RALU-RING®

Product Bulletin 450

Superior performance by design™

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RALU-RING®

Subject page

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.

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RALU-RING®
in metal
with bead reinforcement

Sizes mm	Surface m²/m³	Free Vol. %
25x25x0.4	215	98
38x38x0.5	135	97
38x38x0.4	135	97
50x50x0.5	105	98
50x50x0.4	105	98

Other wall thickness available upon request.

The weights for RALU-RING® 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-RING®

made of plastic

Polypropylene and polyethylene of different grades

Nominal Sizes	Surface m²/m³	Free Vol. %
5/8“ -15	320	94
1“ -25	190	94
1 ½“ -38	150	95
2“ -50	110	95
3 ½“ -90	75	90
5“ -125	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

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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-RING® 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®, 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-RING®.

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 specify gravity of the polypropylene tower packings can be raised to above 1.

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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)

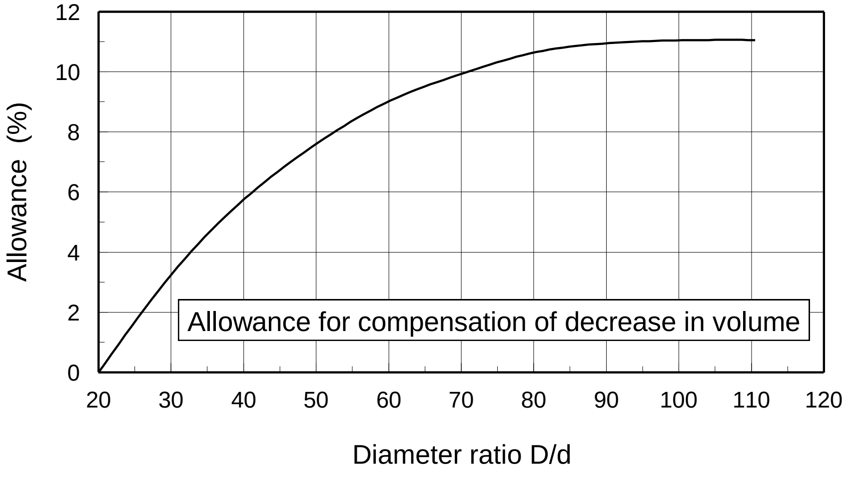
(Teflon in various material grades)

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.

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.

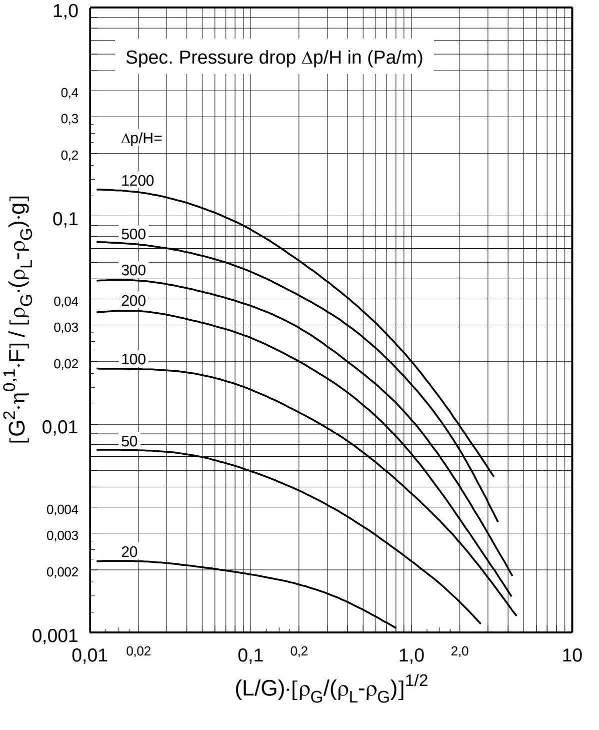
If the plastic or metal packings are, for instance, thrown into the column, this may result in a further decrease in volume due to abnormally compact packing.

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

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 ½"	15	19-20 ¾"	25 1"	30-35	38 1 ½"	50 2"	70-75 3"	90 3 ½"
RASCHIG SUPER-RING®	Metal Plastic			131	102	72 105	59	46	39 40	31	
RALU-FLOW®	Plastic					75			38		
RASCHIG RING	Ceramic Metal	3200 1280	1900 980	1250 566	840	510 380	340 280	310 270	210 190	120 105	
PALL-Ring	Ceramic Metal Plastic			 230 320		350 157 171	180 103 140	 92 	142 66 82		 52 52
RALU-RING®	Metal Plastic					157 135		92 80	66 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**		
Δ p = 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.

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

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.

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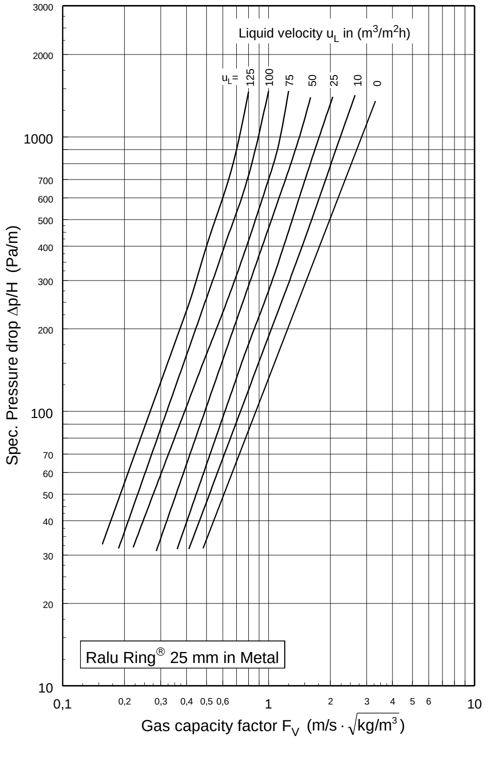
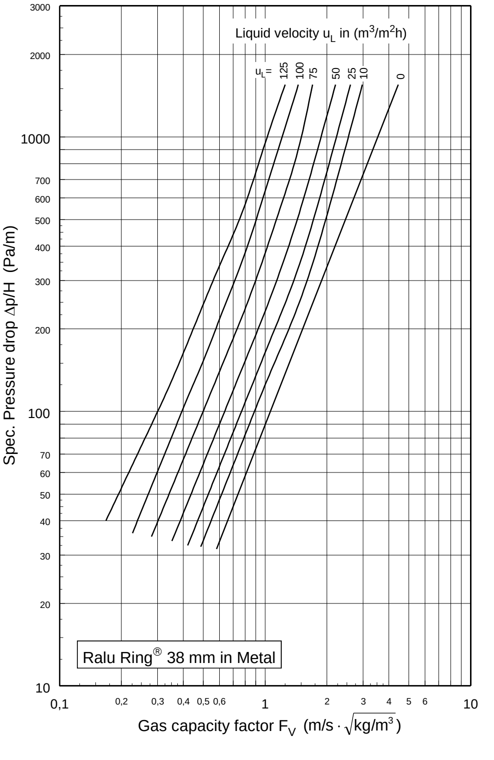
Pressure drop with metal RALU-RING®

mixture water / air

RALU-RING® 25 mm



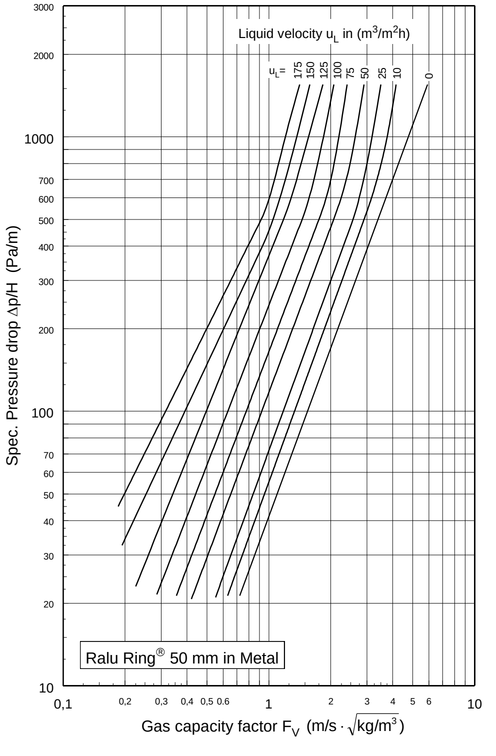
RALU-RING® 38 mm



Pressure drop with metal RALU-RING®

mixture water / air

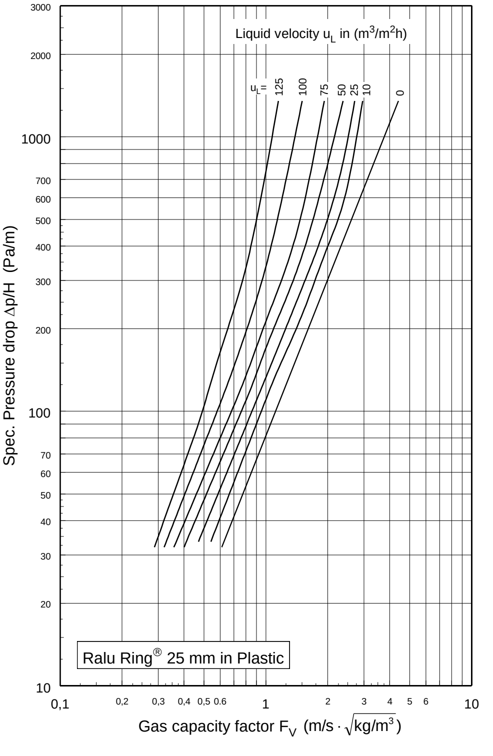
RALU-RING® 50 mm



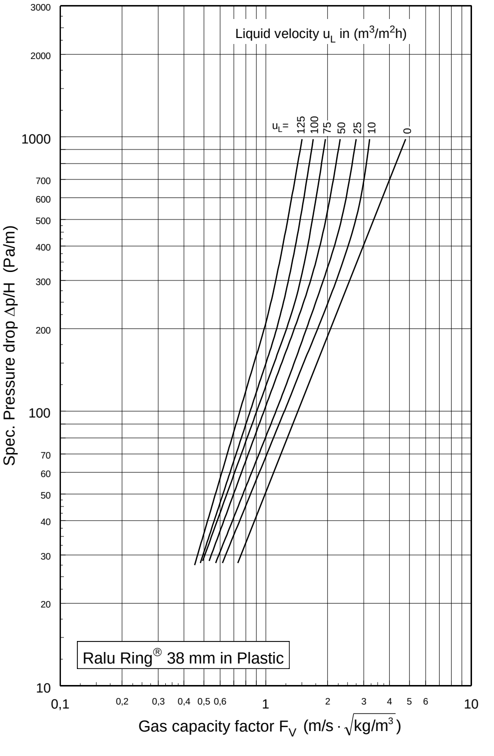
Pressure drop with plastic RALU-RING®

mixture water / air

RALU-RING® 25 mm



RALU-RING® 38 mm



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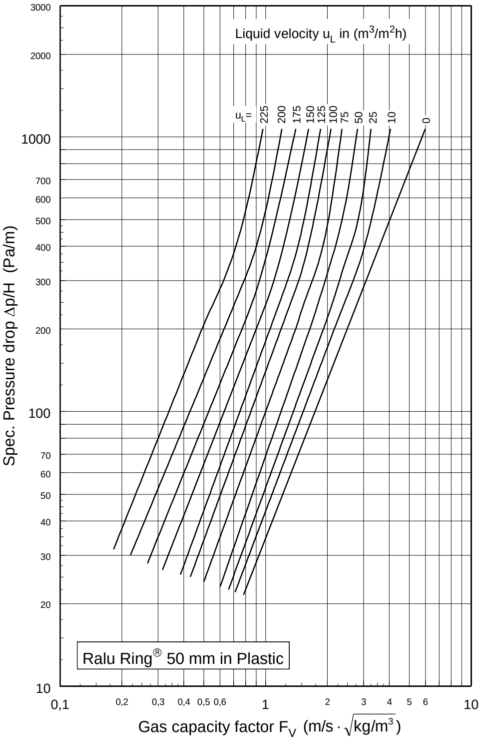
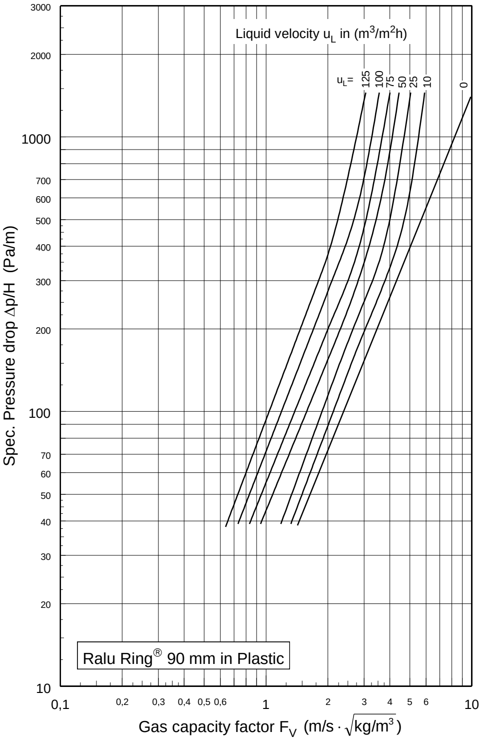
Pressure drop with plastic RALU-RING®

mixture water / air

RALU-RING® 50 mm

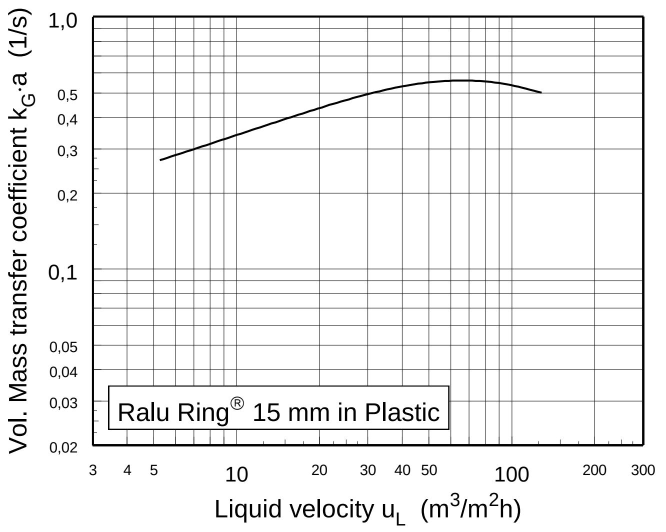


RALU-RING® 90 mm



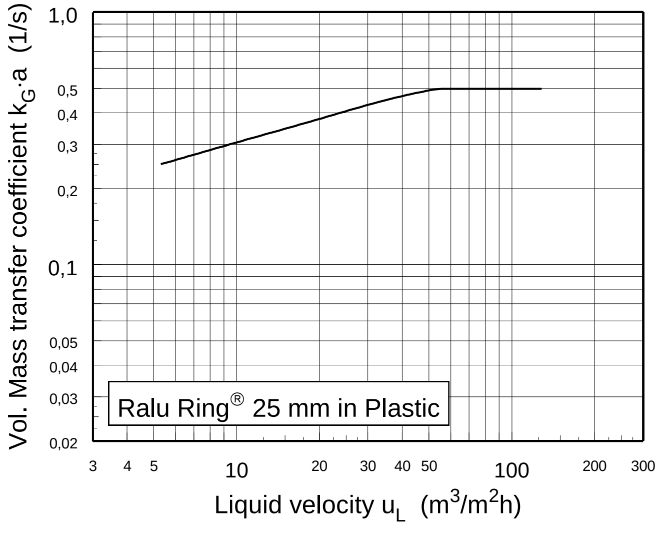
Absorption of CO_2 into NaOH for plastic RALU-RING®

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)

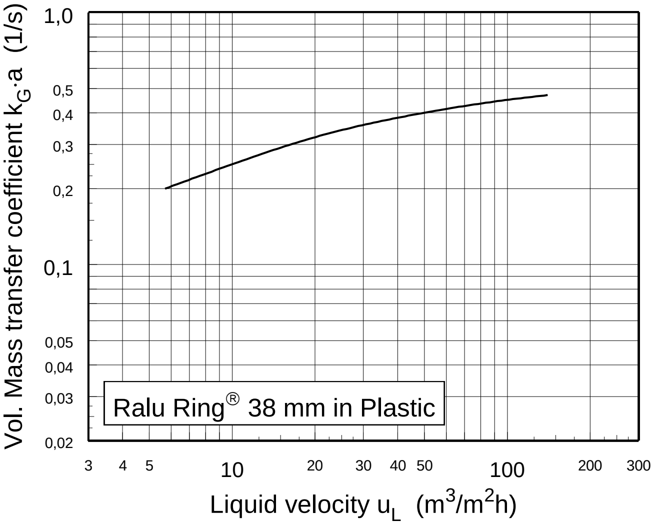


RALU-RING® 25 mm

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

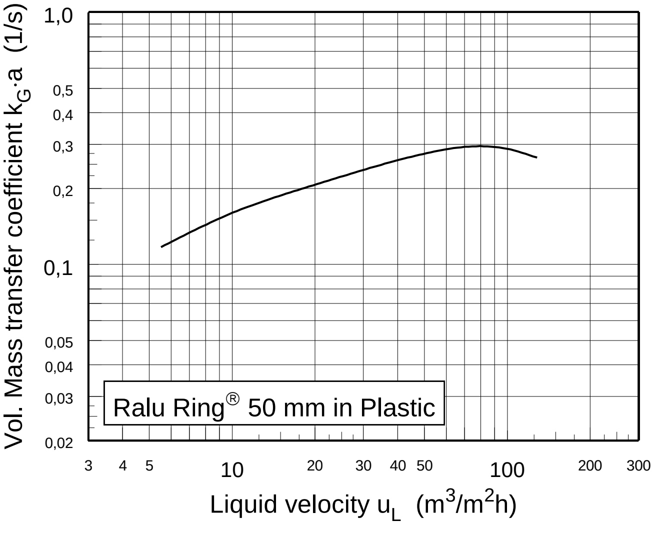
Absorption of CO_2 into NaOH for plastic RALU-RING®

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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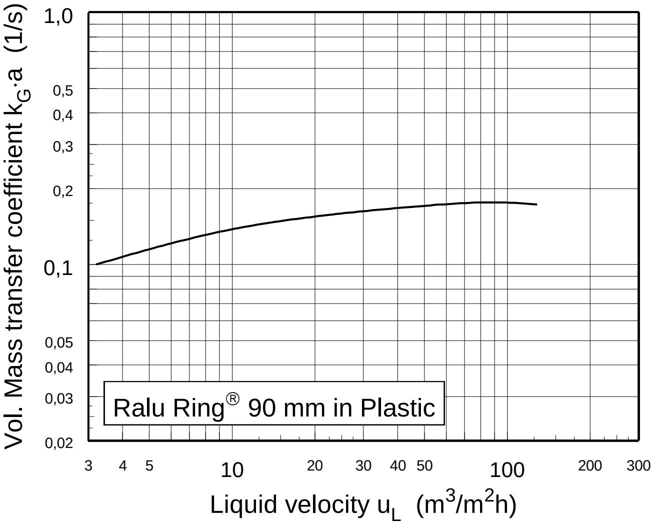
Absorption of CO_2 into NaOH for plastic RALU-RING®

Values calculated back to unused alkaline solution

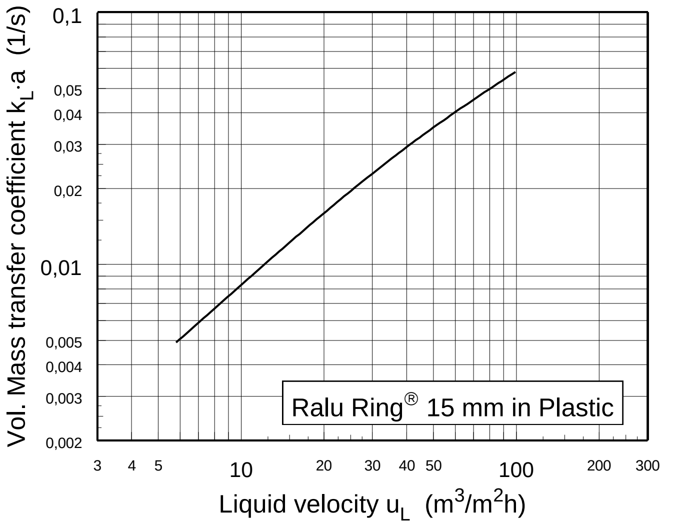


RALU-RING® 90 mm

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

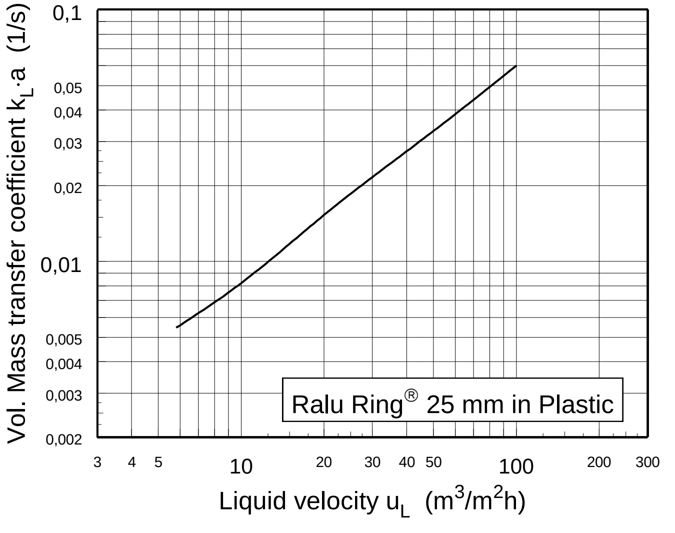
Desorption of oxygen from water for plastic RALU-RING®

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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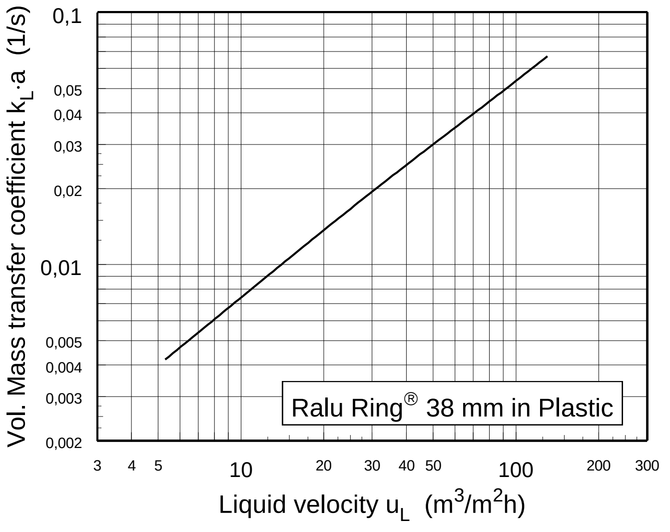
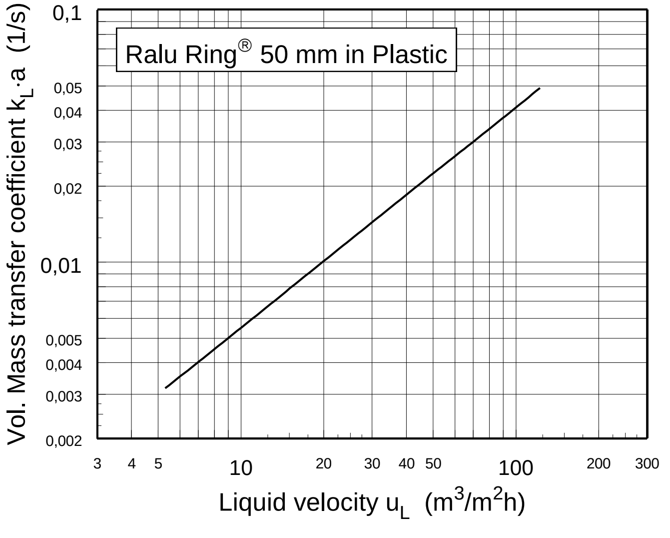
Desorption of oxygen from water for plastic RALU-RING®

into a flow of nitrogen



RALU-RING® 38 mm

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

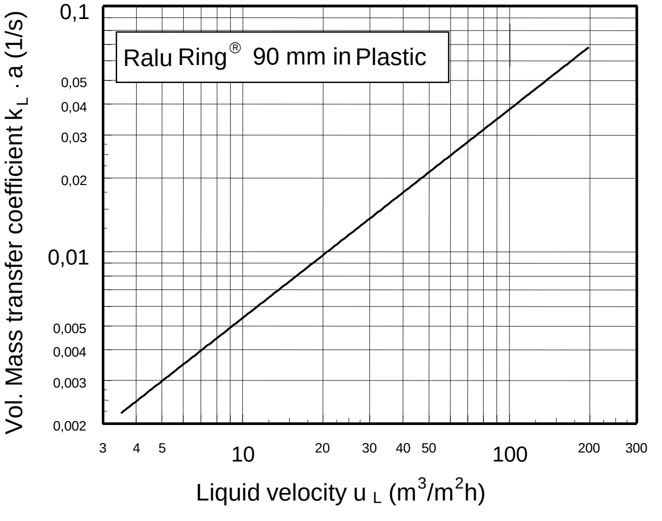


RALU-RING® 50 mm

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

RASCHIG

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

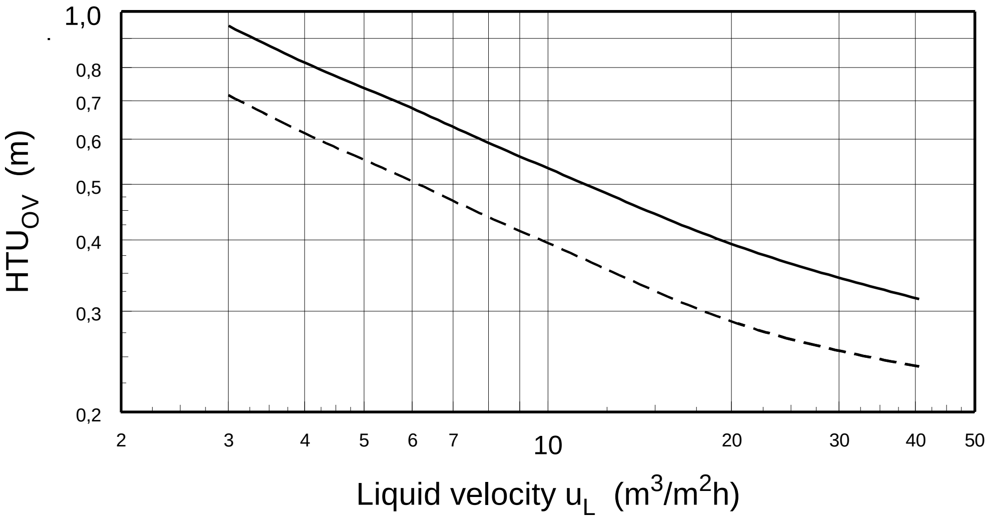


RALU-RING® 90 mm

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

Height of a transfer unit HTU_{OV} for plastic RALU-RING® 50 mm

in the gaseous phase as a function of the irrigation density

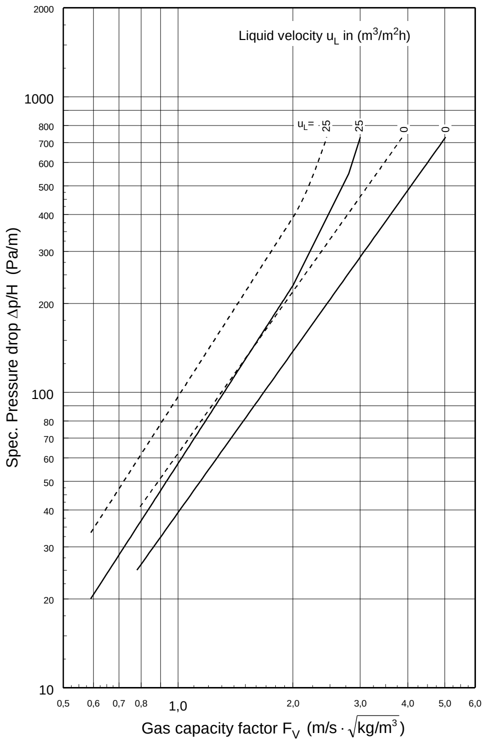


This graph shows the height necessary for the RALU-RING® in the gaseous phase of a transfer unit as a function of the irrigation density for the F factors:

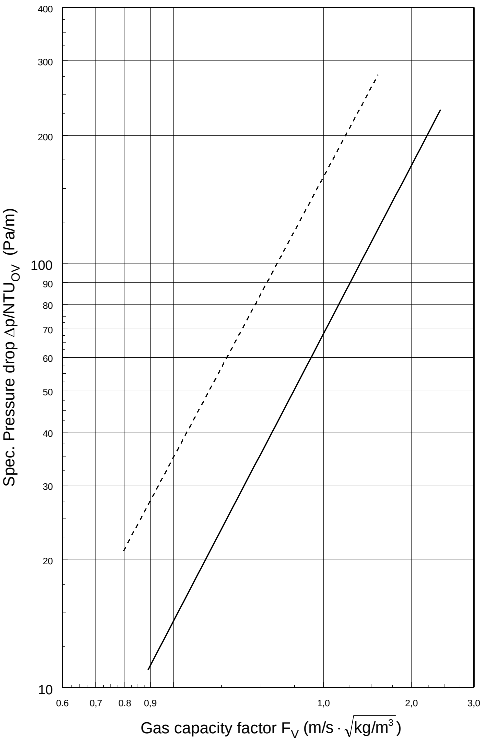
$F_V = 1$ ($Pa^{0,5}$) _ _ _ _ _
and
FV = 2 ($Pa^{0,5}$) ________
ds = 300 mm
H = 1350 mm
System: air-NH_3/water

Comparison graph
RALU-RING® / PALL Ring in plastic

Specific pressure drop Δp/H as a function of the gas capacity factor F_V



Specific pressure drop $Δp/NTU_{OV}$ 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 (m³/m²h)

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 25 mm RALU RING® and the 25 mm PALL Ring in plastic applies to the system air-NH_3/water at the irrigation rate of approx. 15 m³/m²h.
ds = 300 mm
H = 1350 mm
u_L 10 ... 15 m³/(m³h)
System: air-NH_3/water

_ _ _ _ _ PALL-RING
_______ RALU-RING®

Nomenclature

Latin symbols

a	m^2/m^3	specific surface area of packing
a_{Ph}	m^2/m^3	specific effective surface area of packing
C_S	m/s	$= u_V (\rho_V /(\rho_L - \rho_V))^{1/2}$ capacity factor
D_S, d_S	m	column diameter
F_V, F_G	m/s $(kg/m^3)^{1/2}$	$= u_V (\rho_V)^{1/2}$ gas capacity factor
F	-	Packing factor
g	m/s^2	= 9.81 m/s^2, acceleration
H	m	section height
HETP	m	height equivalent to a theoretical plate
HTU_{OV}	m	overall gas side height of a transfer unit
$k_G a_{Ph}$	1/s	volumetric mass transfer coefficient in gas phase
$k_L a_{Ph}$	1/s	volumetric mass transfer coefficient in liquid phase
L	kg/h	Liquid mass flow rate
h_L	m^3/m^3	superficial liquid hold-up
n_{th}	-	number of theoretical stages
p	bar	pressure
u_L	m^3/m^2h	superficial liquid velocity
u_V	m/s	superficial gas velocity
V, G	kg/h	Vapor mass flow rate

Greek symbols

$\beta_V a_{Ph}$	1/s	volumetric mass transfer coefficient in gas phase
$\beta_L a_{Ph}$	1/s	volumetric mass transfer coefficient in liquid phase
ρ_L	kg/m^3	liquid density
ρ_V	kg/m^3	gas density
$\Delta p/H$	mbar/m	specific pressure drop
η	Pas, kg/(ms)	dynamic viscosity

Subscripts

Fl	flooding condition
L	liquid phase
V	vapour phase