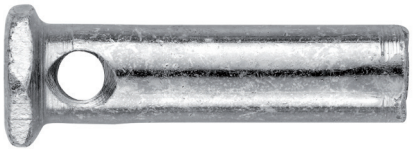
EF ELEPHANT FEET FERRULE

PRODUCT FEATURES

- Stress-free anchoring close to edge and reduced anchor spacing.
- Cast-in placement eliminates the need of drilling, important when the reinforcing is in the fixing zone.
- Ideal for shallow embedment as the anchor can be tied on the reinforcement for better load distribution over a wider area to become an integral part of the reinforcing structure.
- Suitable for high tension, cracked concrete zone areas, pre-tensioning and post tensioning concrete structures.
- High tension and shear load capacities with high tensile steel grade bolts.
- Cross bar creates "ductile" failure behaviour to increase safety.
- Excellent product replacement to cast-in channel for curtain wall fixings.
- Sizes available up to M30.

MATERIAL SPECIFICATIONS

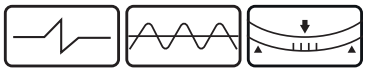
- Hot forged carbon steel; zinc galvanised ≥ 5µm & hot dipped galvanised ≥ 40µm.
- Hot forged stainless steel 304 (A2) & 316 (A4).



SUBSTRATES

- RC concrete C20/25 to C50/60 at maximum according to EN 206-1:2000-12.

LOADING ZONES



BASIC LOADING DATA FOR EF; EF-GH; EF-S & EF-SS

- For static and quasi-static loadings.
- For cracked and non-cracked concrete.
- Only a single anchor is considered.
- No anchor spacing and edge distance influences.
- Concrete compressive strength C20/25 ($f_{ck,cube}$ = 25 N/mm²).

CHARACTERISTIC RESISTANCE [F_{Rk}]

Anchor Size		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
Non-Cracked Concrete												
Tensile Load, N_{Rk}	[kN]	13.5	18.2	26.1	32.3	51.0	35.1	55.5	69.5	92.0	106.2	125.7
Cracked Concrete												
Tensile Load, N_{Rk}	[kN]	9.6	12.9	18.6	23.0	36.4	25.0	39.6	49.5	65.6	75.7	89.6
Shear Load, V_{Rk}	[kN]											
~ Carbon Steel		17.4	25.3	25.3	47.1	47.1	73.5	73.5	105.9	105.9	155.8	155.8
~ Stainless Steel		24.4	35.4	35.4	65.9	65.9	102.9	102.9	148.3	148.3	218.0	218.0

DESIGN RESISTANCE [R_{Rd}]

Anchor Size		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
Non-Cracked Concrete												
Tensile Load, N_{Rd}	[kN]	9.0	12.1	17.4	21.5	34.0	23.4	37.0	46.3	61.3	70.8	83.8
Cracked Concrete												
Tensile Load, N_{Rd}	[kN]	6.4	8.6	12.4	15.3	24.2	16.7	26.4	33.0	43.7	50.5	59.7
Shear Load, V_{Rd}	[kN]											
~ Carbon Steel		13.9	20.2	20.2	37.7	37.7	58.8	58.8	84.7	84.7	124.6	124.6
~ Stainless Steel		15.6	22.7	22.7	42.3	42.3	66.0	66.0	95.0	95.0	139.7	139.7

RECOMMENDED LOAD [F_{Rec}]

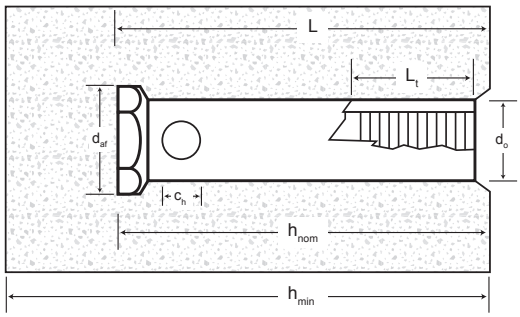
Anchor Size		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
Non-Cracked Concrete												
Tensile Load, N_{Rec}	[kN]	6.4	8.6	12.4	15.4	24.3	16.7	26.4	33.1	43.8	50.6	59.9
Cracked Concrete												
Tensile Load, N_{Rec}	[kN]	4.6	6.2	8.9	10.9	17.3	11.9	18.8	23.6	31.2	36.1	42.7
Shear Load, V_{Rec}	[kN]											
~ Carbon Steel		9.9	14.5	14.5	26.9	26.9	42.0	42.0	60.5	60.5	89.0	89.0
~ Stainless Steel		11.2	16.2	16.2	30.2	30.2	47.1	47.1	67.9	67.9	99.8	99.8

EF ELEPHANT FEET FERRULE

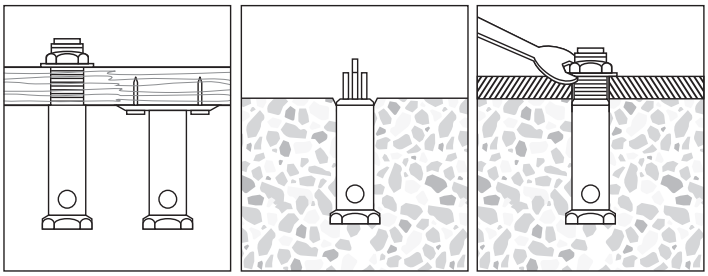
SETTING DETAILS

ANCHOR SIZE		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
Anchor Length, L	[mm]	45	55	70	70	95	70	95	95	120	125	175
Thread Length, L_t	[mm]	20	25	35	35	40	35	40	50	75	50	75
Recommended Torque, T_{inst}	[Nm]	17	30		75		144		250		300	
Embedment Depth, h_{nom}	[mm]	50	60	75	75	100	75	100	100	125	130	180
Effective Anchorage Depth, h_{ef}	[mm]	39	47	62	60	85	60	85	80	105	105	155
Outer Diameter, d_0	[mm]	16	17		22		26		32		42	
Base Diameter, d_{af}	[mm]	19	22		29		32		38		48	
Cross Hole Diameter, C_h	[mm]	9			11				15			
Bar Size At Cross Hole	[mm]	R8			R10				Y12			
Minimum Concrete Thickness, h_{min}	[mm]	70	85	105	105	145	105	145	145	180	160	265
Critical Anchor Spacing, s_{cr}	[mm]	117	141	186	180	255	180	255	240	315	315	465
Minimum Anchor Spacing, s_{min}	[mm]	39	47	62	60	85	60	85	80	105	105	155
Critical Edge Distance, c_{cr}	[mm]	59	71	93	90	128	90	128	120	158	158	233
Minimum Edge Distance, c_{min}	[mm]	39	47	62	60	85	60	85	80	105	105	155

SETTING DIAGRAM



INSTALLATION PROCEDURES



1. Secure firmly the ferrule on the formwork and reinforcing system, if required.
2. Pour the concrete.
3. Upon concrete cured, remove the formwork leaving the ferrule firmly embedded.
4. Attach fixture upon concrete cured.

MECHANICAL PROPERTIES

ANCHOR SIZE		M10	M12	M16	M20	M24	M30
Cross Sectional Area, A_s	[mm²]	58.0	84.3	157.0	245.0	353.0	519.0
Nominal Tensile Strength, f_{uk}	[N/mm²]						
~ Carbon Steel		500	500	500	500	500	500
~ Stainless Steel		700	700	700	700	700	700
Elastic Moment Of Resistance, W_{el}	[mm³]	62.3	109.2	277.5	540.9	935.5	1,668.0
Design Bending Moment, $M_{Rd,s}$	[Nm]						
~ Carbon Steel		29.9	52.4	133.2	259.6	449.0	800.6
~ Stainless Steel		33.5	58.8	149.4	291.3	503.7	898.2

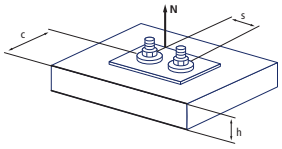
The design bending moment is derived from $M_{Rd,s} = M_{Rk,s} / \gamma_{Ms,N}$ where the partial safety factor is 1.25 for carbon steel and 1.56 for stainless steel. The recommended bending moment is derived from $M_{Rec,s} = M_{Rd,s} / \gamma_F$ where the partial safety factor is 1.4.

TENSION LOAD [N_{Rd}]

Design Tensile Resistance, N_{Rd}: lower value of [$N_{Rd,s}$; $N_{Rd,c}$]

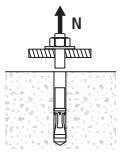
Design Steel Tensile Resistance: $N_{Rd,s}$

Design Concrete Cone / Pull-Out Resistance: $N_{Rd,c} = N^0_{Rd,c} * \Psi_{\beta,N} * \Psi_{s,N} * \Psi_{c,N}$



STEEL TENSILE RESISTANCE [$N_{Rd,s}$]

- For static and quasi-static loadings.
- Only a single anchor is considered.
- For cracked and non-cracked concrete.
- Data valid only for specified steel grade.

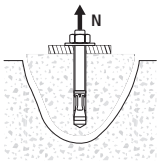


ANCHOR SIZE		M10	M12	M16	M20	M24	M30
$N_{Rd,s}$	[kN]						
~ Carbon Steel		19.3	28.1	52.3	81.7	117.7	173.0
~ Stainless Steel		21.7	31.6	58.8	91.7	132.1	194.3

The design steel tensile resistance is derived from $N_{Rd,s} = N_{Rk,s} / \gamma_{Ms,N}$ where the partial safety factor is 1.5 for carbon steel and 1.87 for stainless steel. The recommended load is derived from $N_{Rec,s} = N_{Rd,s} / \gamma_F$ where the partial safety factor is 1.4.

CONCRETE CONE / PULL-OUT RESISTANCE [$N_{Rd,c}$]

- For static and quasi-static loadings.
- For cracked and non-cracked concrete.
- Only a single anchor is considered.
- No anchor spacing and edge distance influences.
- Concrete compressive strength C20/25 ($f_{ck,cube}$ = 25 N/mm²).
- Loading applicable to both carbon steel and stainless steel anchor.



ANCHOR SIZE		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
h_{ef}	[mm]	39	47	62	60	85	60	85	80	105	105	155
Non-Cracked Concrete												
$N^o_{Rd,c}$	[kN]	9.0	12.1	17.4	21.5	34.0	23.4	37.0	46.3	61.3	70.8	83.8
Cracked Concrete												
$N^o_{Rd,c}$	[kN]	6.4	8.6	12.4	15.3	24.2	16.7	26.4	33.0	43.7	50.5	59.7

The design concrete cone resistance is derived from $N^0_{Rd,c} = N^0_{Rk,c} / \gamma_{Mc,N}$ where the partial safety factor is 1.5. The recommended load is derived from $N^0_{Rec,c} = N^0_{Rd,c} / \gamma_F$ where the partial safety factor is 1.4.

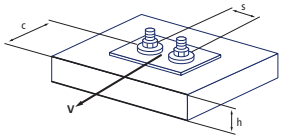
SHEAR LOAD [V_{Rd}]

Design Shear Resistance, V_{Rd}: lower value of [$V_{Rd,s}$; $V_{Rd,c}$; $V_{Rd,cp}$]

Design Steel Shear Resistance: $V_{Rd,s}$

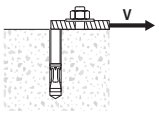
Design Concrete Edge Shear Resistance: $V_{Rd,c} = V^0_{Rd,c} * \Psi_{\beta,V} * \Psi_{\alpha,V} * \Psi_{sc,V}$

Design Concrete Pry-Out Resistance: $V_{Rd,cp} = V^0_{Rd,cp} * \Psi_{\beta,V} * \Psi_{s,N} * \Psi_{c,N}$



STEEL SHEAR RESISTANCE [$V_{Rd,s}$]

- For static and quasi-static loadings.
- Only a single anchor is considered.
- For cracked and non-cracked concrete.
- Data valid only for specified steel grade.

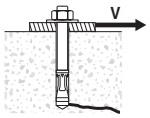


ANCHOR SIZE		M10	M12	M16	M20	M24	M30
$V_{Rd,s}$	[kN]						
~ Carbon Steel		13.9	20.2	37.7	58.8	84.7	124.6
~ Stainless Steel		15.6	22.7	42.3	66.0	95.0	139.7

The design steel shear resistance is derived from $V_{Rd,s} = V_{Rk,s} / \gamma_{Ms,v}$ where the partial safety factor is 1.25 for carbon steel and 1.56 for stainless steel. The recommended load is derived from $V_{Rec,s} = V_{Rd,s} / \gamma_F$ where the partial safety factor is 1.4.

CONCRETE EDGE SHEAR RESISTANCE [$V_{Rd,c}$]

- For cracked and non-cracked concrete.
- Only a single anchor is considered.
- No anchor spacing and edge distance influences.
- Single embedded depth is used for loading tabulation.
- Concrete compressive strength C20/25 ($f_{ck,cube}$ = 25 N/mm²).
- Loading applicable to both carbon steel and stainless steel anchor.

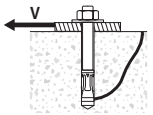


ANCHOR SIZE		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
h_{ef}	[mm]	39	47	62	60	85	60	85	80	105	105	155
c_{min}	[mm]	39	47	62	60	85	60	85	80	105	105	155
Non-Cracked Concrete												
$V^0_{Rd,c}$	[kN]	4.4	6.0	9.1	9.9	16.7	10.7	18.1	18.3	27.6	31.6	56.7
Cracked Concrete												
$V^0_{Rd,c}$	[kN]	3.1	4.3	6.5	7.0	11.8	7.6	12.8	13.0	19.5	22.4	40.1

The design concrete edge shear resistance is derived from $V^0_{Rd,c} = V^0_{Rk,c} / \gamma_{Mc,V}$ where the partial safety factor is 1.5. The recommended load is derived from $V^0_{Rec,c} = V^0_{Rd,c} / \gamma_F$ where the partial safety factor is 1.4.

CONCRETE PRY-OUT RESISTANCE [$V_{Rd,cp}$]

- For cracked and non-cracked concrete.
- Only a single anchor is considered.
- No anchor spacing and edge distance influences.
- Single embedded depth is used for loading tabulation.
- Concrete compressive strength C20/25 ($f_{ck,cube}$ = 25 N/mm²).
- Loading applicable to both carbon steel and stainless steel anchor.



ANCHOR SIZE		M10x45	M12x55	M12x70	M16x70	M16x95	M20x70	M20x95	M24x95	M24x120	M30x125	M30x175
h_{ef}	[mm]	39	47	62	60	85	60	85	80	105	105	155
Non-Cracked Concrete												
$V^0_{Rd,cp}$	[kN]	9.0	12.1	34.8	43.0	68.0	46.8	74.0	92.6	122.6	141.6	167.6
Cracked Concrete												
$V^0_{Rd,cp}$	[kN]	6.4	8.6	24.8	30.7	48.5	33.4	52.8	66.0	87.4	101.0	119.5

The design concrete pry-out resistance is derived from $V^0_{Rd,cp} = V^0_{Rk,cp} / \gamma_{Mp,v}$ where the partial safety factor is 1.5. The recommended load is derived from $V^0_{Rec,cp} = V^0_{Rd,cp} / \gamma_F$ where the partial safety factor is 1.4.

COMBINED TENSION & SHEAR

Combined Tension & Shear: $\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leq 1.2$

The resultant force must be satisfied with the above conditions. The designer must cross check the loading conditions, types of applied loads and substrate to ensure the recommended anchor is applicable to the actual site applications. This would avoid any design faults which commonly caused by inconclusive load requirements with respective to actual site conditions.

INFLUENCING FACTORS - TENSION

INFLUENCE OF CONCRETE STRENGTH ON PULL-OUT AND CONCRETE CONE RESISTANCE [$\Psi_{\beta,N}$]

$$\Psi_{\beta,N} = \sqrt{\frac{f_{ck,cube}}{25}}$$

Limits: 25 MPa $\leq f_{ck,cube} \leq$ 60 MPa

Concrete Strength Designation (ENV 206)		C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 50/60
Concrete Cylinder Strength, $f_{ck,cyl}$	[MPa]	20	25	30	35	40	50
Concrete Cube Strength, $f_{ck,cube}$	[MPa]	25	30	37	45	50	60
Concrete Strength Factor, $\Psi_{\beta,N}$		1.00	1.10	1.22	1.34	1.41	1.55

INFLUENCE OF ANCHOR SPACING [$\psi_{s,N}$]

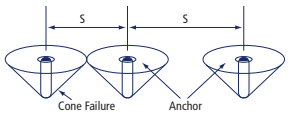
Anchor Spacing 's' [mm]	Effective Depth [mm]							
	39	47	60	62	80	85	105	155
39	0.67							
47	0.70	0.67						
60	0.76	0.71	0.67					
62	0.76	0.72	0.67	0.67				
80	0.84	0.78	0.72	0.72	0.67			
85	0.86	0.80	0.74	0.73	0.68	0.67		
105	0.95	0.87	0.79	0.78	0.72	0.71	0.67	
117	1.00	0.91	0.83	0.81	0.74	0.73	0.69	
141		1.00	0.89	0.88	0.79	0.78	0.72	
155			0.93	0.92	0.82	0.80	0.75	0.67
180			1.00	0.98	0.88	0.85	0.79	0.69
186				1.00	0.89	0.86	0.80	0.70
240					1.00	0.97	0.88	0.76
255						1.00	0.90	0.77
315							1.00	0.84
465								1.00
Critical Spacing 's_{cr}' [mm]	117	141	180	186	240	255	315	465
Minimum Spacing 's_{min}' [mm]	39	47	60	62	80	85	105	155

$$\Psi_{s,N} = 0.5 + \frac{s}{6 * h_{ef}}$$

Limits: $s_{min} \leq s \leq s_{cr}$

$s_{min} = 1.0 * h_{ef}$

$s_{cr} = 3.0 * h_{ef}$



INFLUENCE OF EDGE DISTANCE [$\psi_{c,N}$]

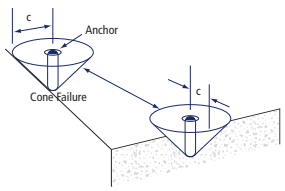
Edge Distance 'c' [mm]	Effective Depth [mm]							
	39	47	60	62	80	85	105	155
39	0.76							
47	0.86	0.76						
59	1.00	0.88						
60		0.89	0.76					
62		0.91	0.78	0.76				
71		1.00	0.85	0.83				
80			0.92	0.90	0.76			
85			0.96	0.93	0.79	0.76		
90			1.00	0.97	0.82	0.79		
93				1.00	0.84	0.80		
105					0.91	0.87	0.76	
120					1.00	0.95	0.83	
128						1.00	0.86	
155							0.98	0.76
158							1.00	0.77
233								1.00
Critical Edge Distance 'c_{cr}' [mm]	59	71	90	93	120	128	158	233
Minimum Edge Distance 'c_{min}' [mm]	39	47	60	62	80	85	105	155

$$\Psi_{c,N} = 0.29 + 0.47 * \frac{c}{h_{ef}}$$

Limits: $c_{min} \leq c \leq c_{cr}$

$c_{min} = 1.0 * h_{ef}$

$c_{cr} = 1.5 * h_{ef}$



INFLUENCING FACTORS - SHEAR

INFLUENCE OF CONCRETE STRENGTH ON CONCRETE EDGE SHEAR AND CONCRETE PRY-OUT RESISTANCE [$\Psi_{\beta,V}$]

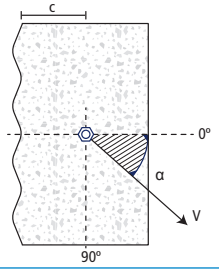
$$\Psi_{\beta,V} = \sqrt{\frac{f_{ck,cube}}{25}}$$

Limits: 25 MPa $\leq f_{ck,cube} \leq$ 60 MPa

Concrete Strength Designation (ENV 206)		C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 50/60
Concrete Cylinder Strength, $f_{ck,cyl}$	[MPa]	20	25	30	35	40	50
Concrete Cube Strength, $f_{ck,cube}$	[MPa]	25	30	37	45	50	60
Concrete Strength Factor, $\Psi_{\beta,V}$		1.00	1.10	1.22	1.34	1.41	1.55

INFLUENCE OF SHEAR LOAD DIRECTION [$\Psi_{\alpha,V}$]

Load Type	Angle, α [°]	$\Psi_{\alpha,V}$
Oblique 0°	0° < α ≤ 15°	1.00
Oblique 30°	15° < α ≤ 37.5°	1.14
Oblique 45°	37.5° < α ≤ 52.5°	1.35
Oblique 60°	52.5° < α ≤ 67.5°	1.71
Oblique 90°	67.5° < α ≤ 90°	2.00

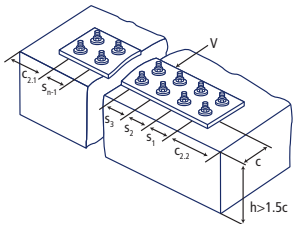


INFLUENCE OF ANCHOR SPACING AND EDGE DISTANCE ON CONCRETE EDGE SHEAR RESISTANCE [$\Psi_{sc,V}$]

$$\Psi_{sc,V} = \frac{c}{c_{min}} * \sqrt{\frac{c}{c_{min}}}$$ for single anchor towards a concrete edge

$$\Psi_{sc,V} = \frac{3c + s}{6c_{min}} * \sqrt{\frac{c}{c_{min}}}$$ for two anchors when $s \leq 3c$

$$\Psi_{sc,V} = \frac{3c + s_1 + s_2 + s_{n-1}}{3nc_{min}} * \sqrt{\frac{c}{c_{min}}}$$ for multiple anchors when s_1 to $s_{n-1} \leq 3c$ and $c_2 \geq 1.5c$



$\Psi_{sc,V}$		c / c_{min} 1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
Edge influence with single anchor		1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00
s / c_{min}	1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
	1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
	2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
	2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
	3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
	3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
	4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
	4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
	5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
	5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
	6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
	6.5							3.24	3.53	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
	7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
	7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
	8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
	8.5											5.05	5.40	5.75	6.10	6.47	6.83
	9.0											5.20	5.55	5.90	6.26	6.63	7.00
	9.5												5.69	6.05	6.42	6.79	7.17
	10.0													6.21	6.58	6.95	7.33
	10.5														6.74	7.12	7.50
	11.0															7.28	7.67
	11.5																7.83
	12.0																8.00