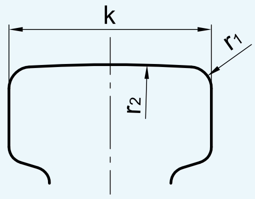
Basis of calculation for crane rail wheels

DIN 15 070
FEM 1.001

Table1. **Symbol and unit**

symbol	unit	description	explanation
c_1	–	material coefficient	Values in accordance with table 2
c_2	–	speed coefficient	Values in accordance with table 3a and 3b
c_3	–	operating time coefficient	Values in accordance with table 4
d_1	mm	Travelling wheel diameter	Running surface diameter
n	min^{-1}	Speed of crane wheel	Values in accordance with table 3b
p	N/mm^2	Pressure	$p = \frac{R}{c_2 \cdot c_3 \cdot d_1 (k - 2 r_1)}$
p_{zul}	N/mm^2	Permissible pressure between crane wheel and rail	$p_{zul} = 5{,}6\ c_1$
k r_1 r_2	mm mm mm	Rail head width Radius of curvature of rail head Radius of camber of rail head	 For cambered crane rails the ideal effective rail head width will be $k-2r_1$.
$k-2r_1$	mm	Ideal effective rail head width	Values for crane rails in accordance with table 5
v	m/min	Speed of crane wheel	
R	N	Wheel force	For crane travelling wheels $R = \frac{R_{min} + 2 R_{max}}{3}$ For trolley travelling wheels $R = R_{max}$
R_{max} R_{min}	N N	Maximum wheel force Minimum wheel force	R_{max} and R_{min} should be determined from the most frequent operating positions of the loaded trolley
R_0	N	Characteristic wheel force	Values in accordance with table 6

Calculation of crane rail wheels

The wheel force is calculated using the formula:

R £ $p_{zul} \cdot c_2 \cdot c_3 \cdot d_1 \cdot (k-2r_1)$ (1)

From the above is abtained the crane wheel diameter

$$d_1 \geq \frac{R}{p_{zul} \cdot c_2 \cdot c_3 \cdot (k - 2 r_1)} \quad (2)$$

The characteristic wheel force R_0 is abtained from equation (1), where:

$p_{zul} = 5{,}6\ N/mm^2$
$c_2 = 1$
$c_3 = 1$

are applied for $R_0 = 5{,}6 \cdot d_1 \cdot (k-2r_1)$ (3)

When using the characteristic wheel force the permissible wheel force can be calculated in simplified fashion using the formula:

R £ $R_0 \cdot c_1 \cdot c_2 \cdot c_3$ (4)

Rail/crane wheel material matching

Tabelle 2. **Permissible pressure p_{zul} and material coefficient c_1**

material minimum tensile strength [N/mm²]		p_{zul}	c_1
rail	wheel	[N/mm²]	
590	£ 330	2,8	0,50
	410	3,6	0,63
	490	4,5	0,80
	590	5,6	1,00
≥ 690	≥ 740	7,0	1,25
	≥ 800	7,2	1,29
	≥ 900	7,8	1,39
≥ 700	≥ 1000	8,5	1,52

The hardening of the running surfaces with a depth of 0,01×diameter can be considered selecting p_{zul}.

Basis of calculation for crane rail wheels

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Table 3a. **speed coefficient c_2**

wheel-Ø d_1	c_2 for v in m/min														
	10	12,5	16	20	25	31,5	40	50	63	80	100	125	160	200	250
200	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77	0,72	0,66	–	–	–
250	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77	0,72	0,66	–	–
315	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77	0,72	0,66	–
400	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77	0,72	0,66
500	1,15	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77	0,72
630	1,17	1,15	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82	0,77
710	–	1,16	1,14	1,13	1,12	1,1	1,07	1,04	1,02	0,99	0,96	0,92	0,89	0,84	0,79
800	–	1,16	1,15	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87	0,82
900	–	–	1,16	1,14	1,13	1,12	1,1	1,07	1,04	1,02	0,99	0,96	0,92	0,89	0,84
1000	–	–	1,17	1,15	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91	0,87
1100	–	–	–	1,16	1,14	1,13	1,12	1,1	1,07	1,04	1,02	0,99	0,96	0,92	0,89
1250	–	–	–	1,17	1,15	1,14	1,13	1,11	1,09	1,06	1,03	1	0,97	0,94	0,91

Tabelle 3b.
wheel speed n from speed coefficient c_2

c_2	n^a [min^{-1}]
0,66	200
0,72	160
0,77	125
0,79	112
0,82	100
0,84	90
0,87	80
0,89	71
0,91	63
0,92	56
0.94	50
0,96	45
0,97	40
0,99	35,5
1	31,5
1,02	28
1,03	25
1,04	22,4
1,06	20
1,07	18
1,09	16
1,1	14
1,11	12,5
1,12	11,2
1,13	10
1,14	8
1,15	6,3
1,16	5,6
1,17	5

Table 4. **operating time coefficient c_3**

operating time of travelling gear (referred to 1 hour)	c_3
bis 16%	1,25
über 16 bis 25%	1,12
über 25 bis 40%	1
über 40 bis 63%	0,9
über 63%	0,8

Tabelle 5. **ideal effective rail head width ($k-2r_1$)**

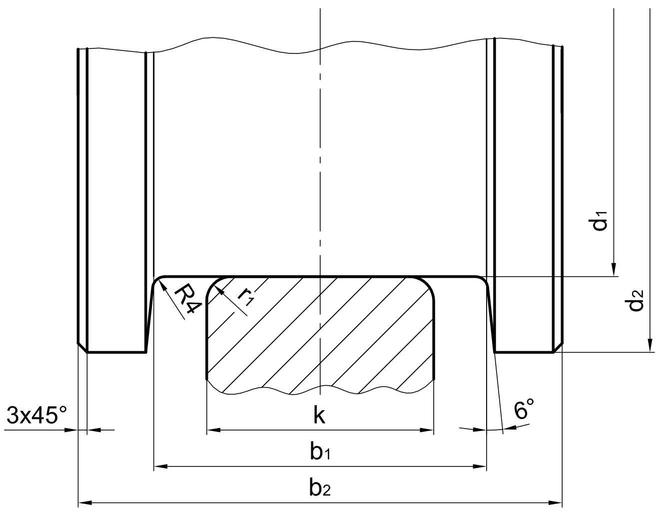
crane rails			r_1	$k-2r_1$
as per	designation			
DIN	new	previous	mm	mm
536 Teil 1	A 45	KS 22	4	37
	A 55	KS 32	5	45
	A 65	KS 43	6	53
	A 75	KS 56	8	59
	A 100	KS 75	10	80
	A 120	KS 101	10	100
536 Teil 2	F 100	–	5	90
	F 120	–	5	110

Tabelle 6. **characterisitc wheel force R_0**

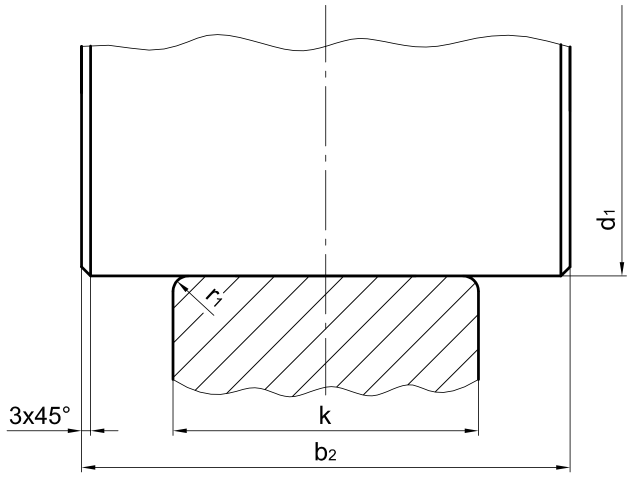
wheel-Ø d_1	R_0 in N for narroc wheels				R_0 in N for broad wheels					R_0 in N for wheels without wheelflange	
	for crane rail				for crane rail					for crane rail	
	A 45	A 55	A 65	A 75	A 55	A 65	A 75	A 100	A 120	F 100	F 120
200	41 000	50 000	–	–	–	–	–	–	–	–	–
250	52 000	63 000	–	–	–	–	–	–	–	–	–
315	65 000	79 000	–	–	79 000	93 000	–	–	–	–	–
400	83 000	101 000	–	–	101 000	119 000	132 000	–	–	202 000	–
500	104 000	126 000	–	–	126 000	148 000	165 000	–	–	252 000	–
630	–	159 000	187 000	–	–	187 000	208 000	282 000	–	318 000	388 000
710	–	178 000	211 000	235 000	–	–	235 000	318 000	398 000	358 000	437 000
800	–	201 000	237 000	264 000	–	–	264 000	358 000	448 000	403 000	493 000
900	–	–	267 000	297 000	–	–	297 000	403 000	504 000	454 000	554 000
1000	–	–	297 000	330 000	–	–	330 000	448 000	560 000	504 000	616 000
1120	–	–	–	–	–	–	–	502 000	627 000	–	–
1250	–	–	–	–	–	–	–	560 000	700 000	–	–

Running surface profiles of crane wheels and correlation of crane rails to wheel-diameter

DIN 15 072



Crane wheels with wheel flange



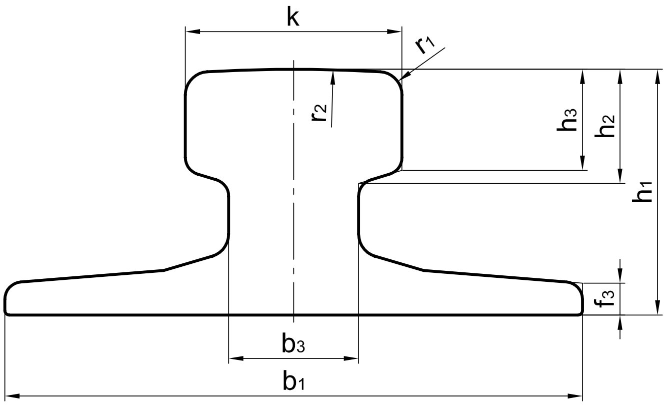
Crane wheels without wheel flange

Crane wheel-Ø d_1	d_2	for crane wheels with narrow wheel flange						for crane wheels with broad wheel flange							for crane wheels without wheel flange		
		for crane rail[1]				b_1	b_2	for crane rail[1]					b_1	b_2	for crane rail[2]		b_2
		A 45	A 55	A 65	A 75			A 55	A 65	A 75	A 100	A 120			F 100	F 120	
h9		k				max.		k					max.		k		
200	230	45	–	–	–	55	90	–	–	–	–	–	–	–	–	–	–
250	280	45	–	–	–	55	90	–	–	–	–	–	–	–	–	–	–
315	350	45	–	–	–	55	90	55	–	–	–	–	65	110	–	–	–
400	440	45	55	–	–	65	110	55	65	75	–	–	90	140	100	–	140
500	540	45	55	–	–	65	110	55	65	75	–	–	90	140	100	–	140
630	680	–	55	65	–	75	120	–	65	75	100	–	110	160	100	120	160
710	760	–	–	65	75	90	140	–	–	75	100	120	160	210	100	120	210
800	850	–	–	65	75	90	140	–	–	75	100	120	160	210	100	120	210
900	950	–	–	65	75	90	140	–	–	75	100	120	160	210	–	120	210
1000	1050	–	–	65	75	90	140	–	–	75	100	120	160	210	–	120	210
1120	1180	–	–	–	–	–	–	–	–	–	100	120	160	220	–	–	–
1250	1310	–	–	–	–	–	–	–	–	–	100	120	160	220	–	–	–
r_1		4	5	6	8	–	–	5	6	8	10	10	–	–	5	5	–

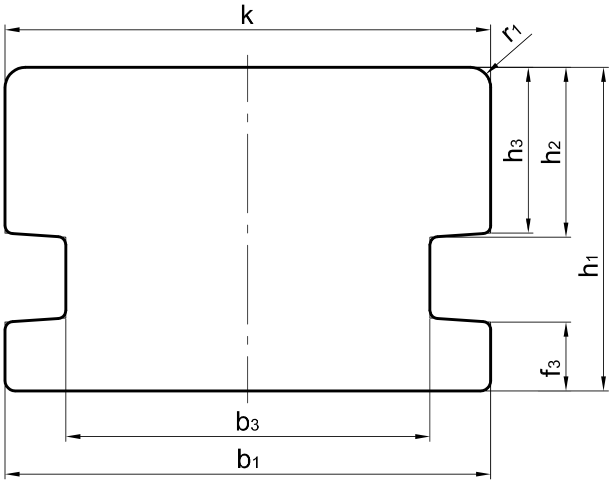
1) Crane rail acc. to DIN 536-1.
2) Crane rail acc. to DIN 536-2.

Champignon rail acc. to DIN 536

main dimensions for information, dimensions can vary depending on the producer



Crane rail Form A



Crane rail Form F

nominal size	k	b_1	b_3	h_1	h_2	h_3	f_3	r_1	r_2	ideal effective rail head width $k-2r_1$ (acc. to DIN 15 070)
A 45	45	125	24	55	24	20	8	4	400	37
A 55	55	150	31	65	28,5	25	9	5	400	45
A 65	65	175	38	75	34	30	10	6	400	53
A 75	75	200	45	85	39,5	35	11	8	500	59
A 100	100	200	60	95	45,5	40	12	10	500	80
A 120	120	220	72	105	55,5	47,5	14	10	600	100
A 150	150	220	80	150	64,5	50	14	10	800	130
F 100	100	100	70	80	42	41	17	5	–	90
F 120	120	120	90	80	42	41	17	5	–	110