
0,60 mm	0,65 mm	1,25 mm	2,00 mm	2,80 mm	2,80 mm
0,65 mm	0,65 mm	1,30 mm	2,10 mm	2,85 mm	2,85 mm
0,70 mm	0,65 mm	1,35 mm	2,10 mm	3,20 mm	3,20 mm
0,75 mm	0,65 mm	1,40 mm	2,20 mm	3,45 mm	3,45 mm
0,65 mm	0,75 mm	1,45 mm	2,20 mm	3,05 mm	3,05 mm

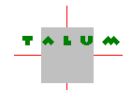
Table 5

3.6 TECHNOLOGICAL CHARACTERISTICS (OSF, OSEF, DSI)

3.6.1 VOLUME OF CHANNELS SYSTEM

Nominal volume (**V_n**) of channels is determinated by customers drawing. If the nominal volume of channels is not requested, then the volume is set up with the production of the samples. If the volume is not within the tolerances, then we ask for confirmation of modification or harmonization of nominal volume.

Tolerances of volume for OSF, OSEF evaporators pannel: ➤ tolerance border TM = $V_n \pm 10 \%$ ($\pm 7\% *$) ➤ control border KM = 60% TM ($\pm 6\%V_n$)	Tolerances of volume for DSI evaporators pannel: ➤ tolerance border TM = $V_n \pm 6 \%$ ➤ control border KM = 60% TM ($\pm 4\%V_n$)
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The volume is measured on automatic device, the results are automatically transferred in quality documents and in working order.

* On special customer requirement, with employment of statistical method, the nominal evaporator system volume, could be set up after few deliveries to $\pm 7\%$ and cp and cpk index $> 1,33$.

3.6.2 HUMIDITY IN THE CHANNELS OF EVAPORATOR PANEL (DIN 8964)

- Humidity in blowing air: **max 30 ppm**, automatic procedure (DEWPOINT meter) set on blowing device .
- Internal humidity in channels: **max 50 mg/m²** internal surface of channels (analysis P₂O₅).

3.6.3 PURITY OF CHANNELS SYSTEM (DIN 8964)

Determination of internal surface of the channels system could be doubtful due to allowed length and width of the channel's system and tolerances of the channels. Therefore the volume of the channels system is used to calculate impurities inside the channels system and the volume is used for calculation of internal surface. Impurity is expressed in m² of inside channels system. Whole production process of evaporators panels up to cutting to the final dimensions is automatized, controlled and it is in accordance with following max. values.

3.6.3.1 DISSOLUBLE AND UNDISSOLUBLE IMPURITY (DIN 8964)

Preparation of blowing air include avtomated cleaning devices and ultra filtration of high pressure air and assure max. limit of 50% of DIN 8964 impurity values for OSF, OSEF and DSI evaporators.

- dissolvable rinseable impurity : **max. 20 mg / m²**
- undissolvable rinseable impurity: **max. 30 mg / m²**
- total: **max. 50 mg / m²**

3.6.3.2 UNDISSOLUBLE REMAINS (graphite-carbon)

Max: **200 mg/m²** calculated on inside surface of the channels, measurement uncertainty $\pm 30 \text{ mg/m}^2$.

Note:

Methodology for defining of inside surface is:

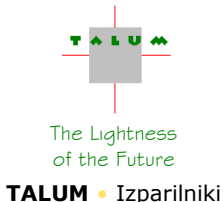
- the channels are cut with shears to separate both layers of the channel
- weighing of appr. 45 g of the separated channels (2 dm² of channels surface): **M**
- thickness of layer is measured: **d**
- calculation of inside surface of the channel: **S_n**

$$S_n = M / (d \times \sigma_{Al}) ; \sigma_{Al} = 2,7 \text{ kg/dm}^3$$

3.6.4 LEAKAGE AND TESTING PRESSURE

All evaporators panels are produced to stand a testing pressure:

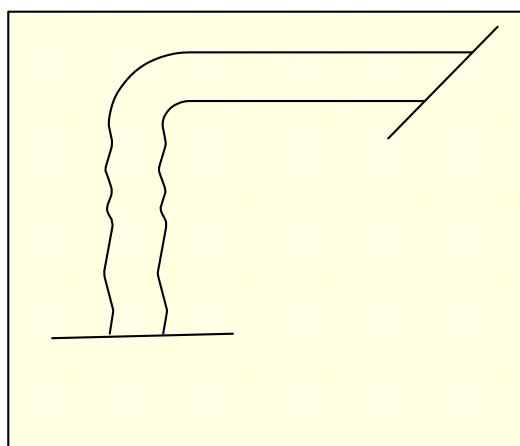
- Max. 5,5 bars for evaporators panels with thickness 0,6 mm of Al Zr layer –flat one ; tolerances under the channel is up to 0,1 mm with channel width up to 11 mm.
- Max. 6 bars for evaporators panel with thickness 0,65 mm of Al Zr layer –flat one tolerances under the channel is up to 0,1 mm with channel width up to 13 mm.
- Max. 8 bars for evaporators panel with thickness 0,75 mm of Al Zr layer –tolerances under the channel is up to 0,1 mm with channel width up to 13 mm.

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- Inappropriate testing pressure may cause convexity deformation over 0,1 mm in form of constant deformation.
- Min. 24 bars without leakage (with deformation of entire panel until crack appears).

3.6.5 UNEVENNESS – CORRUGATION OF CHANNELS (OSF, OSEF, DSI)

Unevenness (corrugation) is coming out from painting of channels picture on clean strip surface on the printing-machine, during the rolling process (figure 6).



picture 6

Corrugation is evident on channels that are crossing the rolling direction. Unevenness is allowed within 10 % tolerance from the cross section of the channels according to drawing.

3.6.6 UNEVENNESS – CURVATURE OF DSI EVAPORATOR PANEL

Unevenness is caused by rolling procedure of two layers of the strip, by inflation procedure and by design modifications or channels directions.

It appears inside the evaporators pannel and on the edges as well.

Stretcher/ device is installed to prevent unevenness out of tolerances:

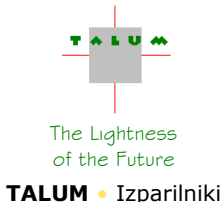
- max 1,5 mm/100 mm with width of panel up to 486 mm
- max 2,5 mm/100 mm with width of panel beyond 486 mm (technological channels assuring straightness are not possible)

Customer needs to confirm acceptable level of unevenness for each type of evaporator panel.

3.6.7 UNEVENNESS – CURVATURE of OSF, OSEF evaporator panels

3.6.7.1 FLATNESS UNDER THE CHANNELS – visibility of channels on flat side

The reason for unevenness it is in a technological procedure of OSF, OSEF evaporator panels – i.e. blowing (tensions occurred by transformation), different mechanical properties of both layers, different position of the channels on the panel (change in direction), minimum radius of channels, width of channels, minimum distance between the channels, shape and size of collectors within the channel's system.

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There are two unevennesses appearing under the channels:

OSF → One Side Flat: Unevenness under the channels $\leq 0,05 \text{ mm}$ on flat side of the panel

OSEF → One Side Extra Flat: Unevenness is not visible (adjusting layer thickness is essential).

3.6.7.2 UNEVENNESS – CURVATURE of whole evaporator panel (OSF, OSEF)

The reason appears due to different layers with different mechanical characteristics of OSEF panel and production technology (internal tensions in material) causing the curvature.

For that reason a stretcher is installed in production line assuring the continuing stretching of the raw panels.

Stretcher is used to make sure that unevenness is held within the following tolerances:

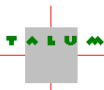
- $< 0,4 \% / L$ (for instance: 4 mm / 1 m) **in longitudinal direction of rolling and**
- **$< 0,5 \%$ in cross direction of rolling** (for instance: 2,5 mm / 500 mm).

3.6.8 SURFACE OF EVAPORATOR PANEL (OSF, OSEF, DSI)

Surface of evaporator panel is dry, smoothly, bright, without corrosive spots and larger mechanical damages.

The following smaller damages on surface of evaporators are allowed according to cutting operation and arranging the packaging unit:

- Maximum one scratch is allowed across the total surface (channel side). with maximal depth x width 20 μm x 80 μm (without burrs on edge). A few smaller scratches are also allowed which totally do not exceed one scratch across whole surface.
- A few smaller scratches are also allowed on flat side of the panel if they totally do not exceed the a.m. dimensions.
- Edge burrs on cut part is allowed with maximal dimension of 0,3 mm.
- Colouring of the panel because of burned oil is allowed (braun spots).
- No deep scratches, traces of tools, crushes are allowed on channels system.
- Defect on channels system or narrowing of cross section of channels, spots on the channels (caused in process of painting the channels picture) must not exceed:
 - max. length of defect: 1 mm
 - max. narrowing of channels: 0,5 mm - max. no. of defects / m²:
- No defect or narrowing of the channels are allowed in inlet section, in capillary tube section and in section of calibration of connection point on evaporator panel.

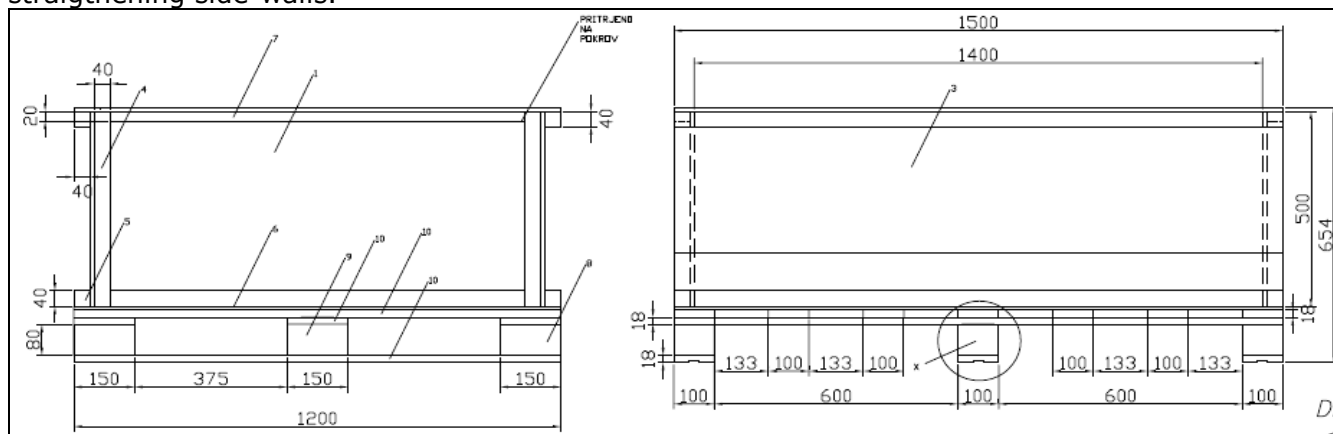
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4 PACKAGING, LABELLING, QUALITY DOCUMENTS

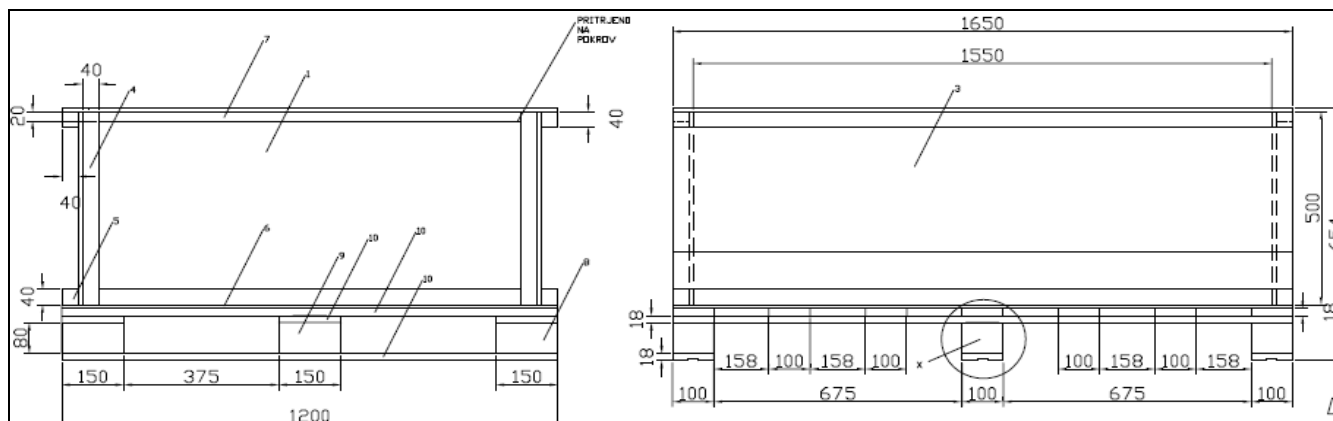
4.1 PACKAGING

4.1.1 PACKAGING IN WOODEN BOXES - standardized

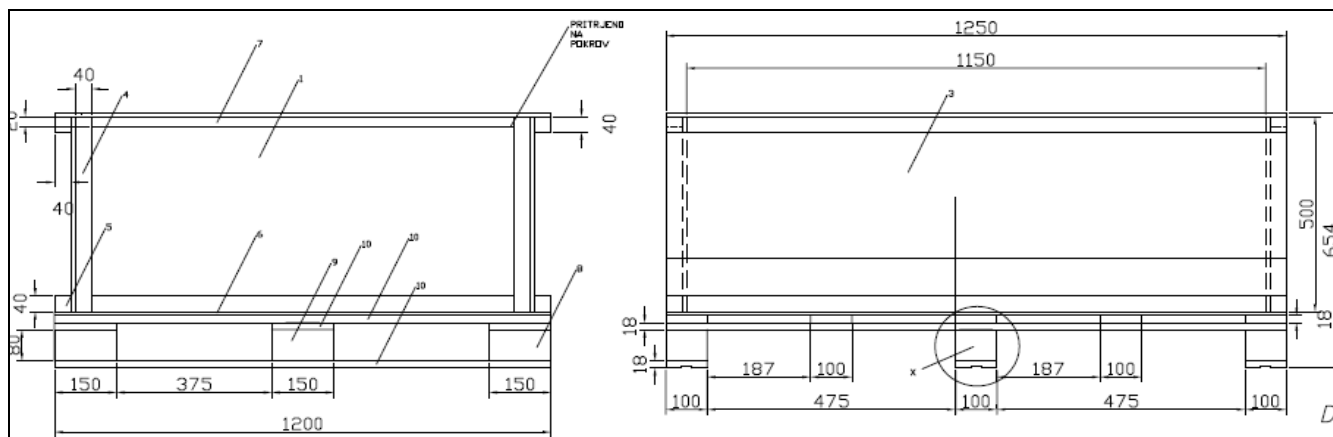
Evaporators panels are packed in standard wooden boxes upwards and horizontal untill filling up of the box volume. There is wavy card board on inside side of box to isolate plates form the wood (picture 7 to 11). The panels are not separated and they touch between themselves. Wooden box is designed to sustain a normal transport, manipulation and storage. The boxes of the same dimensions are allowed to be stored in MAXIMAL of two layers, properly positioned on vertical straightening side-walls.



picture 7: Wooden box, PR 30662- box dimensions: **1500x1200 mm**



picture 8: Wooden box, PR 30663- box dimensions: **1650x1200 mm**



picture 9: Wooden box, PR 30664- box dimensions: **1250x1200 mm**

Technical drawing showing two views of a rectangular frame assembly. The left view is a side elevation, and the right view is a top-down plan view.

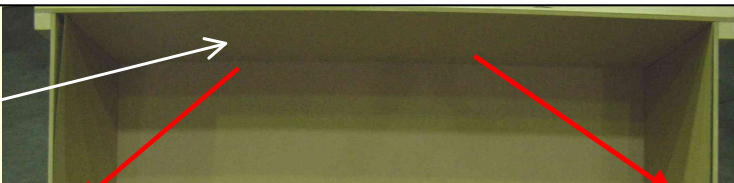
Left View (Side Elevation):

- Overall width: 1200
- Overall height: 800
- Top horizontal member (1) is attached to a vertical member (2) via a bracket (7) and a fastener (8).
- Bottom horizontal member (3) is attached to a vertical member (4) via a bracket (9) and a fastener (10).
- Labels: "PRITRŽENÍ NA POKROV" (Attachment to the roof).

Right View (Top-down Plan View):

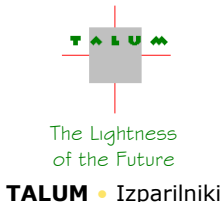
- Overall width: 800
- Overall height: 886
- Inner dimensions: 700 (width) x 750 (height).
- Bottom horizontal member (3) is shown with a dashed line indicating its position.
- Bottom horizontal member (3) is attached to a vertical member (4) via a bracket (9) and a fastener (10).
- Label: "x" points to a fastener (10) on the bottom horizontal member (3).

Cardboard on the box sides



The diagram shows a perspective view of an open rectangular box. The interior of the box is lined with a light-colored material, likely cardboard. A white arrow points from the text 'Cardboard on the box sides' to the top edge of the box. Three red arrows point to the interior surfaces: one to the left side wall, one to the right side wall, and one to the bottom floor of the box.

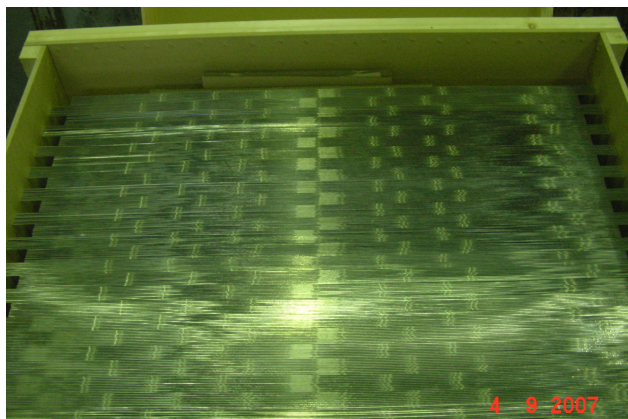
OBR 20.3.003.01 – OP 20.3.001

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Evaporators are inserted in wooden box upright. Panels are not separated between themselves, they are in contact (figure 13).

The boxes must be handle with care and they can stand normal condition of transportation and handling.

Each box is covered with cover and tie up with plastic ribbons. The label of contents is on box side.



picture 13: evaporators in box



picture 14: tied up box

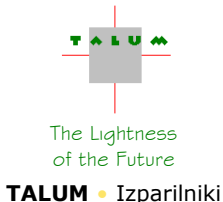
Transportation (also on short distances) must be performed maximal of 2 boxes in height.

Depositing in storehouse should be max. 2 in height if the palettes shelves are not aviable.

There must be assured, that only the same boxes are put one on one in the way that correctly sit on the box beneath. For this purpose the box sides are strengthen.

By customer special request dimensions of wooden box could be adapted to evaporator dimensions, but one of the side of the carrier wooden palete must be 1200mm.

Also the packing procedure could include the wrapping paper between the evaporator panels on customer request and written declaration of adequateness of the way of packing.

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4.1.2 PACKAGING IN METAL (BOX) palette

Packaging in metal BOX paletts is in use only on special customer request and written agreement which define the system of managing with palettes (returning, costs, mending, ...).

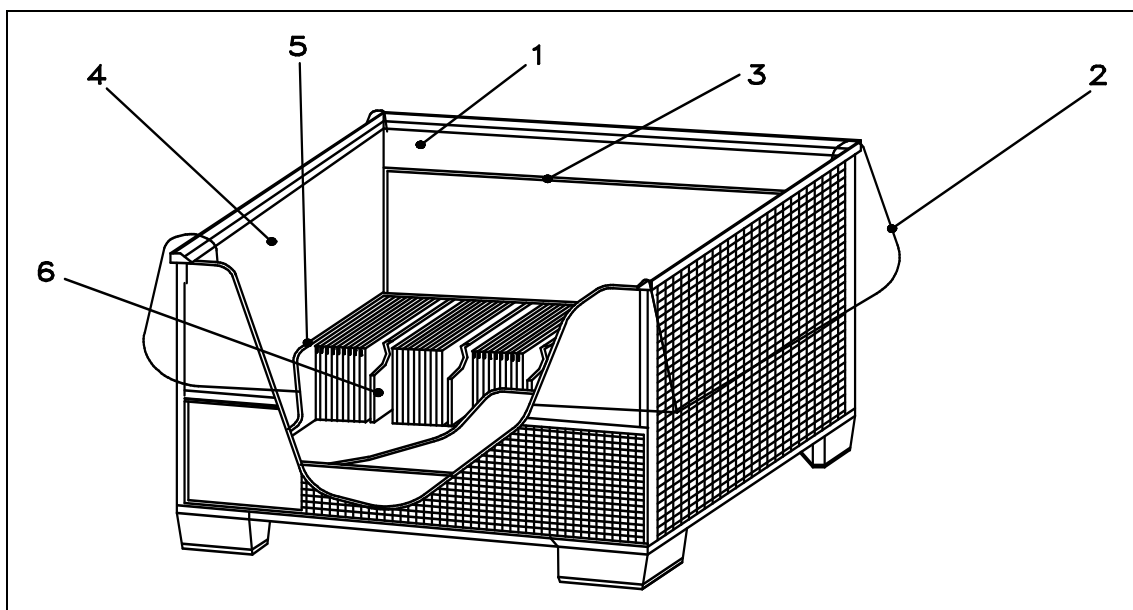
Evaporators are packing in the metal palette upright, up to fill up the box volume.

The box contents is protected ahead of environment influence with multi layers packing materials (look at figure 15):

- Exterior paper envelope (240 g /m²) poz.1 and 4
- Pet folie (0,03 mm) poz.2
- All sides are coverd with cardboard poz.3 and 4
- Depend to arrange evaporators in layers, cardboard are put between the layers
- All used material are recycable

There are three types of metal palettes in use:

1. standand metal palette (DIN 15155),
2. collapsible box palette 1240 mm (dimensions are based on DIN 15155),
3. collapsible box palette 1700 mm (extended width).



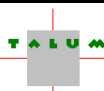
picture 15: multi layers packing materials



picture 16: collapsible box palette 1240 mm



picture 17: collapsible box palette 1700 mm

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4.2 LABELING

On the longer box side is label with data:

- Manufacturer
- Product name
- Product code (type, customer artickel Nr.)
- Evaporator dimensions
- Packing Nr.
- Customer
- Order Nr.
- Evaporator material quality
- Charge
- Packing date
- Net weight
- Quantity (pieces nr.)

4.3 QUALITY DOCUMENTS

Beside the standard transportation documents on special customer request we could equipped shipment with quality documents:

- ☐ First samples: **Samples quality report.**
The customer should check the samples and confirm the quality suitability in writing.
- ☐ On special customer request, the special periodic quality report with statistical data could be dispatched.