

RALU-RING

Product Bulletin 450

Superior performance by design™

RASCHIG GMBH

JAEGER PRODUCTS, INC.



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RALU-RING

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The data in this brochure is based on numerous tests and careful studies.

However, it can and is only intended to provide non-binding advice.

No guarantee claims can be derived from this information.





RALU RINGS

in metal
with bead reinforcement

| Sizes mm | Weight kg/m ³ | Number per m ³ | Surface m ² /m ³ | Free Volume % |
|---------------|-----------------------------|------------------------------|---|------------------|
| 25 x 25 x 0,4 | 310 | 51 000 | 215 | 98 |
| 38 x 38 x 0,5 | 260 | 14 500 | 135 | 97 |
| 38 x 38 x 0,4 | 210 | 14 500 | 135 | 97 |
| 50 x 50 x 0,5 | 200 | 6 300 | 105 | 98 |
| 50 x 50 x 0,4 | 160 | 6 300 | 105 | 98 |

Other wall thickness available upon request.

The weights for RALU RINGS made of other metal alloys are obtained by multiplication with the following factors:

| | |
|------------------|------|
| Aluminium | 0.35 |
| Monel and Nickel | 1.13 |
| Copper | 1.14 |
| Brass | 1.09 |
| Titanium | 0.6 |
| Hastelloy | 1.3 |



RALU RINGS

made of plastic

Polypropylene and polyethylene of different grades

| Nominal Sizes | Weight kg/m ³ | Number per m ³ | Surface m ² /m ³ | Free Volume % |
|---------------|--------------------------|---------------------------|--|---------------|
| 5/8" - 15 | 80 | 170 000 | 320 | 94 |
| 1" - 25 | 56 | 36 000 | 190 | 94 |
| 1 ½ " - 38 | 65 | 13 500 | 150 | 95 |
| 2" - 50 | 55 | 5 780 | 110 | 95 |
| 3 ½ " - 90 | 40 | 1 000 | 75 | 90 |
| 5" - 125 | 30 | 800 | 60 | 97 |

Multiplication factors to determine the weights for the high-performance thermoplastics listed below:

| | | |
|---|----------|------------|
| Polyethersulfone | (PES) | 1,85 |
| Polyphenylene sulfide | (PPS) | 1,80 |
| Liquid crystal polymer | (LCP) | 1,83 |
| Polyvinylidene fluoride | (PVDF) | 2,0 |
| fluor. Ethylenpropylene | (FEP) | 2,40 |
| Perfluoralkoxypolymer | (PFA) | 2,40 |
| Ethylen-Chlortrifluorethylen | (E-CTFE) | 1,97 |
| Ethylen-Tetrafluorethylen | (E-TFE) | 2,20 |
| Polyarylether Ketone | (PAEK) | 1,44 |
| Fluoroplastics | (Teflon) | 2,15 - 2,4 |
| Polypropylene 30 % fiberglass-reinforced | | 1,25 |
| Polyethylene | | 1,10 |



RALU-RING

A high-efficiency tower packing for distillation, rectification, absorption and desorption.

This tower packing is characterised by the following properties.

- high permeability to gas and liquid flow**
- large void fraction**
- high mass transfer efficiency**
- high mechanical stability**
- low pressure drop**
- low dead weight**
- low tendency to maldistribution**
- low danger of fouling**

The RALU RING made of metal

is a modified PALL Ring with increased stability and reduced expenditure of material. The cylinder wall is reinforced with three circumferential beads.

Therefore RALU RINGS in the 2" size with a material thickness of 0,5 mm can be packed up to a height of approx. 15 meters without risk of deformation. However, for the sake of better distribution of the liquid, only in exceptional cases will such a great bed height of designed without subdivisions into lower beds.

The RALU RING made of plastic

is a modified PALL Ring, protected by West German patent DGM 82 12 260.1, which stands out for its more favorable pressure drop values and lower expenditure of material as compared to conventional PALL Rings.

If existing columns are reequipped with RALU RING's, a decrease in operating costs and higher separation efficiency at a constant bed height will be achieved. At an unchanged separation efficiency, the bed height can be reduced, thus decreasing the pressure drop.



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RALU-RING

Materials

most often used for manufacturing RALU RINGS.

Metals

mainly carbon steel and chromium-nickel steels but also special alloys such as brass, Hastelloy, Monel, Incoloy, as well as aluminium, nickel, copper, etc.

Plastics

mainly thermoplastics, such as polypropylene, polyethylene in various grades.

High-performance thermoplastics, such as polyethylene sulfide, polyvinylidene fluoride, polyether sulfone and liquid crystal polymers are being used in even increasing range of applications.

As a rule, we always use virgin materials. Regenerated material are only used upon special request.

Our standard range comprises the following polypropylene:

polypropylene standard (PP)

for operating temperatures of up to approx. 70 °C (158 °F).

heat-endurance stabilised polypropylene (LTHA)

for operating temperatures of up to approx. 110 °C (230 °F).

30 % fibreglass-reinforced polypropylene (GFR)

for operating temperatures of up to approx. 135 °C (275 °F).

Furthermore, it is also possible to offer various additive master batches. Thus, for example, for special applications, the specific gravity of the polypropylene tower packings can be raised to above 1.



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RALU-RING

The following high-performance thermoplastics are used:

Polyether sulfone (PES)

operating temperature range up to approx. 180 °C (356 °F).

cold resistance down to approx. -100 °C (-148 °F).

Polyphenylene sulfide (PPS)

operating temperature range up to approx. 220 °C (428 °F),

temporarily permissible up to 260 °C (500 °F),

cold resistance down to approx. -50 °C (-58 °F).

Liquid crystal polymer (LCP)

operating temperature range, depending on type, up to a maximum of 240 °C (464 °F).

Polyvinylidene fluoride (PVDF)

operating temperature range up to approx. 140 °C (284 °F),

cold resistance down to approx. -40 °C (-40 °F).

Fluoroplastics (TEFLON, e.g. FEP, PFA)

(Teflon in various material grades)

operating temperature range, depending on type, up to a maximum of 260 °C (500 °F).

cold resistance down to approx. -200 °C (-328 °C).

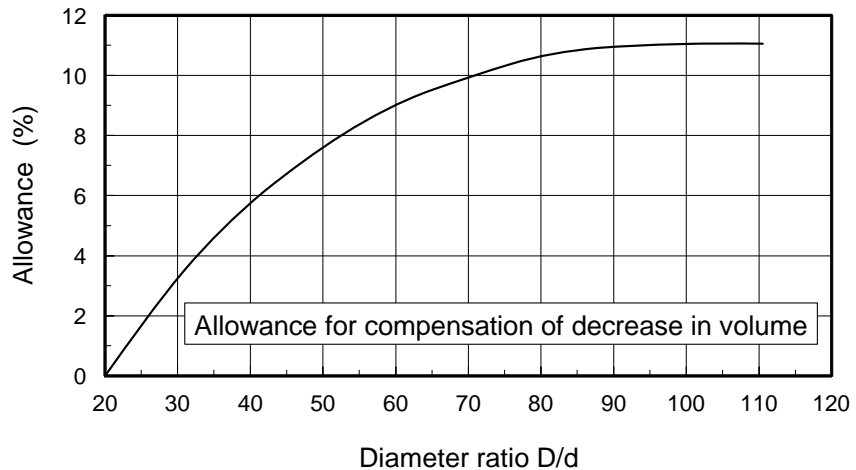
In evaluating the individual plastics, the interaction between the physical and chemical load should always be taken into account.

The various application possibilities and plastics grades must be tested before each individual application and, if need be, this must done by means of laboratory tests.



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Compensation for the "decrease in volume" for dumped packings



The values indicated in the tables for dumped packings are valid for a diameter ratio vessel: packing size of $D : d = 20$. Since the arrangement of the packings is less compact near the vessel wall than in the interior of the bed, the number of packings per cubic meter increases with the diameter ratio.

The opposite diagram shows by which "allowance" the theoretically calculated vessel volume for diameter ratios of more than 20 must be increased in order to completely fill the space required.

If the plastic or metal packings are, for instance, thrown into the column, this may result in a further decrease in volume due to abnormally compact packing.

D = diameter of the vessel to be filled
 d = diameter or nominal size of the packings



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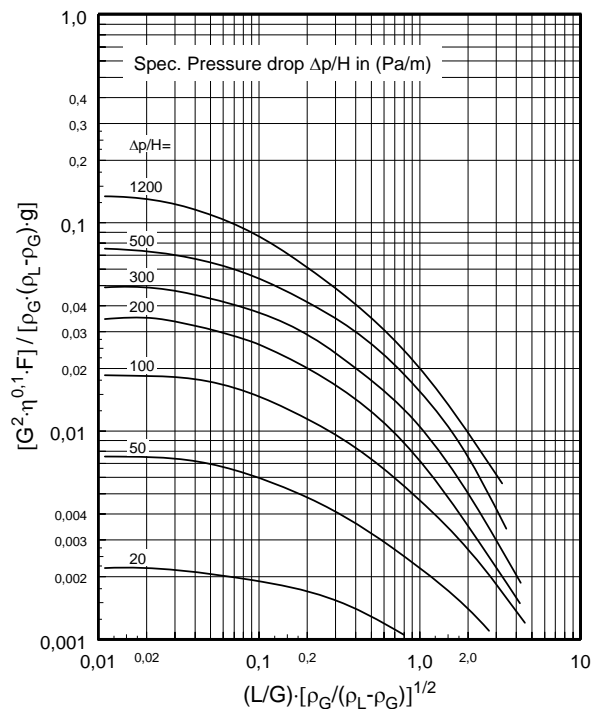


Generally applicable pressure drop diagram for tower packings

Optimum results with packed columns can only be obtained with well-designed liquid distributors, support grids and hold-down grids!

Please note that this diagram no longer applies in case of foaming liquids.

| | | | |
|----------|---|------------------------------------|---------------------|
| L | = | liquid flow rate | kg/m ² s |
| L' | = | liquid flow rate | kg/h |
| G | = | gas flow rate | kg/m ² s |
| G' | = | gas flow rate | kg/h |
| ρ_L | = | liquid density | kg/m ³ |
| ρ_G | = | gas density | kg/m ³ |
| F | = | packing factor | (see table) |
| η | = | liquid viscosity | mPa · s |
| g | = | 9,81 = acceleration due to gravity | m/s ² |





Tower packing factor

Tower packing factor F in 1/m

Table 1

| Tower packing | Material | Nominal size of the tower packings | | | | | | | | | |
|---------------------------|----------|------------------------------------|------------|------|---------------|----------|-------|--------------|----------|-------------|--------------|
| | | 10 | 12 1/2" | 15 | 19-20 3/4" | 25 1" | 30-35 | 38 1 1/2" | 50 2" | 70-75 3" | 90 3 1/2" |
| RASCHIG SUPER-RING | Metal | | | 131 | 102 | 72 | 59 | 46 | 39 | 31 | |
| | Plastic | | | | | 105 | | | 40 | | |
| RALU-FLOW | Plastic | | | | | 75 | | | 38 | | |
| RASCHIG RING | Ceramic | 3200 | 1900 | 1250 | 840 | 510 | 340 | 310 | 210 | 120 | |
| | Metal | 1280 | 980 | 566 | | 380 | 280 | 270 | 190 | 105 | |
| PALL Ring | Ceramic | | | | | 350 | 180 | | 142 | | |
| | Metal | | | 230 | | 157 | 103 | 92 | 66 | | 52 |
| | Plastic | | | 320 | | 171 | 140 | | 82 | | 52 |
| RALU RING | Metal | | | | | 157 | | 92 | 66 | | |
| | Plastic | | | | | 135 | | 80 | 55 | | 38 |
| TORUS SADDLE | Ceramic | | 660 | | 480 | 320 | | 170 | 130 | 72 | 68 |
| SUPER TORUS SADDLE | Plastic | | | | | | | 165 | 104 | | 50 |
| BERL SADDLE | Ceramic | 1500 | 790 | | 560 | 360 | 220 | | 150 | | |

Table 2

| Sherwood-abscissa value x | | < 0.5 | | | 0.5 to 3.75 | | | > 3.75 | | |
|-----------------------------|----------|-------|-----|-----|-------------|-----|-----|--------|-----|-----|
| $\Delta p = \text{mm WS/m}$ | | 40 | 80 | 125 | 40 | 80 | 125 | 40 | 80 | 125 |
| RASCHIG RING | Ceramics | | | | | | | | | |
| | 25 x 3 | 541 | 508 | 512 | 574 | 502 | 472 | 443 | 394 | 361 |
| | 38 x 4 | 302 | 289 | 295 | 295 | 269 | 262 | 246 | 213 | 197 |
| | 50 x 5 | 239 | 239 | 236 | 226 | 210 | 203 | 170 | 164 | 154 |
| RASCHIG RING | Metal | | | | | | | | | |
| | 25 x 1.6 | 518 | 472 | 466 | 456 | 400 | 331 | 292 | 253 | 220 |
| | 38 x 1.6 | 308 | 279 | 262 | 246 | 213 | 213 | 131 | 141 | 138 |
| | 50 x 1.6 | 236 | 233 | 217 | 197 | 177 | 164 | 125 | 125 | 121 |
| PALL Ring | Metal | | | | | | | | | |
| | 25 x 0.6 | 170 | 157 | 154 | 177 | 171 | 174 | 148 | 138 | 138 |
| | 38 x 0.8 | 98 | 95 | 92 | 128 | 118 | 112 | 112 | 102 | 89 |
| | 50 x 0.9 | 82 | 92 | 75 | 85 | 79 | 72 | 69 | 66 | 66 |
| TORUS SADDLE | Ceramics | | | | | | | | | |
| | 1" | | 318 | 321 | | 299 | 305 | | 276 | 246 |
| | 1 1/2" | 164 | 161 | 171 | 174 | 161 | 157 | 131 | 128 | 115 |
| | 2" | 125 | 128 | 131 | 128 | 112 | 108 | 102 | 102 | 98 |



Tower packing factor

The graph shown on page 27 that is valid for all types of tower packings and for mass system or operating conditions as well as Table 1 showing the tower packing factors are based on a Sherwood correlation postulated in 1938, which has been updated in accordance with the level of engineering valid at the time.

Table 1 shows the tower packing factors F in 1/m that constitute an important characteristic parameter, seeing that the square root of the tower packing factor is inversely proportional to the gas flow rate of the packed bed.

This correlation can clearly be seen by taking the example of 50 mm PALL Rings made of metal with a tower packing factor of 66 and 2" = 50 mm TORUS SADDLES made of ceramics with a tower packing factor of 130. The tower packing factors show that the gas flow rate for metal PALL Rings is 40 percent higher than for the TORUS SADDLES.

$$\frac{G_{\text{Pall-Ring}}}{G_{\text{Torus-Saddle}}} = \frac{\sqrt{130}}{\sqrt{66}} = 1,4$$

Thorough tests have shown that the tower packing factors indicated in Table 1 cannot be seen at constant values, but rather that they change within a certain range, depending on the load of the liquid or gas. The types of tower packings which show the highest pressure drop, such as RASCHIG RINGS, also tend to change most with respect to their tower packing factor.

The tower packing factors in Table 1 can be consulted for planning columns. This results in column diameters that are somewhat overdimensioned, especially in case of large flow rates of liquid and particularly when RASCHIG RINGS are used.

Table 2 shows that the fluctuation range of the tower packing factors F for four different types of tower packings in the most common sizes as a function of the abscissa value of the generally applicable pressure drop diagram.

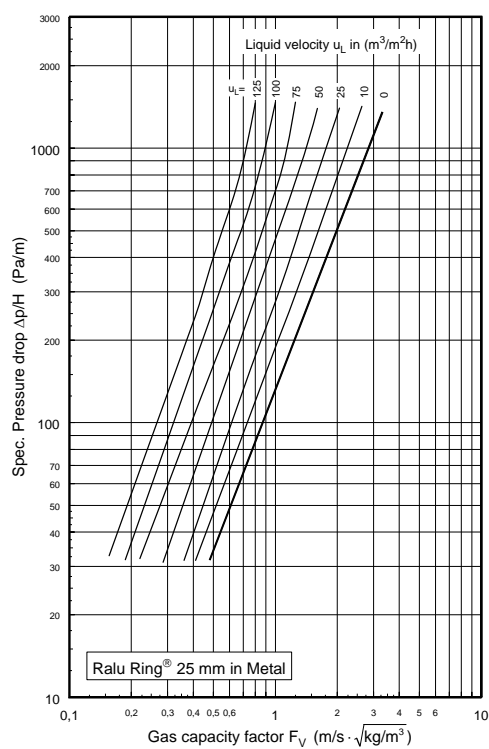
$$X = \frac{L}{G} \left(\frac{\rho_G}{\rho_L - \rho_G} \right)^{1/2}$$

Abscissa value of 3.75 and up are usually found only with absorption columns and strippers; values of 0.5 and below occur with most distillation columns.

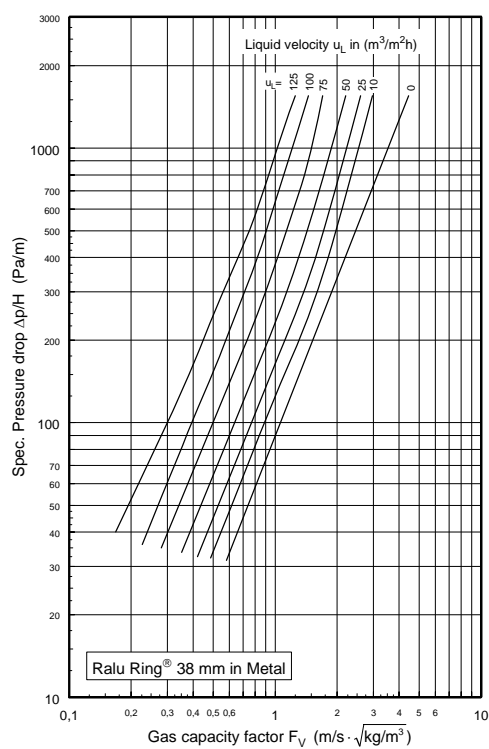


Pressure drop with metal RALU-RINGS mixture water / air

RALU-RING 25 mm



RALU-RING 38 mm

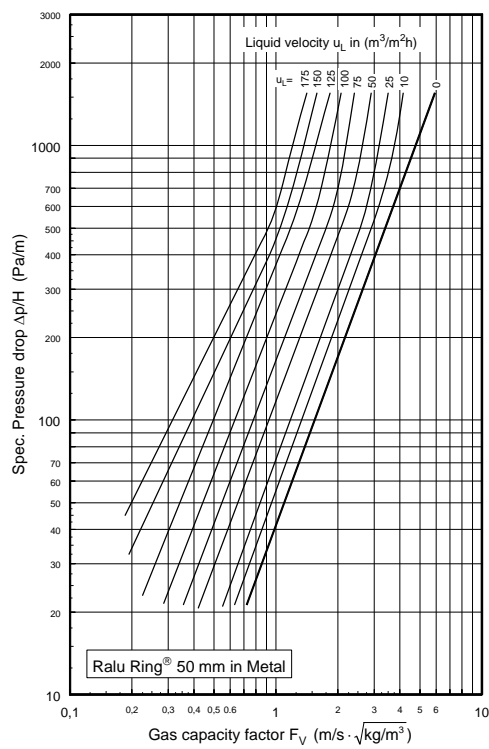


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Pressure drop with metal RALU-RINGS mixture water / air

RALU-RING 50 mm

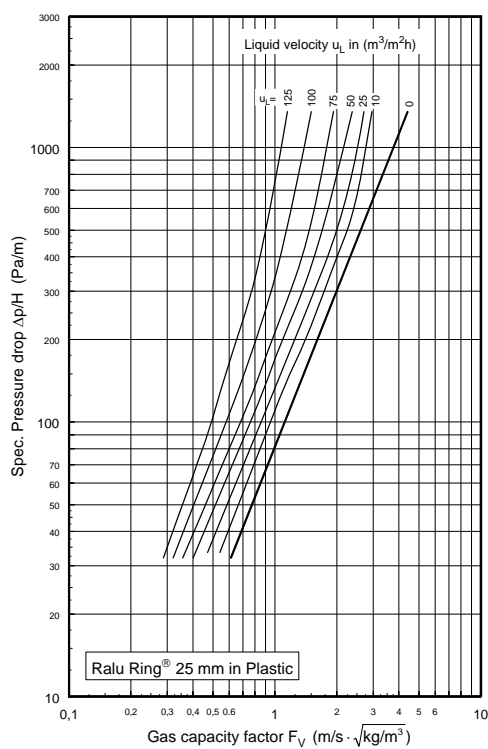


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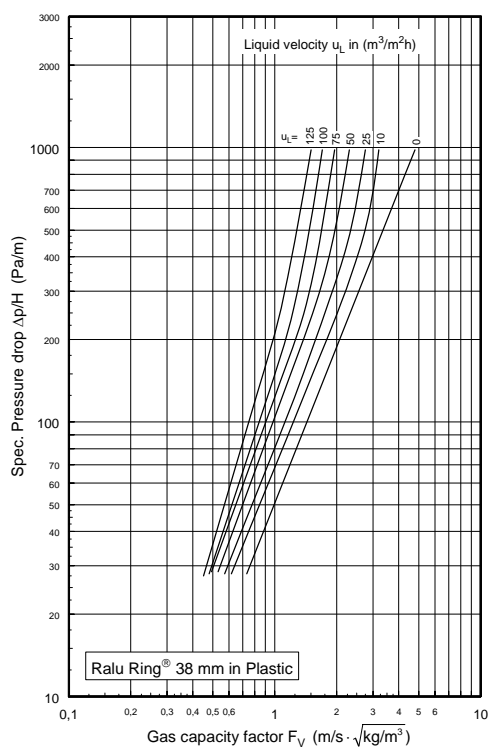


Pressure drop with plastic RALU-RINGS mixture water / air

RALU-RING 25 mm



RALU-RING 38 mm

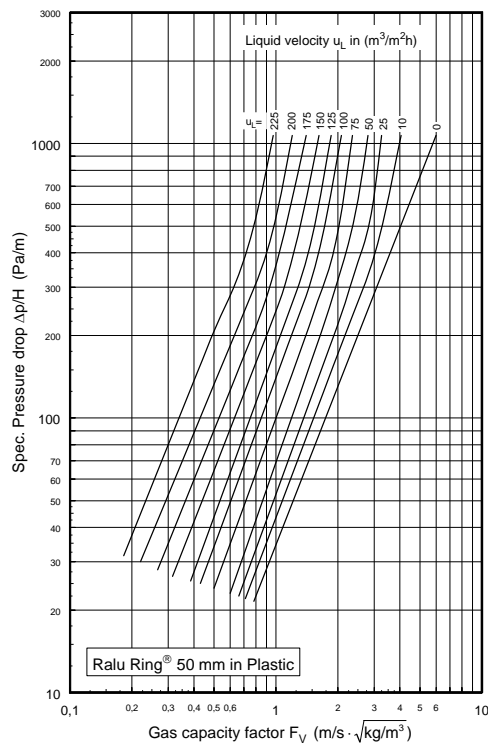


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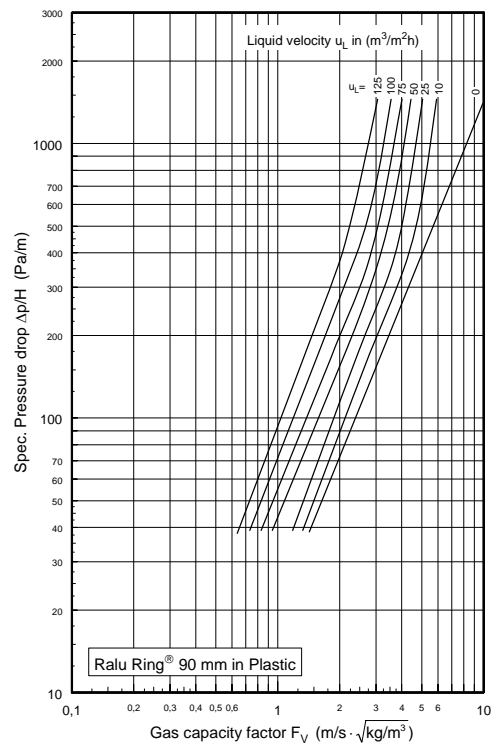


Pressure drop with plastic RALU-RINGS mixture water / air

RALU-RING 50 mm



RALU-RING 90 mm

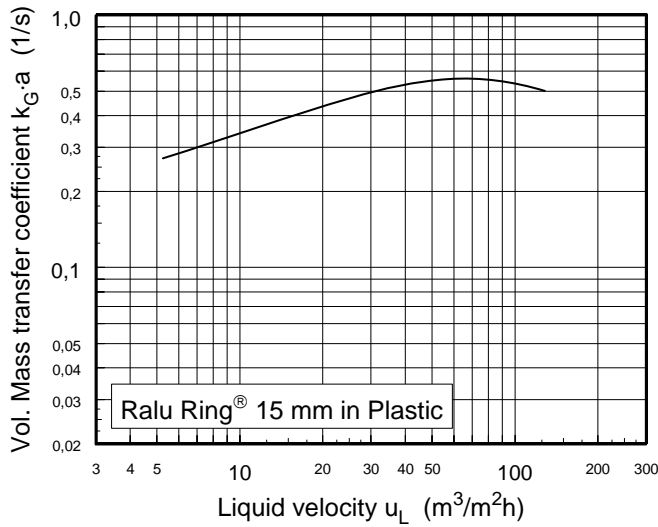


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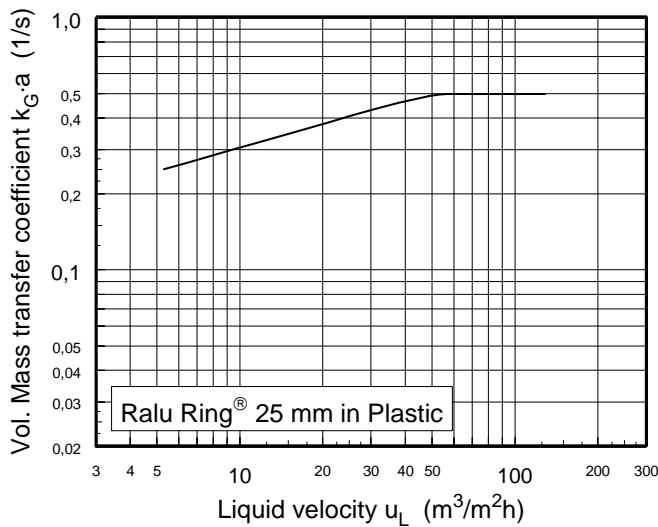
Absorption of CO₂ into NaOH for plastic RALU-RINGS

Values calculated back to unused alkaline solution



RALU-RING 15 mm

Diameter: 290 mm
Packed bed height: 1 m
Alkaline solution concentration: 4%
Gas concentration: approx. 1%
Temperature: 20 °C (68 °F)



RALU-RING 25 mm

Diameter: 290 mm
Packed bed height: 1 m
Alkaline solution concentration: 4%
Gas concentration: approx. 1%
Temperature: 20 °C (68 °F)

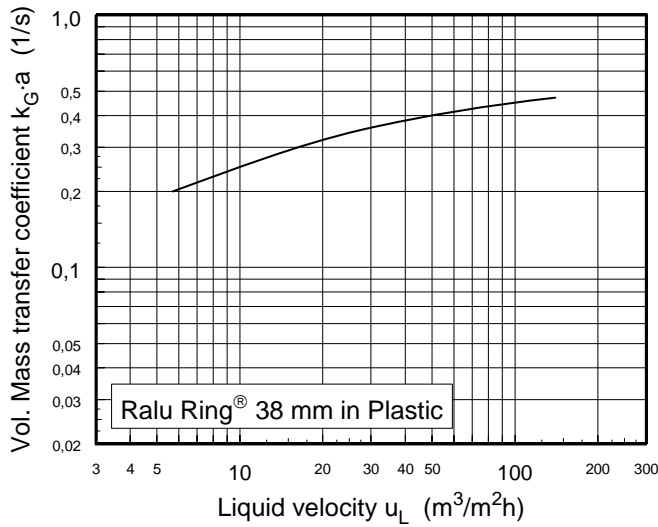


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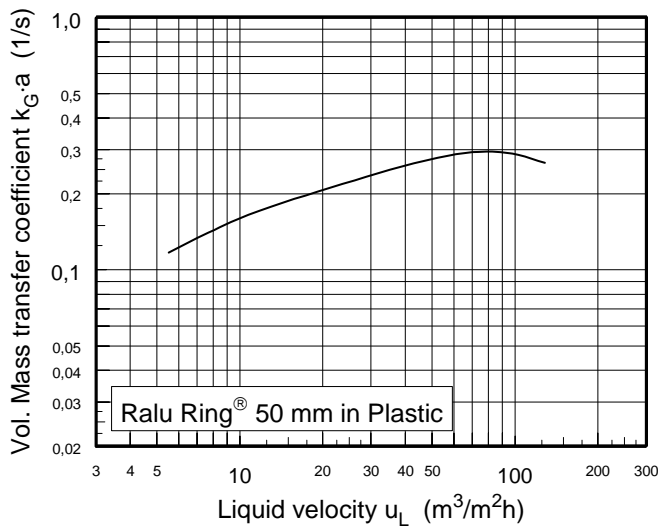
Absorption of CO₂ into NaOH for plastic RALU-RINGS

Values calculated back to unused alkaline solution



RALU-RING 38 mm

Diameter: 290 mm
Packed bed height: 1 m
Alkaline solution concentration: 4%
Gas concentration: approx. 1%
Temperature: 20 °C (68 °F)



RALU-RING 50 mm

Diameter: 400 mm
Packed bed height: 1 m
Alkaline solution concentration: 4%
Gas concentration: approx. 1%
Temperature: 20 °C (68 °F)

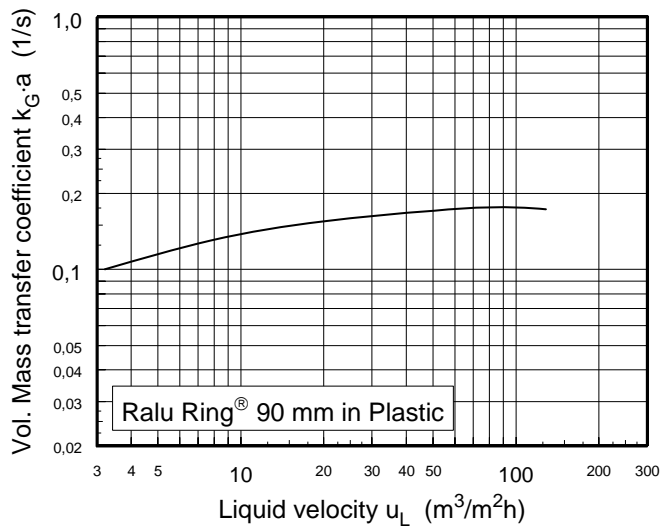


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Absorption of CO₂ into NaOH for plastic RALU-RINGS

Values calculated back to unused alkaline solution



RALU-RING 90 mm

Diameter: 400 mm

Packed bed height: 1 m

Alkaline solution concentration: 4%

Gas concentration: approx. 1%

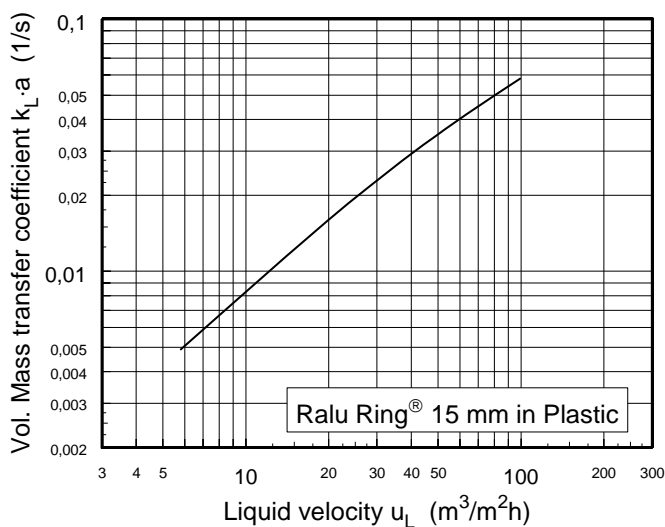
Temperature: 20 °C (68 °F)



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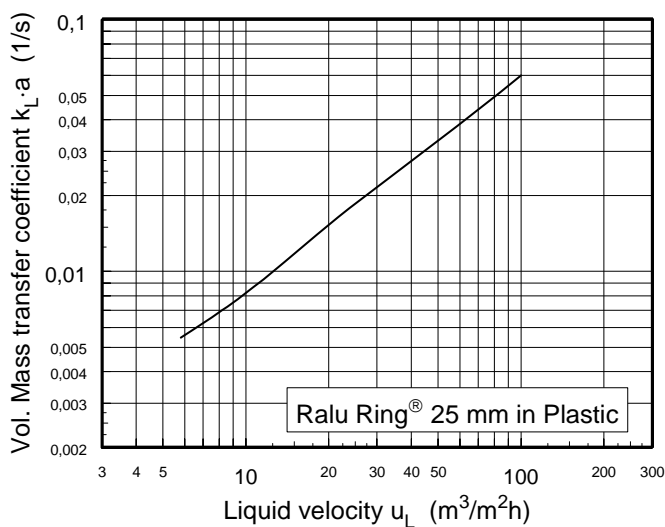


Desorption of oxygen from water for plastic RALU-RINGS into a flow of nitrogen



RALU-RING 15 mm

Diameter: 290 mm
Packed bed height: 1 m
Temperature: 20 °C (68 °F)



RALU-RING 25 mm

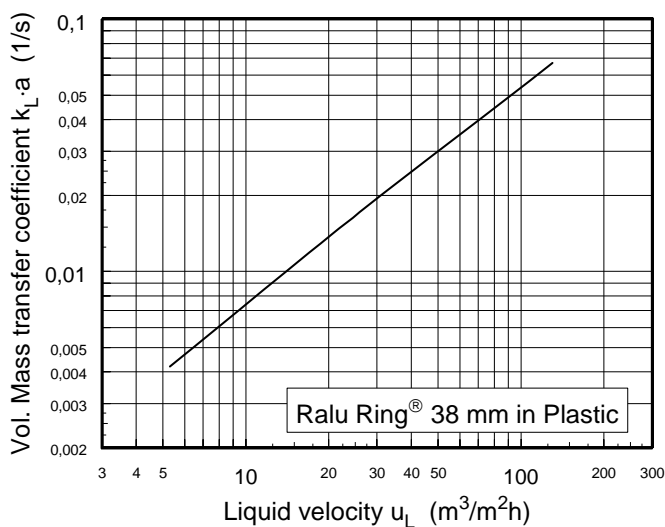
Diameter: 290 mm
Packed bed height: 1 m
Temperature: 20 °C (68 °F)



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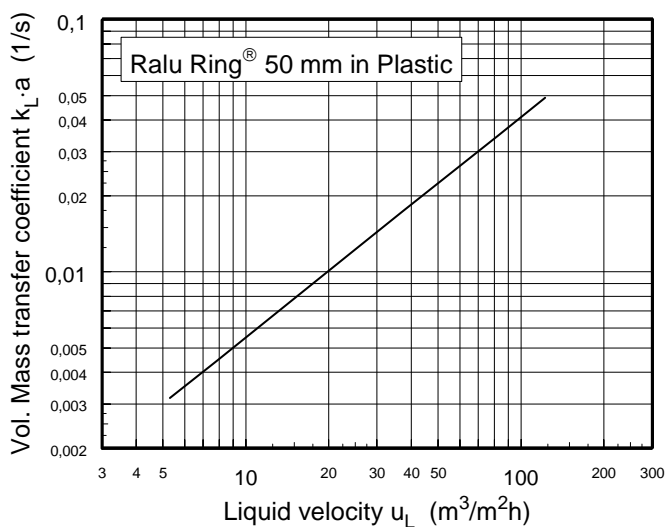


Desorption of oxygen from water for plastic RALU-RINGS into a flow of nitrogen



RALU-RING 38 mm

Diameter: 290 mm
Packed bed height: 1 m
Temperature: 20 °C (68 °F)



RALU-RING 50 mm

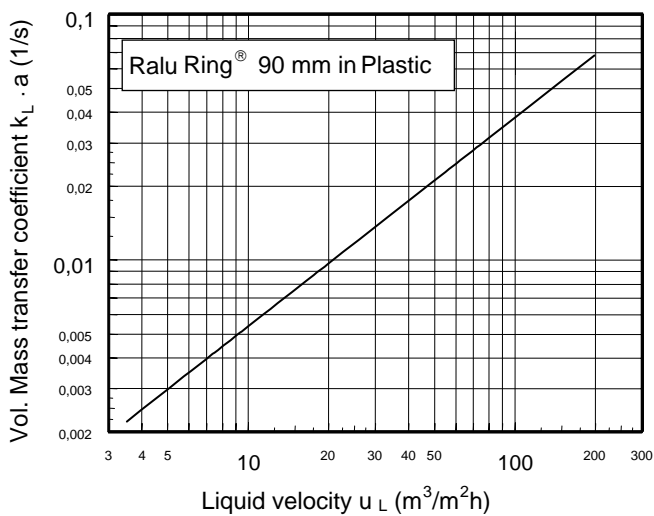
Diameter: 400 mm
Packed bed height: 1 m
Temperature: 20 °C (68 °F)



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Desorption of oxygen from water for plastic RALU-RINGS into a flow of nitrogen



RALU-RING 90 mm

Diameter: 400 mm

Packed bed height: 1 m

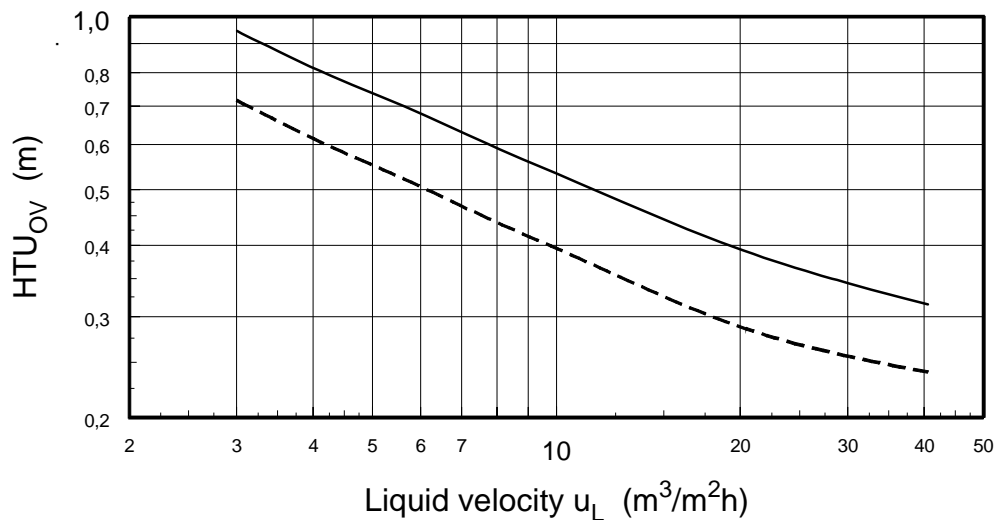
Temperature: 20 °C (68 °F)



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Height of a transfer unit HTU_{OV} for plastic RALU-RINGS 50 mm in the gaseous phase as a function of the irrigation density



This graph shows the height necessary for the RALU RING in the gaseous phase of a transfer unit as a function of the irrigation density for the F factors:

$$F_V = 1 \text{ (Pa}^{0.5}\text{)} \text{ -----}$$

and

$$F_V = 2 \text{ (Pa}^{0.5}\text{)} \text{ -----}$$

$ds = 300 \text{ mm}$

$H = 1350 \text{ mm}$

System: air-NH₃/water

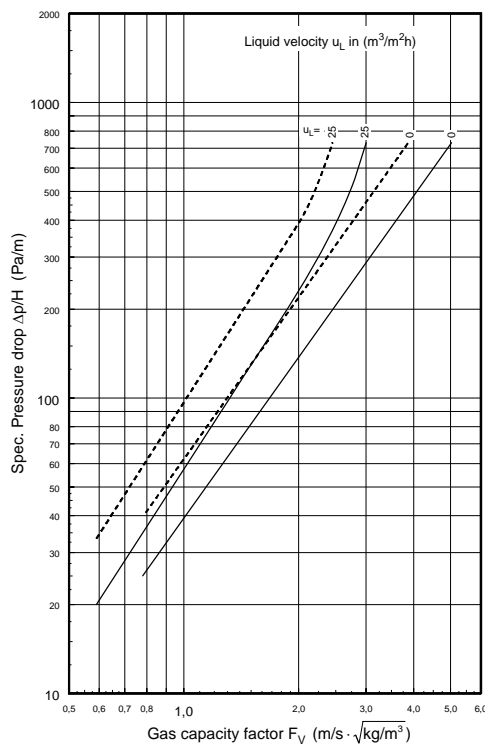


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Comparison graph RALU RING / PALL Ring in plastic

Specific pressure drop $\Delta p/H$ as a function of the gas capacity factor F_V

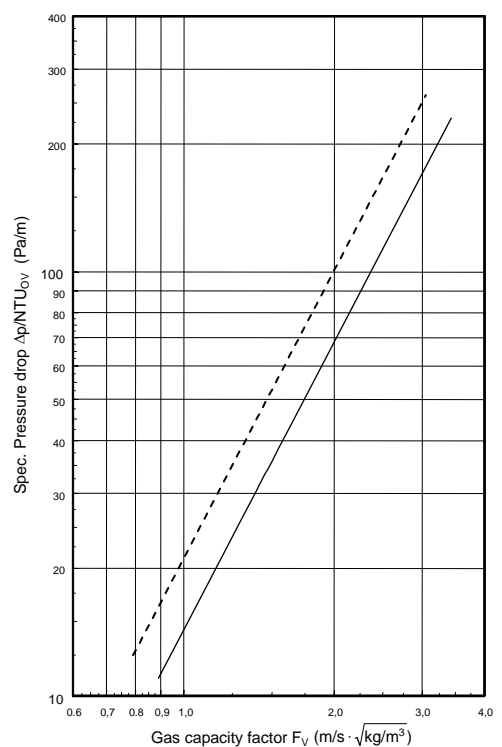


The graph shows the pressure drop related to 1-meter packed bed height as a function of the gas capacity factor F_V . The graph shows the differences in the dry and wet pressure drops between the 50 mm PALL Ring and the 50 mm RALU RING.

$ds = 750$ mm
 $H = 3000$ mm
 irrigation rate u_L (m^3/m^2h)

----- PALL RING
 _____ RALU RING

Specific pressure drop $\Delta p/NTU_{OV}$ as a function of the gas capacity factor F_V



The graph shows the pressure drop with respect to the number of transfer units as a function of the gas capacity factor F_V . The comparison of the plastic 50 mm RALU RING and the 50 mm PALL Ring in plastic applies to the system air-NH₃/water at the irrigation rate of approx. 15 m³/m²h.

$ds = 300$ mm
 $H = 1350$ mm
 u_L 10 ... 15 m³/m²h
 System: air-NH₃/water

