Brick and Wall Sizes

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(H. Pessard, updated version 17/01/03)

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The aim of the meeting was to end up with **detailed specifications for the brick wall support**, to let the Frascati and Napoli groups, which share responsibilities in its construction, finalise their technical drawings and start tendering and ordering procedures. These specifications mostly concern the **trays and their positioning**. They are intended to be presented to the Collaboration for endorsement at the next general meeting in Strasbourg.

The first job has been to finish freezing all the brick dimensions and the clearances around it in order to guarantee a safe brick manipulation. We had first to **fix the brick thickness** (along the beam direction) that was still not completely defined.

ALL DIMENSIONS IN THIS DOCUMENT ARE IN MILLIMETRES.

Preliminary remarks:

- We stick for the Changeable Sheet Support (CSS) with a maximum thickness of 2.15. There are discussions on the composition of the CSS to ensure an efficient protection of the CS against background tracks from lead radioactivity. Improvements in this respect are believed to be possible within the given thickness (possibly associating a half millimetre steel plate to a moulded plastic support).
- In the previous discussions on brick size (October 1st-2nd, 2002), we took as input values 0.108 for the laminated paper thickness and 0.4 for the wrapping carton thickness (precisely 0.39/0.41 min/max values). We use the same values, keeping in mind that they could change, depending on propositions from industries involved in the BAM project. Salvatore proposed to produce Excel sheets giving brick dimensions with a single input of these thickness. As we want to freeze the brick wall dimensions, any increase of thickness would have to be compensated.
- In fact, we have in mind that there are possible further improvements relative to the brick construction as we see it now. For example an increase of laminated paper thickness could be compensated by

  another way proposed by a BAM contributor of packaging the brick with paper. Such a change could be accepted in general if size is smaller or equal.

  another way proposed by a BAM maker to form the pile than the carton box, which introduces local over thickness, a delicate glue choice, etc.

  As we freeze the brick support dimensions, if changes bring slightly more space, it will be used to improve comfort and safety in the brick operation and/or construction. Another example is the possible reduction of the small rolls that form on the brick ridges by applying the vacuum in several steps. The benefit would be more shallow grooves for the skates, increasing their rigidity.

1. Brick dimensions review

1.1. Brick and CS thickness

We start from the previously defined ECC:

	Horizontal (max/min)	Vertical (max/min)	Thickness (max/min)
ECC	126.886/126.696	102.562/102.332	77.262/74.942

We keep the previous values for the CS+CSS thickness

CS+CSS	3.35/3.25

but the meaning is slightly changed: the max/min values were 'depending on glue thickness (0.1-0.2 mm)', we consider now a glue thickness of 0.1 plus a CSS thickness tolerance of ± 0.05

Notes on CS:

CS thickness is as before globally taken as 1.0
Laminated paper for CS is assumed to be the same as for the ECC, 0.108 thick
CS is folded on the ECC top (as assumed in the first Brick Wall size document)

We thoroughly rechecked the thickness of

ECC + (compensation of CSS)	76.234/73.914

If we add the CS+CSS and the glue ECC-CSS (0.1), we arrive to

ECC+[CS+CSS]	79.684/77.264

1.2. Additional Protection

We consider the Additional Protection (AP), intended to protect the higher part of the brick and its CS, and to keep the origami folded wings from ungluing.

Notes on Additional Protection:

AP stays within the skate thickness, **it does not add to the total brick thickness**
AP should leave free the space for the vacuum sucker, or be proven to connect correctly to the vacuum sucker and stand a 20 kg pulling force
AP should allow to see the code bars both on ECC and on CS

1.3. Putting the skates

The most recent skates, called 'linked skates', have been delivered at CERN. Their aspect is deceiving, as the very thin linking band does not stay straight. May be this can be improved by the gluing. We decide in any case to maintain the principle of a fixed length between the skates, which has many conceptual advantages when the ECC thickness varies (brick better localisation and reduced tray flexion). The length will be kept fixed by a actual link band or just by a size defining piece when the brick is being glued to the skates.

the glue thickness is evaluated to be 0.05 when attaching the skates

along the beam direction, the skate thickness is defined as before to be 1.5

We review the **skate contribution to the full brick size in all directions**.

Horizontally, the skate additional contribution to size is:
0.7 (skate thickness) -0.1 (corner folding compensation) +0.05 (skate glue) = 0.65
for both ends it is = 1.3 with no additional tolerance.
Added to the ECC+[CS+CSS] 126.90/126.70 , it makes 128.2/128.0

Vertically, the skate additional contribution to size is
1.0 (skate thickness) –(0.41/0.39 +0.1) (compensated: 1 carton +glue) +0.05 (skate glue) = 0.54/0.56 max/min (sic)
As ECC+[CS+CSS] is ECC +Top of CS folded (0.35),
Adding it to ECC+[CS+CSS] 102.91/102.68 gives 103.45/103.24

Along the beam, we consider the thickness of the brick with skates.
We choose the ECC positioning option in the skates 'ECC close to the CS', that is brick variability is absorbed on the side opposite to CS.
The double carton layer is chosen to be on top, not at the skates level
On the CS side, the skate contribution is
1.5 (skate thickness) –(2x0.108+0.1+0.04) (compensated: 2 origami +1 {air gap +glue} +1 welding) +0.05 (skate glue) = 1.194
On the side opposite to CS, the skate contribution is
1.5 (skate thickness) –(2x0.108+0.1+0.41/0.39+0.1) (compensated: 2 origami +1 {air gap +glue} +1 carton +1 carton glue) +0.05 (skate glue) = 0.724
For the full brick thickness, only the maximum dimension is relevant (we do not add a tolerance in addition to the *largest* brick thickness, we take it on the plasticity of the skates). It is 79.684 + 1.194 + 0.724 = 81.602. We round it to 81.6.

Then the **final dimensions of the brick with its skates** are:

	Horizontal (max/min)	Vertical (max/min)	Thickness (max)
The Brick w. skates	128.2/128.0	103.45/103.24	81.6

2. The Tray

2.1. Brick sliding clearance

With the previous skates philosophy, we had reduced the sliding clearance to twice 0.25 because we were in most cases in a much larger clearance situation and only the *thickest* bricks would slide with 0.25 clearances. As we have decided to fix the skate separation to the distance needed for the thickest brick, we consider to be always moving the thickest brick and we go back to twice 0.5 clearance. We have then a total clearance of 1.0 along the beam direction.

2.2. Discussion on the tray thickness

About the discussion which took place on the tray thickness, we recall a few elements:

- Measurements on the wall prototype at LAPP (I. Monteiro) have shown vertical deformations of a 0.5 thick tray under a brick load to vary between 0.3 and 0.4 at the middle point A between the ribbons along the tray, and at the internal edge of the sliding band (7.0 wide) in the perpendicular direction.
- Above deformations cross check with calculations made by E. Vanzanella.
- The deformations at A are not much changed if the brick is moved against the opposite band instead of against the measured band (both positions differ by 3 mm across the tray width).
- Emanuele computed the deformation at its middle B of the band linking the two sides of the tray (the tray crossing band situated along the tray at the ribbons) with updated tray dimensions: 10 mm wide sliding bands instead of 7, tray crossing bands 16 mm wide.
- With a 3 mm brick clearance, deformations at B range within 0.2-0.3 for 0.5 tray thickness. They decrease quickly when tray thickness increases. The values might also decrease for a 1 mm clearance.
- Deformations of 0.5 thick trays are not small. A. Franceschi is also considering wall transportation when he speaks in favour of a tray thickness increase
- Increasing tray thickness leads to additional welding tests
- Tray thickness ranging between 0.5 and 0.8 are considered. Clearances would be adapted to the choice, i. e. increased according to the deformations. This means that **the vertical step value is fixed**, as no room for deformation at 0.8 thickness leaves then room for additional deformations of 0.3 mm at 0.5 thickness.

In conclusion, vertically the step is chosen as 104.5 +0.8 for tray thickness = 105.3.
The situation of the total width of the tray (distance between facing ribbons) is complicated by the fact that capacities of chamfering the skates are limited for skates with 1.5 lateral thickness and require a internal radius of 0.7 or less in the folding of the tray edge.

Provided this condition on the tray folding radius is satisfied, the distance between ribbons can be set to 81.6 (brick) +1.0 (clearance) +twice the tray thickness.

A 0.7 thickness, reducing considerably the deformations, was finally chosen after the meeting.
Strong insurance is given that folding radii of 0.7 or less can be guaranteed (0.5 seems quite possible), so distance between ribbons can be set to 84.0.
The vertical step of the wall stays at 105.3

2.3. Tray dimensions, shape and other specifications

Starting from the conclusions above, we can summarise the tray specifications.

Tray thickness: = 0.7 (nominal)
Tray folding radius: < 0.7
Tray internal width: = 82.6 –0 +0.2
Tray external width (internal width + twice the tray thickness of 0.7) and Wall thickness (external width + twice the ribbon thickness of 0.8), nominally 84.0 and 85.6, are under evaluation in terms of tolerances.
Vertical distance between trays: = 105.3 step including tray thickness
Height of tray edges: = 7.0 above tray thickness (as before)
Tray total length: 26 nominal bricks @128.1 + 0.7 (tray thickness) at back of tray +2.6 (buffer for brick length variation at tray entrance) + 25 (tray front part, extension for BMS docking, see below) = 3357.9 + 3. mm entrance guides ~ 3361

Holes in tray floor:

Width of sliding bands:

10.5 mm wide sliding bands are requested starting from internal tray face: 1.5 (skate thickness) + 3.5 (groove for corner fold variation and/or CS space) + 4.0 (brick bearing band) +1.0 (total clearance) + 0.5 (separation from edge of hole)
The 10.5 width can be made larger if there is any advantage to do so (tray rigidity).

Length of holes:

The proposed 16 mm width for the tray crossing bands is OK, it can also be made larger (up to 21 mm).
Cutting procedures for holes: laser cut, no smudges to the best possible extent

Tray entrance:

At the entrance end of the tray, the vertically folded edges will extend on a further approximate 3 mm length, curved towards the outside to ease brick entrance. Curvature will not go beyond the 0.8 mm ribbon thickness (design as in the previous wall prototypes)
Between these entrance edges, the cutting profile of the 0.7 mm thick tray plate will be 'rounded' in the best possible way to be less offensive towards the entering bricks.

Tray front extension:

The tray has an extension of 25 mm at the front part, to allow precise tray docking by the manipulator bridge. The extension floor will be used for a very precise adjustment of the vertical position of the bridge relative to the tray.

Two perpendicular slit shaped holes, to be used by sensors to adjust X (along tray) and Z (along beam) BMS bridge position, should be positioned relative to the tray edges and the tray end line with the best possible precision.

Shape and position of the slit holes to be cut out in the 25 mm extension should be proposed by Annecy and agreed by LNF-Napoli groups. The cutting procedure will be the same as for the other holes, laser cut and no smudges to the best possible extent.

Back of tray:

The back of tray stopper will be welded to resist to accidental pushing efforts (up to 50 kg).

To minimise the gap between the two half walls, **there will be no buffer space at the tray back end to account for variations of the brick train**. Procedures where the brick train will not be pushed against the tray stopper (in order to reduce to a minimum the pushing efforts on the emulsion bricks) are being considered, but will have to stick to this principle.

Inside tray space:

With the mentioned clearances of 0.5 mm on each side of the brick (thickness) and 1mm in high to guarantee a safe brick manipulation, we can summarise the space inside the tray, using the average brick size for horizontal (128.1) and including the tolerances of tray welding position, and on tray shape:

Inside Tray	3331.60 +2.60/-2.60	104.60 +0.00/-0.10	82.6 +0.20/-0.00

3. The Brick Wall

3.1. Positioning of trays within a wall

On the vertical direction Y, the error given on the vertical step of 105.3 is ±0.1. It is insured by positioning pieces below every ribbon welding location.

The maximum tilt angle in the vertical plane YZ is then 0.2/84., of the order of a 0.002 radian and should not cause any problem.

The horizontal positioning of the tray, i. e. the tilt angle in the vertical plane XY, is given by the same reference pieces and should in principle be smaller.

For the precision of tray positioning in the lateral X direction, reference pieces are used against the back of tray stopper.

3.2. Wall global positioning

Precise positioning the brick half-plane in X, Y and Z and small tilt angles in YZ, XY and XZ can be thoroughly achieved, as top and bottom beams of the plane are supposed to have tuneable positions and angles in the 3 directions. Apart from the time available to finely tune the plane alignment, the most important is to develop methods to make precise enough measurements on these beams positions and angles.

3.3. Wall overall dimensions

Total wall size (only bricks, stop at the average line): {26 nominal bricks @128.1 + 0.7 (tray thickness) +1.0 (train length uncertainty)} x 2 + 2.0 mm half wall gap
= 6664.6 mm
Total wall height: 64 x 105.3 steps = 6739.2

The Wall	6664.6	6739.2	85.6

This size stays well inside the TT active surface.

Annex 1(Updated 17/01/2003)

Break down of dimensions for each brick component and brick construction phase.

	HORIZONTAL		VERTICAL		THICKNESS	
Emulsion	125.10 +0.40/-0.55		99.80 +0.20/-0.35		0.29 +0.01/-0.01	
	max : 125.50		max :100.00		max :0.30	
	min :124.55		min :99.45		min :0.28	
Carton					0.40 +0.01/-0.01	
					max :0.41	
					min :0.39	
Laminated paper					0.108	
CS	127.00/126.50*		102.00		1.00	
CSS	125.00		99.60		2.15**	
Lead	125.50 +0.10/-0.00		100.00 +0.10/-0.00		1.00 +0.01/-0.01	
	max :125.60		max :100.10		max :1.01	
	min :125.50		min :100.00		min :0.99	
Pile (max/min) (57emul/56 lead)	125.65/125.50		100.15/100.00		73.66/71.40	
		Bottom	Top		CS opposite	CS side
ECC walls (thickness including carton+origami+gluing+folding)	0.618/0.598	1.028/0.988	1.384/1.344		2.056/2.016	1.546/1.526
ECC (Pile + ECC walls)	126.886/126.696		102.562/102.332		77.262/74.942	
CS+CSS (CS + CSS thickness+ glue 0.1+piling tolerances +CSS thickness tolerance)	126.60/126.50		102.10/102.00		3.35/3.25***	

ECC+[CS+CSS] (+glue0.1+pil.tol)	126.90/126.70	102.91/102.68 (ECC+Top of CS folded = 0.35)	73.66 / 71.40 pile 2.056 / 2.016 ECC wall opp to CS 0.41 / 0.39 carton 0.108 / 0.108 laminated paper
case A		compensation of ECC with CS support	76.234/73.914
		+ CS support thickness	79.684/77.264
ECC+[CS+CSS] + additional protection (+0.4 add. protection in horizontal and thickness) **brick without skates**	127.3/127.1	102.91/102.68	80.084/77.664
Brick (case **A**) ECC+[CS+CSS]+Skate(1.5) + Glue(0.05)	128.2/128.0	103.45/103.24	81.602/----
		skate contribution to thickness	CS side +1.194 CS opposite +0.724
Inside Tray	3330.60 +2.60/-2.60 Average brick 128.1 x 26	104.60 +0.00/-0.10 max brick + 1.05 clearance including tolerance on tray welding	82.6 +0.20/-0.00 max brick + 1.0 clearance + 0.2 tray tolerance
Wall (tray thickness =0.7)	6664.6 3330.6x 2 + 3.4 (3.4= 2x0.7 tray +2 semi wall gap)	6739.20 105.3 x 64	85.6 + tolerances

* Due to the min size of the ECC= 126.696, the CS horizontal size must be 126.50

** According to plastic moulding requests (1mm required in the minimum thickness place of CSS to guarantee rigidity).

*** Glue thickness 0.1 mm