PALL-RING

Product Bulletin 350

Superior performance by design™

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PALL-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.

Operational data for PALL-Rings made of metal

Sizes mm	Surface m^2/m^3	Free Vol. %
10x0.3	515	94
15x0.3	360	95
25x0.5	215	95
25x0.6	215	95
38x0.6	135	96
50x0.8	105	96
80x1.2	80	96

* All of the given weights refer to the stainless steel versions in the indicated material thickness.
Other wall thickness available upon request.

The weights for PALL-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

Operational data for PALL-Rings made of special stoneware/porcelain

Size mm	Surface m^2/m^3	Free Vol. %
for dumped packing		
25x25x3	220	75
35x35x4	165	78
50x50x5	120	78
80x80x8	80	79
100x100x10	55	81
for stacked packing		
80x80x8	150	69
100x100x10	81	74
120x120x12	58	74

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Operational data PALL-Rings made of plastics

Plastics	Size mm	Surface m^2/m^3	Free Vol. %
Polypropylene and polyethylene of different grades	15x15	350	88
	25x25	220	91
	35x35	160	93
	50x50	110	93
	90x90	90	94

The weights for the high-performance thermoplastics below are obtained by multiplication with the following factors:

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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Materials

PALL Rings are made of three main groups of materials:

Metals

Mainly carbon steel and alloyed chrome-nickel steels. Special alloys such as Hastelloy, Incoloy, Monel titanium and zirconium are being used more and more frequently, and are also processed.

Ceramics

The most frequently processed materials are special stoneware and special hard porcelain. These ceramic materials are densely sintered, they have great resistance to high temperatures and a uniform material structure.

Plastics

Most of the production of thermoplastics consists of polypropylene grades in various versions. In addition to polyethylene, high-performance plastics are also used. As a standard procedure, Raschig uses virgin materials. Regenerates are only processed upon special request.

Depending on the stress caused by temperature and chemical attack, the following quality grades of polypropylene must be distinguished:

standard polypropylene (PP)

or permanent temperatures of up to approx. 70 °C (158 °F).

heat-endurance stabilised polypropylene (LTHA)

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

Under permanent thermal stress, this specially stabilised material has approximately twice the service life of normally stabilised polypropylene.

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30 % fibreglass-reinforced polypropylene (GFR)

This is a fibreglass reinforced grade. The fibreglass part of approx. 30 percent is completely surrounded with plastic. As a result, the chemical resistance is about the same as that of nonereinforced polypropylene.

Operating temperature range up to approx. 135 °C (275°F).

Polyether sulfone (PES)

a highly temperature-resistant amorphous thermoplastic.

Operating temperature range up to approx. 180 °C (356 °F), cold resistance down to approx.

-100 °C (-148 °F).

Polyphenylene sulphide (PPS)

a technical high performance thermoplastic, usually in connection with fibreglass and special mineral fillers. Operating temperature range up to approx. 220 °C (428 °F), briefly 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)

a thermoplastic fluoroplastic, 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)

which can be processed by the injection moulding technique, e.g. FEP 100, PFA 340, can also be offered. Depending on the grade, the heat resistance ranges up to approx. 260 °C (500 °F), while the cold resistance goes down to -200 °C (-328 °F).

The various application possibilities and plastic grades must be checked on a case-to-case basis.

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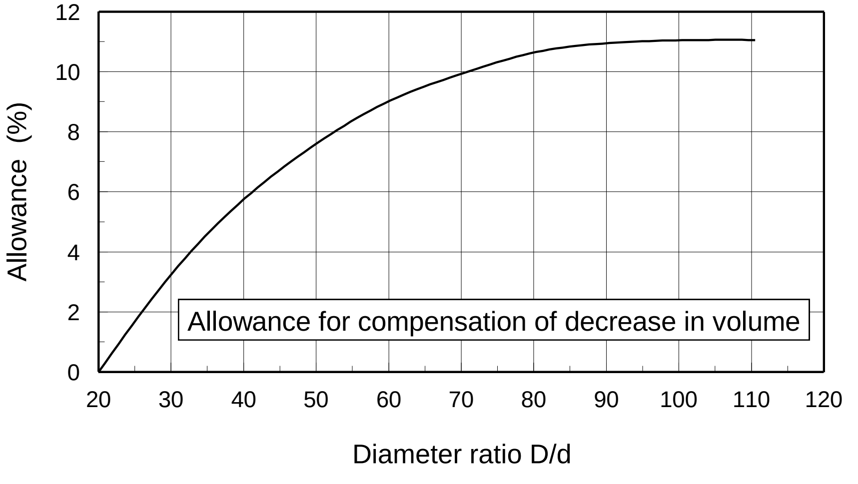
Compensation for the "decrease in volume" for dumped packings



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.

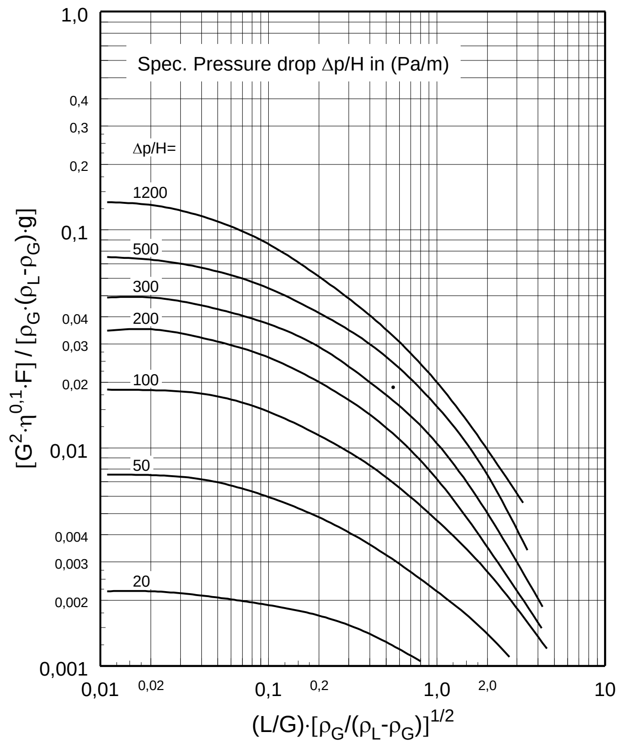
The opposite diagram shows by which "allowance" the theoretically calculated vessel volume for diameter ratios of more than 20 must be increased in order to completely fill the space required.

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

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.



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	kg/m² s
L'	= liquid flow	kg/h
G	= gas flow	kg/m² s
G'	= gas flow	kg/h
ρ_L	= spec. gravity of the liquid	kg/m³
ρ_G	= spec. gravity of the gas	kg/m³
F	= tower packing factor	(see table)
η	= viscosity of the liquid	mPa · s
g	= 9,81 = acceleration due to gravity	m/s²

Tower packing factor

Table 1

		Nominal size of the tower packings									
Tower packing	Material	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			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**		
Δ p = mm WS/m		40	80	125	40	80	125	40	80	125
RASCHIG'S 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'S 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 3 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 regularly 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 factors 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.

$$\frac{G_{\text{Pall Rings}}}{G_{\text{Torus Saddles}}} = \frac{\sqrt{130}}{\sqrt{66}} = 1{,}4$$

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 a absorption columns and strippers; values of 0.5 and below occur with most distillation columns.

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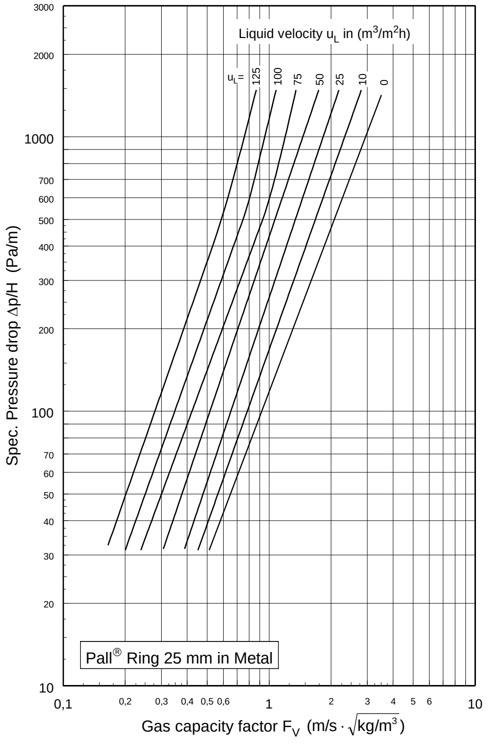
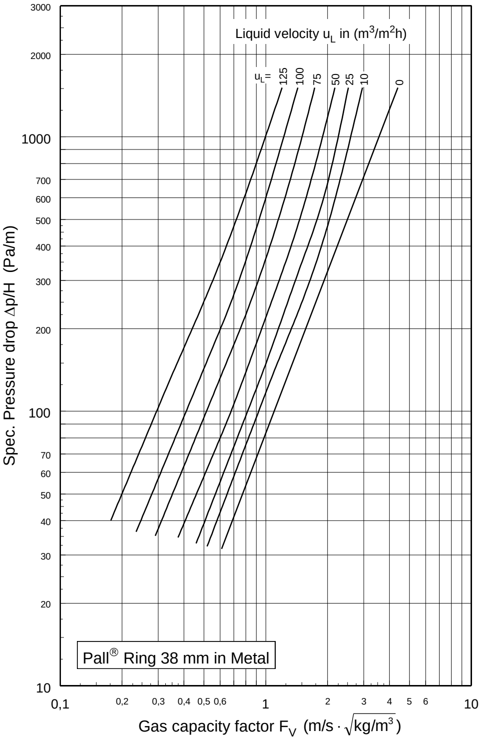
Pressure drop with metal PALL-RINGS

mixture air / water

PALL-RING 25 mm



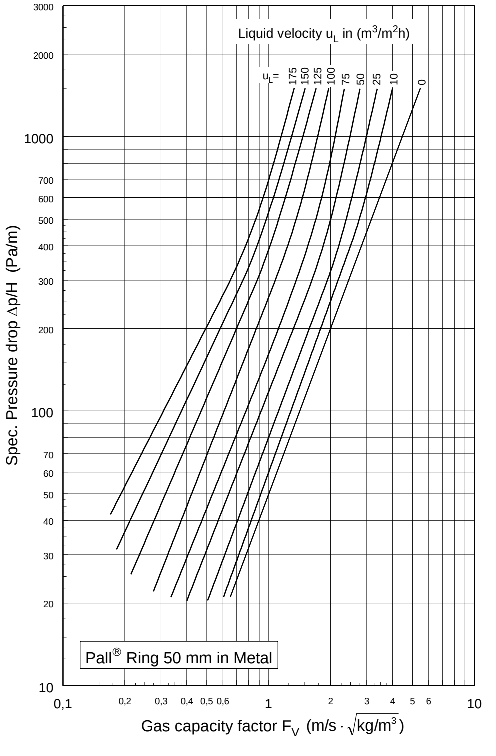
PALL-RING 38 mm



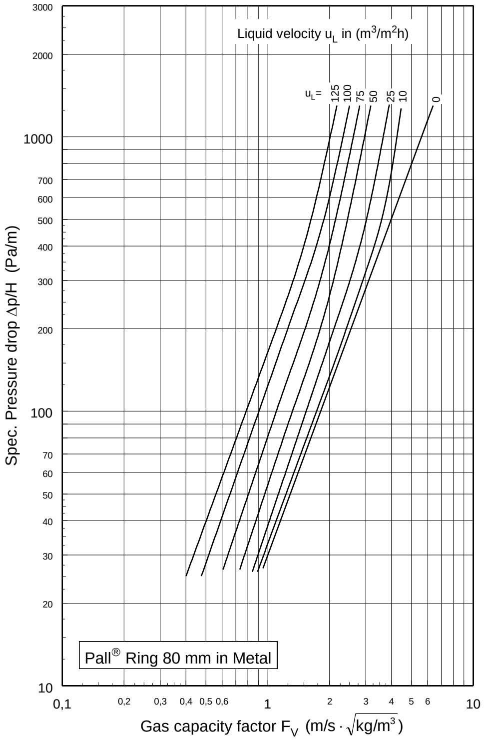
Pressure drop with metal PALL-RINGS

mixture air / water

PALL-RING 50 mm



PALL-RING 80 mm



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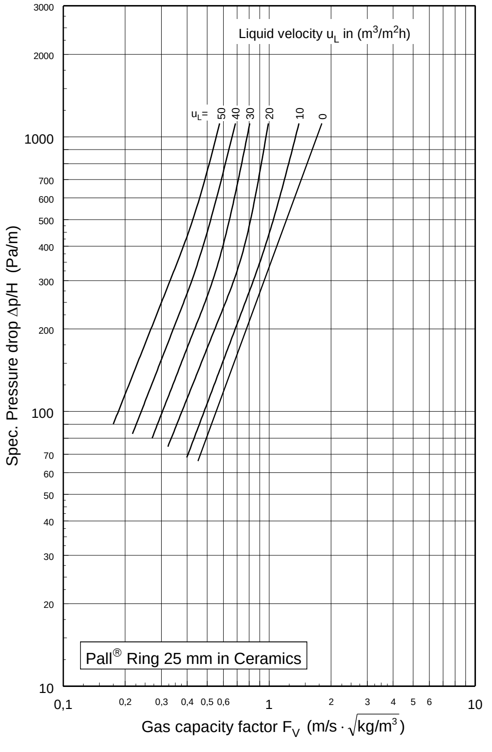
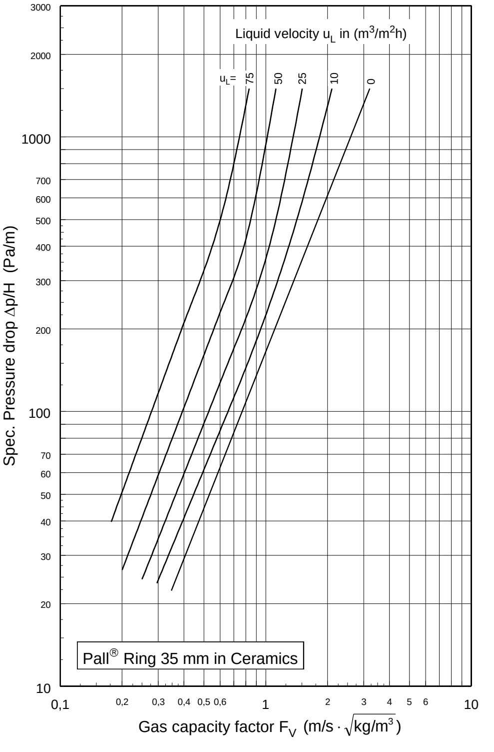
Pressure drop with ceramic PALL-RINGS

mixture air / water

PALL-RING 25 mm



PALL-RING 35 mm



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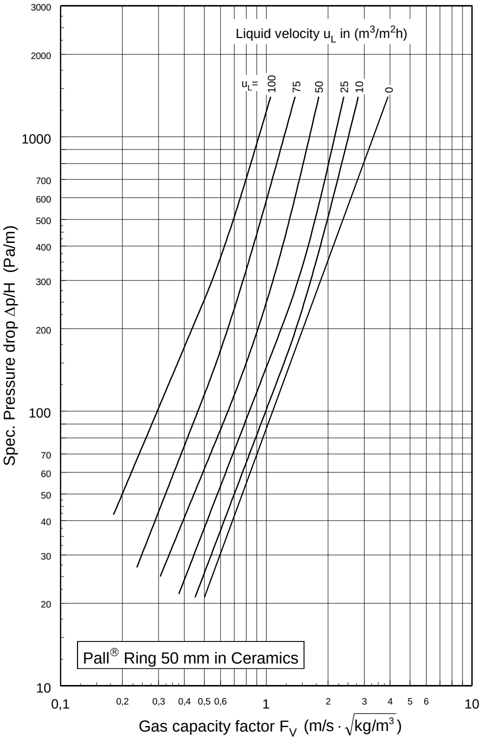
Pressure drop with ceramic PALL-RINGS

mixture air / water

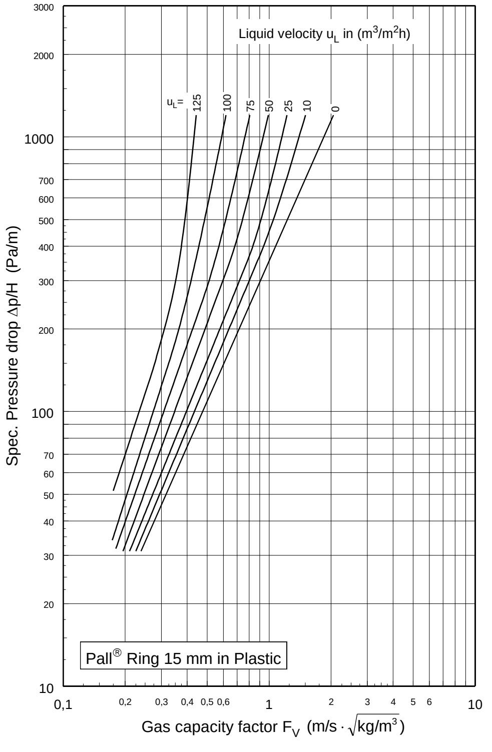
PALL-RING 50 mm



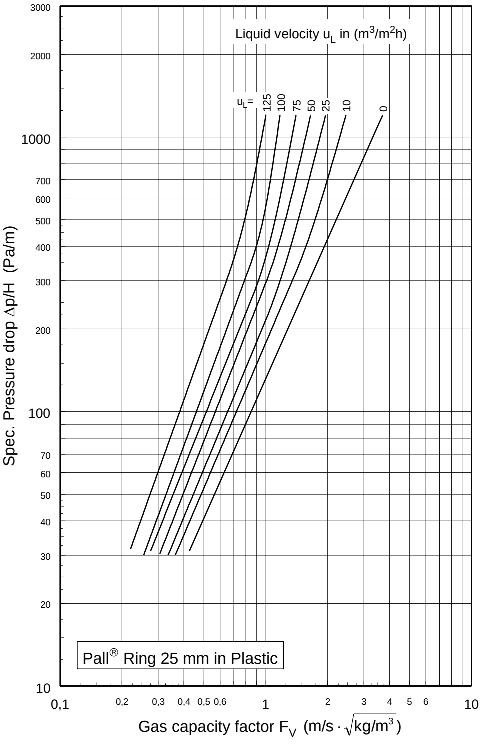
Pressure drop with polypropylene PALL-RINGS

mixture air / water

PALL-RING 15 mm



PALL-RING 25 mm



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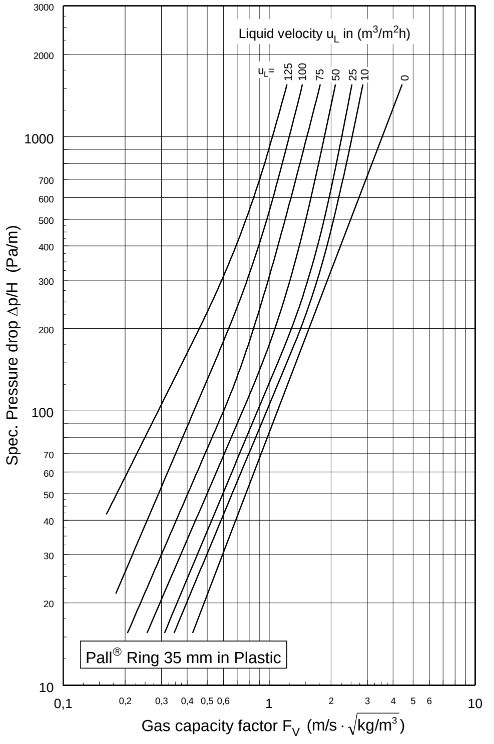
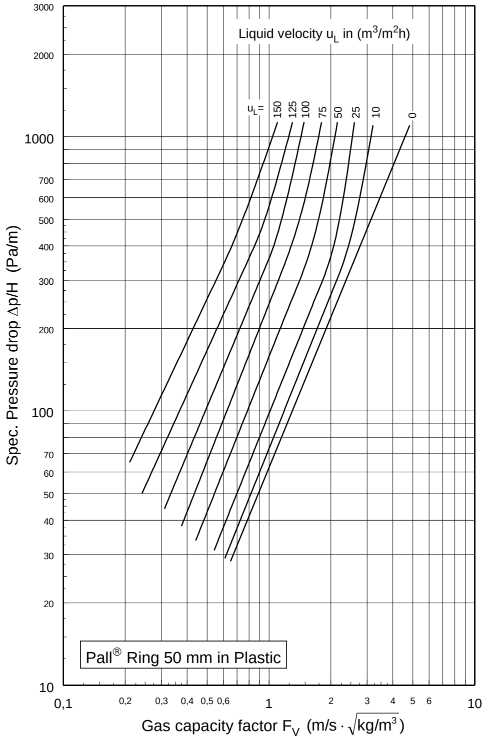
Pressure drop with polypropylene PALL-RINGS

mixture air / water

PALL-RING 35 mm



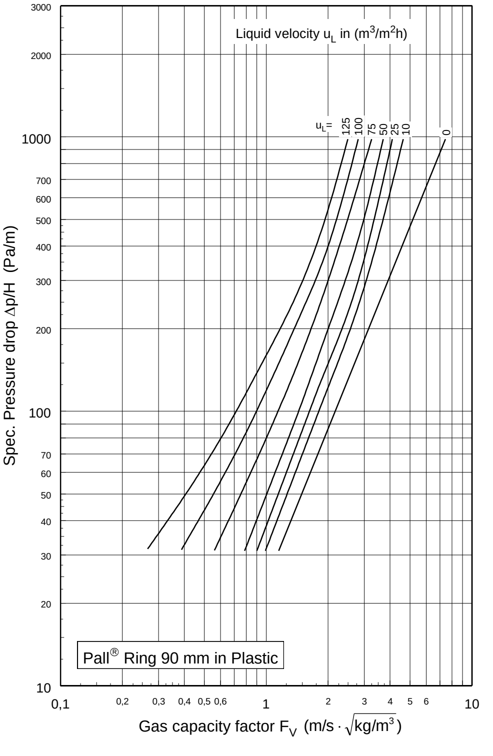
PALL-RING 50 mm



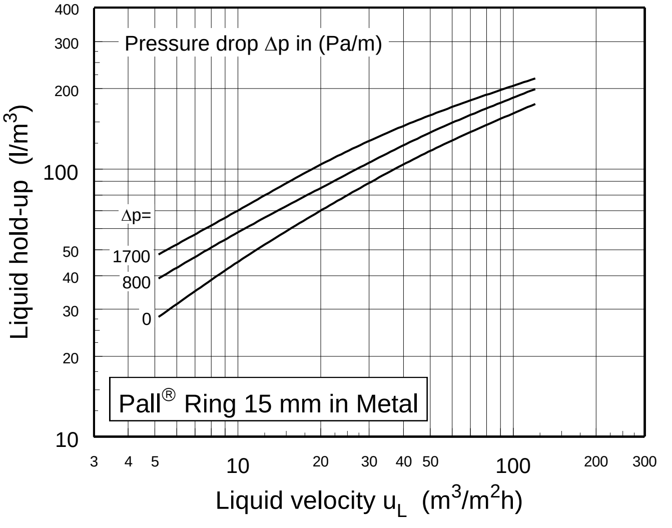
Pressure drop with polypropylene PALL-RINGS

mixture air / water

PALL-RING 90 mm

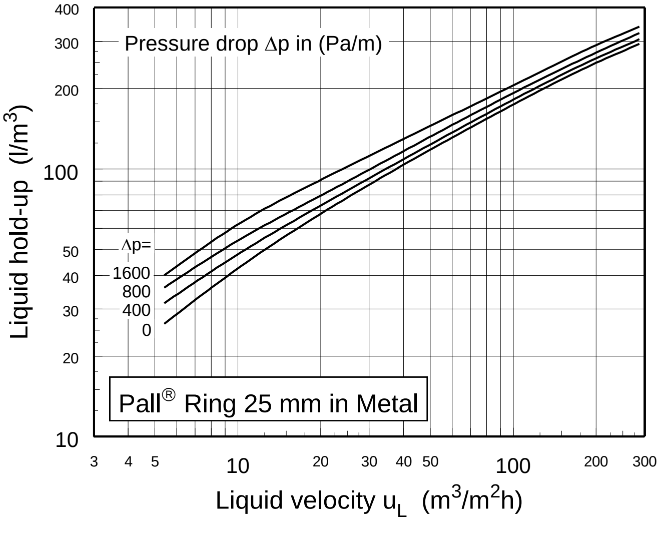


Liquid hold-up in columns with metal PALL-RINGS



PALL-RING 15 mm

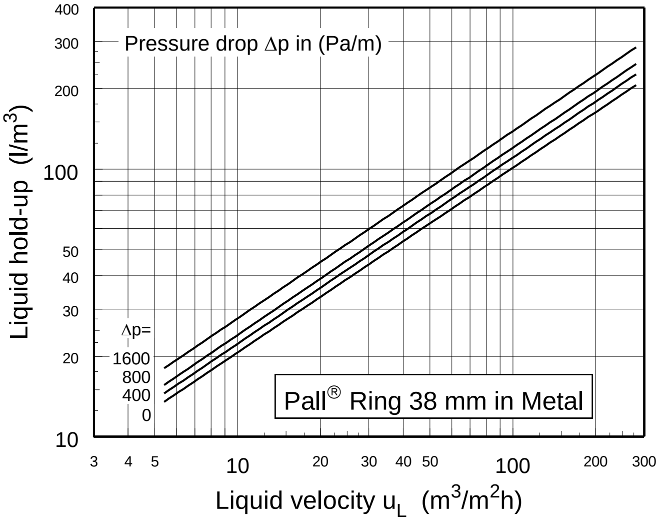
Diameter of column: approx.380 mm
Height of packed bed: approx. 1,7 m



PALL-RING 25 mm

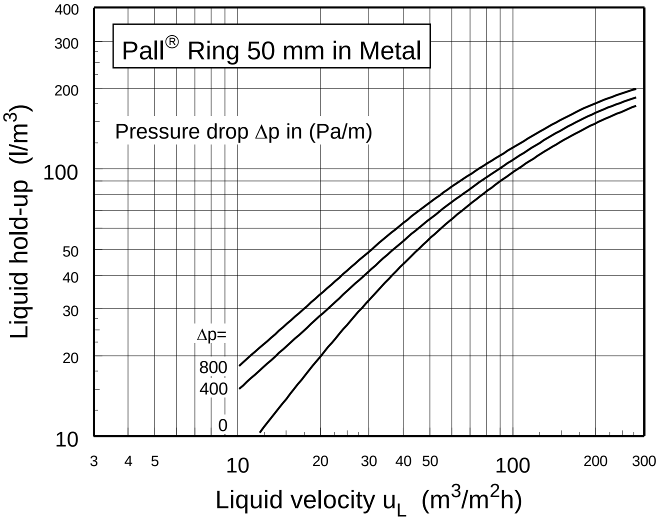
Diameter of column: approx.750 mm
Height of packed bed: approx. 3 m

Liquid hold-up in columns with metal PALL-RINGS



PALL-RING 38 mm

Diameter of column: approx.750 mm
Height of packed bed: approx. 3 m



PALL-RING 50 mm

Diameter of column: approx.750 mm
Height of packed bed: approx. 6 m

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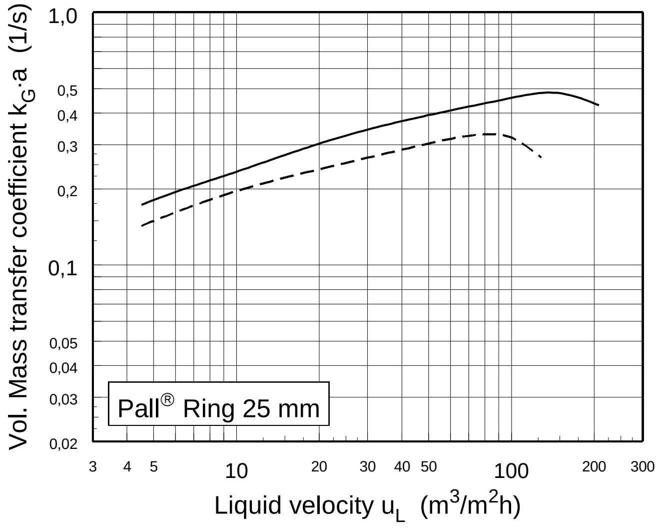
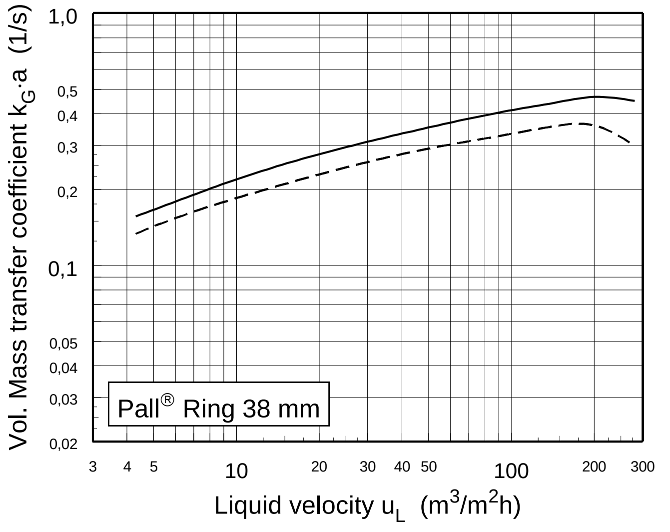
Absorption of CO_2 into NaOH for metal and plastic PALL-RINGS



PALL-RING 25 mm

Diameter of column: 760 mm
Packing height: 3 m
Gas rate: 2200 kg/m3h
Gas concentration: 1% (mean value)
Liquid concentration: 4 % NaOH
Liquid temperature: 24 °C (75 °F)



PALL-RING 38 mm

Diameter of column: 760 mm
Packing height: 3 m
Gas rate: 2200 kg/m3h
Gas concentration: 1% (mean value)
Liquid concentration: 4 % NaOH
Liquid temperature: 24 °C (75 °F)

——————— metal PALL Rings
- - - - - - - - plastic PALL Rings

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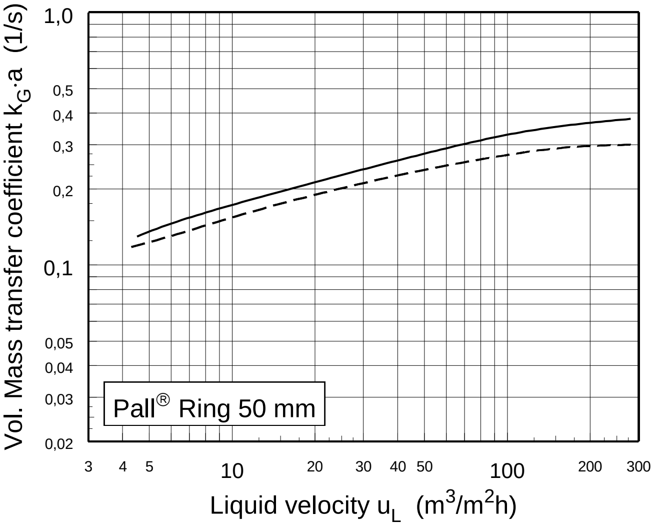
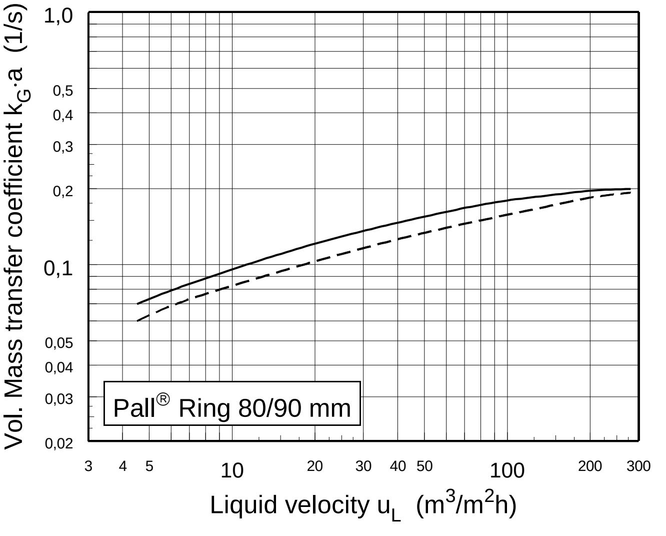
Absorption of CO_2 into NaOH for metal and plastic PALL-RINGS



PALL-RING 50 mm

Diameter of column: 760 mm
Packing height: 3 m
Gas rate: 2200 kg/m3h
Gas concentration: 1% (mean value)
Liquid concentration: 4 % NaOH
Liquid temperature: 24 °C (75 °F)



PALL-RING 80/90 mm

Diameter of column: 760 mm
Packing height for 80 mm of metal: 3 m
Packing height for 90 mm of metal: 2,3 m
Gas rate: 2200 kg/m3h
Gas concentration: 1% (mean value)
Liquid concentration: 4 % NaOH
Liquid temperature: 24 °C (75 °F)

———————— metal PALL-Rings
- - - - - - - - - - plastic PALL- Rings

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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

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