FORM DQP 2.01-1
LEVEL 1 CHECK PRINT SIGN-OFF SHEET

Client Name:	**Ohio Department of Transportation**
Job Title:	**Cleveland Innerbelt Design-Build Contract**
Job Number:	**CUY-90-14.90**
Document Title:	Delta Girder Catwalk Design

Check Level (Mark One):

- [X] 1A 100% Document Check
- [ ] 1B 100% Input Check

Enter description below:

	Print Name	Signature	Date
[X] Originator	Mark Currie	Mark Currie	4/19/11
[X] Checker	Kyle Berg	KB	4-21-11
[X] Backchecker	Mark Currie	Mark Currie	5/1/11
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Insert an "X" in the box to indicate a required QC activity.

For DELTA GIRDER CATWALK	Job no. 491633	Sheet no. 1
Made by MCL	Checked by KDB	Backchecked by MCL
Date 4/18/11	Date 4-21-11	Date 5/1/11

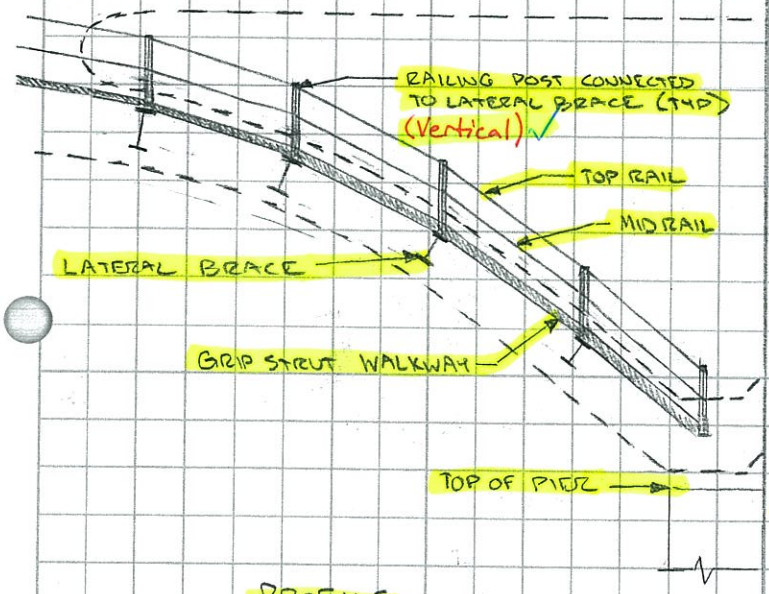
HNTB

DESCRIPTION

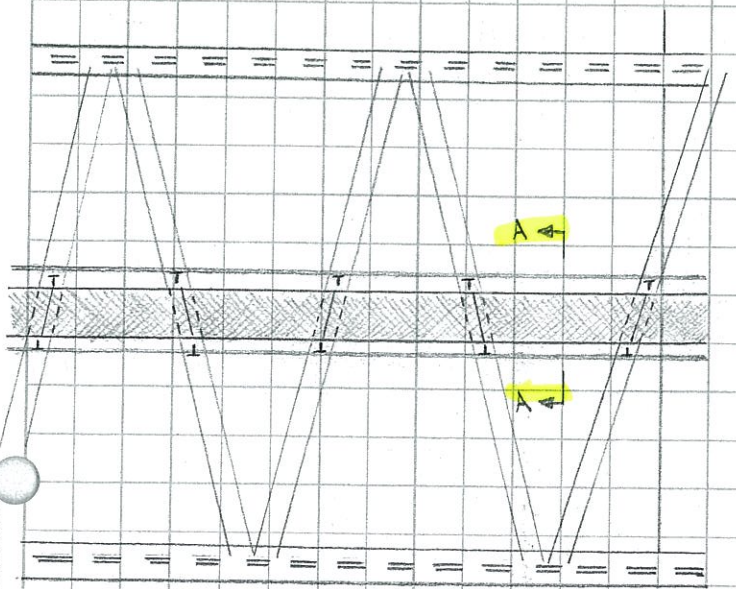
DESIGN CATWALK SYSTEM THAT WILL BE USED IN DELTA GIRDERS

ASSUMPTIONS

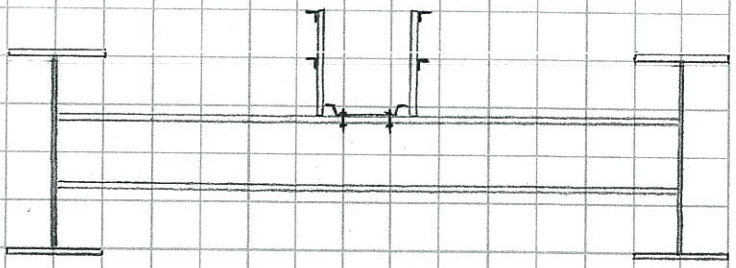
-USE HEAVY DUTY GRIP STRUT WITH 2' WIDE WALKWAY. SINCE KICK PLATE IS A PART OF THE GRIP STRUT, NO ADDITIONAL KICK PLATE SHALL BE PROVIDED.



PROFILE



PLAN



SECTION A-A

* USE SIMILAR DESIGN CHECKS FOR CATWALK COMPONENTS AS WAS USED FOR UPPER CATWALKS (BY DMS)

DEAD LOAD (DL):

$W_{HANDRAILS} = 2(7.17) = 14.34$ PLF (TOP + MID - R
(L3x3x5/16)

*FROM RRG DWG, MAX LATERAL BRACE SPACING IS < 12'. ALL POSTS WILL BE AT LAT BRACE LOCA

GRATING/GRIP STRUT = 17.5 PLF

WT RAILING POST = 3.5'(22.5 PLF) = 80 LB

LIVE LOAD (LL):

2009 Edition

PER AASHTO 3.6.1.6.6, USE 85 PSF FOR PEDESTRIAN LOAD ON CATWALK.

NOTE ON INCLINATION OF WALKWAY

(1910.24e)

PER OSHA REQUIREMENTS, WALKWAY SURFAC INCLINES MUST NOT EXCEED 30° IF NO LADDER IS PROVIDED. FROM CAD DWG.

For DELTA GIRDER CATWALK	Job no. 491633	Sheet no. 2
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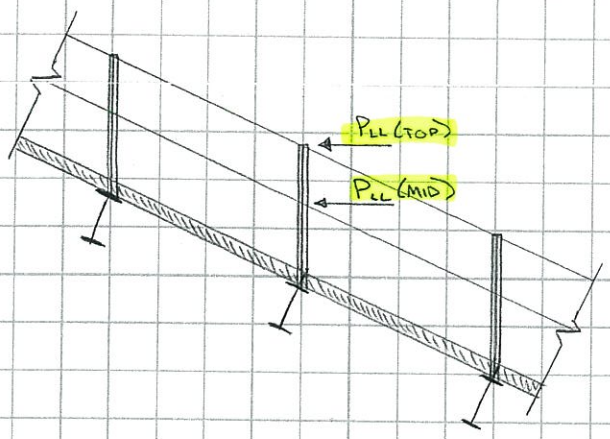
DESIGN CONNECTION BETWEEN RAILING POSTS (WT's) AND LATERAL BRACES



$P_{LL(TOP)} = 200$ LB (OSHA Appendix G to Subpart R - 1926.502) ✓

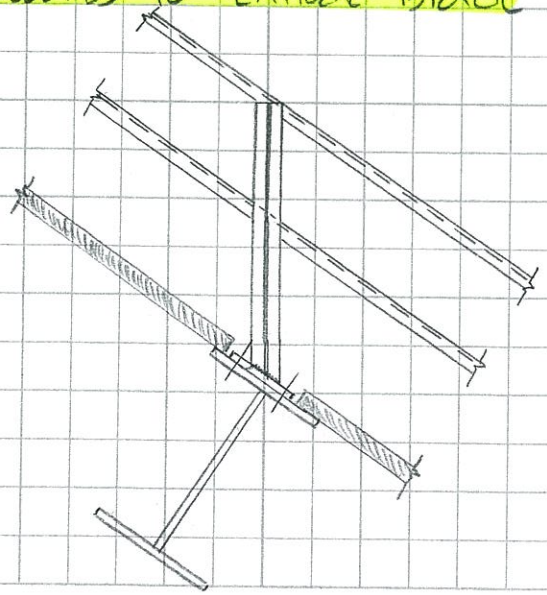
$P_{LL(MID)} = 150$ LB

$P_{u\ TOTAL} = 1.75(200+150) = 612.5$ LB

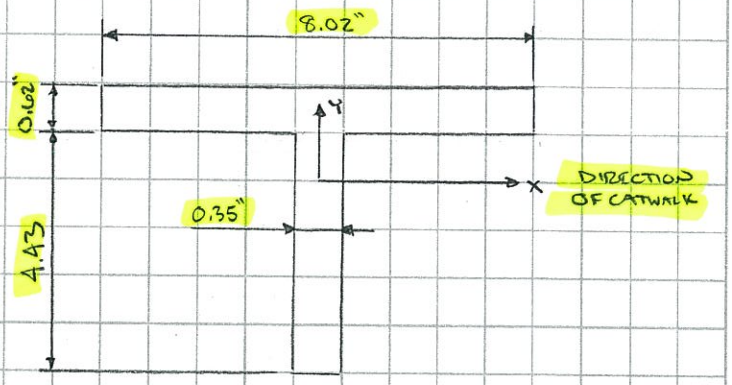
$M_{u TOTAL} = 1.75[1.75(150) + 3.5(200)]$

$= 1684$ LB-FT $= 20.21^{11-K}$

WELD BASE PLATE TO RAILING POSTS AT ANGLE TO MAKE POST VERTICAL. ADD BASE PLATE THAT WILL BE BOLTED TO LATERAL BRACE



WELD DESIGN FOR WT / BASE PLATE



WELD AROUND WT5x22.5

* INCINATION WILL ONLY INCREASE AMOUNT OF WELD

- TRY MIN FILLET WELD = 1/4"

SHEAR (IN DIRECTION OF CATWALK - X)

$R_r = 0.6\,\phi_{ez}\,F_{exx}$ [6.13.3.2.3b-1] ✓

$= 0.6(0.80)(70) = 33.6$ KSI

$V_n = R_r A_e$ [6.13.3.2.4b] ✓

$A_e = 0.707\left(\frac{1}{4}\right)\left(8.02 + (8.02 - 0.35)\right)$

$= 2.77\ IN^2$

$V_n = 33.6(2.77) = 93K >> 612.5$ LB

OK

BY INSPECTION, SHEAR ALSO OK FOR LOADS PERPENDICULAR TO CATWALK.

For DELTA CORRIDOR CATWALK	Job no. 491633	Sheet no. 3
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BENDING

$$\bar{Y} = \frac{2(4.43)(4.43/2) + (8.02-0.35)(4.43) + 8.02(5.05)}{2(4.43) + (8.02-0.35) + 8.02}$$

$= 3.83"$ FROM BASE OF STEM

$$I_x = \frac{2(4.43)^3}{12} + 2(4.43)(3.83 - 4.43/2)^2 + (8.02-0.35)(4.43-3.83)^2 + 8.02(5.05-3.83)^2$$

$= 52.30\ w^3$

$$I_y = \frac{2(8.02)^3}{12} - \frac{(0.35)^3}{12} + 2(4.43)\left(\frac{0.35}{2}\right)^2$$

$= 86.24\ w^3$

$$\frac{M_y}{I_x} = \frac{20.21(5.05-3.83)}{52.30} = 0.47\ ^k/_w$$

$$\frac{M_x}{I_y} = \frac{20.21(8.02/2)}{86.24} = 0.93\ ^k/_w$$

$$\text{MAX SHEAR} = \frac{612.5\ \text{LB}}{2(4.43)+2(8.02)-0.35} = 25\ ^{LB}/_w$$

(SMALL) ∴ NEGLECT

$$V_n = 0.6\,\phi_{ez}\,F_{exx}\,t_e$$

$= 0.6(0.80)(70)(0.707)(0.25) = 5.94\ ^k/_w$

$5.94\ ^k/_w > 0.93\ ^k/_w$ ∴ OK

USE 1/4" FILLET WELD ALL-AROUND WT5×22.5

DESIGN BOLTED CONNECTION BETWEEN BASE PLATE AND TOP FLANGE OF LATERAL BRACE.

TRY 4 - 5/8" ϕ A325 BOLTS WITH MIN CENTER-TO-CENTER SPACING OF 4" IN BOTH DIRECTIONS.

BOLT SHEAR

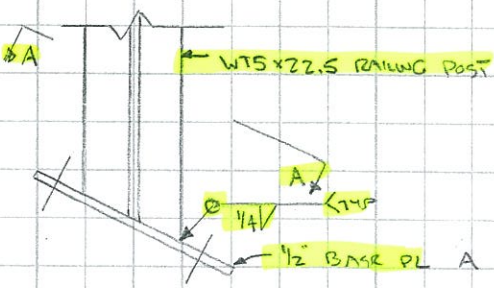
612.5 LB / 4 BOLTS IS NEGLIGIBLE ∴ SAY O

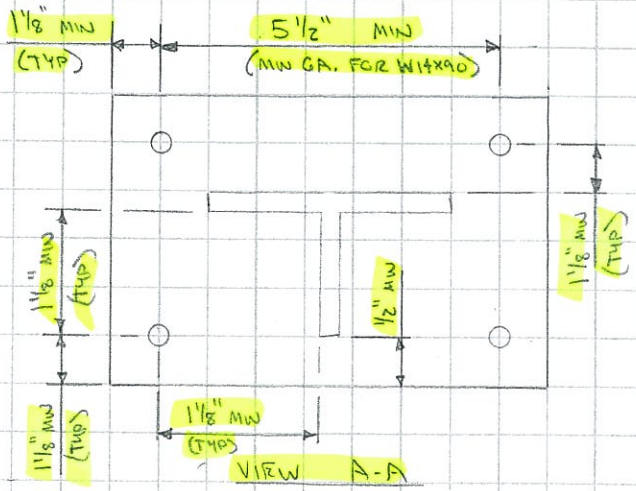
MOMENT

COUPLE FORCES $20.21^{"\text{-}k}/(4"\times 2\ \text{BOLTS}) = 2.52^k$

2.52 K (T) << MIN PRETENSION FOR A32

USE 5/8" ϕA325 BOLTS TO CONNECT RAILING POST BASE PLATE TO TOP FLANGE OF LATERAL BRACE.





*DIMENSIONS WILL CHANGE WITH SLOPE

For DELTA GIRDER CATWALK	Job no. 49633	Sheet no. 4
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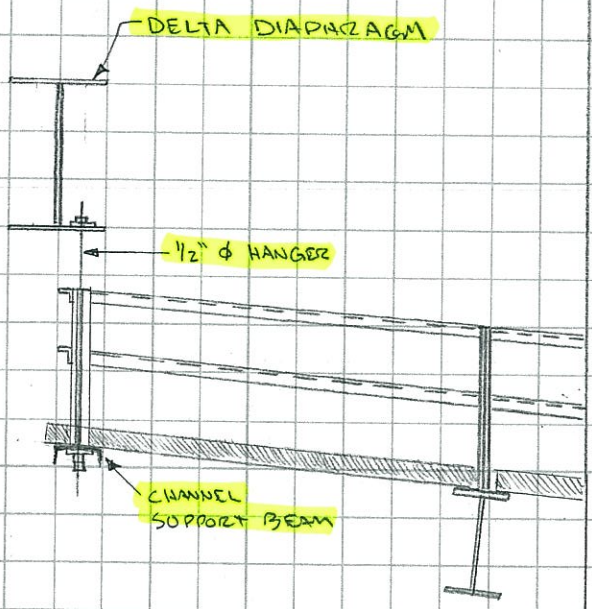
DESIGN SUPPORT FOR CATWALK AT DELTA DIAPHRAGM, AS NO LATERAL BRACE WILL BE PRESENT

-USE 1/2" ϕ HANGER RODS WITH CROSS-MEMBER TO SUPPORT CATWALK.



PROFILE

LOADS TO HANGERS

-ASSUME LARGEST POSSIBLE CLEAR SPAN FOR CAT WALK OF 13' FOR LOADS.

$P_{ANGLES} = 14.34(13) = 187$ LB ← Assumes Full Length DL to Hanger ✓

$P_{GRATING} = 17.5(13)/2 = 114$ LB

$P_{POST} = 22.5(3.5'\text{TALL}) = 80$ LB

$P_{X\text{-BRACE}}$ (SUPPORT BEAM ✓) $= 10\ PLF(5'/2) = 25$ LB (C10x25 ✓)

$P_{DL} = 187 + 114 + 80 + 25 + 10\%\ \text{MISC.}$

$= 450$ LB / HANGER

$P_{LL} = 85\ PSF(13')\left(\frac{2'}{2\ \text{HANGERS}}\right) = 1105$ LB

Full Length ✓

$P_u = 1.25(450) + 1.75(1105)$

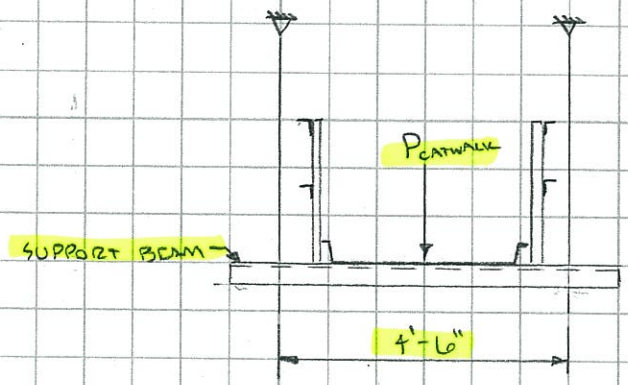
$= 2500$ LB

HANGER TENSILE RESISTANCE

$P_r = \phi_1 F_y A_g = 0.95(36)(0.196) = 6.7$ K

$6.7\text{K} > 2.5\text{K}$ ∴OK

SUPPORT BEAM



ASSUME FULL CATWALK LOAD APPLIED TO CENTER OF SUPPORT BEAM. (CONSERVATIVE

$M = \frac{PL}{4} = \frac{2(2.5\text{K})(54")}{4} = 67.5^{11\text{-K}}$

TRY USING C10x25 FOR SUPPORT BEAM ORIENTED W WEAK AXIS WITH FLANGES POINTING DOWN.

For DELTA GIRDER CATWALK	Job no. 49633	Sheet no. 5
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HNTB

PER AISC (2005) THIS SHAPE HAS COMPACT WEB AND FLANGES (16.1-55)

PER AASHTO 6.12.2.2.5, "FOR CHANNELS IN FLEXURE (WEAK AXIS), NOMINAL FLEXURAL RESISTANCE SHALL BE DETERMINED BY 6.12.2.2.1 AND SHALL NOT EXCEED $1.6 F_y S_y$.

$M_n = M_p = F_y Z_y \leq 1.6 F_y S_y$

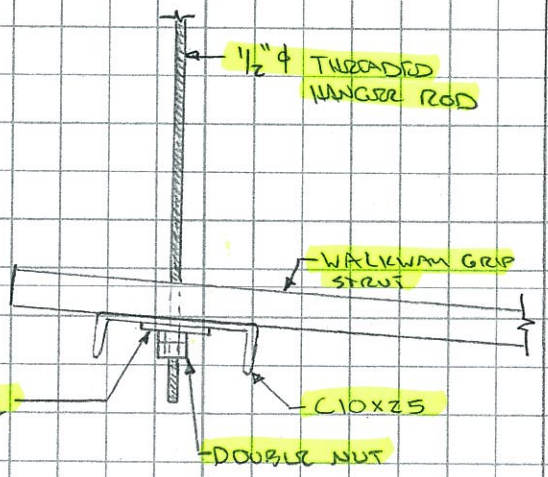
$= 36(3.18) \leq 1.6(36)(1.47)$

$= 114^{k-in} \leq 85^{k-in}$

$M_r = \phi_s M_n = 1.0(85) = 85^{k-in}$

$85^{k-in} > 67.5^{k-in}$ ∴ OK

USE C10X25 AS SUPPORT BEAM FOR CATWALK UNDER DELTA DIAPHRAGM



For DELTA GIRDER CATWALK	Job no. 49633	Sheet no. 6
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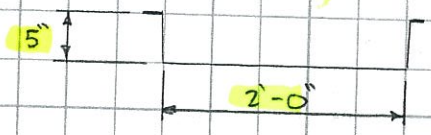
HNTB

DETERMINE WALKWAY GRIP STRUT TO BE USED FOR DELTA GIRDER CATWALK

FROM ATTACHED LOAD TABLE, USE 10 GAUGE GRIP STRUT 24" WIDE. FOR A 85 PSF PEDESTRIAN LOAD, THIS GRIP STRUT CAN SPAN A MAX 13', WHICH IS GREATER THAN THE <12' SPACES BETWEEN LATERAL BRACE SUPPORTS.



MENICHOLS CATALOG NUMBER:

H-55010-W OR SIMILAR

-NO KICK PLATE REQUIRED

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Cleveland Catwalk Design Check	Backchecked by	DMS	Date	3/15/2011		

Filename: N:\49633\Bridges\Design\Final Design\Unit 2\Excel\[Catwalk - angle design check.xls]Hand Rail L3x3x0.375

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Catwalk Handrail L3 x 3 x 3/8

Note: This spreadsheet is valid only for single angle members using **equal** leg angles.

Per the NSBA (National Steel Bridge Alliance) Vol. II, Chap. 2b Highway Structures Design Handbook, May 1999, pages 3-66 through 3-71:

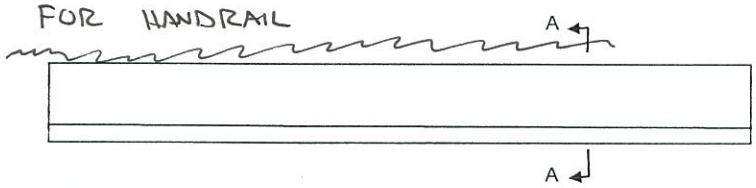
"Since the angle is connected through one leg only, the member is subjected to combined flexure (moments about both principal axes due to the eccentricity of the applied axial load) and axial compression. For single angles laterally unrestrained, as in this example, the flexural behavior can be evaluated by resolving moments into principal axis components and determining the sum of these principal axis flexural effects.

For this design the 4th Edition of AASHTO LRFD will be followed when applicable, but in many cases AASHTO references the 13th edition of AISC which will also be followed. It was also helpful to use the "Specifications for Load Resistance Factor Design of Single-Angle Members" contained in the 2nd Edition of AISC LRFD (pages 6-281 thru 6-288) to help navigate the 13th Edition AISC code.

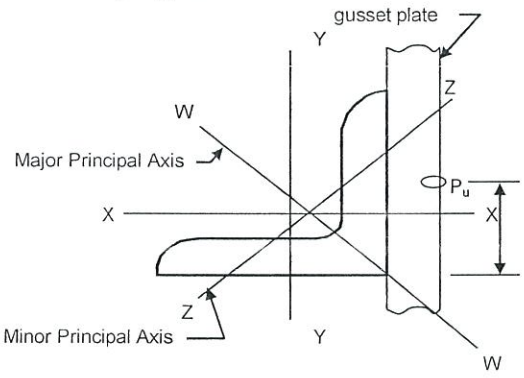
Section of these design calculations reference each of these codes in the following ways:
AASHTO = 4th Edition of AASHTO LRFD, AISC = 13th Edition of AISC and SAM = Specifications for Load Resistance Factor Design of Single-Angle Members"

All dimensions in kips and inches unless noted otherwise.

*SAME DESIGN FOR UPPER CATWALKS FOR HANDRAIL



F_D = Applied Force



SECTION A-A

INPUT

Try a L3x3x3/8

P_u = FACTORED force in the member

P_u = 0.00 kips

g = gusset plate thickness (see sketch below)

g = 0.000 in.

A = angle area

A = 2.11 in^2

b = angle leg length

b = 3.0 in.

t = angle leg thickness

t = 0.3750 in.

x = y = distance from X-X and Y-Y axis to back of parallel leg (see sketch below)

x = y = 0.884 in.

r_z = radius of gyration about the Minor Principal Axis (Z-Z)

r_z = 0.581 in.

$r_x = r_y$ = radius of gyration about the (X-X) and (Y-Y) Axes

$r_x = r_y$ = 0.910 in.

$I_x = I_y$ = moment of inertia about the (X-X) and (Y-Y) Axes

$I_x = I_y$ = 1.75 in^4

K = effective length factor in the plane of buckling;

K = 1

L = length of the member between points of support for buckling about the vertical (Y-Y) axis;

L = 150.00 in.

L = length of the member between points of support for buckling about the Principal (W-W) and (Z-Z) Axes;

L = 150.00 in.

F_y = yield stress of the steel;

F_y = 36 ksi

E = modulus of elasticity of the steel;

E = 29000 ksi

12.5' CONSERVATIVE FOR RAILING POST SPACING IN DELTA GIRDER

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	Checked by	LJD	Date	3/14/2011	Sheet No.	2
Cleveland Catwalk Design Check	Backchecked by	DMS	Date	3/15/2011		

Filename: N:\49633\Bridges\Design\Final Design\Unit 2\Excel\[Catwalk - angle design check.xls]Hand Rail L3x3x0.375

MEMBER PROPERTIES

$r = \sqrt{\frac{I}{A}}$ therefore, $r^2 = I/A$

therefore, $I = Ar^2$

I_z = 0.71 in^4

$I_w = I_x + I_y - I_z$ = 2.79 in^4

r_w = 1.15 in.

c_w = 2.12 in.

c_z = 1.25 in.

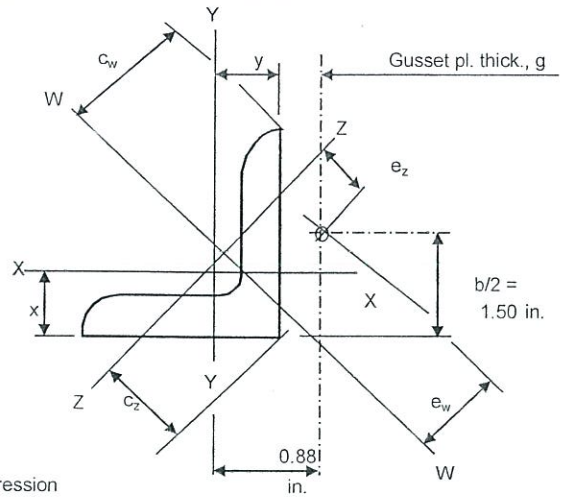
e_w = 1.06 in.

e_z = 0.19 in.

$S_z = I_z/c_z$ = 0.57 in^3

S_c = elastic section modulus to the tip in compression relative to the axis of bending

$S_c = I_w/c_w$ = 1.31 in^3



AXIAL COMPRESSION AISC E7 since Equations identical to (but in different form than) to AASHTO 6.9.2.1 & 6.9.4. and AISC covers more situations than AASHTO.

The design strength of compression members shall be $\Phi_c P_n$ calculated as follows

Does Not Apply to this Example

$\Phi_c = 0.90$

$P_n = A_g F_{cr}$

Determine the critical buckling stress F_{cr} of the member for buckling about the minor principal axis (Z-Z axis):

b/t = 8.00 $0.45\sqrt{\frac{E}{F_y}} =$ 12.77 $0.910\sqrt{\frac{E}{F_y}} =$ 25.83

when:

$\frac{b}{t} \le 0.45\sqrt{\frac{E}{F_y}}$ then, Q = 1.0

$0.45\sqrt{\frac{E}{F_y}} < \frac{b}{t} < 0.910\sqrt{\frac{E}{F_y}}$ $Q = 1.340 - 0.761\frac{b}{t}\sqrt{\frac{F_y}{E}}$

$\frac{b}{t} \ge 0.910\sqrt{\frac{E}{F_y}}$ $Q = \frac{0.534\ E}{F_y\left(\frac{b}{t}\right)^2}$

Therefore, the reduction factor for local buckling, Q = 1.00

$\frac{Kl}{r} =$ 258.176 $4.71\sqrt{\frac{E}{QF_y}} =$ 133.681 $F_e = \frac{\pi^2 E}{\left(\frac{Kl}{r}\right)^2} =$ 4.3 ksi

when: then,

$\frac{Kl}{r} \le 4.71\sqrt{\frac{E}{QF_y}}$ $F_{cr} = Q\left(0.658^{\frac{QF_y}{F_e}}\right)F_y$

$\frac{Kl}{r} > 4.71\sqrt{\frac{E}{QF_y}}$ $F_{cr} = \left[\frac{0.877}{1}\right]F_e$

Check KL/r <= 120 MoDOT EPG 751.14.5.4

kl/r = 258.176 NG

Therefore F_{cr} = 3.77 ksi <== GOVERNS

Determine the critical buckling stress F_{cr} of the member for buckling about the vertical geometric axis (Y-Y axis):

$\frac{Kl}{r} =$ 164.835 $4.71\sqrt{\frac{E}{QF_y}} =$ 133.681 $F_e = \frac{\pi^2 E}{\left(\frac{Kl}{r}\right)^2} =$ 10.5341114

when: then,

$\frac{Kl}{r} \le 4.71\sqrt{\frac{E}{QF_y}}$ $F_{cr} = Q\left(0.658^{\frac{QF_y}{F_e}}\right)F_y$

$\frac{Kl}{r} > 4.71\sqrt{\frac{E}{QF_y}}$ $F_{cr} = \left[\frac{0.877}{1}\right]F_e$

Check KL/r <= 120 MoDOT EPG 751.14.5.4

kl/r = 164.835 NG

Therefore F_{cr} = 9.24 ksi

Therefore USE F_{cr} = 3.77 ksi

$P_n = A_g F_{cr}$ = 7.95 kips OK

FLEXURE: MAJOR-AXIS BENDING

Stresses in the strut caused by torsion resulting from differential deflections of adjacent girders are ignored. Therefore, the angle will be conservatively assumed to be without lateral-torsional restraint along its entire length and, as a result, will be designed considering bending about both principal axes, as specified in AISC F10. According to AISC F10, the allowable bending stress for equal-leg angles subjected to major-axis (W-W) bending shall be determined by the minimum allowable stress determined from either the limit states of local buckling (F10-3) or lateral-torsional buckling (F10-2).

Local Buckling

The limit state of local buckling must be checked when the tip of the angle is in compression (AISC F10-3): First check compactness from AISC Table B4.1.

b/t = 8.00 $0.54\sqrt{\frac{E}{F_y}}$ = 15.33 $0.910\sqrt{\frac{E}{F_y}}$ = 25.83

when: then,

$\frac{b}{t} \le 0.540\sqrt{\frac{E}{F_y}}$ $M_n = 1.5F_yS_c$

$0.540\sqrt{\frac{E}{F_y}} < \frac{b}{t} \le 0.91\sqrt{\frac{E}{F_y}}$ $M_n = F_yS_c\left[2.43 - 1.72\left(b/t\sqrt{\frac{F_y}{E}}\right)\right]$

$\frac{b}{t} > 0.91\sqrt{\frac{E}{F_y}}$ $M_n = 0.71\,E\,S_c / (b/t)^2$

Therefore M_n = 70.96 in-k

Lateral-Torsional Buckling

According to AISC F10-2iii, for equal-leg angles subjected to bending about the major principal axis (W-W), the nominal flexural strength, M_n is computed as:

$M_e = C_b\frac{0.46Eb^2t^2}{l}$ = 148.57 in-k $M_y = F_yS$ = 47.31 in-k

where: Cb = 1.32 for this loading case

when $M_e \le M_y$ $M_n = [0.92 - 0.17\,M_e/M_y]\,M_e$

when $M_e > M_y$ $M_n = [1.92 - 1.17\,(M_y/M_e)^{.5}]\,M_y \le 1.5M_y$

Therefore, M_n = 59.60 in-k

Therefore USE M_n = 59.60 in-k

FLEXURE: MINOR-AXIS BENDING

According to AISC (also reference SAM 5.3 for more clarification), the nominal design strength M_n for equal-leg angles about the minor principal axis (Z-Z) when the tips of the angle are in tension and the corner of the angle is in compression (which is the case here when angle is in axial compression) shall be computed according to AISC F10-2 as follows:

$M_n = 1.5M_y$

where,

M_y = yield moment about the axis of bending = F_yS = 20.51 in-k

$M_n = 1.5M_y$ = 30.77 in-k

Ultimate Moment Calculations

*Since equal leg angles, principal axis at 45, z component = w component

			Factored Loads		z & w components		Muz & Muw				
Vertical											
w_{DL} =	7.2	plf	9	plf	6.36	plf	1.49	k-in	Total Muz =	14.62	k-in
w_{LL} =	0	plf	0	plf	0.00	plf	0.00	k-in	Total Muw =	14.62	k-in
P_{LL} =	200	lb	350	lb	350	lb	13.13	k-in			
Transverse											
w_{LL} =	0	plf	0	plf	0.00	plf	0.00	k-in			

P_u =	0.00	kips	f_a =	0.00	ksi
P_n =	7.95	kips	F_a =	3.77	ksi
M_{uw} =	14.62	in-k	f_{bw} =	11.12	ksi
M_{nw} =	59.60	in-k	F_{bw} =	45.35	ksi
M_{uz} =	14.62	in-k	f_{bz} =	25.66	ksi
M_{nz} =	30.77	in-k	F_{bz} =	54.00	ksi

FLEXURE AND AXIAL COMPRESSION

According to AISC H1:

Members subjected to both axial compression and bending stresses shall be proportioned to satisfy the following requirements (note since this is SAM notation and there is some question whether our angles should be designed like this in the new AISC, we will also check H2):

For $\frac{P_u}{\phi P_n} \geq 0.2$

$$\left|\frac{P_u}{\phi P_n}+\frac{8}{9}\left(\frac{M_{uw}}{\phi_b M_{nw}}+\frac{M_{uz}}{\phi_b M_{nz}}\right)\right| \leq 1.0 \qquad \text{(H1-1a)}$$

$\frac{P_u}{\phi P_n} < 0.2$

$$\left|\frac{P_u}{2\phi P_n}+\left(\frac{M_{uw}}{\phi_b M_{nw}}+\frac{M_{uz}}{\phi_b M_{nz}}\right)\right| \leq 1.0 \qquad \text{(H1-1b)}$$

$\Phi = \Phi_c$ = 0.9

Φ_b = 0.9

$$\left|\frac{f_a}{F_a}+\frac{f_{bw}}{F_{bw}}+\frac{f_{bz}}{F_{bz}}\right| \leq 1.0 \qquad \text{(H2-1)}$$

In Equations C2-1a and C2-2 since M_n represents the flexural strength of the compression side, the corresponding M_u shall be multiplied by B_1.

where,

$$B_1 = \frac{C_m}{1-\frac{\alpha P_r}{P_{e1}}} \geq 1.0 \qquad \text{(C2-2)}$$

Cm is assumed to be 1.0, "For members whose ends are unrestrained."

α = 1.0 where, $P_{e1} = \frac{\pi^2 EI}{(KI)^2}$

αP_{rz} =	0.00	αP_{rw} =	0.00
P_{e1z} =	9.06 kips	P_{e1w} =	35.46 kips
B_{1z} =	1.000	B_{1w} =	1.000

The member is checked for the interaction of flexure axial compression according to AISC SAM Sections H1 & H2:

$\frac{P_u}{\phi P_n}$ = 0.00 Since <0.2, check interaction using Equation (H1-1b).

Pu/2ΦPn +[(B1w Muw/Φb Mnw) + (B1z Muz/Φb Mnz)] = 0.80 <= 1.00

OK, flexure-compression interaction is OK.

fa/Fa +[(B1w fbw/Fbw) + (B1z fbz/Fbz)] = 0.72 <= 1.00

OK, flexure-compression interaction is OK.

HNTB The HNTB Companies	Made by	DMS	Date	3/8/2011	Job No.	49633
	Checked by	LJD	Date	3/14/2011	Sheet No.	5
Cleveland Catwalk Design Check	Backchecked by	DMS	Date	3/15/2011		

Filename: N:\49633\Bridges\Design\Final Design\Unit 2\Excel\[Catwalk - angle design check.xls]Hand Rail L3x3x0.375

EAR Note: Uses geometric section

AISC G4

C_v = 1

b = 3.0 in = width of leg resisting shear force

A_w = 1.125 in^2 = area of leg resisting shear force

$Vn = 0.6F_yA_wC_v$ = 24.3 k

AASHTO 6.12.1.2.3, 6.5.4.2, 6.10.9.2

$Vp = 0.58F_{yw}Dt_w$ = 23.49 k

C = 1.00 (to be conservative)

Vn = CVp = 23.49 k

Φ_v = 1.00 (AASHTO 6.5.4.2)

$Vr = \Phi_vVn$ = 23.49 k

V_u = 2.0 k SHEAR OK

(compare to AASHTO)

DEFLECTION

AISC Table 3-23, AASHTO 2.5.2.6.2

Loads on Prinicipal Axis

w_{LL} = 0.0 plf $w_{LL}\Delta$ = 0.000 in

P_{LL} = 200.0 lb $P_{LL}\Delta$ = 0.277 in

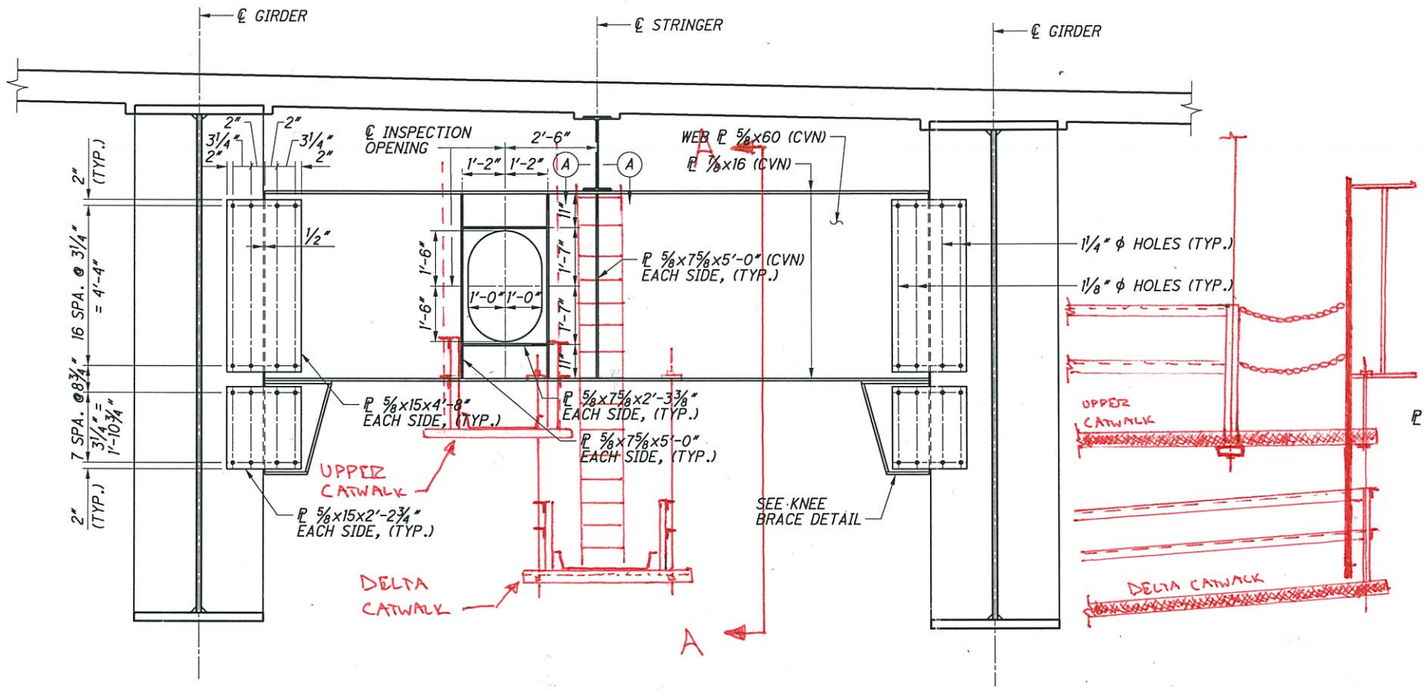
Total Δ = 0.277 in

* Geometric axis Ix used for deflection calculations

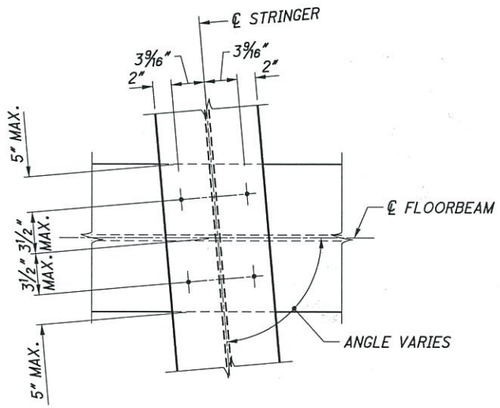
Max Allowed Deflection = 3" = 3 in

Deflection OK

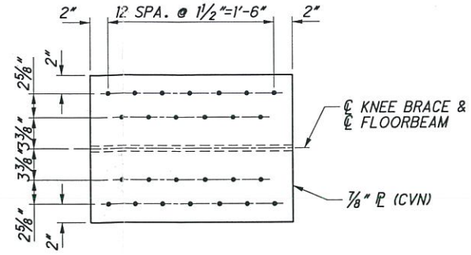
See OSHA 1926.502(b)(4)

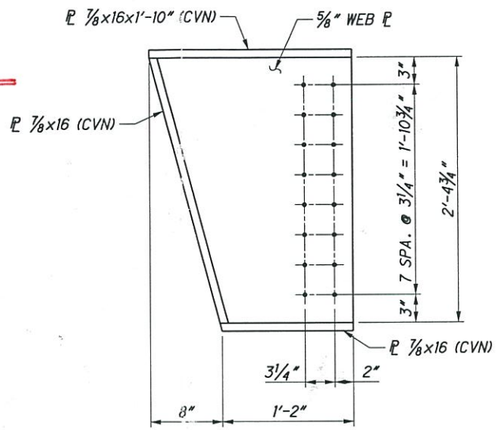


TYPE B FLOORBEAM



SECTION A-A





KNEE BRACE DETAIL

NOTES:

1. WHERE A SHAPE OR PLATE IS DESIGNATED (CVN), FURNISH MATERIAL THAT MEETS THE MINIMUM NOTCH TOUGHNESS REQUIREMENTS AS SPECIFIED IN 711.01
2. DIAPHRAGMS SHALL BE DETAILED, FABRICATED AND INSTALLED SO THAT THEY ARE UNLOADED AT ERECTION, ALLOWING GIRDER WEBS TO BE THEORETICALLY VERTICAL OR PLUMB UNDER THE STEEL DEAD LOAD CONDITION.
3. ALL STEEL IS GRADE 50.
4. ALL SURFACES SHALL BE PAINTED WITH A COATING MEETING CLASS B SURFACE CONDITION REQUIREMENTS.
5. ALL BOLTS ARE 1" ϕ, A325 HIGH STRENGTH BOLTS. ALL HOLES FOR DIAPHRAGM, KNEE BRACE, AND CORRESPONDING HOLES IN CONNECTION PLATES ARE 1 1/8" ϕ HOLES. ALL HOLES IN STIFFENER AND CORRESPONDING HOLES IN CONNECTION PLATES ARE 1 1/4" ϕ HOLES. ALL HOLES FOR CONNECTION BETWEEN DIAPHRAGM FLANGE AND KNEE BRACE FLANGE ARE 1 1/8" ϕ.

PRELIMINARY NOT FOR CONSTRUCTION

CHECK PRINT (INITIAL & DATE)
MADE BY:
CORRECTED BY:
VERIFIED BY:
CHECKED BY:
BACKCHECKED BY:

Date:17-APR-2011
Model:WorkSheet
File:IP_PWP:dms82863\49633-S-BR-SSD06-U2StlSteel.dgn

ENGINEER'S SEAL

NO.	REVISIONS	DATE

DESIGN AGENCY WALSH HNTB WALSH CONSTRUCTION

CLEVELAND'S INNERBELT BRIDGES

OHIO DEPARTMENT OF TRANSPORTATION

MAIN SPAN
UNIT 2
STRUCTURAL STEEL

SUPERSTRUCTURE DETAILS
BRIDGE NO. CUY-90-1524
I-90 WEST BOUND

DESIGNED	DRAWN	REVIEWED	DATE
CHECKED	CHECKED	STRUCTURE FILE NUMBER 1809431	

CUY-90-14.90
PID No. 77332/85531

36/66

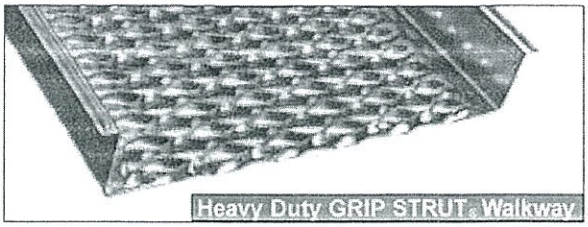
0/0

Heavy Duty GRIP STRUT®

Loading Information

For regular GRIP STRUT® loading—see pages 4-12

- Catwalks • Mining Operations • Offshore Drilling Rigs
- Overhead Storage Space • Petroleum Processing
- Skywalks • Walkways • Water/Waste Plant Flooring


Heavy Duty GRIP STRUT® Walkway

8-DIAMOND PLANK (36" WIDTH) — Clear Span — HEAVY DUTY — Plank — LOAD TABLE

Material	Height in.	#/LF	Catalog Number	Load Type	2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"
STEEL 10 ga.	2	19.9	H-82010	U	689	441	306	225	172	136	110	91	77	65	56	49	43	34	28	23	19
				D	0.05	0.08	0.11	0.15	0.19	0.24	0.30	0.35	0.41	0.47	0.54	0.62	0.69	0.85	1.04	1.24	1.45
				C	2067	1653	1378	1181	1033	919	827	752	689	636	590	551	517	459	413	376	344
				D	0.04	0.06	0.09	0.12	0.15	0.19	0.24	0.28	0.33	0.38	0.44	0.49	0.55	0.68	0.81	0.98	1.16
	2-1/2	20.4	H-82510	U	1044	668	464	341	261	206	167	138	116	99	85	74	65	52	42	35	29
				D	0.05	0.07	0.10	0.14	0.18	0.23	0.27	0.32	0.36	0.42	0.49	0.55	0.62	0.79	0.96	1.15	1.35
				C	3133	2507	2089	1790	1567	1393	1253	1139	1044	964	895	836	783	696	627	570	522
				D	0.04	0.06	0.08	0.11	0.14	0.18	0.22	0.25	0.29	0.34	0.39	0.44	0.50	0.63	0.76	0.91	1.08
	3	20.9	H-83010	U	1111	711	494	363	278	219	178	147	123	105	91	79	69	55	44	37	31
				D	0.04	0.06	0.08	0.11	0.15	0.18	0.22	0.26	0.30	0.34	0.39	0.44	0.48	0.58	0.68	0.80	0.95
				C	3333	2667	2222	1905	1667	1481	1311	1212	1111	1026	952	889	833	741	667	606	556
				D	0.03	0.05	0.07	0.09	0.12	0.15	0.17	0.21	0.24	0.28	0.31	0.35	0.39	0.47	0.55	0.64	0.76
	4	21.8	H-84010	U	1822	1166	810	595	456	360	292	241	202	173	149	130	114	90	73	60	50
				D	0.03	0.05	0.07	0.09	0.12	0.14	0.17	0.20	0.23	0.27	0.31	0.35	0.39	0.47	0.56	0.66	0.78
				C	5467	4373	3644	3124	2733	2430	2187	1988	1822	1682	1562	1458	1367	1215	1039	994	911
				D	0.03	0.04	0.06	0.07	0.09	0.11	0.14	0.16	0.19	0.22	0.25	0.28	0.31	0.38	0.45	0.53	0.63
STEEL 9 ga.	2	22.1	H-8209	U	758	485	337	248	189	150	121	100	85	72	62	54	47	37	31	25	21
				D	0.05	0.08	0.11	0.15	0.19	0.24	0.30	0.35	0.41	0.47	0.54	0.62	0.69	0.85	1.04	1.24	1.45
				C	2274	1818	1516	1299	1136	1011	910	827	758	700	649	606	569	505	454	414	378
				D	0.04	0.06	0.09	0.12	0.15	0.19	0.24	0.28	0.33	0.38	0.44	0.49	0.55	0.68	0.81	0.98	1.16
	2-1/2	22.7	H-8259	U	1148	735	510	375	287	227	184	152	128	109	94	81	72	57	46	39	32
				D	0.05	0.07	0.10	0.14	0.18	0.23	0.27	0.32	0.36	0.42	0.49	0.55	0.62	0.79	0.96	1.15	1.35
				C	3446	2758	2298	1969	1724	1532	1378	1253	1148	1060	985	920	861	766	690	627	574
				D	0.04	0.06	0.08	0.11	0.14	0.18	0.22	0.25	0.29	0.34	0.39	0.44	0.50	0.63	0.76	0.91	1.08
	3	23.9	H-8309	U	1222	782	543	399	306	241	196	162	135	116	100	87	76	61	48	41	34
				D	0.04	0.06	0.08	0.11	0.15	0.18	0.22	0.26	0.30	0.34	0.39	0.44	0.48	0.58	0.68	0.80	0.95
				C	3666	2934	2444	2096	1834	1629	1442	1333	1222	1129	1047	978	916	815	734	667	612
				D	0.03	0.05	0.07	0.09	0.12	0.15	0.17	0.21	0.24	0.28	0.31	0.35	0.39	0.47	0.55	0.64	0.76
Available by Special Order	4	24.2	H-8409	U	2004	1283	891	655	502	396	321	265	222	190	164	143	125	99	80	66	55
				D	0.03	0.05	0.07	0.09	0.12	0.14	0.17	0.20	0.23	0.27	0.31	0.35	0.39	0.47	0.56	0.66	0.78
				C	6014	4810	4008	3436	3006	2673	2406	2187	2004	1850	1718	1604	1504	1337	1143	1093	1002
				D	0.03	0.04	0.06	0.07	0.09	0.11	0.14	0.16	0.19	0.22	0.25	0.28	0.31	0.38	0.45	0.53	0.63

WALKWAY—24", 30" & 36" WIDTH — Clear Span — HEAVY DUTY — Walkway — LOAD TABLE

Width	Gauge	Depth in.	#/LF	Catalog Number	Load Type	4'-0"	5'-0"	6'-0"	7'-0"	8'-0"	9'-0"	10'-0"	11'-0"	12'-0"	13'-0"	14'-0"	15'-0"	16'-0"	18'-0"	20'-0"	22'-0"	24'-0"
24"	10	5	17.5	H-55010-W	U	937	600	417	306	234	185	150	124	104	89	77	67	59	46	38	31	26
					D	0.38	0.39	0.42	0.38	0.38	0.38	0.39	0.47	0.56	0.66	0.77	0.88	1.01	1.26	1.59	1.89	2.25
					C	3750	3000	2500	2143	1875	1667	1500	1364	1250	1153	1071	1000	938	833	750	682	625
					D	0.30	0.31	0.34	0.31	0.30	0.30	0.31	0.38	0.45	0.53	0.61	0.70	0.80	1.01	1.25	1.51	1.80
24"	9	5	19.6	H-5509-W	U	1031	660	459	337	257	204	165	136	114	98	85	74	65	51	42	34	29
					D	0.38	0.39	0.42	0.38	0.38	0.38	0.39	0.47	0.56	0.66	0.77	0.88	1.01	1.26	1.59	1.89	2.25
					C	4125	3300	2750	2357	2063	1834	1650	1500	1375	1268	1178	1100	1032	916	825	750	688
					D	0.30	0.31	0.34	0.31	0.30	0.30	0.31	0.38	0.45	0.53	0.61	0.70	0.80	1.01	1.25	1.51	1.80
30"	10	5	19.9	H-65010-W	U	916	586	407	299	229	182	146	121	102	87	75	65	57	45	36	30	25
					D	0.37	0.43	0.40	0.40	0.46	0.42	0.41	0.41	0.49	0.57	0.66	0.75	0.86	1.09	1.33	1.62	1.92
					C	4584	3666	3056	2619	2291	2037	1834	1667	1528	1410	1309	1222	1146	1019	916	834	763
					D	0.30	0.34	0.32	0.32	0.37	0.34	0.33	0.33	0.39	0.45	0.53	0.61	0.69	0.87	1.08	1.30	1.55
30"	9	5	22.1	H-6509-W	U	1007	644	447	328	251	200	160	133	112	95	82	71	62	49	39	33	27
					D	0.37	0.43	0.40	0.40	0.46	0.42	0.41	0.41	0.49	0.57	0.66	0.75	0.86	1.09	1.33	1.62	1.92
					C	5042	4032	3361	2880	2520	2240	2017	1833	1680	1551	1439	1344	1260	1120	1007	917	839
					D	0.30	0.34	0.32	0.32	0.37	0.34	0.33	0.33	0.39	0.45	0.53	0.61	0.69	0.87	1.08	1.30	1.55
36"	10	5	22.7	H-85010-W	U	556	356	247	181	139	110	89	73	62	53	45	39	35	27	22	18	15
					D	0.39	0.39	0.33	0.32	0.33	0.36	0.39	0.42	.051	0.60	0.69	0.79	0.91	1.15	1.40	1.67	1.98
					C	3330	2667	2222	1905	1667	1481	1333	1212	1111	1026	952	889	833	741	667	606	556
					D	0.31	0.31	0.26	0.26	0.26	0.29	0.31	0.34	0.41	0.48	0.55	0.64	0.72	0.92	1.13	1.37	1.63
36"	9	5	25.3	H-8509-W	U	611	391	271	199	152	121	97	80	68	58	49	42	38	29	24	19	16
					D	0.39	0.39	0.33	0.32	0.33	0.36	0.39	0.42	0.51	0.60	0.69	0.79	0.91	1.15	1.40	1.67	1.98
					C	3663	2933	2444	2095	1833	1629	1466	1333	1222	1128	1047	977	916	815	733	666	611
					D	0.31	0.31	0.26	0.26	0.26	0.29	0.31	0.34	0.41	0.48	0.55	0.64	0.72	0.92	1.13	1.37	1.63

GRIP STRUT® Load Tables

ISO 9002 Certified

Cut-to-Size or Full Planks

GRIP STRUT® 4-DIAMOND PLANK (9-1/2" WIDTH) — LOAD TABLE

Material	Height in. (mm)	#/LF (Kg/m)	Catalog Number		Clear Span 2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'
STEEL 14 GA.	1-1/2 (38.1)	3.6 (5.36)	41514	U	663	426	296	219	168	134	109	90	77								
				D	.06	.10	.14	.20	.26	.33	.41	.50	.59								
				C	525	421	352	303	266	238	215	197	182								
				D	.05	.08	.11	.16	.21	.26	.33	.40	.47								
	2 (50.8)	3.8 (5.65)	42014	U	1100	705	491	362	278	220	179	148	125	107	93	81	72	58	47		
				D	.06	.09	.13	.17	.23	.29	.36	.43	.52	.61	.71	.82	.94	1.20	1.51		
				C	730	698	583	501	440	392	354	323	298	276	258	242	228	205	187		
				D	.04	.07	.10	.14	.18	.23	.28	.35	.41	.49	.57	.66	.75	.96	1.20		
	2-1/2 (63.5)	4.1 (6.10)	42514	U	1262	809	563	415	318	252	205	170	144	123	106	93	82	66	54	45	
				D	.04	.06	.08	.11	.14	.18	.23	.28	.33	.39	.45	.52	.60	.76	.95	1.17	
				C	730	730	669	574	504	449	406	370	341	316	295	277	261	235	214	197	
				D	.02	.04	.06	.09	.12	.15	.18	.22	.26	.31	.36	.42	.48	.61	.76	.94	
STEEL 12 GA.	1-1/2 (38.1)	5.0 (7.44)	41512	U	906	581	405	298	229	182	148	123	104	89	77	67	60				
				D	.07	.11	.16	.21	.28	.36	.44	.54	.64	.76	.89	1.02	1.17				
				C	718	575	481	413	363	324	292	267	246	228	213	200	189				
				D	.06	.09	.13	.17	.23	.29	.35	.43	.52	.61	.71	.82	.94				
	2 (50.8)	5.4 (8.04)	42012	U	1398	896	624	460	353	280	228	189	160	137	119	104	92	74	61	51	43
				D	.05	.08	.11	.16	.20	.26	.32	.39	.47	.55	.65	.75	.85	1.10	1.38	1.69	2.03
				C	1107	887	741	637	559	499	451	412	380	353	329	309	292	264	241	222	206
				D	.04	.06	.09	.12	.16	.21	.26	.31	.37	.44	.52	.60	.68	.88	1.10	1.35	1.63
	2-1/2 (63.5)	5.7 (8.48)	42512	U	2090	1339	931	685	525	416	338	280	236	201	174	152	134	107	87	73	62
				D	.04	.06	.09	.13	.17	.21	.26	.32	.38	.44	.52	.60	.68	.87	1.08	1.32	1.58
				C	1400	1325	1106	949	832	741	668	609	559	518	482	452	425	380	345	316	293
				D	.03	.05	.07	.10	.13	.17	.21	.25	.30	.36	.41	.48	.54	.69	.86	1.05	1.27
	3 (76.2)	6.1 (9.08)	43012	U	2644	1694	1177	866	664	525	426	353	297	254	219	192	169	134	110	91	77
				D	.04	.06	.08	.11	.14	.18	.22	.27	.32	.38	.44	.51	.58	.74	.92	1.12	1.35
				C	1400	1400	1398	1200	1051	936	844	769	706	653	608	569	535	478	434	397	367
				D	.02	.04	.06	.09	.11	.15	.18	.22	.26	.31	.35	.41	.47	.59	.74	.90	1.08
ALUM. ALLOY 5052 12 GA. .080"	1-1/2* (38.1)	1.28 (1.90)	41512-A	U	499	319	222	163	124	98											
				D	.10	.15	.22	.31	.40	.51											
				C	395	316	263	226	197	175											
				D	.08	.12	.18	.25	.32	.41											
	2 (50.8)	1.37 (2.03)	42012-A	U	732	468	325	239	183	145	117	97	81	69							
				D	.08	.13	.18	.25	.33	.42	.52	.63	.74	.87							
				C	568	463	386	331	290	257	232	211	192	177							
				D	.06	.10	.15	.20	.27	.34	.42	.51	.59	.69							
STAIN-LESS STEEL 304 16 ga.	2 (50.8)	3.2 (4.76)	42016-S	U	720	462	322	238	183	145	118	98	83	71	59						
				D	.05	.08	.11	.16	.20	.26	.32	.39	.47	.55	.61						
				C	570	457	382	329	289	258	234	214	197	184	165						
				D	.04	.06	.09	.12	.16	.21	.26	.31	.38	.44	.49						

Chart Notes: (all charts on this page)
1) Spans in shaded area produce deflection of 1/4" or less under uniform load of 100 lbs./SF
2) *indicates items available by special order
3) Loading available for .100" gauge and Stainless 316L and some 3" heights-please inquire

GRIP STRUT® 5-DIAMOND PLANK (11-3/4" WIDTH) — LOAD TABLE

Material	Height in. (mm)	#/LF (Kg/m)	Catalog Number		Clear Span 2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'
STEEL 14 ga.	1-1/2 (38.1)	4.2 (6.25)	51514	U	536	344	240	177	136	108	88	74	62								
				D	.06	.10	.14	.20	.26	.33	.41	.50	.60								
				C	525	422	353	304	267	239	216	198	183								
				D	.05	.08	.12	.16	.21	.26	.33	.40	.48								
	2 (50.8)	4.4 (6.55)	52014	U	890	571	397	293	225	178	145	120	102	87	76	66	59	47			
				D	.06	.09	.13	.17	.23	.29	.36	.43	.52	.61	.71	.83	.95	1.21			
				C	707	699	584	502	440	393	355	324	299	277	259	243	230	207			
				D	.04	.07	.10	.14	.18	.23	.29	.35	.42	.49	.57	.66	.76	.97			
	2-1/2 (63.5)	4.7 (6.99)	52514	U	1021	655	456	336	258	204	166	138	116	100	86	76	67	54	44		
				D	.04	.06	.08	.11	.14	.18	.23	.28	.33	.39	.45	.52	.60	.77	.96		
				C	707	707	669	575	505	450	407	371	342	317	296	278	262	236	216		
				D	.02	.04	.06	.09	.12	.15	.18	.22	.26	.31	.36	.42	.48	.62	.77		
STEEL 12 ga.	1-1/2 (38.1)	5.9 (8.78)	51512	U	710	456	318	235	181	144	117	98	83	71	62	55	49				
				D	.07	.11	.15	.21	.28	.35	.44	.53	.64	.76	.89	1.03	1.18				
				C	695	558	467	402	354	317	287	263	244	227	213	201	190				
				D	.05	.08	.12	.17	.22	.28	.35	.43	.51	.60	.71	.82	.95				
	2 (50.8)	6.2 (9.23)	52012	U	1131	725	505	372	286	227	185	154	130	111	97	85	75	60	50	42	
				D	.05	.08	.11	.16	.20	.26	.32	.39	.47	.56	.65	.75	.86	1.11	1.39	1.70	
				C	1107	888	742	638	561	501	453	414	382	355	332	312	295	266	243	224	
				D	.04	.06	.09	.12	.16	.21	.26	.31	.38	.44	.52	.60	.69	.89	1.11	1.36	
	2-1/2 (63.5)	6.6 (9.82)	52512	U	1691	1083	753	554	425	337	273	226	151	141	123	109	87	71	59	59	50
				D	.04	.06	.09	.13	.17	.21	.26	.32	.38	.45	.52	.60	.68	.87	1.09	1.33	1.60
				C	1115	1115	1106	950	833	742	669	610	561	519	484	453	426	382	347	319	295
				D	.02	.04	.07	.10	.13	.17	.21	.25	.30	.36	.41	.48	.55	.70	.87	1.06	1.28
	3 (76.2)	7.0 (10.4)	53012	U	2138	1370	952	701	537	425	345	286	241	206	178	155	137	109	89	74	63
				D	.04	.06	.08	.11	.14	.18	.22	.27	.32	.38	.44	.51	.58	.74	.93	1.13	1.36
				C	1115	1115	1115	1115	1052	937	845	770	707	654	609	570	537	480	436	399	369
				D	.02	.03	.05	.08	.11	.15	.18	.22	.26	.31	.36	.41	.47	.60	.74	.90	1.09
ALUM. ALLOY 5052 12 ga. .080"	1-1/2* (38.1)	1.49 (2.22)	51512-A	U	403	255	179	132	100												
				D	.10	.15	.22	.31	.40												
				C	395	316	263	226	197												
				D	.08	.12	.18	.25	.32												
	2 (50.8)	1.59 (2.36)	52012-A	U	592	379	263	193	148	117	95	78									
				D	.08	.13	.18	.25	.33	.42	.52	.63									
				C	466	466	386	331	290	257	232	211									
				D	.05	.10	.15	.20	.27	.34	.42	.51									
STAIN-LESS STEEL 304 16 ga.	2 (50.8)	3.7 (5.51)	52016-S	U	583	374	261	192	148	118	96	80	68	58	48						
				D	.05	.08	.11	.16	.20	.26	.32	.39	.47	.56	.61						
				C	464	458	323	330	290	259	235	215	199	185	165						
				D	.03	.06	.09	.12	.16	.21	.26	.32	.38	.45	.49						

Load Table Symbols:
U-uniform load (lbs./SF)
C-concentrated load (lb.)
D-deflection (inches)

GRIP STRUT® 8-DIAMOND PLANK (18-3/4" WIDTH) — LOAD TABLE

Material	Height in. (mm)	#/LF (Kg/m)	Catalog Number		Clear Span 2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'
STEEL 14 ga.	1-1/2 (38.1)	6.1 (9.1)	81514	U	337	217	151	112	86	69	56	47									
				D	.33	.27	.26	.29	.33	.38	.45	.55									
				C	263	211	178	153	135	121	110	101									
				D	.16	.15	.15	.16	.17	.19	.22	.25									
	2 (50.8)	6.3 (9.4)	82014	U	540	358	250	184	142	113	92	76	65	55	48	42					
				D	.48	.37	.34	.32	.34	.38	.43	.50	.58	.66	.77	.87					
				C	437	349	292	251	220	198	179	164	152	141	132	124					
				D	.24	.21	.20	.19	.20	.21	.23	.26	.29	.32	.36	.40					
	2 1/2 (63.5)	6.6 (9.8)	82514	U	540	411	286	211	162	129	105	87	74	63	55	48	43				
				D	.46	.39	.35	.28	.27	.28	.31	.35	.39	.44	.50	.57	.64				
				C	450	402	335	287	252	225	205	188	173	161	151	142	134				
				D	.24	.22	.20	.19	.19	.19	.20	.21	.23	.24	.27	.29	.32				
STEEL 12 ga.	1 1/2 (38.1)	8.5 (12.6)	81512	U	446	287	201	148	115	91	75	63	53	46	40						
				D	.27	.22	.22	.26	.32	.39	.47	.56	.67	.80	.92						
				C	359	280	235	203	179	161	146	135	125	117	110						
				D	.12	.12	.12	.14	.16	.19	.22	.26	.30	.35	.40						
	2 (50.8)	8.9 (13.2)	82012	U	710	456	318	235	181	144	117	98	83	71	62	54	58				
				D	.31	.25	.23	.25	.28	.31	.37	.44	.51	.60	.68	.79	.90				
				C	554	444	371	319	282	253	229	210	194	181	169	160	151				
				D	.17	.15	.14	.15	.16	.17	.19	.22	.25	.28	.32	.36	.40				
	2 1/2 (63.5)	9.2 (13.7)	82512	U	810	680	473	348	267	212	172	143	120	103	89	78	69	55	45		
				D	.33	.31	.27	.26	.27	.29	.32	.37	.42	.49	.55	.63	.72	.90	1.12		
				C	800	663	553	475	416	371	334	307	282	262	244	229	216	194	177		
				D	.23	.20	.18	.18	.18	.18	.19	.21	.23	.25	.28	.31	.34	.41	.50		
	3 (76.2)	9.6 (14.3)	83012	U	810	810	598	440	337	267	217	180	152	130	112	98	87	69	57	47	40
				D	.32	.35	.30	.27	.26	.28	.31	.34	.39	.43	.49	.56	.62	.78	.96	1.17	1.40
				C	800	800	699	600	526	468	422	385	353	327	307	288	271	243	221	203	189
				D	.22	.23	.22	.20	.20	.20	.20	.21	.22	.24	.26	.28	.31	.37	.44	.52	.61
ALUM. ALLOY 5052 12 ga. .080"	1 1/2* (38.1)	2.11 (3.13)	81512-A	U	253	162	112	83													
				D	.49	.40	.39	.44													
				C	198	158	132	113													
				D	.24	.22	.22	.24													
	2* (50.8)	2.20 (3.27)	82012-A	U	308	237	165	121	93	73	59	49									
				D	.54	.50	.44	.44	.47	.53	.61	.71									
				C	290	232	193	166	145	129	116	106									
				D	.32	.28	.27	.27	.28	.30	.32	.36									
	2 1/2* (63.5)	2.29 (3.40)	82512-A	U	308	308	248	182	139	110	89	74	62	53							
				D	.51	.57	.54	.49	.50	.52	.57	.65	.73	.83							
				C	350	348	290	249	218	194	174	158	145	134							
				D	.37	.39	.35	.33	.33	.34	.35	.37	.40	.43							

GRIP STRUT® 10-DIAMOND PLANK (24" WIDTH) — LOAD TABLE

Material	Height in. (mm)	#/LF (Kg/m)	Catalog Number		Clear Span 2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'
STEEL 14 ga.	2 (50.8)	7.4 (11.0)	102014	U	300	300	228	168	128	102	82	68	57	49	42						
				D	.46	.48	.42	.38	.38	.41	.44	.49	.55	.62	.70						
				C	400	400	343	294	257	229	206	187	172	158	147						
				D	.34	.35	.32	.30	.29	.29	.30	.31	.33	.35	.37						
	3 (76.2)	7.9 (11.8)	103014	U	300	300	300	264	202	160	130	107	90	77	66	58	51	40			
				D	.42	.43	.46	.44	.39	.36	.35	.36	.39	.44	.45	.49	.54	.65			
				C	400	400	400	400	400	360	324	295	270	249	232	216	203	180			
				D	.33	.33	.34	.35	.37	.35	.33	.33	.32	.32	.33	.34	.35	.38			
STEEL 12 ga.	2 (50.8)	10.4 (15.5)	102012	U	475	416	289	212	162	128	104	86	72	62	53	46					
				D	.40	.39	.33	.31	.31	.34	.38	.44	.48	.56	.63	.71					
				C	650	520	434	372	325	289	260	237	217	200	186	174					
				D	.26	.22	.19	.20	.20	.21	.22	.23	.25	.28	.31	.34					
	3 (76.2)	11.1 (16.5)	103012	U	475	475	475	392	300	237	192	159	133	114	98	85	75	59	48		
				D	.38	.39	.42	.38	.36	.34	.35	.37	.39	.43	.47	.52	.58	.70	.85		
				C	900	900	800	686	600	534	480	437	400	369	343	320	300	267	240		
				D	.34	.35	.33	.29	.27	.26	.26	.26	.26	.27	.29	.30	.32	.36	.41		

GRIP STRUT® 10-DIAMOND WALKWAY (24" WIDTH) — LOAD TABLE

Material	Height in. (mm)	#/LF (Kg/m)	Catalog Number		Clear Span 2'-0"	2'-6"	3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"	7'-6"	8'-0"	9'-0"	10'-0"	11'-0"	12'
STEEL 14 ga.	4-1/2 Depth	8.9 (13.2)	104514-U Walkway	U	300	300	300	300	300	263	213	176	148	126	109	95	83	66	53	43	
				D	.41	.41	.42	.45	.48	.47	.42	.40	.40	.41	.43	.45	.47	.55	.64	.75	
				C	400	400	400	400	400	400	400	400	400	400	380	355	333	296	266	242	
				D	.32	.33	.33	.33	.34	.35	.36	.38	.39	.41	.42	.41	.41	.42	.44	.47	
STEEL 12 ga.	4-1/2 Depth	12.5 (18.6)	104512-U Walkway	U	475	475	475	475	475	420	340	281	236	201	173	151	133	105	85	70	59
				D	.37	.37	.38	.40	.43	.43	.39	.37	.37	.37	.39	.41	.44	.51	.59	.69	.80
				C	900	900	900	900	900	900	850	773	709	654	607	567	531	472	425	387	354
				D	.34	.34	.35	.35	.36	.37	.37	.35	.34	.33	.33	.33	.33	.35	.37	.40	.44

Wall-Mount Welded Ladders

- 350 lbs. rated capacity
- Meet OSHA requirements

Welded construction gives these ladders exceptional strength, durability, and long life. All come with wall mounting brackets that offset the ladder 7″ for toe clearance (fasteners for mounting the brackets to the ladder are included). Ladders also have two welded-on floor mounting brackets. All mounting brackets have one 7/16″ hole (fasteners not included). Rungs are 16″ wide and serrated for slip resistance. The first rung is 9″ off the floor. Choose from ladders without and with a walk-through extension.

Steel and ***Type 304 stainless steel*** ladders have 3/8″×2″ side rails and 1 7/8″ deep rungs. The 8- and 10-ft. ladders come with two wall-mounting brackets; all other sizes come with four. Steel ladders have a gray primed finish. ***Aluminum*** ladders have 1/2″×2 1/2″ side rails and 2″ deep rungs. The 8-ft. ladder comes with two wall-mounting brackets; the 10- and 12-ft. come with four; and the 14- and 16-ft. come with six.

Ladders with Walk-Through Extension—Walk-through is 21″ wide with handrails that extend 42″. Made of flat bar stock.

With Walk-Through Extension

Height to Top Rung (A)	O'all Height	Steel O'all Width		Each	Type 304 Stainless Steel O'all Width		Each	Aluminum O'all Width		Each
Without Extension										
7′9″	8′	16 3/4″	7981T11	$318.57	16 3/4″	80015T51	$782.75	17″	79135T21	$407.17
9′9″	10′	16 3/4″	7981T12	367.98	16 3/4″	80015T52	918.47	17″	79135T22	504.47
11′9″	12′	16 3/4″	7981T21	434.73	16 3/4″	80015T61	1,096.39	17″	79135T23	576.30
13′9″	14′	16 3/4″	7981T13	499.60	16 3/4″	80015T53	1,280.86	17″	79135T24	647.85
15′9″	16′	16 3/4″	7981T14	560.31	16 3/4″	80015T54	1,421.73	17″	79135T25	690.59
With Walk-Through Extension										
7′9″	11′3″	21 3/4″	7981T41	378.08	21 3/4″	80015T55	1,129.13	22″	79135T31	510.28
9′9″	13′3″	21 3/4″	7981T42	441.09	21 3/4″	80015T56	1,237.53	22″	79135T32	575.15
11′9″	15′3″	21 3/4″	7981T51	494.61	21 3/4″	80015T62	1,475.55	22″	79135T33	641.34
13′9″	17′3″	21 3/4″	7981T43	544.32	21 3/4″	80015T57	1,629.81	22″	79135T34	732.29
15′9″	19′3″	21 3/4″	7981T44	617.20	21 3/4″	80015T58	1,770.70	22″	79135T35	784.63

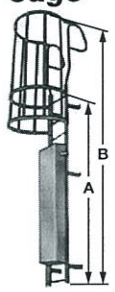
Steel Ladders with Welded-On Cage

- 300 lbs. rated capacity
- Meet OSHA requirements and ANSI A14.3

Ladders come in sections no longer than 7 ft. for easy handling, plus cage comes already welded to the ladder for quick assembly. Cages start 7 ft. above the bottom rung and extend beyond the top rung by 42″. Walk-through is 24″ wide and has a 42″ high handrail. Inside dimensions of the cage are 32 1/2″ Wd.×28″ Dp.; the flared bottom is 36 1/2″ Wd.×32″ Dp. Rungs are 16″ Wd.×3/4″ Dia. and have a ribbed surface. Side rails are 1/4″×2″×2″ steel angle. All have a gray powder-coated finish.

To assemble, bolt ladder sections together end-to-end (fasteners included). Welded-on mounting brackets have one 9/16″ dia. hole (fasteners not included) and offset the ladder 7″ for toe clearance.

Optional security cover prevents unauthorized access to ladders. Can be welded or bolted on (holes must be drilled) to open from either side (fasteners not included). Lockout is made of steel with a gray powder-coated finish and is 6′ Ht.×19 1/2″ Wd.×6″ Dp. The hasp accepts a padlock (not included) with a 3/8″ or smaller shackle diameter.



With Optional Security Cover

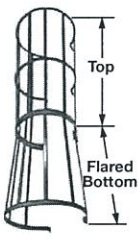
Height to Top Rung (A)	O'all Height with Cage (B)	Ladder Width		Each
12′1 1/2″	15′7 1/2″	20″	80265T21	$991.35
16′1 1/2″	19′7 1/2″	20″	80265T25	1,357.36
20′1 1/2″	23′7 1/2″	20″	80265T29	1,626.55
24′1 1/2″	27′7 1/2″	20″	80265T34	1,983.55
27′1 1/2″	30′7 1/2″	20″	80265T37	2,132.45
Optional Security Cover			79745T36	370.00

Steel Modular Cages

- Meet OSHA requirements and ANSI A14.3

OSHA requires a ladder cage when ladder heights are greater than 20 feet from the floor to the top rung. Steel modular cages let you create the cage that best fits your ladder.

Each section is fully welded and mounts to the side rails of stationary ladders (not to walls or other cages) that have an overall width of 16″ to 18″. Inside dimensions for top and mid sections are 32 1/2″ Wd.×28″ Dp.; the flared bottom section is 36 1/2″ Wd.×32″ Dp. All sections have a gray powder-coated finish and attach with clamps (included) that accommodate side rails 2″ wide or less. To get started, measure your ladder's height. Keep in mind that OSHA requires cages start between 7 and 8 ft. from the ground.



Top section should extend at least to the top of the ladder for hatch opening use. Top section is required for walk-through applications and should extend 42″ above the top rung. ***Mid sections*** extend the length of the cage, or can act as a top section for hatch opening use. ***Bottom section*** flares out for entry and exit.

Note: At least one top or mid section and one flared bottom section are required for every assembly.

		Each
7′ Top Section	8271T12	$321.30
2′ Mid Section	8271T14	180.60
3′ Mid Section	8271T16	189.00
4′ Mid Section	8271T18	203.70
4′ Flared Bottom Section	8271T21	207.90

Steel Ladders

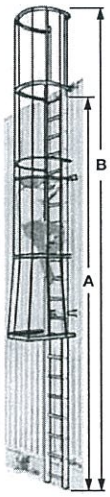
- 300 lbs. rated capacity
- Meet OSHA requirements and ANSI A14.3

Made of galvanized steel, these ladders resist corrosion and weathering. Side rails are 1 5/8″×2 7/16″ and rungs are 16″ Wd.×1″ Dia. with a knurled finish. Choose from ladders with and without a cage. OSHA requires a cage when the distance from the floor to the top rung is more than 20 feet.

Ladders with Cage—Include an unassembled cage (assembly hardware, splice kit, and mounting brackets are included). Flexibility in mounting and lower freight costs are the benefits of doing some of the assembly yourself.

Cages start between 7 and 8 ft. from the ground and extend beyond the highest rung by 42″ for a walk-through exit. Inside dimensions of cage are 27″ Wd.×30″ Dp.; flared bottom is 35″ Wd.×34″ Dp.

Optional security cover prevents unauthorized access. Lockout covers five rungs and is secured by two hooks at the top and a U-clamp at the bottom. Hasp accepts a padlock (not included) with a 3/8″ or smaller shackle diameter. Lockout is made of galvanized steel and is 66″ Ht.×19 1/2″ Wd.×2″ Dp.



Ladder with Cage

Ht. to Top Rung (A)	O'all Ladder Ht.	O'all Ht. with Cage (B)	Ladder Width		Each
10′6″	11′	14′1″	19 1/4″	8140T68	$765.35
12′6″	13′	16′1″	19 1/4″	8140T69	816.78
14′6″	15′	18′1″	19 1/4″	8140T67	953.46
16′6″	17′	20′1″	19 1/4″	8140T71	997.74
20′6″	21′	24′1″	19 1/4″	8140T66	1,270.53
24′6″	25′	28′1″	19 1/4″	8140T72	1,392.25
29′6″	30′	33′1″	19 1/4″	8140T86	1,647.28
Optional Security Cover				8140T78	153.06

Ladders without Cage—Get the height you need by connecting ladders of different lengths. Ladders connect without drilling by using the splice kit (sold separately) and mount to the wall with the mounting bracket kit (sold separately).

Splice kit includes splice plates and fasteners. Order one splice kit for every additional ladder section after the first.

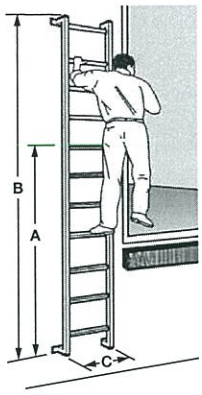
Mounting bracket kit comes with wall mounting brackets that offset the ladder 7″ for toe clearance (fasteners for mounting the brackets to the ladder are included). The brackets have two 13/32″×3/4″ slots for mounting to the wall (fasteners not included). Two kits are recommended for 4- to 8-ft. ladders; three kits are recommended for 10-ft. ladder.

Optional walk-through extension is 24″ wide with handrails that extend 42″.

Height to Top Rung (A)	O'all Height	O'all Width		Each
3′6″	4′	19 1/4″	8142T61	$93.94
4′6″	5′	19 1/4″	8142T62	114.50
7′6″	8′	19 1/4″	8142T63	182.55
9′6″	10′	19 1/4″	8142T64	228.36
Splice Kit			8142T67	16.84
Mounting Bracket Kit			8142T66	17.92
Optional Walk-Through Extension			8142T68	104.45

Dock & Wall-Mount Ladders

Wall-Mount Side Step Steel Dock Ladders

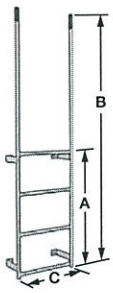


- 300 lbs. rated capacity
- Meet OSHA requirements

Mount these ladders wherever you need side entry. Ladders have four 19″ Wd.×1″ Dia. smooth rungs at the top for comfortable hand grips. Rungs are 19″ Wd.×2½″ Dp. and serrated for slip resistance. Ladders are offset 7¼″ for toe clearance and mount to the wall with four welded-on brackets that have one ⅜″ dia. mounting hole (fasteners not included). Color is gray enamel.

Max. Climbing Ht. (A)	O'all Ht. (B)	O'all Wd. (C)		Each
1′5″	5′6″	26⅛″	8177T11	$161.25
2′5″	6′6″	26⅛″	8177T12	173.53
3′5″	7′6″	26⅛″	8177T13	196.31
4′5″	8′6″	26⅛″	8177T14	210.16
5′5″	9′6″	26⅛″	8177T15	233.12
6′5″	10′6″	26⅛″	8177T16	245.39
7′5″	11′6″	26⅛″	8177T17	268.18
8′5″	12′6″	26⅛″	8177T18	287.45
9′5″	13′6″	26⅛″	8177T19	311.22

Wall-Mount Walk-Through Steel Dock Ladders

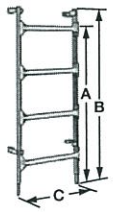


- 500 lbs. rated capacity
- Meet OSHA requirements

Made of 1¹⁄₁₆″ OD steel pipe with a yellow enamel finish, these are our highest capacity dock ladders. Walk-through is 18″ wide and the handrails have 4½″ long red vinyl handgrips. Rungs are 18″ Wd.× 1¹⁄₁₆″ Dp. and have a smooth surface. Units are offset 8″ for toe clearance. Ladders with 2′2″ to 4′2″ height to top rung have four mounting brackets; 5′2″ to 8′2″ height to top rung have six mounting brackets; and 9′2″ height to top rung have eight mounting brackets. All mounting brackets have one ⅜″ dia. mounting hole (fasteners not included).

Ht. to Top Rung (A)	O'all Ht. (B)	O'all Wd. (C)		Each
2′2″	5′8″	20″	8248T11	$109.71
3′2″	6′8″	20″	8248T12	140.97
4′2″	7′8″	20″	8248T13	172.26
5′2″	8′8″	20″	8248T14	203.58
6′2″	9′8″	20″	8248T15	234.91
7′2″	10′8″	20″	8248T16	258.82
8′2″	11′8″	20″	8248T17	291.87
9′2″	12′8″	20″	8248T18	325.89

Offset Rung Wall-Mount Steel Ladders



- 250 lbs. rated capacity
- Meet OSHA requirements

Mount these ladders to the wall and the rungs are offset 3″ for toe clearance; use the included mounting brackets and get 7½″ of toe clearance to meet OSHA requirements. All are galvanized steel and have built-in splices so you can connect ladders to create the length you need.

Rungs are 16″ Wd.×1⅜″ Dia. with a dimpled surface for slip resistance. Mounting brackets have one ¹³⁄₃₂″× ¾″ slotted hole (fasteners not included) and mount to the side rails. The 4-ft. ladder has four mounting brackets; the 5- and 8-ft. have six mounting brackets.

Note: The first rung of the ladder cannot be more than 12″ from the floor.

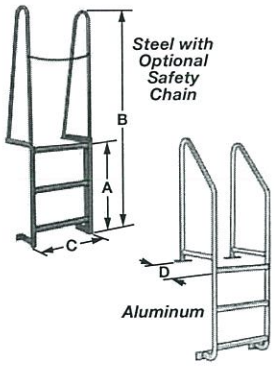
Ht. to Top Rung (A)	O'all Ht. (B)	O'all Wd. (C)		Each
3′6″	4′	19⅜″	7983T73	$75.67
4′6″	5′	19⅜″	7983T74	96.47
7′6″	8′	19⅜″	7983T75	133.93

Telescoping Ladder Extension Posts

Add safety and convenience to your wall and tank ladders with these telescoping posts. They are 1½″ square, extend 42″ above the ladder top, and lock in place to guide you and provide stability. A release lever lets you lower the post when it's not in use. Posts fit ¾″ to 1¼″ diameter rungs on ladders with up to 14″ center-to-center rung spacing. They mount to the top two rungs (hardware included).

Finish		Each
Safety Yellow Enamel Steel	8135T31	$343.94
Hot-Dipped Galvanized Steel	8135T32	466.67
Aluminum	8135T33	448.48
Type 304 Stainless Steel	8135T34	1,055.39

Dock-Mount Walk-Through Ladders



- 300 lbs. rated capacity
- Meet OSHA requirements

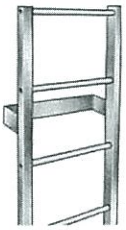
Install these ladders at dock and loading areas or at other raised levels in your facility. All have serrated rungs for slip resistance and handrails for easy entry and exit.

Steel ladders are offset 7¼″ for toe clearance. Rungs are 19″ Wd.×2½″ Dp. and handrails are 1″ diameter tubing. Walk-through is 19⅛″ wide. The two welded-on mounting angles at the top have two ⅜″ dia. mounting holes; the two welded-on mounting brackets at the bottom have one ⅜″ dia. mounting hole (fasteners not included). Color is gray. *Optional safety chain* stretches across ladder to deter access.

Aluminum ladders are offset 7″ for toe clearance. Rungs are 18″ Wd.×2″ Dp. Handrails are 1¹¹⁄₁₆″ diameter tubing. Walk-through is 18″ wide. All units have welded-on mounting brackets with two ⁹⁄₁₆″ dia. mounting holes (fasteners not included). Ladders up to 5′6″ height to top rung have four mounting brackets; all others have six mounting brackets.

Ht. to Top Rung (A)	O'all Ht. (B)	O'all Wd. (C)	Dp. (D)		Each
Steel					
2′6″	6′	24″	16″	8190T12	$186.47
3′6″	7′	24″	16″	8190T13	206.38
4′6″	8′	24″	16″	8190T14	230.28
5′6″	9′	24″	16″	8190T15	244.79
6′6″	10′	24″	16″	8190T16	253.85
7′6″	11′	24″	16″	8190T17	277.42
8′6″	12′	24″	16″	8190T18	297.37
9′6″	13′	24″	16″	8190T19	331.36
Optional Safety Chain for Steel Ladders				8190T51	51.63
Aluminum					
2′6½″	6′	25½″	24″	79435T61	337.35
3′6½″	7′	25½″	24″	79435T71	379.71
4′6½″	8′	25½″	24″	79435T81	422.05
5′6½″	9′	25½″	24″	79435T82	492.08
6′6½″	10′	25½″	24″	79435T83	566.03
7′6½″	11′	25½″	24″	79435T84	586.96
8′6½″	12′	25½″	24″	79435T85	634.44
9′6½″	13′	25½″	24″	79435T86	678.01

Versatile-Mount Steel Ladder



Ladder with Optional Mounting Bracket

- 300 lbs. rated capacity
- Meet OSHA requirements (when used with mounting brackets) and ANSI A14.3

Mount these ladders to walls, tanks, and pipes or connect multiple ladders for more height. Made of galvanized steel, rungs are 16″ Wd.×1″ Dia. with a knurled finish and side rails are 1⅝″ Wd.×2⁷⁄₁₆″ Thick. Ladders can be mounted or connected to another ladder with a mounting bracket (sold separately).

Mounting Bracket— Provides 7″ for toe clearance as required to meet OSHA requirements. Hardware is included to mount the bracket to the ladder; however, bracket must be drilled to the desired bolt hole size for mounting to a surface (fasteners not included). Bracket is zinc electro-galvanized steel. Each ladder requires two brackets (one for the top and one for the bottom). If connecting multiple ladders, one mounting bracket is required for each additional ladder section.

Height to Top Rung	O'all Ht.	O'all Wd.		Each
7′6″	8′	19¼″	8142T63	$182.55
9′6″	10′	19¼″	8142T64	228.36
Mounting Bracket			8073T5	51.58

Antislip Ladder Rung Covers

Weld these covers to the rungs of your wall and tank ladders for excellent slip resistance. Covers are U-shaped and made of 16-ga. galvanized steel with an aluminum oxide grit surface. Fit square and round rungs. Cut the 4- and 10-ft. lengths to the size you need.

For Rung Depth/Dia.	*16″ Length*	Each	*4-ft. Length*	Each	*10-ft. Length*	Each
¾″	8115T91	$19.09	8115T96	$41.11	8115T94	$96.11
1″	8115T92	21.65	8115T97	47.89	8115T95	112.96

- **Part Number:** 1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** D
- **Subpart Title:** Walking-Working Surfaces
- **Standard Number:** 1910.24
- **Title:** Fixed industrial stairs.

1910.24(a)

"Application of requirements." This section contains specifications for the safe design and construction of fixed general industrial stairs. This classification includes interior and exterior stairs around machinery, tanks, and other equipment, and stairs leading to or from floors, platforms, or pits. This section does not apply to stairs used for fire exit purposes, to construction operations to private residences, or to articulated stairs, such as may be installed on floating roof tanks or on dock facilities, the angle of which changes with the rise and fall of the base support.

..1910.24(b)

1910.24(b)

"Where fixed stairs are required." Fixed stairs shall be provided for access from one structure level to another where operations necessitate regular travel between levels, and for access to operating platforms at any equipment which requires attention routinely during operations. Fixed stairs shall also be provided where access to elevations is daily or at each shift for such purposes as gauging, inspection, regular maintenance, etc., where such work may expose employees to acids, caustics, gases, or other harmful substances, or for which purposes the carrying of tools or equipment by hand is normally required. (It is not the intent of this section to preclude the use of fixed ladders for access to elevated tanks, towers, and similar structures, overhead traveling cranes, etc., where the use of fixed ladders is common practice.) Spiral stairways shall not be permitted except for special limited usage and secondary access situations where it is not practical to provide a conventional stairway. Winding stairways may be installed on tanks and similar round structures where the diameter of the structure is not less than five (5) feet.

1910.24(c)

"Stair strength." Fixed stairways shall be designed and constructed to carry a load of five times the normal live load anticipated but never of less strength than to carry safely a moving concentrated load of 1,000 pounds.

1910.24(d)

"Stair width." Fixed stairways shall have a minimum width of 22 inches.

1910.24(e)

"Angle of stairway rise." Fixed stairs shall be installed at angles to the horizontal of between 30 deg. and 50 deg. Any uniform combination of rise/tread dimensions may be used that will result in a stairway at an angle to the horizontal within the permissible range. Table D-1 gives rise/tread dimensions which will produce a stairway within the permissible range, stating the angle to the horizontal produced by each combination. However, the rise/tread combinations are not limited to those given in Table D-1.

Table D-1

Angle to horizontal	Rise (in inches)	Tread run (in inches)
30 deg. 35'	6 1/2	11
32 deg. 08'	6 3/4	10 3/4
33 deg. 41'	7	10 1/2
35 deg. 16'	7 1/4	10 1/4
36 deg. 52'	7 1/2	10
38 deg. 29'	7 3/4	9 3/4
40 deg. 08'	8	9 1/2
41 deg. 44'	8 1/4	9 1/4
43 deg. 22'	8 1/2	9
45 deg. 00'	8 3/4	8 3/4
46 deg. 38'	9	8 1/2
48 deg. 16'	9 1/4	8 1/4
49 deg. 54'	9 1/2	8

..1910.24(f)

1910.24(f)

"Stair treads." All treads shall be reasonably slip-resistant and the nosings shall be of nonslip finish. Welded bar grating treads without nosings are acceptable providing the leading edge can be readily identified by personnel descending the stairway and provided the tread is serrated or is of definite nonslip design. Rise height and tread width shall be uniform throughout any flight of stairs including any foundation structure used as one or more treads of the stairs.

1910.24(g)

"Stairway platforms." Stairway platforms shall be no less than the width of a stairway and a minimum of 30 inches in length measured in the direction of travel.

1910.24(h)

"Railings and handrails." Standard railings shall be provided on the open sides of all exposed stairways and stair platforms. Handrails shall be provided on at least one side of closed stairways preferably on the right side descending. Stair railings and handrails shall be installed in accordance with the provisions of 1910.23.

1910.24(i)

"Vertical clearance." Vertical clearance above any stair tread to an overhead obstruction shall be at least 7 feet measured from the leading edge of the tread.

[39 FR 23502, June 27, 1974, as amended at 43 FR 49744, Oct. 24, 1978; 49 FR 5321, Feb. 10, 1984]

Next Standard (1910.25)

Regulations (Standards - 29 CFR) - Table of Contents

- **Part Number:** 1926
- **Part Title:** Safety and Health Regulations for Construction
- **Subpart:** R
- **Subpart Title:** Steel Erection
- **Standard Number:** 1926 Subpart R App G
- **Title:** 1926.502 (b)-(e) Fall Protection Systems Criteria and Practices.

Appendix G to Subpart R -- § 1926.502 (b)-(e) Fall Protection Systems Criteria and Practices

(b)

"Guardrail systems." Guardrail systems and their use shall comply with the following provisions:

(b)(1)

Top edge height of top rails, or equivalent guardrail system members, shall be 42 inches (1.1 m) plus or minus 3 inches (8 cm) above the walking/working level. When conditions warrant, the height of the top edge may exceed the 45-inch height, provided the guardrail system meets all other criteria of this paragraph (§ 1926.502(b)).

Note: When employees are using stilts, the top edge height of the top rail, or equivalent member, shall be increased an amount equal to the height of the stilts.

(b)(2)

Midrails, screens, mesh, intermediate vertical members, or equivalent intermediate structural members shall be installed between the top edge of the guardrail system and the walking/working surface when there is no wall or parapet wall at least 21 inches (53 cm) high.

(b)(2)(i)

Midrails, when used, shall be installed at a height midway between the top edge of the guardrail system and the walking/working level.

(b)(2)(ii)

Screens and mesh, when used, shall extend from the top rail to the walking/working level and along the entire opening between top rail supports.

(b)(2)(iii)

Intermediate members (such as balusters), when used between posts, shall be not more than 19 inches (48 cm) apart.

(b)(2)(iv)

Other structural members (such as additional midrails and architectural panels) shall be installed such that there are no openings in the guardrail system that are more than 19 inches (.5 m) wide.

(b)(3)

Guardrail systems shall be capable of withstanding, without failure, a force of at least 200 pounds (890 N) applied within 2 inches (5.1 cm) of the top edge, in any outward or downward direction, at any point along the top edge.

(b)(4)

When the 200 pound (890 N) test load specified in paragraph (b)(3) of this section (§ 1926.502) is applied in a downward direction, the top edge of the guardrail shall not deflect to a height less than 39 inches (1.0 m) above the walking/working level. Guardrail system components selected and constructed in accordance with the appendix B to subpart M of this part will be deemed to meet this requirement.

(b)(5)

Midrails, screens, mesh, intermediate vertical members, solid panels, and equivalent structural members shall be capable of withstanding, without failure, a force of at least 150 pounds (666 N) applied in any downward or outward direction at any point along the midrail or other member.

(b)(6)

Guardrail systems shall be so surfaced as to prevent injury to an employee from punctures or lacerations, and to prevent snagging of clothing.

(b)(7)

The ends of all top rails and midrails shall not overhang the terminal posts, except where such overhang does not constitute a projection hazard.

(b)(8)

Steel banding and plastic banding shall not be used as top rails or midrails.

(b)(9)

Top rails and midrails shall be at least one-quarter inch (0.6 cm) nominal diameter or thickness to prevent cuts and lacerations. If wire rope is used for top rails, it shall be flagged at not more than 6-foot intervals with high-visibility material.

(b)(10)

When guardrail systems are used at hoisting areas, a chain, gate or removable guardrail section shall be placed across the access opening between guardrail sections when hoisting operations are not taking place.

(b)(11)

When guardrail systems are used at holes, they shall be erected on all unprotected sides or edges of the hole.

(b)(12)

When guardrail systems are used around holes used for the passage of materials, the hole shall have not more than two sides provided with removable guardrail sections to allow the passage of materials. When the hole is not in use, it shall be closed over with a cover, or a guardrail system shall be provided along all unprotected sides or edges.

(b)(13)

When guardrail systems are used around holes which are used as points of access (such as ladderways), they shall be provided with a gate, or be so offset that a person cannot walk directly into the hole.

(b)(14)

Guardrail systems used on ramps and runways shall be erected along each unprotected side or edge.

(b)(15)

Manila, plastic or synthetic rope being used for top rails or midrails shall be inspected as frequently as necessary to ensure that it continues to meet the strength requirements of paragraph (b)(3) of this section (§ 1926.502).

(c)

Safety net systems. Safety net systems and their use shall comply with the following provisions:

(c)(1)

Safety nets shall be installed as close as practicable under the walking/working surface on which employees are working, but in no case more than 30 feet (9.1 m) below such level. When nets are used on bridges, the potential fall area from the walking/working surface to the net shall be unobstructed.

(c)(2)

Safety nets shall extend outward from the outermost projection of the work surface as follows:

Vertical distance from working level to horizontal plane of net	Minimum required horizontal distance of outer edge of net from the edge of the working surface
Up to 5 feet	8 feet
More than 5 feet up to 10 feet	10 feet
More than 10 feet	13 feet

(c)(3)

Safety nets shall be installed with sufficient clearance under them to prevent contact with the surface or structures below when subjected to an impact force equal to the drop test specified in paragraph (4) of this section [§ 1926.502].

(c)(4)

Safety nets and their installations shall be capable of absorbing an impact force equal to that produced by the drop test specified in paragraph (c)(4)(i) of this section [§ 1926.502].

(c)(4)(i)

Except as provided in paragraph (c)(4)(ii) of this section (§ 1926.502), safety nets and safety net installations shall be drop-tested at the jobsite after initial installation and before being used as a fall protection system, whenever relocated, after major repair, and at 6-month intervals if left in one place. The drop-test shall consist of a 400 pound (180 kg) bag of sand 30+ or -2 inches (76+ or -5 cm) in diameter dropped into the net from the highest walking/working surface at which employees are exposed to fall hazards, but not from less than 42 inches (1.1 m) above that level.

(c)(4)(ii)

When the employer can demonstrate that it is unreasonable to perform the drop-test required by paragraph (c)(4)(i) of this section (§ 1926.502), the employer (or a designated competent person) shall certify that the net and net installation is in compliance with the provisions of paragraphs (c)(3) and (c)(4)(i) of this section (§ 1926.502) by preparing a certification record prior to the net being used as a fall protection system. The certification record must include an identification of the net and net installation for which the certification record is being prepared; the date that it was determined that the identified net and net installation were in compliance with paragraph (c)(3) of this section (§ 1926.502) and the signature of the person making the determination and certification. The most recent certification record for each net and net installation shall be available at the jobsite for inspection.

(c)(5)

Defective nets shall not be used. Safety nets shall be inspected at least once a week for wear, damage, and other deterioration. Defective components shall be removed from service. Safety nets shall also be inspected after any occurrence which could affect the integrity of the safety net system.

(c)(6)

Materials, scrap pieces, equipment, and tools which have fallen into the safety net shall be removed as soon as possible from the net and at least before the next work shift.

(c)(7)

The maximum size of each safety net mesh opening shall not exceed 36 square inches (230 cm) nor be longer than 6 inches (15 cm) on any side, and the opening, measured center-to-center of mesh ropes or webbing, shall not be longer than 6 inches (15 cm). All mesh crossings shall be secured to prevent enlargement of the mesh opening.

(c)(8)

Each safety net (or section of it) shall have a border rope for webbing with a minimum breaking strength of 5,000 pounds (22.2 kN).

(c)(9)

Connections between safety net panels shall be as strong as integral net components and shall be spaced not more than 6 inches (15 cm) apart.

(d)

"Personal fall arrest systems." Personal fall arrest systems and their use shall comply with the provisions set forth below. Effective January 1, 1998, body belts are not acceptable as part of a personal fall arrest system.

Note: The use of a body belt in a positioning device system is acceptable and is regulated under paragraph (e) of this section (§ 1926.502).

(d)(1)

Connectors shall be drop forged, pressed or formed steel, or made of equivalent materials.

(d)(2)

Connectors shall have a corrosion-resistant finish, and all surfaces and edges shall be smooth to prevent damage to interfacing parts of the system.

(d)(3)

Dee-rings and snaphooks shall have a minimum tensile strength of 5,000 pounds (22.2 kN).

(d)(4)

Dee-rings and snaphooks shall be proof-tested to a minimum tensile load of 3,600 pounds (16 kN) without cracking, breaking, or taking permanent deformation.

(d)(5)

Snaphooks shall be sized to be compatible with the member to which they are connected to prevent unintentional disengagement of the snaphook by depression of the snaphook keeper by the connected member, or shall be a locking type snaphook designed and used to prevent disengagement of the snaphook by the contact of the snaphook keeper by the connected member. Effective January 1, 1998, only locking type snaphooks shall be used.

(d)(6)

Unless the snaphook is a locking type and designed for the following connections, snaphooks shall not be engaged:

(d)(6)(i)

directly to webbing, rope or wire rope;

(d)(6)(ii)

to each other;

(d)(6)(iii)

to a dee-ring to which another snaphook or other connector is attached;

(d)(6)(iv)

to a horizontal lifeline; or

(d)(6)(v)

to any object which is incompatibly shaped or dimensioned in relation to the snaphook such that unintentional disengagement could occur by the connected object being able to depress the snaphook keeper and release itself.

(d)(7)

On suspended scaffolds or similar work platforms with horizontal lifelines which may become vertical lifelines, the devices used to connect to a horizontal lifeline shall be capable of locking in both directions on the lifeline.

(d)(8)

Horizontal lifelines shall be designed, installed, and used, under the supervision of a qualified person, as part of a complete personal fall arrest system, which maintains a safety factor of at least two.

(d)(9)

Lanyards and vertical lifelines shall have a minimum breaking strength of 5,000 pounds (22.2 kN).

(d)(10)(i)

Except as provided in paragraph (d)(10)(ii) of this section [§ 1926.502], when vertical lifelines are used, each employee shall be attached to a separate lifeline.

(d)(10)(ii)

During the construction of elevator shafts, two employees may be attached to the same lifeline in the hoistway, provided both employees are working atop a false car that is equipped with guardrails; the strength of the lifeline is 10,000 pounds [5,000 pounds per employee attached] (44.4 kN); and all other criteria specified in this paragraph for lifelines have been met.

(d)(11)

Lifelines shall be protected against being cut or abraded.

(d)(12)

Self-retracting lifelines and lanyards which automatically limit free fall distance to 2 feet (0.61 m) or less shall be capable of sustaining a minimum tensile load of 3,000 pounds (13.3 kN) applied to the device with the lifeline or lanyard in the fully extended position.

(d)(13)

Self-retracting lifelines and lanyards which do not limit free fall distance to 2 feet (0.61 m) or less, ripstitch lanyards, and tearing and deforming lanyards shall be capable of sustaining a minimum tensile load of 5,000 pounds (22.2 kN) applied to the device with the lifeline or lanyard in the fully extended position.

(d)(14)

Ropes and straps (webbing) used in lanyards, lifelines, and strength components of body belts and body harnesses shall be made from synthetic fibers.

(d)(15)

Anchorages used for attachment of personal fall arrest equipment shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 5,000 pounds (22.2 kN) per employee attached, or shall be designed, installed, and used as follows:

(d)(15)(i)

as part of a complete personal fall arrest system which maintains a safety factor of at least two; and

(d)(15)(ii)

under the supervision of a qualified person.

(d)(16)

Personal fall arrest systems, when stopping a fall, shall:

(d)(16)(i)

limit maximum arresting force on an employee to 900 pounds (4 kN) when used with a body belt;

(d)(16)(ii)

limit maximum arresting force on an employee to 1,800 pounds (8 kN) when used with a body harness;

(d)(16)(iii)

be rigged such that an employee can neither free fall more than 6 feet (1.8 m), nor contact any lower level;

(d)(16)(iv)

bring an employee to a complete stop and limit maximum deceleration distance an employee travels to 3.5 feet (1.07 m); and,

(d)(16)(v)

have sufficient strength to withstand twice the potential impact energy of an employee free falling a distance of 6 feet (1.8 m), or the free fall distance permitted by the system, whichever is less.

Note: If the personal fall arrest system meets the criteria and protocols contained in Appendix C to subpart M, and if the system is being used by an employee having a combined person and tool weight of less than 310 pounds (140 kg), the system will be considered to be in compliance with the provisions of paragraph (d)(16) of this section [§ 1926.502]. If the system is used by an employee having a combined tool and body weight of 310 pounds (140 kg) or more, then the employer must appropriately modify the criteria and protocols of the Appendix to provide proper protection for such heavier weights, or the system will not be deemed to be in compliance with the requirements of paragraph (d)(16) of this section (§ 1926.502).

(d)(17)

The attachment point of the body belt shall be located in the center of the wearer's back. The attachment point of the body harness shall be located in the center of the wearer's back near shoulder level, or above the wearer's head.

(d)(18)

Body belts, harnesses, and components shall be used only for employee protection (as part of a personal fall arrest system or positioning device system) and not to hoist materials.

(d)(19)

Personal fall arrest systems and components subjected to impact loading shall be immediately removed from service and shall not be used again for employee protection until inspected and determined by a competent person to be undamaged and suitable for reuse.

(d)(20)

The employer shall provide for prompt rescue of employees in the event of a fall or shall assure that employees are able to rescue themselves.

(d)(21)

Personal fall arrest systems shall be inspected prior to each use for wear, damage and other deterioration, and defective components shall be removed from service.

(d)(22)

Body belts shall be at least one and five-eighths ($1^{5/8}$) inches (4.1 cm) wide.

(d)(23)

Personal fall arrest systems shall not be attached to guardrail systems, nor shall they be attached to hoists except as specified in other subparts of this Part.

(d)(24)

When a personal fall arrest system is used at hoist areas, it shall be rigged to allow the movement of the employee only as far as the edge of the walking/working surface.

(e)

Positioning device systems. Positioning device systems and their use shall conform to the following provisions:

(e)(1)

Positioning devices shall be rigged such that an employee cannot free fall more than 2 feet (.9 m).

(e)(2)

Positioning devices shall be secured to an anchorage capable of supporting at least twice the potential impact load of an employee's fall or 3,000 pounds (13.3 kN), whichever is greater.

(e)(3)

Connectors shall be drop forged, pressed or formed steel, or made of equivalent materials.

(e)(4)

Connectors shall have a corrosion-resistant finish, and all surfaces and edges shall be smooth to prevent damage to interfacing parts of this system.

(e)(5)

Connecting assemblies shall have a minimum tensile strength of 5,000 pounds (22.2 kN)

(e)(6)

Dee-rings and snaphooks shall be proof-tested to a minimum tensile load of 3,600 pounds (16 kN) without cracking, breaking, or taking permanent deformation.

(e)(7)

Snaphooks shall be sized to be compatible with the member to which they are connected to prevent unintentional disengagement of the snaphook by depression of the snaphook keeper by the connected member, or shall be a locking type snaphook designed and used to prevent disengagement of the snaphook by the contact of the snaphook keeper by the connected member. As of January 1, 1998, only locking type snaphooks shall be used.

(e)(8)

Unless the snaphook is a locking type and designed for the following connections, snaphooks shall not be engaged:

(e)(8)(i)

directly to webbing, rope or wire rope;

(e)(8)(ii)

to each other;

(e)(8)(iii)

to a dee-ring to which another snaphook or other connector is attached;

(e)(8)(iv)

to a horizontal lifeline; or to depress the snaphook keeper and release itself.

(e)(8)(v)

to any object which is incompatibly shaped or dimensioned in relation to the snaphook such that unintentional disengagement could occur by the connected object being able to depress the snaphook keeper and release itself.

(e)(9)

Positioning device systems shall be inspected prior to each use for wear, damage, and other deterioration, and defective components shall be removed from service.

(e)(10)

Body belts, harnesses, and components shall be used only for employee protection (as part of a personal fall arrest system or positioning device system) and not to hoist materials.

[66 FR 5277, Jan. 18, 2001]

Next Standard (1926 Subpart R App H)

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- **Part Number:** 1910
- **Part Title:** Occupational Safety and Health Standards
- **Subpart:** D
- **Subpart Title:** Walking-Working Surfaces
- **Standard Number:** 1910.23
- **Title:** Guarding floor and wall openings and holes.

1910.23(a)

"Protection for floor openings."

1910.23(a)(1)

Every stairway floor opening shall be guarded by a standard railing constructed in accordance with paragraph (e) of this section. The railing shall be provided on all exposed sides (except at entrance to stairway). For infrequently used stairways where traffic across the opening prevents the use of fixed standard railing (as when located in aisle spaces, etc.), the guard shall consist of a hinged floor opening cover of standard strength and construction and removable standard railings on all exposed sides (except at entrance to stairway).

1910.23(a)(2)

Every ladderway floor opening or platform shall be guarded by a standard railing with standard toeboard on all exposed sides (except at entrance to opening), with the passage through the railing either provided with a swinging gate or so offset that a person cannot walk directly into the opening.

1910.23(a)(3)

Every hatchway and chute floor opening shall be guarded by one of the following:

..1910.23(a)(3)(i)

1910.23(a)(3)(i)

Hinged floor opening cover of standard strength and construction equipped with standard railings or permanently attached thereto so as to leave only one exposed side. When the opening is not in use, the cover shall be closed or the exposed side shall be guarded at both top and intermediate positions by removable standard railings.

1910.23(a)(3)(ii)

A removable railing with toeboard on not more than two sides of the opening and fixed standard railings with toeboards on all other exposed sides. The removable railings shall be kept in place when the opening is not in use.

Where operating conditions necessitate the feeding of material into any hatchway or chute opening, protection shall be provided to prevent a person from falling through the opening.

1910.23(a)(4)

Every skylight floor opening and hole shall be guarded by a standard skylight screen or a fixed standard railing on all exposed sides.

1910.23(a)(5)

Every pit and trapdoor floor opening, infrequently used, shall be guarded by a floor opening cover of standard strength and construction. While the cover is not in place, the pit or trap opening shall be constantly attended by someone or shall be protected on all exposed sides by removable standard railings.

1910.23(a)(6)

Every manhole floor opening shall be guarded by a standard manhole cover which need not be hinged in place. While the cover is not in place, the manhole opening shall be constantly attended by someone or shall be protected by removable standard railings.

1910.23(a)(7)

Every temporary floor opening shall have standard railings, or shall be constantly attended by someone.

..1910.23(a)(8)

1910.23(a)(8)

Every floor hole into which persons can accidentally walk shall be guarded by either:

1910.23(a)(8)(i)

A standard railing with standard toeboard on all exposed sides, or

1910.23(a)(8)(ii)

A floor hole cover of standard strength and construction. While the cover is not in place, the floor hole shall be constantly attended by someone or shall be protected by a removable standard railing.

1910.23(a)(9)

Every floor hole into which persons cannot accidentally walk (on account of fixed machinery, equipment, or walls) shall be protected by a cover that leaves no openings more than 1 inch wide. The cover shall be securely held in place to prevent tools or materials from falling through.

1910.23(a)(10)

Where doors or gates open directly on a stairway, a platform shall be provided, and the swing of the door shall not reduce the effective width to less than 20 inches.

1910.23(b)

"Protection for wall openings and holes."

1910.23(b)(1)

Every wall opening from which there is a drop of more than 4 feet shall be guarded by one of the following:

..1910.23(b)(1)(i)

1910.23(b)(1)(i)

Rail, roller, picket fence, half door, or equivalent barrier. Where there is exposure below to falling materials, a removable toe board or the equivalent shall also be provided. When the opening is not in use for handling materials, the guard shall be kept in position regardless of a door on the opening. In addition, a grab handle shall be provided on each side of the opening with its center approximately 4 feet above floor level and of standard strength and mounting.

1910.23(b)(1)(ii)

Extension platform onto which materials can be hoisted for handling,and which shall have side rails or equivalent guards of standard specifications.

1910.23(b)(2)

Every chute wall opening from which there is a drop of more than 4 feet shall be guarded by one or more of the barriers specified in paragraph (b)(1) of this section or as required by the conditions.

1910.23(b)(3)

Every window wall opening at a stairway landing, floor, platform, or balcony, from which there is a drop of more than 4 feet, and where the bottom of the opening is less than 3 feet above the platform or landing, shall be guarded by standard slats, standard grill work (as specified in paragraph (e)(11) of this section), or standard railing.

Where the window opening is below the landing, or platform, a standard toe board shall be provided.

1910.23(b)(4)

Every temporary wall opening shall have adequate guards but these need not be of standard construction.

..1910.23(b)(5)

1910.23(b)(5)

Where there is a hazard of materials falling through a wall hole, and the lower edge of the near side of the hole is less than 4 inches above the floor, and the far side of the hole more than 5 feet above the next lower level, the hole shall be protected by a standard toeboard, or an enclosing screen either of solid construction, or as specified in paragraph (e)(11) of this section.

1910.23(c)

"Protection of open-sided floors, platforms, and runways."

1910.23(c)(1)

Every open-sided floor or platform 4 feet or more above adjacent floor or ground level shall be guarded by a standard railing (or the equivalent as specified in paragraph (e)(3) of this section) on all open sides except where there is entrance to a ramp, stairway, or fixed ladder. The railing shall be provided with a toeboard wherever, beneath the open sides,

1910.23(c)(1)(i)

Persons can pass,

1910.23(c)(1)(ii)

There is moving machinery, or

1910.23(c)(1)(iii)

There is equipment with which falling materials could create a hazard.

1910.23(c)(2)

Every runway shall be guarded by a standard railing (or the equivalent as specified in paragraph (e)(3) of this section) on all open sides 4 feet or more above floor or ground level. Wherever tools, machine parts, or materials are likely to be used on the runway, a toeboard shall also be provided on each exposed side.

Runways used exclusively for special purposes (such as oiling, shafting, or filling tank cars) may have the railing on one side omitted where operating conditions necessitate such omission, providing the falling hazard is minimized by using a runway of not less than 18 inches wide. Where persons entering upon runways become thereby exposed to machinery, electrical equipment, or other danger not a falling hazard, additional guarding than is here specified may be essential for protection.

..1910.23(c)(3)

1910.23(c)(3)

Regardless of height, open-sided floors, walkways, platforms, or runways above or adjacent to dangerous equipment, pickling or galvanizing tanks, degreasing units, and similar hazards shall be guarded with a standard railing and toe board.

1910.23(d)

"Stairway railings and guards."

1910.23(d)(1)

Every flight of stairs having four or more risers shall be equipped with standard stair railings or standard handrails as specified in paragraphs (d)(1)(i) through (v) of this section, the width of the stair to be measured clear of all obstructions except handrails:

1910.23(d)(1)(i)

On stairways less than 44 inches wide having both sides enclosed, at least one handrail, preferably on the right side descending.

1910.23(d)(1)(ii)

On stairways less than 44 inches wide having one side open, at least one stair railing on open side.

1910.23(d)(1)(iii)

On stairways less than 44 inches wide having both sides open, one stair railing on each side.

1910.23(d)(1)(iv)

On stairways more than 44 inches wide but less than 88 inches wide, one handrail on each enclosed side and one stair railing on each open side.

1910.23(d)(1)(v)

On stairways 88 or more inches wide, one handrail on each enclosed side, one stair railing on each open side, and one intermediate stair railing located approximately midway of the width.

..1910.23(d)(2)

1910.23(d)(2)

Winding stairs shall be equipped with a handrail offset to prevent walking on all portions of the treads having width less than 6 inches.

1910.23(e)

"Railing, toe boards, and cover specifications."

1910.23(e)(1)

A standard railing shall consist of top rail, intermediate rail, and posts, and shall have a vertical height of 42 inches nominal from upper surface of top rail to floor, platform, runway, or ramp level. The top rail shall be smooth-surfaced throughout the length of the railing. The intermediate rail shall be approximately halfway between the top rail and the floor, platform, runway, or ramp. The ends of the rails shall not overhang the terminal posts except where such overhang does not constitute a projection hazard.

1910.23(e)(2)

A stair railing shall be of construction similar to a standard railing but the vertical height shall be not more than 34 inches nor less than 30 inches from upper surface of top rail to surface of tread in line with face of riser at forward edge of tread.

1910.23(e)(3)

[Reserved]

1910.23(e)(3)(i)

For wood railings, the posts shall be of at least 2-inch by 4-inch stock spaced not to exceed 6 feet; the top and intermediate rails shall be of at least 2-inch by 4-inch stock. If top rail is made of two right-angle pieces of 1-inch by 4-inch stock, posts may be spaced on 8-foot centers, with 2-inch by 4-inch intermediate rail.

..1910.23(e)(3)(ii)

1910.23(e)(3)(ii)

For pipe railings, posts and top and intermediate railings shall be at least 1 1/2 inches nominal diameter with posts spaced not more than 8 feet on centers.

1910.23(e)(3)(iii)

For structural steel railings, posts and top and intermediate rails shall be of 2-inch by 2-inch by 3/8-inch angles or other metal shapes of equivalent bending strength with posts spaced not more than 8 feet on centers.

1910.23(e)(3)(iv)

The anchoring of posts and framing of members for railings of all types shall be of such construction that the completed structure shall be capable of withstanding a load of at least 200 pounds applied in any direction at any point on the top rail.

1910.23(e)(3)(v)

Other types, sizes, and arrangements of railing construction are acceptable provided they meet the following conditions:

1910.23(e)(3)(v)(a)

A smooth-surfaced top rail at a height above floor, platform, runway, or ramp level of 42 inches nominal;

1910.23(e)(3)(v)(b)

A strength to withstand at least the minimum requirement of 200 pounds top rail pressure;

1910.23(e)(3)(v)(c)

Protection between top rail and floor, platform, runway, ramp, or stair treads, equivalent at least to that afforded by a standard intermediate rail;

..1910.23(e)(4)

1910.23(e)(4)

A standard toeboard shall be 4 inches nominal in vertical height from its top edge to the level of the floor, platform, runway, or ramp. It shall be securely fastened in place and with not more than 1/4-inch clearance above floor level. It may be made of any substantial material either solid or with openings not over 1 inch in greatest dimension.

Where material is piled to such height that a standard toeboard does not provide protection, paneling from floor to intermediate rail, or to top rail shall be provided.

1910.23(e)(5)

1910.23(e)(5)(i)

A handrail shall consist of a lengthwise member mounted directly on a wall or partition by means of brackets attached to the lower side of the handrail so as to offer no obstruction to a smooth surface along the top and both sides of the handrail. The handrail shall be of rounded or other section that will furnish an adequate handhold for anyone grasping it to avoid falling. The ends of the handrail should be turned in to the supporting wall or otherwise arranged so as not to constitute a projection hazard.

1910.23(e)(5)(ii)

The height of handrails shall be not more than 34 inches nor less than 30 inches from upper surface of handrail to surface of tread in line

with face of riser or to surface of ramp.

1910.23(e)(5)(iii)

The size of handrails shall be: When of hardwood, at least 2 inches in diameter; when of metal pipe, at least 1 1/2 inches in diameter. The length of brackets shall be such as will give a clearance between handrail and wall or any projection thereon of at least 3 inches. The spacing of brackets shall not exceed 8 feet.

..1910.23(e)(5)(iv)

1910.23(e)(5)(iv)

The mounting of handrails shall be such that the completed structure is capable of withstanding a load of at least 200 pounds applied in any direction at any point on the rail.

1910.23(e)(6)

All handrails and railings shall be provided with a clearance of not less than 3 inches between the handrail or railing and any other object.

1910.23(e)(7)

Floor opening covers may be of any material that meets the following strength requirements:

1910.23(e)(7)(i)

Trench or conduit covers and their supports, when located in plant roadways, shall be designed to carry a truck rear-axle load of at least 20,000 pounds.

1910.23(e)(7)(ii)

Manhole covers and their supports, when located in plant roadways, shall comply with local standard highway requirements if any; otherwise, they shall be designed to carry a truck rear-axle load of at least 20,000 pounds.

1910.23(e)(7)(iii)

The construction of floor opening covers may be of any material that meets the strength requirements. Covers projecting not more than 1 inch above the floor level may be used providing all edges are chamfered to an angle with the horizontal of not over 30 degrees. All hinges, handles, bolts, or other parts shall set flush with the floor or cover surface.

..1910.23(e)(8)

1910.23(e)(8)

Skylight screens shall be of such construction and mounting that they are capable of withstanding a load of at least 200 pounds applied perpendicularly at any one area on the screen. They shall also be of such construction and mounting that under ordinary loads or impacts, they will not deflect downward sufficiently to break the glass below them. The construction shall be of grillwork with openings not more than 4 inches long or of slatwork with openings not more than 2 inches wide with length unrestricted.

1910.23(e)(9)

Wall opening barriers (rails, rollers, picket fences, and half doors) shall be of such construction and mounting that, when in place at the opening, the barrier is capable of withstanding a load of at least 200 pounds applied in any direction (except upward) at any point on the top rail or corresponding member.

1910.23(e)(10)

Wall opening grab handles shall be not less than 12 inches in length and shall be so mounted as to give 3 inches clearance from the side framing of the wall opening. The size, material, and anchoring of the grab handle shall be such that the completed structure is capable of withstanding a load of at least 200 pounds applied in any direction at any point of the handle.

1910.23(e)(11)

Wall opening screens shall be of such construction and mounting that they are capable of withstanding a load of at least 200 pounds applied horizontally at any point on the near side of the screen. They may be of solid construction, of grillwork with openings not more than 8 inches long, or of slatwork with openings not more than 4 inches wide with length unrestricted.

[39 FR 23502, June 27, 1974, as amended at 43 FR 49744, Oct. 24, 1978; 49 FR 5321, Feb. 10, 1984]

Next Standard (1910.24)

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