transfair

CFC free refrigerator technology

technologie de réfrigérateur sans CFC

FCKW freie Kühlschranktechnologie

GmbH

TRANSFAIR ENGINEERING:

SURVEY ABOUT THE CFC FREE REFRIGERATOR PRODUCTION PART 3:

Designing and prototyping of refrigerator and freezer cabinets and doors

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FOR ROUNDED DOORS NEEDED:

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3. DOOR PROFILE WITH HANDLE

FOR VERTICAL FREEZER NEEDED, FOR REFRIGERATOR WITH ROUND DOORS RECOMMENDED:

4. TOP FRONT
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- freezer liner sides (cut to square sizes)

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-Polyethylene 500 mm w
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- 30 x5 mm

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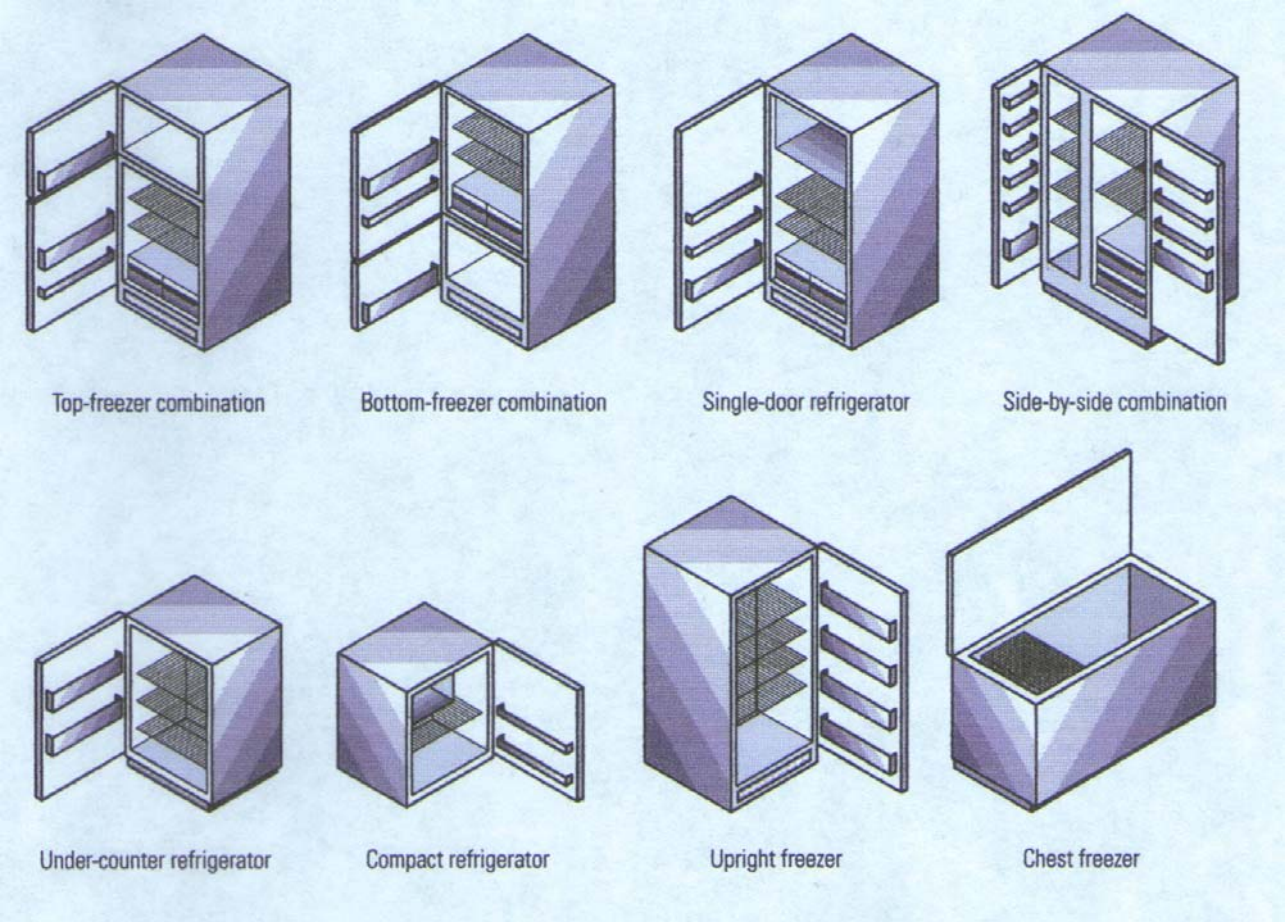
- Carton or EPS top (and corners) with shrinking ethylene foil
- Internal EPS plates
- Plastic foils

BASIC DESIGN TYPES OF HOUSEHOLD REFRIGERATORS AND FREEZERS



The freezer temperatures are <-18°C, <-12°C or <-5°C, the refrigerator temperatures are between 0-10°C. Top freezer combinations can be single or 2-doors. The single door models have an internal freezer box. The 2-door top freezer combinations are in large dimensions (16-18 cu.ft = 450-510l) most sold in North America (more than 70% of the market volume of 10 Mio./year) and Middle East, in medium and smaller dimensions in Far East, while in European markets (total maekt volume 10 Mio./year) medium and smaller sizes (240-320l) are more sold - often as built-in units (see underneath) or as stand alone units more bottom freezer combinations are sold than top freezer combinations and. In India (Market volume 3.6 Mio/year) and China (Market volume 11 Mio./year) still 80% of the market are models with volumes <200 l. But markets are changing. Beside of such bread-and-butter models higher value models are growing steadily.

In the past the side-by-side combination was only found in USA, but meanwhile spread out in other market areas.

Special refrigerator designs today provide not only 2 compartment with 2 different temperature zones (refrigerator: 05-8°C, freezer: normally <-18°C), but add a vegetable zone with humidity control and/or fresh fish and meat zone of about 0°C. some foodstuff needs high humidity (95% r.H.), other low to keep fresh. In the last 5 years larger stand-alone unit (like side by side) are growing in the upper market segments all over the world, but still totally are underneath 5-7% of these markets, except USA.

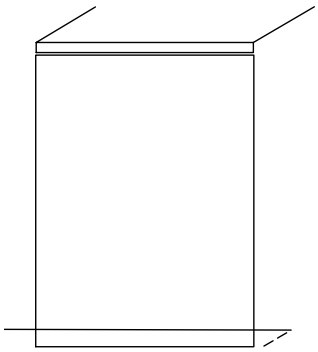
Bottom freezer combination.

3-door model with fresh food drawer

Side by side Refrigerator Freezer combination

European Standard Sizes for Stand-Alone Refrigerators and Freezers:

The refrigerator sizes in Europe are strongly standardized as result of small kitchen designs and furniture grids of 600x600mm, which is not only relevant for the built-in units, but also for stand-alone units:

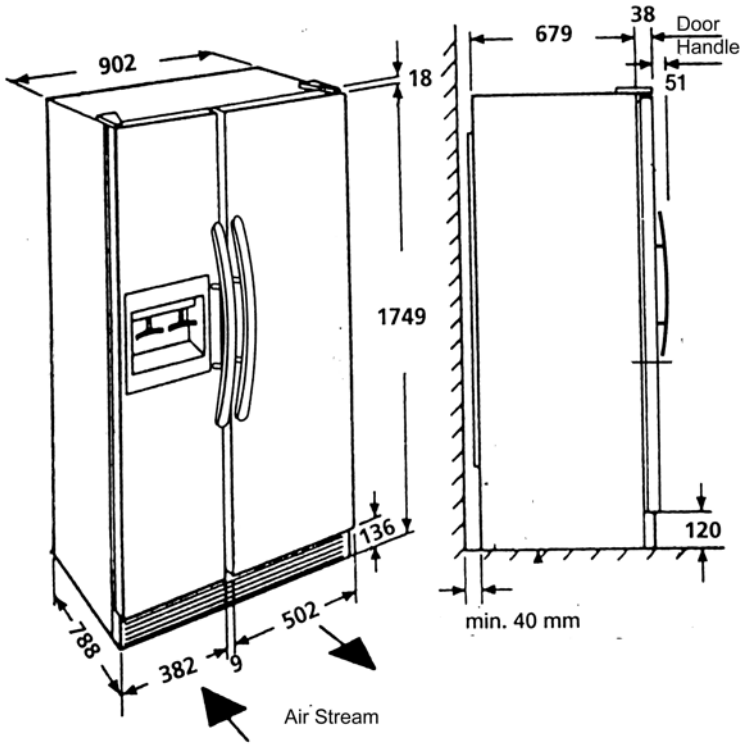


The normal width is 595 mm for stand-alone refrigerators, refrigerator-freezer-combinations and vertical freezers. As result of foaming it increases by 2-5 mm on half height. The standard overall deepness – with few exceptions – should be inside the 600mm grid, taking into consideration the space for the condenser on the backside of the refrigerator of 40mm and the door in front of the refrigerator of 50 mm it results to a side wall deepness of 508 mm. Some larger models >1750mm increases the width of 600 mm to get bigger insulations, normally to 660mm.

In some Eastern European markets with lower purchase power there exist still some top freezer models in the range of 200-220 l gross with height in the range of 130 mm.

To be able to offer refrigerators into large market distribution channels a producer must often be able to offer the full range of models, at least different refrigerator-freezer combinations and freezers in the heights about 1450mm and 1750mm. These standard models are the bread-and-butter models in Europe often sold in scales with limited margins per sold refrigerator. Bigger margins are earned on special designs, like large stand-alone in side-by-side (1750-1850 h x 900-920mm w x750-860 d mm), classic retro design models, 3 door models and models with special features. But to manufacture these special designs a much bigger investment in equipment and tooling is needed. For marketing and image reasons it is important for a brand to have a state-of-art model in their program and to advertise it to show the technical and quality performance, even if their sales and profit is irrelevant, taking into consideration the larger investment. By achieving a high quality image the bread-and-butter models of this brand can be sold better.

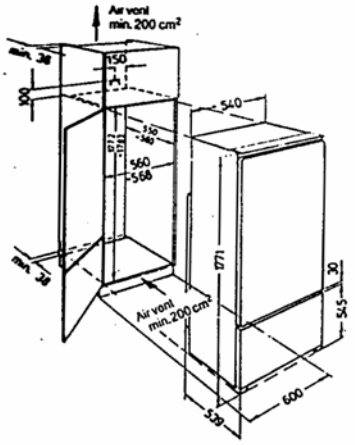
For example Samsung has purchased their top model design with complicated tandem evaporator controls (see Transfair Engineering: Cooling circuit design, Chapter 5.5.6.) from Prof. Rademacher and his team from Maryland University for about US$ 1 Mio and presented it into different new markets. But their main sales were made on cheaper models. So such high investment on design was cheaper as it could be reached by a marketing campaign to build up such an image.



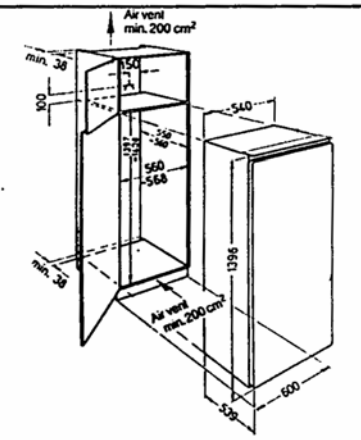
Dimensions for a typical side by side refrigerator-freezer combination

European Standard Dimensions for Building In Refrigerators and Freezers and their Net Capacities

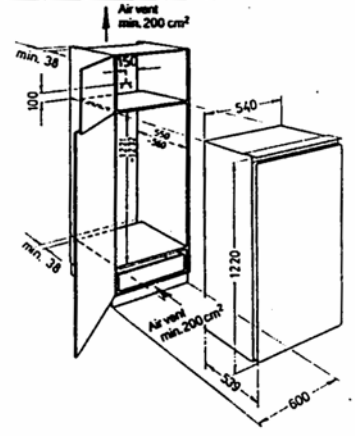
Refrigerators and freezers



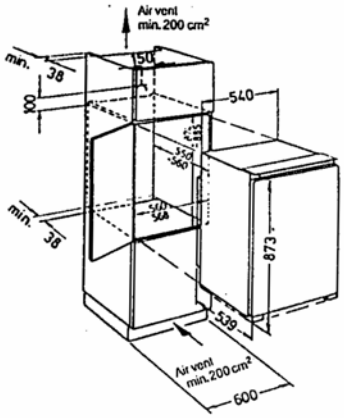
max.totals 289 1/12,2 cuft for ex. Refr. 243 1/8,5 cuft with Freezer 47 1/1,7 cuft



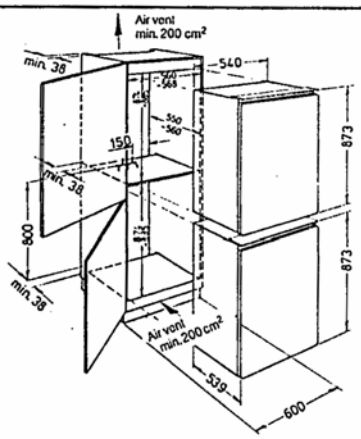
max.totals Refr. 276 1/9,7 cuft or Freezer 186 1/6,8 cuft or Refr. 258 1/9,1 cuft incl. 20 1/0,7 cuft freezer compart.



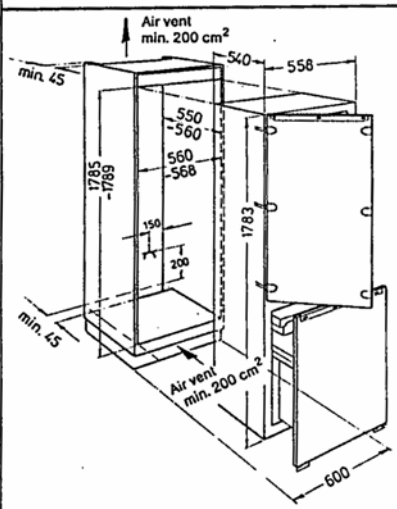
max.totals Refr. 226 1/8 cuft or Freezer 146 1/5,2 cuft



max.total Refr. 171 1/6,0 cuft and Freezer 106 1/3,7 cuft

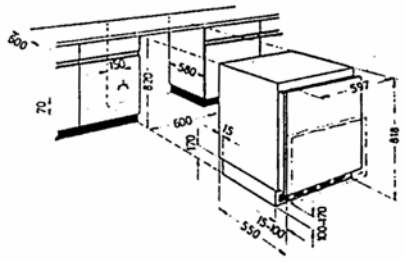


max.total Refr. 171 1/6,0 cuft and Freezer 106 1/3,7 cuft



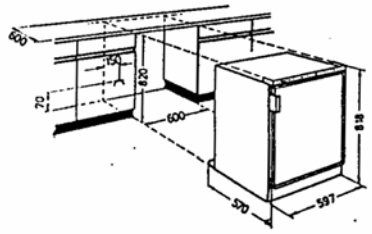
max. total 276 1/9,7 cuft incl. 40 1/1,4 cuft Freezer comp. and 70 1/2,6 cuft cool zone

Refrigerators and freezers



max. total Refr.154 1/5,4 cuft or Freezer 100 1/3,5 cuft or Refr.131 1/4,6 cuft incl.181/ 0,6 cuft Freezer compartment

Built under models with decor frames



decor panel dimensions:
H x W = 677 x 585

max. total Refr. 162 1/5,7 cuft or Freezer 100 1/3,5 cuft

Insulation thickness

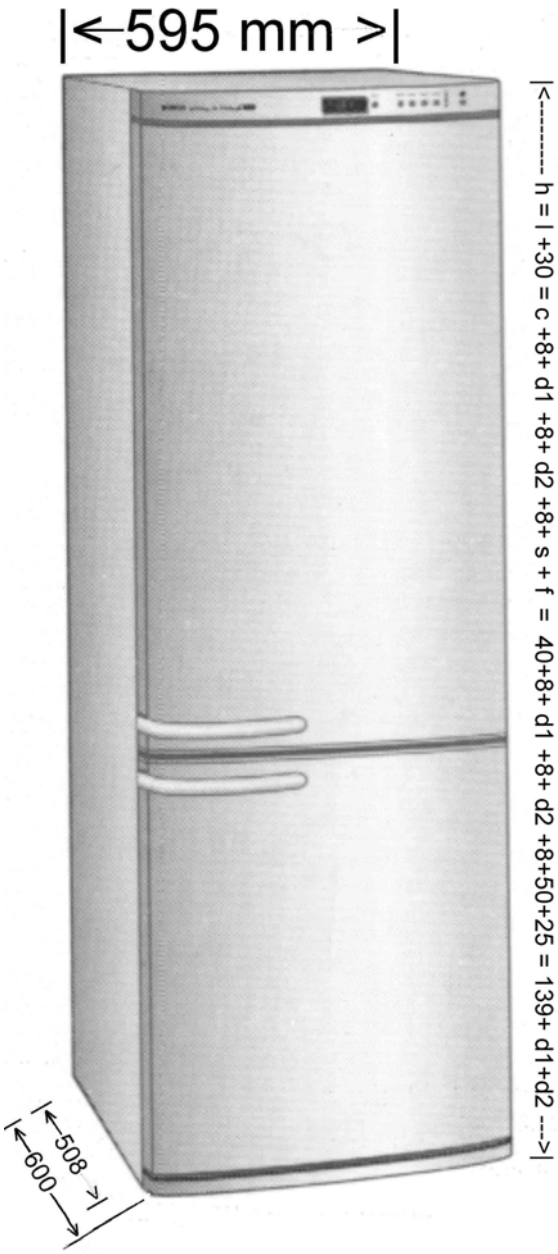
Minimum insulation for refrigerators is 35 mm.

In 1997 and 1998 a lot of refrigerator manufacturing companies concentrated to increase wall thickness to reach energy consumption levels above the class C acc. to international classification. Some even uses insulation in the level of 50-65 mm for refrigerators. But since 2000 the insulation of refrigerators went back to previous thicknesses by developing higher energy efficient cooling circuits, using high efficient compressors, better adjusted cooling circuits, eliminating accumulators etc. (see Transfair Engineering: Survey about CFC-free Refrigerator Production - Part 4: Designing and Prototyping of Refrigerator and Freezer Cooling Circuits, Düsseldorf 2003).

Minimum insulation for freezers is 50 mm.

To reach energy consumption levels above the class C acc. to international classification an insulation in the level of 60-65 mm is used, but also in this case more efficient cooling circuits can reach often much lower energy consumption that increased insulation (see Transfair Engineering: Survey about CFC-free Refrigerator Production - Part 4: Designing and Prototyping of Refrigerator and Freezer Cooling Circuits, Düsseldorf 2003).

Proposed Model design platform and sizes:



Parameters:

h	Refrigerator height
l	Side panel length l
d1, d2	Height of upper and lower doors

Fixed values:

c	Top panel height: 40 mm to enable freezer front control if needed
8 mm	distances between to doors
s	Front base height: 50 mm
f	Feet height 25 mm +0/-15
w	Width of refrigerator: 595 mm
d	deepness of refrigerator: 600-630 mm (Bombée door type)
w_p	Width of Side panel: 508 mm

Proposed models:

First phase:

1250h x 595w x 630 d 2-door top freezer
1450h x 595w x 630 d 2-door bottom freezer
1650h x 595w x 630 d 2-door bottom freezer

Further phases:

1250h x 595w x 630 d 1-door top freezer
1650h x 595w x 630 d 1-door refrigerator
1650h x 595w x 630 d 1-door freezer
1850h x 595w x 630 d 2-door bottom freezer
1749h x 902w x 679 d Side by Side model
850h x 595w x 630 d Table top refrigerator with freezer compartment

MODERN SWIMMING PANEL CONSTRUCTION

Till today American and Far East producers use a U-bend steel cabinet construction, while nearly all European use a panel construction often combined with **swimming self positioning panels, cross rails and food liners which do not need so tight tolerances during manufacturing.**

What are the main differences concerning required tolerances of material and manufacturing processes, stability and costs?

U-bend construction requires very narrow tolerances concerning:
- steel sheet sizes (sides, diagonals, thickness),
- punching, blanking and piercing positions,
- profiling bends and dimensions,
- edge bending and u-bending,
- welding of upper right and left corner and, if made, cross rails, separator sheet between compressor compartment and foam and/or steel back sheet, and
- exact and rectangular pre-assembly of the steel body parts for welding and exact pre-assembly of the food liner.

Any small deviation will accumulate in the upper right and left corner cuts – as a result of the U-bend- where you can find overlapping or space. These corners are under insulation and quality points of view already one of the most sensitive areas. The gasket has always from its side problems to close properly at these corners as a result of
- burrs of door gasket welds in these corners,
- lack of magnet stripe because of gravity and
- less elasticity as a result of welding.

If also the metal body is bad manufactured (overlapping/lack of material) hot wet air will condense or even enter into the refrigerator. And if these corners of a u-bend model are even not welded and pre-painted sheets or popular surfaces with metallic looks are used, the steel will corrode very fast. These areas are visible each time the door is opened and the insulation will be further reduced by the corrosion.

In addition deviations can cause **foam leaks, scratches or bends** during foaming and last not least cause problems in the door assembly (hinge positions, rectangularity) which needs at the end a lot more adjustments.

All developing countries still have many workers with low technical understanding, low industrial experience and low benchmarks concerning quality and efforts of being 100% perfect. Under such working circumstances a construction should be selected in a way that it can absorb more deviations in material and work operations as others.

Customers today want an **organic refrigerator form** not only with rounded doors (Bombée type), but even rounded **in 3 dimensions** easier to be performed with plastic tops allowing to round from the sides to the top. In this case steel on top is obsolete and a U-form is wasting steel by about 15%.

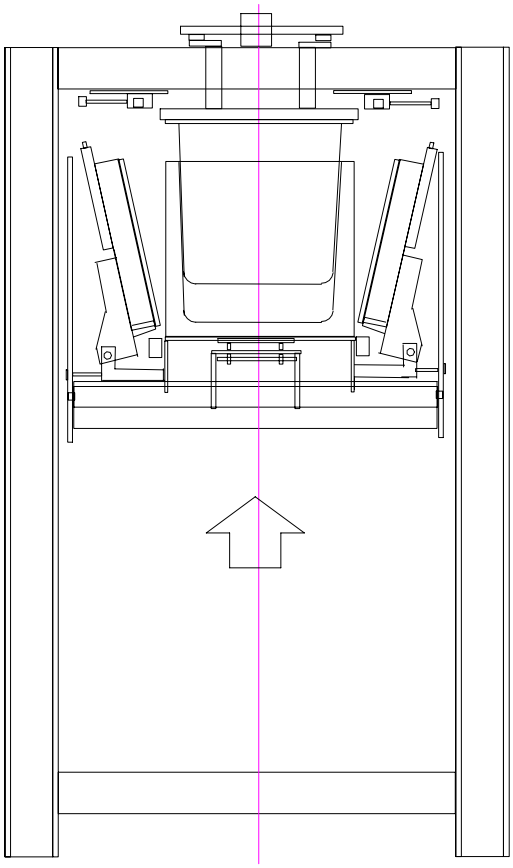
The **market demand in colours and metallic looks** (metallic colour or plastic foils on steel sheets) are increasing on stand-alone refrigerator models often not anymore possible to be realized in the painting lines of the refrigerator manufacturer. Therefore the manufacturers went over to use more and more pre-painted or other surface treated steel sheets for their refrigerator. But U-form refrigerators with these pre-painted or other treated sheets have the corrosion problem while panel type construction covers the blank cutting parts of the steel inside the top cover so no rust could be seen.

All these U-shape steel cabinet problems can be significantly reduced, but not eliminated with a construction nowadays used in Europe.

SWIMMING PANEL CONSTRUCTION (till cabinet foaming)

Such a body construction consists normally up to the foaming only of 2 steel side panels, reinforced with a profile in the compressor compartment area, 2-3 cross rails on the upper and lower front and as middle traverse in case of a 2 door model, the food liner(s) and a hollow profile sheet of PE/PP-copolymer (Trade name: Polianda) covering the foam on top, back and bottom including the compressor compartment, with parts already mounted inside the foam area (evaporator, anti-dew coil, etc.

A swimming construction still needs side panels and cross rails (=front traverses) punched and bended with tolerances of 0.3-0.5 mm and vacuum foamed food liner with max. 3 mm tolerances; but normally no deviation can accumulate; de-bending because of heat does not have such bad results like in a rigid u-bend construction. But the main advantage is the quite high tolerances during pre-assembly operations can be absorbed.



How these tolerances can be absorbed and how at the end we receive a correct manufactured and dimensioned refrigerator? The trick is the foaming during which all parts are correct positioned and with the foam fixed.

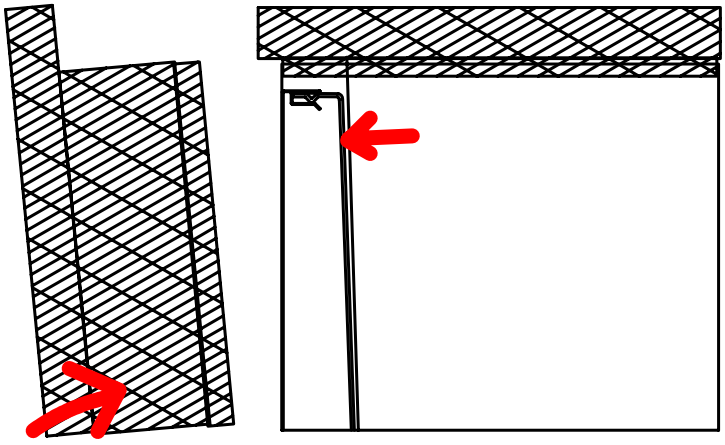
Then swimming construction was developed 1981-1982 together with new stationary designs of cabinet foaming fixtures.

A foaming fixture closes in 3 phases:

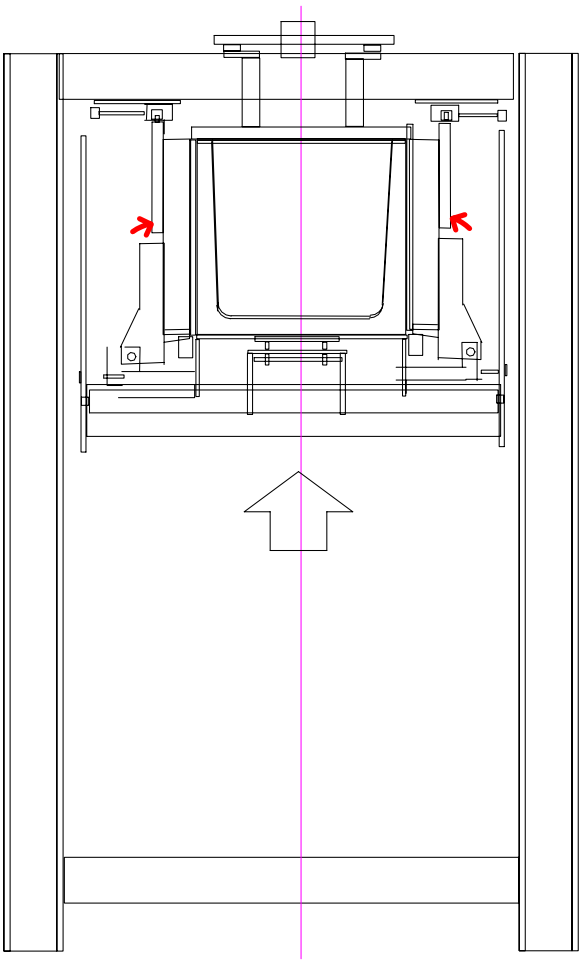
1st Phase: Adjustment of liner position by plug entry

In the first phase the refrigerator foodliners are correctly positioned and centered. Either the plug moves down (Hennecke, Perros/QS, OMS, Krauss-Maffei) or the bottom with still open side walls moves upwards (Cannon Crios).

Under the condition that the jig is calibrated, the plug is really centered (Cannon Crios and Hennecke have 2 calibrated centering pins and 2 holes in each plug support, so that by correct calibration each plug can be put on each station without any adjustment.

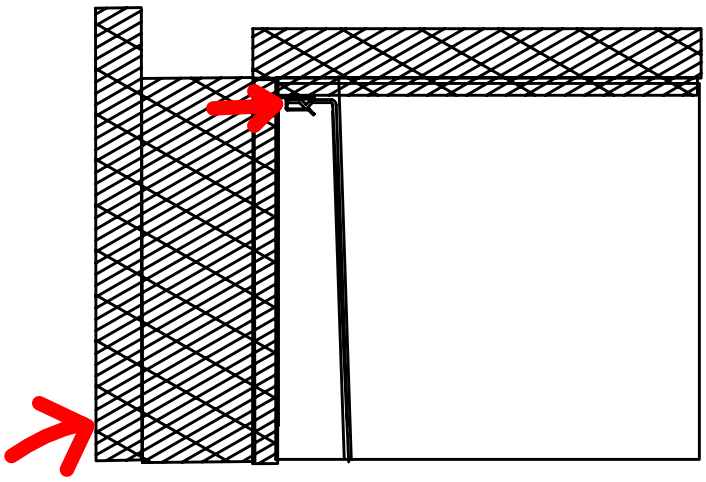


With a NC-made cube plug the jigs should be 1 or twice per year calibrated centering of plug and side walls, parallel side walls, parallel closing, correct rectangular top etc.).



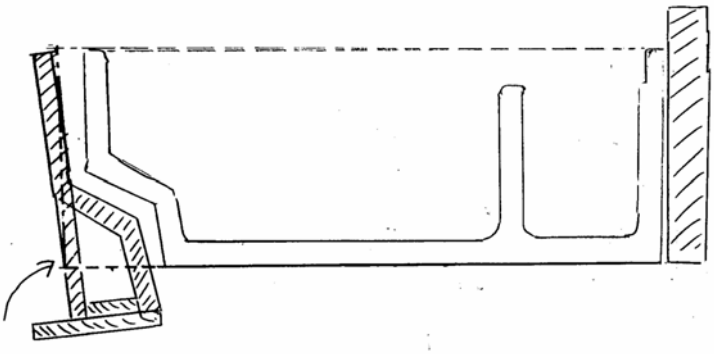
2nd Phase: Adjustment of side panels to liner by turning the side support and closing into the upper lock profile.

In the 2nd phase the side panels are aligned by the turning side walls with finally are locked, so that the tolerances between these 2 side walls and the liner should remain inside of 1 mm (except diagonals, which could be 2-2,5 mm)



At this stage the 2 side panels are parallel, but still one panel could be nearer to the top support as the other one. The 3rd phase adjust it by turning the bottom and compressor compartment support into the closing this the 3rd phase

3rd Phase: Adjustment of top and bottom and right positioning of side panels by closing the bottom compressor support



But at this stages the upper and lower cross rail as well as the middle cross rail still could be slightly incorrect, for example not on the same level as the side panels, or slightly turned and some of these mistakes can be corrected by the quite high foam pressure if the refrigerator is correctly foamed and if the construction details allow it.

How to foam correctly?

Quality relevant factors are

- Foam materials and its characteristics (see Transfair Engineering: Foaming today);
- The geometry of the refrigerator cavity to be filled with foam and

- The bath tube position of jig (refrigerator door opening upwards); foaming in bell position (door opening downwards) is not economic and still reduces foam quality. It needs 2-3 foaming machines working in parallel to inject at same time with 2-3 mixing heads inside the refrigerator back wall;
- The foam injection point, which should allow injecting the Polyol-Isocyanate compound mixture in a central area, which minimize the distances the foam, has to rise and its quantity differences needed to fill bigger walls of freezers and thinner walls of fridges. The best injection point is in the middle areas of the back wall, slightly in direction to upper side if freezer is up or more in direction to lower side if freezer is down. But such so called top flow jigs are about 30% more expensive. The second best position is in the back wall from compressor compartment mainly used today or even from the top in the back wall. Injection in the bottom plate is also bad for the quality and to foam by this way medium and large refrigerators it needs 3-5% more foam to squeeze the material the long way to fill all cavity areas. It causes density differences.

So if the foam pressure on the cross rails are still sufficient it will push the upper and lower cross rails in the upper corners of the cabinet mould to reach the same front level to doors as the side panels (+/- 0,3mm). And even the middle cross rail on a 2-door model will be squeezed by the foam pressure so that the front of this cross rail to the doors will be on the same level as the front of the side panels to the door (+/- 0,3mm). But this can be reached only by optimal foam injection inside back panel from backside of refrigerator or from compressor compartment side and only if the materials, its quality, temperature and foam rise time is good selected.

If we have to fight to get from a bottom plate injection sufficient material inside the top insulation inside the foam rise time, how it can built up the pressure to position the cross rail there correctly?

Construction details are very relevant to use the cabinet foaming station to reduce tolerances and of course the stations and jigs must be correct and regular calibrated to reduce tolerances.