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45501/X/01

BUTTONFIX™ FIXING SYSTEM

STRENGTH TESTING

Sandberg LLP
5 Carpenters Place
Clapham High Street
London SW4 7TD

Tel: 020 7565 7000
Fax: 020 7565 7101
email: mail@sandberg.co.uk
web: www.sandberg.co.uk

SANDBERG

CONSULTING ENGINEERS

INVESTIGATION INSPECTION
MATERIALS TESTING

Sandberg LLP
5 Carpenters Place
London SW4 7TD

Tel: 020 7565 7000
Fax: 020 7565 7101
email: clapham@sandberg.co.uk
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Buttonfix Limited

This report comprises:
3 pages of text
Plates 1 to 4
Appendices A to D

11th April 2012

Partners: N C D Sandberg S M Pringle S C Clarke D J Ellis P Tate A A Willmott R A Rogerson J M Caldon M A Eden J D French
Senior Associates: Dr R M Harris C Morgan G S Mayers R D Easthope J Williamson
Associates: R H Gostomski D Hunt P Sotiropoulos I M Hudson S R P Morris M I Ingle
Consultants: T Carbray Prof F M Burdekin J L Pickering Prof M Grantham

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BUTTONFIX™ FIXING SYSTEM

STRENGTH TESTING

1 INTRODUCTION

Sandberg have tested the Buttonfix™ fixing system for strength, based on typical screw or bolt fixings into an MDF board.

The Buttonfix™ fixing system can be used in four different ways, which are illustrated in Plates 1 through 4. Each of these was tested, first using screw fixings and then using bolt fixings.

1.1 Screw Fixings

For the recessed options the socket and button were each fixed into 18 mm thick MDF using CSK wood screws. For the button these screws were 5.0×25 mm long, and for the socket they were 4.0×20 mm long.

For the face-fixed options the socket was fixed onto 18 mm MDF using 4.0×20 mm round headed wood screws, whilst the button was fixed as for the recessed option.

None of the fixing screws were so long as to pass through the MDF.

The fixings were initially hand-tightened, and then torqued up to 1.5 Nm.

1.2 Bolt Fixings

For the recessed options the socket was fixed into 18 mm thick MDF using M4×30 mm CSK bolts with a single plain washer and nut to the rear.

For the face-fixed options the socket was fixed onto 18 mm thick MDF using M4×30 mm round-headed bolts with a plain washer under the head and a single plain washer and nut to the rear.

For all of these options the button was fixed to 18 mm MDF using a M5×30 mm CSK bolt with a single plain washer and nut to the rear.

The fixings were initially hand-tightened, and then torqued up to 1.5 Nm.

1.3 Loading

The fixings were tested with the test load applied perpendicular to the base unit (fixings in tension), and then with the load applied parallel to the base unit (fixings in shear).

Three fixings were tested in each of the perpendicular and parallel loading directions. New fixings were used for each test.

The peak load was recorded at the moment of failure.

2 RESULTS

2.1 Screw Fixings

The results are summarised in Appendix A. These loads apply to a single Buttonfix™ fixing.

For the parallel and perpendicular loads a lowest expected value has been calculated. This is approximately equal to the mean value less three standard deviations, and therefore represents at least 99% of all fixings. For design purposes we would recommend that a factor of safety of 1.4 is applied to these values.

At least four fixings will typically be used, in a symmetrical two-over-two arrangement. The peak load that can be supported by such a set of four fixings has been calculated as shown in Appendix B. The key dimensions are the vertical separation of the fixings and the distance that the load is applied forward of the fixing plane. We would not recommend that the load is applied further forward of the fixing plane than the vertical separation of the fixings.

The results shown in black in Appendix B are for the situation where the shear load dominates the strength of the fixings. We would recommend that the fixings are used in this region of the charts, where the strength of the fixings is least likely to be affected by the tightness or length of the fixing screws.

The results shown in blue in Appendix B are for the situation where the fixings are likely to fail by direct pull-out of the uppermost fixings. In this region the fixing strength will be affected by the tightness or length of the fixing screws.

2.2 Bolt Fixings

The results are summarised in Appendix C. These loads apply to a single Buttonfix™ fixing.

For the parallel and perpendicular loads a lowest expected value has been calculated. This is approximately equal to the mean value less three standard deviations, and therefore represents at least 99% of all fixings. For design purposes we would recommend that a factor of safety of 1.4 is applied to these values.

At least four fixings will typically be used, in a symmetrical two-over-two arrangement. The peak load that can be supported by such a set of four fixings has been calculated as shown in Appendix D. The key dimensions are the vertical separation of the fixings and the distance that the load is applied forward of the fixing plane. We would not recommend that the load is applied further forward of the fixing plane than the vertical separation of the fixings.

The results shown in black in Appendix D are for the situation where the shear load dominates the strength of the fixings. We would recommend that the fixings are used in this region of the charts, where the strength of the fixings is substantially greater.

The results shown in blue in Appendix D are for the situation where the fixings are likely to fail by direct pull-out of the uppermost fixings.

Buttonfix Limited

for Sandberg LLP

A handwritten signature in blue ink, appearing to read 'RMA', is written over a horizontal blue line. The signature is contained within a light-colored rectangular box.

Dr R M Harris

File reference: 45501x01_rmh_rep.wpd

11th April 2012

PLATES

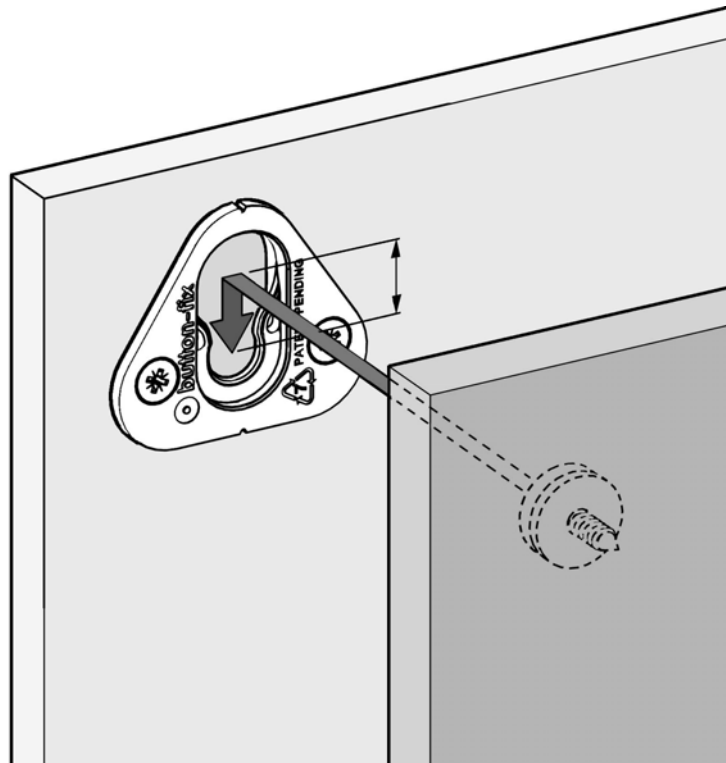


PLATE 1 Buttonfix™ - Recessed Mounting with Vertical Slot

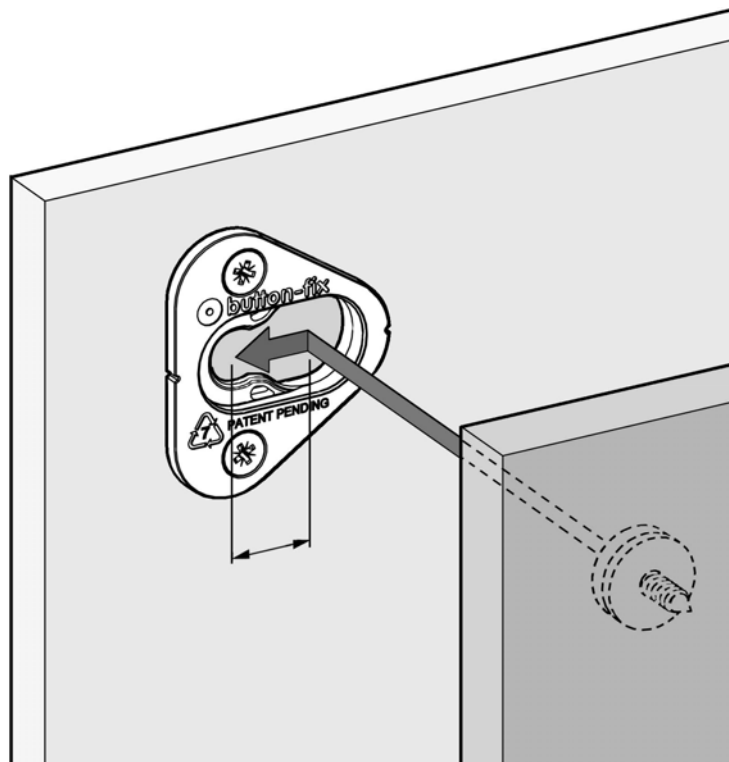


PLATE 2 Buttonfix™ - Recessed Mounting with Horizontal Slot

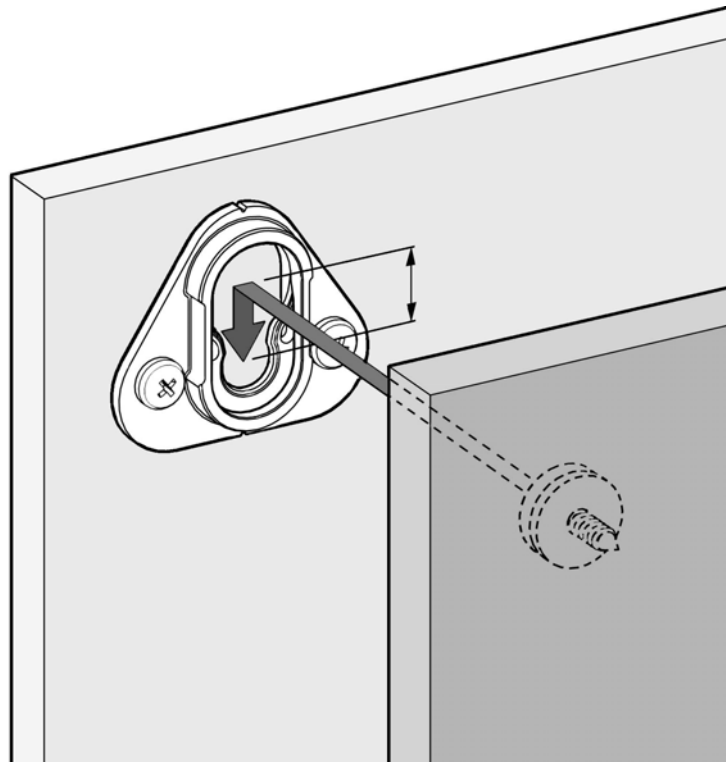


PLATE 3 Buttonfix™ - Face-Fixed Mounting with Vertical Slot

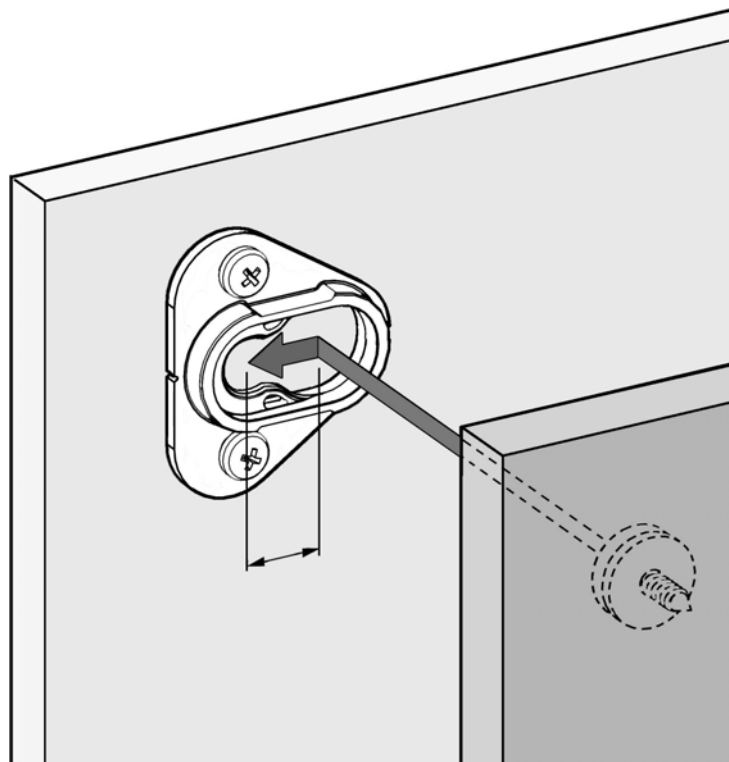


PLATE 4 Buttonfix™ - Face-Fixed Mounting with Horizontal Slot

APPENDIX A

Full Test Results for the Screw-fixed Buttonfix™ Fixing System

Buttonfix	1st series	Screw-fixed	Mounting	Slot	Test	Parallel	Perpendicular
						0°	89°
						kg	kg
Recessed	Vertical	1	180.0	86.7			
		2	219.2	89.7			
		3	201.9	85.7			
		Ave	200.4	87.4			
		SD	19.6	2.1			
		Ave-3SD	141.4	81.1			
		LEV	146.2	81.1			
		Recessed	Horizontal	1	198.8	78.5	
				2	196.8	81.6	
				3	209.0	72.4	
Ave	201.5			77.5			
SD	6.5			4.7			
Ave-3SD	181.9			63.5			
LEV	182.0			63.9			
Face-fixed	Vertical	1	170.3	81.6			
		2	189.7	81.6			
		3	185.6	82.6			
		Ave	181.9	81.9			
		SD	10.2	0.6			
		Ave-3SD	151.2	80.2			
		LEV	151.8	80.1			
Face-fixed	Horizontal	1	172.3	87.7			
		2	178.4	78.5			
		3	174.4	87.7			
		Ave	175.0	84.6			
		SD	3.1	5.3			
		Ave-3SD	165.7	68.7			
		LEV	165.5	69.1			

In all cases the button fixing pulled out of th

All screws secured at 1.5Nm torque

APPENDIX B

Limiting Loads for Pairs of Screw-Fixed Buttonfix™ Fixings in Various Configurations

Buttonfix™ Design Loads in kg for 2x2 Symmetrical Fixing Arrangement

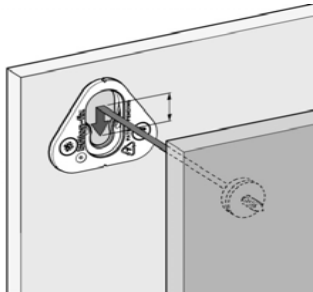
Recessed, vertical slot, screw-fixed into 18 mm MDF

Single fixing strength:

Shear: 146.2 kg

Pull-out: 81.1 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	209	209	154	116						
200	209	209	209	209	116					
300	209	209	209	209	174	116				
400	209	209	209	209	209	154	116			
500	209	209	209	209	209	193	145	116		
600	209	209	209	209	209	209	174	139		
700	209	209	209	209	209	209	203	162		
800	209	209	209	209	209	209	209	185	124	
900	209	209	209	209	209	209	209	209	139	
1000	209	209	209	209	209	209	209	209	154	116
1250	209	209	209	209	209	209	209	209	193	145
1500	209	209	209	209	209	209	209	209	209	174
1750	209	209	209	209	209	209	209	209	209	203

- 1 Button fixed with 5x25 mm CSK wood screw, 1.5 Nm fixing torque
- 2 Socket fixed with 4x20 mm CSK wood screws, 1.5 Nm fixing torque

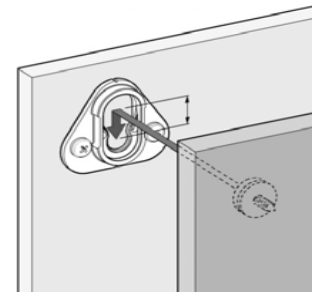
Face-fixed, vertical slot, screw-fixed into 18 mm MDF

Single fixing strength:

Shear: 151.8 kg

Pull-out: 80.1 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	217	217	153	114						
200	217	217	217	217	114					
300	217	217	217	217	172	114				
400	217	217	217	217	217	153	114			
500	217	217	217	217	217	191	143	114		
600	217	217	217	217	217	217	172	137		
700	217	217	217	217	217	217	200	160		
800	217	217	217	217	217	217	217	183	122	
900	217	217	217	217	217	217	217	206	137	
1000	217	217	217	217	217	217	217	217	153	114
1250	217	217	217	217	217	217	217	217	191	143
1500	217	217	217	217	217	217	217	217	217	172
1750	217	217	217	217	217	217	217	217	217	200

- 1 Button fixed with 5x25 mm CSK wood screw, 1.5 Nm fixing torque
- 2 Socket fixed with 4x20 mm round head wood screws, 1.5 Nm fixing torque

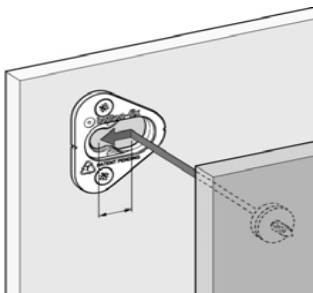
Recessed, horizontal slot, screw-fixed into 18 mm MDF

Single fixing strength:

Shear: 182.0 kg

Pull-out: 63.9 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	260	183	122	91						
200	260	260	243	183	91					
300	260	260	260	260	137	91				
400	260	260	260	260	183	122	91			
500	260	260	260	260	228	152	114	91		
600	260	260	260	260	260	183	137	110		
700	260	260	260	260	260	213	160	128		
800	260	260	260	260	260	243	183	146	97	
900	260	260	260	260	260	260	205	164	110	
1000	260	260	260	260	260	260	228	183	122	91
1250	260	260	260	260	260	260	260	228	152	114
1500	260	260	260	260	260	260	260	260	183	137
1750	260	260	260	260	260	260	260	260	213	160

- 1 Button fixed with 5x25 mm CSK wood screw, 1.5 Nm fixing torque
- 2 Socket fixed with 4x20 mm CSK wood screws, 1.5 Nm fixing torque

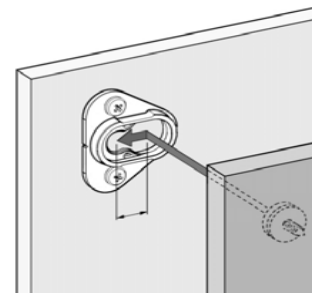
Face-fixed, horizontal slot, screw-fixed into 18 mm MDF

Single fixing strength:

Shear: 165.5 kg

Pull-out: 69.1 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	236	197	132	99						
200	236	236	236	197	99					
300	236	236	236	236	148	99				
400	236	236	236	236	197	132	99			
500	236	236	236	236	236	165	123	99		
600	236	236	236	236	236	197	148	118		
700	236	236	236	236	236	230	173	138		
800	236	236	236	236	236	236	197	158	105	
900	236	236	236	236	236	236	222	178	118	
1000	236	236	236	236	236	236	236	197	132	99
1250	236	236	236	236	236	236	236	236	165	123
1500	236	236	236	236	236	236	236	236	197	148
1750	236	236	236	236	236	236	236	236	230	173

- 1 Button fixed with 5x25 mm CSK wood screw, 1.5 Nm fixing torque
- 2 Socket fixed with 4x20 mm round head wood screws, 1.5 Nm fixing torque

APPENDIX C

Full Test Results for the Bolt-fixed Buttonfix™ Fixing System

Buttonfix 2nd series Bolt-fixed				Parallel	Perpendicular
Mounting	Slot	Test		0°	89°
				kg	kg
Recessed	Vertical	1		409.9	142.7
		2		406.9	140.7
		3		400.7	137.6
		Ave		405.8	140.3
		SD		4.7	2.6
		Ave-3SD		391.8	132.6
		LEV		391.3	132.4
		Recessed	Horizontal	1	
2				388.5	140.7
3				382.4	142.7
Ave				381.0	135.1
SD				8.2	11.5
Ave-3SD				356.3	100.7
LEV				355.8	102.4
Face-fixed	Vertical			1	
		2		288.6	132.5
		3		298.8	142.7
		Ave		295.1	132.5
		SD		5.6	10.2
		Ave-3SD		278.2	101.9
		LEV		277.8	103.7
		Face-fixed	Horizontal	1	
2				209.0	147.8
3				205.0	132.5
Ave				206.7	144.4
SD				2.1	10.6
Ave-3SD				200.4	112.6
LEV				200.2	113.9

With parallel loading either the button or the socket broke

With perpendicular loading either the button slipped out of the socket or the socket broke

All bolts secured at 1.5Nm torque

APPENDIX D

Limiting Loads for Pairs of Bolt-Fixed Buttonfix™ Fixings in Various Configurations

Buttonfix™ Design Loads in kg for 2x2 Symmetrical Fixing Arrangement

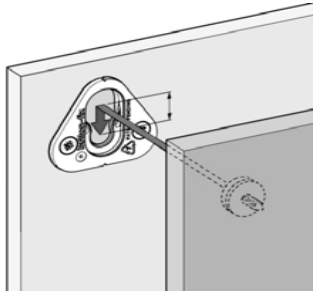
Recessed, vertical slot, bolt-fixed into 18 mm MDF

Single fixing strength:

Shear: 391.3 kg

Pull-out: 132.4 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	559	378	252	189						
200	559	559	504	378	189					
300	559	559	559	559	284	189				
400	559	559	559	559	378	252	189			
500	559	559	559	559	473	315	236	189		
600	559	559	559	559	559	378	284	227		
700	559	559	559	559	559	441	331	265		
800	559	559	559	559	559	504	378	303	202	
900	559	559	559	559	559	559	426	340	227	
1000	559	559	559	559	559	559	473	378	252	189
1250	559	559	559	559	559	559	559	473	315	236
1500	559	559	559	559	559	559	559	559	378	284
1750	559	559	559	559	559	559	559	559	441	331

1 Button fixed with M5x30 mm CSK bolt, 1.5 Nm fixing torque

2 Socket fixed with M4x30 mm CSK bolt, 1.5 Nm fixing torque

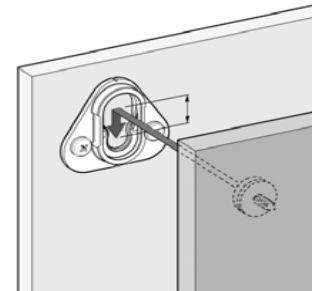
Face-fixed, vertical slot, bolt-fixed into 18 mm MDF

Single fixing strength:

Shear: 277.8 kg

Pull-out: 103.7 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	397	296	198	148						
200	397	397	395	296	148					
300	397	397	397	397	222	148				
400	397	397	397	397	296	198	148			
500	397	397	397	397	370	247	185	148		
600	397	397	397	397	397	296	222	178		
700	397	397	397	397	397	346	259	207		
800	397	397	397	397	397	395	296	237	158	
900	397	397	397	397	397	397	333	267	178	
1000	397	397	397	397	397	397	370	296	198	148
1250	397	397	397	397	397	397	397	370	247	185
1500	397	397	397	397	397	397	397	397	296	222
1750	397	397	397	397	397	397	397	397	346	259

1 Button fixed with M5x30 mm CSK bolt, 1.5 Nm fixing torque

2 Socket fixed with M4x30 mm round head bolt, 1.5 Nm fixing torque

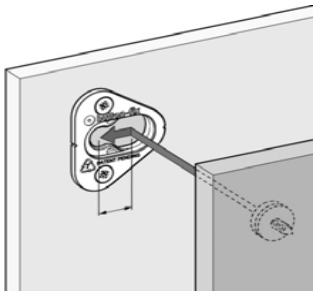
Recessed, horizontal slot, bolt-fixed into 18 mm MDF

Single fixing strength:

Shear: 355.8 kg

Pull-out: 102.4 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	508	293	195	146						
200	508	508	390	293	146					
300	508	508	508	439	219	146				
400	508	508	508	508	293	195	146			
500	508	508	508	508	366	244	183	146		
600	508	508	508	508	439	293	219	176		
700	508	508	508	508	508	341	256	205		
800	508	508	508	508	508	390	293	234	156	
900	508	508	508	508	508	439	329	263	176	
1000	508	508	508	508	508	488	366	293	195	146
1250	508	508	508	508	508	508	457	366	244	183
1500	508	508	508	508	508	508	508	439	293	219
1750	508	508	508	508	508	508	508	508	341	256

1 Button fixed with M5x30 mm CSK bolt, 1.5 Nm fixing torque

2 Socket fixed with M4x30 mm CSK bolt, 1.5 Nm fixing torque

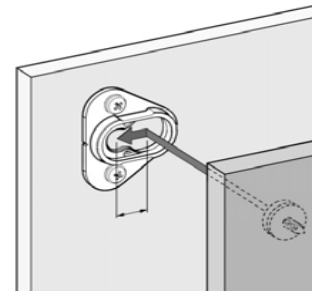
Face-fixed, horizontal slot, bolt-fixed into 18 mm MDF

Single fixing strength:

Shear: 200.2 kg

Pull-out: 113.9 kg

Safety factor: 1.4 -



Vertical Spacing [mm]	Load Offset - Cantilever [mm]									
	25	50	75	100	200	300	400	500	750	1000
100	286	286	217	163						
200	286	286	286	286	163					
300	286	286	286	286	244	163				
400	286	286	286	286	286	217	163			
500	286	286	286	286	286	271	203	163		
600	286	286	286	286	286	286	244	195		
700	286	286	286	286	286	286	285	228		
800	286	286	286	286	286	286	286	260	174	
900	286	286	286	286	286	286	286	286	195	
1000	286	286	286	286	286	286	286	286	217	163
1250	286	286	286	286	286	286	286	286	271	203
1500	286	286	286	286	286	286	286	286	286	244
1750	286	286	286	286	286	286	286	286	286	285

1 Button fixed with M5x30 mm CSK bolt, 1.5 Nm fixing torque

2 Socket fixed with M4x30 mm round head bolt, 1.5 Nm fixing torque

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Where our involvement consists exclusively of testing samples, the results and our conclusions relate only to the samples tested.