TS-324™ Engineering Properties

The material in this document is intended for general information only. Any use of this material in relation to any specific application should be determined of suitability for the application by professionally qualified design personnel. Those making use of or relying upon the material assume all risks and liability arising from such use or reliance.

Building Research Systems shall not be responsible for damage or failure due to misapplication or improper design.

Appropriate Design Documents To be Used In Conjunction With This Data:

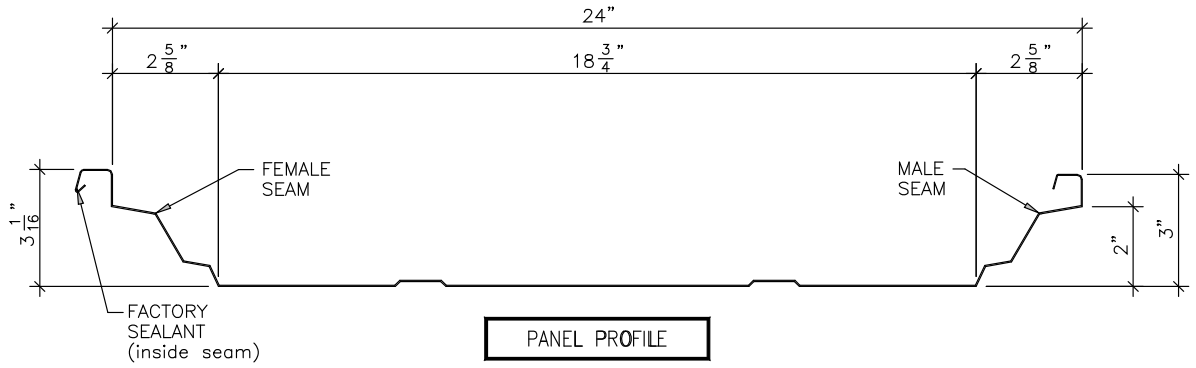
- International Building Code (IBC) and Local Amendments, Latest Adopted Edition for Building Site.
- ASCE 7, Latest Edition.
- MBMA Metal Building Systems Manual, Latest Edition.
- MBMA Metal Roofing Systems Design Manual, Latest Edition.
- MBMA Metal Roofing Systems Performance Guide Specification, Latest Edition
- AISI North American Specification for the Design of Cold-Formed Steel Structural Members (AISI S100), Latest Edition.
- AISI North American Specification for A Design Guide for Standing Seam Roof Panels, Latest Edition.
- Factory Mutual® FM 1-28, Latest Edition, and relevant assemblies (when required)
- Underwriters Laboratories® constructions, Latest Edition (when required)

The TS-324 panel is developed to function as a system when appropriately designed using the tested clips, High Capacity Rake Starter Plate, High Capacity Rake plate, High Capacity Eave Plate, and the Superior Seam Technology Architectural Details. The resistance capacity can be varied over a roof plane through clip and seam type selection by uplift zone. It is the designer's responsibility to calculate the design loads and specify the appropriate clips and seams to resist the required loading. Please contact BRS if you need assistance with the material contained within this document.

Material contained in the document subject to change without notice. Check website for latest data.

4.0 Engineering Properties - Section Properties and Load span Tables

4.1 *"TS-324"* Panel Profile



4.2 Section Properties

Gauge	Thickness in.	Weight psf	Yield Stress ksi	Allowable Shear kips/ft	Top in Compression (Positive Bending)			Bottom in Compression (Negative Bending)		
					Ixx in4/ft	Sxx in3/ft	Ma in.kips/ft	Ixx in4/ft	Sxx in3/ft	Ma in.kips/ft
24	0.0221	1.133	50.0	0.97	0.3620	0.1517	4.541	0.1520	0.1066	2.310
22	0.0275	1.406	50.0	1.34	0.4475	0.1879	5.626	0.1965	0.1336	3.088

Notes on Section Properties:

* Section properties and allowables are calculated in accordance with North American Specification for the Design of Cold-Formed Steel Structural Members (2016 Edition & 2018 Supplement)
* Design Thickness is bare steel thickness.
* I +/- is for deflection determination, S +/- is for bending determination & Ma is allowable bending moment.
* Ma is allowable bending moment and Va is allowable shear.
* All values are for one foot of panel width.
* Minimum deliverable bare steel thickness should not be less than 0.95 of design thickness.

Web Crippling:

24 gauge: Allowable intermediate bearing at 2.5" = 0.613 kips/ft
Allowable end bearing at 2.5" = 0.393 kips/ft

22 gauge: Allowable intermediate bearing at 2.5" = 0.907 kips/ft
Allowable end bearing at 2.5" = 0.577 kips/ft

*Specified web crippling values are for bare panel only. End bearing assumes panels are fastened to end supports. Ends with inside closures will not web cripple due to closure support. Clip compression capacity as tested in system assembly may govern the interior bearing capacity.

4.3 *"TS-324"* Allowable Gravity Loads - *All Loads in Pounds per Square Foot*

A. **24 Gauge Material** (F_y = 50 ksi)

Allowable Live Loads (lb/ft²)										
Gauge	Span Condition		Span (ft)							
			2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
24	SS	Stress	756.8	484.3	336.3	247.1	189.2	149.5	121.1	84.1
		L/180	3955.2	2025.1	1171.9	738.0	494.4	347.2	253.1	146.5
	DS	Stress	345.1	229.1	162.5	121.0	93.4	74.3	60.4	42.2
		L/180	9519.4	4873.9	2820.6	1776.2	1189.9	835.7	609.2	352.6
	TS	Stress	392.0	262.4	187.1	139.7	108.2	86.1	70.1	49.1
		L/180	7463.7	3821.4	2211.5	1392.7	933.0	655.3	477.7	276.4

B. **22 Gauge Material** (F_y = 50 ksi)

Allowable Live Loads (lb/ft²)										
Gauge	Span Condition		Span (ft)							
			2.0	2.5	3.0	3.5	4.0	4.5	5.0	6.0
22	SS	Stress	937.6	600.1	416.7	306.1	234.4	185.2	150.0	104.2
		L/180	4889.4	2503.3	1448.7	912.3	611.2	429.2	312.9	181.1
	DS	Stress	463.7	307.4	217.8	162.0	125.1	99.4	80.8	56.5
		L/180	11767.7	6025.1	3486.7	2195.7	1471.0	1033.1	753.1	435.8
	TS	Stress	527.3	352.3	250.9	187.2	144.9	115.3	93.9	65.7
		L/180	9226.6	4724.0	2733.8	1721.6	1153.3	810.0	590.5	341.7

Notes on Load Table:

* Allowable load based on stress is the smallest load due to bending, shear and combined bending and shear.
* Allowable load based on deflection limit cannot exceed allowable load based on stress.
* These loads are for panel strength. Frames, purlins, clips, fasteners and all supports must be designed to resist all loads imposed on the panel.
* Allowable uplift loads based on stress have not been increased by 33.33 % for wind uplift.
* Allowable loads for deflection are based on deflection limitation of span/180.
* For roof panels, self-weight of the panel has to be deducted from the allowable inward load to arrive at the actual 'live load' carrying capacity of the panel.
* SS = Simple span, DS = Double Span and TS = Three or more spans

4.4 *"TS-324"* Allowable Wind Uplift Loads - *All Loads in Pounds per Square Foot*

A. **24** Gauge Material (F_y = 50 ksi) with MPS 600 Series or FC 600 Series Clip

RollLok® Seam Test Report: C1672-1

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	104.0	61.1	63.0
2.5		55.6	57.8
3.0		47.2	49.1
3.5		40.4	42.0
4.0		35.4	36.8
4.5		31.4	32.6
5.0	48.5	28.3	29.4

TripleLok® Seam Test Report: C1672-2

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	145.6	85.5	88.2
2.5		78.4	80.8
3.0		71.3	73.6
3.5		61.1	63.0
4.0		53.5	55.2
4.5		47.6	49.1
5.0	72.8	42.8	44.1

QuadLok® Seam Test Report: C1672-3

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	185.5	108.8	112.4
2.5		99.7	103.0
3.0		89.8	92.8
3.5		77.0	79.6
4.0		67.4	69.6
4.5		59.9	61.9
5.0	91.9	53.9	55.7

1. The above tabulated loads are generated from certified ASTM E-1592 testing using BRS's MPS 600 series or FC 600 series clips and **a BRS compliant seamer**. ***These design loads are not valid with other clips or seamers.***
2. Intermediate design loads are interpolated from ultimate test loads.
3. Design loads contain a safety factors calculated per AISI.
4. COE design load contains a 1.65 safety factor per COE 07416 Specification.
5. These load capacities are for the panel itself. Frames, purlins, clips, fasteners, and all supports must be designed to resist all loads imposed by the panel.
6. Allowable wind uplift loads have *not* been increased by 33% as allowed by some codes when wind load controls.
7. This material is subject to change without notice. Contact Building Research Systems for most current values.
8. **MPS 600 Series Clips:** MPS 602, 602-3, 603, 603-3, 607, 608, 605, 609 **FC 600 Series clips**: FC 602, 603, 607, 608, 609

4.4 *"TS-324"* Allowable Wind Uplift Loads (cont.) - *All Loads in Pounds per Square Foot*

B. **22** Gauge Material (F_y = 50 ksi)

RollLok® Seam Test Report: C739

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.5	114.4	57.2	69.3
3.0		52.5	63.6
3.5		47.8	57.9
4.0		42.3	51.3
4.5		37.6	45.6
5.0	67.6	33.8	41.0

TripleLok® Seam Test Report: C596

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.5	119.6	59.8	72.3
3.0		55.6	67.4
3.5		51.5	62.4
4.0		47.3	57.3
4.5		43.2	52.4
5.0	78.0	39.0	47.3

1. The above tabulated loads are generated from certified ASTM E-1592 testing using BRS's MPS 600 series or FC 600 series clips and **a BRS compliant seamer**. ***These design loads are not valid with other clips or seamers.***
2. Intermediate design loads are interpolated from ultimate test loads.
3. Design loads contain a safety factor of 2.0 per AISI.
4. COE design load contains a 1.65 safety factor per COE 07416 Specification.
5. These load capacities are for the panel itself. Frames, purlins, clips, fasteners, and all supports must be designed to resist all loads imposed by the panel.
6. Allowable wind uplift loads have *not* been increased by 33% as allowed by some codes when wind load controls.
7. This material is subject to change without notice. Contact Building Research Systems for most current values.
8. **MPS 600 Series Clips:** MPS 602, 602-3, 603, 603-3, 607, 608, 605, 609 **FC 600 Series clips**: FC 602, 603, 607, 608, 609

4.4 *"TS-324"* Allowable Wind Uplift Loads (cont.) - *All Loads in Pounds per Square Foot*

C. **24** Gauge Material (F_y = 50 ksi) with BA-602-8 or BA-603-8 Clip

TripleLok® Seam Test Report: Interpolated

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	180.5	106.0	109.4
2.5		97.0	100.1
3.0		86.4	89.1
3.5		74.1	76.4
4.0		64.8	66.8
4.5		57.6	59.4
5.0	88.4	51.9	53.6

QuadLok® Seam Test Report: Interpolated

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	246.7	144.8	149.5
2.5		132.2	136.4
3.0		114.4	118.0
3.5		98.1	101.2
4.0		85.8	88.5
4.5		76.3	78.7
5.0	117.0	68.7	70.9

1. The above tabulated loads are generated from certified ASTM E-1592 testing using BRS's BA 602-8 and BA 603-8 clips and **a BRS compliant seamer**. ***These design loads are not valid with other clips or seamers.***
2. Intermediate design loads are interpolated from ultimate test loads.
3. Design loads contain a safety factors calculated per AISI.
4. COE design load contains a 1.65 safety factor per COE 07416 Specification.
5. These load capacities are for the panel itself. Frames, purlins, clips, fasteners, and all supports must be designed to resist all loads imposed by the panel.
6. Allowable wind uplift loads have *not* been increased by 33% as allowed by some codes when wind load controls.
7. This material is subject to change without notice. Contact Building Research Systems for most current values.

4.4 *"TS-324"* Allowable Wind Uplift Loads (cont.) - *All Loads in Pounds per Square Foot*

D. **24** Gauge Material (F_y = 50 ksi) with BA-602-12 or BA-603-12 Clip

TripleLok® Seam Test Report: Interpolated

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	217.6	127.8	131.9
2.5		116.8	120.5
3.0		102.6	105.8
3.5		87.9	90.7
4.0		76.9	79.3
4.5		68.4	70.6
5.0	105.0	61.5	63.6

QuadLok® Seam Test Report: C1417-2

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	312.0	183.3	189.1
2.5		166.8	172.1
3.0		140.7	145.1
3.5		120.6	124.4
4.0		105.5	108.9
4.5		93.8	96.8
5.0	143.8	84.4	87.2

1. The above tabulated loads are generated from certified ASTM E-1592 testing using BRS's BA 602-12 and BA 603-12 clips and a **BRS compliant seamer**. ***These design loads are not valid with other clips or seamers.***
2. Intermediate design loads are interpolated from ultimate test loads.
3. Design loads contain a safety factors calculated per AISI.
4. COE design load contains a 1.65 safety factor per COE 07416 Specification.
5. These load capacities are for the panel itself. Frames, purlins, clips, fasteners, and all supports must be designed to resist all loads imposed by the panel.
6. Allowable wind uplift loads have not been increased by 33% as allowed by some codes when wind load controls.
7. This material is subject to change without notice. Contact Building Research Systems for most current values.

4.4 *"TS-324"* Allowable Wind Uplift Loads (cont.) - *All Loads in Pounds per Square Foot*

E. **24** Gauge Material (F_y = 50 ksi) with BA-602-16 or BA-603-16 Clip

TripleLok® Seam Test Report: C1417-1

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0	254.8	149.7	154.4
2.5		136.6	140.9
3.0		118.7	122.4
3.5		101.7	104.9
4.0		89.0	91.8
4.5		79.1	81.6
5.0	121.7	71.2	73.8

QuadLok® Seam

Span	1592 Test Ultimate Load	1592 Design Load	COE Design Load
2.0			
2.5			
3.0			
3.5			
4.0			
4.5			
5.0			

1. The above tabulated loads are generated from certified ASTM E-1592 testing using BRS's BA 602-16 and BA 603-16 clips and a **BRS compliant seamer**. ***These design loads are not valid with other clips or seamers.***
2. Intermediate design loads are interpolated from ultimate test loads.
3. Design loads contain a safety factors calculated per AISI.
4. COE design load contains a 1.65 safety factor per COE 07416 Specification.
5. These load capacities are for the panel itself. Frames, purlins, clips, fasteners, and all supports must be designed to resist all loads imposed by the panel.
6. Allowable wind uplift loads have not been increased by 33% as allowed by some codes when wind load controls.
7. This material is subject to change without notice. Contact Building Research Systems for most current values.

4.5 *"TS-324"* Clip Data:

Clip		Tab Length (in)	Base		Stand Off (in)	UL	FM
PT #	Type		Std (2 hole)	Stabilizing (4 hole)			
FC 602	1	4 5/16			1/2	X	
FC 603	1	4 5/16			1 1/2	X	
FC 607	1	4 5/16			2	X	
FC 608	1	4 5/16			2 1/2	X	
FC 609	1	4 5/16			3	X	
MPS 602	2	4 5/16		X	1/2	X	X
MPS 603	2	4 5/16		X	1 1/2	X	X
MPS 602-3	3	4 5/16	X		1/2	X	
MPS 603-3	3	4 5/16	X		1 1/2	X	
MPS 607	2	4 5/16			2	X	
MPS 608	2	4 5/16		X	2 1/2	X	
MPS 609	2	4 5/16		X	3	X	
BA 602-8	4	8		X	1/2	X	X
BA 603-8	4	8		X	1 1/2	X	X
BA 602-12	4	12		X	1/2	X	
BA 603-12	4	12		X	1 1/2	X	
BA 602-16	4	16		X	1/2	X	
BA 603-16	4	16		X	1 1/2	X	

1 – Fixed Clip
2 – Purlin Stabilizing
3 – Standard
4 – Wind/Expansion clip

4.6 *"TS-324"* Allowable Panel Run for Various Temperature Differentials:

Clip PT #	Tab Length	Base Holes	Slide One Way	Temp diff 100^0	Temp diff 125^0	Temp diff 150^0
MPS 60X-3	4 5/16	2	1.325	170'	135'	115'
MPS 60X	4 5/16	4	1.625	210'	165'	140'
BA 60X-8	8	4	2.375	305'	245	200'
BA 60X-12	12	4	3.90	500'	410'	340'

Note: Longer slide offsets may require additional secondary framing bracing.

4.7 *"TS-324"* Insulation Thickness and Clip Standoff Guidelines

Building Research Systems has reviewed the recent changes with insulation properties with the addition of higher clip standoffs and now offers the following recommendations for thermal spacer blocks. These are general guidelines, and the roof designer is responsible for choosing the proper clip and thermal block combination based on the insulation densities they are specifying. Under filled cavities can allow roof rumble or foot traffic problems and over filled cavities can cause pan distortion or purlin read through. Over filling the cavity also causes panel module/ coverage to grow due to the panel pan being held above the designed elevation for the respective clip height. This chart was constructed with 1/8" of space per 1" of compressed insulation. Verify with the insulation manufacturer per their density.

TS-324 Open Framing

Insulation Thickness	Standard Stand-offs			Extended Stand-off		
	0" Stand-off[1]	1/2" Stand-off	1 1/2" Stand-off	2" Stand-off[3]	2 1/2" Stand-off[3]	3" Stand-off[3]
No Insulation	Not Required	1/2" Block	Unsuitable	Unsuitable	Unsuitable	Unsuitable
3" insulation	Unsuitable	Not Required	1" Block	Unsuitable	Unsuitable	Unsuitable
4" insulation	Unsuitable	Not Required	3/4" Block	Unsuitable	Unsuitable	Unsuitable
6" insulation	Unsuitable	Unsuitable	1/2" Block	1" Block	Unsuitable	Unsuitable
8" insulation	Unsuitable	Unsuitable	Not Required	3/4" Block	1" Block	Unsuitable
10" insulation[2]	Unsuitable	Unsuitable	Unsuitable	1/2" Block	3/4" Block	1" Block
12" insulation[2]	Unsuitable	Unsuitable	Unsuitable	Not Required	1/2" Block	3/4" Block

1. Available in fixed clip only.
2. Insulation should be slit at clips or combination of 6" faced insulation and 2' wide unfaced batts used.
3. BRS recommends use of module tools during roof panel installation.

TS-324 Over Screw-Down Roof (1 1/4" major ribs)

Insulation Thickness	Extended Stand-off		
	2" Stand-off[3]	2 1/2" Stand-off[3]	3" Stand-off[3]
No Insulation	Unsuitable	Unsuitable	Unsuitable
3" insulation	3/8" block	3/4" block	Unsuitable
4" insulation	not required	5/8" block	1" block
6" insulation	Unsuitable	1/2" block	3/4" block

1. Roof designer required to determine existing roof vapor barrier suitability.

4.8 *"TS-324"* High Capacity Rake and Starter Rake Plate Testing

Report C2178_R1

Test Date:	1.16.2018
Type:	Pull Test
Description:	
Rake Plate	RP-005, RP-015, RP-030 and RP-138
Fastener	(2) 1/4"-14 x 1.25" long SDS with RP-005, RP-015, RP-030
	1/4"-14 x 1.25" long Shoulder SDS with RP-138
Support Thickness	16 ga.

Test	Rake Plate	Ultimate Load (lbs)	Failure Mode
1	RP-005	813	Plate rolled off clip
2	RP-005	790	Plate rolled off clip
3	RP-005	794	Plate rolled off clip
Average		799	
4	RP-015	841	Plate rolled off clip
5	RP-015	824	Plate rolled off clip
6	RP-015	806	Plate rolled off clip
Average		824	
7	RP-030	761	Plate rolled off clip
8	RP-030	818	Plate rolled off clip
9	RP-030	782	Plate rolled off clip
Average		787	

RP-030 Design Example

Ultimate Tested Load = 787#

Fastener/Retainer Clip locations per part = 7

Total load per 10' part = 787 x 7 = 5509#

Design Load = 5509# / s.f. of 1.72 = 3202.9#

3202.9#/10' = 320.3 plf

320.3plf / 1.5' max tributary* = **213.5 psf design load**

*Max Tributary = ½ Panel width + ½ gable trim width

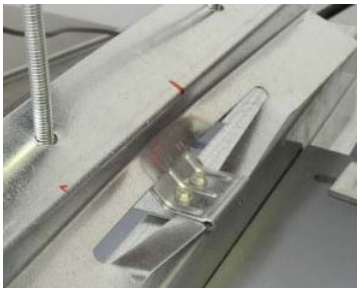


Figure 1- Note part is still attached at deemed failure.

4.9 *"TS-324"* Air and Water Infiltration Testing

ASTM E1680-95 (2003) C1796-1

Test Number	Static Pressure Difference psf	Air Infiltration Rate	
		cfm/ft2	cfm/lin.ft
1	1.57	0.0007	0.0015
2	6.24	0.0018	0.0035
3	30.00	0.0042	0.0083
4	40.00	0.0046	0.0093

ASTM E1646-95 (2003) C1796-1

Test Number	Static Pressure Difference psf	Water Infiltration
1	12	None
2	20	None

Note: All testing done with ***"RollLok®"*** Seam – other seams would have increased performance values.

4.10 Additional Testing Available:

ASTM E 455-16 Diaphragm Shear Strength
C2120-1

ASTM E 1592 Uplift Testing
C1950-1
TS-324 E 1592 A-C Secured Test Report
TS-324 E 1592 D-F Secured Test Report
TS-324 E 1592 I-L Secured Test Report

FM4471 Appendix G *Susceptibility to Leakage Test Procedure for Class 1 Panel Roofs*
201-0254T-09L

FM 4471

UL 90
Constructions No.s 552, 552A, 552B

4.11 Additional Testing Addendums:

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