

Steel Joists, Joist Girders and Steel Deck

Roof Design with Steel Deck

Presented by NUCOR/Vulcraft

With contributions by the Steel Joist Institute

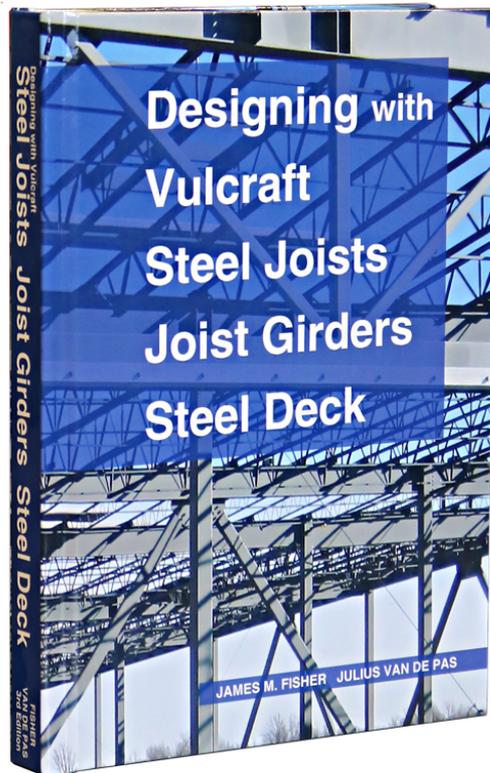
Topics

- Function of Roof Decks
- Roof Deck Types and Properties
- Connections
- Design Example

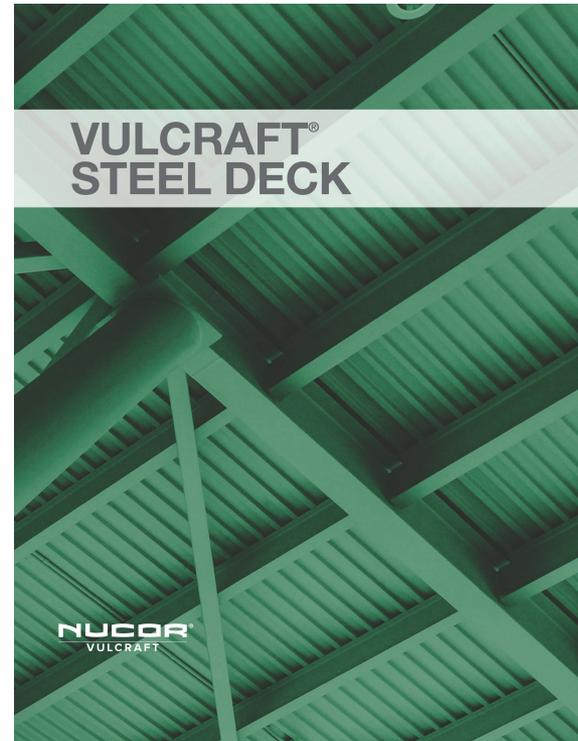


See References

Book and Catalog can be found at: [Vulcraft Literature](#)



Book
Chapter 2



Deck catalog

Roof Decks

- What are roof decks and why do we need them?
 - Roof decks provide a structural member which supports roofing materials
 - Roof decks are used to provide a lateral force resisting system (i.e., diaphragm)
 - Roof decks provide lateral support to their supporting joists
 - Several types of roof deck systems available



Roof Decks

This presentation concentrates on steel decks produced by Vulcraft:

- Steel decks are designed in accordance with the American Iron and Steel Specification, “North American Specification for the Design of Cold-Formed Steel Structural Members”, AISI S100-16.
- Steel decks are used for most steel roof systems to support roofing materials.

Another popular steel roof is a “Standing Seam Roof” (SSR):

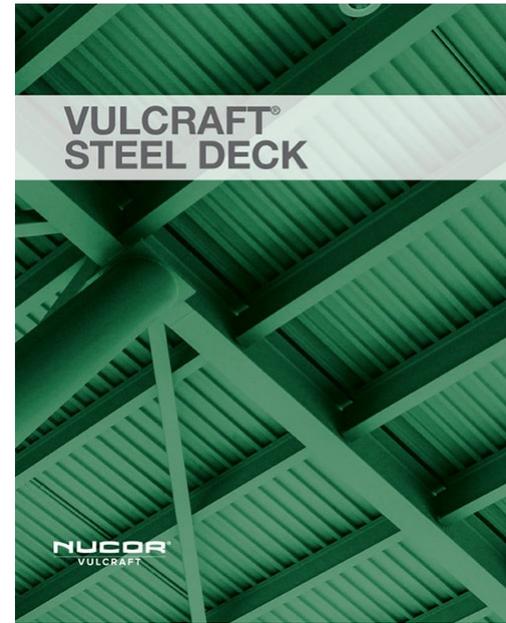
- SSR are used primarily by the Metal Building Industry and are supported by cold formed members.
- SSR have limited strength and stiffness for the lateral support of steel joists. When used with steel joists additional bridging is required to prevent the joists from lateral buckling.



Vulcraft Roof Decks

Reference Vulcraft catalog
(Nucor, 2018a)

[Vulcraft Literature](#)



ROOF DECKS

1.5B ROOF DECKS

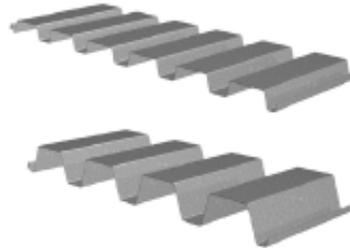
COVER WIDTHS: 30", 36"

GAGES: 24, 22, 20, 19, 18, 16

32" WIDE 3N ROOF DECKS

COVER WIDTH: 32"

GAGES: 22, 20, 19, 18, 16



Use of 1.5B, 22 or 20 gage deck is very common. The 1.5 indicates the rib height of the deck.



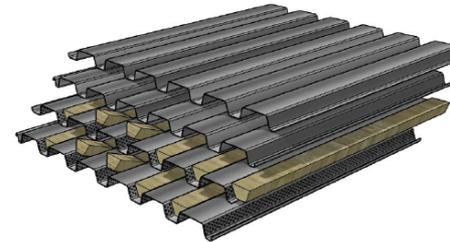
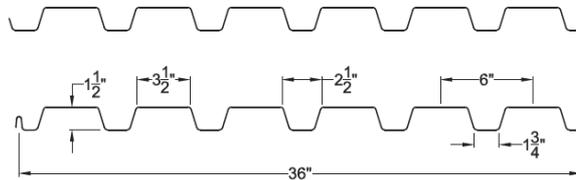
B (WR) Deck Properties

VULCRAFT®

1.5B / 1.5BI / 1.5BA / 1.5BIA ROOF DECK

- Maximum Sheet Length 42'-0"
- Extra charge for lengths under 6'-0"
- ICC ESR-1227
- FM Global Approved

DIMENSIONS



ROOF

SECTION PROPERTIES

Deck Type	Design Thickness (in.)	Deck Weight (psf)	Section Properties					
			I_p (in ⁴ /ft)	S_p (in ³ /ft)	I_n (in ⁴ /ft)	S_n (in ³ /ft)	V_a (lbs/ft)	F_y (ksi)
B24	0.0239	1.46	0.107	0.120	0.135	0.131	2634	60
B22	0.0295	1.78	0.155	0.186	0.183	0.192	1818	33
B20	0.0358	2.14	0.201	0.234	0.222	0.247	2193	33
B19	0.0418	2.49	0.246	0.277	0.260	0.289	2546	33
B18	0.0474	2.82	0.289	0.318	0.295	0.327	2870	33
B16	0.0598	3.54	0.373	0.408	0.373	0.411	3578	33

VULCRAFT®
VULCRAFT/VERCO

Vulcraft Deck Materials and Finishes

MATERIAL

Galvanized fluted decks are formed from either ASTM A653 or A1063 steel. Painted/painted or mill finished (black) uncoated fluted roof decks are formed from either ASTM A1008 or A1039 steel.

Cellular deck sections are fabricated from galvanized steel conforming to ASTM A653 or A1063.

FINISHES

Vulcraft offers a selection of finishes: primer painted over cold-rolled or galvanized, galvanized, or black (uncoated).

Primer painted: Prior to applying a baked-on acrylic medium gray or white primer, the cold-rolled or galvanized sheet is chemically cleaned and pre-treated.

Galvanized: Galvanized decks are supplied from mill coated sheets and are offered in two zinc coated finishes. Coating designation G60 is the standard galvanized material of the deck industry. Coating designation G90 is a heavier, zinc coating often specified for exposed exterior applications or other project specific requirements. Other ASTM A653 galvanized coatings may be available on special request – contact your Vulcraft representative regarding availability.

Designation	Yield Strength (ksi)	Tensile Strength (ksi)
A653 ¹	40 to 80	55 to 82
A1063	60	70
A1008	41.3	49.3
A1039	74.0	87.7

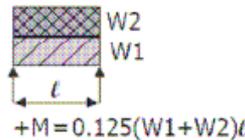
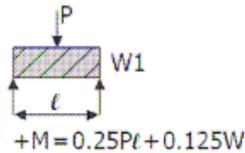
1 Yield and Tensile strengths depend on Class Designation



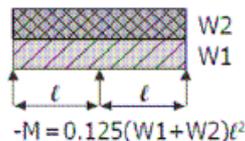
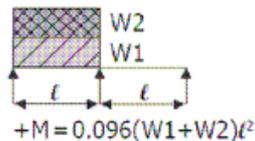
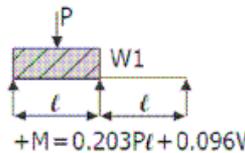
APPENDIX 1

Non-Composite Deck Construction Loading Diagrams

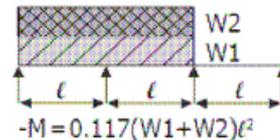
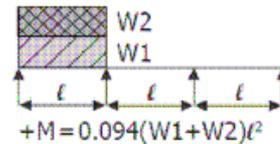
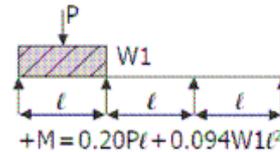
Simple Span Condition



Double Span Condition



Triple Span Condition



Notes:

P = concentrated construction live load (150 lb.)

I = in.⁴/ft. –deck moment of inertia

W1 = slab weight + deck weight

W2 = uniform construction live load (50 psf)

E = 29.5 x 10⁶ psi

l = clear span length (ft.)



Deck Connections

- Deck sheets are connected to the joists (Support fasteners) and to one another (side lap connectors)
- Functions of deck support fasteners:
 - Provide lateral stability to the joists by transferring the stability forces into the deck
 - Provide resistance to uplift forces on the deck
 - Provide strength and stiffness to the roof diaphragm
- Functions of side lap connectors:
 - Prevent the deck sheets from separating
 - Provide added diaphragm strength and stiffness



Deck Connections- Support Fasteners

Fastening to joists:

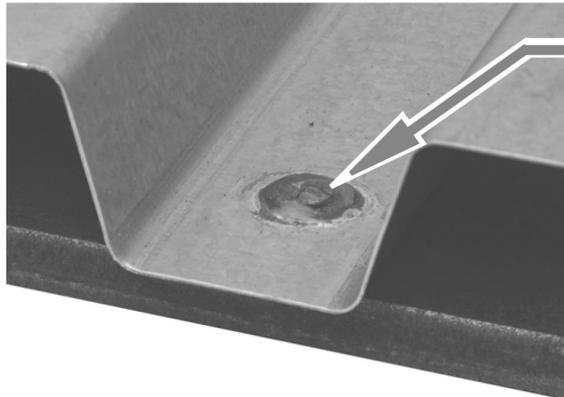
- Arc spot weld / Weld with washer (for $t < 0.028$ in.)
- Screw (self-drilling & self-tapping)
- Power-driven fastener such as Hilti and Pneutek



Deck Connections- Support Fasteners

Fastening to joists:

Why use
Weld
Washers



Arc Spot
Weld

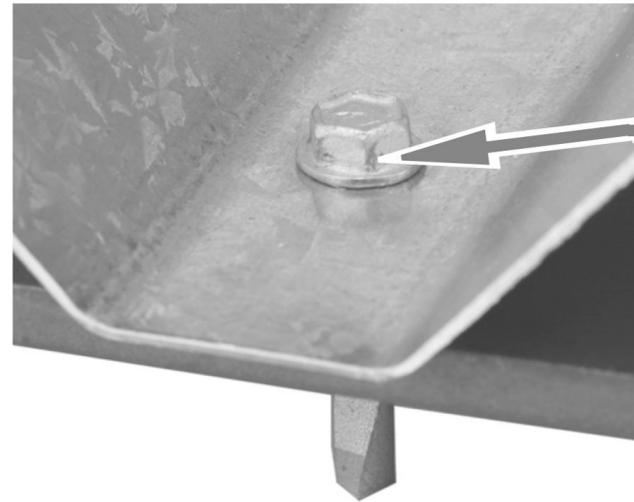
Arc Spot Weld
With washer



Arc Seam
Weld

Deck Connections- Support Fasteners

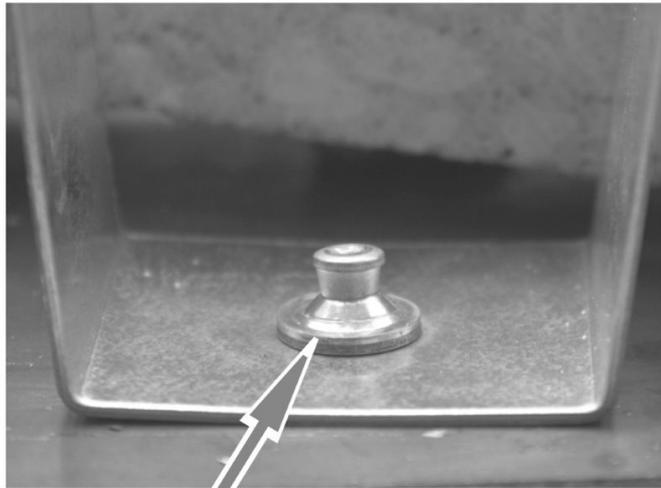
Fastening to joists:



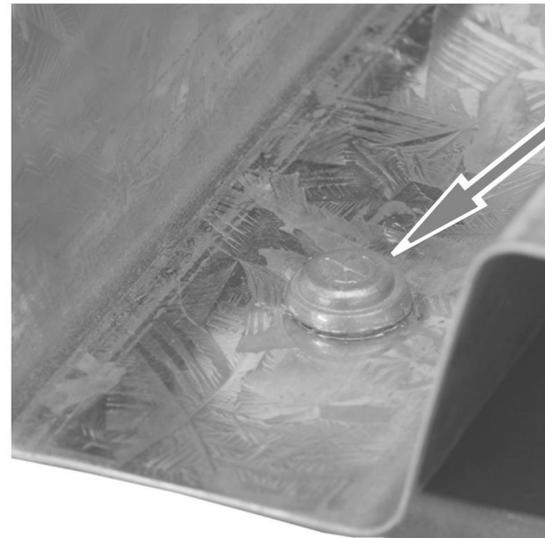
#12
Screw

Deck Connections- Support Fasteners

Fastening to joists:



Hilti X-ENP-19
L15 Fastener



Pneutek
Fastener

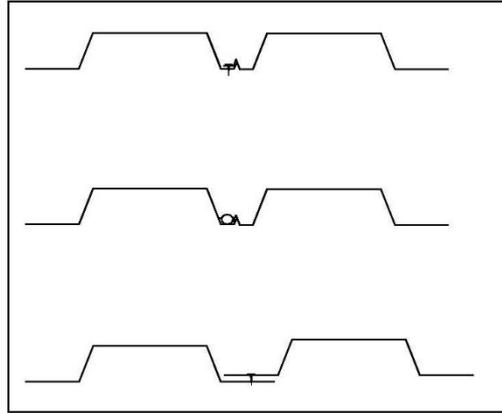
Deck Connections- Support Fasteners

Attachment Patterns 1.5B-36	
36/4	
36/5	
36/7	
36/9	
36/11	
36/14	

Attachment Patterns 3NL-32	
32/3	
32/5	
32/7	
32/10	



Deck Connections- Side-lap Fastening



Number of fasteners per span in the load tables



PunchLok Tool



PunchLok



Steel Deck Example

Select the required thickness for a steel deck:

Given:

1.5B deck

Span = 6.0 ft

Three Span Condition:

Uniform Load = 60 psf

Assumed Uniform Deck Dead Load = 2 psf

Factory Mutual Wind Uplift Rating 1-75



Steel Deck Design Example

Design Procedure:

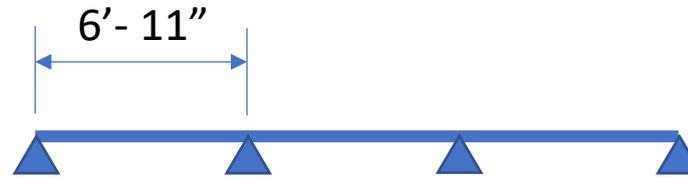
Determine required deck thickness based on:

- Maximum construction spans
 - Steel Deck Institute Requirements
 - FM Global Requirements
- Uniform gravity load strength
- Uplift load strength
- Web crippling strength



Maximum Construction Spans (Steel Deck Institute Requirements)

Recommended Maximum Spans for Constructions and Maintenance Loads Standard 1 1/2" and 3" Roof Deck					
Deck Type	Span Condition	Gage Number	ASD Span (ft-in)	ASD Cantilever Span (ft-in)	
NARROW RIB	Single	NR22	22	2'-11"	0'-10"
		NR20	20	3'-08"	1'-00"
		NR18	18	5'-00"	1'-03"
		NR16	16	6'-05"	1'-07"
	Double or Triple	NR22	22	3'-07"	
		NR20	20	4'-06"	
		NR18	18	6'-02"	
		NR16	16	7'-11"	
INTERMEDIATE RIB	Single	IR22	22	3'-05"	0'-11"
		IR20	20	4'-03"	1'-01"
		IR18	18	5'-10"	1'-06"
		IR16	16	7'-06"	1'-10"
	Double or Triple	IR22	22	4'-03"	
		IR20	20	5'-03"	
		IR18	18	7'-02"	
		IR16	16	9'-03"	
WIDE RIB	Single	WR22	22	5'-08"	1'-06"
		WR20	20	7'-00"	1'-10"
		WR18	18	9'-06"	2'-05"
		WR16	16	12'-02"	3'-00"
	Double or Triple	WR22	22	6'-11"	
		WR20	20	8'-07"	
		WR18	18	11'-08"	
		WR16	16	15'-00"	
DEEP RIB	Single	DR22	22	11'-11"	3'-04"
		DR20	20	15'-04"	4'-02"
		DR18	18	21'-01"	5'-07"
		DR16	16	27'-05"	7'-01"
	Double or Triple	DR22	22	14'-07"	
		DR20	20	18'-11"	
		DR18	18	26'-00"	
		DR16	16	33'-09"	



Three Span Condition

WR22	Double or Triple	22	6'-11"
WR20		20	8'-07"
WR18		18	11'-08"
WR16		16	15'-00"

Note: 22 Gage deck is satisfactory 6.0 ft < 6'-11"

Spans shown are calculated using 33 ksi steel and Allowable Strength Design and considered to be conservative. Longer spans may be permitted by LRFD designs or for higher strength steels. Consult deck manufacturer for further guidance. Refer to the deck manufacturer's catalogs or the SDI Floor Deck Design Manual (FDCM) for construction span table for floor deck.

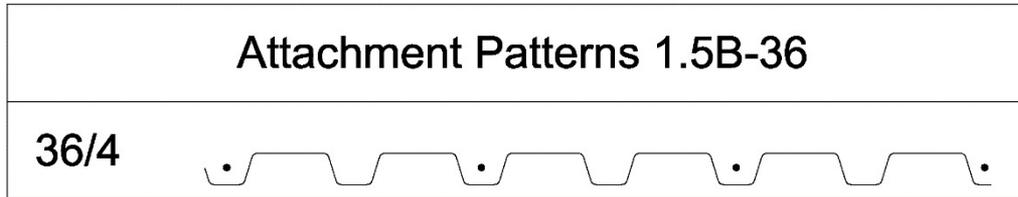
Note: Center to center spans greater than 21 feet exceed rolling lengths for Vulcraft/Vercro deck for the two-span condition.

Table 2.3.1 Steel Deck Institute Recommended Spans

Maximum Construction Spans (FM Global Requirements)

The tables below provide an abbreviated listing of FM approved spans (C-C) for Vulcraft Decks. The complete listing for Vulcraft decks is available at: [Vulcraft Literature](#)

The Engineer of Record must investigate the design, including the deck components and selected attachments, as published by FM Global as found at: [FM Global](#).



ALLOWABLE SPANS (c-c)

No. of Spans	Deck	5/8" Arc Spot Welds @ 36/4			5/8" Arc Spot Welds @ 36/7		
		1-60	1-75	1-90	1-60	1-75	1-90
1	1.5(B,BI)22	6'-1"	6'-1"	6'-1"	6'-1"	6'-1"	6'-1"
	1.5(B,BI)20	6'-8"	6'-8"	6'-8"	6'-8"	6'-8"	6'-8"
	1.5(B,BI)18	7'-9"	7'-9"	7'-9"	7'-9"	7'-9"	7'-9"
	1.5(B,BI)16	8'-8"	8'-8"	8'-8"	8'-8"	8'-8"	8'-8"
2	1.5(B,BI)22	6'-7"	5'-3"	4'-4"	7'-2"	7'-2"	7'-2"
	1.5(B,BI)20	7'-10"	6'-3"	5'-3"	7'-11"	7'-11"	7'-11"
	1.5(B,BI)18	9'-1"	8'-2"	6'-10"	9'-1"	9'-1"	9'-1"
	1.5(B,BI)16	10'-3"	10'-1"	8'-5"	10'-3"	10'-3"	10'-3"
3	1.5(B,BI)22	7'-2"	6'-7"	5'-5"	7'-2"	7'-2"	7'-2"
	1.5(B,BI)20	7'-11"	7'-10"	6'-7"	7'-11"	7'-11"	7'-11"
	1.5(B,BI)18	9'-1"	9'-1"	8'-6"	9'-1"	9'-1"	9'-1"
	1.5(B,BI)16	10'-3"	10'-3"	10'-3"	10'-3"	10'-3"	10'-3"

Note: 22 Gage deck is satisfactory 6.0 ft < 6'-7"



Allowable Uniform Loads (1.5 B Deck) From Vulcraft Steel & Floor Deck Manual

VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total Load (psf) / Load Causing Deflection of L/240 or 1 inch (psf)										
			Span (ft-in.) ctr to ctr of supports										
			5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0
1	B24	4'-8	115 / 56	95 / 42	80 / 32	68 / 26	59 / 20	51 / 17	45 / 14	40 / 11	35 / 10	32 / 8	29 / 7
	B22	5'-7	98 / 81	81 / 61	68 / 47	58 / 37	50 / 30	44 / 24	38 / 20	34 / 17	30 / 14	27 / 12	25 / 10
	B20	6'-5	123 / 105	102 / 79	86 / 61	73 / 48	63 / 38	55 / 31	48 / 26	43 / 21	38 / 18	34 / 15	31 / 13
	B19	7'-1	146 / 129	121 / 97	101 / 75	86 / 59	74 / 47	65 / 38	57 / 31	51 / 26	45 / 22	40 / 19	36 / 16
	B18	7'-8	168 / 152	138 / 114	116 / 88	99 / 69	85 / 55	74 / 45	65 / 37	58 / 31	52 / 26	46 / 22	42 / 19
	B16	8'-8	215 / 196	178 / 147	149 / 113	127 / 89	110 / 71	96 / 58	84 / 48	74 / 40	66 / 34	60 / 29	54 / 24
2	B24	5'-10	124 / 153	103 / 115	86 / 88	74 / 70	64 / 56	56 / 45	49 / 37	43 / 31	39 / 26	35 / 22	31 / 19
	B22	6'-11	100 / 213	83 / 160	70 / 124	59 / 97	51 / 78	45 / 63	39 / 52	35 / 43	31 / 37	28 / 31	25 / 27
	B20	7'-9	128 / 267	106 / 201	89 / 155	76 / 122	66 / 97	57 / 79	51 / 65	45 / 54	40 / 46	36 / 39	32 / 33
	B19	8'-5	150 / 320	124 / 240	104 / 185	89 / 145	77 / 116	67 / 95	59 / 78	52 / 65	47 / 55	42 / 47	38 / 40
	B18	9'-1	169 / 369	140 / 277	118 / 213	101 / 168	87 / 134	76 / 109	67 / 90	59 / 75	53 / 63	48 / 54	43 / 46
	B16	10'-3	213 / 471	176 / 354	149 / 273	127 / 214	110 / 172	95 / 140	84 / 115	74 / 96	66 / 81	60 / 69	54 / 59
3	B24	5'-10	154 / 120	128 / 90	108 / 69	92 / 55	79 / 44	69 / 35	61 / 29	54 / 24	48 / 21	43 / 17	39 / 15
	B22	6'-11	124 / 167	103 / 126	87 / 97	74 / 76	64 / 61	56 / 50	49 / 41	43 / 34	39 / 29	35 / 24	31 / 21
	B20	7'-9	159 / 209	132 / 157	111 / 121	95 / 95	82 / 76	72 / 62	63 / 51	56 / 43	50 / 36	45 / 31	40 / 26
	B19	8'-5	186 / 250	154 / 188	130 / 145	111 / 114	96 / 91	84 / 74	74 / 61	65 / 51	58 / 43	52 / 37	47 / 31
	B18	9'-1	210 / 289	174 / 217	147 / 167	126 / 132	108 / 105	95 / 86	83 / 71	74 / 59	66 / 50	59 / 42	54 / 36
	B16	10'-3	264 / 369	219 / 277	185 / 214	158 / 168	136 / 135	119 / 109	105 / 90	93 / 75	83 / 63	74 / 54	67 / 46

Notes:

- 1) Minimum exterior bearing length required is 1.50 inches. Minimum interior bearing length is 3.00 inches. If these minimum lengths are not provided, web crippling must be checked.
- 2) FM Global approved spans available on page 23.

Allowable Uniform Live load = 87 psf > 60 psf 22 gage is ok



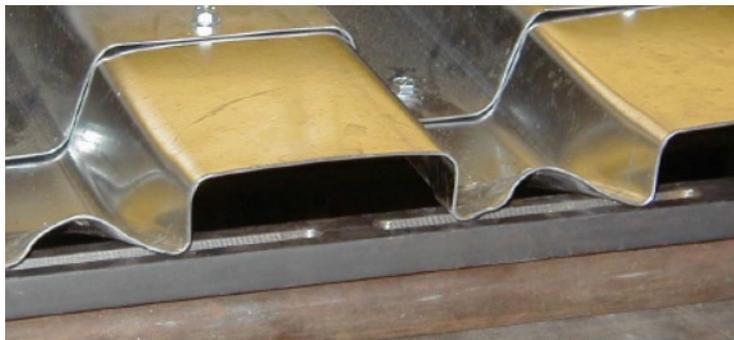
Web Crippling Strength

Definitions:

Web Crippling, Limit state of local failure of web plate in the immediate vicinity of a concentrated load or reaction.

One-flange loading or reaction shall be defined as the condition where the clear distance between the bearing edges of adjacent opposite concentrated *loads* or reactions is equal to or greater than $1.5h$.

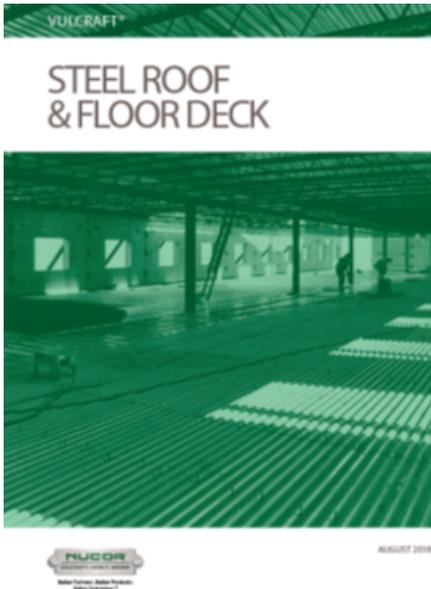
Two-flange loading or reaction shall be defined as the condition where the clear distance between the bearing edges of adjacent opposite concentrated *loads* or reactions is less than $1.5h$.



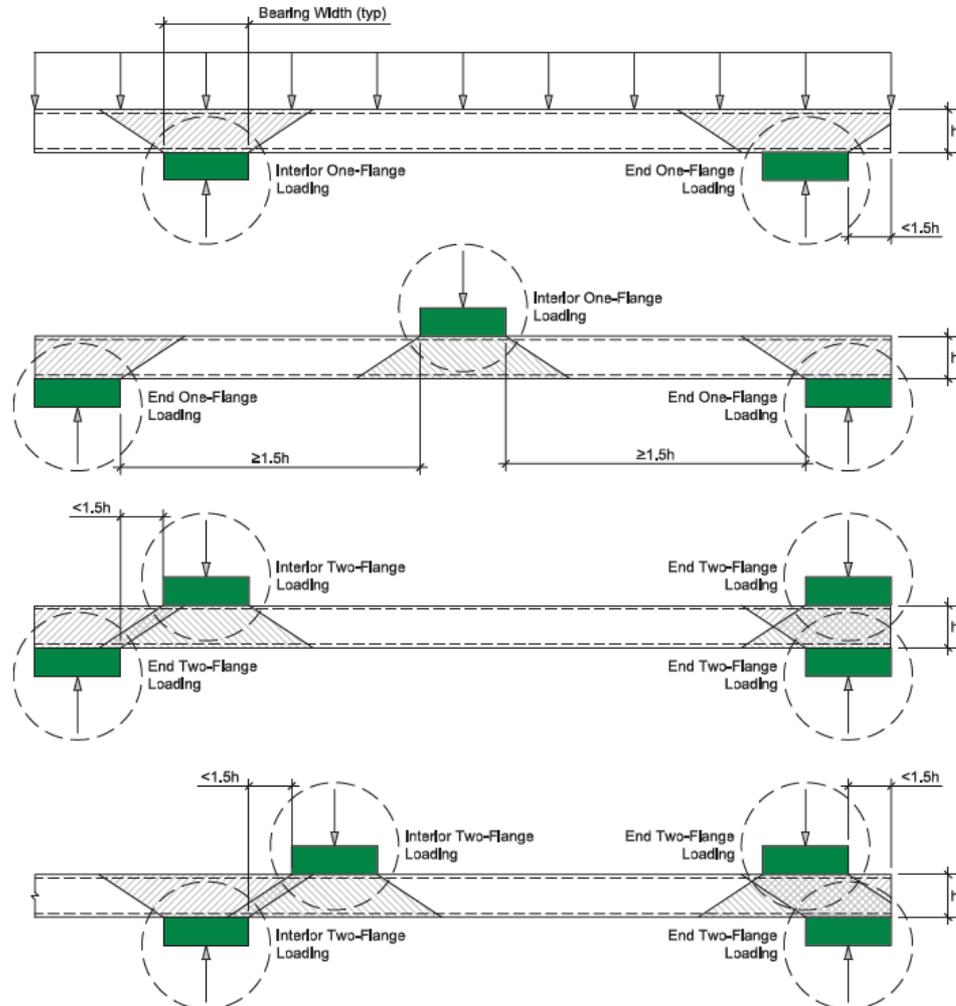
Web Crippling Strength

[Vulcraft Literature](#)

Legacy Literature



Web Crippling: One vs. Two Flange Loading



Reactions for Web Crippling Check

Determine maximum reactions for web crippling¹:

Uniform dead load:

$$\text{Exterior Reaction} = 0.400wL = (0.400)(2 \text{ psf})(6.0 \text{ ft}) = 4.8 \text{ lbs.}$$

$$\text{Interior Reaction} = 1.1wL = (1.1)(2 \text{ plf})(6.0 \text{ ft}) = 13.2 \text{ lbs.}$$

Partial span live load:

$$\text{Exterior Reaction} = 0.450wL = (0.450)(60 \text{ plf})(6.0 \text{ ft}) = 162.0 \text{ lbs.}$$

$$\text{Interior Reaction} = 1.2wL = (1.2)(60 \text{ plf})(6.0 \text{ ft}) = 432 \text{ lbs.}$$

Total Reactions:

$$\text{Exterior:} = 4.8 \text{ lbs.} + 162 \text{ lbs} = 166.8 \text{ lbs.}$$

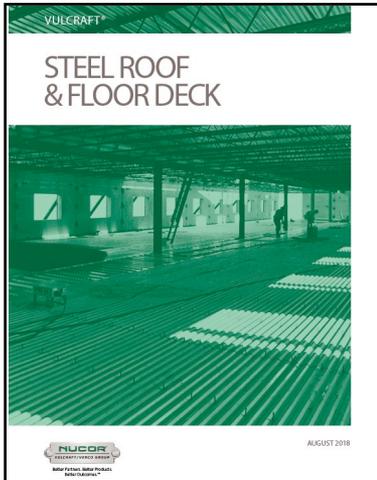
$$\text{Interior} = 13.2 \text{ lbs.} + 432 \text{ lbs.} = 445.2 \text{ lbs.}$$

¹Reaction equations are taken from the AISC Manual Table 3-23

Steel Deck Weight

1.5B-36/1.5BI-36/1.5PLB-36 ROOF DECKS GRADE 50 STEEL

ASD

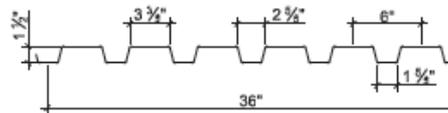


1.5B ROOF DECKS

- 1.5B-36 Deck used with Side-lap Screws
- 1.5BI-36 Deck used with TSWs or BPs
- 1.5PLB-36 Deck used with PunchLok® II System



Nominal Dimensions



Section Properties

Deck Gage	Deck Weight w_{dl} (psf)	Base Metal Thickness t (in.)	Yield Strength F_y (ksi)	Effective Moment of Inertia at Service Load $I_e = (2I_x + I_y)/3$		Effective Section Modulus at $F_y = 50$ ksi		Allowable Moment		Vertical Web Shear V_n/Ω (lb/ft)
				I_{e+} (in ⁴ /ft)	I_{e-} (in ⁴ /ft)	S_{e+} (in ³ /ft)	S_{e-} (in ³ /ft)	$M_n + \Omega$ (lb-ft/ft)	$M_n - \Omega$ (lb-ft/ft)	
22	1.8	0.0295	50	0.155	0.178	0.169	0.179	422	447	2654
20	2.0	0.0358	50	0.197	0.217	0.224	0.229	559	571	3207
19	2.3	0.0418	50	0.239	0.257	0.266	0.278	663	693	3728
18	2.6	0.0474	50	0.277	0.290	0.306	0.318	763	793	4209
16	3.3	0.0598	50	0.364	0.387	0.393	0.402	981	1003	5261

Deck Flange Loading-Vulcraft Design Tools

[Vulcraft Design Tools](#)

Steel Deck Selection

Unit System	Imperial	▼
Design Method	ASD	▼
Deck Options	Roof Deck	▼
Deck Type	1.5B-36	▼
Deck Gage	22	▼
Deck Grade	Grade 50	▼

Web Crippling Bearing Length Table Range

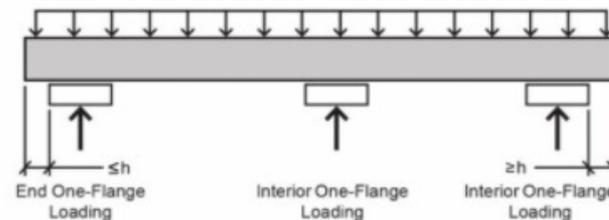
Start Table at Bearing Width (in.)	1.00	≥ 0.75
Table Bearing Width Increment at (in.)	0.50	

22 Gage 1.5B-36 Grade 50

Steel Deck Reaction Allowable Strength



One Flange Loading for Uniform Load



Reaction Allowable Strength at Supports Based on Web Crippling for One Flange Loading, ASD (plf)									
Bearing Width (in.)		1.00	1.50	2.00	2.50	3.00	3.50	3.82	3.82
End	R_n/Ω	712	807	887	958	1021	1080	1115	1115
Interior	R_n/Ω	1086	1208	1310	1400	1482	1557	1602	1602

Web Crippling Strength does not control



Design Results

**Use 1.5 B Deck, 22 Gage
with
5/8" arc spot welds @ 36/4
Use 2 #10 S.L.S.**



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