WEAVER CONSTRUCTION MANAGEMENT, INC.
3679 S. Huron St., Suite 404
Englewood, CO 80110
Phone: (303) 789-4111 FAX: (303) 789-4310

SUBMITTAL TRANSMITAL

July 26, 2011
WCM Submittal No: 05500-001

PROJECT: **Harold Thompson Regional WRF**
Birdsall Rd.
Fountain, CO 80817
Job No. 2908

ENGINEER: **GMS, Inc.**
611 No. Weber St., #300
Colorado Springs, CO 80903
719-475-2935 Roger Sams

OWNER: **Lower Fountain Metropolitan Sewage Disposal District**
901 S. Santa Fe Ave.
Fountain, CO 80817
719-382-5303 James Heckman

CONTRACTOR: **Rocky Mountain Railings**
11839 E. 51st Ave.
Denver, CO 80239

SUBJECT: Handrail Submittal

SPEC SECTION: 05500 – Metal Fabrications

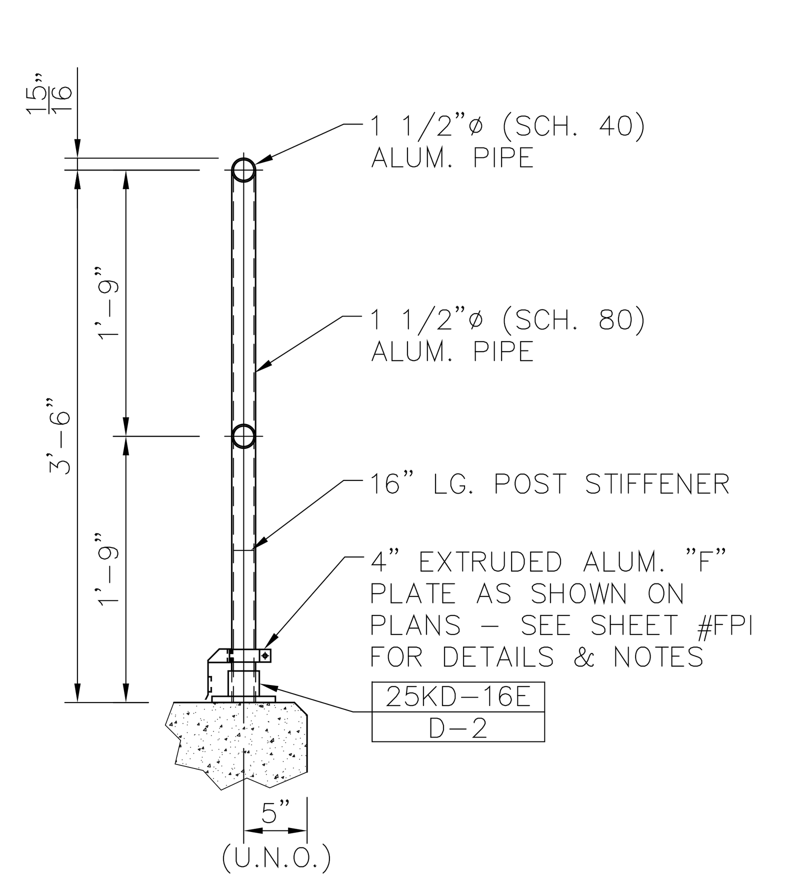
PREVIOUS SUBMISSION DATES: None

DEVIATIONS FROM SPEC: ____ YES _X_ NO

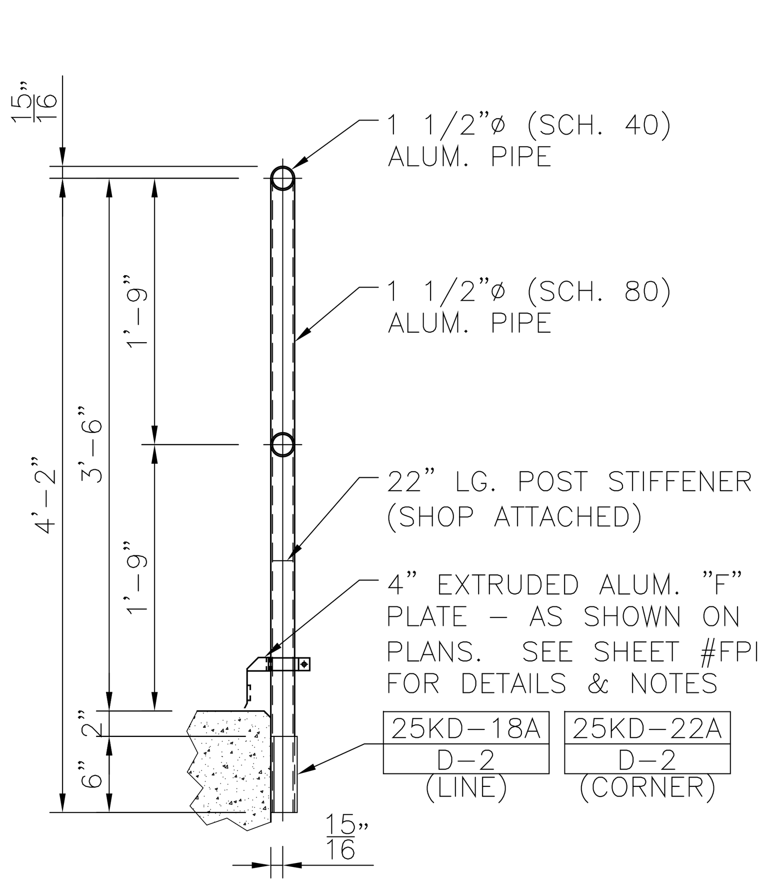
CONTRACTOR'S STAMP: This submittal has been reviewed by Weaver General Construction and approved with respect to the means, methods, techniques, & safety precautions & programs incidental thereto. Weaver General Construction also warrants that this submittal complies with contracted documents and comprises on deviations thereto:

Contractor's Stamp:	Engineer's Stamp:
Date: 7/26/11 Reviewed by: H.C. Myers (X) Reviewed Without Comments ( ) Reviewed With Comments	

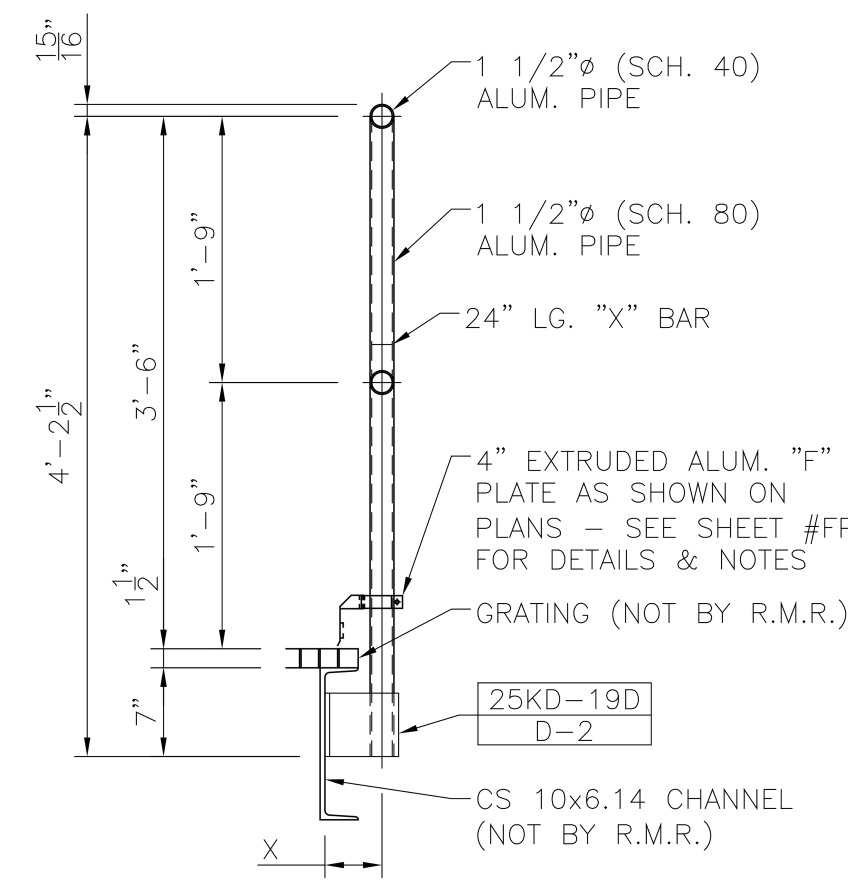
ENGINEER'S
COMMENTS:____



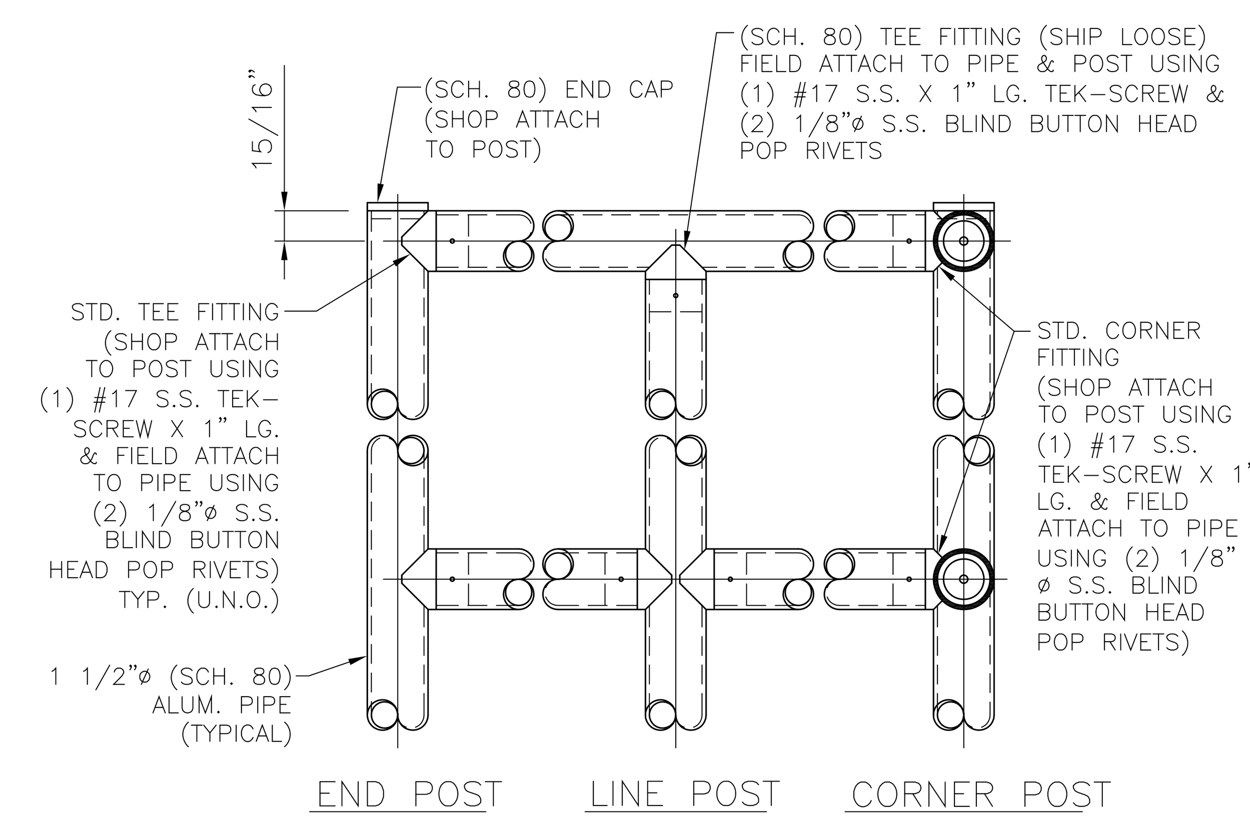
SECTION A D-1



SECTION B D-1

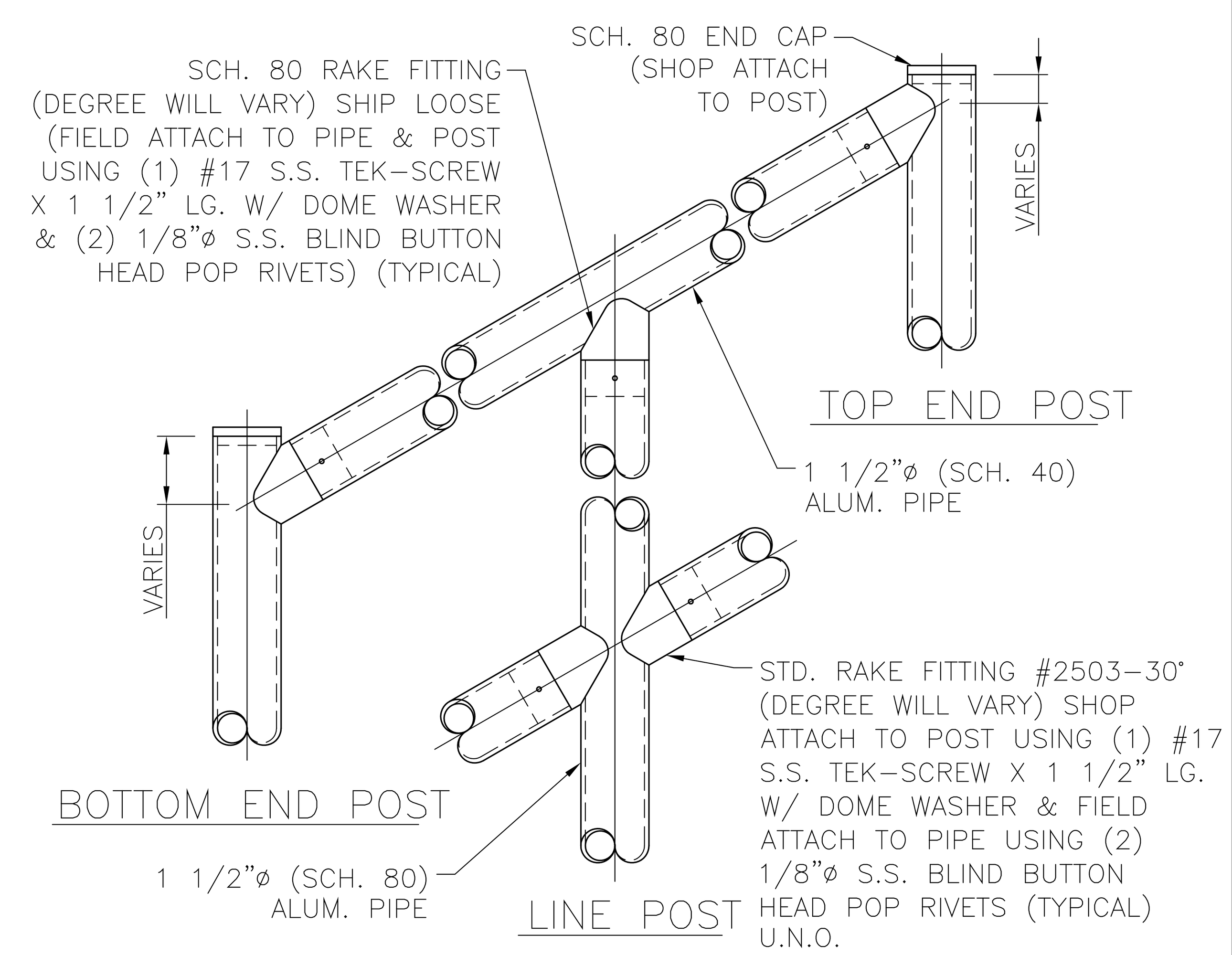


SECTION C D-1



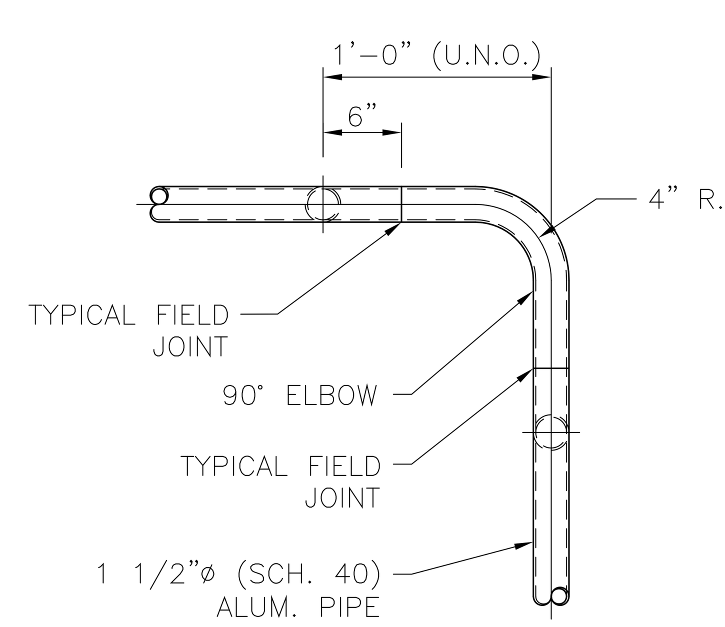
TYPICAL LEVEL RAIL CONNECTIONS

25KD-2



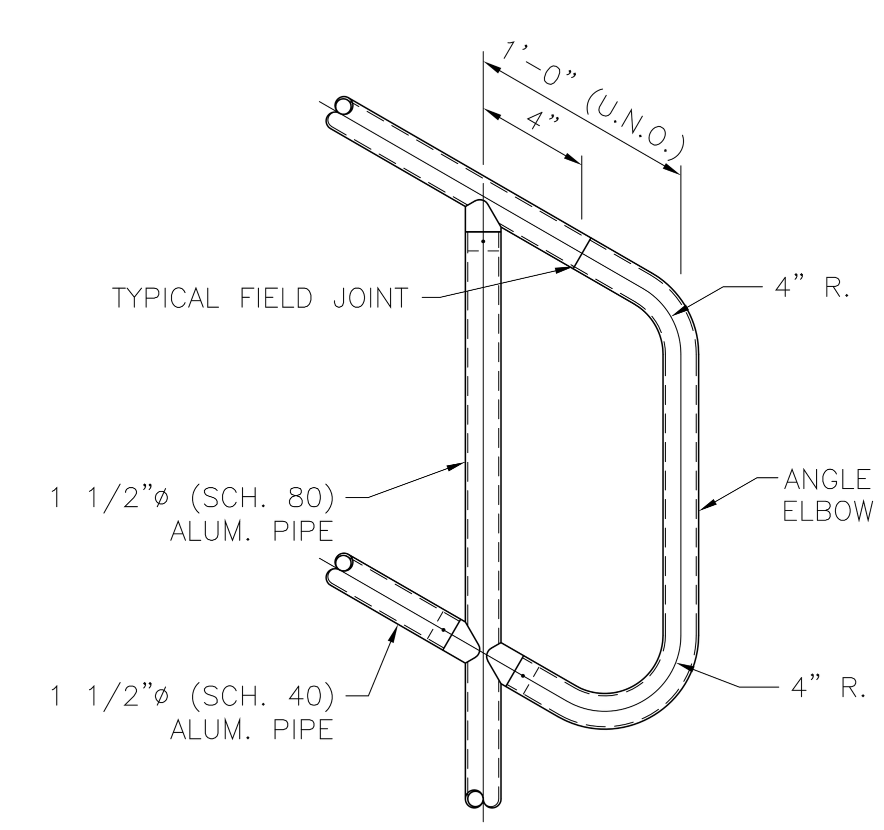
TYPICAL RAKE RAIL CONNECTIONS

25KD-3



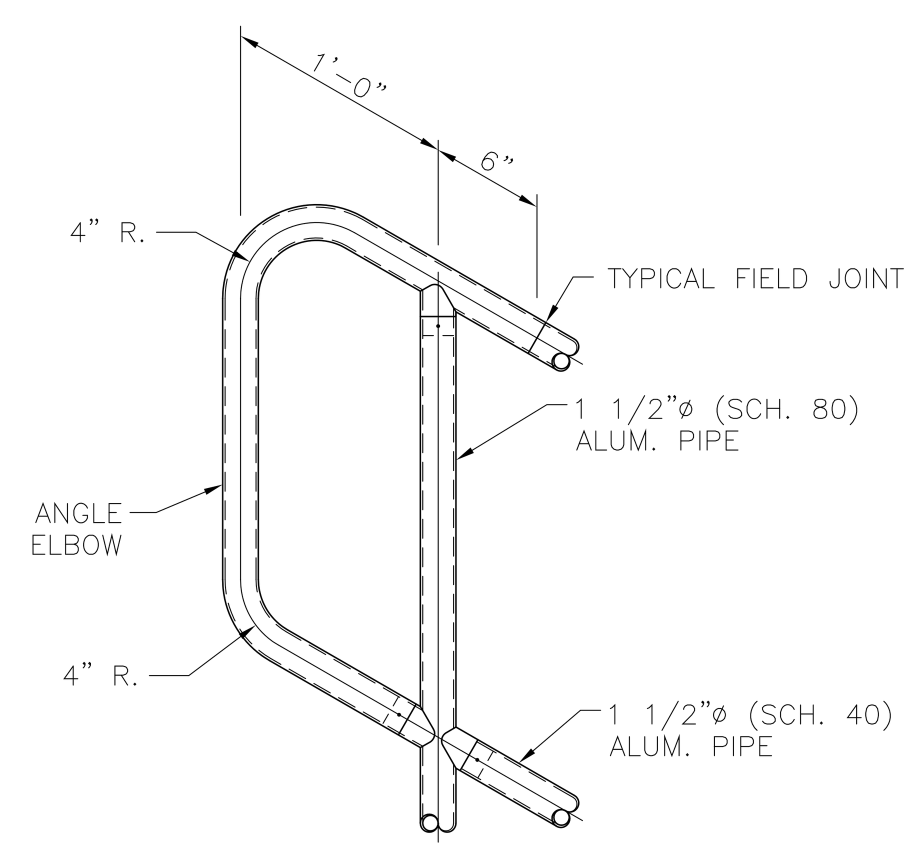
TYPICAL CORNER

25KD-4



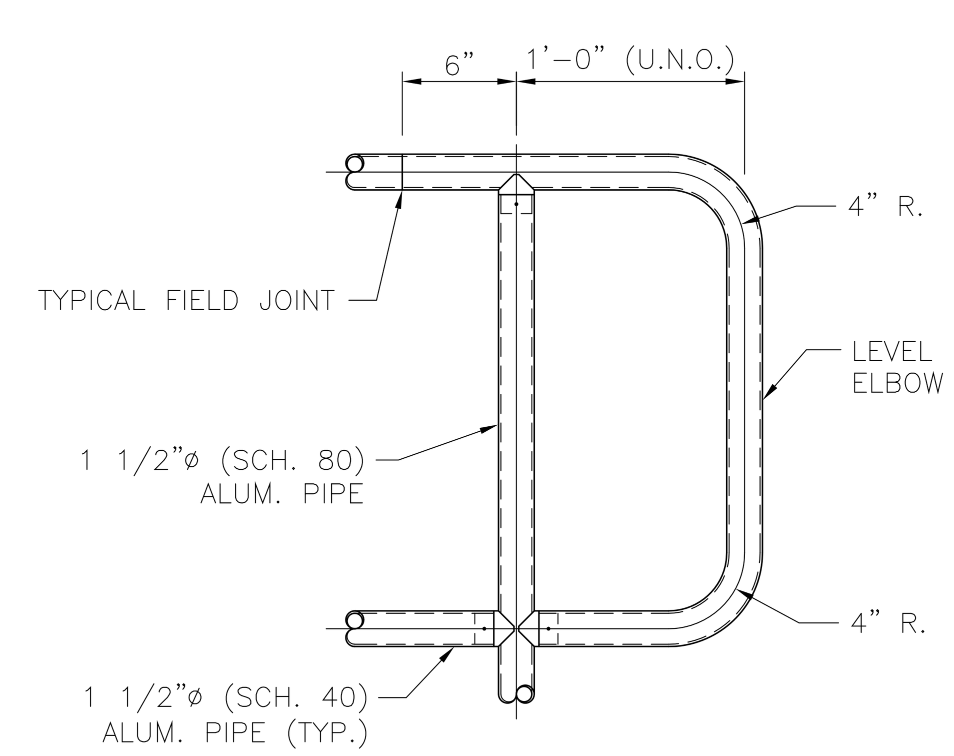
BOTTOM RAKE P-END

25KD-5A



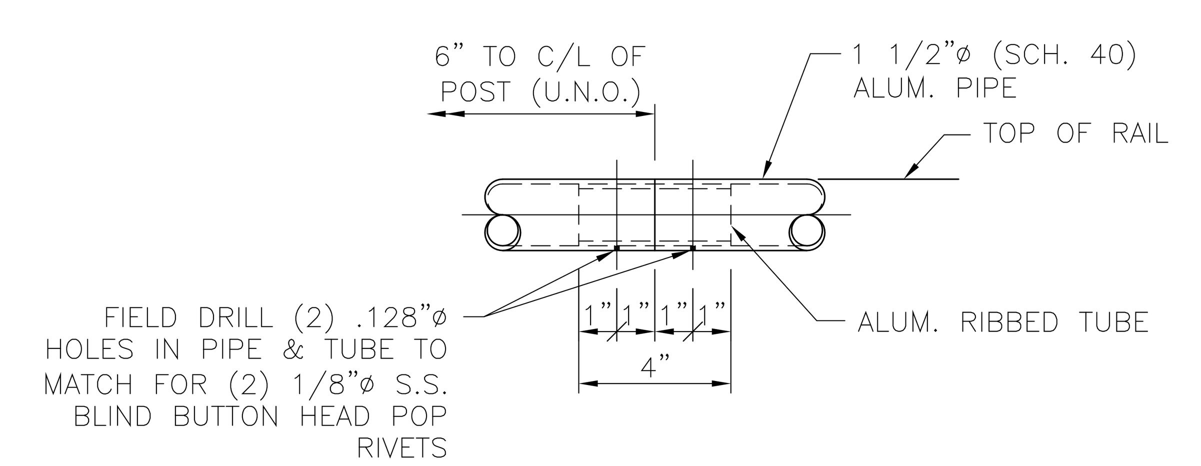
TOP RAKE P-END

25KD-6A



LEVEL P-END

25KD-7A



ERECTOR NOTE!
NO FIELD JOINT REQ'D IN INTERMEDIATE RAIL.

TYPICAL FIELD JOINT

25KD-8 (LOCATED WHERE REQ'D. FOR STRUCTURAL STABILITY)

GENERAL NOTES!

25KD-1

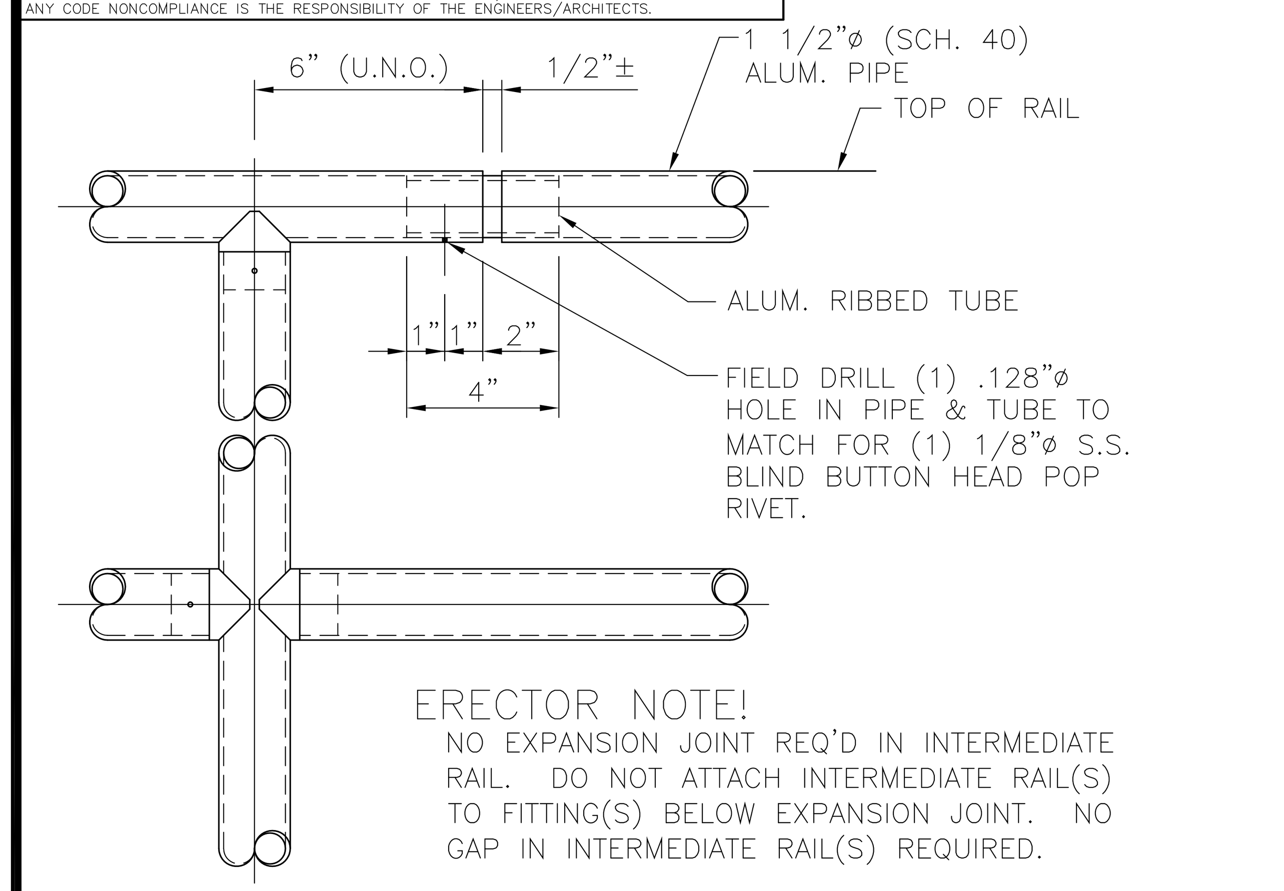
1) ALL RAIL TO BE OF MECHANICAL CONSTRUCTION U.N.O..
2) ALL RAILS TO BE FABRICATED FROM 1 1/2"ø (SCH. 40) ALUMINUM PIPE (6105-T5 ALLOY).
3) ALL POSTS TO BE FABRICATED FROM 1 1/2"ø (SCH. 80) ALUMINUM PIPE (6105-T5 ALLOY).
4) ALL COMPONENTS TO BE 6105-T5 ALLOY.
5) ALL FASTENERS (SELF TAPPING SCREWS, BLIND RIVETS, MACHINE BOLTS, EXPANSION ANCHORS, ETC.) TO BE STAINLESS STEEL. (TYPE 304)
6) ALL RAILING SURFACES IN CONTACT WITH CONCRETE OR DISSIMILAR METALS SHALL RECEIVE ONE SHOP APPLIED COAT OF BITUMINOUS PAINT.
7) ALL BOLTS USED TO MOUNT RAILINGS TO FLOORS, WALLS, STEEL, ETC. ARE BY RAILING MFR.
8) ALL KICK PLATES ("F" TYPE TOE BOARD) SHALL BE SHIPPED LOOSE IN 24'-0" LG. STOCK LENGTHS FOR FIELD CUTTING & DRILLING AS REQ'D.
9) ALL POSTS ARE FURNISHED CUT TO LENGTH WITH FITTINGS & MOUNTING PLATES ATTACHED (EXCEPT FOR TOP FITTING AT LEVEL & RAKE LINE POSTS).
10) PIPE FOR STRAIGHT RAIL IS FURNISHED IN 24'-0" STOCK LENGTHS FOR CUTTING & DRILLING AS REQ'D.
11) ELBOWS W/ A 4" C/L RADIUS ARE FURNISHED AS REQ'D. & MUST BE FIELD CUT TO FIT FIELD CONDITIONS.
12) ALL RAIL WHEN PROPERLY INSTALLED SHALL MEET OR EXCEED OSHA REQUIREMENTS.
13) MAX. POST SPACING TO BE 6'-0" C/C.
14) ALL RAIL IS TO BE FINISHED IN ACCORDANCE WITH THE ALUMINUM ASSOCIATION'S DESIGNATION M10C22A41.
15) ALL DIMENSIONS SHOWN THROUGHOUT THIS SET ARE APPROXIMATE AND SHALL BE FIELD VERIFIED DURING ERECTION.

ROCKY MOUNTAIN RAILINGS
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

HAROLD D. THOMPSON W.R.F. FOUNTAIN, CO.	DESIGNER GSM INC.
DETAILS 2500 KNOCK DOWN	CUSTOMER WEAVER CONSTRUCTION
FINISH M10C22A41	CONTRACTOR
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11
ERECTION BY OTHERS	JOB NO. R1940
FIELD CHECKED BY OTHERS	DRAWING NO. D-1
CUSTOMER P.O./JOB 2908-05470	
L/F	

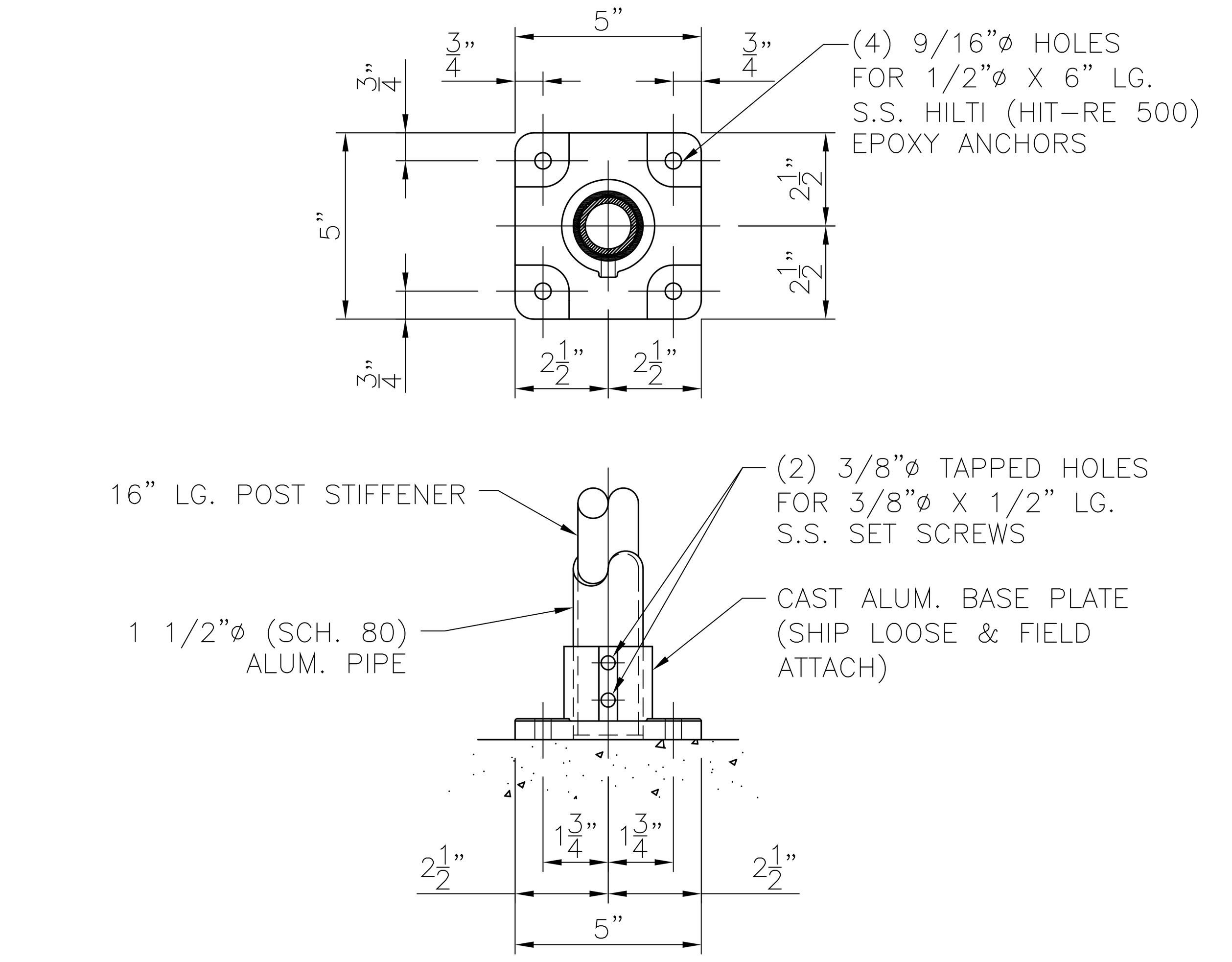
NO. REVISION BY DATE

REFER TO CONTRACT DWG. DWG NO.



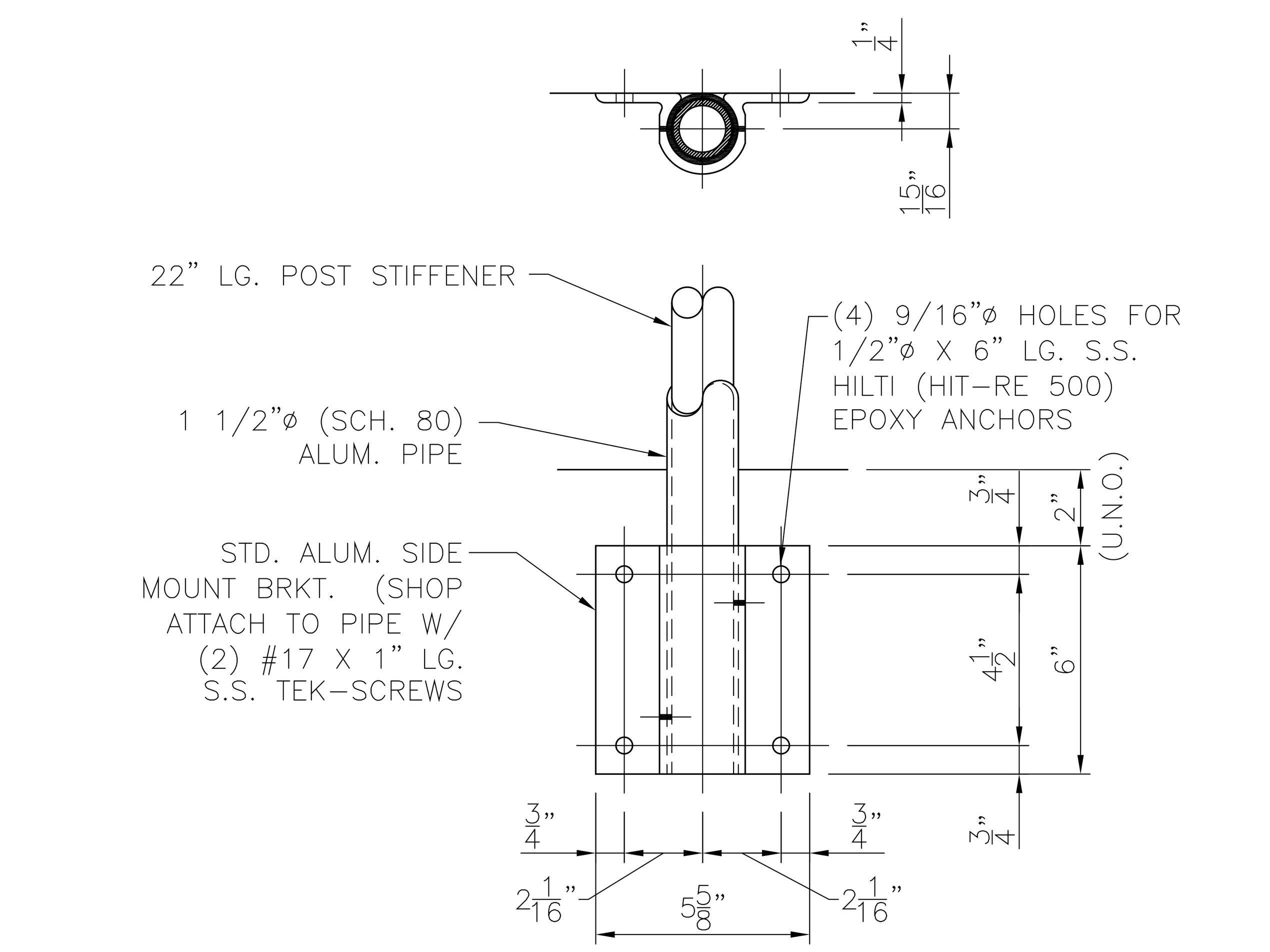
TYPICAL EXPANSION JOINT

25KD-9 (LOCATED AT BUILDING EXPANSION JOINT & AT 24'-0" MAX. O/C)



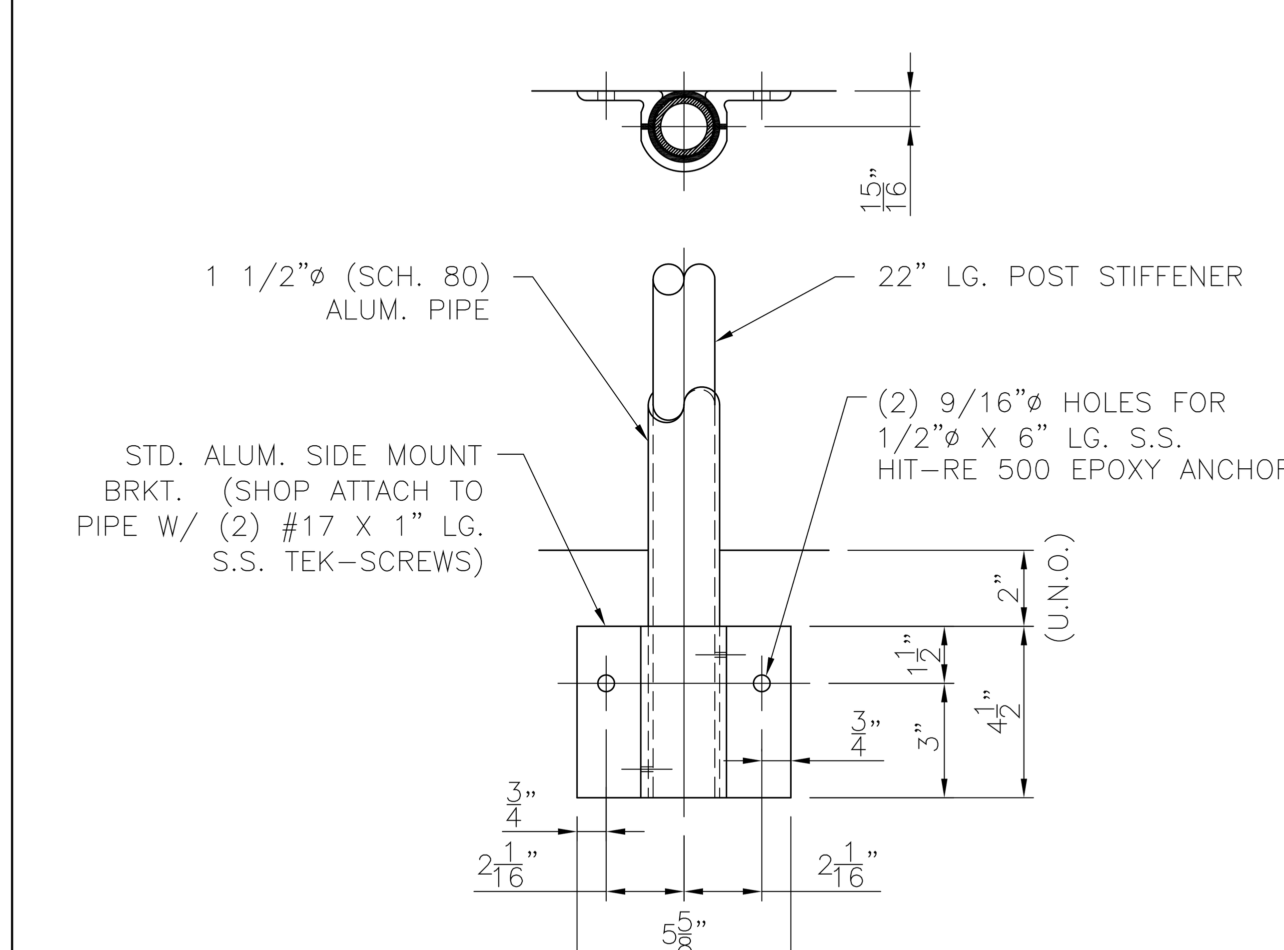
LEVEL CONC. LINE POST

25KD-16E



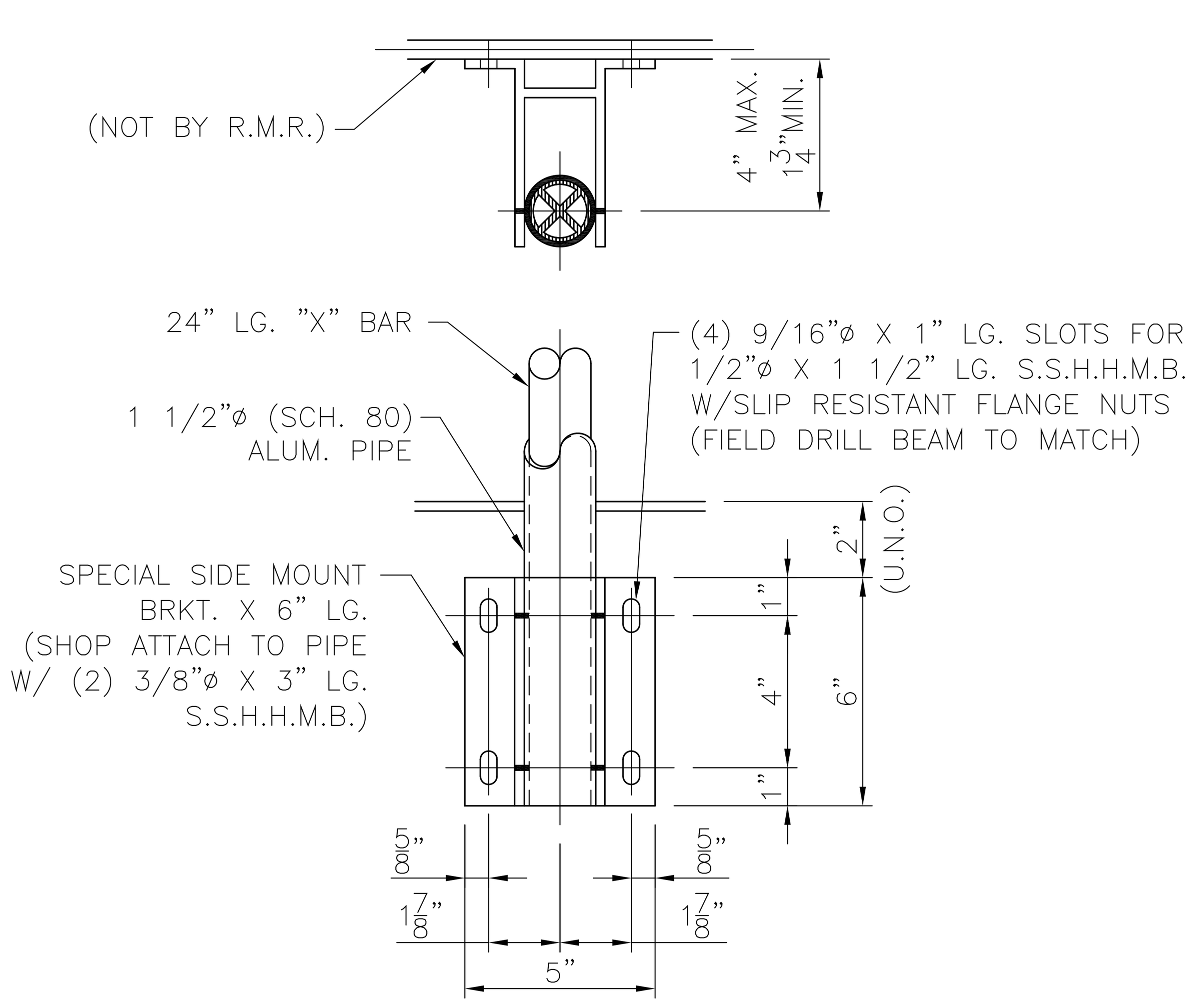
CONC. SIDE MOUNT 4-HOLE

25KD-18A



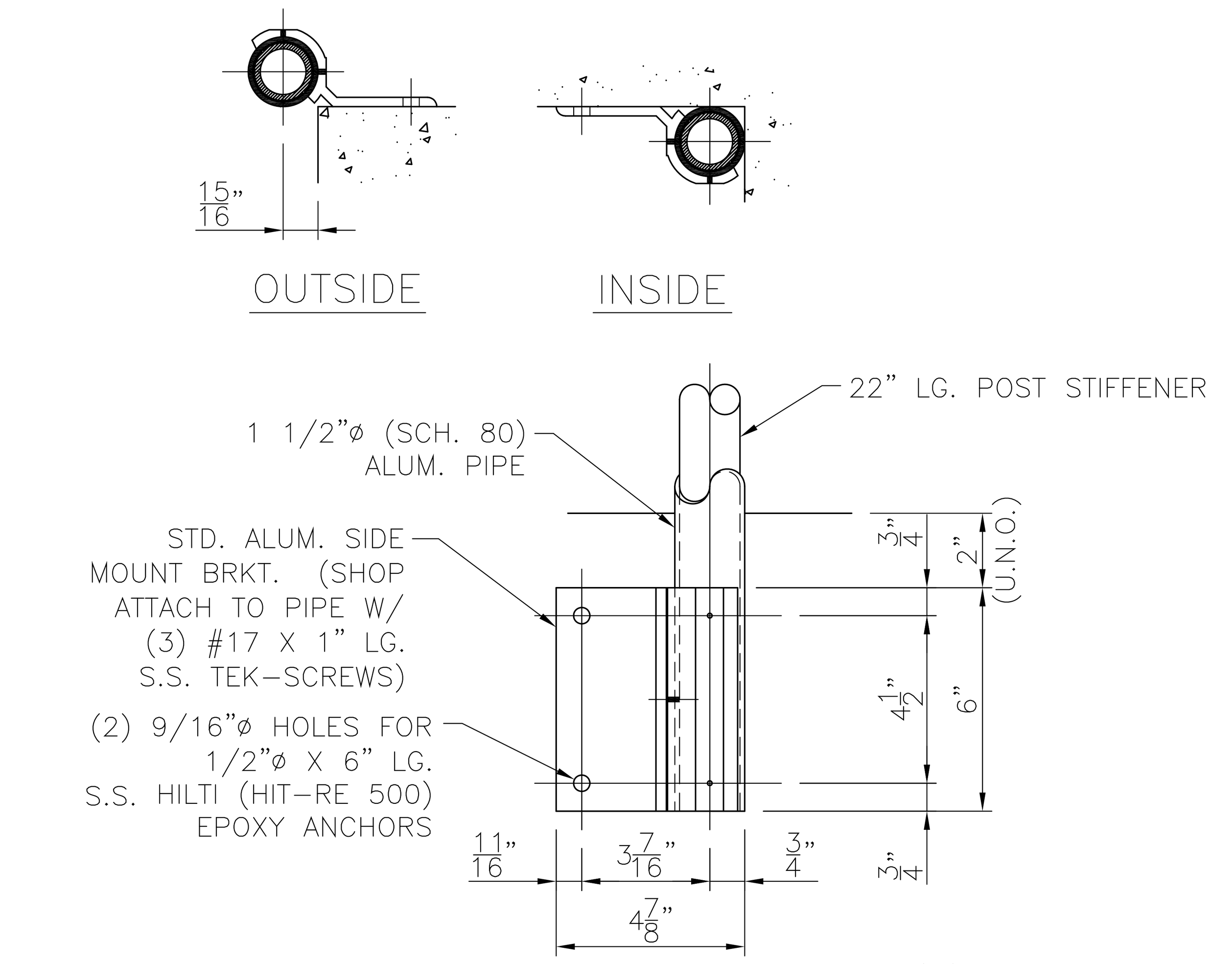
CONC. SIDE MOUNT 2-HOLE

25KD-18E



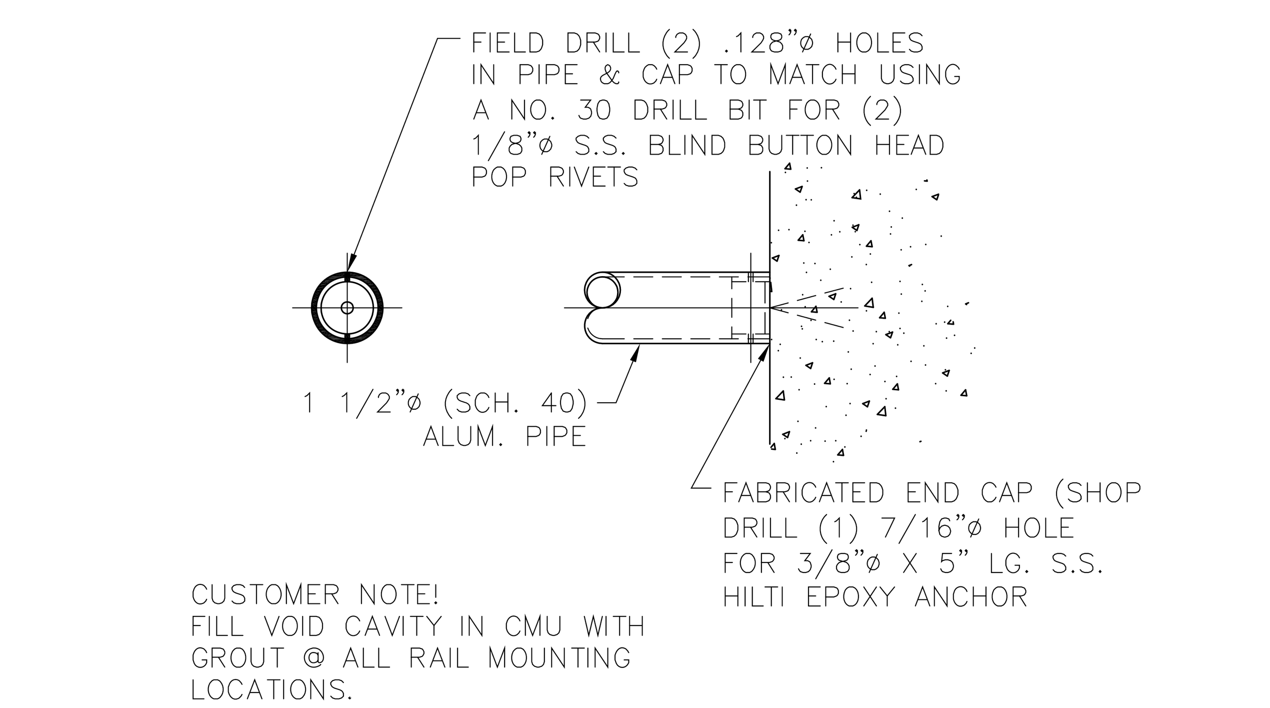
SPECIAL SIDE MOUNT 4-HOLE

25KD-19D



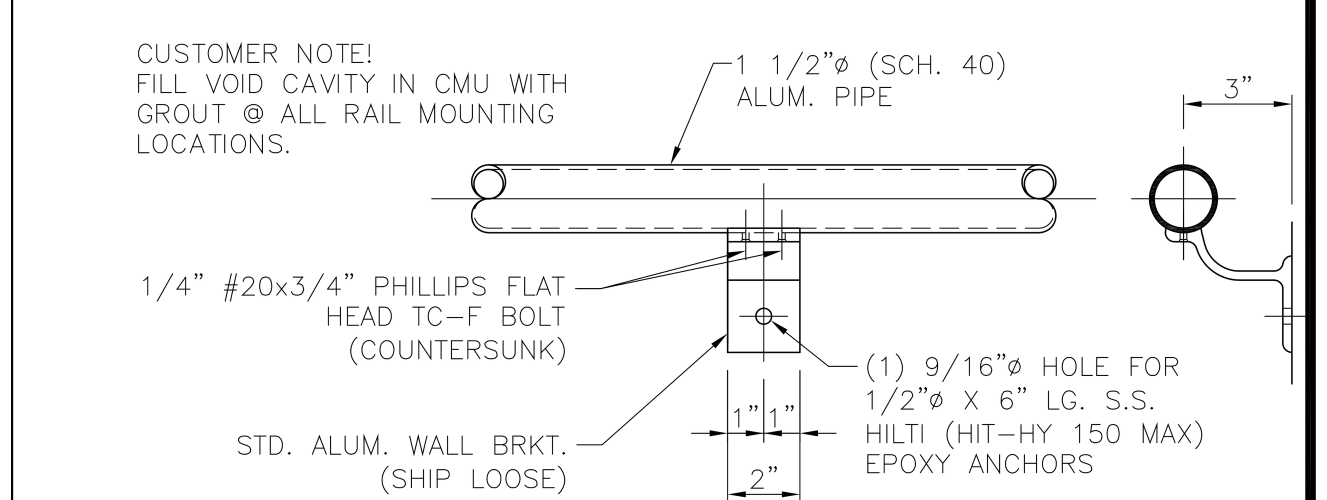
CONC. CORNER SIDE MOUNT

25KD-22A



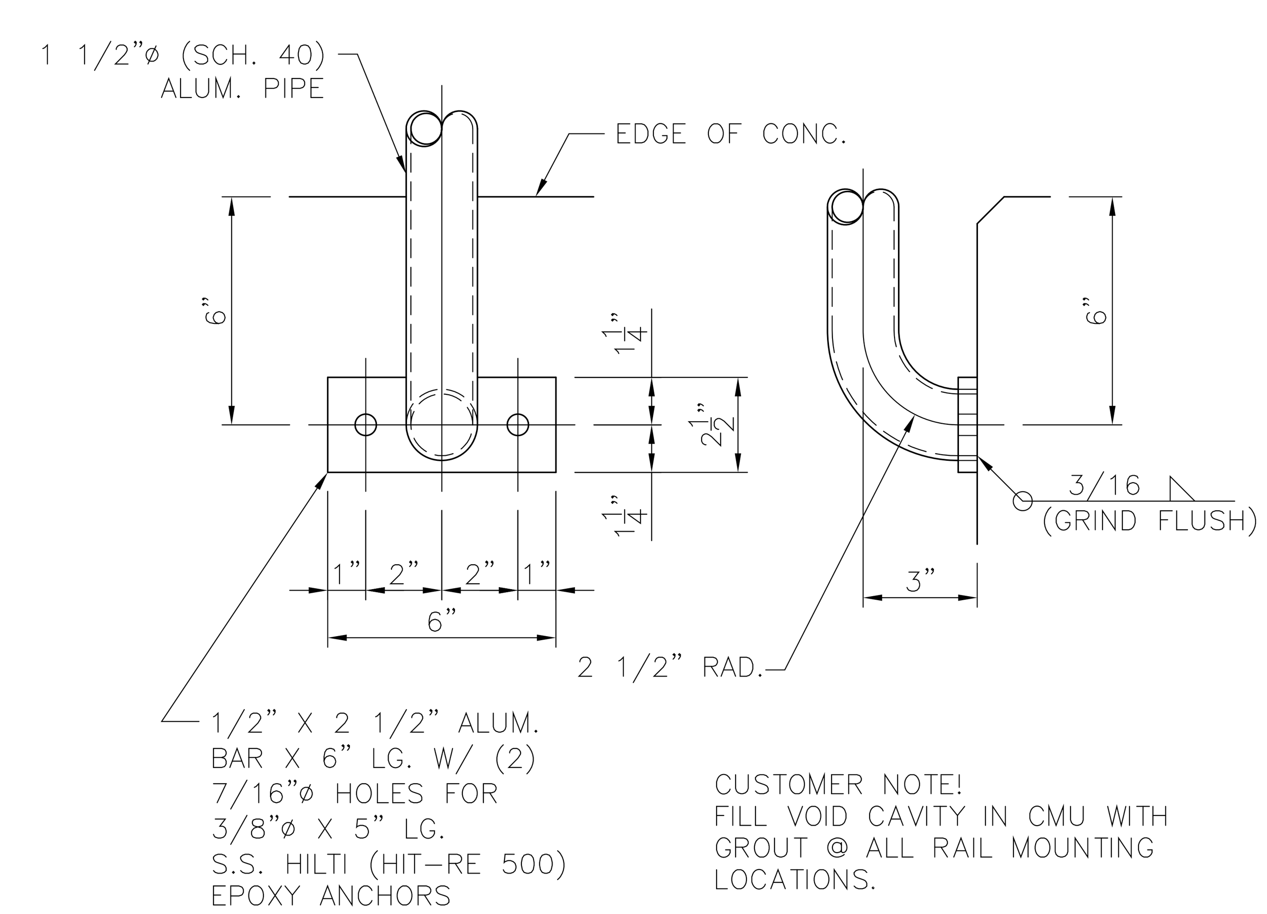
WALL MOUNT END CAP

25KD-33



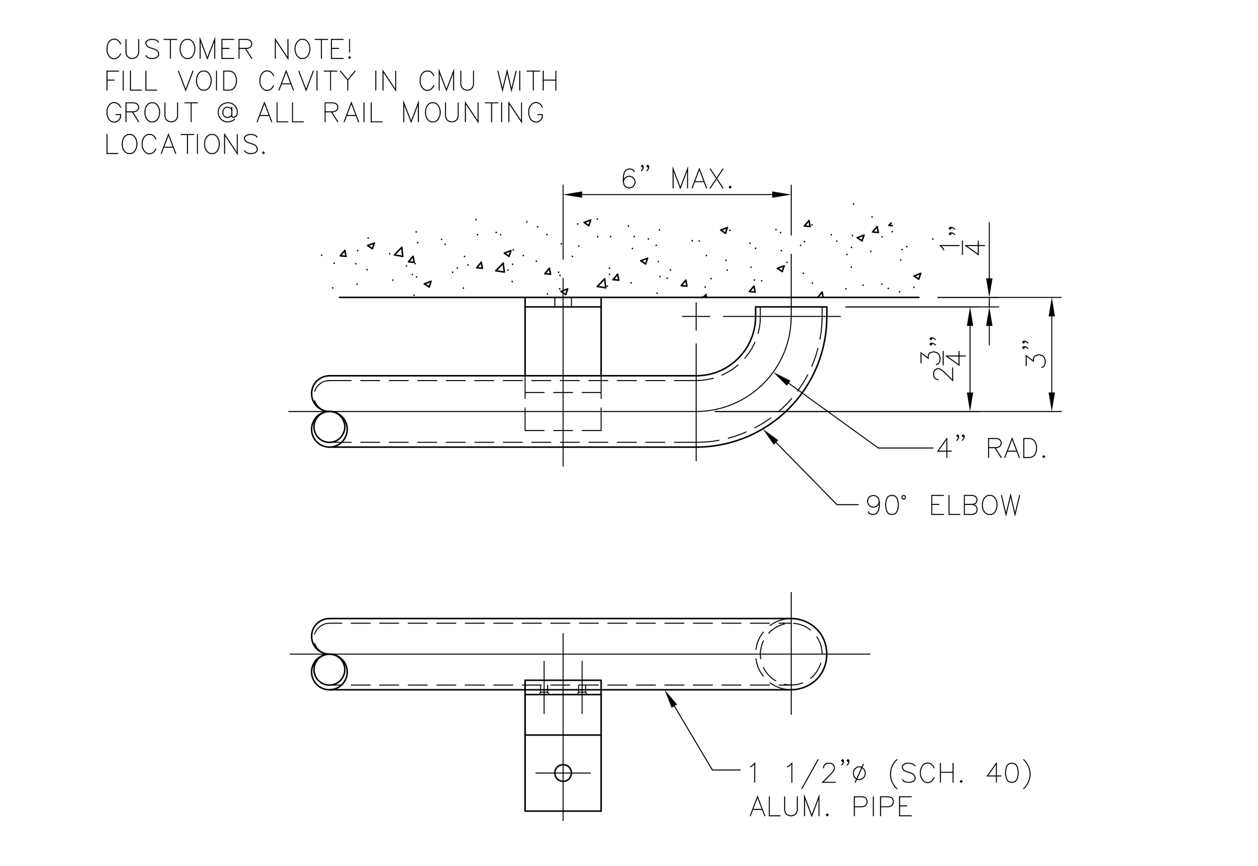
WALL BRACKET

25KD-35



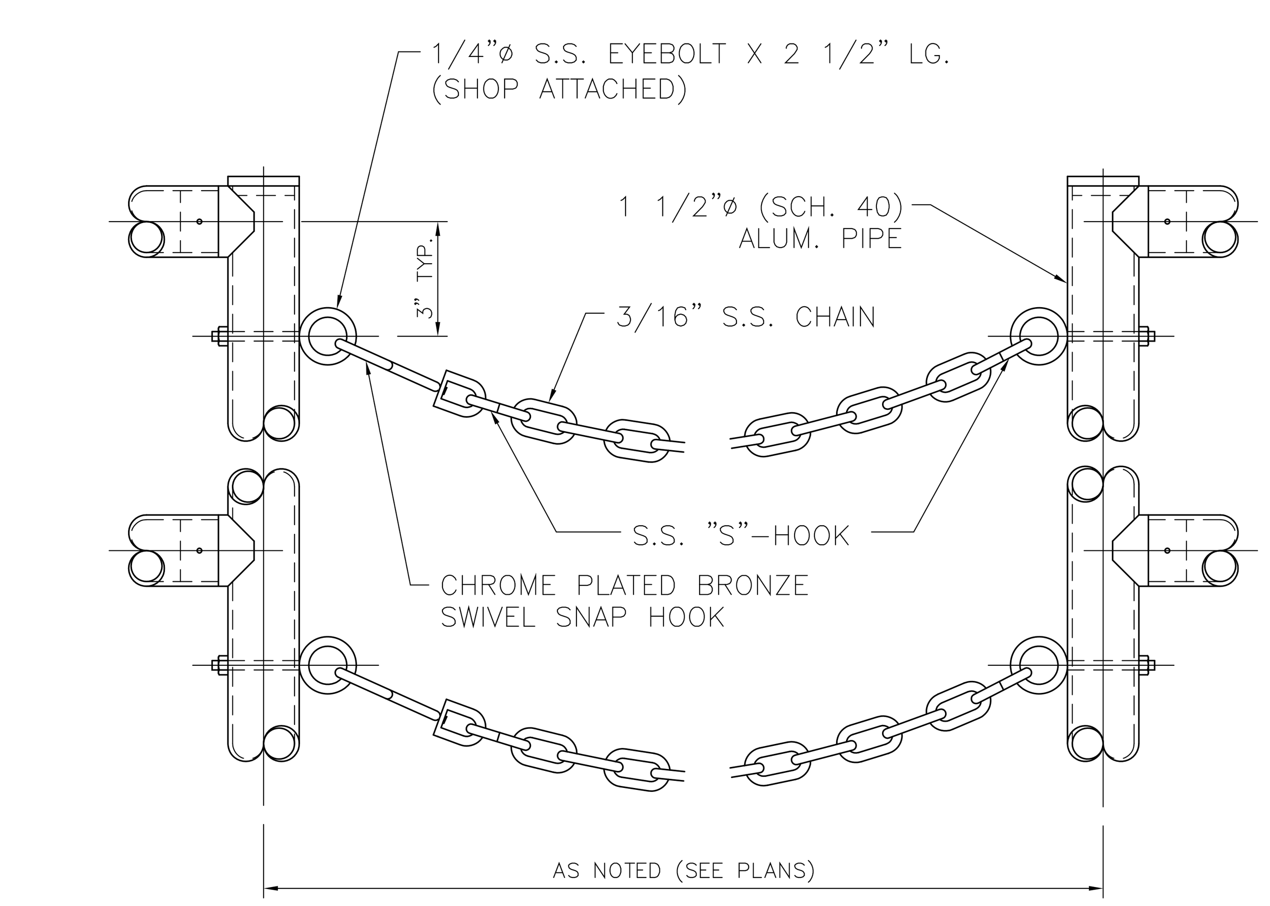
WALL RAIL LINE POST

25KD-35A



WALL RAIL END RETURN

25KD-36



CHAIN OPENING

CH-3A (TABCO 2500-2 LINE)

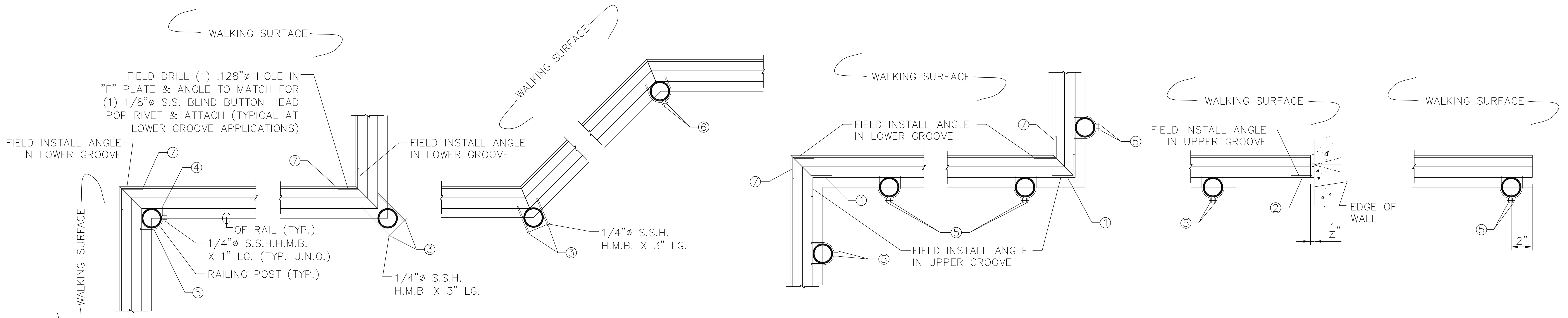
ROCKY MOUNTAIN RAILINGS

11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

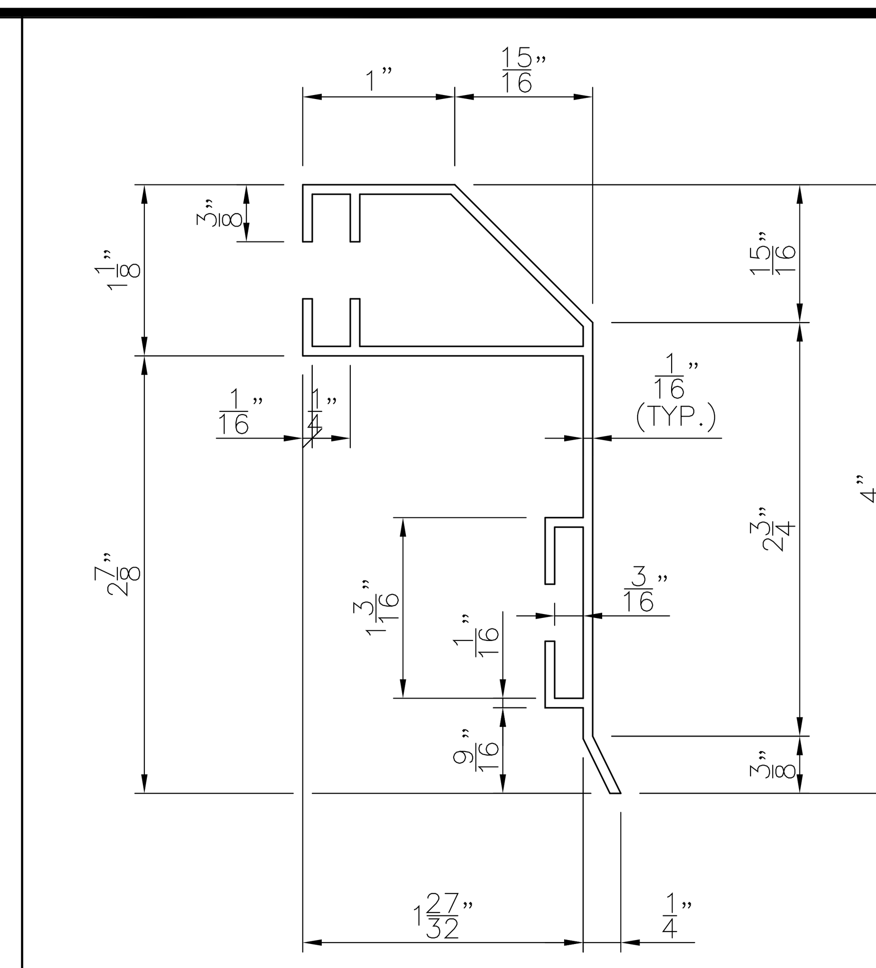
HAROLD D. THOMPSON W.R.F. FOUNTAIN, CO.	DESIGNER: GSM INC.
DETAILS: 2500 KNOCK DOWN	CUSTOMER: WEAVER CONSTRUCTION
FINISH: M10C22A41	CONTRACTOR:
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11
ERECTION BY: OTHERS	JOB NO. R1940
FIELD CHECKED BY: OTHERS	
CUSTOMER P.O./JOB: 2908-05470	DRAWING NO. D-2

NO.	REVISION	BY	DATE
L/F			

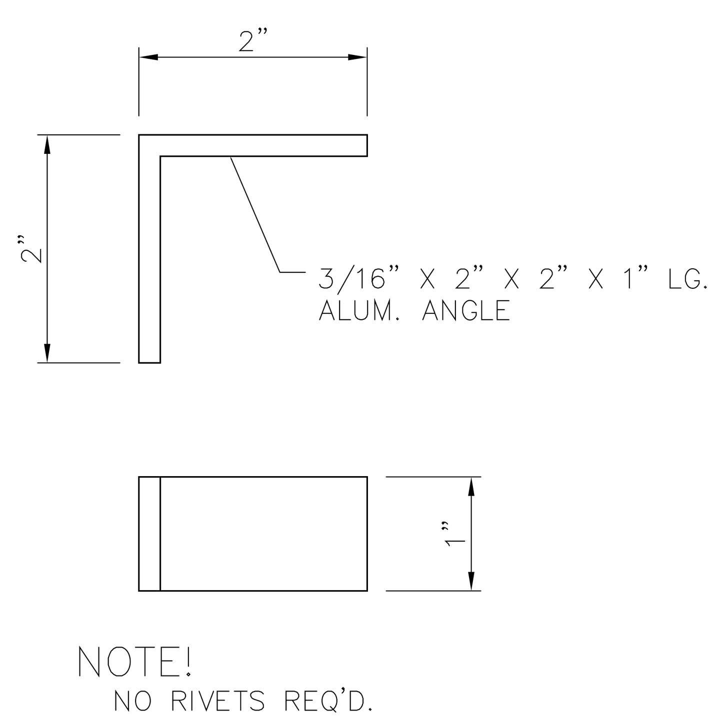
REFER TO CONTRACT DWG. ___ DWG NO. ___



TYPICAL "F" PLATE CONDITIONS

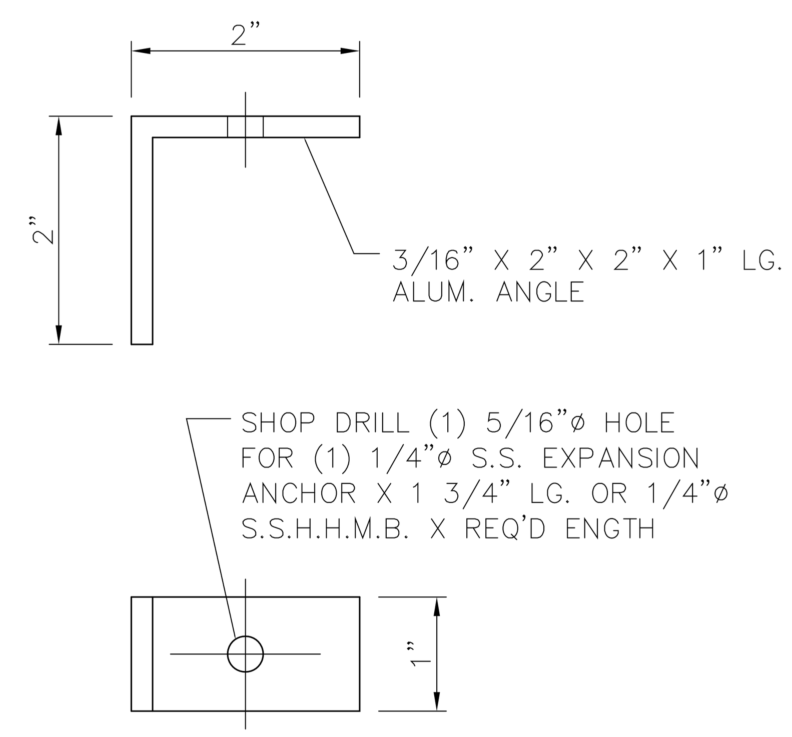


"F" PLATE SECTION



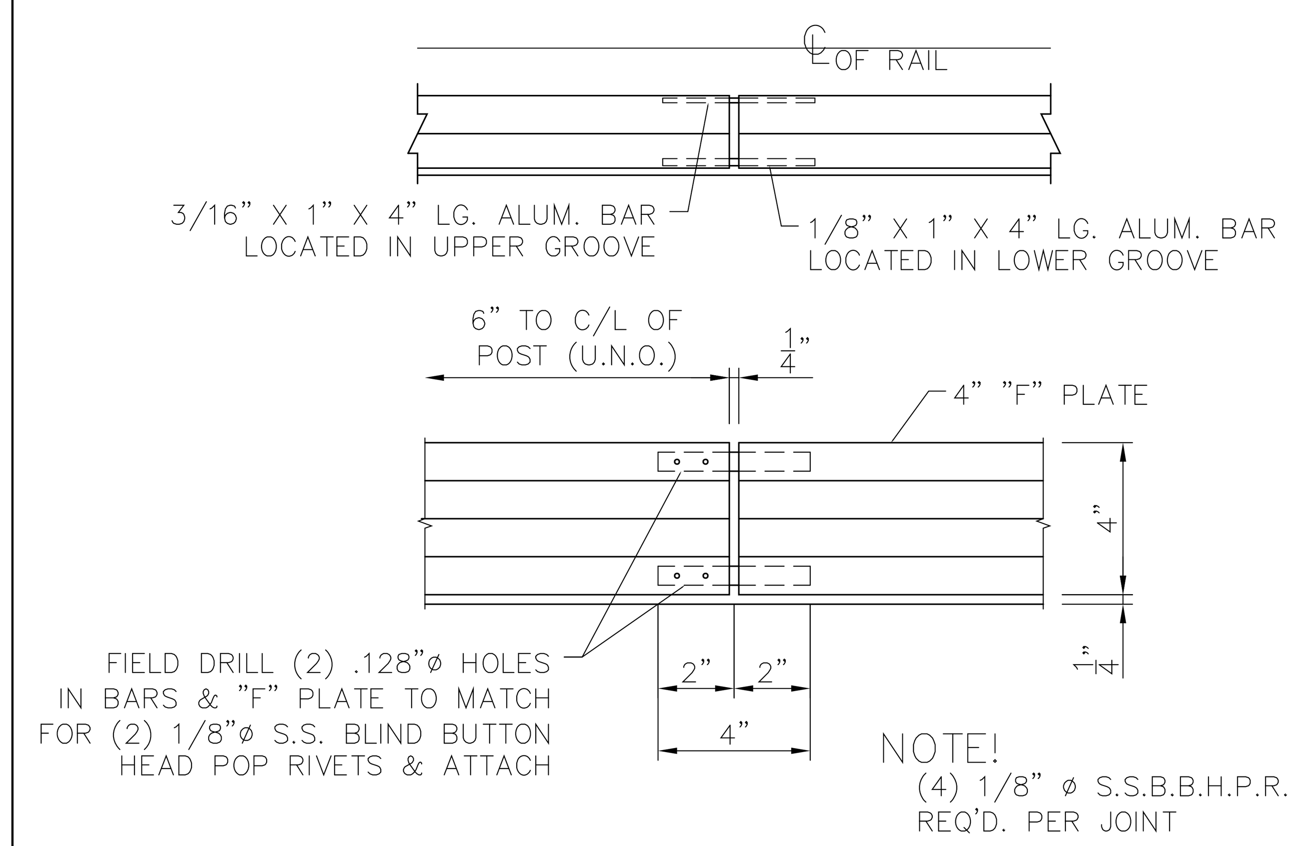
NOTE!
NO RIVETS REQ'D.

DETAIL 1
(INSIDE & OUTSIDE 90° CORNER W/ NO POSTS)



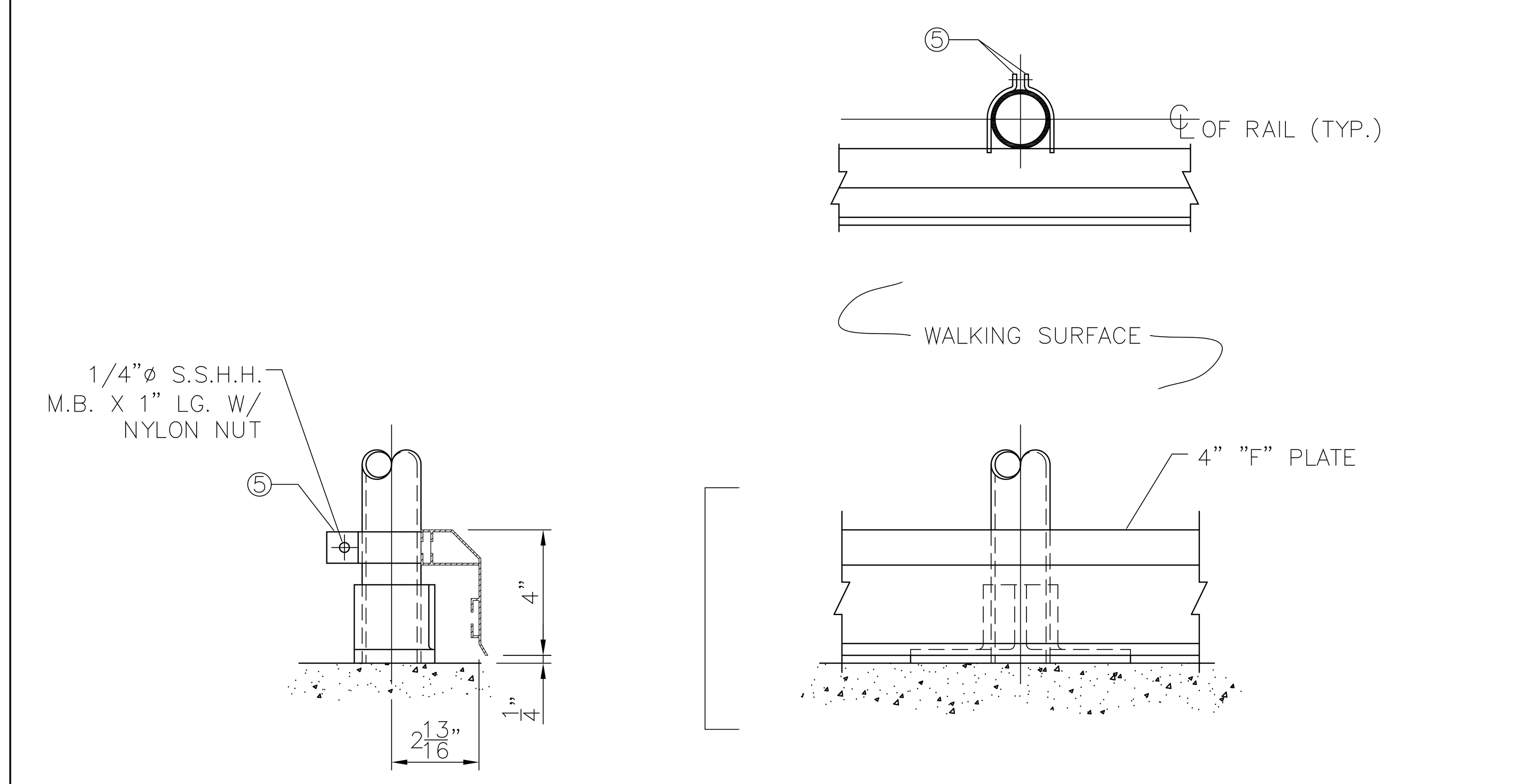
NOTE!
NO RIVETS REQ'D.

DETAIL 2
(END WALL TERMINATION)

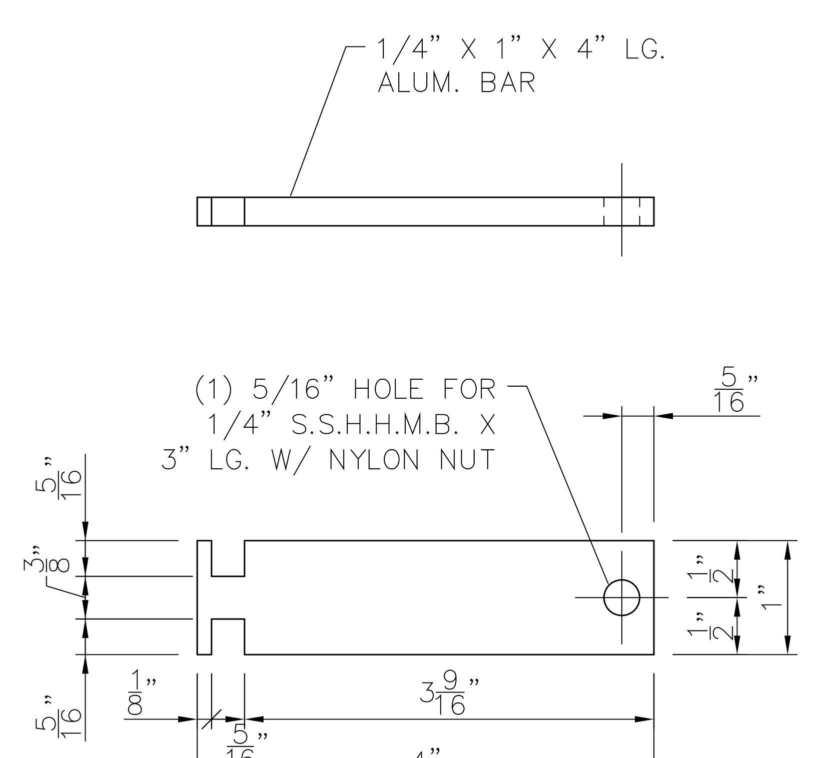


NOTE!
(4) 1/8" ø S.S.B.B.H.P.R.
REQ'D. PER JOINT

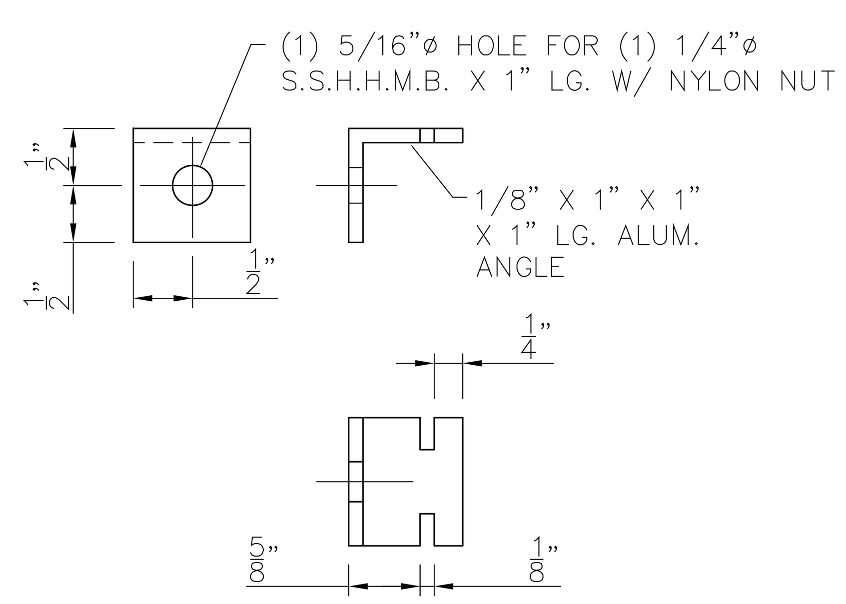
"F" PLATE EXPANSION JOINT



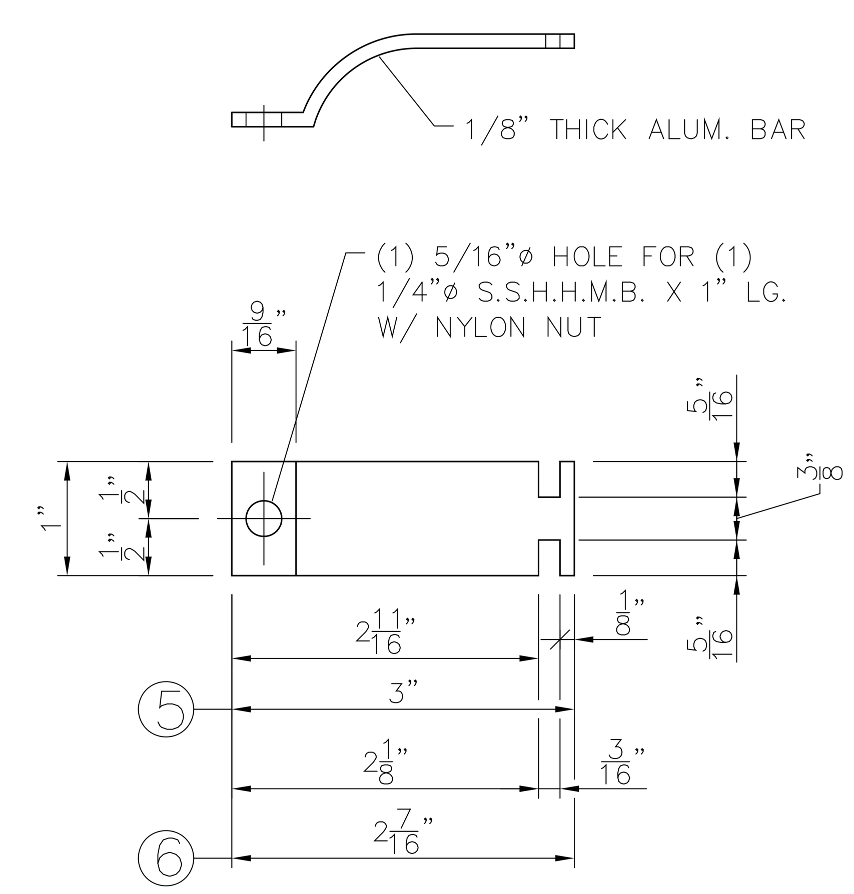
ELEVATION OF "F" PLATE AT POST



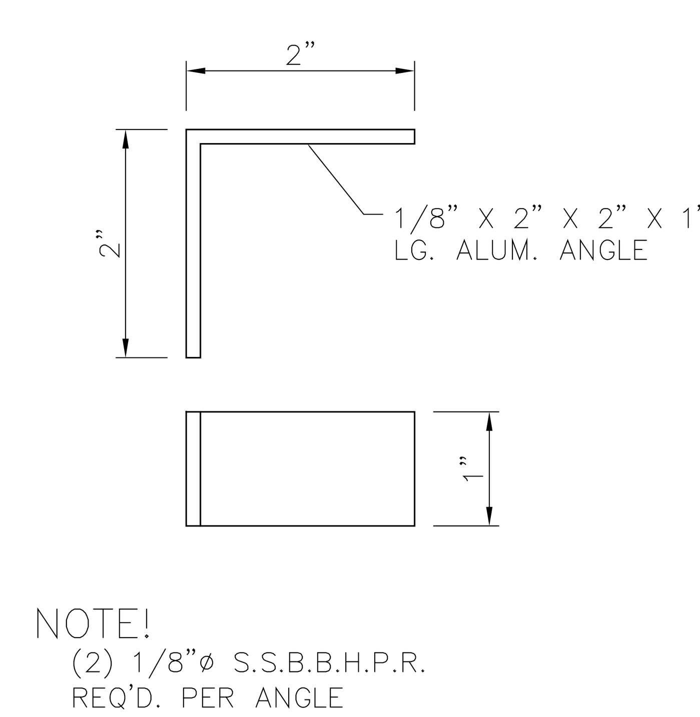
DETAIL 3



DETAIL 4



DETAIL 5 & 6



NOTE!
(2) 1/8"ø S.S.B.B.H.P.R.
REQ'D. PER ANGLE

DETAIL 7
(INSIDE & OUTSIDE 90° CORNERS)

TYPICAL NOTES:

1.) ALL KICK PLATE SHALL BE:
   a) 4" EXTRUDED ALUMINUM "F" PLATE.
   b) SHIPPED LOOSE IN 24'-0" STOCK LENGTHS FOR FIELD CUTTING AND DRILLING AS REQ'D.
   c) FIELD ATTACHED TO POSTS.

2.) REFERENCE GENERAL NOTES FOR RIVET TYPE.

3.) ALWAYS INSTALL RIVETS W/ BUTTON HEAD TOWARDS WALKING SURFACE.

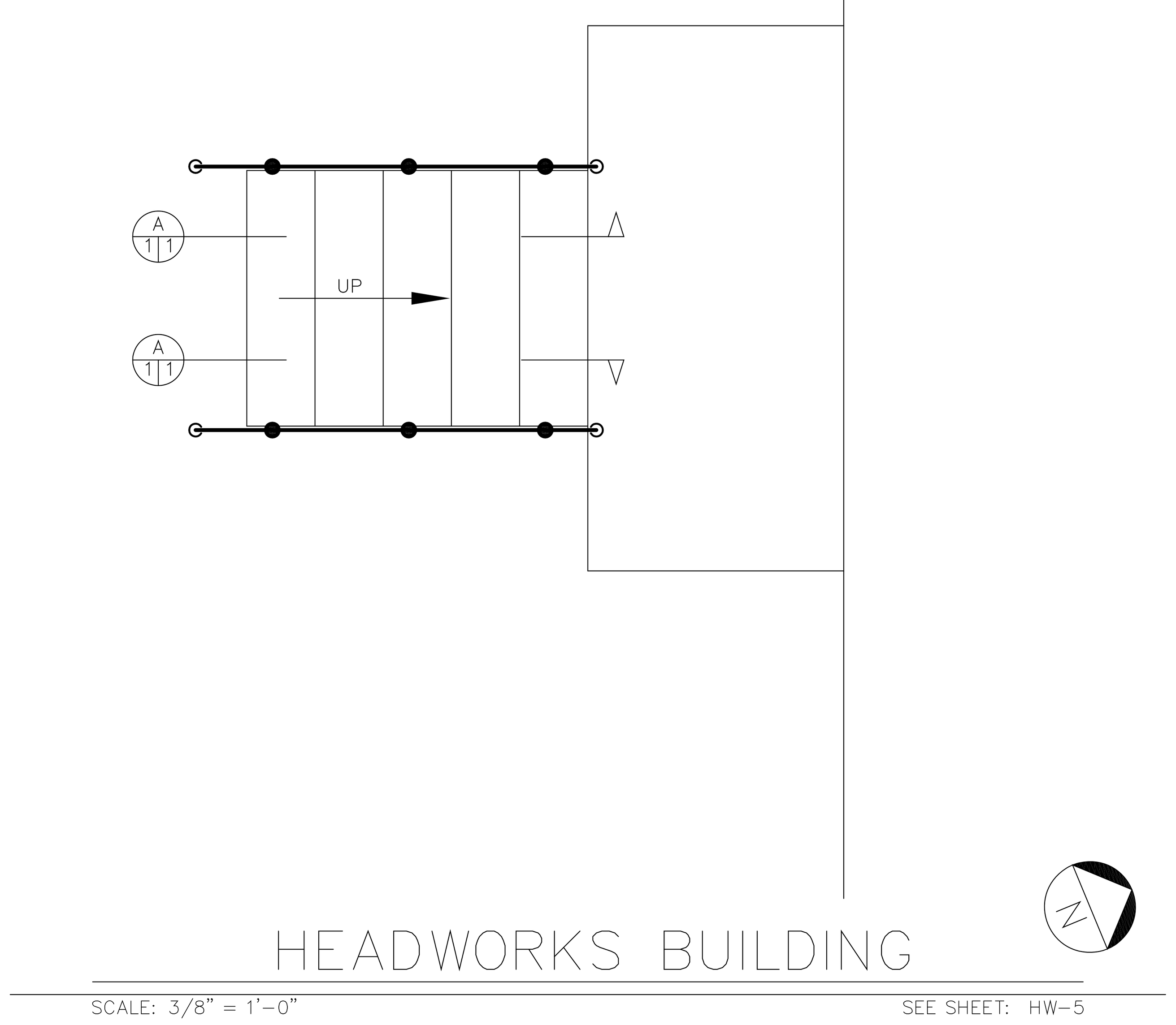
ROCKY MOUNTAIN RAILINGS
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

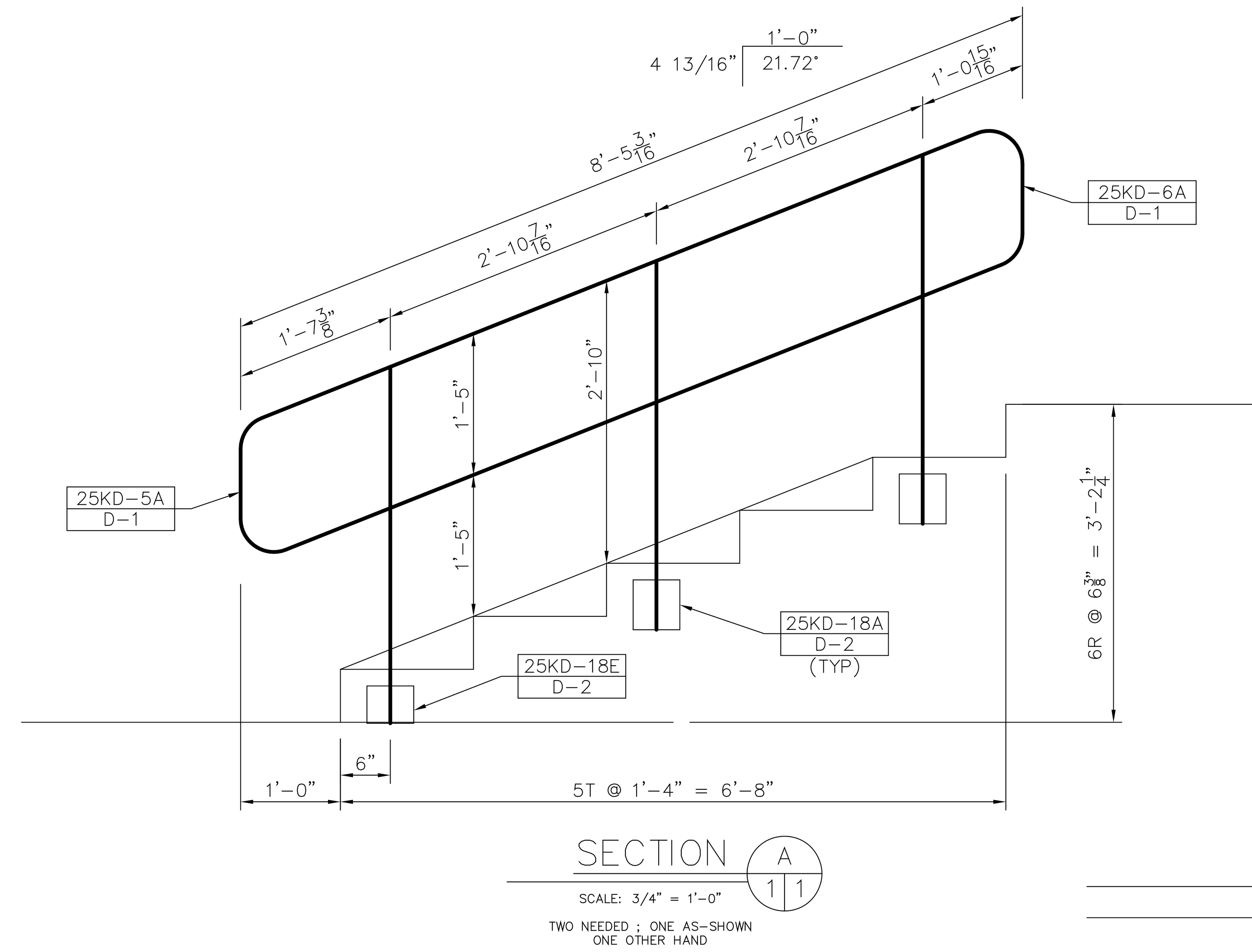
	HAROLD D. THOMPSON W.R.F. FOUNTAIN, CO.
DESIGNER	GSM INC.
CUSTOMER	WEAVER CONSTRUCTION
CONTRACTOR	
DETAILS	"F" TYPE KICK PLATE
FINISH	M10C22A41
DR.	DDB
DATE	7/26/11
SCALE	AS NOTED
ERECTION BY	OTHERS
FIELD CHECKED BY	OTHERS
CUSTOMER P.O./JOB	2908-05470
L/F	
NO.	9P
PRINTS FOR	APPROVAL
DATE	07-26-11
JOB NO.	R1940
DRAWING NO.	FPI

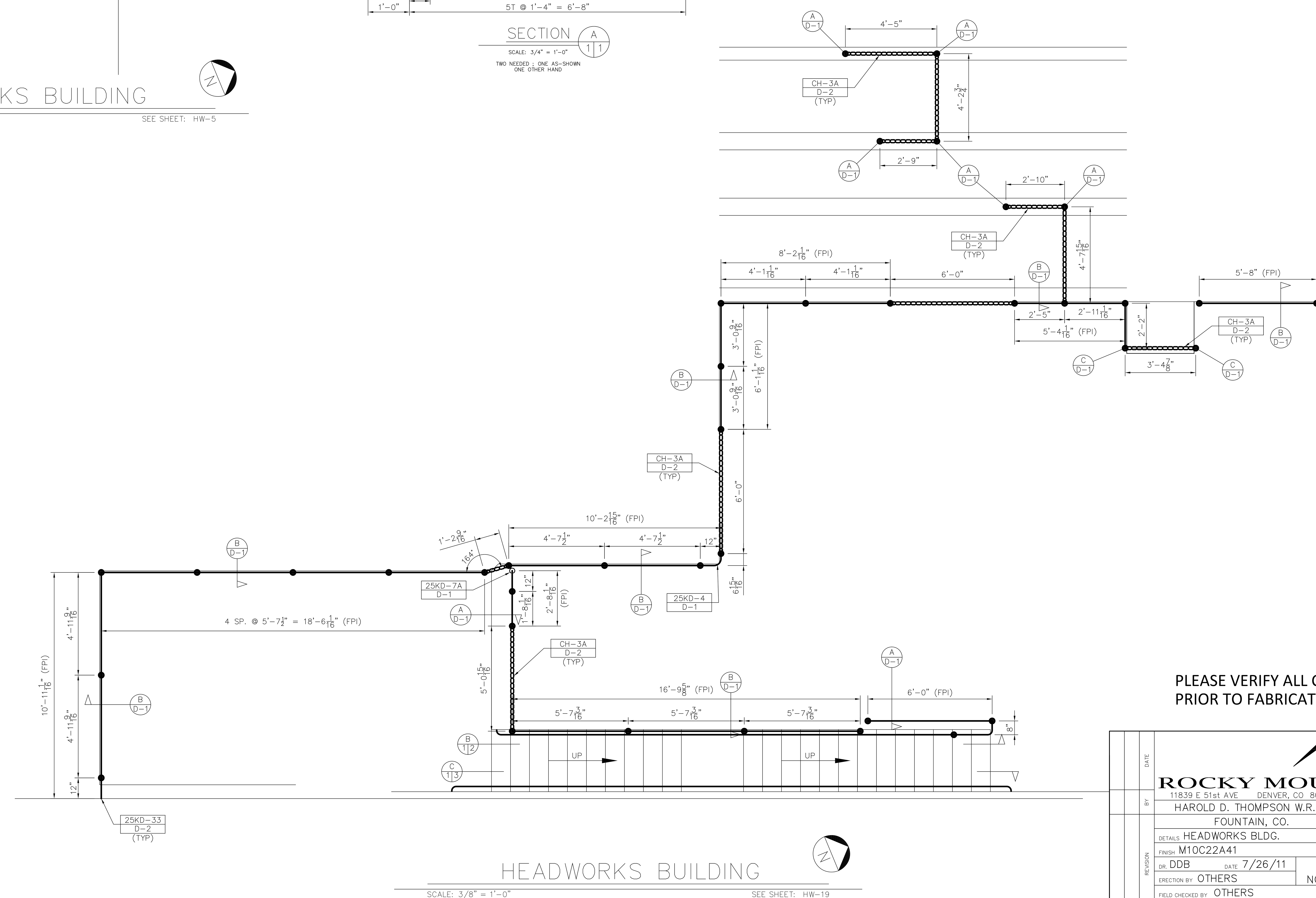
REVISION | NO. | BY | DATE

REFER TO CONTRACT DWG. ___ DWG. NO. ___

TOTAL POST	43
BASE MT.	11
EMBED	N/A
SIDE MT.	32







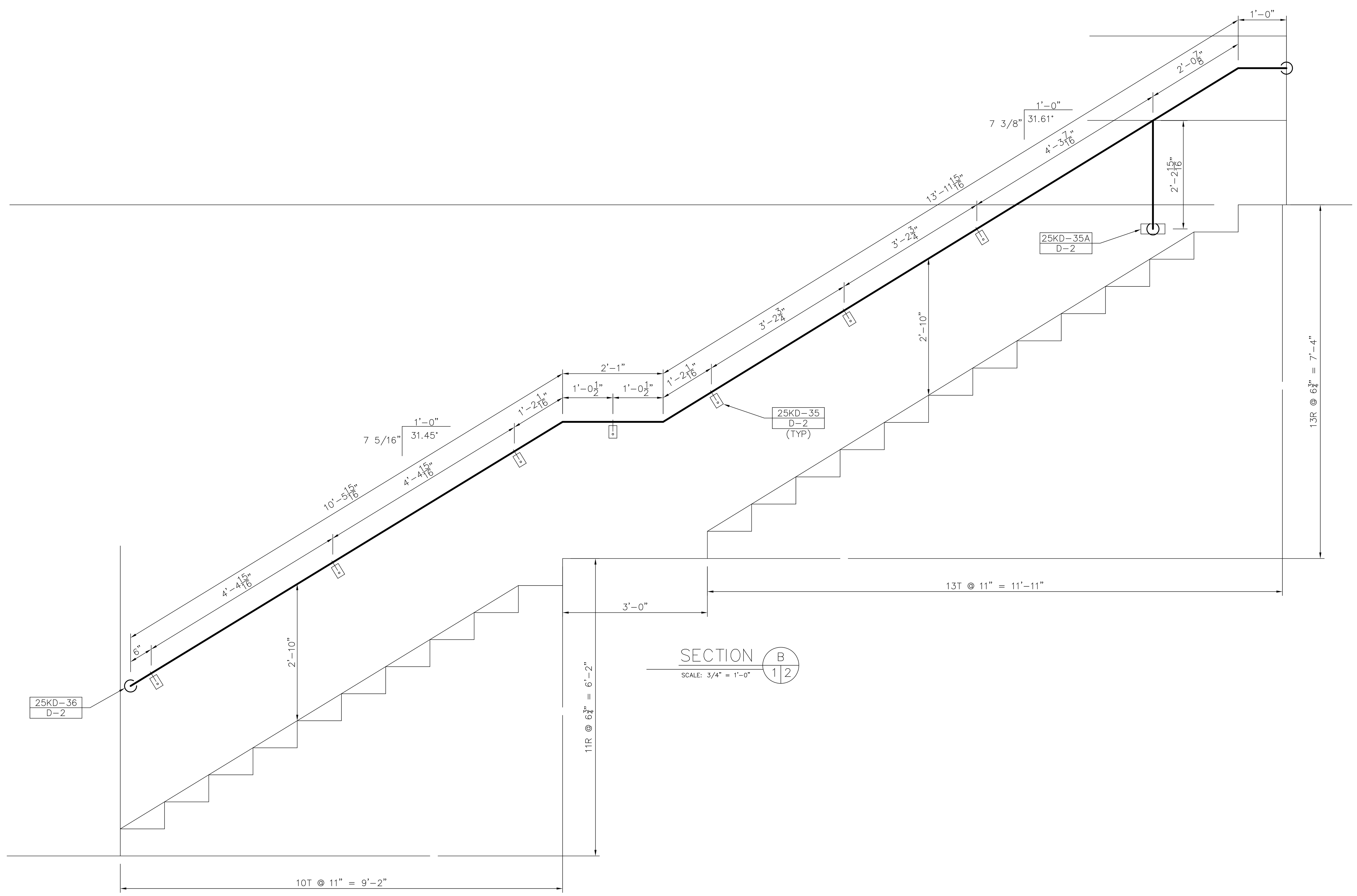
PLEASE VERIFY ALL CONCRETE STAIR DIMENSIONS
PRIOR TO FABRICATION.

ROCKY MOUNTAIN RAILINGS
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

HAROLD D. THOMPSON W.R.F.	DESIGNER GSM INC.
FOUNTAIN, CO.	CUSTOMER WEAVER CONSTRUCTION
DETAILS HEADWORKS BLDG.	CONTRACTOR
FINISH M10C22A41	
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11 JOB NO. R1940
ERECTION BY OTHERS	
FIELD CHECKED BY OTHERS	DRAWING NO. 1
CUSTOMER P.O./JOB 2908-05470	
L/F	

NO.	REVISION	BY	DATE

REFER TO CONTRACT DWG. ___ DWG. NO. ___



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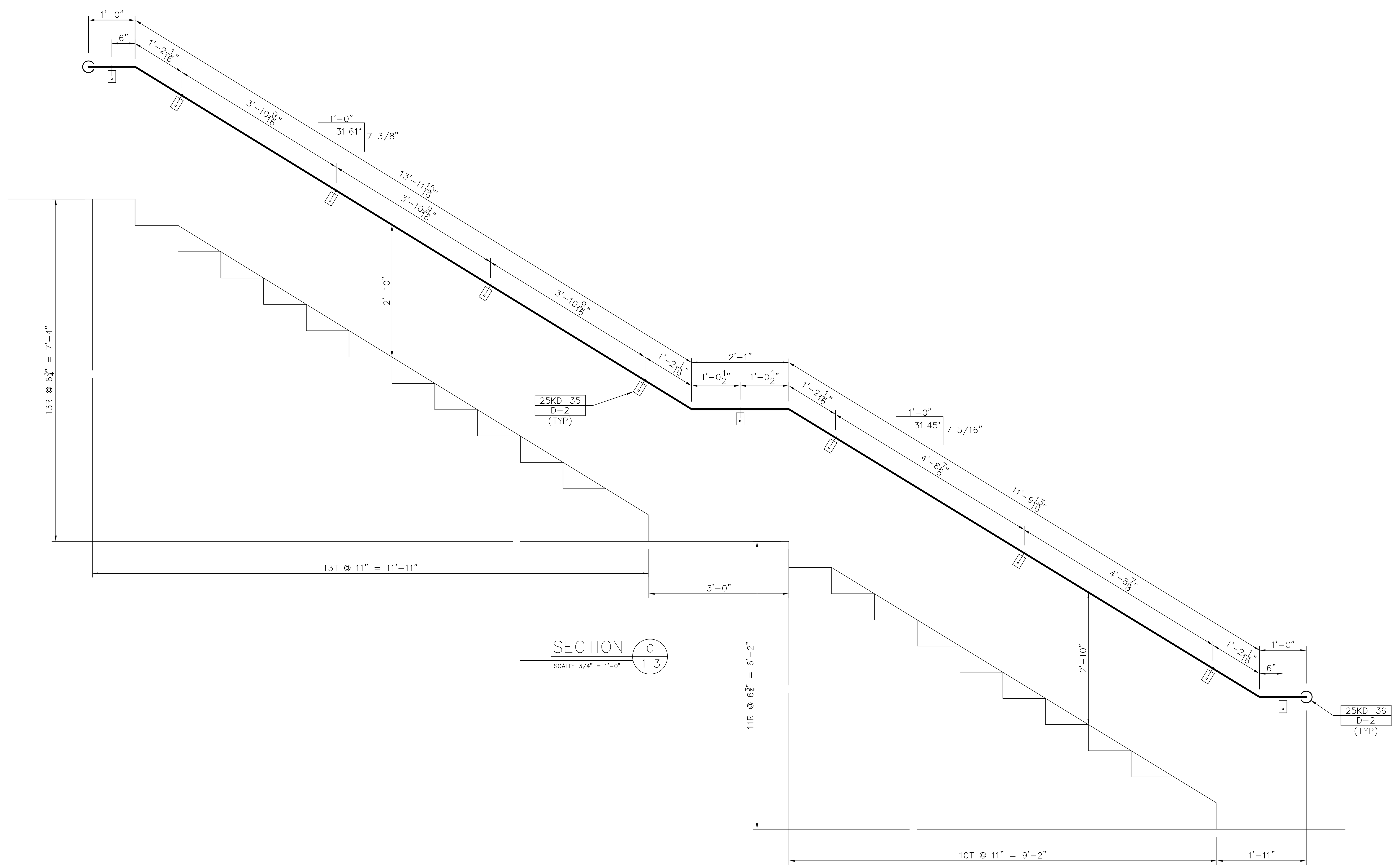
PRIOR TO FABRICATION.

ROCKY MOUNTAIN RAILINGS
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

HAROLD D. THOMPSON W.R.F. FOUNTAIN, CO.	DESIGNER GSM INC.
DETAILS STAIR DETAILS	CUSTOMER WEAVER CONSTRUCTION
FINISH M10C22A41	CONTRACTOR
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11
ERECTION BY OTHERS	JOB NO. R1940
FIELD CHECKED BY OTHERS	DRAWING NO. 2
CUSTOMER P.O./JOB 2908-05470	
L/F	

NO.	REVISION	BY	DATE

REFER TO CONTRACT DWG. ___ DWG. NO. ___



PLEASE VERIFY ALL CONCRETE STAIR DIMENSIONS
PRIOR TO FABRICATION.

ROCKY MOUNTAIN RAILINGS

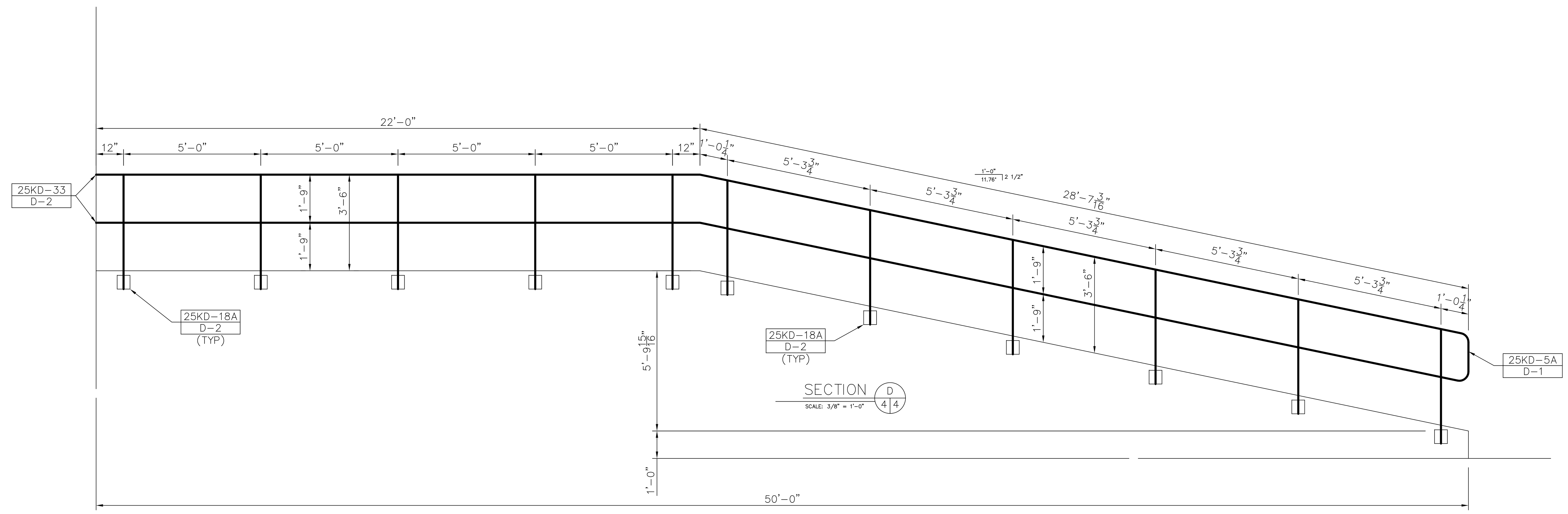
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

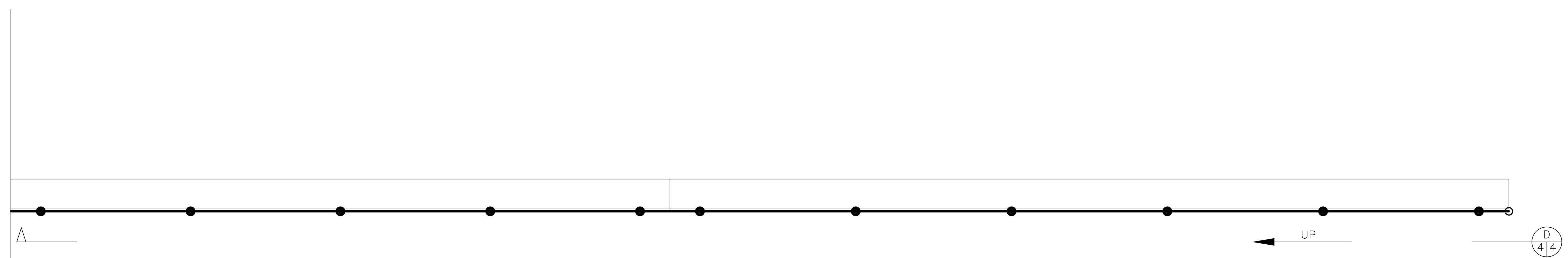
HAROLD D. THOMPSON W.R.F. FOUNTAIN, CO.	DESIGNER GSM INC.	
DETAILS STAIR SECTION	CUSTOMER WEAVER CONSTRUCTION	
FINISH M10C22A41	CONTRACTOR	
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11	JOB NO. R1940
ERECTION BY OTHERS		DRAWING NO. 3
FIELD CHECKED BY OTHERS		
CUSTOMER P.O./JOB 2908-05470		
L/F		

NO.	REVISION	BY	DATE

REFER TO CONTRACT DWG. ___ DWG. NO. ___

TOTAL POST	11
BASE MT.	N/A
EMBED	N/A
SIDE MT.	11





HEADWORKS BUILDING – RETAINING WALL

SCALE: 3/8" = 1'-0"

SEE SHEET: HW-5

PLEASE VERIFY ALL CONCRETE STAIR DIMENSIONS PRIOR TO FABRICATION.

ROCKY MOUNTAIN RAILINGS
11839 E 51st AVE DENVER, CO 80239 PHONE (303) 432-0003 FAX (303) 432-2038

HAROLD D. THOMPSON W.R.F.	DESIGNER GSM INC.
FOUNTAIN, CO.	CUSTOMER WEAVER CONSTRUCTION
DETAILS RETAINING WALL DETAIL	CONTRACTOR
FINISH M10C22A41	
DR. DDB DATE 7/26/11 SCALE AS NOTED	NO. 9P PRINTS FOR APPROVAL DATE 07-26-11 JOB NO. R1940
ERECTION BY OTHERS	
FIELD CHECKED BY OTHERS	DRAWING NO. 4
CUSTOMER P.O./JOB 2908-05470	
L/F	

NO.	REVISION	BY	DATE

REFER TO CONTRACT DWG. ___ DWG. NO. ___

ATEC Associates, Inc.
5150 East 65th Street
Indianapolis, Indiana 46220 4871
317-849-4990
Telex 232 0055 ASAS

Corporate Office:
Indianapolis, IN

Offices:
Atlanta GA
Baltimore MD
Birmingham AL
Calumet City IL
Chicago IL
Cincinnati OH
Dallas TX
Dayton OH
Denver CO
Destin FL
Gary IN
Gaithersburg MD
Harrisburg PA
Huntsville AL
Lexington KY
Louisville KY
Newport NC
Raleigh NC
Salisbury MD
Savannah GA
Washington DC

Affiliates:
Alexandria VA
Norfolk VA

February 10, 1986

Tuttle Aluminum and Bronze Company
120 Shadow Lawn Drive
Noblesville, Indiana 46060

ATTN: Mr. Doug Waugh

RE: Load Testing of Aluminum Hand
Rail Structure - TABCO 2500
Tuttle Aluminum and Bronze Company
Noblesville, Indiana
ATEC Job No. 21-62016

Gentlemen:

Submitted herewith are results of load testing of an aluminum hand rail structure at the referenced site. This testing was performed on February 7, 1986 on the railing configuration noted below.

Three independent loads were applied to the rail structure. (See attached sketch of the rail structure) The loads were applied horizontally at a midspan, horizontally at a post and vertically at a midspan. The load was applied by a hydraulic jack attached to a fork lift. A calibrated proving ring was attached to the rail at loading locations for measurement of load. The loads were then applied by jacking the pump against the proving ring until the desired load was reached.

Deflection readings were made at maximum loading (200#) and then again after release of load to determine any permanent deflection. This was measured as deflection of the top rail horizontally (for horizontal loading) and the top rail vertically (for vertical loading).

The following is the construction description of the TABCO 2500 - Mechanical Connections railing system:

TABCO 2500 CONSTRUCTION

Aluminum rail was constructed of 1-1/2" (Sch 40) aluminum pipe, top, intermediate, and post. All pipe to pipe connections were mechanically attached with fittings and rivets. The posts were welded to 3/8" X 2-1/2" x 6" aluminum base plates and mounted to a concrete floor with two (2) 3/8" x 2-3/4" stainless steel TRUBOLTS.

We appreciate the opportunity to be of service to you on this project. If you have any questions, please give me a call at this office.

Very truly yours;

ATEC ASSOCIATES, INC.

Thomas J. Struewing
Project Engineer

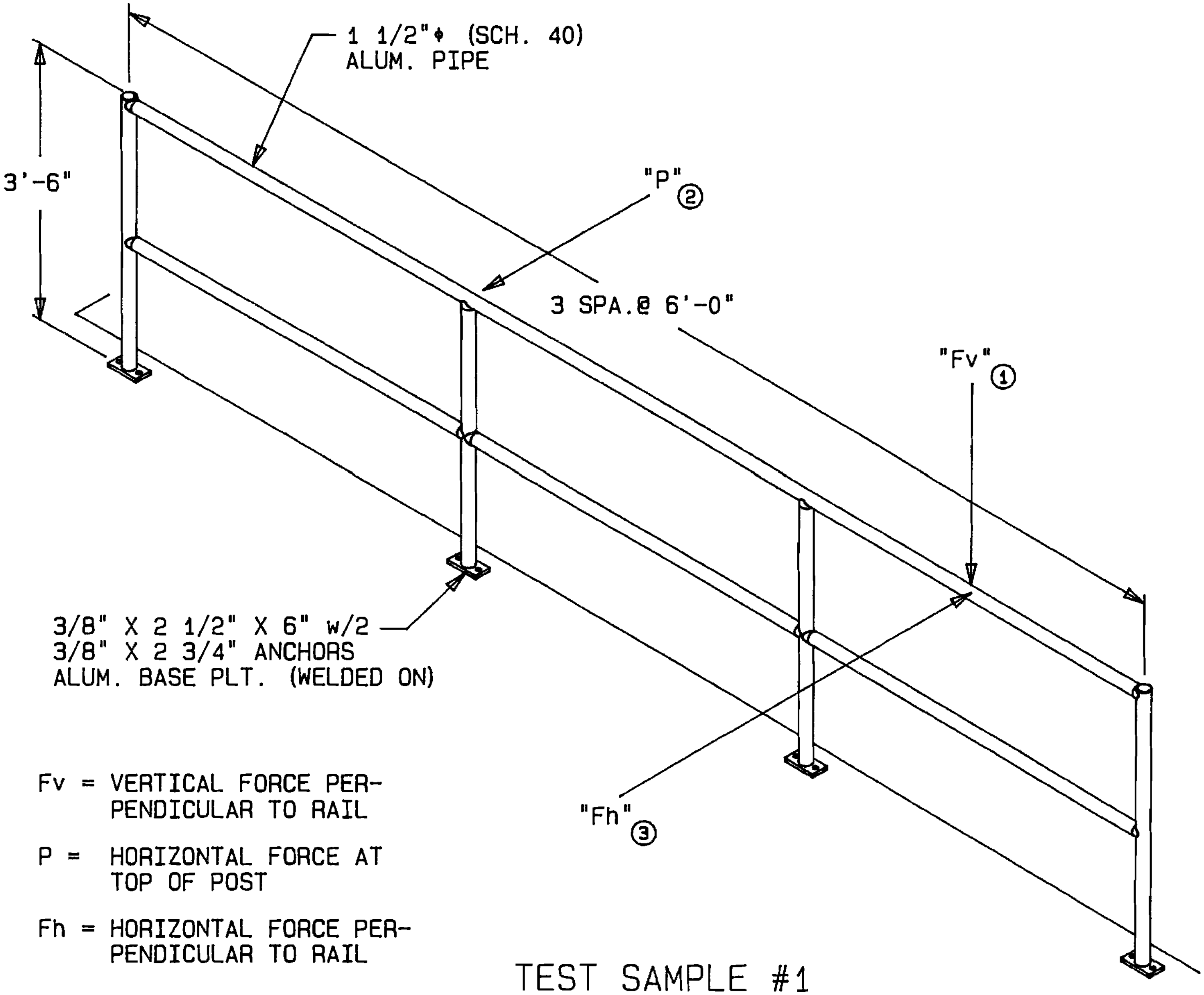
TJS/cas

Load Test of Aluminum Railing
Tuttle Aluminum and Bronze Company
Noblesville, Indiana
ATEC Job No. 21-62016

TABCO 2500 - Mechanical Connections

	Deflection	Permanent Set *
Horizontal load at Midspan = 200# (Fh)	1-9/16"	1/16"
Vertical Load at Midspan = 200# (Fv)	0.127"	0.00"
Horizontal Load at Post = 200# (P)	1-5/16"	0"

* Deflection after release of load



Fv = VERTICAL FORCE PERPENDICULAR TO RAIL

P = HORIZONTAL FORCE AT TOP OF POST

Fh = HORIZONTAL FORCE PERPENDICULAR TO RAIL

TEST SAMPLE #1

ROCKY MOUNTAIN RAILINGS

Re: Alloy Temper for Rocky Mountain Railings, Inc. Aluminum Pipe

Subject: Increased Yield Strength and Anodizing

As of 01/01/2007, Rocky Mountain Railings, Inc. has changed the use of alloy 6063-T6, 1-1/2" Sch. 40 pipe to the use of Aluminum Alloy 6105-T5, The reasons for the change is as follows:

1). 6105-T5 has an ultimate minimum tensile strength of 38 KSI, and 6063-T6 has 22 KSI (See Alcoa Conformance Chart) This alloy meets or exceeds OSHA and UBC loading requirements.

2). Alloy 6105-T5 is also equivalent to alloy 6061-T6 in terms of tensile and yield strength. Alloy 6061-T6 is also a commonly specified alloy due to its superior strength. However the anodizing finish of 6061-T6 does not match Rocky Mountain Railings, Inc. standard clear anodize of our fittings 6105-T5 is a near perfect match in finish, Therefore a more aesthetic appearance.

Although Rocky Mountain Railings, Inc. has endured cost impact for the use of alloy 6105-T5, We have not passed this cost to our customers. We feel that the increased strength of alloy and the appearance of the finish have helped in the submittal process and a feeling of satisfaction, knowing that we are supplying a quality product to our customer.

If you have any questions, Please call at (303)-432-0003

11939 E. 51ST Ave. Denver, CO. 80239. Phone (303) 432-0003. Fax (303) 432-2038

ALCOA Alcoa Engineered Products

ALLOY 6005/6105

Understanding Extruded Aluminum Alloys

Among Alcoa Engineered Products' structural 6XXX series alloys, 6005 and 6105 are medium strength alloys that are very similar to alloy 6061 except they contain higher amounts of silicon. These alloys are used in designs that require moderate strength, but are generally not recommended for applications where the structure may be susceptible to impact or overloading.

When bending is required, the naturally aged -T1 temper is preferred. However, due to the excess silicon content, properties may increase more rapidly with room temperature aging than typically experienced with 6063 and 6061 alloys. In comparison to 6061, alloys 6005 and 6105 are easier to extrude and are less quench sensitive, allowing them to be used for more complex shapes. Alloys 6005 and 6105, when produced to a -T5 temper, have the same minimum tensile and yield strength as 6061-T6. In comparison to 6063, alloys 6005 and 6105 in -T5 tempers have better machinability and strength properties than 6063-T6.

Alloys 6005 and 6105 can also be welded or brazed using various commercial methods (caution: direct contact with dissimilar materials can cause galvanic corrosion). The heat from welding or brazing can reduce strength in the weld region. Consult the Material Safety Data Sheet (MSDS) for proper safety and handling precautions when using 6005 and 6105 alloys.

These alloys also offer good finishing characteristics and respond well to common anodizing methods such as clear, clear and color dye and hardcoat.

Typical applications for alloys 6005 and 6105 include:

- Automotive connector stock
- Structural members
- Hand rail tubing
- Seamless tubing
- Ladder structures

6005/6105 Temper Designations and Definitions

Standard Tempers	Standard Temper Definitions*
F	As fabricated. There is no special control over thermal conditions and there are no mechanical property limits.
T1	Cooled from an elevated temperature shaping process and naturally aged. (See Note A.)
T5	Cooled from an elevated temperature shaping process & artificially aged. (See Note A.)
Alcoa Special Tempers**	**Alcoa Special Temper Definitions**
(For 6005 Alloy only)	
T1S14	A maximum formability special temper for product that will be formed within 1 to 2 weeks after shipment. Samples are aged and tested in the -T5 condition to verify heat treat capability.
T5S3	An underaged temper to increase formability at a sacrifice of mechanical properties.
T5511	Same mechanical property limits as -T5. Stretched 1-3% for stress relief.

*For further details of definitions, see Aluminum Association's Aluminum Standards and Data manual and Tempers for Aluminum and Aluminum Alloy Products.
Note A: Applies to products that are not cold worked after cooling from an elevated temperature shaping process, or in which the effect of cold work in flattening or straightening may not be recognized in mechanical properties.
**Alcoa Special Temper designations are unregistered tempers for reference only and provided for customer use to identify unique processing, material, or end use application characteristics.

Alloy 6005 Chemical Analysis

Liquidus Temperature: 1210°F **Solidus Temperature:** 1125°F **Density:** 0.097 lb./in.^{3}

Percent Weight	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others Each	Others Total	Aluminum
Minimum	.6	—	—	—	.40	—	—	—	—	—	
Maximum	.9	.35	.10	.10	.6	.10	.10	.10	.05	.15	Remainder

Alloy 6105 Chemical Analysis

Liquidus Temperature: 1200°F **Solidus Temperature:** 1110°F **Density:** 0.097 lb./in.^{3}

Percent Weight	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others Each	Others Total	Aluminum
Minimum	.6	—	—	—	.45	—	—	—	—	—	
Maximum	1.0	.35	.10	.15	.8	.10	.10	.10	.05	.15	Remainder

Alloy	Average Coefficient of Thermal Expansion (68° to 212°F)
6005	13.0 X 10^{-6} (inch per inch per °F)
6105	13.0 X 10^{-6} (inch per inch per °F)

Alloy 6005/6105 Mechanical and Physical Property Limits

Temper	Specified Section or Wall Thickness (inches)[2]		Tensile Strength (ksi) Ultimate		Tensile Strength (ksi) Yield (0.2% offset)		Elongation[3] Percent Min. in 2 inch or 4D[4]	Typical Thermal Conductivity at 77°F btu-in./ft²hr°F	Typical Electrical Conductivity[5] (% IACS)
	Min.	Max.	Min.	Max.	Min.	Max.			
Alloy 6005 Standard Tempers[1]									
F	All		No Properties Apply					N/A	N/A
T1	—	.500	25.0	—	15.0	—	16	1250	47
T5	—	.124	38.0	—	35.0	—	8	1310	49
T5	.125	—	38.0	—	35.0	—	10	1310	49
Alloy 6105 Standard Tempers[1]									
F	All		No Properties Apply					N/A	46
T1	—	.500	25.0	—	15.0	—	16	1220	—
T5	—	.500	38.0	—	35.0	—	8	1340	50
Alloy 6005 Special Tempers*									
T1S14[6]	—	.124	38.0	—	35.0	—	8	1250	47
T1S14[6]	.125	—	38.0	—	35.0	—	10	1250	47
T5S3	All		35.0	—	30.0	—	8	N/A	N/A
T5511[7]	—	.124	38.0	—	35.0	—	8	1310	49
T5511[7]	.125	—	38.0	—	35.0	—	10	1310	49

① The mechanical property limits for standard tempers are listed in the Property Limits section of the Aluminum Association's Aluminum Standards and Data manual and Tempers for Aluminum and Aluminum Alloy Products. ② The thickness of the cross section from which the tension test specimen is taken determines the applicable mechanical properties. ③ For materials of such dimensions that a standard test specimen cannot be taken, or for shapes thinner than .062", the test for elongation is not required. ④ D=Specimen diameter. ⑤ Minimum, unless stated as typical. ⑥ These properties apply to the material after proper artificial aging. No properties apply to shipped product. ⑦ For stress-relieved tempers, the characteristics and properties other than those specified may differ somewhat from the corresponding characteristics and properties of material in the basic temper.

*Alcoa Special Temper designations are unregistered tempers for reference only and provided for customer use to identify unique processing, material, or end use application characteristics.

Comparative Characteristics of Related Alloys/Tempers[1]

Alloy	Temper	Formability (D C B A)	Machinability (D C B A)	General Corrosion Resistance (D C B A)	Weldability (Arc with Inert Gas) (D C B A)	Brazeability (D C B A)	Anodizing Response (D C B A)	Typical Conductivity (%IACS) (40 50 60)
6005	-T1	N/A	N/A	N/A				
	-T5, T511	N/A	N/A	N/A				
6105	-T1	N/A	N/A	N/A				
	-T5	N/A	N/A	N/A				
6061	-T4							
	-T6							
6063	-T4							
	-T6							
6262	-T6							

① Rating: A=Excellent B=Good C=Fair D=Poor For further details of explanation of ratings for, see Aluminum Association's Aluminum Standards and Data manual.

Alcoa Distribution and Industrial Products

53 Pottsville Street
Cressona, PA 17929
Phone: 800-233-3165
FAX: 800-252-4646

…T VARIOUS TEMPERATURES①

Table 3 (continued)

Elongation in 2 in., percent
46
35
32
30
36
50
60
80
110
130
46
35
32
30
36
50
60
80
110
130
39
30
27
25
31
50
60
[illegible]
32
23
20
18
20
37
45
80
110
130
36
21
18
16
19
32
45
80
110
130

Alloy and Temper	Temp., °F	Tensile Strength, ksi		Elongation in 2 in., percent
		Ultimate	Yield②	
5456-O	−320	62	26	32
	−112	46	23	25
	− 18	45	23	22
	75	45	23	20
	212	42	22	31
	300	31	20	50
	400	22	17	60
	500	17	11	80
	600	11	7.5	110
	700	6	4.2	130
6053-T6, -T651	75	37	32	13
	212	32	28	13
	300	25	24	13
	400	13	12	25
	500	5.5	4	70
	600	4	2.7	80
	700	2.9	2	90
6061-T6, -T651	−320	60	47	22
	−112	49	42	18
	− 18	47	41	17
	75	45	40	17
	212	42	38	18
	300	34	31	20
	400	19	15	28
	500	7.5	5	60
	600	4.6	2.7	85
	700	3	1.8	95
6063-T1	−320	34	16	44
	−112	26	15	36
	− 18	24	14	34
	75	22	13	33
	212	22	14	18
	300	21	15	20
	400	9	6.5	40
	500	4.5	3.5	75
	600	3.2	2.5	80
	700	2.3	2	105
6063-T5	−320	37	24	28
	−112	29	22	24
	− 18	28	22	23
	75	27	21	22
	212	24	20	18
	300	20	18	20
	400	9	6.5	40
	500	4.5	3.5	75
	600	3.2	2.5	80
	700	2.3	2	105

TYPICAL TENSILE PROPERTIES AT VARIOUS TEMPERATURES①

Table 3 (continued)

Alloy and Temper	Temp., °F	Tensile Strength, ksi		Elongation in 2 in., percent
		Ultimate	Yield②	
6063-T6	−320	47	36	24
	−112	38	33	20
	− 18	36	32	19
	75	35	31	18
	212	31	28	15
	300	21	20	20
	400	9	6.5	40
	500	4.5	3.5	75
	600	3.3	2.5	80
	700	2.3	2	105
6151-T6	−320	57	50	20
	−112	50	46	17
	− 18	49	45	17
	75	48	43	17
	212	43	40	17
	300	28	27	20
	400	14	12	30
	500	6.5	5	50
	600	5	3.9	43
	700	4	3.2	35
6262-T651	−320	60	47	22
	−112	49	42	18
	− 18	47	41	17
	75	45	40	17
	212	42	38	18
	300	34	31	20
6262-T9	−320	74	67	14
	−112	62	58	10
	− 18	60	56	10
	75	58	55	10
	212	53	52	10
	300	38	37	14
	400	15	13	34
	500	8.5	6	48
	600	4.6	2.7	85
	700	3	1.8	95

Alloy and Temper	Temp., °F	Tensile Strength, ksi		Elongation in 2 in., percent
		Ultimate	Yield②	
7075-T6, -T651	−320	102	92	9
	−112	90	79	11
	− 18	86	75	11
	75	83	73	11
	212	70	65	14
	300	31	27	30
	400	16	13	55
	500	11	9	65
	600	8	6.5	70
	700	6	4.6	70
7075-T73, -T7351	−320	92	72	14
	−112	79	67	14
	− 18	76	65	13
	75	73	63	13
	212	63	58	15
	300	31	27	30
	400	16	13	55
	500	11	9	65
	600	8	6.5	70
	700	6	4.6	70
7079-T6, -T651	−320	92	80	12
	−112	82	70	14
	− 18	79	68	14
	75	78	68	14
	212	67	60	18
	300	33	28	37
	400	16	13	60
	500	11	8.5	100
	600	7.5	6	175
	700	5.5	4.3	175

31,000 YIELD x .66 = 20,[illegible] DS

40,000# YIELD x .66 = 26,400 DS

21,000# YIELD x .66 = 13,860 DS

①Lowest strengths during 10,000 hours of exposure at testing temperature under no load; stress applied at 5,000 psi/min to yield strength and then at strain rate of 0.05 in./in./min to failure. Under some conditions of temperature and time, the application of heat will adversely affect certain other properties of some alloys. For specific information concerning the suitability of the various alloys for use at elevated temperatures, the nearest sales office of Aluminum Company of America should be consulted.

②Offset equals 0.2 percent.

③Preferred alloy designation is 6101.

Marson

Stainless Rivets

Stainless Rivet • Stainless Mandrel • IFI Grade 51

Buttonhead

AFS Part No.	D Rivet Dia. Nom. Inch (mm)	Drill No. & Hole Size (mm)	H Head Dia. Nom. Inch (mm)	E Head Height Max. Inch (mm)	L Rivet Length Max. Inch	L Rivet Length Max. (mm)	Grip Range Inch	Grip Range (mm)	Typical Ultimate Strength (Lbs.) (newtons) Shear	Typical Ultimate Strength (Lbs.) (newtons) Tensile
SSB4-1S	1/8"(.125)	#30(.129-.133)	.250	.040	.212	5.4	.032-.062	0.8-1.6	520	600
SSB4-2S	3.2	3.3(3.28-3.38)	6.35	1.02	.275	7.0	.063-.125	1.7-3.2	2310	2660
SSB4-3S					.337	8.6	.126-.187	3.3-4.8		
SSB4-4S					.400	10.2	.188-.250	4.9-6.4		
SSB4-5S					.462	11.7	.251-.312	6.5-7.9		
SSB4-6S					.525	13.4	.313-.375	8.0-9.5		
SSB4-8S					.650	16.5	.376-.500	9.6-12.7		
SSB5-2S	5/32"(.156)	#20(.160-.164)	.312	.045	.300	7.6	.062-.125	1.6-3.2	785	1040
SSB5-3S	4.0	4.1(4.06-4.16)	7.92	1.14	.338	8.0	.126-.187	3.2-4.8	3490	4620
SSB5-4S					.425	10.8	.188-.250	4.9-6.4		
SSB5-6S					.550	14.0	.251-.375	6.5-9.5		
SSB5-8S					.675	17.2	.376-.500	9.6-12.7		
SSB5-10S					.800	20.3	.501-.625	12.8-15.9		
SSB6-2S	3/16"(.187)	#11(.192-.196)	.375	.066	.325	8.3	.062-.125	1.6-3.2	1150	1300
SSB6-4S	4.8	4.9(4.88-4.98)	9.53	1.40	.450	11.5	.126-.250	3.3-6.4	5110	5780
SSB6-6S					.575	14.6	.251-.375	6.5-9.5		
SSB6-8S					.700	17.8	.376-.500	9.6-12.7		
SSB6-10S					.825	21.0	.501-.625	12.8-15.9		
SSB6-12S					.950	24.2	.626-.750	16.0-19.1		
SSB6-16S					1.200	30.5	.751-1.000	19.1-25.4		
SSB8-4S	1/4"(.250)	F(.257-.261)	.500	.074	.500	12.7	.062-.250	1.6-6.4	1700	2100
SSB8-6S	6.4	6.5(6.53-6.63)	12.70	1.88	.625	15.9	.251-.375	6.5-9.5	7560	9340
SSB8-8S					.750	19.1	.376-.500	9.6-12.7		
SSB8-10S					.875	21.0	.501-.625	12.8-15.9		
SSB8-12S					1.000	25.4	.626-.750	16.0-19.1		

Large Flange

AFS Part No.	D Rivet Dia. Nom. Inch (mm)	Drill No. & Hole Size (mm)	H Head Dia. Nom. Inch (mm)	E Head Height Max. Inch (mm)	L Rivet Length Max. Inch	L Rivet Length Max. (mm)	Grip Range Inch	Grip Range (mm)	Shear	Tensile
SSBL4-2S	1/8"(.125)	#30(.129-.133)	.375	.045	.275	7.0	.032-.125	0.8-3.2	520	600
SSBL4-3S	3.2	3.3(3.28-3.38)	9.53	1.14	.337	8.6	.126-.187	3.3-4.8	2310	2660
SSBL4-4S					.400	10.2	.188-.250	4.9-6.4		
SSBL6-4S	3/16"(.187)	#11(.192-.196)	.615	.082	.450	11.5	.062-.250	1.6-6.4	1150	1300
SSBL6-6S	4.8	4.9(4.88-4.98)	15.88	2.08	.575	14.6	.251-.375	6.5-9.5	5110	5780
SSBL6-8S					.700	17.8	.376-.500	9.6-12.7		
SSBL6-10S					.825	21.0	.501-.625	12.8-15.9		
SSBL6-12S					.950	24.2	.626-.750	16.0-19.1		

120° Countersunk

AFS Part No.	D Rivet Dia. Nom. Inch (mm)	Drill No. & Hole Size (mm)	H Head Dia. Nom. Inch (mm)	E Head Height Max. Inch (mm)	L Rivet Length Max. Inch	L Rivet Length Max. (mm)	Grip Range Inch	Grip Range (mm)	Shear	Tensile
SSC4-2S	1/8"(.125)	#30(.129-.133)	.220	.045	.275	7.0	.063-.125	1.7-3.2	520	600
SSC4-3S	3.2	3.3(3.28-3.38)	5.59	1.14	.337	8.6	.126-.187	3.3-4.8	2310	2660
SSC4-4S					.400	10.2	.188-.250	4.9-6.4		
SSC4-5S					.462	11.7	.251-.312	6.5-7.9		
SSC6-4S	3/16"(.187)	#11(.192-.196)	.350	.050	.407	10.3	.126-.250	3.3-6.4	1150	1300
	4.8	4.9(4.88-4.98)	8.89	1.27					5110	5780

KLIK-FAST RIVETS conform to IFI-114 (inch) and IFI-505 (metric). Millimeters (mm) and newtons (N) are in green.

Meet our stainless lineup

Standard

Countersink

Closed-End

APPLICATION

COVERAGE RATES

	Dry Mils (Microns)	Wet Mils (Microns)	Sq Ft/Gal (m^2/Gal)
Suggested	10.0 (255)	15.5 (395)	103 (9.5)
Minimum	8.0 (205)	12.5 (320)	128 (11.9)
Maximum	12.0 (305)	19.0 (480)	86 (7.9)

Allow for overspray and surface irregularities. Film thickness is rounded to the nearest 0.5 mil or 5 microns. Application of coating below minimum or above maximum recommended dry film thicknesses may adversely affect coating performance.

MIXING Stir thoroughly, making sure no pigment remains on the bottom of the can.

THINNING Use No. 2 Thinner. For air or airless spray, brush or roller, thin up to 5% or ¼ pint (190 mL) per gallon if necessary. Drum heaters or inline heaters may be necessary to maintain application viscosity during cool weather.

SURFACE TEMPERATURE Minimum 40°F (4°C) Maximum 135°F (57°C)
The surface should be dry and at least 5°F (3°C) above the dew point.

APPLICATION EQUIPMENT

Air Spray

Gun	Fluid Tip	Air Cap	Air Hose ID	Mat'l Hose ID	Atomizing Pressure	Pot Pressure
DeVilbiss MBC or JGA	E	704	3/8" or 1/2" (9.5 or 12.7 mm)	1/2" or 3/4" (12.7 or 19 mm)	50 psi (3.4 bar)	20 psi (1.4 bar)

Low temperatures or longer hoses require higher pot pressure.

Airless Spray

Tip Orifice	Atomizing Pressure	Mat'l Hose ID	Manifold Filter
0.017"-0.031" (430-785 microns)	2400-3000 psi (165-207 bar)	3/8" or 1/2" (9.5 or 12.7 mm)	60 mesh (250 microns)

Use appropriate tip/atomizing pressure for equipment, applicator technique and weather conditions.
Roller: Use high quality synthetic nap covers. Short nap for smooth surfaces. Long nap for rough surfaces. **Note:** Two or more coats may be required to obtain recommended film thicknesses.
Brush: Use high quality nylon or synthetic bristle brushes. **Note:** Two or more coats may be required to obtain recommended film thicknesses.

CLEANUP Flush and clean all equipment immediately after use with the recommended thinner or xylol.

DATA SHEET

TUTTLE ALUMINUM
120 SHADLOWLAWN DRIVE

FISHERS IN 46038

COAL TAR CTG. H.B. TNEMEC

FOR COATINGS, RESINS, AND RELATED MATERIALS
(APPROVED BY THE U.S. DEPARTMENT OF LABOR AS
'ESSENTIALLLY SIMILAR' TO FORM OSHA-20)
(MEETS REQUIREMENTS OF CFR 29 PART 1910.1200,
OSHA'S HAZARD COMMUNICATION STANDARD) NPCA 1-84

SECTION 1 - MANUFACTURER AND PRODUCT INFORMATION

CHEMICAL PRODUCT IDENTIFICATION:
PRODUCT ID . . . . : F046-0465 5G
PRODUCT CLASS . . . . : COAL TAR
TRADE NAME . . . : COAL TAR CTG. H.B. TNEMEC
FORMULA VERSION NUMBER . . . . : 5
MSDS PREPARATION DATE . . . . : 01/18/2001
MANUFACTURER IDENTIFICATION:
NAME . . . . : TNEMEC COMPANY, INC.
ADDRESS . . . . : 123 WEST 23RD AVENUE
NORTH KANSAS CITY, MO. 64116-3064
TELEPHONE . . . . : 816-474-3400
EMERGENCY TELEPHONE . . . . : 816-474-1425

SECTION 2 - HAZARDOUS INGREDIENTS

---

1 MAGNESIUM SILICATE
CAS# 14807-96-6
TALC (NO ASBESTOS FIBERS/RESPIRABLE DUST)
PCT BY WT: 11-20
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0002.00 MG/M3
OSHA PEL/TWA: 0002.00 MG/M3

2
CAS# 7727-43-7
BARIUM SULFATE (TOTAL DUST)
PCT BY WT: 21-30
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0010.00 MG/M3
OSHA PEL/TWA: 0010.00 MG/M3

3
CAS# 65996-93-2
REFINED COAL TAR PITCH (CONTAINS PPAH'S)
PCT BY WT: 34.4860
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0000.20 MG/M3
OSHA PEL/TWA: 0000.20 MG/M3

---

4 METHYLBENZENE
CAS# 108-88-3
TOLUENE
PCT BY WT: 5.6690 VAPOR PRESSURE: 22.000 MMHG @ 68F
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0050.00 PPM
OSHA PEL/TWA: 0100.00 PPM
OSHA STEL: 0150.00 PPM

5
CAS# 100-41-4
ETHYL BENZENE
PCT BY WT: 2.6770 VAPOR PRESSURE: 6.000 MMHG @ 68F
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0100.00 PPM
ACGIH TLV/STEL: 0125.00 PPM
OSHA PEL/TWA: 0100.00 PPM
OSHA STEL: 0125.00 PPM

---

6 XYLENE
CAS# 1330-20-7
DIMETHYLBENZENE
PCT BY WT: 11.0730 VAPOR PRESSURE: 5.100 MMHG @ 68F
EXPOSURE LIMIT:
ACGIG TVL/TWA: 0100.00 PPM
ACGIH TLV/STEL: 0150.00 PPM
OSHA PEL/TWA: 0100.00 PPM
OSHA STEL: 0150.00 PPM

****
This product contains one or more reported carcinogens or suspected carcinogens which are noted NTP, IARC, or OSHA-Z in the other limits

TNEMEC COMPANY, INC.
MATERIAL SAFETY DATA SHEET

F046-0465 5G

COAL TAR CTG. H.B. TNEMEC

SECTION 4 - FIRST AID MEASURES

EYE CONTACT:
Flush immediately with large amounts of clean water under low pressure for at least 15 minutes. Consult a physician.
SKIN CONTACT:
Wash affected area with soap and water. Remove contaminated clothing. Dispose of or launder accordingly. Consult a physician if skin irritation persists.
INHALATION:
Remove affected individual to fresh air. Treat symptomatically. If breathing is difficult, administer oxygen. If breathing has stopped give artificial respiration. Consult a physician.
INGESTION:
Drink 1 or 2 glasses of water to dilute. Do not induce vomiting. Consult a physician or poison control center IMMEDIATELY. Treat symptomatically.
NOTE TO PHYSICIAN:

SECTION 5 - FIRE AND EXPLOSION HAZARD DATA

FIRE AND EXPLOSIVE PROPERTIES OF THE CHEMICAL:

Flammability Classification	:	
Flashpoint	:	80.0
Explosion Level	:	Low - 1.0
		High - -N/A
Flammability Limits	:	Lower - -N/A
		Higher - -N/A

EXTINGUISHING MEDIA:
Foam, carbon dioxide, and dry chemical.
FIRE-FIGHTING PROCEDURES AND EQUIPMENTS:
Keep away from heat, open flames, sparks, and areas where static charge may be generated. Do not apply to hot surfaces due to possible fire and explosion risk. For closed containers, pressure build-up and possible explosion might occur due to extreme heat exposure. Solvent vapors are heavier than air and may travel considerable distance to a source of ignition and flash back. Water may be used to cool unruptured containers. Wear self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode to prevent inhalation of hazardous decomposition products. Use appropriate extinguishing media to control fire. Water may cause violent frothing if sprayed directly into containers of burning liquid.

SECTION 6 - SPILL OR LEAK PROCEDURES

CLEAN-UP:
Remove all sources of ignition. Spills may be collected with inert, absorbent material for proper disposal. Use non-sparking tools, protective gloves, goggles and clothing, adequate ventilation, avoid the breathing of vapors and use respiratory protective devices. Transfer absorbent material to suitable containers for proper disposal.

SECTION 7 - SPECIAL PRECAUTIONS

HANDLING AND STORAGE:
Store in dry area. Keep closures tight and upright to prevent leakage. Do not store in high temperature areas or near fire or open flame. Refer to product data sheet for recommended storage temperatures.
SPECIAL COMMENTS:
Prevent prolonged breathing of airborne contaminants such as vapor, spray mists, or dusts. Prevent contact with skin and eyes. Do not take internally. Keep out of reach of children. Do not reuse or alter containers without proper industrial cleaning. Do not weld or flame cut empty, uncleaned containers due to potential fire and explosion hazard. Consult product data sheet for proper application instructions.

TNEMEC COMPANY, INC.
MATERIAL SAFETY DATA SHEET

F046-0465 5G

COAL TAR CTG. H.B. TNEMEC

SECTION 12 - ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION:

SECTION 13 - DISPOSAL CONSIDERATIONS

WASTE DISPOSAL:
Dispose of in accordance with Federal, state, and local regulations regarding pollution.

SECTION 14 - TRANSPORT INFORMATION

DOT HAZARD CLASS ....:
TRANSPORTATION ASSISTANCE:
Contact Tnemec's Traffic department @ (816) 474-3400.

SECTION 15 - REGULATORY INFORMATION

FEDERAL REGULATIONS:
This product contains the following toxic chemicals subject to the reporting requirements of Section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 and of 40 CFR 372:

TOLUENE
CAS# 108-88-3 PCT BY WT: 5.6690

ETHYL BENZENE
CAS# 100-41-4 PCT BY WT: 2.6770

DIMETHYLBENZENE
CAS# 1330-20-7 PCT BY WT: 11.0730

STATE REGULATIONS:

SECTION 16 - OTHER INFORMATION

Prepared by . . . . : Kevin Settles
Date of issue . . . . : 01/18/2001
Last Revision Date . . . . : 02/23/1997

MSDS Prepared for . . . . : TUTTLE ALUMINUM
120 SHADLOWLAWN DRIVE

FISHERS IN 46038

MSDS Last Prepared . . . . : 04/27/2000

HMIS Information: Health- 3* Flammability- 3
Reactivity- 1

For specific information regarding occupational safety and health standards, please refer to the Code of Federal Regulations, Title 29, Part 1910.
To the best of our knowledge, the information contained herein is accurate. However, neither the Tnemec Company or any of its subsidiaries assume any liability whatsoever for the accuracy of completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist.

FOR COATINGS, RESINS, AND RELATED MATERIALS
(APPROVED BY THE U.S. DEPARTMENT OF LABOR AS
'ESSENTIALLLY SIMILAR' TO FORM OSHA-20)
(MEETS REQUIREMENTS OF CFR 29 PART 1910.1200,
OSHA'S HAZARD COMMUNICATION STANDARD) NPCA 1-84

SECTION 1 - MANUFACTURER AND PRODUCT INFORMATION

CHEMICAL PRODUCT IDENTIFICATION:
PRODUCT ID . . . . : F041-0002 5G
PRODUCT CLASS . . . . : THINNER
TRADE NAME . . . : THINNER CLEAR
FORMULA VERSION NUMBER . . . . : 2
MSDS PREPARATION DATE . . . . : 01/18/2001
MANUFACTURER IDENTIFICATION:
NAME . . . . : TNEMEC COMPANY, INC.
ADDRESS . . . . : 123 WEST 23RD AVENUE
NORTH KANSAS CITY, MO. 64116-3064
TELEPHONE . . . . : 816-474-3400
EMERGENCY TELEPHONE . . . . : 816-474-1425

SECTION 2 - HAZARDOUS INGREDIENTS

1
CAS# 100-41-4
ETHYL BENZENE
PCT BY WT: 19.9980 VAPOR PRESSURE: 6.000 MMHG @ 68F
EXPOSURE LIMIT:

ACGIG TVL/TWA:	0100.00	PPM
ACGIH TLV/STEL:	0125.00	PPM
OSHA PEL/TWA:	0100.00	PPM
OSHA STEL:	0125.00	PPM

2 XYLENE
CAS# 1330-20-7
DIMETHYLBENZENE
PCT BY WT: 80.0020 VAPOR PRESSURE: 5.100 MMHG @ 68F
EXPOSURE LIMIT:

ACGIG TVL/TWA:	0100.00	PPM
ACGIH TLV/STEL:	0150.00	PPM
OSHA PEL/TWA:	0100.00	PPM
OSHA STEL:	0150.00	PPM

****
This product contains one or more reported carcinogens or suspected carcinogens which are noted NTP, IARC, or OSHA-Z in the other limits recommended column.
****
****
This substance contains a material classified as a hazardous air pollutant.
****

SECTION 3 - HEALTH HAZARD INFORMATION

EMERGENCY OVERVIEW:
POTENTIAL HEALTH EFFECTS:
EYE:
Severe irritation.
Redness, tearing, blurred vision.
SKIN:
Moderate irritation, drying of skin, defatting and possible dermatitis.
INHALATION - OVEREXPOSURE TO SOLVENT VAPORS OR SPRAY MIST:
Nasal and respiratory irritation, anesthetic effects, dizziness, possible unconsciousness and asphyxiation, stupor, weakness, fatigue, nausea, and headache.
INHALATION - OVEREXPOSURE TO FREE PIGMENT DUST:
INGESTION:
Gastrointestinal irritation, nausea, vomiting, diarrhea, death, aspiration into the lungs which can be fatal.
CHRONIC EFFECTS:
NOTICE: Reports have associated repeated and prolonged occupational overexposure to solvents with permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the vapors may be harmful or fatal.
Based on an International Agency for Research on Cancer (IARC) conclusion

TNEMEC COMPANY, INC.
MATERIAL SAFETY DATA SHEET

F041-0002 5G

THINNER CLEAR

SECTION 6 - SPILL OR LEAK PROCEDURES

CLEAN-UP:
Remove all sources of ignition. Spills may be collected with inert, absorbent material for proper disposal. Use non-sparking tools, protective gloves, goggles and clothing, adequate ventilation, avoid the breathing of vapors and use respiratory protective devices. Transfer absorbent material to suitable containers for proper disposal.

SECTION 7 - SPECIAL PRECAUTIONS

HANDLING AND STORAGE:
Store in dry area. Keep closures tight and upright to prevent leakage. Do not store in high temperature areas or near fire or open flame. Refer to product data sheet for recommended storage temperatures.
SPECIAL COMMENTS:
Prevent prolonged breathing of airborne contaminants such as vapor, spray mists, or dusts. Prevent contact with skin and eyes. Do not take internally. Keep out of reach of children. Do not reuse or alter containers without proper industrial cleaning. Do not weld or flame cut empty, uncleaned containers due to potential fire and explosion hazard. Consult product data sheet for proper application instructions.

SECTION 8 - SAFE HANDLING AND USE INFORMATION

HYGIENIC PRACTICES:
Wash hands and other contaminated skin areas with warm soap and water before eating.
EYE PROTECTION:
Use chemical resistant splash type goggles.
RESPIRATORY PROTECTION:
Respiratory protective devices must be used when engineering and administration controls are not adequate to maintain Threshold Limit Values (TLV) and Permissible Exposure Limits (PEL) of airborne contaminants below the listed values for those hazardous ingredients identified in Section II of this MSDS. Observe OSHA regulations for respirator use (CFR 29, 1910.134) whenever a respirator is used. Particulate, chemical cartridge, air purifying half-mask respirators can be used within certain limitations; consult the respirator manufacturer for specific uses and limitations. Where airborne contaminant concentrations are unknown, the use of a NIOSH/MSHA approved fresh-air supplied respirator is mandatory.
OTHER PROTECTION:
Use Chemical resistant gloves.
Use chemical resistant coveralls or apron to protect against skin and clothing contamination.
Use protective cream where skin contact is likely.
VENTILATION:
Sufficient ventilation, in volume and pattern, should be provided through both local and general exhaust to keep the air contaminant concentration below current applicable OSHA Permissible Exposure Limits (PEL) and ACGIH's Threshold Limit Values (TLV). Appropriate ventilation should be employed to remove hazardous decomposition products formed during welding or flame cutting operations of surfaces coated with this product.
Heavier than air solvent vapors should be removed from lower levels of work area due to potential explosion hazard and all ignition sources (non-explosion proof equipment) should be eliminated if flammable mixtures will be encountered.

SECTION 9 - PHYSICAL AND CHEMICAL PROPERTIES

Vapor Pressure	6.00
Vapor Density	-N/A
Boiling Range	Lower - 275.0 °F Higher - 288.0 °F
Formula Weight per Volume	7.2000 LB/GL
VOC IN LBS PER GALLON	7.200
Evaporation Rate	9.400 (Ether = 1)

TNEMEC COMPANY, INC.
MATERIAL SAFETY DATA SHEET

F041-0002 5G

THINNER CLEAR

MSDS Last Prepared . . . . : 04/27/2000

HMIS Information: Health- 2 Flammability- 3
Reactivity- 1

For specific information regarding occupational safety and health standards, please refer to the Code of Federal Regulations, Title 29, Part 1910.
To the best of our knowledge, the information contained herein is accurate. However, neither the Tnemec Company or any of its subsidiaries assume any liability whatsoever for the accuracy of completeness of the information contained herein. Final determination of suitability of any material is the sole responsibility of the user. All materials may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards which exist.

ROCKY MOUNTAIN RAILINGS

Basic Cleaning Procedures for Anodic Finishes

Cleaning of light surface soil may be accomplished using the following methods:

- Flush surface with water using moderate pressure to remove soil. If soil is still adhering after drying, a mild detergent may be necessary.

- When mild detergent or soap is necessary, it should be used with brushing (non-metal) or sponging. The surface must be thoroughly rinsed with clean water after the use of any cleaning agent. It may be necessary to sponge the surface while rinsing, particularly if the cleaner is permitted to dry on the surface. Mild detergents ruled safe for bare hands should be safe for coated aluminum. Stronger detergents should be carefully spot tested and may necessitate the use of rubber gloves, long handled brushes, etc.

- If surface soil still adheres after following the procedures above, cleaning using a palm-sized nylon pad can be employed. Thoroughly wet pad with clean water or a mild detergent. Rub the metal surface in the direction of the metal grain with uniform pressure. After scrubbing, the metal surface should be rinsed thoroughly using clean water to remove all residues. Solvents may be used to remove non-water soluble deposits. Extreme care must be exercised when solvents are used since they may damage organic sealants, gaskets and painted finishes. If solvents are used, rinse the surface completely with clean water.

Cleaning Precautions

- Never use aggressive alkaline or acid cleaners on aluminum finishes. Do not use cleaners containing trisodium phosphate, phosphoric acid, hydrochloric acid, hydrofluoric acid, fluorides, or similar compounds on anodized aluminum surfaces. Always follow the cleaner manufacturer's recommendations as to the proper cleaner and concentration. Test-clean a small area first. Different cleaners should not be mixed.

- It is preferable to clean the metal when shaded. Do not attempt to clean hot, sun-heated surfaces since possible chemical reactions on hot metal surfaces will be highly accelerated and non-uniform. Also, avoid cleaning in freezing temperatures or when metal temperatures are sufficiently cold to cause condensation. Surfaces cleaned under these adverse conditions can become streaked or tainted that they cannot be restored to their original appearance.

11939 E. 51st Ave. Denver, CO. 80239. Phone (303) 432-0003. Fax (303) 432-2038

References

VOLUNTARY GUIDE SPECIFICATION FOR CLEANING AND MAINTENANCE OF ARCHITECTURAL ANODIZED ALUMINUM, AAMA 609.1
American Architectural Manufacturers Association

Attached are page(s) from the 2008 Hilti North American Product Technical Guide. For complete details on this product, including data development, product specifications, general suitability, installation, corrosion, and spacing & edge distance guidelines, please refer to the Technical Guide, or contact Hilti.

Hilti, Inc.
5400 South 122nd East Avenue
Tulsa, OK 74146

1-800-879-8000
www.hilti.com

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No charge.
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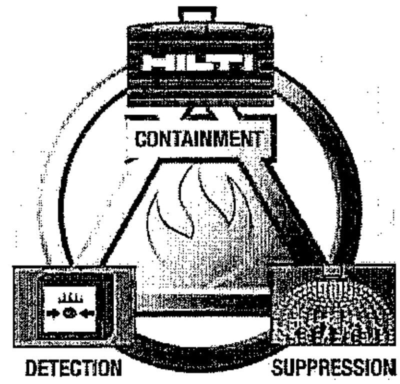


Firestop Systems

When it comes to Life Safety and building code compliance, Hilti provides complete solutions with a wide range of products and unmatched technical support.

- Firestop Systems Guides
  - Through Penetrations
  - Joint Penetrations
- FACT Program
- FS 411
- BASIC Training
- Engineering Judgements
- Firestop Design Center online at **www.us.hilti.com** or **www.hilti.ca**

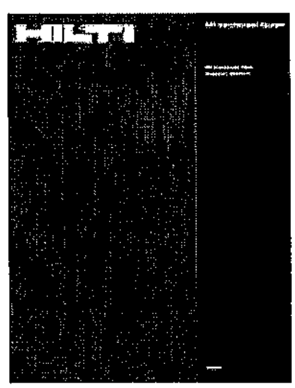
Hilti Diaphragm Deck Design

The Hilti Diaphragm Deck Design Program allows designers to quickly and accurately design roof deck and composite floor deck diaphragms.

- Ability to design with innovative Hilti fasteners for frame and sidelap connection
- Creates easy to use load tables with span ranges based on user input
- Allows for different safety factors depending on load type, building code and field quality control
- Direct link to Hilti website

Hilti Online

- Technical Library
- Design Centers
- Interactive Product Advisors
- Full-line Product Catalog
- Online Ordering
- Maps to Hilti locations
- "Contact Us" program to answer your questions



MI - Industrial Pipe Support Technical Guide

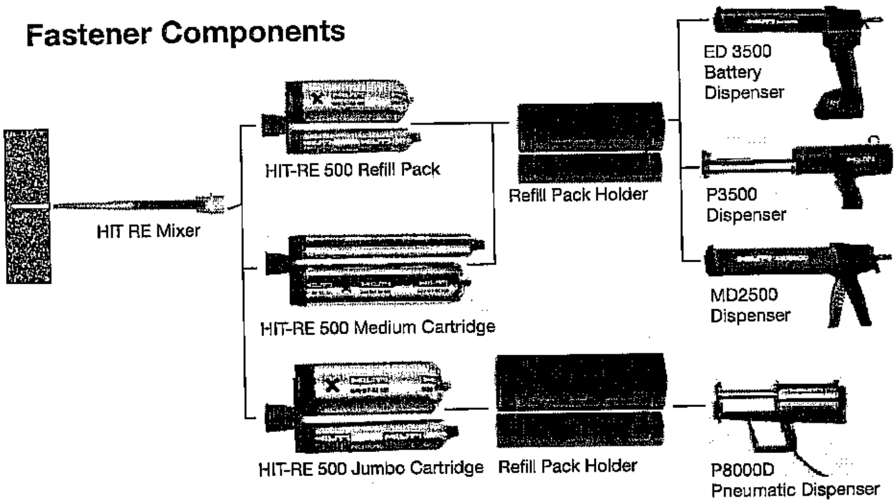
A guide to specifying the Hilti modular pipe support system for medium to heavy loads without welding.

- MI System is the ideal solution for pipes up to 24 in. diameter
- Reliable fastenings without welds
- Easily installed

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

4.2.7.1 Product Description

Fastener Components



The Hilti HIT-RE 500 System is a high strength, two part epoxy adhesive. The system consists of a side-by-side adhesive refill pack, a mixing nozzle, a HIT dispenser with refill pack holder, and either a threaded rod, rebar, HIS internally threaded insert or smooth epoxy coated bar. HIT-RE 500 is specifically designed for fastening into solid base materials such as concrete, grout, stone or solid masonry. HIT-RE 500 may be used in underwater fastenings and for oversized holes up to 2 times the rod diameter (2-1/2" rod and 3" max. hole diameter) and for diamond-cored holes.

Product Features

- Superior bond performance
- Use in diamond cored or pneumatic drilled holes and under water up to 165 feet (50 m)
- Meets DOT requirements for most states; contact the Hilti Technical Staff
- Meets requirements of ASTM C 881-90, Type IV, Grade 2 and 3, Class A, B, C except gel times
- Meets requirements of AASHTO specification M235, Type IV, Grade 3, Class A, B, C except gel times
- Mixing tube provides proper mixing, eliminates measuring errors and minimizes waste
- Contains no styrene; virtually odorless
- Extended temperature range from 23°F to 104°F (-5°C to 40°C)
- Excellent weathering resistance; Resistance against elevated temperatures
- Suitable for oversized holes
- Seismic qualified per IBC®/IRC® 2003, IBC®/IRC® 2000 and UBC® 1997 (ICC-ES AC58). Please refer to ESR-1682.

Listings/Approvals

City of Los Angeles
Research Report #25514
NSF/ANSI Std 61
certification for use in potable water
European Technical Approval
ETA-04/0027
ETA-04/0028
ETA-04/0029

Code Compliance

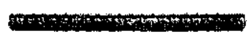
IBC®/IRC® 2003 (ICC-ES AC58)
IBC®/IRC® 2000 (ICC-ES AC58)
UBC® 1997 (ICC-ES AC58)
LEED®: Credit 4.1-Low Emitting Materials

The Leadership in Energy and Environmental Design (LEED®) Green Building Rating system™ is the nationally accepted benchmark for the design, construction and operation of high performance green buildings.

Components

HAS Threaded Rods

HIS Internally Threaded Inserts



Rebar (supplied by contractor)

Smooth, epoxy coated bar (supplied by contractor)

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

Guide Specifications

Master Format Section:

03250 (Concrete accessories)

Related Sections:

03200 (Concrete Reinforcing-Reinforcing Accessories)
05050 (Metal Fabrication)
05120 (Structural Steel; Masonry Accessories)

Injectable adhesive shall be used for installation of all reinforcing steel dowels or threaded anchor rods and inserts into new or existing concrete. Adhesive shall be furnished in side-by-side refill packs which keep component A and component B separate. Side-by-side packs shall be designed to compress during use to minimize waste volume. Side-by-side packs shall also be designed to accept static mixing nozzle which thoroughly blends component A and component B and allows injection directly into drilled hole. Only injection tools and static mixing nozzles as supplied by manufacturer shall be used. Manufacturer's instructions shall be followed. Injection adhesive shall be formulated to include resin and hardener to provide optimal curing speed as well as high strength and stiffness. Typical curing time at 68°F (20°C) shall be approximately 12 hours.

Injection adhesive shall be HIT-RE 500, as furnished by Hilti.

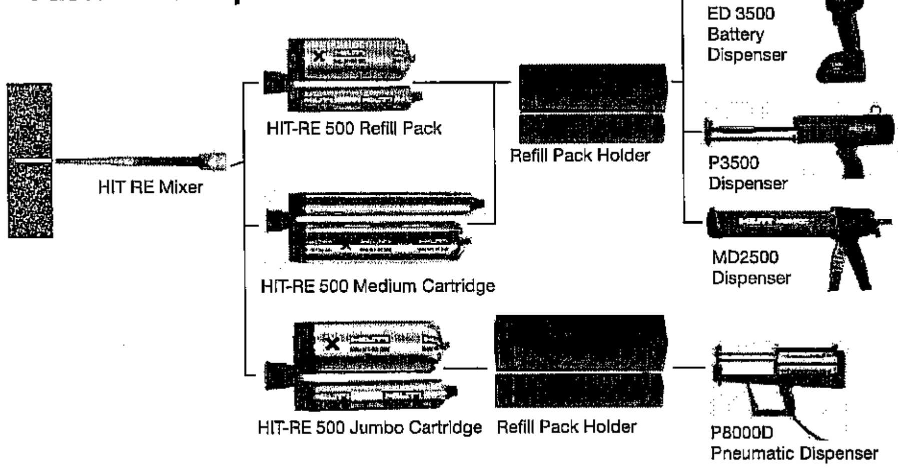
Anchor Rods Shall be furnished with chamfered ends so that either end will accept a nut and washer. Alternatively, anchor rods shall be furnished with a 45 degree chisel point on one end to allow for easy insertion into the adhesive-filled hole. Anchor rods shall be manufactured to meet the following requirements:

1. ISO 898 Class 5.8
2. ASTM A 193, Grade B7 (high strength carbon steel anchor);
3. AISI 304 or AISI 316 stainless steel, meeting the requirements of ASTM F 593 (condition CW).

Special order length HAS Rods may vary from standard product.

Nuts and Washers Shall be furnished to meet the requirements of the above anchor rod specifications.

Fastener Components



4.2.7.2 Material Specifications

Material Properties for HIT-RE 500 – Cured Adhesive

Bond Strength ASTM C882-91[1]		
2 day cure	12.4 MPa	1800 psi
7 day cure	12.4 MPa	1800 psi
Compressive Strength ASTM D-695-96[1]	82.7 MPa	12,000 psi
Compressive Modulus ASTM D-695-96[1]	1493 MPa	0.22×10^6 psi
Tensile Strength 7 day ASTM D-638-97	43.5 MPa	6310 psi
Elongation at break ASTM D-638-97	2.0%	2.0%
Heat Deflection Temperature ASTM D-648-95	63°C	146°F
Absorption ASTM D-570-95	0.06%	0.06%
Linear Coefficient of Shrinkage on Cure ASTM D-2566-86	0.004	0.004
Electrical resistance DIN IEC 93 (12.93)	6.6×10^{13} Ω/m	1.7×10^{12} Ω/in.

1 Minimum values obtained as the result of tests at three cure temperatures (23, 40, 60°F).

Material Specifications

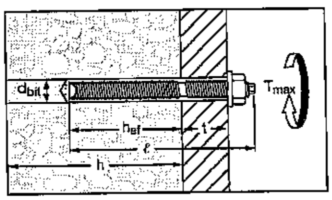
	Mechanical Properties f_y ksi (MPa)	Mechanical Properties min. f_u ksi (MPa)
Standard HAS-E rod material meets the requirements of ISO 898 Class 5.8	58 (400)	72.5 (500)
High Strength or 'Super HAS' rod material meets the requirements of ASTM A 193, Grade B7	105 (724)	125 (862)
Stainless HAS rod material meets the requirements of ASTM F 593 (304/316) Condition CW 3/8" - 5/8"	65 (448)	100 (689)
Stainless HAS rod material meets the requirements of ASTM F 593 (304/316) Condition CW 3/4" -1 1/4"	45 (310)	85 (586)
HIS Insert 11MnPb30+C Carbon Steel conforming to DIN 10277-3	54.4 (375)	66.7 (460)
HIS-R Insert X5CrNiMo17122 K700 Stainless Steel conforming to DIN EN 10088-3	50.8 (350)	101.5 (700)
HAS Super & HAS-E Standard Nut material meets the requirements of ASTM A 563, Grade DH		
HAS Stainless Steel Nut material meets the requirements of ASTM F 594		
HAS-E Carbon Steel and Stainless Steel Washers meet dimensional requirements of ANSI B18.22.1 Type A Plain		
HAS Super & HAS-E Standard Washers meet the requirements of ASTM F 436		
All HAS-E & HAS Super Rods (except 7/8") & HAS-E Standard, HIS inserts, nuts & washers are zinc plated to ASTM B 633 SC 1		
7/8" Standard HAS-E & HAS Super rods hot-dip galvanized in accordance with ASTM A 153		

Note: Special Order steel rod material may vary from standard steel rod materials.

4.2.7.3 Technical Data

HIT-RE 500 Installation Specification Table for HAS Threaded Rods

Details \ HAS Rod Size			in. (mm)	3/8 (9.5)	1/2 (12.7)	5/8 (15.9)	3/4 (19.1)	7/8 (22.2)	1 (25.4)	1-1/4 (31.8)
d_{bit} bit diameter[1]			in.	7/16	9/16	3/4	7/8	1	1-1/8	1-3/8
h_{nom} std. depth of embed.			in. (mm)	3-3/8 (90)	4-1/2 (110)	5-5/8 (143)	6-3/4 (171)	7-7/8 (200)	9 (229)	11-1/4 (286)
T_{max} max. tightening torque	HAS-E Rods	Embed. $\geq h_{nom}$	ft lb (N·m)	18 (24)	30 (41)	75 (102)	150 (203)	175 (237)	235 (319)	400 (540)
	HAS SS HAS-Super	Embed. $< h_{nom}$	ft lb (N·m)	15 (20)	20 (27)	50 (68)	105 (142)	125 (169)	165 (224)	280 (375)
h min. base material thickness			(in.)	$1.5 h_{ef}$						
Approx. number of fastenings per cartridge at standard embedment[2]										
Small Cartridge				52	28	11	7	5	4	2
Medium Cartridge				84	45	18	11	8	6	3
Jumbo Cartridge				255	137	56	37	27	19	12



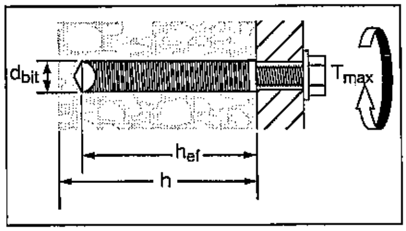
1 Use matched tolerance carbide tipped bits or Hilti matched tolerance DD-B or DD-C diamond core bits.

2 Assumes no waste.

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

HIT-RE 500 Installation Specification Table for HIS Inserts

Details \ HIS Insert	in. (mm)	3/8 (9.5)	1/2 (12.7)	5/8 (15.9)	3/4 (19.1)
d_{bit} bit diameter[1, 2]	in.	11/16	7/8	1-1/8	1-1/4
h_{nom} std. embed. depth	in. (mm)	4-1/4 (110)	5 (125)	6-5/8 (170)	8-1/4 (210)
ℓ_{th} useable thread length	in. (mm)	1 (25)	1-3/16 (30)	1-1/2 (40)	2 (50)
T_{max} Max. tightening torque	ft lb (N·m)	18 (24)	35 (47)	80 (108)	160 (217)
h min. base material thickness	in. (mm)	6-3/8 (162)	7-1/2 (191)	10 (254)	12-3/8 (314)
Approx. number of fastenings per cartridge at standard embedment[2]					
Small Cartridge		27	16	6	4
Medium Cartridge		49	30	11	8
Jumbo Cartridge		168	105	38	27



1 Use matched tolerance carbide tipped bits or Hilti matched tolerance DD-B or DD-C diamond core bits.

2 Assumes no waste.

HIT-RE 500 Installation Specification Table for Rebar in Concrete

Details \ Rebar Size:		No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11
Bit diameter[1, 2, 3]	in.	1/2	5/8	3/4	7/8	1	1-1/8	1-3/8	1-1/2	1-3/4
h_{nom} std. embed. depth	in. (mm)	3-3/8 (86)	4-1/2 (114)	5-5/8 (143)	6-3/4 (171)	7-7/8 (200)	9 (229)	10-1/8 (257)	11-1/4 (286)	12-3/8 (314)
Approx. number of fastenings per cartridge at standard embedment[3]										
Small Cartridge		44	25	16	11	8	6	3	2	1
Medium Cartridge		72	41	27	18	13	10	5	3	2
Jumbo Cartridge		221	125	83	56	41	31	14	11	7

1 Rebar diameters may vary. Use smallest drill bit which will accommodate rebar.

2 Use matched tolerance carbide tipped bits or Hilti matched tolerance DD-B or DD-C diamond core bits.

3 Assumes no waste.

HIT-RE 500 Installation Specification Table for Metric Rebar in Concrete (Canada Only)

Details \ Rebar Size:		10M	15M	20M	25M	30M	35M
Bit diameter[1, 2]	in.	5/8	3/4	1	1-1/8	1-3/8	1-3/4
h_{nom} std. embed. depth	(mm)	115	145	200	230	260	315
Approx. number of fastenings per cartridge at standard embedment[2]							
Small Cartridge		20	17	5	6	3	1
Medium Cartridge		32	28	9	10	5	2
Jumbo Cartridge		98	84	27	31	16	7

1 Rebar diameters may vary. Use smallest bit which will accommodate rebar.

2 Assumes no waste.

Combined Shear and Tension Loading

$$\left(\frac{N_d}{N_{rec}}\right)^{5/3} + \left(\frac{V_d}{V_{rec}}\right)^{5/3} \leq 1.0$$ (Ref. Section 4.1.8.3)

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

HIT-RE 500 Allowable and Ultimate Bond/Concrete Capacity for HAS Rods in Normal Weight Concrete[1,2,3,4]

Anchor Diameter in (mm)	Embedment Depth in (mm)	HIT-RE 500 Allowable Bond/Concrete Capacity				HIT-RE 500 Ultimate Bond/Concrete Capacity			
		Tensile		Shear		Tensile		Shear	
		f'c = 2000 psi (13.8 MPa) lb (kN)	f'c = 4000 psi (27.6 MPa) lb (kN)	f'c = 2000 psi (13.8 MPa) lb (kN)	f'c = 4000 psi (27.6 MPa) lb (kN)	f'c = 2000 psi (13.8 MPa) lb (kN)	f'c = 4000 psi (27.6 MPa) lb (kN)	f'c = 2000 psi (13.8 MPa) lb (kN)	f'c = 4000 psi (27.6 MPa) lb (kN)
3/8 (9.5)	1-3/4 (44)	645 (2.9)	1095 (4.9)	1510 (6.7)	2135 (9.5)	2580 (11.5)	4370 (19.4)	4530 (20.2)	6405 (28.4)
	3-3/8 (86)	2190 (9.7)	2585 (11.5)	3155 (14.0)	4460 (19.8)	8760 (39.0)	10345 (46.0)	9460 (42.1)	13380 (59.5)
	4-1/2 (114)	2420 (10.8)	2585 (11.5)	4855 (21.6)	6860 (30.5)	9685 (43.1)	10335 (46.0)	14560 (64.8)	20580 (91.5)
1/2 (12.7)	2-1/4 (57)	1130 (5.0)	1965 (8.7)	2510 (11.2)	3550 (15.8)	4530 (20.2)	7860 (35.0)	7525 (33.5)	10640 (47.3)
	4-1/2 (114)	4045 (18.0)	5275 (23.5)	5610 (25.0)	7935 (35.3)	16185 (72.0)	21095 (93.8)	16820 (74.8)	23800 (105.9)
	6 (152)	4775 (21.2)	5380 (23.9)	8635 (38.4)	12210 (54.3)	19095 (84.9)	21520 (95.7)	25900 (115.2)	36620 (162.9)
5/8 (15.9)	2-7/8 (73)	1690 (7.5)	3045 (13.5)	5245 (23.3)	7420 (33.0)	6770 (30.1)	12175 (54.2)	15735 (70.0)	22250 (99.0)
	5-5/8 (143)	6560 (29.2)	7355 (32.7)	8760 (39.0)	12395 (55.1)	26240 (116.7)	29420 (130.9)	26280 (116.9)	37180 (165.4)
	7-1/2 (190)	7320 (32.6)	7515 (33.4)	13615 (60.6)	19080 (84.9)	29290 (130.3)	30060 (133.7)	40480 (180.1)	57240 (254.6)
3/4 (19.1)	3-3/8 (86)	2310 (10.3)	4515 (20.1)	7335 (32.6)	10370 (46.1)	9250 (41.1)	18065 (80.4)	22000 (97.9)	31108 (138.4)
	6-3/4 (172)	8670 (38.6)	10755 (47.8)	12615 (56.1)	17840 (79.4)	34685 (154.3)	43020 (191.4)	37840 (168.3)	53520 (238.1)
	9 (229)	10385 (46.2)	12995 (57.8)	19430 (86.4)	27470 (122.2)	41535 (184.8)	51985 (231.2)	58280 (259.2)	82400 (366.5)
7/8 (22.2)	4 (101)	3005 (13.4)	5665 (25.2)	7795 (34.7)	11020 (49.0)	12030 (53.5)	22670 (100.8)	23375 (104.0)	33050 (147.0)
	7-7/8 (200)	12495 (55.6)	15875 (70.6)	17175 (76.4)	24290 (108.0)	49975 (222.3)	63495 (282.4)	51520 (229.2)	72860 (324.1)
	10-1/2 (267)	14705 (65.4)	16185 (72.0)	26440 (117.6)	37390 (166.3)	58820 (261.6)	64730 (287.9)	79320 (352.8)	112160 (498.9)
1 (25.4)	4-1/2 (114)	3945 (17.5)	8440 (37.5)	10035 (44.6)	14190 (63.1)	15790 (70.2)	33765 (150.2)	30104 (133.9)	42565 (189.3)
	9 (229)	13845 (61.6)	17365 (77.2)	22435 (99.8)	31720 (141.1)	55380 (246.3)	69465 (309.0)	67300 (299.4)	95160 (423.3)
	12 (305)	17935 (79.8)	17935 (79.8)	34535 (153.6)	48830 (217.2)	71740 (319.1)	71740 (319.1)	103600 (460.8)	146480 (651.6)
1-1/4 (31.8)	5-5/8 (143)	5760 (25.6)	12815 (57.0)	14760 (65.7)	20870 (92.8)	23045 (102.5)	51270 (228.1)	44280 (197.0)	62610 (278.5)
	11-1/4 (286)	24610 (109.5)	31620 (140.7)	35050 (155.9)	49570 (220.5)	98430 (437.8)	126480 (562.6)	105140 (467.7)	148710 (661.5)
	15 (381)	34130 (151.8)	35270 (156.9)	53960 (240.0)	76300 (339.4)	136525 (607.3)	141090 (627.6)	161880 (720.1)	228900 (1018.2)

1 Influence factors for spacing and/or edge distance are applied to concrete/bond values above, and then compared to the steel value. The lesser of the values is to be used for the design.

2 Average ultimate concrete shear capacity based on Concrete Capacity Design (CCD) method for standard and deep embedment and based on testing for shallow embedment.

3 All values based on holes drilled with carbide bit and cleaned with brush per manufacturer's instructions. Ultimate tensile concrete/bond loads represent the average values obtained in testing.

4 For underwater applications up to 165 feet/50m depth reduce the tabulated concrete/bond values 30% to account for reduced mechanical properties of saturated concrete.

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

Allowable Steel Strength for Carbon Steel & Stainless Steel HAS Rods[1]

Rod Diameter in. (mm)	HAS-E Standard ISO 898 Class 5.8		HAS Super ASTM A 193 B7		HAS SS AISI 304/316 SS	
	Tensile lb (kN)	Shear lb (kN)	Tensile lb (kN)	Shear lb (kN)	Tensile lb (kN)	Shear lb (kN)
3/8 (9.5)	2640 (11.7)	1360 (6.0)	4555 (20.3)	2345 (10.4)	3645 (16.2)	1875 (8.3)
1/2 (12.7)	4700 (20.9)	2420 (10.8)	8100 (36.0)	4170 (18.5)	6480 (28.8)	3335 (14.8)
5/8 (15.9)	7340 (32.7)	3780 (16.8)	12655 (56.3)	6520 (29.0)	10125 (45.0)	5215 (23.2)
3/4 (19.1)	10570 (47.0)	5445 (24.2)	18225 (81.1)	9390 (41.8)	12390 (55.1)	6385 (28.4)
7/8 (22.2)	14385 (64.0)	7410 (33.0)	24805 (110.3)	12780 (56.9)	16865 (75.0)	8690 (38.6)
1 (25.4)	18790 (83.6)	9680 (43.0)	32400 (144.1)	16690 (74.2)	22030 (98.0)	11350 (50.5)
1-1/4 (31.8)	29360 (130.6)	15125 (67.3)	50620 (225.2)	26080 (116.0)	34425 (153.1)	17735 (78.9)

1 Steel strength as defined in AISC Manual of Steel Construction (ASD):

Tensile = 0.33 x F_u x Nominal Area
Shear = 0.17 x F_u x Nominal Area

Ultimate Steel Strength for Carbon Steel & Stainless Steel HAS Rods[1]

Rod Diameter in. (mm)	HAS-E Standard ISO 898 Class 5.8			HAS Super ASTM A 193 B7			HAS SS AISI 304/316 SS		
	Yield lb (kN)	Tensile lb (kN)	Shear lb (kN)	Yield lb (kN)	Tensile lb (kN)	Shear lb (kN)	Yield lb (kN)	Tensile lb (kN)	Shear lb (kN)
3/8 (9.5)	4495 (20.0)	6005 (26.7)	3605 (16.0)	8135 (36.2)	10350 (43.4)	6210 (27.6)	5035 (22.4)	8280 (36.8)	4970 (22.1)
1/2 (12.7)	8230 (36.6)	10675 (47.5)	6405 (28.5)	14900 (66.3)	18405 (79.0)	11040 (49.1)	9225 (41.0)	14720 (65.5)	8835 (39.3)
5/8 (15.9)	13110 (58.3)	16680 (74.2)	10010 (44.5)	23730 (105.6)	28760 (125.7)	17260 (76.8)	14690 (65.3)	23010 (102.4)	13805 (61.4)
3/4 (19.1)	19400 (86.3)	24020 (106.9)	14415 (64.1)	35120 (156.2)	41420 (185.7)	24850 (110.5)	15050 (66.9)	28165 (125.3)	16800 (75.2)
7/8 (22.2)	26780 (119.1)	32695 (145.4)	19620 (87.3)	48480 (215.7)	56370 (256.9)	33825 (150.5)	20775 (92.4)	38335 (170.5)	23000 (102.3)
1 (25.4)	35130 (156.3)	42705 (190.0)	25625 (114.0)	63600 (282.9)	73630 (337.0)	44180 (196.5)	27255 (121.2)	50070 (222.7)	30040 (133.6)
1-1/4 (31.8)	56210 (250.0)	66730 (296.8)	40035 (178.1)	101755 (452.6)	115050 (511.8)	69030 (307.1)	43610 (194.0)	78235 (348.0)	46940 (208.8)

1 Steel strength as defined in AISC Manual of Steel Construction 2nd Ed. (LRFD):

Yield = F_y x Tensile Stress Area
Tensile = 0.75 x F_u x Nominal Area
Shear = 0.45 x F_u x Nominal Area

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

HIT-RE 500 Allowable Bond/Concrete Capacity and Steel Strength for HIS Carbon Steel and HIS-R Stainless Steel Internally Threaded Inserts

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	HIT-RE 500 Allowable Bond/Concrete Capacity[2]		Steel Bolt Strength[1,2]			
		Tensile $f'_c \geq 2000$ psi (13.8 MPa) lb (kN)	Shear $f'_c \geq 2000$ psi (13.8 MPa) lb (kN)	ASTM A 325 Carbon Steel		ASTM F 593 Stainless Steel	
				Tensile[1] lb (kN)	Shear[1] lb (kN)	Tensile[1] lb (kN)	Shear[1] lb (kN)
3/8 (9.5)	4-1/4 (108)	2870 (12.8)	1565 (7.0)	4370 (19.4)	2250 (10.0)	3645 (16.2)	1875 (8.3)
1/2 (12.7)	5 (127)	4530 (20.1)	2890 (12.9)	7775 (34.6)	4005 (17.8)	6480 (28.8)	3335 (14.8)
5/8 (15.9)	6-5/8 (168)	8255 (36.7)	4635 (20.6)	12150 (54.0)	6260 (27.8)	10125 (45.0)	5215 (23.2)
3/4 (19.1)	8-1/4 (210)	9030 (40.1)	6695 (29.8)	17945 (77.8)	9010 (40.1)	12395 (55.1)	6385 (28.4)

HIT-RE 500 Ultimate Bond/Concrete Capacity and Steel Strength for HIS Carbon Steel and HIS-R Stainless Steel Internally Threaded Inserts

Anchor Diameter in. (mm)	Embedment Depth in. (mm)	HIT-RE 500 Ultimate Bond/Concrete Capacity[2]		Ultimate Bolt Strength[1,2]			
		Tensile $f'_c \geq 2000$ psi (13.8 MPa) lb (kN)	Shear $f'_c \geq 2000$ psi (13.8 MPa) lb (kN)	ASTM A 325 Carbon Steel		ASTM F 593 Stainless Steel	
				Tensile[1] lb (kN)	Shear[1] lb (kN)	Tensile[1] lb (kN)	Shear[1] lb (kN)
3/8 (9.5)	4-1/4 (108)	11480 (51.0)	6260 (27.8)	9935 (44.2)	5960 (26.5)	8280 (36.8)	4970 (22.1)
1/2 (12.7)	5 (127)	18115 (80.5)	11565 (51.4)	17665 (78.6)	10600 (47.2)	14720 (65.5)	8835 (39.3)
5/8 (15.9)	6-5/8 (168)	33025 (146.9)	18550 (82.5)	27610 (122.8)	16565 (73.7)	23010 (102.4)	13805 (61.4)
3/4 (19.1)	8-1/4 (210)	36125 (160.6)	26775 (119.1)	39760 (176.9)	23855 (106.1)	28165 (125.3)	16900 (75.1)

1 Steel values in accordance with AISC

ASTM A 325 bolts: $F_y = 92$ ksi, $F_u = 120$ ksi

ASTM F 593 (AISI 304/316): $F_y = 65$ ksi, $F_u = 100$ ksi for 3/8" thru 5/8"

$F_y = 45$ ksi, $F_u = 85$ ksi for 3/4"

Allowable Load Values

Tension = $0.33 \times F_u \times A_{nom}$

Shear = $0.17 \times F_u \times A_{nom}$

Ultimate Load Values

Tension = $0.75 \times F_u \times A_{nom}$

Shear = $0.45 \times F_u \times A_{nom}$

2 Use lower value of either bond/concrete capacity or steel strength.

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

HIT-RE 500 Ultimate Bond Strength and Steel Strength for Rebar in Concrete[1]

Nominal Rebar Size	Embed. Depth in. (mm)	Concrete Compressive Strength						Grade 60 Rebar	
		f'c = 2000 psi (13.8 MPa)			f'c = 4000 psi (27.6 MPa)				
		Ultimate Bond Strength lb (kN)	Embed. to Develop Yield Strength[1] in. (mm)	Embed. to Develop Tensile Strength[1] in. (mm)	Ultimate Bond Strength lb (kN)	Embed. to Develop Yield Strength[1] in. (mm)	Embed. to Develop Tensile Strength[1] in. (mm)	Yield Strength lb (kN)	Tensile Strength lb (kN)
#3	3-3/8 (86)	10105 (45.0)	2-1/4 (57)	3-3/8 (86)	10810 (48.1)	2-1/8 (54)	3-1/4 (84)	6600 (29.4)	9900 (44.0)
	4-1/2 (114)	10920 (48.6)			10810 (48.1)				
#4	4-1/2 (114)	15980 (71.1)	3-3/8 (86)	5-5/8 (143)	18540 (82.5)	3 (76)	4-3/8 (111)	12000 (53.4)	18000 (80.1)
	6 (152)	18830 (83.8)			18655 (83.0)				
#5	5-5/8 (143)	20630 (91.8)	5-1/8 (130)	8-7/8 (225)	27790 (123.6)	3-7/8 (98)	5-3/4 (146)	18600 (82.7)	27900 (124.1)
	7-1/2 (191)	24870 (110.6)			27790 (128.6)				
#6	6-3/4 (171)	33695 (149.9)	5-3/8 (136)	9-3/8 (238)	44675 (198.7)	4 (102)	6 (152)	26400 (117.4)	39600 (176.2)
	9 (229)	38960 (173.3)			44870 (200.0)				
#7	7-7/8 (200)	40525 (180.3)	7 (178)	12-3/8 (314)	59340 (264.0)	4-7/8 (124)	7-1/4 (184)	36000 (160.1)	54000 (240.2)
	10-1/2 (267)	48460 (215.6)			61720 (274.6)				
#8	9 (229)	63940 (284.4)	8-1/4 (210)	12-7/8 (327)	72820 (323.9)	5-7/8 (149)	8-7/8 (225)	47400 (210.9)	71100 (316.3)
	12 (305)	69610 (309.7)			72950 (324.5)				
#9	10-1/8 (257)	72245 (321.4)	8-1/2 (216)	13 (330)	81235 (361.4)	7-1/2 (191)	12 (305)	60000 (266.9)	90000 (400.4)
	13-1/2 (343)	94205 (419.1)			84015 (373.7)				
#10	11-1/4 (286)	92000 (409.3)	9-3/8 (238)	17-7/8 (454)	96725 (430.3)	8-7/8 (225)	14 (356)	76200 (339.0)	114300 (508.5)
	15 (381)	95850 (426.4)			97070 (431.8)				
#11	12-3/8 (314)	118615 (527.6)	9-7/8 (251)	18-3/4 (476)	123120 (547.7)	9-1/2 (241)	16-1/2 (419)	93600 (416.4)	140400 (624.6)
	16-1/2 (419)	123570 (549.7)			123790 (550.7)				

1 Based on comparison of average ultimate adhesive bond test values versus minimum yield and ultimate tensile strength of rebar. For more information, contact Hilti.

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

HIT-RE 500 Bond Strength and Steel Strength for Metric Rebar in Concrete (Canada Only) 1, 2, 3, 4, 5, 6, 7

Rebar Size	HIT-RE 500 Tensile Bond Strength					Strength Properties of Metric Rebar	
		f'_c = 14 MPa		f'_c = 28 MPa		f_y = 400 MPa	f_u = 600 MPa
	Embedment Depth mm (in)	Ultimate Bond kN (lb)	Allowable Bond kN (lb)	Ultimate Bond kN (lb)	Allowable Bond kN (lb)	Yield Strength kN (lb)	Tensile Strength kN (lb)
10M	115 (4-1/2)	71.1 (15980)	17.8 (3995)	82.5 (18540)	20.6 (4635)	40 (8990)	60 (13490)
	150 (6)	83.8 (18830)	20.9 (4705)	83.0 (18655)	20.7 (4665)		
15M	145 (5-5/8)	91.8 (20630)	22.9 (5155)	123.7 (27810)	30.9 (6950)	80 (17985)	120 (26975)
	190 (7-1/2)	110.6 (24870)	27.6 (6215)	123.6 (27790)	30.9 (6945)		
20M	200 (7-7/8)	180.3 (40525)	45.1 (10130)	264 (59340)	66 (14835)	120 (26975)	180 (40465)
	265 (10-1/2)	215.6 (48460)	53.9 (12115)	274.6 (61720)	68.6 (15430)		
25M	230 (9)	284.4 (63940)	71.0 (15985)	323.9 (72820)	81.0 (18205)	200 (44960)	300 (67440)
	305 (12)	309.7 (69610)	77.4 (17400)	324.5 (72950)	81.1 (18235)		
30M	260 (10-1/8)	321.4 (72245)	80.3 (18060)	361.4 (81235)	90.3 (20305)	280 (62945)	420 (94415)
	345 (13-1/2)	419.1 (94205)	104.8 (23550)	373.7 (84015)	93.4 (21000)		
35M	315 (12-3/8)	527.6 (118615)	131.9 (29650)	547.7 (123120)	136.9 (30780)	400 (89920)	600 (134880)
	420 (16-1/2)	549.7 (123570)	137.4 (30890)	550.7 (123790)	137.6 (30945)		

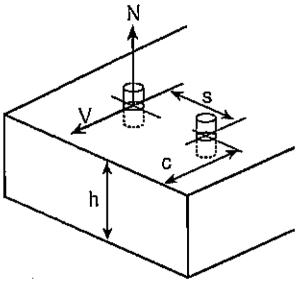
1 Based on minimum steel strength and nominal cross-sectional area of rebar.
2 Use lesser value of bond strength or steel strength.
3 Minimum concrete thickness must be equal to 1.5 times the anchor embedment.
4 Testing done with imperial rebar in same size holes.
5 Allowable tension for adhesive bond based on a safety factor of 4.0.
6 For anchor spacing and edge distance guidelines, please refer to the following pages.
7 Ultimate tensile concrete/bond loads represent the average values obtained in testing.

HIT-RE 500 Ultimate Tensile Strength for Smooth Epoxy Coated Dowel Bars in Concrete ≥ 2410 psi (15.9 MPa)

Anchor Diameter in. (mm)	Drill Bit Diameter in. (mm)	Embedment Depth in. (mm)	Ultimate Tensile Load lb (kN)
1 (25.4)	1-1/8 (29)	9 (229)	40385 (179.7)
1-1/4 (31.8)	1-3/8 (34.9)		
1-1/2 (38.1)	1-5/8 (41)		

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

Anchor Spacing and Edge Distance Guidelines in Concrete



Note: Tables apply for listed embedment depths. Reduction factors for other embedment depths must be calculated using equations below.

Spacing Tension/Shear
$s_{min} = 0.5\ h_{ef}$, $s_{cr} = 1.5\ h_{ef}$
$f_A = 0.3(s/h_{ef}) + 0.55$
for $s_{cr} > s > s_{min}$

Edge Distance Tension
$c_{min} = 0.5\ h_{ef}$, $c_{cr} = 1.5\ h_{ef}$
$f_{RN} = 0.3(c/h_{ef}) + 0.55$
for $c_{cr} > c > c_{min}$

Edge Distance Shear (⊥ toward edge)
$c_{min} = 0.5\ h_{ef}$, $c_{cr} = 2.0\ h_{ef}$
$f_{RV1} = 0.54(c/h_{ef}) - 0.09$
for $c_{cr} > c > c_{min}$

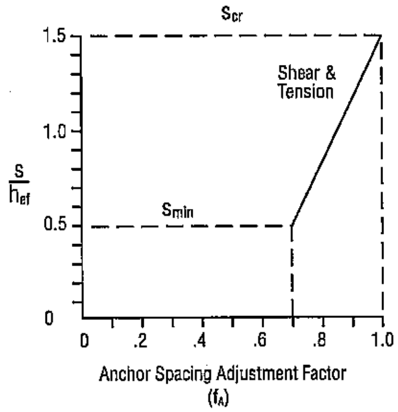
Edge Distance Shear (II to or away from edge)
$c_{min} = 0.5\ h_{ef}$, $c_{cr} = 2.0\ h_{ef}$
$f_{RV2} = 0.36(c/h_{ef}) + 0.28$
for $c_{cr} > c > c_{min}$

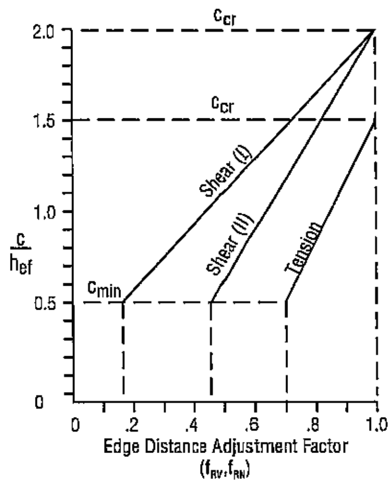
Anchor Spacing Adjustment Factors

s = Actual spacing
h_{ef} = Actual embedment
s_{min} = $0.5\ h_{ef}$
s_{cr} = $1.5\ h_{ef}$

Edge Distance Adjustment Factors

c = Actual edge distance
h_{ef} = Actual embedment
c_{min} = $0.5\ h_{ef}$ Tension and shear
c_{cr} = $1.5\ h_{ef}$ Tension
= $2.0\ h_{ef}$ Shear
⊥ = Perpendicular to edge
II = Parallel to edge





Load Adjustment Factors for 3/8" Diameter Anchor

Anchor Diameter:		3/8" diameter											
Adjustment Factor		Spacing Tension/Shear, f_A			Edge Distance Tension, f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)		1-3/4	3-3/8	4-1/2	1-3/4	3-3/8	4-1/2	1-3/4	3-3/8	4-1/2	1-3/4	3-3/8	4-1/2
Spacing (s)/Edge Distance (c), in.	7/8	0.70			0.70			0.18			0.46		
	1	0.72			0.72			0.22			0.49		
	1 11/16	0.84	0.70		0.84	0.70		0.43	0.18		0.63	0.46	
	2	0.89	0.73		0.89	0.73		0.53	0.23		0.69	0.49	
	2 1/4	0.94	0.75	0.70	0.94	0.75	0.70	0.60	0.27	0.18	0.74	0.52	0.46
	2 5/8	1.00	0.78	0.73	1.00	0.78	0.73	0.72	0.33	0.23	0.82	0.56	0.49
	3		0.82	0.75		0.82	0.75	0.84	0.39	0.27	0.90	0.60	0.52
	3 1/2		0.86	0.78		0.86	0.78	1.00	0.47	0.33	1.00	0.65	0.56
	4		0.91	0.82		0.91	0.82		0.55	0.39		0.71	0.60
	5 1/16		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
	5 1/2			0.92			0.92		0.79	0.57		0.87	0.72
	6			0.95			0.95		0.87	0.63		0.92	0.76
	6 3/4			1.00			1.00		1.00	0.72		1.00	0.82
	8									0.87			0.92
	9									1.00			1.00

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

Anchor Spacing and Edge Distance Guidelines in Concrete

Note: Tables apply for listed embedment depths. Reduction factors for other embedment depths must be calculated using equations below.

Load Adjustment Factors for 1/2" Diameter Anchor

Anchor Diameter:	1/2" diameter											
Adjustment Factor	Spacing Tension/Shear, f_A			Edge Distance Tension, f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	2-1/4	4-1/2	6	2-1/4	4-1/2	6	2-1/4	4-1/2	6	2-1/4	4-1/2	6
Spacing (s)/Edge Distance (c), in. 1												
1-1/8	0.70			0.70			0.18			0.46		
1-1/2	0.75			0.75			0.27			0.52		
1-3/4	0.78			0.78			0.33			0.56		
2	0.82			0.82			0.39			0.60		
2-1/4	0.85	0.70		0.85	0.70		0.45	0.18		0.64	0.46	
2-1/2	0.88	0.72		0.88	0.72		0.51	0.21		0.68	0.48	
3	0.95	0.75	0.70	0.95	0.75	0.70	0.63	0.27	0.18	0.76	0.52	0.46
3-3/8	1.00	0.78	0.72	1.00	0.78	0.72	0.72	0.32	0.21	0.82	0.55	0.48
4		0.82	0.75		0.82	0.75	0.87	0.39	0.27	0.92	0.60	0.52
4-1/2		0.85	0.78		0.85	0.78	1.00	0.45	0.32	1.00	0.64	0.55
5		0.88	0.80		0.88	0.80		0.51	0.36		0.68	0.58
6		0.95	0.85		0.95	0.85		0.63	0.45		0.76	0.64
6-3/4		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
7			0.90			0.90		0.75	0.54		0.84	0.70
8			0.95			0.95		0.87	0.63		0.92	0.76
9			1.00			1.00		1.00	0.72		1.00	0.82
10									0.81			0.88
11									0.90			0.94
12									1.00			1.00

Spacing Tension/Shear

$s_{min} = 0.5\ h_{ef},\ s_{cr} = 1.5\ h_{ef}$

$f_A = 0.3(s/h_{ef}) + 0.55$

for $s_{cr}>s>s_{min}$

Edge Distance Tension

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 1.5\ h_{ef}$

$f_{RN} = 0.3(c/h_{ef}) + 0.55$

for $c_{cr}>c>c_{min}$

Edge Distance Shear (⊥ toward edge)

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 2.0\ h_{ef}$

$f_{RV1} = 0.54(c/h_{ef}) - 0.09$

for $c_{cr}>c>c_{min}$

Edge Distance Shear (II to or away from edge)

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 2.0\ h_{ef}$

$f_{RV2} = 0.36(c/h_{ef}) + 0.28$

for $c_{cr}>c>c_{min}$

Load Adjustment Factors for 5/8" and 3/4" Diameter Anchors

Anchor Diameter	5/8" diameter											
Adjustment Factor	Spacing Tension/Shear f_A			Edge Distance Tension f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	2-7/8	5-5/8	7-1/2	2-7/8	5-5/8	7-1/2	2-7/8	5-5/8	7-1/2	2-7/8	5-5/8	7-1/2
Spacing (s)/Edge Distance (c), in. 1-7/16	0.70			0.70			0.18			0.46		
1-11/16	0.73			0.73			0.23			0.49		
2	0.76			0.76			0.29			0.53		
2-13/16	0.84	0.70		0.84	0.70		0.44	0.18		0.63	0.46	
3-3/8	0.90	0.73		0.90	0.73		0.54	0.23		0.70	0.50	
3-3/4	0.94	0.75	0.70	0.94	0.75	0.70	0.61	0.27	0.18	0.75	0.52	0.46
4-5/16	1.00	0.78	0.72	1.00	0.78	0.72	0.72	0.32	0.22	0.82	0.56	0.49
4-1/2		0.79	0.73		0.79	0.73	0.76	0.34	0.23	0.84	0.57	0.50
5-1/16		0.82	0.75		0.82	0.75	0.86	0.40	0.27	0.91	0.60	0.52
5-5/8		0.85	0.78		0.85	0.78	0.97	0.45	0.32	0.98	0.64	0.55
5-3/4		0.86	0.78		0.86	0.78	1.00	0.46	0.32	1.00	0.65	0.56
6-3/4		0.91	0.82		0.91	0.82		0.56	0.40		0.71	0.60
8-7/16		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
10-1/8			0.96			0.96		0.88	0.64		0.93	0.77
11-1/4			1.00			1.00		1.00	0.72		1.00	0.82
12									0.77			0.86
13-1/2									0.88			0.93
15									1.00			1.00
16												
18												

Anchor Diameter	3/4" diameter											
Adjustment Factor	Spacing Tension/Shear f_A			Edge Distance Tension f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	3-3/8	6-3/4	9	3-3/8	6-3/4	9	3-3/8	6-3/4	9	3-3/8	6-3/4	9
Spacing (s)/Edge Distance (c), in. 1-7/16												
1-11/16	0.70			0.70			0.18			0.46		
2	0.73			0.73			0.23			0.49		
2-13/16	0.80			0.80			0.36			0.58		
3-3/8	0.85	0.70		0.85	0.70		0.45	0.18		0.64	0.46	
3-3/4	0.88	0.72		0.88	0.72		0.51	0.21		0.68	0.48	
4-5/16	0.93	0.74		0.93	0.74		0.60	0.26		0.74	0.51	
4-1/2	0.95	0.75	0.70	0.95	0.75	0.70	0.63	0.27	0.18	0.76	0.52	0.46
5-1/16	1.00	0.78	0.72	1.00	0.78	0.72	0.72	0.32	0.21	0.82	0.55	0.48
5-5/8		0.80	0.74		0.80	0.74	0.81	0.36	0.25	0.88	0.58	0.51
5-3/4		0.81	0.74		0.81	0.74	0.83	0.37	0.26	0.89	0.59	0.51
6-3/4		0.85	0.78		0.85	0.78	1.00	0.45	0.32	1.00	0.64	0.55
8-7/16		0.93	0.83		0.93	0.83		0.59	0.42		0.73	0.62
10-1/8		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
11-1/4			0.93			0.93		0.81	0.59		0.88	0.73
12			0.95			0.95		0.87	0.63		0.92	0.76
13-1/2			1.00			1.00		1.00	0.72		1.00	0.82
15									0.81			0.88
16									0.87			0.92
18									1.00			1.00

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

Anchor Spacing and Edge Distance Guidelines in Concrete

Note: Tables apply for listed embedment depths. Reduction factors for other embedment depths must be calculated using equations below.

Load Adjustment Factors for 7/8" Diameter Anchor

Anchor Diameter:	7/8" diameter											
Adjustment Factor	Spacing Tension/Shear, f_A			Edge Distance Tension, f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	4	7-7/8	10-1/2	4	7-7/8	10-1/2	4	7-7/8	10-1/2	4	7-7/8	10-1/2
Spacing (s)/Edge Distance (c), in. 2	0.70			0.70			0.18			0.46		
2-1/2	0.74			0.74			0.25			0.51		
3	0.78			0.78			0.32			0.55		
3-1/2	0.81			0.81			0.38			0.60		
3-15/16	0.85	0.70		0.85	0.70		0.44	0.18		0.63	0.46	
4-1/2	0.89	0.72		0.89	0.72		0.52	0.22		0.69	0.49	
5	0.93	0.74		0.93	0.74		0.59	0.25		0.73	0.51	
5-1/4	0.94	0.75	0.70	0.94	0.75	0.70	0.62	0.27	0.18	0.75	0.52	0.46
6	1.00	0.78	0.72	1.00	0.78	0.72	0.72	0.32	0.22	0.82	0.55	0.49
6-1/2		0.80	0.74		0.80	0.74	0.79	0.36	0.24	0.87	0.58	0.50
7		0.82	0.75		0.82	0.75	0.86	0.39	0.27	0.91	0.60	0.52
8		0.85	0.78		0.85	0.78	1.00	0.46	0.32	1.00	0.65	0.55
10		0.93	0.84		0.93	0.84		0.60	0.42		0.74	0.62
11-13/16		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
12			0.89			0.89		0.73	0.53		0.83	0.69
14			0.95			0.95		0.87	0.63		0.92	0.76
15-3/4			1.00			1.00		1.00	0.72		1.00	0.82
18									0.84			0.90
20									0.94			0.97
21									1.00			1.00

Spacing Tension/Shear

$s_{min} = 0.5\ h_{ef},\ s_{cr} = 1.5\ h_{ef}$

$f_A = 0.3(s/h_{ef}) + 0.55$

for $s_{cr} > s > s_{min}$

Edge Distance Tension

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 1.5\ h_{ef}$

$f_{RN} = 0.3(c/h_{ef}) + 0.55$

for $c_{cr} > c > c_{min}$

Edge Distance Shear (⊥ toward edge)

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 2.0\ h_{ef}$

$f_{RV1} = 0.54(c/h_{ef}) - 0.09$

for $c_{cr} > c > c_{min}$

Edge Distance Shear (II to or away from edge)

$c_{min} = 0.5\ h_{ef},\ c_{cr} = 2.0\ h_{ef}$

$f_{RV2} = 0.36(c/h_{ef}) + 0.28$

for $c_{cr} > c > c_{min}$

Load Adjustment Factors for 1" and 1-1/4" Diameter Anchors

Anchor Diameter	1" diameter											
Adjustment Factor	Spacing Tension/Shear f_A			Edge Distance Tension f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	4-1/2	9	12	4-1/2	9	12	4-1/2	9	12	4-1/2	9	12
Spacing (s)/Edge Distance (c), in. 2-1/4	0.70			0.70			0.18			0.46		
2-3/4	0.73			0.73			0.24			0.50		
3	0.75			0.75			0.27			0.52		
4	0.82			0.82			0.39			0.60		
4-1/2	0.85	0.70		0.85	0.70		0.45	0.18		0.64	0.46	
5	0.88	0.72		0.88	0.72		0.51	0.21		0.68	0.48	
5-5/8	0.93	0.74		0.93	0.74		0.59	0.25		0.73	0.51	
6	0.95	0.75	0.70	0.95	0.75	0.70	0.63	0.27	0.18	0.76	0.52	0.46
6-3/4	1.00	0.78	0.72	1.00	0.78	0.72	0.72	0.32	0.21	0.82	0.55	0.48
7-1/2		0.80	0.74		0.80	0.74	0.81	0.36	0.25	0.88	0.58	0.51
8-1/4		0.83	0.76		0.83	0.76	0.90	0.41	0.28	0.94	0.61	0.53
9		0.85	0.78		0.85	0.78	1.00	0.45	0.32	1.00	0.64	0.55
10		0.88	0.80		0.88	0.80		0.51	0.36		0.68	0.58
11		0.92	0.83		0.92	0.83		0.57	0.41		0.72	0.61
12		0.95	0.85		0.95	0.85		0.63	0.45		0.76	0.64
13-1/2		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
14			0.90			0.90		0.75	0.54		0.84	0.70
16-7/8			0.97			0.97		0.92	0.67		0.96	0.79
18			1.00			1.00		1.00	0.72		1.00	0.82
20									0.81			0.88
22-1/2									0.92			0.96
24									1.00			1.00
27												
30												

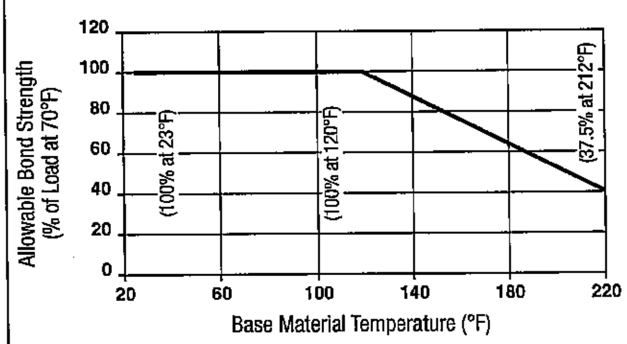
Anchor Diameter	1-1/4" diameter											
Adjustment Factor	Spacing Tension/Shear f_A			Edge Distance Tension f_{RN}			Edge Distance Shear, f_{RV1} (⊥ toward edge)			Edge Distance Shear, f_{RV2} (II to or away from edge)		
Embed. Depth (in.)	5-5/8	11-1/4	15	5-5/8	11-1/4	15	5-5/8	11-1/4	15	5-5/8	11-1/4	15
Spacing (s)/Edge Distance (c), in. 2-1/4												
2-3/4	0.70			0.70			0.18			0.46		
3	0.71			0.71			0.20			0.47		
4	0.76			0.76			0.29			0.54		
4-1/2	0.79			0.79			0.34			0.57		
5	0.82			0.82			0.39			0.60		
5-5/8	0.85	0.70		0.85	0.70		0.45	0.18		0.64	0.46	
6	0.87	0.71		0.87	0.71		0.49	0.20		0.66	0.47	
6-3/4	0.91	0.73		0.91	0.73		0.56	0.23		0.71	0.50	
7-1/2	0.95	0.75	0.70	0.95	0.75	0.70	0.63	0.27	0.18	0.76	0.52	0.46
8-1/4	0.99	0.77	0.72	0.99	0.77	0.72	0.70	0.31	0.21	0.81	0.54	0.48
9		0.79	0.73		0.79	0.73	0.77	0.34	0.23	0.86	0.57	0.50
10		0.82	0.75		0.82	0.75	0.87	0.39	0.27	0.92	0.60	0.52
11		0.84	0.77		0.84	0.77	1.00	0.44	0.31	0.98	0.63	0.54
12		0.87	0.79		0.87	0.79		0.49	0.34		0.66	0.57
13-1/2		0.91	0.82		0.91	0.82		0.56	0.40		0.71	0.60
14		0.92	0.83		0.92	0.83		0.58	0.41		0.73	0.62
16-7/8		1.00	0.89		1.00	0.89		0.72	0.52		0.82	0.69
18			0.91			0.91		0.77	0.56		0.86	0.71
20			0.95			0.95		0.87	0.63		0.92	0.76
22-1/2			1.00			1.00		1.00	0.72		1.00	0.82
24									0.77			0.86
27									0.88			0.93
30									1.00			1.00

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7

Resistance of HIT-RE 500 to Chemicals

Chemical	Chemicals Tested	Resistant	Not Resistant
Alkalinize (Base material concrete)	Concrete drilling mud (10%) pH=12.6	+	
	Concrete drilling mud (10%) pH=13.2	+	
	Concrete potash solution (10%) pH=14.0	+	
Acids	Acetic acid (10%) { concrete was dissolved by acid		-
	Nitric acid (10%)		-
	Hydrochloric acid (10%) 3 month -		-
	Sulfuric acid (10%)		-
Solvents	Benzyl alcohol		-
	Ethanol		-
	Ethyl acetate		-
	Methyl ethyl ketone (MEK)		-
	Trichlorethylene		-
	Xylene (mixture)	+	
Chemicals used on job sites	Concrete plasticizer	+	
	Diesel oil	+	
	Oil	+	
	Petrol	+	
	Oil for form work (forming oil)	+	
Environmental Chemicals	Salt water	+	
	de-mineralized water	+	
	salt spraying test	+	
	SO_2	+	
	Environment / Weather	+	

Influence of Temperature on Bond Strength



Note: Test procedure involves the concrete being held at the elevated temperature for 24 hours then removing it from the controlled environment and testing to failure.

Long term creep test in accordance with AC58 is available; please contact Hilti Technical Services.

Samples of the HIT-RE 500 resin were immersed in the various chemical compounds for up to one year. At the end of the test period, the samples were analyzed. Any samples showing no visible damage and having less than a 25% reduction in bending (flexural) strength were classified as **"Resistant."** Samples that were heavily damaged or destroyed were classified as **"Not Resistant."**

Note: In actual use, the majority of the resin is encased in the base material, leaving very little surface area exposed.

Full Cure Time Table1 (100% of working load)

Base Material Temperature		Approx. Full Curing Time
°F	°C	
23	–5	72 hours
32	0	50 hours
50	10	24 hours
68	20	12 hours
86	30	8 hours
104	40	4 hours

Initial Cure Time Table1 (25% of working load)

Base Material Temperature		Approx. Initial Cure Time
°F	°C	
23	–5	36 hours
32	0	25 hours
50	10	12 hours
68	20	6 hours
86	30	4 hours
104	40	2 hours

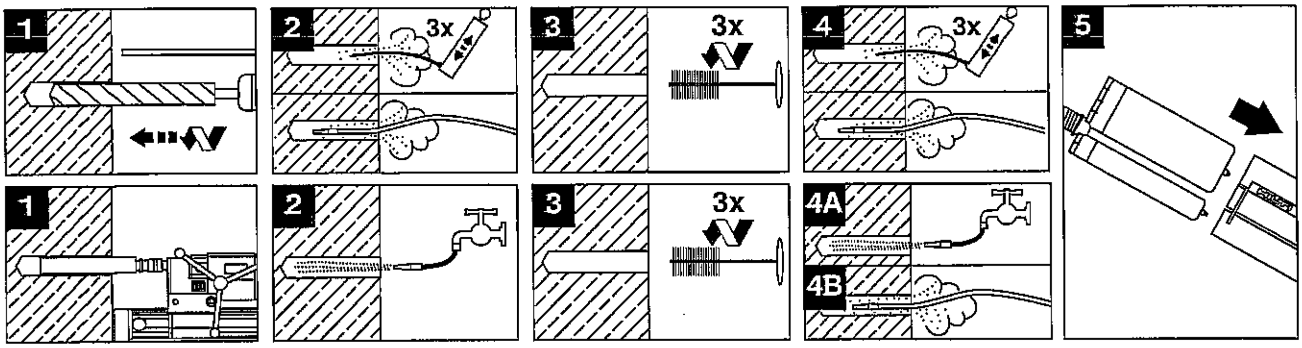
Gel Time Table1 (Approximate)

Base Material Temperature		Approx. Gel Time
°F	°C	
23	–5	4 hours
32	0	3 hours
50	10	2 hours
68	20	30 minutes
86	30	20 minutes
104	40	12 minutes

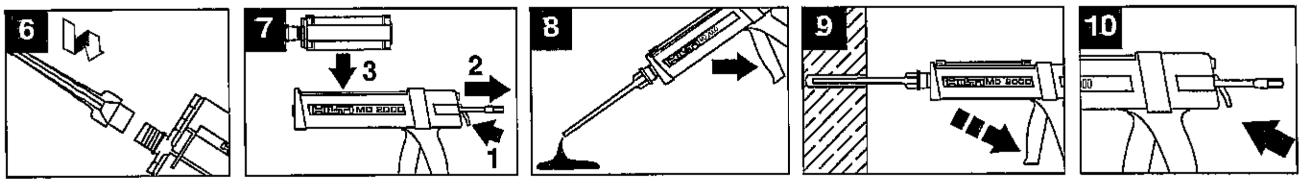
1 Minimum product temperature must be maintained above 41°F (5°C) prior/during installation.

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

4.2.7.4 Installation Instructions

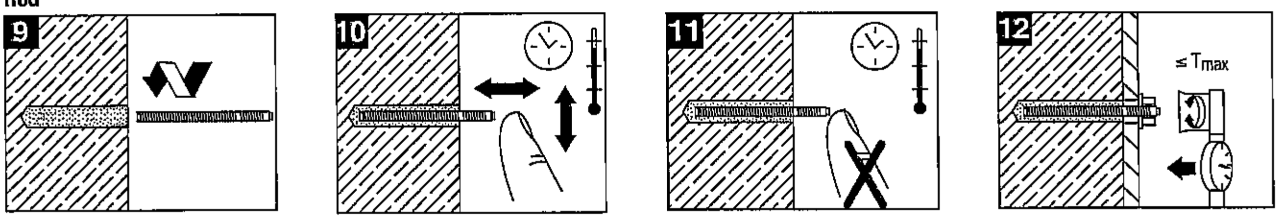


1. Drill anchor hole using carbide or diamond core bits.
2. Insert air nozzle to bottom of hole and blow out hole using a pump, or compressed air. For underwater applications and diamond coring, flush until water runs clear from hole.
3. Clean hole with a nylon or wire brush. Proper hole cleaning is essential.
4. Insert air nozzle to bottom of hole and blow out hole using a pump, or compressed air. For underwater applications and diamond coring, flush until water runs clear from hole. Remove water (e.g. vacuum or comp. air).
5. Insert refill pack into holder. Remove cap covering threaded projection.

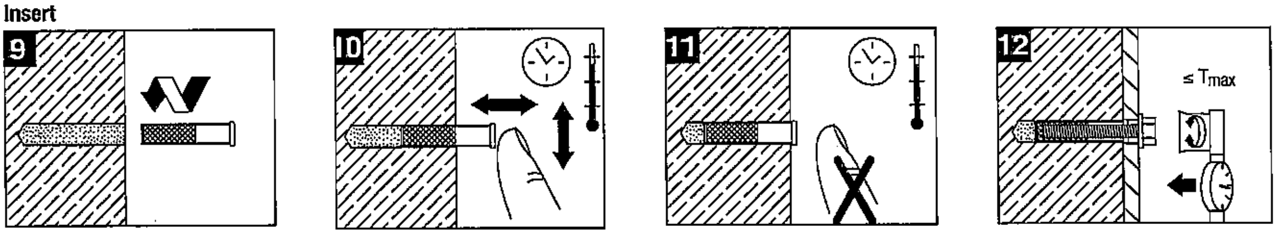


6. Screw on static mixer.
7. Put holder into dispenser.
8. **Discard first three trigger pulls of adhesive from each refill pack or cartridge.**
9. Inject adhesive into hole starting at the bottom until 1/2 to 2/3 full. Use mixer filler tube extensions when needed to reach the hole bottom.
10. Unlock dispenser

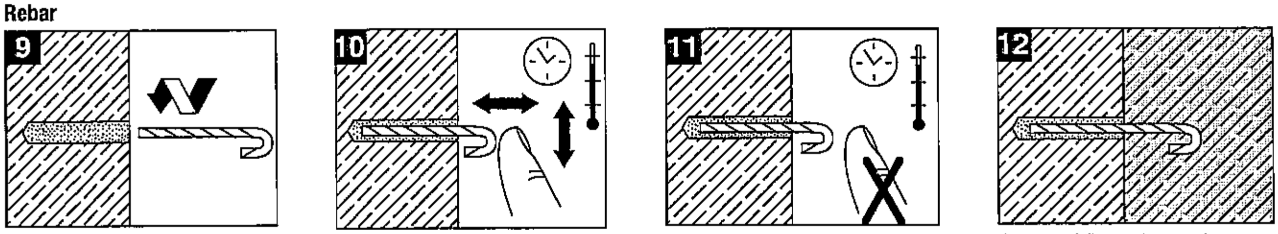
Rod



Insert



Rebar



9. Insert rod, threaded insert or rebar. Twist during installation.
10. Fastener may be adjusted during specified gel time.
11. Do not disturb anchor between specified gel time and initial cure time. At the initial cure time the fastener has 25% of full working load. Work may proceed (e.g. tying rebar, setting steel) which will not exceed 25% of the full working load. Do not torque anchor.
12. After full cure time, apply specified torque as required to secure items to be fastened. Do not exceed maximum torque specified.

HIT HIT-RE 500 Volume Charts

Threaded Rod Installation

Rod Diameter (in.)	Drill Bit[1] Diameter (in.)	Adhesive Volume Required per Inch of embedment (in^3)
1/4	5/16	0.055
3/8	7/16	0.095
1/2	9/16	0.133
5/8	3/4	0.261
3/4	7/8	0.326
7/8	1	0.391
1	1-1/8	0.478
1-1/4	1-3/8	0.626

EXAMPLE:

Determine approximate fastenings for 5/8" rod embedded 10" deep.

$10 \times 0.261 = 2.61$ in^3 of adhesive per anchor
$16.5 \div 2.61 \approx 6$ fastenings per small cartridge
$81.8 \div 2.61 \approx 31$ fastenings per jumbo cartridge

Rebar Installation

Rod Diameter (in.)	Drill Bit[1] Diameter (in.)	Adhesive Volume Required per Inch of embedment (in^3)
#3 or 3/8	1/2	0.110
#4 or 1/2	5/8	0.146
#5 or 5/8	3/4	0.176
#6 or 3/4	7/8	0.218
#7 or 7/8	1	0.252
#8 or 1	1-1/8	0.299
#9 or 1-1/8	1-3/8	0.601
#10 or 1-1/4	1-1/2	0.659
#11 or 1-3/8	1-3/4	1.037

NOTE: Useable volume of HIT-RE 500 refill cartridge is 16.5 in^3 (270 ml).
Useable volume of HIT-RE 500 medium refill cartridge is 26.9 in^3 (440 ml).
Useable volume of HIT-RE 500 jumbo refill cartridge is 81.8 in^3 (1340 ml).

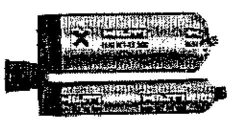
Metric Rebar Installation (Canada Only)

Bar Diameter	Drill Bit[1] Diameter (in.)	Adhesive Volume Required per Inch of embedment (in^3)
10M	5/8	0.186
15M	3/4	0.170
20M	1	0.388
25M	1-1/8	0.289
30M	1-3/8	0.481
35M	1-3/4	0.996

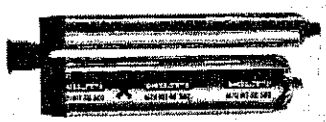
1 Rebar diameter may vary. Use smallest drill bit which will accommodate rebar.

4.2.7.5 Ordering Information

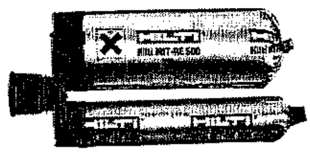
HIT RE Mixer



HIT-RE 500 Refill Pack



HIT-RE 500 Medium Cartridge



HIT-RE 500 Jumbo Cartridge

HIT Adhesives

Item No.	Description
340225	HIT-RE 500 11.1 oz (330 ml) Includes (1) Refill Pack and (1) Mixer with filler tube
369251	HIT-RE 500 MC 11.1 oz (330 ml) Includes (25) Refill Packs and (25) Mixers with filler tube
369110	HIT-RE 500 Medium 16.9 oz (500 ml) Includes (20) Refill Packs and (20) Mixers with filler tube
373958	HIT-RE 500 Jumbo 47.3 oz (1400 ml) Includes (4) Jumbo Refill Packs and (4) Mixers

4.2.7 HIT-RE 500 Epoxy Adhesive Anchoring System

Dispensers

Battery Powered

Item No.	Ordering designation	
3245363	ED3500 2.0 Ah kit	①

Manual

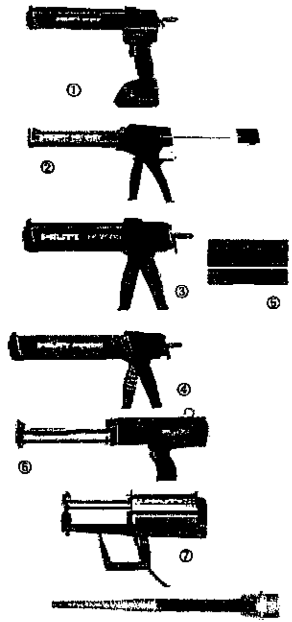
Item No.	Ordering designation	
371291	MD 1000 Manual Dispenser for HIT-ICE	②
229154	MD 2000 dispenser — includes foil pack holder	③
338853	MD 2500 Manual Dispenser	④
229170	Refill Holder Replacement for MD2000, ED 3500 or P-3000HY dispensers	⑤

Pneumatic Dispenser with 1/4" internally threaded compressed air coupling

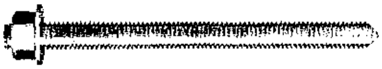
Item No.	Ordering designation	
354180	P-3500 dispenser (for foil packs)	⑥
373959	HIT-P8000D pneumatic dispenser (for jumbo cartridges)	⑦
373960	Jumbo pack holder replacement for P8000D	

Mixers and Filler Tubes

Item No.	Ordering designation	Qty/pkg
337111	HIT-RE-M static mixer (suitable for foil pack and jumbo cartridges)	1


HIT-RE-M Mixer

HIT-RE 500 Epoxy Adhesive Anchoring System 4.2.7



Threaded Rods

HAS Rods 5.8				HAS Super A193, B7 High Strength Rods			HAS-R Rods 304 Stainless Steel			HAS-R Rods 316 Stainless Steel		
Item No. (Box)	Master Carton (MC)	Description (in.)	Qty Box/MC	Item No.	Description	Qty Box	Item No.	Description	Qty Box	Item No.	Description	Qty Box
385417	3432178	3/8 x 3	10/360									
385418	3432179	3/8 x 4-3/8	10/240									
385419	3432180	3/8 x 5-1/8	20/240	68657	3/8x5-1/8	10	385462	3/8x5-1/8	10	3024335	3/8x5-1/8	1
385420	3432181	3/8-8	10/160				385463	3/8 x 8	10			
385421	3432182	3/8 x 12	10/90									
385422	3432183	1/2 x 3-1/8	10/240									
385423	3432184	1/2 x 4-1/2	10/160									
385424	3432185	1/2 x 6-1/2	20/160	68658	1/2x6-1/2	10	385464	1/2x6-1/2	10	3024336	1/2x6-1/2	1
385425	3432239	1/2 x 8	10/120				385465	1/2x8	1			
385426	3432186	1/2 x 10	10/120				385466	1/2x10	1			
										3024337	1/2x11	1
385427	3432187	1/2 x 12	10/80									
385428	3432188	5/8 x 8	20/80	333783	5/8x7-5/8	10	385467	5/8x7-5/8	10	333781	5/8x7-5/8	10
							385468	5/8x10	1			
385429	3432189	5/8 x 9	10/60							3024338	5/8x9	1
385430	3432190	5/8 x 12	10/60							3024339	5/8x12	1
385431	3432191	5/8 x 17	10/40									
385432	3432052	3/4 x 10	10/40	68660	3/4x9-5/8	5	385469	3/4x9-5/8	5	3024340	3/4x9-5/8	1
385433	3432163	3/4 x 11	10/30									
385434	3432164	3/4 x 12	10/30				385470	3/4x12	1			
385435	3432165	3/4 x 14	10/30	3006083	3/4 x 14	5	385471	3/4x14	1			
							385472	3/4x16	1			
385436	3432166	3/4 x 17	10/20									
385437	3432167	3/4 x 19	10/20									
385438	3432168	3/4 x 21	10/20									
385439	3432169	3/4 x 25	10/20									
385440	3432170	7/8 x 10	10/20	68661	7/8x10 (HDG)[1]	5	385473	7/8x10	1			
				3006077	7/8x12 (HDG)[1]	5						
385441	3432171	7/8 x 13	10/20	45259	7/8x16 (HDG)[1]	5						
385442	3432172	1 x 12	4/16	68662	1x12	5	385474	1x12	1	3024341	1x12	4/16
385443	3432173	1 x 14	2/16	3006079	1x14	5						
385444	3432174	1 x 16	2/12	3006080	1x16	5						
385445	3432175	1 x 20	2/12	3006081	1x21	5						
385446	3432176	1-1/4 x 16	4/8	333779	1-1/4x16	4						
385447	3432177	1-1/4 x 22	4/8									
				3006082	1-1/4x23	5						

1 Hot dipped galvanized (7/8" rod only). Coating thickness 2 mils (50.8 μm).

HIS Internally Threaded Inserts

HIS Item No.	HIS-R Item No.	Description	Useable Thread Length (in.)	Qty Box
258020	258029	3/8x4-1/4	1	10
258021	258030	1/2x5	1-3/16	5
258022	258031	5/8x6-5/8	1-1/2	5
258023	258032	3/4x8-1/4	2	5

In The United Sates

PAYMENT TERMS: Net 30 days from date of invoice. Customer agrees to pay all costs incurred by Hilti in collecting any delinquent amounts, including attorney's fees.

FREIGHT: All sales are F.O.B. Destination with transportation allowed via Hilti designated mode. Delivery dates are estimates only. Additional charges for expedited shipments, special handling requirements, and orders below certain dollar amounts shall be the responsibility of Customer. Fuel surcharges may apply depending on market conditions.

CREDIT: All orders sold on credit are subject to Credit Department approval.

RETURN POLICY: Products must be in saleable condition to qualify for return. Saleable condition is defined as unused items in original undamaged packaging and unbroken quantities and in as-new condition. All returns are subject to Hilti inspection and acceptance, and a $125 restocking charge if returned more than 90 days after invoice date. Proof of purchase is required for all returned materials. Special orders products and discontinued items are not eligible for return credit. Dated materials are only returnable in case quantity, and within 30 days after invoice date.

WARRANTY: Hilti warrants that for a period of 12 months from the date it sells a product it will, at its sole option and discretion, refund the purchase price, repair, or replace such product if it contains a defect in material or workmanship. Absence of Hilti's receipt of notification of any such defect within this 12-month period shall constitute a waiver of all claims with regard to such product.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Hilti shall in no event be liable for, and Customer hereby agrees to indemnify Hilti against all claims related to special, direct, indirect, incidental, consequential, or any other damages arising out of or related to the sale, use, or inability to use the product.

ACCEPTANCE OF ORDER: Acceptance is limited to the express terms contained herein, and terms are subject to change by Hilti without notice. Additional or different terms proposed by Customer are deemed material and are objected to and rejected, but such rejection shall not operate as a rejection of the offer unless it contains variances in the terms of the description, quantity, price or delivery schedule of the goods. Orders are not deemed "accepted" by Hilti unless and until it ships the associated items.

DOMESTIC ORIGIN: Any non-domestic Hilti product will be so identified on shipping documents and invoices for customers who properly identify themselves as a federal government entity. All other customers may obtain such information by written request to Hilti, Inc., Contract Compliance, P.O. Box 21148, Tulsa, Oklahoma 74121. Hilti's Quality Department personnel are the only individuals authorized to warrant the country of origin of Hilti products.

BUSINESS SIZE: Hilti is a large business.

PRICES: Prices are those stated on the order, and unless otherwise noted are based on purchasing all items on the order — pricing for individual products may vary for purchases of different quantities or item combinations. Hilti does not maintain most favored customer records, makes no representation with respect to same, and rejects any price warranty terms proposed by Customer. Hilti's published net price list is subject to change without notice.

CONSENT TO JURISDICTION: All transactions made pursuant hereto shall be deemed to have been made and entered into in Tulsa, Oklahoma. Any and all disputes arising directly or indirectly from such transactions shall be resolved in the courts of the County of Tulsa, State of Oklahoma, to the exclusion of any other court, and any resulting judgment may be enforced by any court having jurisdiction of such an action. All transactions shall be governed by and construed in accordance with the laws of the State of Oklahoma.

INDEMNIFICATION: Customer hereby agrees to indemnify Hilti for any costs, including attorney's fees, incurred by Hilti as a result, in whole or in part, of any violation by Customer of any Federal, State or Local statute or regulation, or of any nationally accepted standard. It shall be Customer's sole responsibility to comply with all applicable laws and regulations regarding the handling,use, transportation, or disposal of products upon taking possession of same.

AUTHORIZATION: HILTI LEGAL DEPARTMENT PERSONNEL ARE THE ONLY INDIVIDUALS AUTHORIZED TO MODIFY THESE TERMS AND CONDITIONS, WARRANT PRODUCT SUITABILITY FOR SPECIFIC APPLICATIONS, OR EXECUTE CUSTOMER DOCUMENTS, AND ANY SUCH ACTION IS NULL AND VOID UNLESS IN WRITTEN FORM SIGNED BY SUCH INDIVIDUAL.

In Canada

PAYMENT TERMS: Net 30 days from date of invoice. Customer agrees to pay all costs incurred by Hilti in collecting delinquent amounts, if any, including reasonable attorney's fees.

FREIGHT: Sales are F.O.B. Destination Point with transportation allowed via Hilti designated mode. Additional charges may apply for expedited delivery, special handling requirements, and order under certain limits. A fuel surcharge may apply depending on market conditions.

CREDIT: All orders sold on credit are subject to Credit Department approval.

RETURN POLICY: Product may be returned prepaid (unless otherwise authorized) to Hilti provided:

i) it is returned by the original purchaser

ii) it is not dated product returned more than 30 days after the original delivery date

iii) it is not discontinued, clearance or special order product

iv) it is unused, in original packaging and in unbroken quantities.

Hilti will inspect product and, if the above requirements are satisfied, will credit to customer the original purchase price. A 15% restocking fee may apply.

WARRANTY: Other than the manufacturer's published warranty, no warranties or conditions, express or implied, written or oral, statutory or otherwise are implied. Any and all conditions and warranties implied by law or by the Sale of Goods Act or any similar statutes of any Province are hereby expressly waived.

TITLE TO PRODUCT: Title to product remains with Hilti until the total purchase price of product is paid.

PRICES: Customer agrees to pay Hilti prices set out on invoice. Customer agrees to pay taxes as indicated on invoice unless Hilti receives acceptable exemption certificates.

INDEMNIFICATION: Customer agrees to use product at own risk and to indemnify Hilti against all liabilities, including legal fees, to third parties arising out of the use or possession thereof. Hilti shall in no event be liable for special, incidental or consequential damages.

CHANGES: Hilti sales personnel are not authorized to modify these Terms and Conditions or modify Customer's credit terms. Terms are subject to change by Hilti with reasonable notice to Customer.

CASH SALES: Payment in full is due prior to goods being released.

QUOTATIONS: All terms and conditions apply once customer agrees to purchase product. Quotations on special promotion products are only valid until end of promotion period.

R0001 – RMR Standard Calculations

Aluminum Railing Design Calculations – R11-02-15H

Colorado

Prepared for

Rocky Mountain Railings

Denver, CO

Design Criteria:

Date: 3/8/11

1. Railing live loads per **International Building Code 2009**:

    Guardrails

    50 plf uniform load in any direction on top rail
    200 pound concentrated load in any direction on top rail
    50 pound concentrated load over 1 ft^2 of infill area
    Concentrated load and uniform loads need not be assumed to act concurrently

    Railing deflections per ASTM E985

    Members designed per Aluminum Association Inc, "Aluminum Design Manual"

2. Aluminum member sizes shall be as recommended in the calculation booklet
3. Aluminum alloys shall be as recommended in the calculation booklet
4. Stainless steel fasteners to be minimum **Condition "CW", Fy= 65 ksi**
5. Aluminum welds to be **filler alloy 5356**, unless noted otherwise
6. Concrete strength is assumed to be **F'c= 4,000 psi, normal weight**
7. Additional RISA Finite Element Analysis model data available upon request.

This Certification is limited to the structural design of structural components of this handrail or divider system.
It does NOT include responsibility for:

- Structural design of misc. hardware (latches, hinges, etc.).
- Structural design of concrete slabs and other masonry units
- Structural design of wood blocking or wood framing
- Structural design of all other anchorage substrates
- The manufacture, assembly, or installation of the system.
- Quantities of materials or dimensional accuracy of drawings

Engineers Design Approval Stamp:

COLORADO LICENSED
L. DAVID RICE
40031
PROFESSIONAL ENGINEER

MAR 08 2011

Sheet Number	Description	Date	Revision
PL	Project Location & Specs	2/23/11	
A	Guardrail "A"	2/23/11	
A1-A1B	Guardrail "A" Analysis	2/23/11	
A2	2-Bolt Base Plate	2/23/11	
A3	Corner Base Plate	2/23/11	
A3.1	RISA Data	2/23/11	
A3.2	RISA Data	2/23/11	
B	Guardrail "B"	2/23/11	
B1-B1B	Guardrail "B" Analysis	2/23/11	
B2	Surface Mount Anchorage	2/23/11	
B3	Hilti Adhesive	2/23/11	
C	Guardrail "C"	2/23/11	
C1-C1B	Guardrail "C" Analysis	2/23/11	
C2	Side Mount Anchorage	2/23/11	
C3	Hilti Adhesive	2/23/11	
C4	Corner Side Mount Anchorage	2/23/11	
C4.1	RISA Data	2/23/11	
C4.2	RISA Data	2/23/11	
C5	Hilti Adhesive	2/23/11	
C6	Side Mount Anchorage	2/23/11	
C7	Hilti Adhesive	2/23/11	
D	Guardrail "D"	2/23/11	
D1-D1B	Guardrail "D" Analysis	2/23/11	
D2	Side Mount Anchorage	2/23/11	
D3	Side Mount Anchorage	2/23/11	
E	Guardrail "E"	2/23/11	
E1-E1B	Guardrail "E" Analysis	2/23/11	
E2	Side Mount Anchorage	2/23/11	
E3	Side Mount Anchorage	2/23/11	
F	Guardrail "F"	2/23/11	
F1-F1B	Guardrail "F" Analysis	2/23/11	
F2	Post Embedment in Grout	2/23/11	
M1	Miscellaneous Connections	2/23/11	
M1A	RISA Data	2/23/11	
M2	Wall Rail Post Bracket	2/23/11	
M2A	RISA Data	2/23/11	
M2B	RISA Data	2/23/11	
M3-M3A	Wall or Grab Rail Analysis	2/23/11	
M4	Grab Rail Bracket Analysis	2/23/11	
M5	Wall Rail Bracket Analysis	2/23/11	
M6	Offset Rail Connections	2/23/11	
M7	Wall Mount End Cap	2/23/11	
M8	2-Bolt Raked Base Plate	2/23/11	
	Algor Base Plate Models	2/23/11	
S1	Fastener Spec. Sheet	2/23/11	

Sheet Number	Description	Date

This Certification is limited to the structural design of structural components of this handrail or divider system.
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- Structural design of concrete slabs and other masonry units
- Structural design of wood blocking or wood framing
- Structural design of all other anchorage substrates
- The manufacture, assembly, or installation of the system.
- Quantities of materials or dimensional accuracy of drawings

Engineers Design Approval Stamp:

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L. DAVID RICE
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PROFESSIONAL ENGINEER

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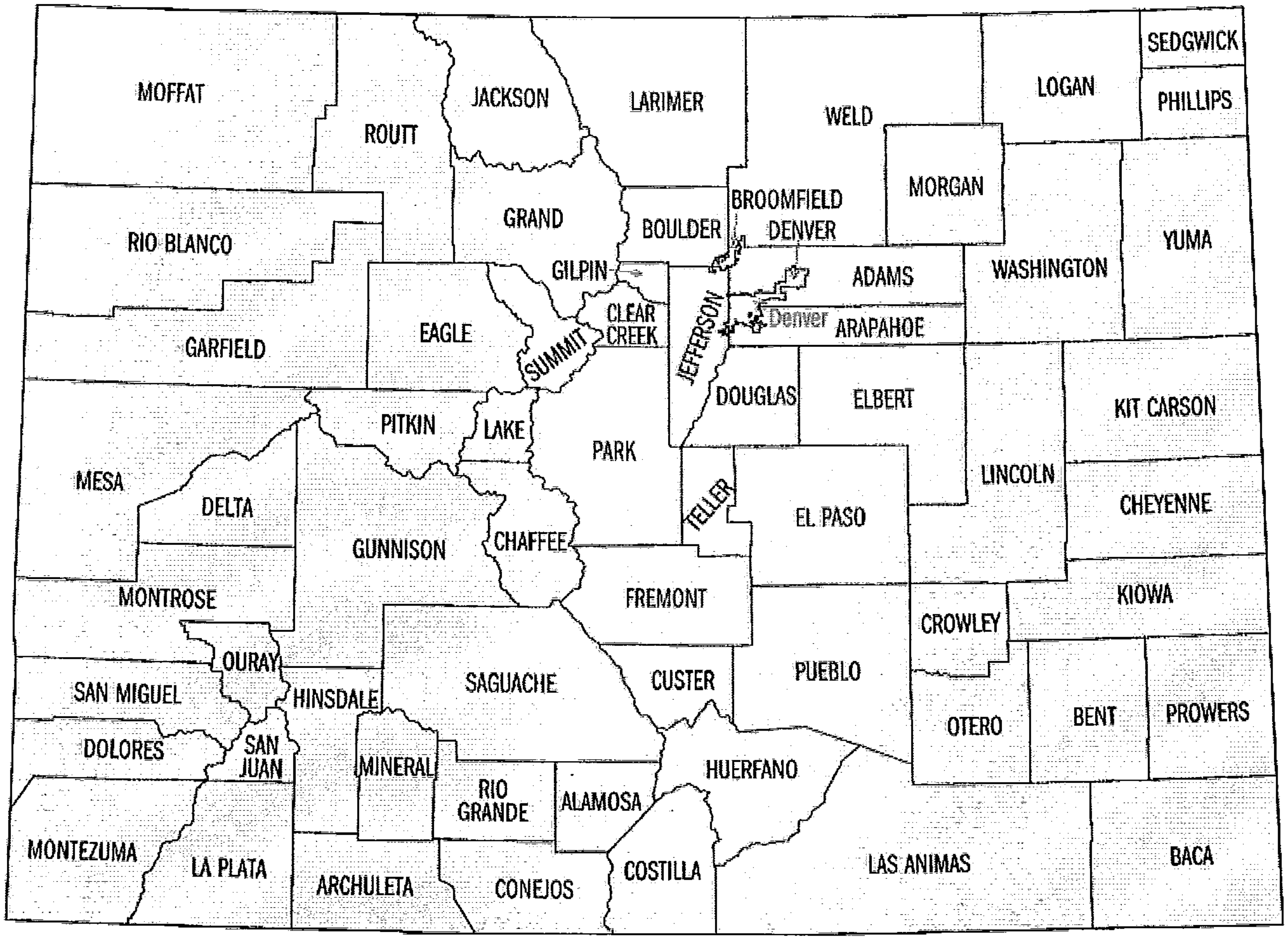


<u>Project Location: Colorado</u>

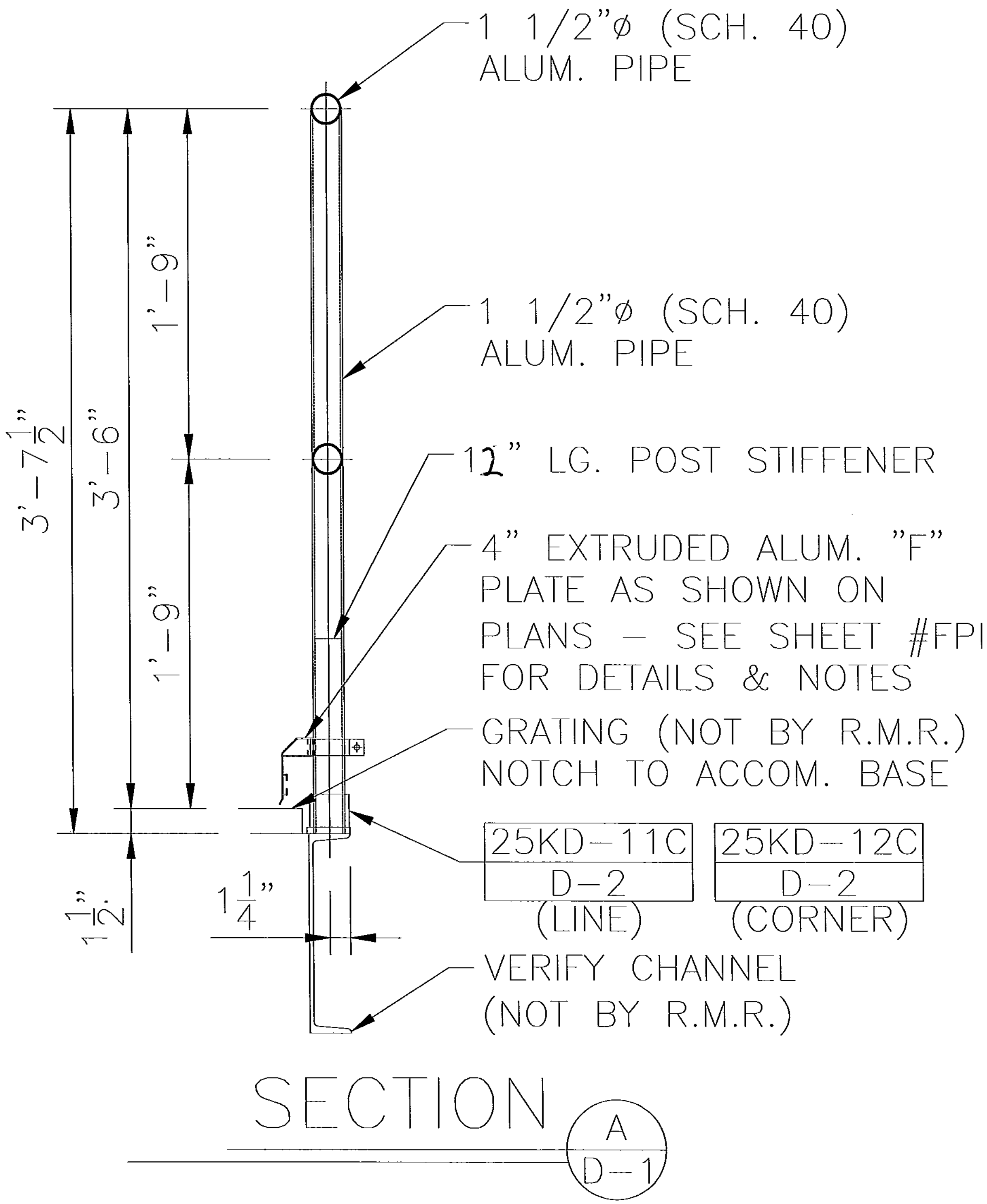
- Design Loads per IBC 2009

  50 plf uniform load in any direction on top rail

  200# concentrated load in any direction on top rail

  50# concentrated load applied to 1 square foot of infill

Guardrail "A"	SHT A



Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ***ENGINEERING***	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description:	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: A
		R0001 - RMR Standard Calcs	Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "A" Analysis	SHT A1

Input Variables:

$F_H := 50$ plf Load Case 1 (Uniform Load)

$F_V := 0$ plf Simultaneous Vertical Uniform Load

$P := 200$ lb Load Case 2 (Point Load)

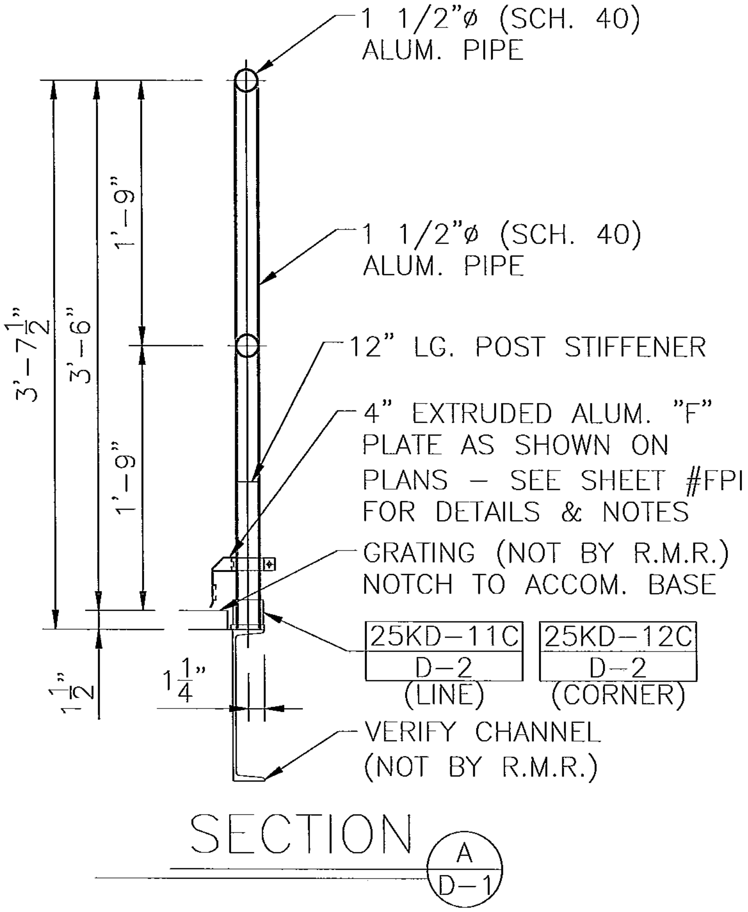
$L_{bp} := 21$ in Unbraced Length of Post

$h := 41$ in Railing Height Above Base Flange

$L := 58$ in **4'-10" MAX POST SPACING**

Number of Railing Spans:
*Note: Post Spacing (Anchor limits the span length)

- 1 span ☑
- 2 span ☑
- 3 or more spans ☑



Railing Section:	Post Section:
☐ 1 1/4" Schd. 40	☐ 1 1/4" Schd. 40
☐ 1 1/4" Schd. 80	☐ 1 1/4" Schd. 80
☑ 1 1/2" Schd. 40	☑ 1 1/2" Schd. 40
☐ 1 1/2" Schd. 80	☐ 1 1/2" Schd. 80
☐ 1 1/2" tube	☐ 1 1/2" tube
☐ 2" Schd. 40	☐ 2" Schd. 40
☐ 2" Schd. 80	☐ 2" Schd. 80

Railing Temper:	Post Temper:
☐ 6063-T5	☐ 6063-T6
☐ 6063-T6	☐ 6005-T5
☑ 6061-T6 or 6105-T5	☑ 6061-T6 or 6105-T5
☐ *4/3 increase allowed*	☐ Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Post Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $\boxed{I_{xtotr} = 0.31}$ in^4 $I_{xtotp} := I_{xp}$ $\boxed{I_{xtotp} = 0.31}$ in^4

$I_{ytotr} := I_{yr}$ $\boxed{I_{ytotr} = 0.31}$ in^4 $I_{ytotp} := I_{yp}$ $\boxed{I_{ytotp} = 0.31}$ in^4

12" Min. Length AL. Ribbed Tube Stub

$I_{st} := 0.174$ in^4 $L_{st} := 9.5$ in

$S_{st} := 0.224$ in^3 $F_{bst} := 25000$ psi

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Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "A" Analysis	SHT A1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.196$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.6$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 1752$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 5374$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.189$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2320$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 7117$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $\boxed{F_{bry} = 25000}$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.21$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.28$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ $\boxed{RAILS = \text{"OK"}}$

Post Analysis:

$E_p := E_r$

Guardrail "A" Analysis	SHT A1 B

$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$ $\Delta_{xp1} = 0.804$ in

$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$ $\Delta_{xp2} = 0.566$ in

Max Deflection:

$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$ $\boxed{\Delta_{tot} = 1.425}$ in

$\Delta_{allp} := \frac{h}{12}$ $\boxed{\Delta_{allp} = 3.42}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 9908$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 7613$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 5355$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 6970$ lb·in

Max Post Stress:

$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$ $\boxed{f_{bpx} = 23351}$ psi

$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$ $\boxed{f_{bpx2} = 19467}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$ $\boxed{f_{bst} = 15902}$ psi

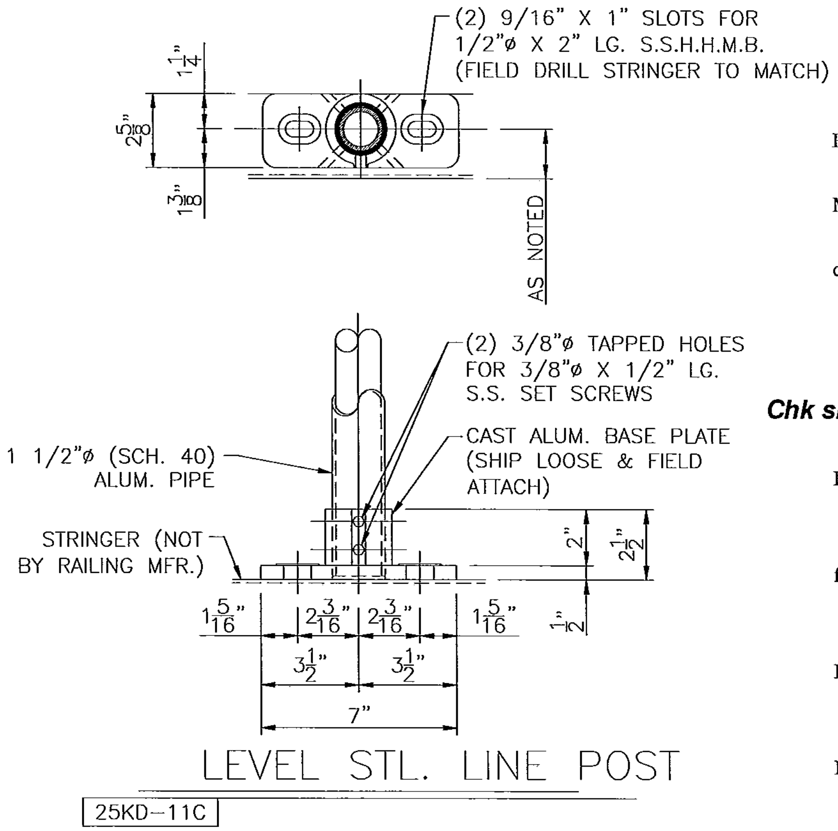
$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$ $Int_{p1} = 0.93$

$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ $\boxed{POSTS = \text{"OK"}}$

2-Bolt Base Plate	SHT A2



$R_{max} := 242$ lb

$M_{max} := 9908 + R_{max} \cdot 2.5 = 10513$ lb·in

$d := 2.5$ in (sleeve dia.)

Chk shear on shoe wall:

$P := \frac{M_{max}}{0.85 \cdot (2.375)}$ $P = 5208$ lb

$f_v := \frac{(P + R_{max})}{2 \cdot (0.315) \cdot (2)}$ $f_v = 4325$ psi

$F_v := \frac{0.57 \cdot (18000)}{1.65}$ $F_v = 6218$ psi

$I := \frac{f_v}{F_v}$ $I = 0.7$ Shear Stress "OK"

Note: 4'10" ℄ Post spacing @ 3'7½" rail height (as shown)
if rail height was 3'6" then ℄ Post Spacing could be 5'0"

Chk Bolts to Steel Stringer:

$V_b := \frac{R_{max}}{2}$ $V_b = 121$ lb

$T_b := \frac{M_{max}}{2 \cdot 1.25}$ $T_b = 4205$ lb

$V_{all} := 0.196 \cdot 23094$ $V_{all} = 4526$ lb

$T_{all} := 0.142 \cdot 40000$ $T_{all} = 5680$ lb

$I_3 := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2$ $I_3 = 0.55$

Use (2) - 1/2" Dia. S.S. Thru-Bolts
Condition "CW" - Fy = 65 ksi

Chk Aluminum Base Plate:

$L1 := 7$ in $D1 := 1.3125$ in

$L2 := 2.625$ in $D2 := 1.25$ in

$t := 0.563$ in

$L := L1 - (2 \cdot D1)$ $L = 4.38$ in

$P := \frac{M_{max}}{d}$ $P = 4205$ lb

$M_{p1} := 0.5 \cdot P \cdot 0.9375$ $M_{p1} = 1971$ in·lb

$F_y := \frac{1.3 \cdot (18000)}{1.65}$ $F_y = 14182$ psi

$t_{req1} := \sqrt{\frac{M_{p1} \cdot 6}{F_y \cdot L2}}$ $t_{req1} = 0.564$ in

$I_2 := \frac{t_{req1}}{t}$ $I_2 = 1$

Use Cast Aluminum Base, as shown
535 casting alloy, Fu= 35 ksi min.

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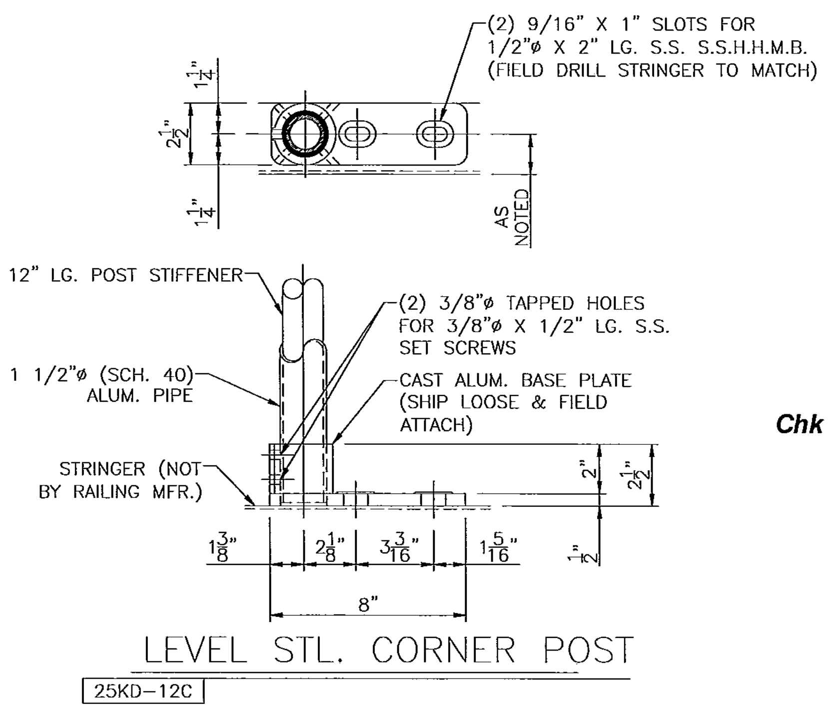
Corner Base Plate	SHT A3



$R_{max} := 101$ lb — *Reactions from RISA Model*

$M_{max} := 0$ lb·in — *(Corner Post Modeled as a Pin Connection)*

$d := 2.5$ in (sleeve dia.)

Chk shear on shoe wall:

$P := \frac{M_{max}}{0.85\cdot(2.375)}$ $P = 0$ lb

$f_v := \frac{(P + R_{max})}{2\cdot(0.315)\cdot(2)}$ $f_v = 80$ psi

$F_v := \frac{0.57\cdot(18000)}{1.65}$ $F_v = 6218$ psi

$I := \frac{f_v}{F_v}$ $I = 0.01$ Shear Stress "OK"

Chk Aluminum Base Plate:

$L1 := 7$ in $D1 := 1.3125$ in

$L2 := 2.625$ in $D2 := 1.25$ in

$t := 0.563$ in

$L := L1 - (2\cdot D1)$ $L = 4.38$ in

$P := \frac{M_{max}}{d}$ $P = 0$ lb

$M_{p1} := P\cdot 0.9375$ $M_{p1} = 0$ in·lb

$F_y := \frac{1.3\cdot(18000)}{1.65}$ $F_y = 14182$ psi

$t_{req1} := \sqrt{\frac{M_{p1}\cdot 6}{F_y\cdot L2}}$ $t_{req1} = 0$ in

$I_2 := \frac{t_{req1}}{t}$ $I_2 = 0$

Use Cast Aluminum Base, as shown
535 casting alloy, Fu= 35 ksi min.

Chk Bolts to Steel Stringer:

$V_b := \frac{R_{max}}{2}$ $V_b = 50.5$ lb

$T_b := \frac{M_{max}}{2\cdot 1.25}$ $T_b = 0$ lb

$V_{all} := 0.196\cdot 23094$ $V_{all} = 4526$ lb

$T_{all} := 0.142\cdot 40000\cdot\frac{0.1875}{0.456}$ $T_{all} = 2336$ lb

$I_3 := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2$ $I_3 = 0$

Use (2) - 1/2" Dia. S.S. Thru-Bolts
or Drill & Tap - 3/16" Min. Thread Engagement
Condition "CW" - Fy = 65 ksi

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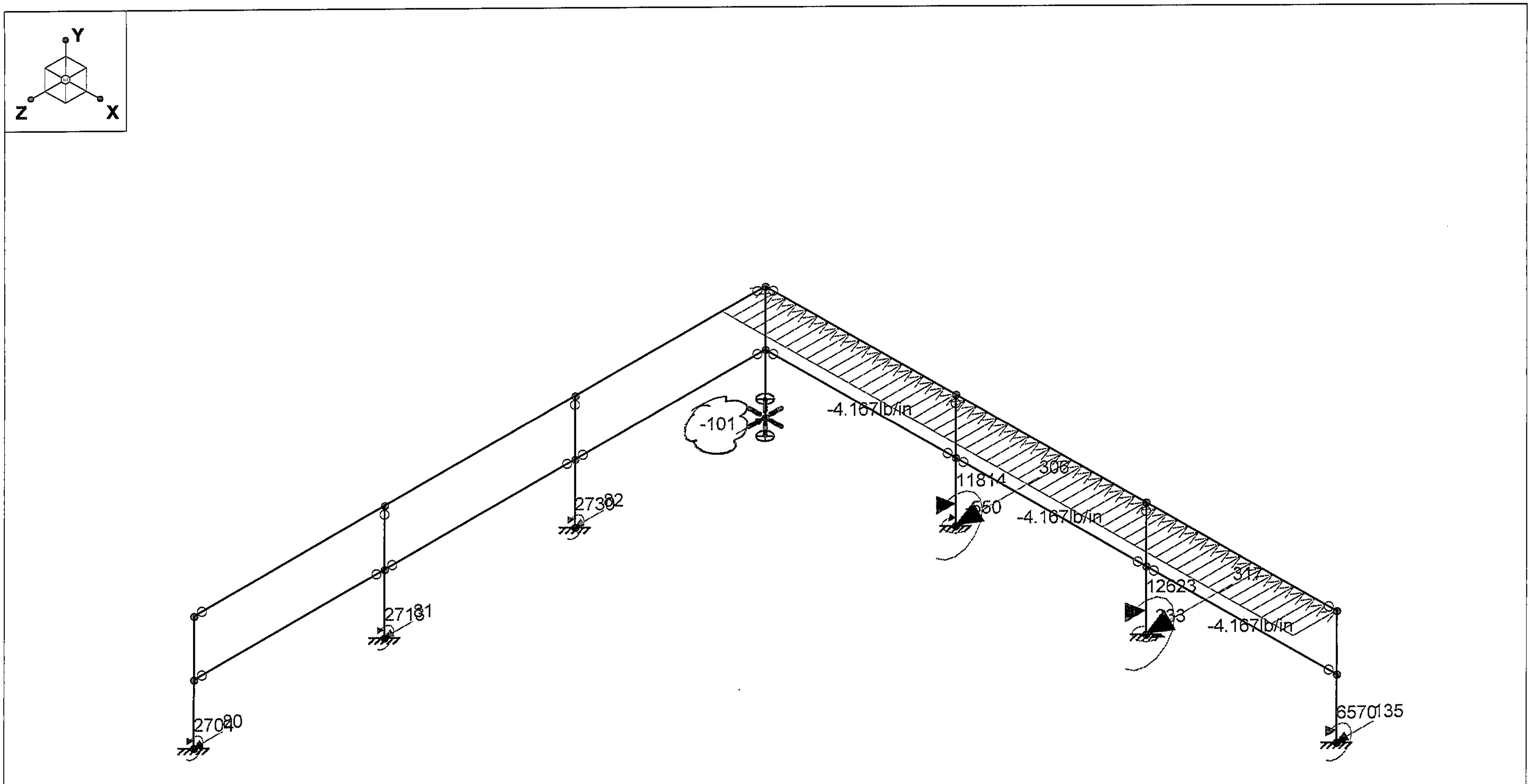
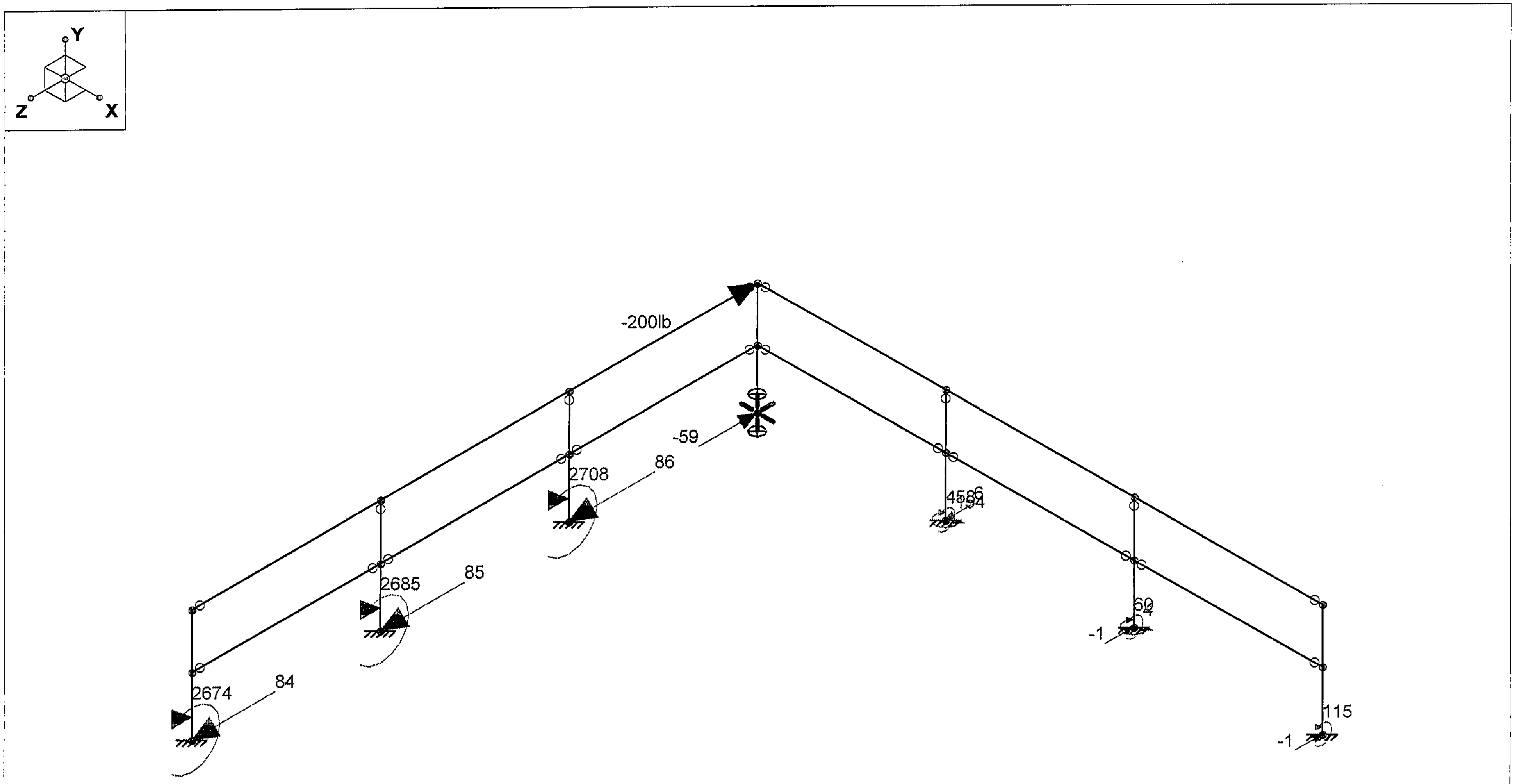
Template:			Engineer: JDB	Sheet No: A3
			Date: 2/23/11	Rev:
			Chk By:	Date:



Loads: BLC 1,
Results for LC 1, Dist 1
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 1
Joe Bauer		Feb 23, 2011 at 5:24 PM
R11-02-15H		Corner Bracket A.r3d

A3.1

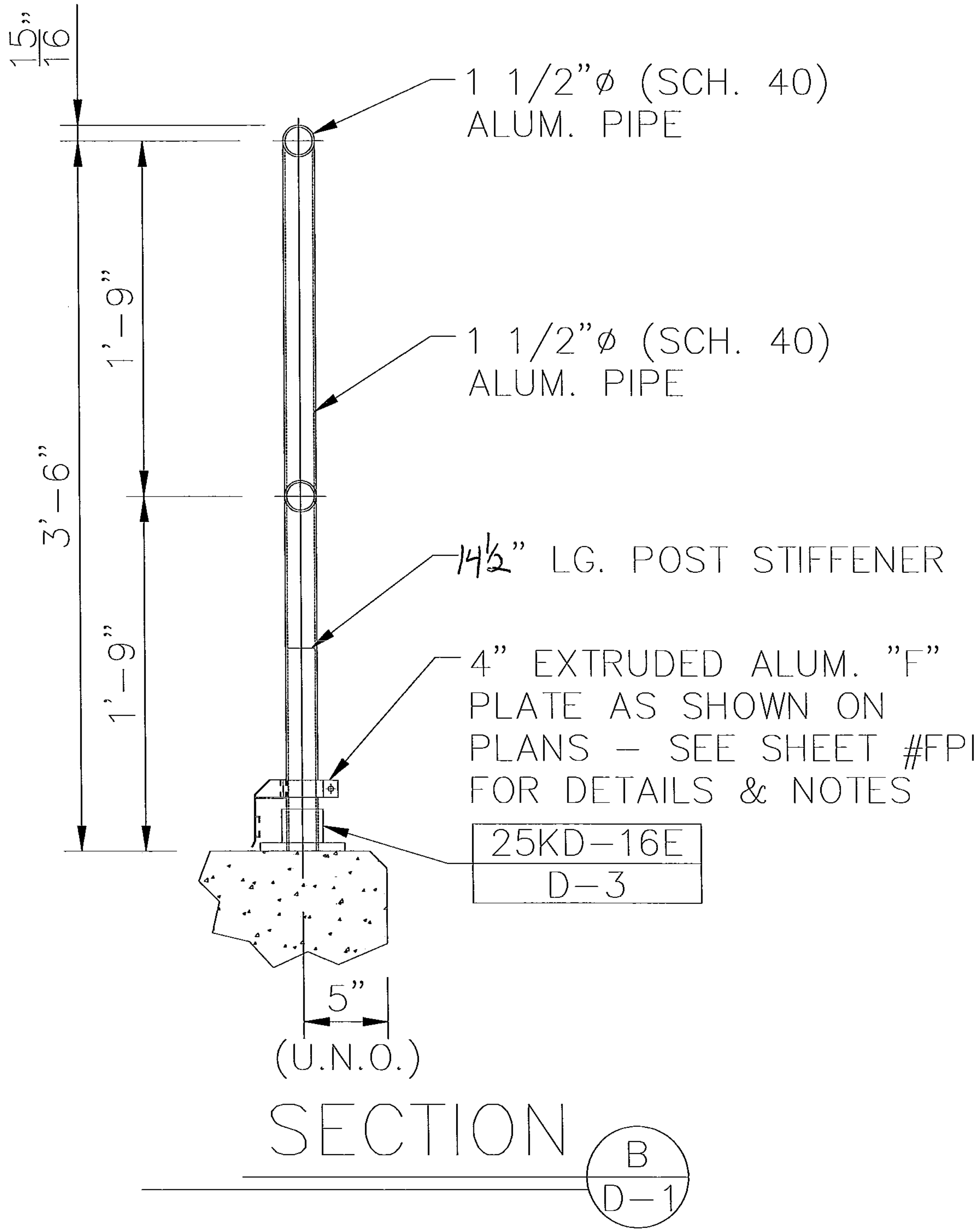


Loads: BLC 2,
Results for LC 2, Point
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 2
Joe Bauer		Feb 23, 2011 at 5:24 PM
R11-02-15H		Corner Bracket A.r3d

A3.2

Guardrail "B"	SHT B



Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ***ENGINEERING***	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: B
			Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

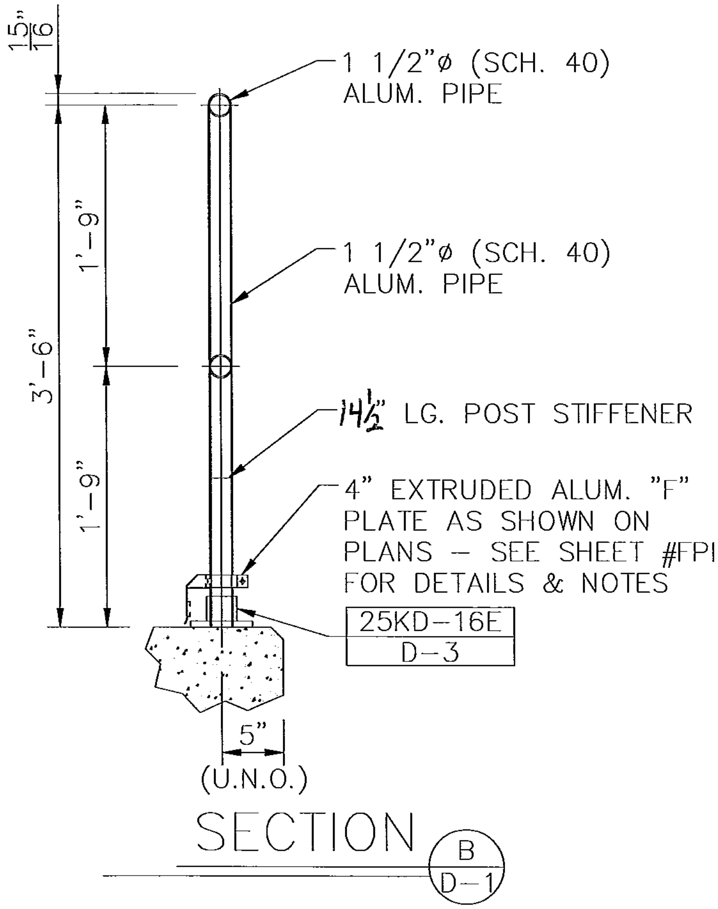
Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "B" Analysis	SHT B1

Input Variables:

$F_H := 50$	plf	Load Case 1 (Uniform Load)
$F_V := 0$	plf	Simultaneous Vertical Uniform Load
$P := 200$	lb	Load Case 2 (Point Load)
$L_{bp} := 21$	in	Unbraced Length of Post
$h := 39.5$	in	Railing Height Above Base Flange
$L := 72$	in	***6'-0" MAX POST SPACING***



Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:	*Post Section:*
[ ] 1 1/4" Schd. 40	[ ] 1 1/4" Schd. 40
[ ] 1 1/4" Schd. 80	[ ] 1 1/4" Schd. 80
[x] 1 1/2" Schd. 40	[x] 1 1/2" Schd. 40
[ ] 1 1/2" Schd. 80	[ ] 1 1/2" Schd. 80
[ ] 1 1/2" tube	[ ] 1 1/2" tube
[ ] 2" Schd. 40	[ ] 2" Schd. 40
[ ] 2" Schd. 80	[ ] 2" Schd. 80

Railing Temper:	*Post Temper:*
[ ] 6063-T5	[ ] 6063-T6
[ ] 6063-T6	[ ] 6005-T5
[x] 6061-T6 or 6105-T5	[x] 6061-T6 or 6105-T5
[ ] *4/3 increase allowed*	[ ] Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Post Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $I_{xtotr} = 0.31$ in^4 $I_{xtotp} := I_{xp}$ $I_{xtotp} = 0.31$ in^4

$I_{ytotr} := I_{yr}$ $I_{ytotr} = 0.31$ in^4 $I_{ytotp} := I_{yp}$ $I_{ytotp} = 0.31$ in^4

14.5" Min. Length AL. Ribbed Tube Stub

$I_{st} := 0.174$ in^4 $L_{st} := 12$ in

$S_{st} := 0.224$ in^3 $F_{bst} := 25000$ psi

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			Engineer: JDB	Sheet No: B1
		R0001 - RMR Standard Calcs	Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "B" Analysis	SHT B1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.466$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0.47$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.75$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 2700$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 2700$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 8282$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 8282$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.361$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2880$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 8834$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if IBC} = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $F_{bry} = 25000$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.66$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.35$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ RAILS = "OK"

Post Analysis:

$E_p := E_r$

Guardrail "B" Analysis	SHT B1 B

$$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp1} = 0.664$ in

$$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp2} = 0.376$ in

Max Deflection:

$$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$$ $\boxed{\Delta_{tot} = 1.5}$ in

$$\Delta_{allp} := \frac{h}{12}$$ $\boxed{\Delta_{allp} = 3.29}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 11850$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 8250$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 4675$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 6715$ lb·in

Max Post Stress:

$$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$$ $\boxed{f_{bpx} = 25307}$ psi

$$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$$ $\boxed{f_{bpx2} = 23282}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$$ $\boxed{f_{bst} = 19018}$ psi

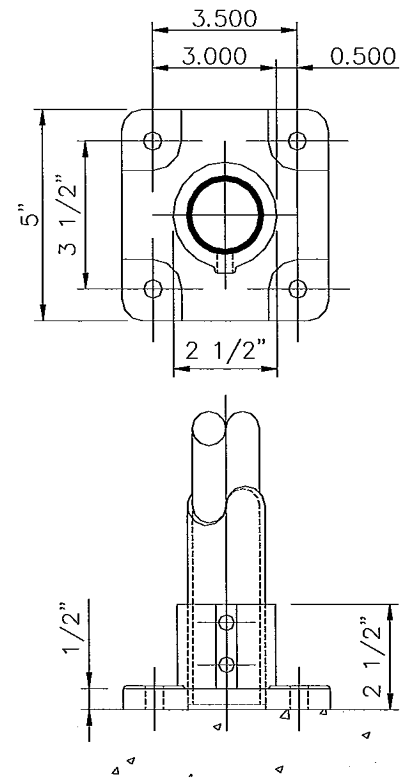
$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$$ $Int_{p1} = 1.01$ *1% Over OK*

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1.014 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$ $\boxed{POSTS = \text{"OK"}}$

Surface Mount Anchor Analysis	SHT B2



$R_{max} := 300$ lb

$M_{max} := 11850 + R_{max} \cdot 2.5 = 12600$ lb·in

$d := 2.5$ in (sleeve dia.)

Chk shear on shoe wall:

$P := \frac{M_{max}}{0.85 \cdot (2.375)}$ $P = 6241$ lb

$f_v := \frac{(P + R_{max})}{2 \cdot (0.315) \cdot (2)}$ $f_v = 5192$ psi

$F_v := \frac{0.57 \cdot (18000)}{1.65}$ $F_v = 6218$ psi

$I := \frac{f_v}{F_v}$ $I = 0.83$ Shear Stress "OK"

Chk Anchor Bolts (assume f'c=4,000 psi conc.):

$V_b := \frac{R_{max}}{4}$ $V_b = 75$ lb

$T_b := \frac{M_{max}}{(L1 - D2) \cdot 0.85 \cdot 2}$ $T_b = 1744$ lb

See Next Sheet for Calculation

Use (4) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-1/4" min.
End Distance = 3"

Chk Aluminum Base Plate:

$L1 := 5$ in $D1 := 0.75$ in

$L2 := 5$ in $D2 := 0.75$ in

$L := L2 - (2 \cdot D2)$ $L = 3.5$ in

$F_y := \frac{1.3 \cdot (18000)}{1.65}$ $F_y = 14182$ psi

$P := \frac{M_{max}}{d \cdot 2}$ $P = 2520$ lb

$M_{pl} := \frac{P \cdot 0.5 \cdot 3^2}{3.5^2}$ $M_{pl} = 926$ in·lb

$t_{req} := \sqrt{\frac{M_{pl} \cdot 6}{F_y \cdot 5}}$ $t_{req} = 0.28$ in

$I := \frac{t_{req}}{0.5}$ $I = 0.56$ Bending Stress "OK"

Use Cast Aluminum Base, as shown
535 casting alloy, Fu= 35 ksi min.

Hilti HIT-RE 500 Epoxy Adjustment for Embed Depth:

Hilti Adhesive	SHT B3

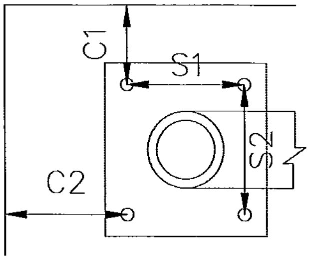
$h_{ef} := 3.5$ in embedment

$s_1 := 3.5$ in spacing 1

$s_2 := 3.5$ in spacing 2

$c_1 := 2.25$ in edge distance 1

$c_2 := 3$ in edge distance 2



Reactions Per Bolt:

$V := 75$ lb shear

$T := 1744$ lb tension

From HILTI Design Guide:

$T_{upper} := 5275$	lb		$h_{efu} := 4.5$	in	
$T_{lower} := 1965$	lb		$h_{efl} := 2.25$	in	
$V_{upper} := 7935$	lb		$h_{efu} = 4.5$	in	
$V_{lower} := 3550$	lb		$h_{efl} = 2.25$	in	

Use (4) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-1/4" min.
End Distance = 3"

Calculations below this line are automatic

$$T_{all} := \frac{(T_{upper} - T_{lower})\cdot(h_{efu} - h_{ef}) - T_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$

$T_{all} = 3804$ lb Interpolated Tension Value

$$V_{all} := \frac{(V_{upper} - V_{lower})\cdot(h_{efu} - h_{ef}) - V_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$

$V_{all} = 5986$ lb Interpolated Shear Value

$$f_{AN1} := \begin{cases} 1.00 & \text{if } s_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_1 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$

$f_{AN1} = 0.85$ Spacing (Tension and Shear)

$$f_{AN2} := \begin{cases} 1.00 & \text{if } s_2 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_2}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_2 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$

$f_{AN2} = 0.85$ Spacing (Tension and Shear)

$$f_{RN} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{c_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RN} = 0.74$ Edge Distance (Tension)

$$f_{RV1} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.54\cdot\left(\frac{c_1}{h_{ef}}\right) - 0.09\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RV1} = 0.26$ Edge Distance (Shear Perpendicular to Edge)

$$f_{RV2} := \begin{cases} 1.00 & \text{if } c_2 \ge 1.5\cdot h_{ef} \\ \left[0.36\cdot\left(\frac{c_2}{h_{ef}}\right) + 0.28\right] & \text{if } 1.5h_{ef} > c_2 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RV2} = 0.59$ Edge Distance (Shear Parallel or Away from Edge)

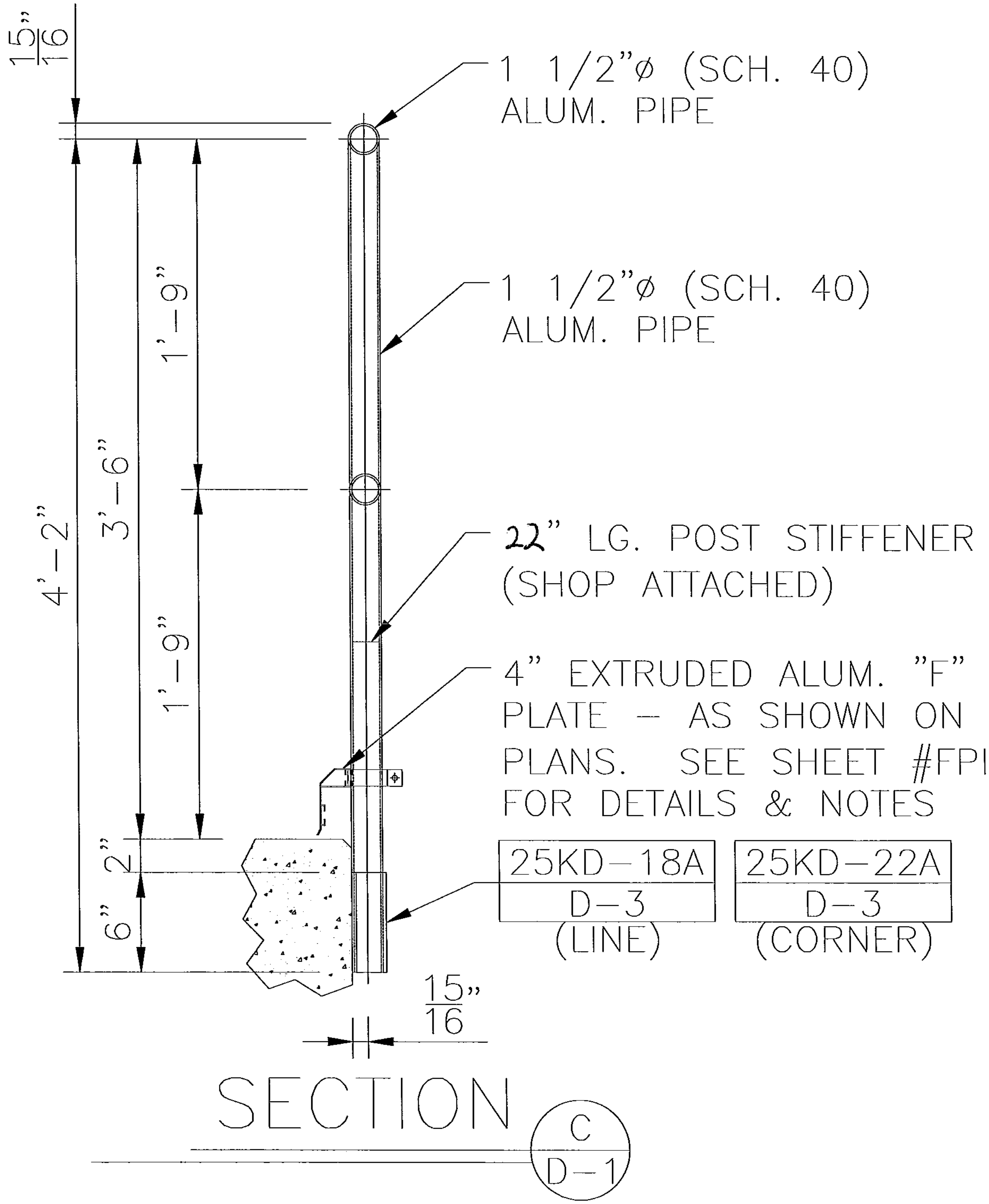
$V_{ball} := V_{all}\cdot f_{AN1}\cdot f_{AN2}\cdot f_{RV1}\cdot f_{RV2}$ $V_{ball} = 655$ lb

$T_{ball} := T_{all}\cdot f_{AN1}\cdot f_{RN}$ $T_{ball} = 2402$ lb

$$I_b := \left(\frac{V}{V_{ball}}\right)^{1.67} + \left(\frac{T}{T_{ball}}\right)^{1.67}$$

$\boxed{I_b = 0.61} < 1.00$

Guardrail "C"	SHT C



Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ENGINEERING	105 School Creek Trail, Luxemburg, WI 54217, Phone: (920)845-1042, Fax: (920)845-1048, www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: C
			Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "C" Analysis	SHT C1

Input Variables:

$F_H := 50$ plf — Load Case 1 (Uniform Load)

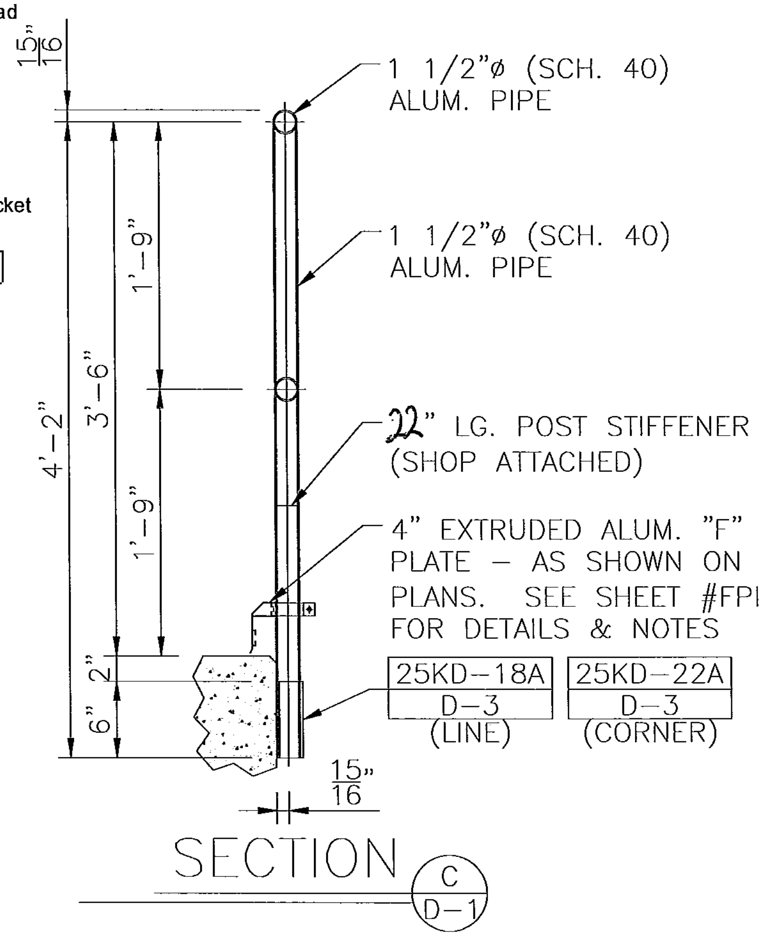
$F_V := 0$ plf — Simultaneous Vertical Uniform Load

$P := 200$ lb — Load Case 2 (Point Load)

$L_{bp} := 23$ in — Unbraced Length of Post

$h := 44$ in — Railing Height Above Anchor Bracket

$L := 72$ in — **6'-0" MAX POST SPACING**



Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:	Post Section:
[ ] 1 1/4" Schd. 40	[ ] 1 1/4" Schd. 40
[ ] 1 1/4" Schd. 80	[ ] 1 1/4" Schd. 80
[x] 1 1/2" Schd. 40	[x] 1 1/2" Schd. 40
[ ] 1 1/2" Schd. 80	[ ] 1 1/2" Schd. 80
[ ] 1 1/2" tube	[ ] 1 1/2" tube
[ ] 2" Schd. 40	[ ] 2" Schd. 40
[ ] 2" Schd. 80	[ ] 2" Schd. 80

Railing Temper:	Post Temper:
[ ] 6063-T5	[ ] 6063-T6
[ ] 6063-T6	[ ] 6005-T5
[x] 6061-T6 or 6105-T5	[x] 6061-T6 or 6105-T5
[ ] *4/3 increase allowed*	[ ] Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Post Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $I_{xtotr} = 0.31$ in^4 $I_{xtotp} := I_{xp}$ $I_{xtotp} = 0.31$ in^4

$I_{ytotr} := I_{yr}$ $I_{ytotr} = 0.31$ in^4 $I_{ytotp} := I_{yp}$ $I_{ytotp} = 0.31$ in^4

22" Min. Length AL. Ribbed Tube Stub

$I_{st} := 0.174$ in^4 $L_{st} := 16$ in

$S_{st} := 0.224$ in^3 $F_{bst} := 25000$ psi

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "C" Analysis	SHT C1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.466$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.75$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 2700$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 8282$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.361$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2880$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 8834$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $F_{bry} = 25000$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.33$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.35$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ RAILS = "OK"

Post Analysis:

$E_p := E_r$

Guardrail "C" Analysis	SHT C1 B

$$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp1} = 0.701$ in

$$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp2} = 0.397$ in

Max Deflection:

$$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$$ $\boxed{\Delta_{tot} = 1.995}$ in

$$\Delta_{allp} := \frac{h}{12}$$ $\boxed{\Delta_{allp} = 3.67}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 13200$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 8400$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 4760$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 7480$ lb·in

Max Post Stress:

$$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$$ $\boxed{f_{bpx} = 25767}$ psi

$$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$$ $\boxed{f_{bpx2} = 25934}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$$ $\boxed{f_{bst} = 21185}$ psi

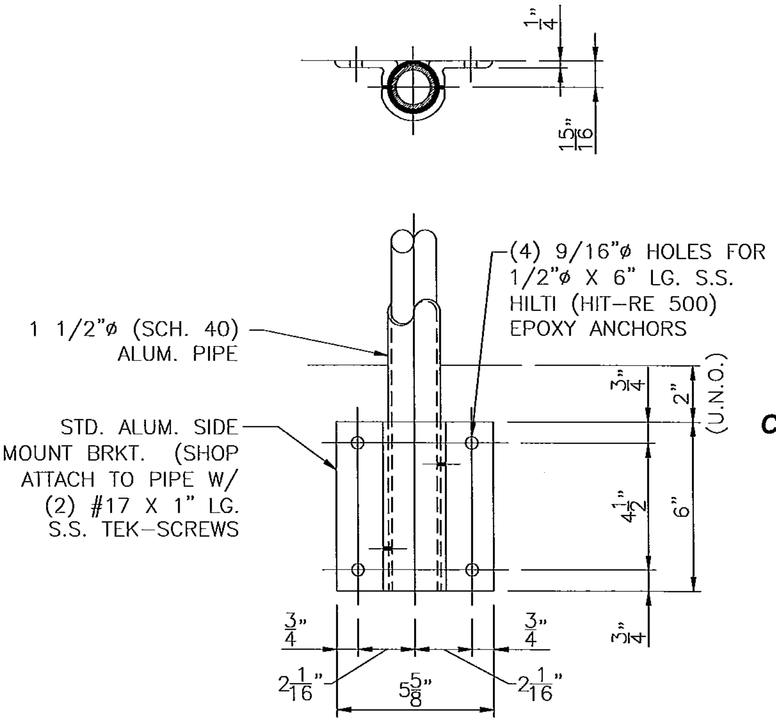
$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$$ $Int_{p1} = 1.04$ *4% Over OK*

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1.04 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$ $\boxed{POSTS = \text{"OK"}}$

Side Mount Anchorage	SHT C2



CONC. SIDE MOUNT 4-HOLE

25KD-18A

$R_{max} := 300$ lb

$M_{max} := 13200 + R_{max} \cdot 3 = 14100$ lb·in

$L1 := 6$ in

$L2 := 5.25$ in

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $P = 2650$ lb

$M_{pl} := \frac{P}{2} \cdot 0.688$ $M_{pl} = 912$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}}$ $t_{req} = 0.18$ in

$I := \frac{t_{req}}{0.25}$ $I = 0.72$

Use Side Mount Bracket, As Shown
6105-T5 alloy

Chk Anchor Bolts: (Assume f'c = 4000 psi Conc.)

$V_b := \frac{R_{max}}{4}$ $V_b = 75$ lb

$T_b := \frac{M_{max}}{L2 \cdot 2 \cdot 0.85} + \frac{R_{max}}{4}$ $T_b = 1655$ lb

See Next Sheet for Calculation

Use (4) - 1/2" Dia. S.S. Threaded Rods
With Hilti HIT-RE 500 Epoxy Adhesive
Embedment = 3-1/2" (min.)
Edge = 2-3/4"
End = 3"

Chk TEK Screws:

$V := \frac{R_{max}}{(2)}$ $V = 150$ lb

$V_{all} := 2148 \cdot 0.333$ $V_{all} = 715$ lb

$I_2 := \left(\frac{V}{V_{all}}\right)$ $I_2 = 0.21$ < 1.0

Use (2) - #17 S.S. TEK Screws
300 Series S.S.
ITW Buildex or Better

Hilti HIT-RE 500 Epoxy Adjustment for Embed Depth:

Hilti Adhesive	SHT C3

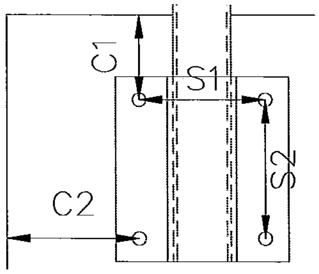
$h_{ef} := 3.5$ in embedment

$s_1 := 4.125$ in spacing 1

$s_2 := 4.5$ in spacing 2

$c_1 := 2.75$ in edge distance 1

$c_2 := 3$ in edge distance 2



Reactions Per Bolt:

$V := 75$ lb shear

$T := 1655$ lb tension

From HILTI Design Guide:

$T_{upper} := 5275$ lb $h_{efu} := 4.5$ in

$T_{lower} := 1965$ lb $h_{efl} := 2.25$ in

$V_{upper} := 7935$ lb $h_{efu} = 4.5$ in

$V_{lower} := 3550$ lb $h_{efl} = 2.25$ in

Use (4) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-1/4" min.
End Distance = 3"

Calculations below this line are automatic

$$T_{all} := \frac{(T_{upper} - T_{lower})\cdot(h_{efu} - h_{ef}) - T_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$ $T_{all} = 3804$ lb Interpolated Tension Value

$$V_{all} := \frac{(V_{upper} - V_{lower})\cdot(h_{efu} - h_{ef}) - V_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$ $V_{all} = 5986$ lb Interpolated Shear Value

$$f_{AN1} := \begin{cases} 1.00 & \text{if } s_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_1 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$

$f_{AN1} = 0.9$ Spacing (Tension and Shear)

$$f_{AN2} := \begin{cases} 1.00 & \text{if } s_2 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_2}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_2 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$

$f_{AN2} = 0.94$ Spacing (Tension and Shear)

$$f_{RN} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{c_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RN} = 0.79$ Edge Distance (Tension)

$$f_{RV1} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.54\cdot\left(\frac{c_1}{h_{ef}}\right) - 0.09\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RV1} = 0.33$ Edge Distance (Shear Perpendicular to Edge)

$$f_{RV2} := \begin{cases} 1.00 & \text{if } c_2 \ge 1.5\cdot h_{ef} \\ \left[0.36\cdot\left(\frac{c_2}{h_{ef}}\right) + 0.28\right] & \text{if } 1.5h_{ef} > c_2 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

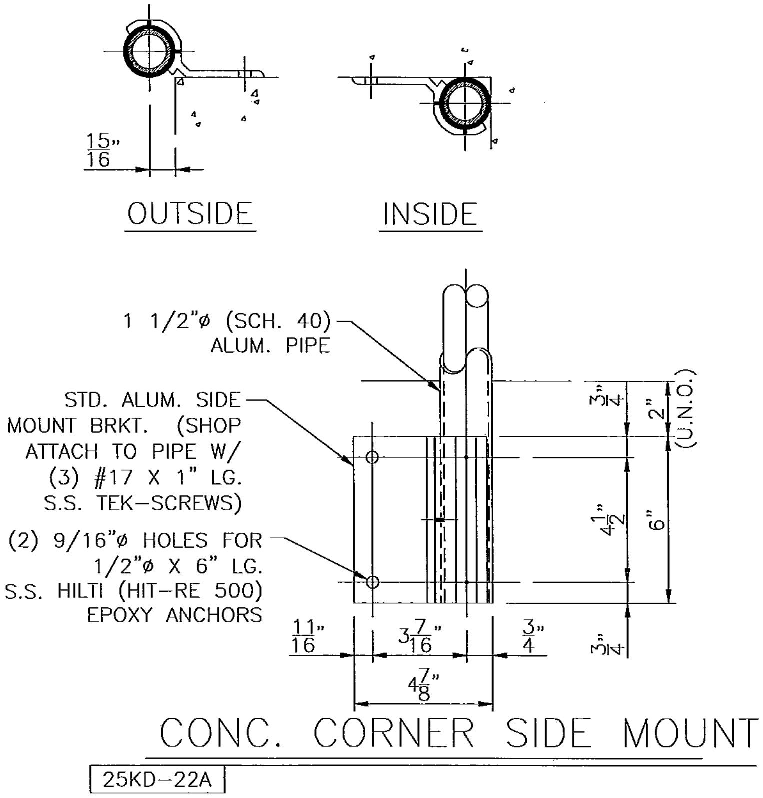
$f_{RV2} = 0.59$ Edge Distance (Shear Parallel or Away from Edge)

$V_{ball} := V_{all}\cdot f_{AN1}\cdot f_{AN2}\cdot f_{RV1}\cdot f_{RV2}$ $V_{ball} = 996$ lb

$T_{ball} := T_{all}\cdot f_{AN1}\cdot f_{RN}$ $T_{ball} = 2701$ lb

$$I_b := \left(\frac{V}{V_{ball}}\right)^{1.67} + \left(\frac{T}{T_{ball}}\right)^{1.67}$$ $I_b = 0.45$ < 1.00

RICE ENGINEERING Template:	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: C3
			Date: 2/23/11	Rev:
			Chk By:	Date:



$R_{max} := 97$ lb — *Reactions from RISA Model*

$M_{max} := 0$ lb·in — *(Corner Post Modeled as a Pin Connection)*

$L1 := 6$ in

$L2 := 5.25$ in

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $\quad P = 97$ lb

$M_{pl} := \frac{P}{2} \cdot 0.688$ $\quad M_{pl} = 33$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}}$ $\quad t_{req} = 0.03$ in

$I := \frac{t_{req}}{0.25}$ $\quad I = 0.14$

Use Side Mount Bracket, As Shown
6105-T5 alloy

Chk Anchor Bolts: (Assume f'c = 4000 psi Conc.)

$V_b := \frac{R_{max}}{2}$ $\quad V_b = 49$ lb

$T_b := \frac{M_{max}}{L2 \cdot 1 \cdot 0.85} + \frac{R_{max}}{2}$ $\quad T_b = 49$ lb

See Next Sheet for Calculation

Use (2) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-3/4" min.
End Distance = 2-1/2"

Chk TEK Screws:

$V := \frac{R_{max}}{(3)}$ $\quad V = 32$ lb

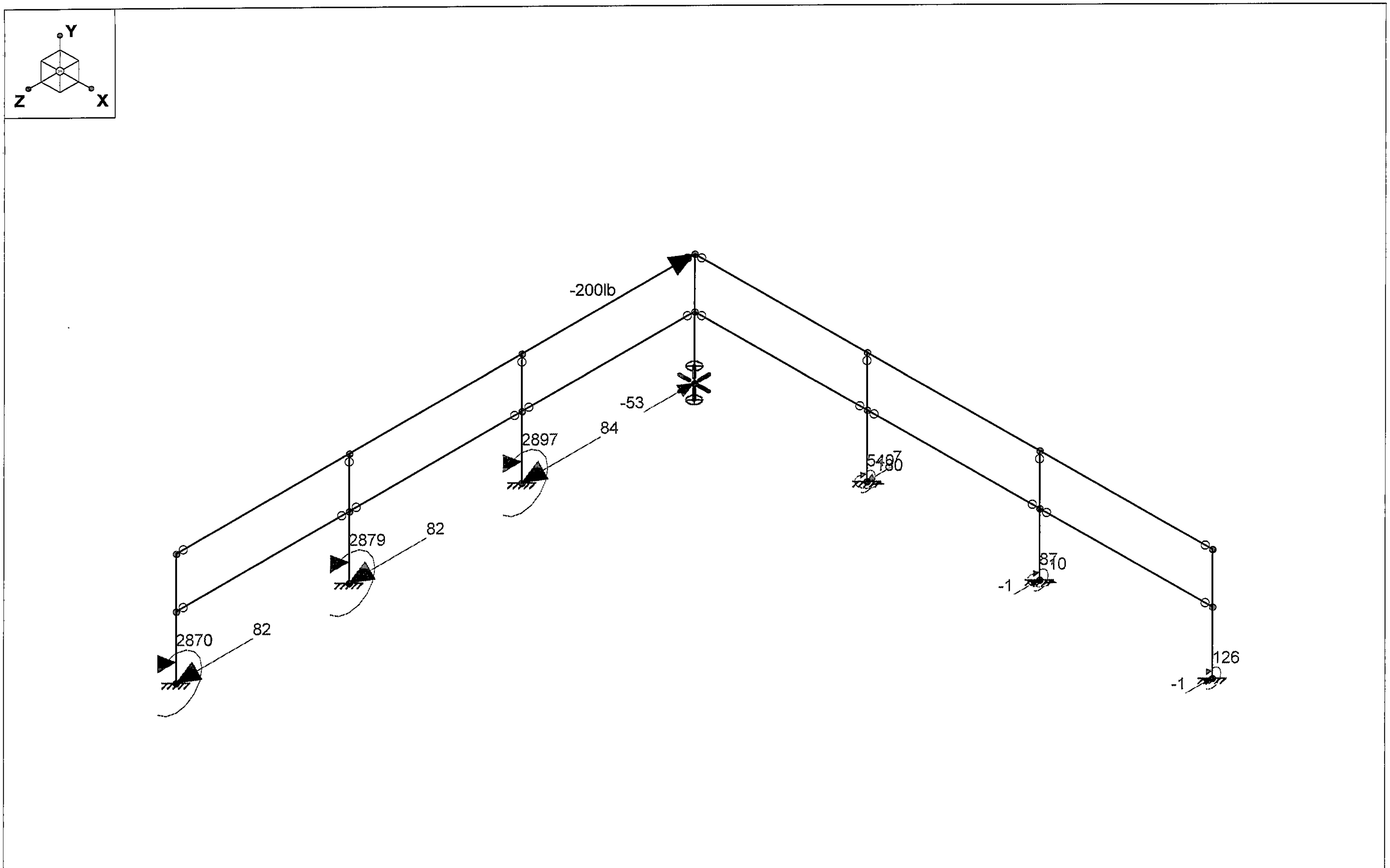
$V_{all} := 2148 \cdot 0.333$ $\quad V_{all} = 715$ lb

$T := \frac{M_{max}}{L2} + \frac{R_{max}}{(2)}$ $\quad T = 49$ lb

$T_{all} := 2065 \cdot 0.33$ $\quad T_{all} = 681$ lb

$I_2 := \left(\frac{V}{V_{all}}\right)^2 + \left(\frac{T}{T_{all}}\right)^2$ $\quad I_2 = 0.01$ < 1.0

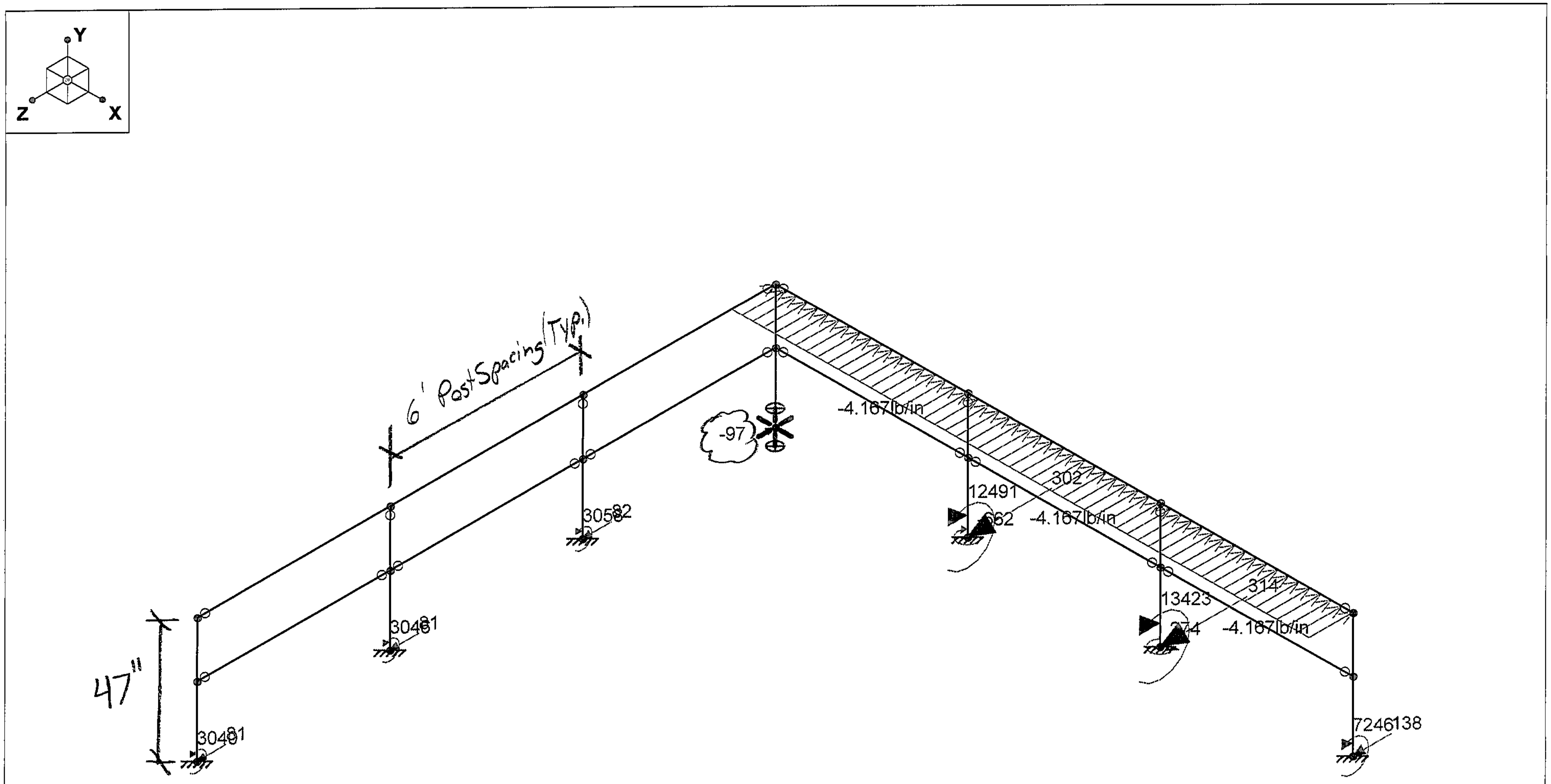
Use (3) - #17 S.S. TEK Screws
300 Series S.S.
ITW Buildex or Better



Loads: BLC 2,
Results for LC 2, Point
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 4
Joe Bauer		Feb 23, 2011 at 4:51 PM
R11-02-15H		Corner Brackets.r3d

C4.1



Loads: BLC 1,
Results for LC 1, Dist 1
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 5
Joe Bauer		Feb 23, 2011 at 4:51 PM
R11-02-15H		Corner Brackets.r3d

C4.2

Hilti HIT-RE 500 Epoxy Adjustment for Embed Depth:

Hilti Adhesive	SHT C5

$h_{ef} := 3.5$ in embedment

$s_2 := 4.5$ in spacing 2

$c_1 := 2.75$ in edge distance 1

$c_2 := 2.5$ in edge distance 2

Reactions Per Bolt:

$V := 49$ lb shear

$T := 49$ lb tension

From HILTI Design Guide:

$T_{upper} := 5275$	lb	$h_{efu} := 4.5$	in		
$T_{lower} := 1965$	lb	$h_{efl} := 2.25$	in		
$V_{upper} := 7935$	lb	$h_{efu} = 4.5$	in		
$V_{lower} := 3550$	lb	$h_{efl} = 2.25$	in		

Use (2) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-3/4" min.
End Distance = 2-1/2"

Calculations below this line are automatic

$$T_{all} := \frac{(T_{upper} - T_{lower})\cdot(h_{efu} - h_{ef}) - T_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$ $T_{all} = 3804$ lb Interpolated Tension Value

$$V_{all} := \frac{(V_{upper} - V_{lower})\cdot(h_{efu} - h_{ef}) - V_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$ $V_{all} = 5986$ lb Interpolated Shear Value

$f_{AN1} := 1.0$ — $f_{AN1} = 1$ Spacing (Tension and Shear)

$$f_{AN2} := \begin{cases} 1.00 & \text{if } s_2 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_2}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_2 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$ $f_{AN2} = 0.94$ Spacing (Tension and Shear)

$$f_{RN} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{c_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$ $f_{RN} = 0.79$ Edge Distance (Tension)

$$f_{RV1} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.54\cdot\left(\frac{c_1}{h_{ef}}\right) - 0.09\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$ $f_{RV1} = 0.33$ Edge Distance (Shear Perpendicular to Edge)

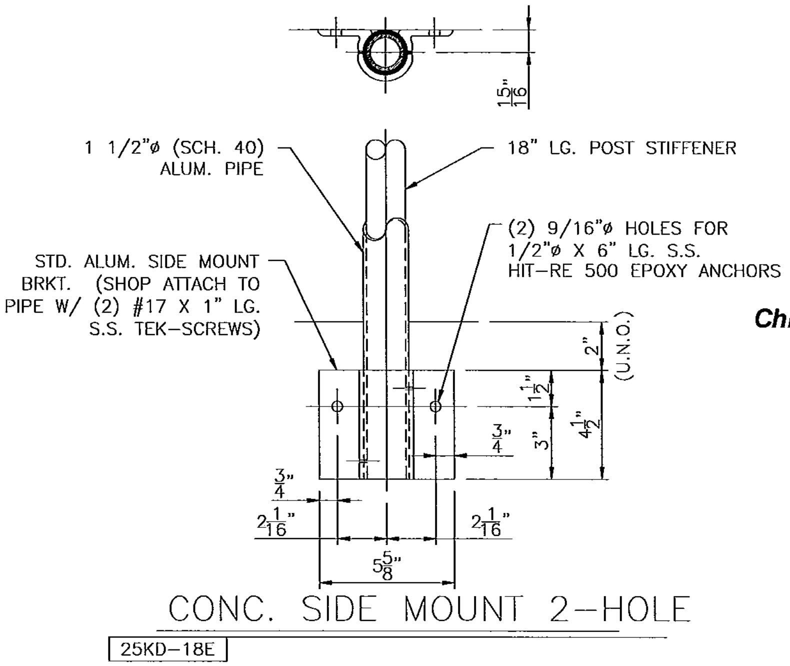
$$f_{RV2} := \begin{cases} 1.00 & \text{if } c_2 \ge 1.5\cdot h_{ef} \\ \left[0.36\cdot\left(\frac{c_2}{h_{ef}}\right) + 0.28\right] & \text{if } 1.5h_{ef} > c_2 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$ $f_{RV2} = 0.54$ Edge Distance (Shear Parallel or Away from Edge)

$V_{ball} := V_{all}\cdot f_{AN1}\cdot f_{AN2}\cdot f_{RV1}\cdot f_{RV2}$ — $V_{ball} = 1006$ lb

$T_{ball} := T_{all}\cdot f_{AN1}\cdot f_{RN}$ — $T_{ball} = 2989$ lb

$$I_b := \left(\frac{V}{V_{ball}}\right)^{1.67} + \left(\frac{T}{T_{ball}}\right)^{1.67}$$ $\boxed{I_b = 0.01}$ < 1.00

Side Mount Anchorage	SHT C6



$R_{max} := 300$ lb

$M_{max} := 13200 + R_{max} \cdot 3 = 14100$ lb·in

$L1 := 4.5$ in

$L2 := 3$ in

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $\quad P = 3433$ lb

$M_{pl} := \frac{P}{2} \cdot 0.688$ $\quad M_{pl} = 1181$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}}$ $\quad t_{req} = 0.24$ in

$I := \frac{t_{req}}{0.25}$ $\quad I = 0.95$

Use Side Mount Bracket, As Shown
6105-T5 alloy

Chk Anchor Bolts: (Assume f'c = 4000 psi Conc.)

Uniform Load

$V_b := \frac{R_{max}}{2}$ $\quad V_b = 150$ lb

$T_b := \frac{M_{max}}{L2 \cdot 2 \cdot 0.85} + \frac{R_{max}}{2}$ $\quad T_b = 2915$ lb

Concentrated Load

$V_{b2} := \frac{200 \cdot 0.85}{2}$ $\quad V_{b2} = 85$ lb

$T_{b2} := \frac{200 \cdot 0.85 \cdot 47}{1.5 \cdot 2 \cdot 0.85} + \frac{200 \cdot 0.85}{2}$ $\quad T_{b2} = 3218$ lb

See Next Sheet for Calculation

Use (2) - 1/2" Dia. S.S. Threaded Rods
With Hilti HIT-RE 500 Epoxy Adhesive
Embedment = 4-1/2"
Edge = 3-1/2"
End = 3"

Chk TEK Screws:

$V := \frac{R_{max}}{(2)}$ $\quad V = 150$ lb

$V_{all} := 2148 \cdot 0.333$ $\quad V_{all} = 715$ lb

$I_2 := \left(\frac{V}{V_{all}}\right)$ $\quad I_2 = 0.21 < 1.0$

Use (2) - #17 S.S. TEK Screws
300 Series S.S.
ITW Buildex or Better

Hilti Adhesive	SHT C7

Hilti HIT-RE 500 Epoxy Adjustment for Embed Depth:

$h_{ef} := 4.5$ in embedment

$s_1 := 4.125$ in spacing 1

$c_1 := 3.5$ in edge distance 1

$c_2 := 3$ in edge distance 2

Reactions Per Bolt:

$V := 85$ lb shear

$T := 3218$ lb tension

From HILTI Design Guide:

$T_{upper} := 5275$	lb		$h_{efu} := 4.5$	in	
$T_{lower} := 1965$	lb		$h_{efl} := 2.25$	in	
$V_{upper} := 7935$	lb		$h_{efu} = 4.5$	in	
$V_{lower} := 3550$	lb		$h_{efl} = 2.25$	in	

Use (2) - 1/2" Dia. S.S. Threaded Rods
W/ Hilti HIT-RE 500 Epoxy Adhesive
Embedment= 3-1/2" min.
Edge Distance= 2-1/4" min.
End Distance = 3"

Calculations below this line are automatic

$$T_{all} := \frac{(T_{upper} - T_{lower})\cdot(h_{efu} - h_{ef}) - T_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$

$T_{all} = 5275$ lb Interpolated Tension Value

$$V_{all} := \frac{(V_{upper} - V_{lower})\cdot(h_{efu} - h_{ef}) - V_{upper}\cdot(h_{efu} - h_{efl})}{-(h_{efu} - h_{efl})}$$

$V_{all} = 7935$ lb Interpolated Shear Value

$$f_{AN1} := \begin{cases} 1.00 & \text{if } s_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{s_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > s_1 > 0.5\cdot h_{ef} \\ \text{"Increase Spacing"} & \text{otherwise} \end{cases}$$

$f_{AN1} = 0.83$ Spacing (Tension and Shear)

$f_{AN2} := 1.0$

$f_{AN2} = 1$ Spacing (Tension and Shear)

$$f_{RN} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.3\cdot\left(\frac{c_1}{h_{ef}}\right) + 0.55\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RN} = 0.78$ Edge Distance (Tension)

$$f_{RV1} := \begin{cases} 1.00 & \text{if } c_1 \ge 1.5\cdot h_{ef} \\ \left[0.54\cdot\left(\frac{c_1}{h_{ef}}\right) - 0.09\right] & \text{if } 1.5h_{ef} > c_1 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RV1} = 0.33$ Edge Distance (Shear Perpendicular to Edge)

$$f_{RV2} := \begin{cases} 1.00 & \text{if } c_2 \ge 1.5\cdot h_{ef} \\ \left[0.36\cdot\left(\frac{c_2}{h_{ef}}\right) + 0.28\right] & \text{if } 1.5h_{ef} > c_2 > 0.5\cdot h_{ef} \\ \text{"Increase Edge Distance"} & \text{otherwise} \end{cases}$$

$f_{RV2} = 0.52$ Edge Distance (Shear Parallel or Away from Edge)

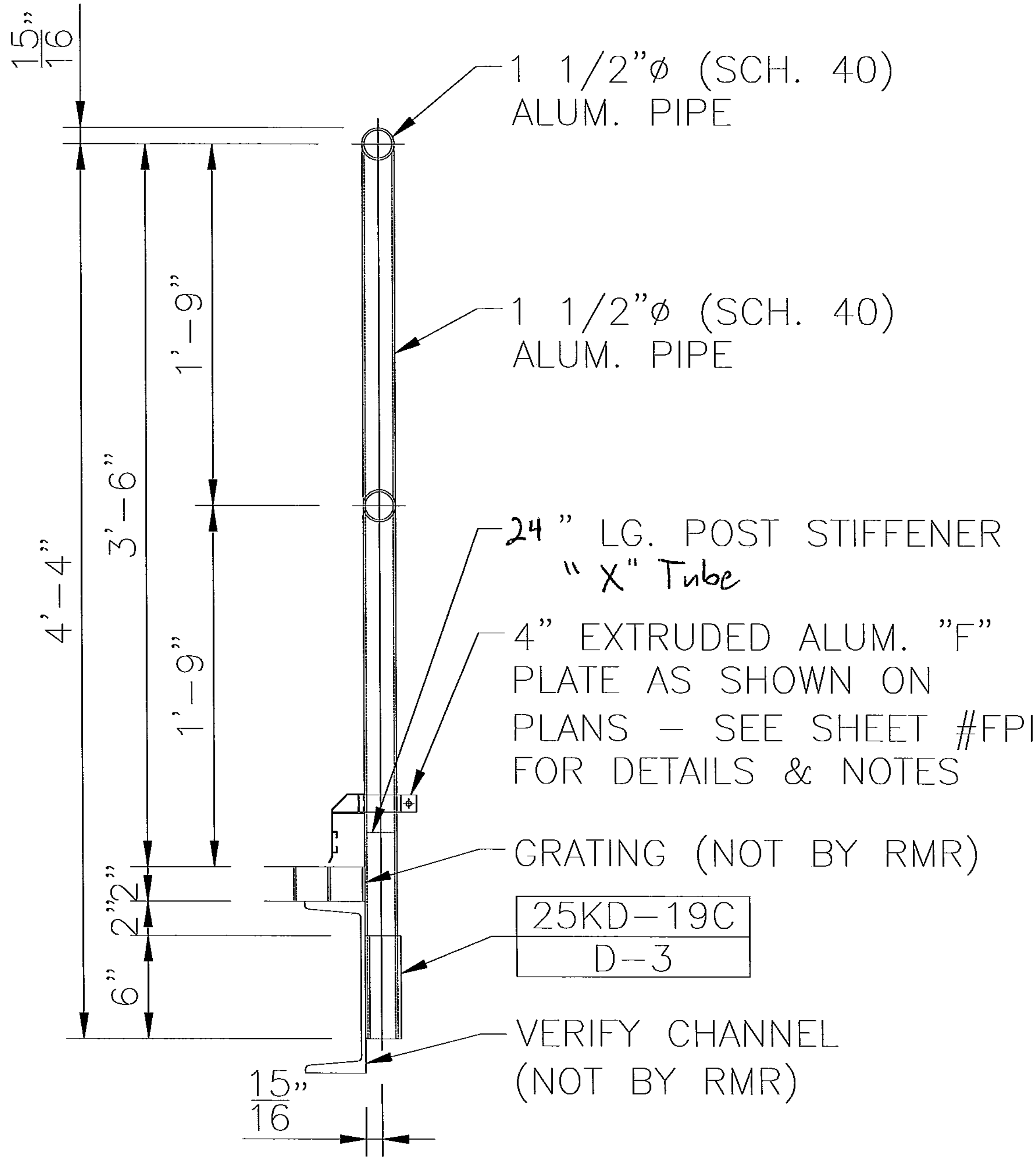
$V_{ball} := V_{all}\cdot f_{AN1}\cdot f_{AN2}\cdot f_{RV1}\cdot f_{RV2}$ $V_{ball} = 1123$ lb

$T_{ball} := T_{all}\cdot f_{AN1}\cdot f_{RN}$ $T_{ball} = 3409$ lb

$$I_b := \left(\frac{V}{V_{ball}}\right)^{1.67} + \left(\frac{T}{T_{ball}}\right)^{1.67}$$

$I_b = 0.92$ < 1.00

Guardrail "D"	SHT D



SECTION D / D–1

Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ENGINEERING	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: D
			Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

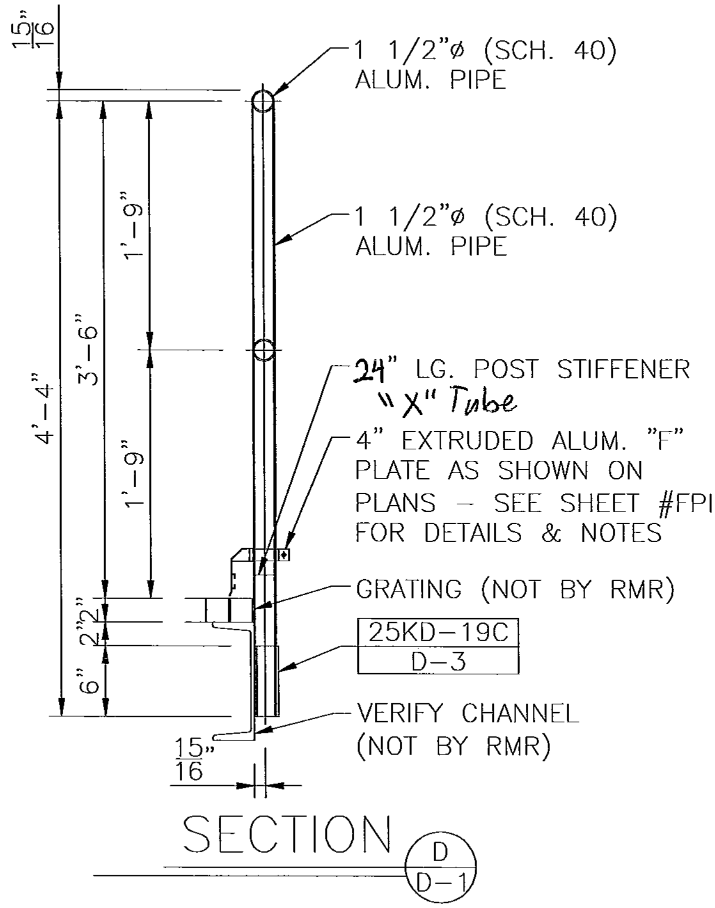
Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "D" Analysis	SHT D1

Input Variables:

$F_H := 50$	plf	Load Case 1 (Uniform Load)
$F_V := 0$	plf	Simultaneous Vertical Uniform Load
$P := 200$	lb	Load Case 2 (Point Load)
$L_{bp} := 25$	in	Unbraced Length of Post
$h := 46$	in	Railing Height Above Anchor Bracket
$L := 72$	in	**6'-0" MAX POST SPACING**



Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:	***Post Section:***
[ ] 1 1/4" Schd. 40	[ ] 1 1/4" Schd. 40
[ ] 1 1/4" Schd. 80	[ ] 1 1/4" Schd. 80
[x] 1 1/2" Schd. 40	[x] 1 1/2" Schd. 40
[ ] 1 1/2" Schd. 80	[ ] 1 1/2" Schd. 80
[ ] 1 1/2" tube	[ ] 1 1/2" tube
[ ] 2" Schd. 40	[ ] 2" Schd. 40
[ ] 2" Schd. 80	[ ] 2" Schd. 80

Railing Temper:	***Post Temper:***
[ ] 6063-T5	[ ] 6063-T6
[ ] 6063-T6	[ ] 6005-T5
[x] 6061-T6 or 6105-T5	[x] 6061-T6 or 6105-T5
[ ] *4/3 increase allowed*	[ ] Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties		*Post Properties*	
Ixr=	0.31	Ixr=	0.31
Iyr=	0.31	Iyr=	0.31
Sxr=	0.326	Sxr=	0.326
Syr=	0.326	Syr=	0.326
R=	0.95	R=	0.95
t=	0.145	t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $I_{xtotr} = 0.31$ in^4 $I_{xtotp} := I_{xp}$ $I_{xtotp} = 0.31$ in^4

$I_{ytotr} := I_{yr}$ $I_{ytotr} = 0.31$ in^4 $I_{ytotp} := I_{yp}$ $I_{ytotp} = 0.31$ in^4

24" Min. Length AL. "X" Tube Stub

$I_{st} := 0.249$ in^4 $L_{st} := 18$ in

$S_{st} := 0.311$ in^3 $F_{bst} := 25000$ psi

RICE ENGINEERING	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description:	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: D1
		R0001 - RMR Standard Calcs	Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "D" Analysis	SHT D1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.466$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.75$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 2700$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 8282$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.361$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2880$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 8834$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if IBC} = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $\boxed{F_{bry} = 25000}$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.33$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.35$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ $\boxed{RAILS = \text{"OK"}}$

Post Analysis:

$E_p := E_r$

Guardrail "D" Analysis	SHT D1 B

$$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp1} = 0.701$ in

$$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp2} = 0.397$ in

Max Deflection:

$$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$$ $\boxed{\Delta_{tot} = 2.036}$ in

$$\Delta_{allp} := \frac{h}{12}$$ $\boxed{\Delta_{allp} = 3.83}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 13800$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 8400$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 4760$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 7820$ lb·in

Max Post Stress:

$$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$$ $\boxed{f_{bpx} = 25767}$ psi

$$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$$ $\boxed{f_{bpx2} = 23475}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$$ $\boxed{f_{bst} = 19765}$ psi

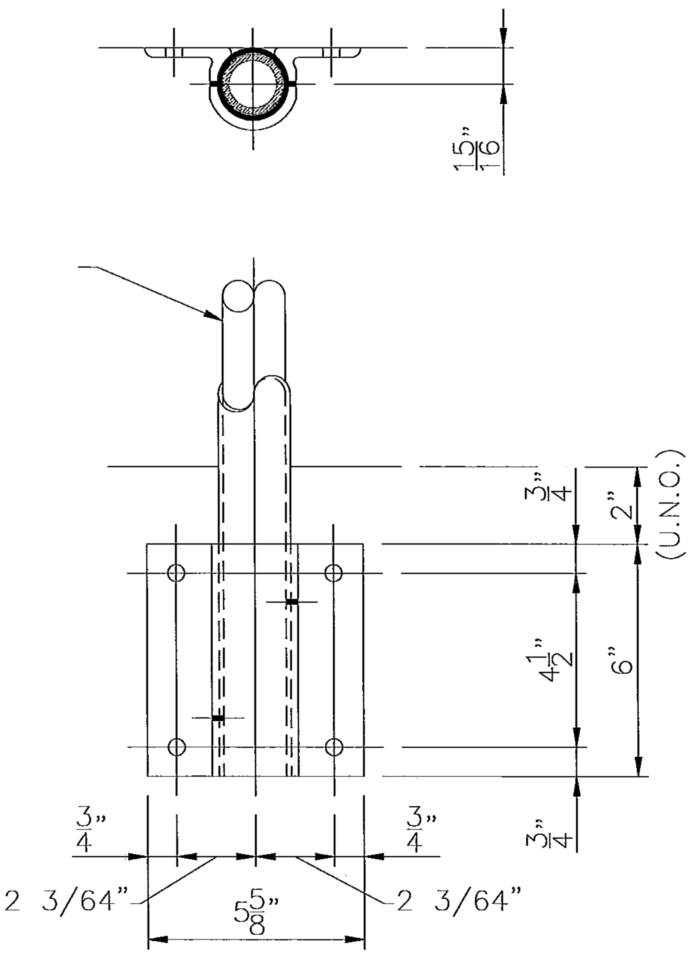
$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$$ $Int_{p1} = 1.03$ *3% Over OK*

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1.034 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$ $\boxed{POSTS = \text{"OK"}}$

Side Mount Anchorage	SHT D2



$R_{max} := 300$ lb

$M_{max} := 13800 + R_{max} \cdot 3 = 14700$ lb·in

$L1 := 6$ in

$L2 := 5.25$ in

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $P = 2750$ lb

$M_{pl} := \frac{P}{2} \cdot 0.688$ $M_{pl} = 946$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}}$ $t_{req} = 0.18$ in

$I := \frac{t_{req}}{0.25}$ $I = 0.74$

<u>Use Side Mount Bracket, As Shown</u>
6105-T5 alloy

Chk Anchor Bolts:

$V_b := \frac{R_{max}}{4}$ $V_b = 75$ lb

$T_b := \frac{M_{max}}{L2 \cdot 2 \cdot 0.85} + \frac{R_{max}}{4}$ $T_b = 1722$ lb

$V_{ball} := 0.196 \cdot 23000$ $V_{ball} = 4508$ lb

$T_{ball} := 0.142 \cdot 40000 \cdot \frac{0.1875}{0.341}$ $T_{ball} = 3123$ lb

$I := \left(\frac{V_b}{V_{ball}}\right)^2 + \left(\frac{T_b}{T_{ball}}\right)^2$ $I = 0.3$ < 1.0

Use (4) - 1/2" Dia. S.S. Thru Bolts
or 3/16" Min. Thread Engagement
Cond "CW", Fy= 65 ksi minimum
Structural Steel Channel
Designed By Others

Chk TEK Screws:

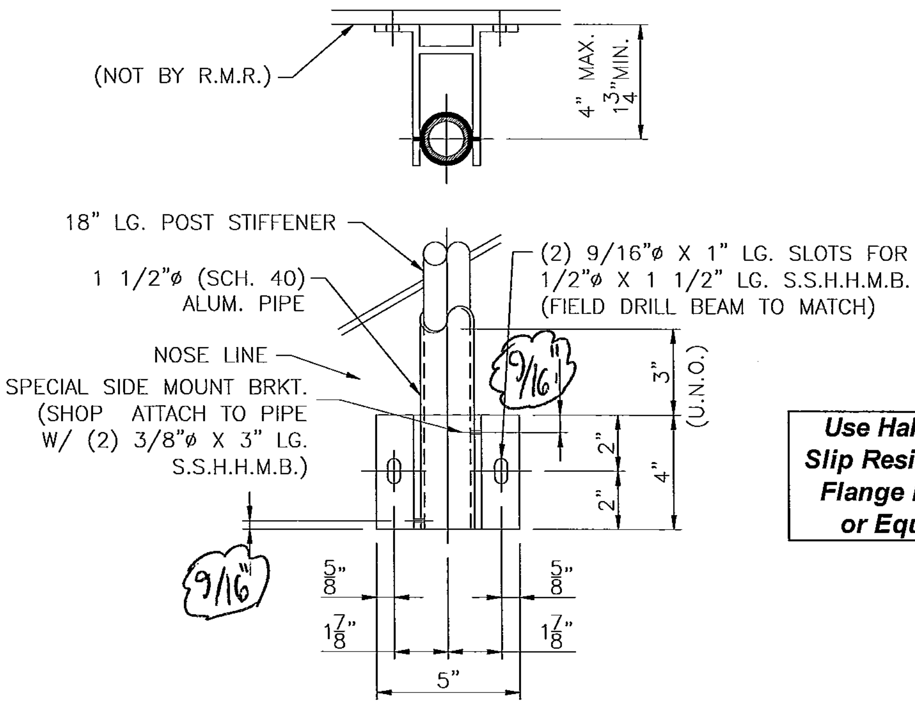
$V := \frac{R_{max}}{(2)}$ $V = 150$ lb

$V_{all} := 2148 \cdot 0.333$ $V_{all} = 715$ lb

$I_2 := \left(\frac{V}{V_{all}}\right)$ $I_2 = 0.21$ < 1.0

Use (2) - #17 S.S. TEK Screws
300 Series S.S.
ITW Buildex or Better

Side Mount Anchorage	SHT D3



SPECIAL SIDE MOUNT 2-HOLE

25KD-19E

$R_{max} := 300$ lb

$M_{max} := R_{max} \cdot 39 = 11700$ lb·in

$L1 := 4$ in

$L2 := 2$ in

Use Halfen Slip Resistant Flange Nuts or Equal

Chk Post Attachment to Bracket:

$$V := \frac{M_{max}}{2.875 \cdot (1)} + \frac{R_{max}}{(2)} \qquad V = 4220 \text{ lb}$$

$$V_{all} := 0.110 \cdot 23000 \cdot (2) \qquad V_{all} = 5060 \text{ lb}$$

Use (2) - 3/8" Dia. S.S. Thru-Bolts @ 2-7/8" O.C.
300 Series S.S.

Chk Extruded Aluminum Bracket:

$$P := \frac{M_{max}}{L1} + R_{max} \qquad P = 3225 \text{ lb}$$

$$M_{pl} := \frac{P}{2} \cdot 0.7 \qquad M_{pl} = 1129 \text{ in·lb}$$

$$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}} \qquad t_{req} = 0.25 \text{ in}$$

$$I := \frac{t_{req}}{0.25} \qquad I = 0.98$$

Use Side Mount Bracket, 4 ___ Long
6105-T5 alloy

Chk Anchor Bolts:

$$V_b := \frac{R_{max}}{2} \qquad V_b = 150 \text{ lb}$$

$$T_b := \frac{M_{max}}{L2 \cdot 2} + \frac{R_{max}}{2} \qquad T_b = 3075 \text{ lb}$$

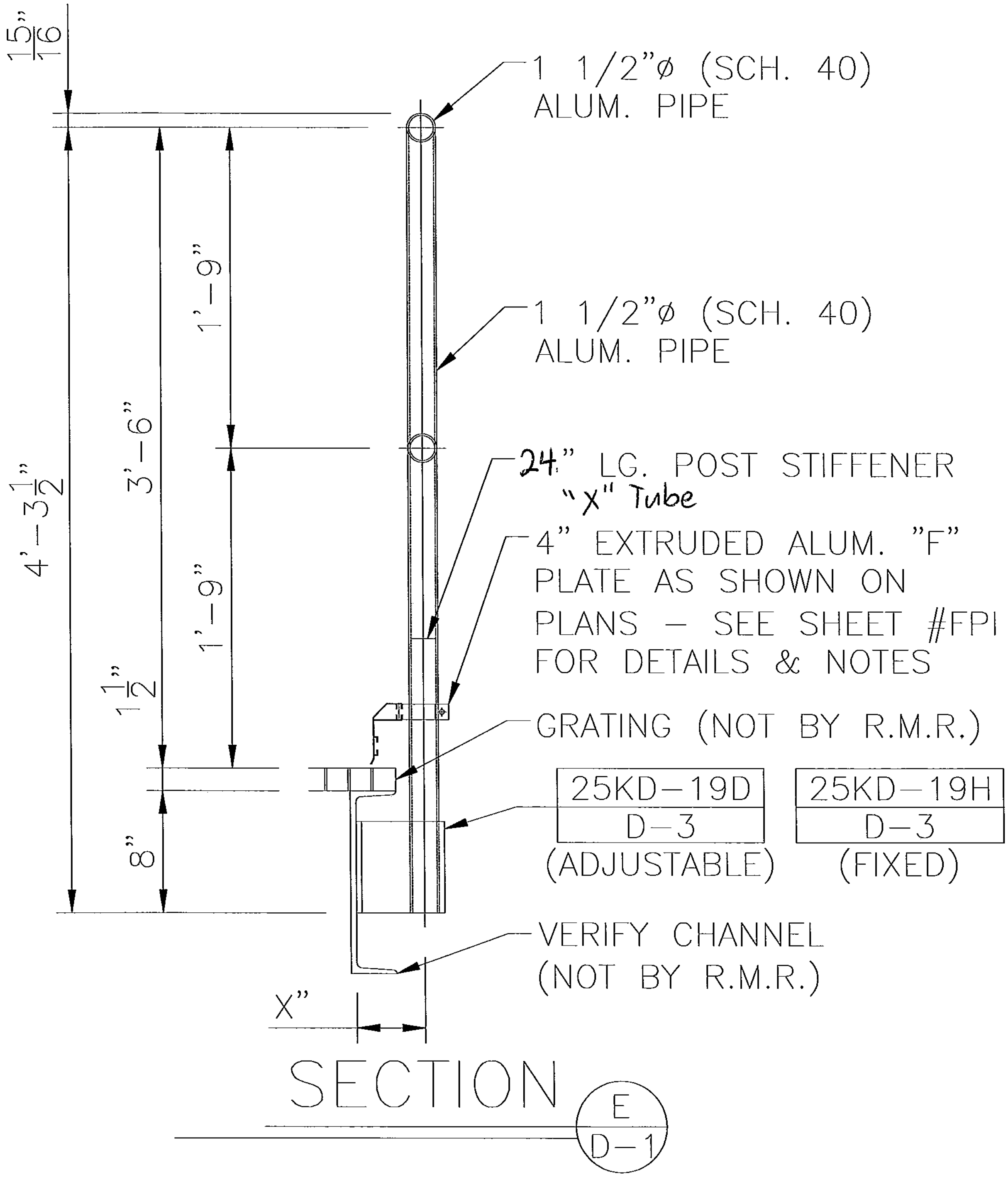
$$V_{all} := 0.196 \cdot 23000 \qquad V_{all} = 4508 \text{ lb}$$

$$T_{all} := 0.142 \cdot 40000 \cdot \frac{0.25}{0.456} \qquad T_{all} = 3114 \text{ lb}$$

$$I := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2 \qquad I = 0.98 < 1.0$$

Use (4) - 1/2" Dia. S.S. Thru Bolts
(or Drill & Tap - 1/4" Min. Thread Engagement)
Cond "CW", Fy= 65 ksi minimum
Steel Stringers Designed By Others

Guardrail "E"	SHT E



Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ENGINEERING Template: REI-MC-5707	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: E
			Date: 2/23/11	Rev:
			Chk By:	Date:

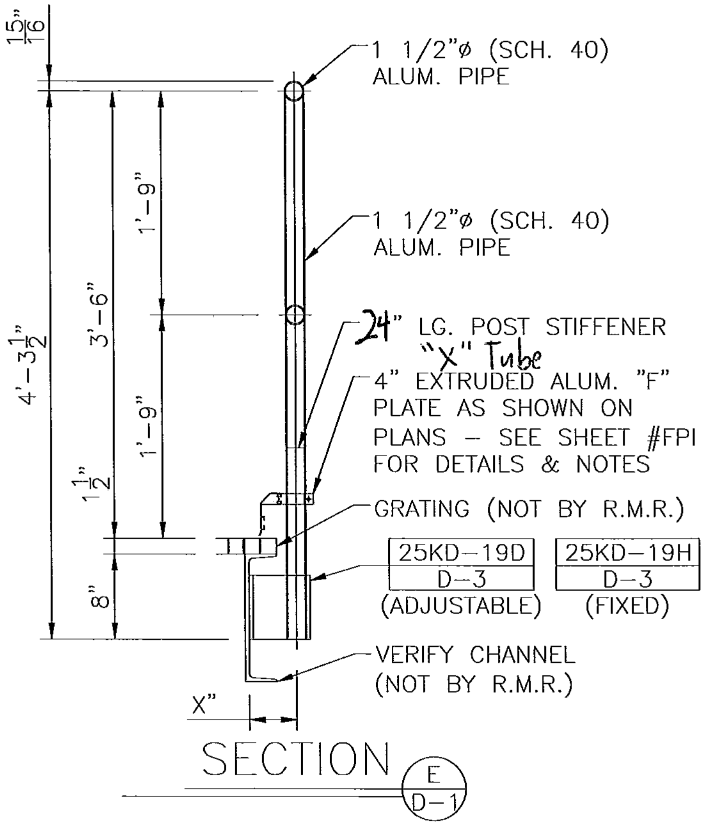
Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "E" Analysis	SHT E1

Input Variables:

$F_H := 50$	plf	Load Case 1 (Uniform Load)
$F_V := 0$	plf	Simultaneous Vertical Uniform Load
$P := 200$	lb	Load Case 2 (Point Load)
$L_{bp} := 24.5$	in	Unbraced Length of Post
$h := 46.5$	in	Railing Height Above Top Anchor Bolt
$L := 72$	in	**6'-0" MAX POST SPACING**



Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:

- [ ] 1 1/4" Schd. 40
- [ ] 1 1/4" Schd. 80
- [x] 1 1/2" Schd. 40
- [ ] 1 1/2" Schd. 80
- [ ] 1 1/2" tube
- [ ] 2" Schd. 40
- [ ] 2" Schd. 80

Post Section:

- [ ] 1 1/4" Schd. 40
- [ ] 1 1/4" Schd. 80
- [x] 1 1/2" Schd. 40
- [ ] 1 1/2" Schd. 80
- [ ] 1 1/2" tube
- [ ] 2" Schd. 40
- [ ] 2" Schd. 80

Railing Temper:

- [ ] 6063-T5
- [ ] 6063-T6
- [x] 6061-T6 or 6105-T5
- [ ] *4/3 increase allowed*

Post Temper:

- [ ] 6063-T6
- [ ] 6005-T5
- [x] 6061-T6 or 6105-T5
- [ ] Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Post Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $I_{xtotr} = 0.31$ in^4 $I_{xtotp} := I_{xp}$ $I_{xtotp} = 0.31$ in^4

$I_{ytotr} := I_{yr}$ $I_{ytotr} = 0.31$ in^4 $I_{ytotp} := I_{yp}$ $I_{ytotp} = 0.31$ in^4

24" Min. Length AL. "X" Tube Stub

$I_{st} := 0.249$ in^4 $L_{st} := 19$ in

$S_{st} := 0.311$ in^3 $F_{bst} := 25000$ psi

RICE ENGINEERING	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
			Engineer: JDB	Sheet No: E1
			Date: 2/23/11	Rev:
Template: REI-MC-5707			Chk By:	Date:

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "E" Analysis	SHT E1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.466$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.75$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 2700$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 8282$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.361$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2880$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 8834$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $\boxed{F_{bry} = 25000}$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.33$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.35$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ $\boxed{RAILS = \text{"OK"}}$

Post Analysis:

$E_p := E_r$

Guardrail "E" Analysis	SHT E1 B

$$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp1} = 0.664$ in

$$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp2} = 0.376$ in

Max Deflection:

$$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$$ $\boxed{\Delta_{tot} = 2.077}$ in

$$\Delta_{allp} := \frac{h}{12}$$ $\boxed{\Delta_{allp} = 3.88}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 13950$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 8250$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 4675$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 7905$ lb·in

Max Post Stress:

$$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$$ $\boxed{f_{bpx} = 25307}$ psi

$$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$$ $\boxed{f_{bpx2} = 23730}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$$ $\boxed{f_{bst} = 19980}$ psi

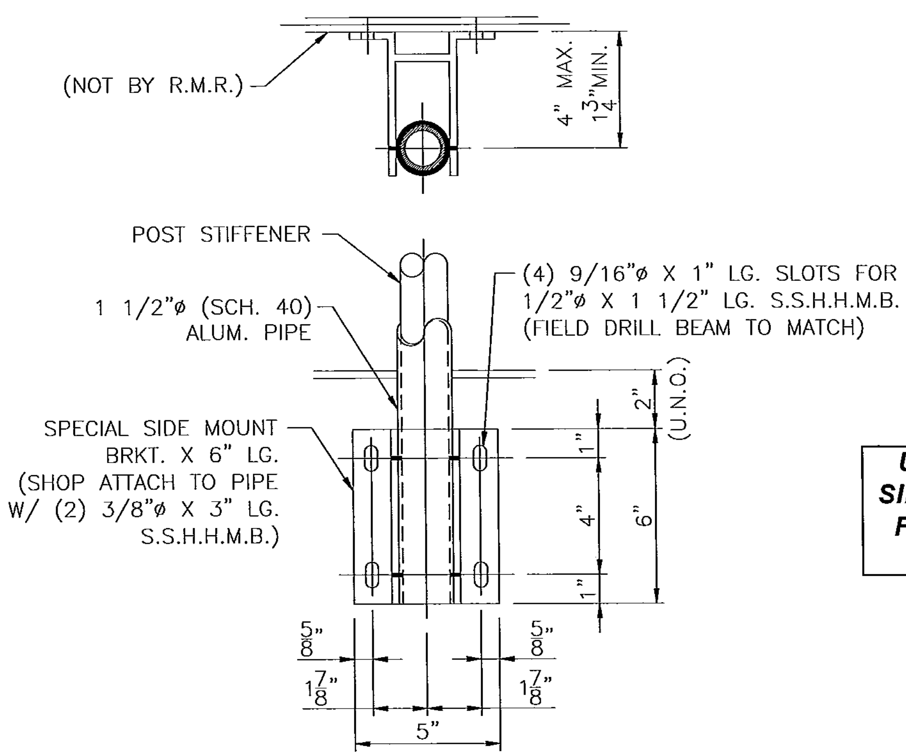
$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$$ $Int_{p1} = 1.01$ *1% Over OK*

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1.014 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$ $\boxed{POSTS = \text{"OK"}}$

Side Mount Anchorage	SHT E2



SPECIAL SIDE MOUNT 4–HOLE

25KD–19D

$R_{max} := 300$ lb

$M_{max} := 13950 + R_{max} \cdot 3 = 14850$ lb·in

$L1 := 6$ in

$L2 := 5$ in

Use Halfen Slip Resistant Flange Nuts or Equal

Chk Post Attachment to Bracket:

$V := \frac{M_{max}}{4 \cdot (1)} + \frac{R_{max}}{(2)}$ $\quad V = 3863$ lb

$V_{all} := 0.110 \cdot 23000 \cdot (2)$ $\quad V_{all} = 5060$ lb

Use (2) - 3/8" Dia. S.S. Thru-Bolts @ 4" O.C.
300 Series S.S.

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $\quad P = 2775$ lb

$M_{pl} := \frac{P}{2} \cdot 0.8125$ $\quad M_{pl} = 1127$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot L1}}$ $\quad t_{req} = 0.2$ in

$I := \frac{t_{req}}{0.25}$ $\quad I = 0.8$

Use Side Mount Bracket, As Shown
6105-T5 alloy

Chk Anchor Bolts:

$V_b := \frac{R_{max}}{4}$ $\quad V_b = 75$ lb

$T_b := \frac{M_{max}}{L2 \cdot 2} + \frac{R_{max}}{4}$ $\quad T_b = 1560$ lb

$V_{all} := 0.196 \cdot 23000$ $\quad V_{all} = 4508$ lb

$T_{all} := 0.142 \cdot 40000 \cdot \frac{0.1875}{0.456}$ $\quad T_{all} = 2336$ lb

$I := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2$ $\quad I = 0.45 < 1.0$

Use (4) - 1/2" Dia. S.S. Thru Bolts
(or Drill & Tap - 3/16" Min. Thread Engagement)
Cond "CW", Fy= 65 ksi minimum
Steel Stringers Designed By Others

Side Mount Anchor	SHT E3

Reactions:

$R_{max} := 300$ lb $L1 := 5$ in

$M_{max} := 13950 + R_{max} \cdot 3 = 14850$ lb·in $L2 := 4$ in

Chk Extruded Aluminum Bracket:

$P := \frac{M_{max}}{L1} + R_{max}$ $P = 3270$ lb

$M_{pl} := \frac{P \cdot 3}{4}$ $M_{pl} = 2453$ in·lb

$t_{req} := \sqrt{\frac{6 \cdot M_{pl}}{28000 \cdot 0.85 \cdot L1}}$ $t_{req} = 0.35$ in

$I := \frac{t_{req}}{0.375}$ $I = 0.94$

Use Extruded Bracket as shown (6105-T5)

Chk Fasteners:

$V := \frac{R_{max}}{2}$ lb (upward) $V = 150$ lb

Use (2) - 3/8" Dia. S.S. Set Screws OK By Inspection

Chk Anchor Bolts (Structural Steel By Others):

$V_b := \frac{R_{max}}{4}$ $V_b = 75$ lb

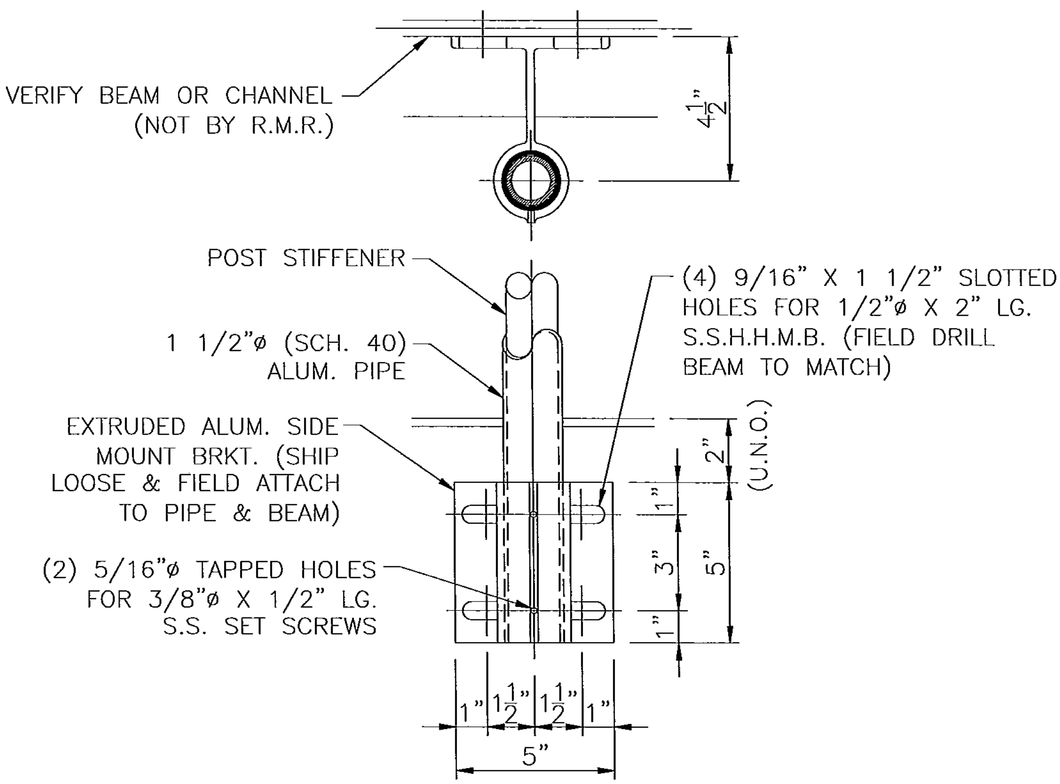
$T_b := \frac{M_{max}}{L2 \cdot 2} + \frac{R_{max}}{4}$ $T_b = 1931$ lb

$V_{all} := 0.196 \cdot 23000$ $V_{all} = 4508$ lb

$T_{all} := 0.142 \cdot 40000 \cdot \frac{0.1875}{0.456}$ $T_{all} = 2336$ lb

$I := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2$ $I = 0.68$ < 1.0

Use (4) - 1/2-13 S.S. Bolts
Drill & Tap or Thru-Bolt
Min. Thread Engagement = 3/16"
(300 Series S.S., Cond. CW, Fy = 65 ksi)



STL. SIDE MOUNT 4-SLOT

25KD-19H

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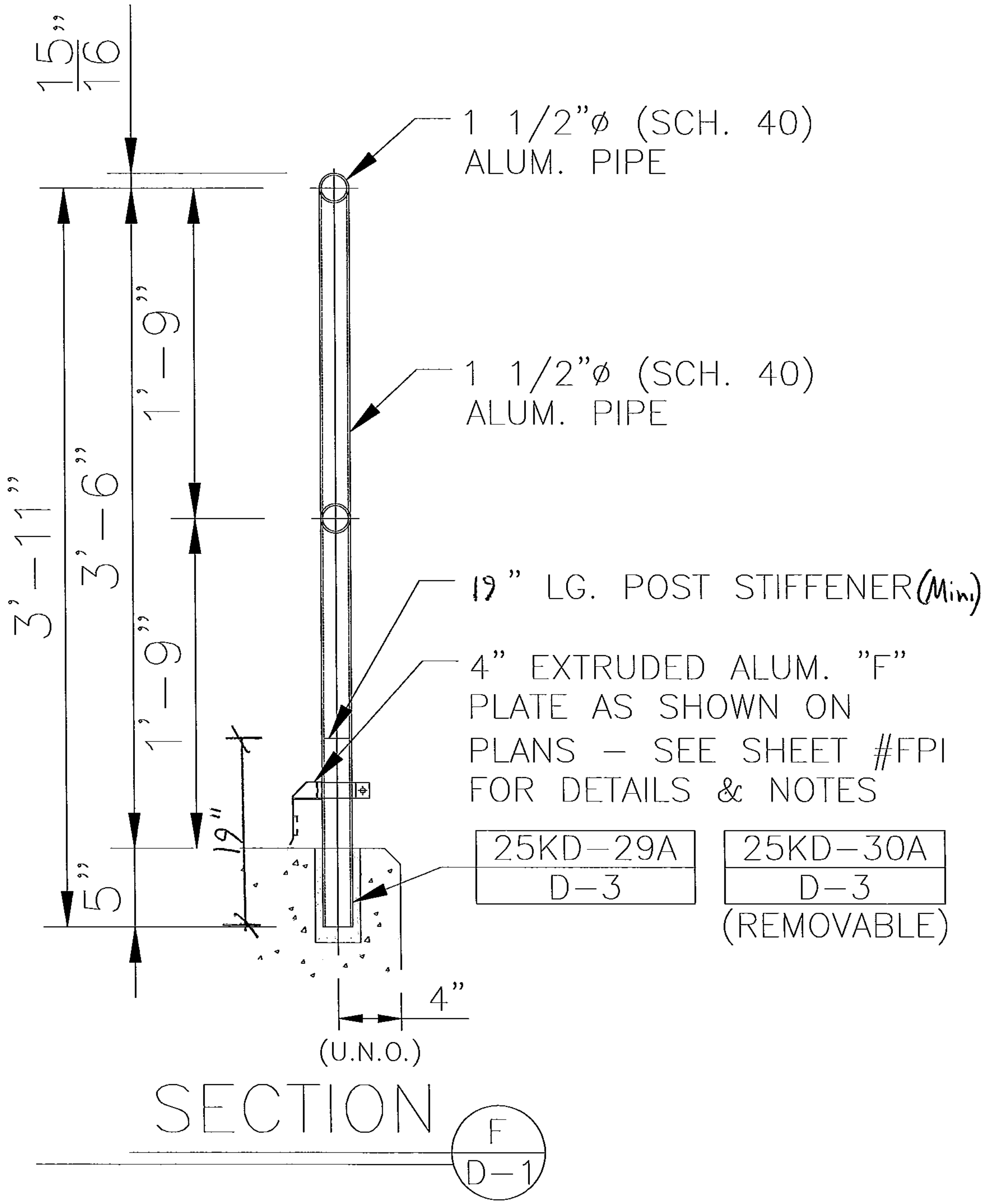
Guardrail "F"	SHT F



Note: *Structural steel, Concrete, CMU and all other anchorage substrates designed by others*

ROCKY MOUNTAIN RAILINGS

RICE ENGINEERING	105 School Creek Trail Luxemburg, WI 54217 Phone: (920)845-1042 Fax: (920)845-1048 www.rice-inc.com	Project Description: R0001 - RMR Standard Calcs	Job No: R11-02-15H	
Template: REI-MC-5707			Engineer: JDB	Sheet No: F
			Date: 2/23/11	Rev:
			Chk By:	Date:

Pipe Railing & Post

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Guardrail "F" Analysis	SHT F1

Input Variables:

$F_H := 50$ plf — Load Case 1 (Uniform Load)

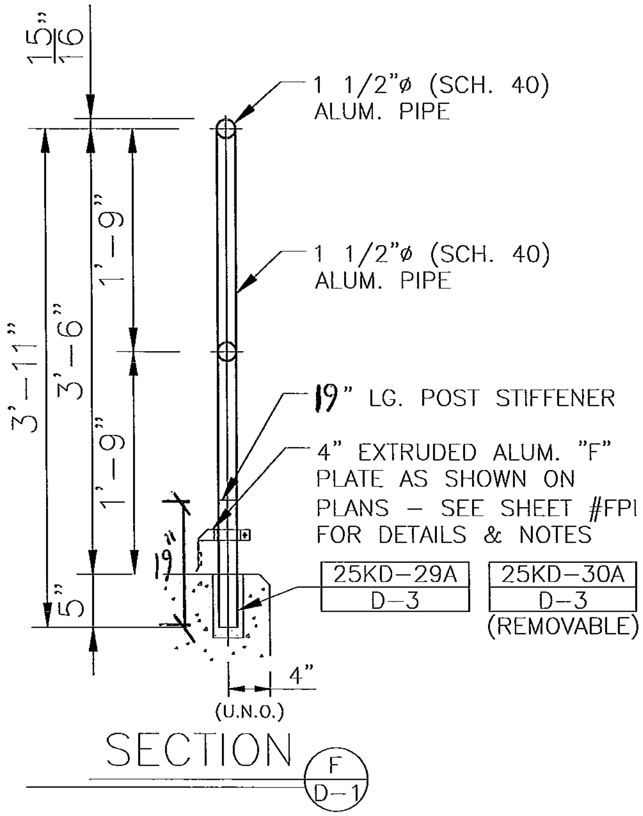
$F_V := 0$ plf — Simultaneous Vertical Uniform Load

$P := 200$ lb — Load Case 2 (Point Load)

$L_{bp} := 21$ in — Unbraced Length of Post

$h := 42$ in — Railing Height

$L := 72$ in — **6'-0" MAX POST SPACING**



Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:

- [ ] 1 1/4" Schd. 40
- [ ] 1 1/4" Schd. 80
- [x] 1 1/2" Schd. 40
- [ ] 1 1/2" Schd. 80
- [ ] 1 1/2" tube
- [ ] 2" Schd. 40
- [ ] 2" Schd. 80

Post Section:

- [ ] 1 1/4" Schd. 40
- [ ] 1 1/4" Schd. 80
- [x] 1 1/2" Schd. 40
- [ ] 1 1/2" Schd. 80
- [ ] 1 1/2" tube
- [ ] 2" Schd. 40
- [ ] 2" Schd. 80

Railing Temper:

- [ ] 6063-T5
- [ ] 6063-T6
- [x] 6061-T6 or 6105-T5
- [ ] *4/3 increase allowed*

Post Temper:

- [ ] 6063-T6
- [ ] 6005-T5
- [x] 6061-T6 or 6105-T5
- [ ] Post Welded to Base Plate

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Post Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

$S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

$S_{R3} := \frac{R_p}{t_p}$ $S_{R3} = 6.55$

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $I_{xtotr} = 0.31$ in^4 $I_{xtotp} := I_{xp}$ $I_{xtotp} = 0.31$ in^4

$I_{ytotr} := I_{yr}$ $I_{ytotr} = 0.31$ in^4 $I_{ytotp} := I_{yp}$ $I_{ytotp} = 0.31$ in^4

19" Min. Length AL. Ribbed Tube Stub

$I_{st} := 0.174$ in^4 $L_{st} := 14$ in

$S_{st} := 0.224$ in^3 $F_{bst} := 25000$ psi

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			Engineer: JDB	Sheet No: F1
			Date: 2/23/11	Rev:
			Chk By:	Date:

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Guardrail "F" Analysis	SHT F1 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.466$ in Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.75$ in Per ASTM Specification E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 2700$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 8282$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 2 - Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.361$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2880$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 8834$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $\boxed{F_{bry} = 25000}$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.33$

$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.35$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ $\boxed{RAILS = \text{"OK"}}$

Post Analysis:

$E_p := E_r$

Guardrail "F" Analysis	SHT F1 B

$$\Delta_{xp1} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp1} = 0.701$ in

$$\Delta_{xp2} := \frac{P \cdot 0.85 \cdot (h - L_{st})^3}{3 \cdot E_p \cdot (I_{xp})}$$ $\Delta_{xp2} = 0.397$ in

Max Deflection:

$$\Delta_{tot} := \frac{W_h \cdot L \cdot (h - L_{st})^3}{3 \cdot E_p \cdot I_{xp}} + \frac{W_h \cdot L \cdot \left[h^3 - (h - L_{st})^3\right]}{3 \cdot \left[(E_p \cdot I_{xp}) + (E_p \cdot I_{st})\right]}$$ $\boxed{\Delta_{tot} = 1.768}$ in

$$\Delta_{allp} := \frac{h}{12}$$ $\boxed{\Delta_{allp} = 3.5}$ in *Per ASTM E985*

Case 1 - Uniform Load:

$M_{xp} := (W_h \cdot L \cdot h) + W_v \cdot L \cdot \Delta_{tot}$ $M_{xpmax} := 0.5 \cdot M_{xp} \cdot q1 + M_{xp}q2 + M_{xp} \cdot q3$ $M_{xpmax} = 12600$ lb·in

$M_{xp2} := W_h \cdot L \cdot (h - L_{st}) + W_v \cdot L \cdot \Delta_{xp1}$ $M_{xpmax2} := 0.5 \cdot M_{xp2} \cdot q1 + M_{xp2}q2 + M_{xp2} \cdot q3$ $M_{xpmax2} = 8400$ lb·in

Case 2 - Point Load:

$M_{xpmax4} := P \cdot (h - L_{st}) \cdot 0.85$ $M_{xpmax4} = 4760$ lb·in

$M_{xpmax3} := (P \cdot h \cdot 0.85)$ $M_{xpmax3} = 7140$ lb·in

Max Post Stress:

$$f_{bpx} := \frac{\max(M_{xpmax2}, M_{xpmax4})}{S_{xp}}$$ $\boxed{f_{bpx} = 25767}$ psi

$$F_{bpx} := \begin{cases} (F_{bpx1} \cdot 1.33) & \text{if } IBC = 1 \\ F_{bpx1} & \text{otherwise} \end{cases}$$ $\boxed{F_{bpx} = 25000}$ psi

Max Post/Stub Combined Stress:

$$f_{bpx2} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{xp}}{(I_{xp} + I_{st}) \cdot S_{xp}}$$ $\boxed{f_{bpx2} = 24755}$ psi

$\boxed{F_{bpx} = 25000}$ psi

Max Stub Stress:

$$f_{bst} := \max(M_{xpmax}, M_{xpmax3}) \cdot \frac{I_{st}}{(I_{xp} + I_{st}) \cdot S_{st}}$$ $\boxed{f_{bst} = 20222}$ psi

$\boxed{F_{bst} = 25000}$ psi

Calculation Results:

$$Int_{p1} := \max\left(\frac{f_{bpx}}{F_{bpx}}, \frac{f_{bpx2}}{F_{bpx}}, \frac{f_{bst}}{F_{bst}}\right)$$ $Int_{p1} = 1.03$ *3% Over OK*

$$POSTS := \begin{cases} \text{"OK"} & \text{if } Int_{p1} \le 1.034 \wedge \frac{\max(\Delta_{xp1}, \Delta_{xp2}, \Delta_{tot})}{\Delta_{allp}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$$ $\boxed{POSTS = \text{"OK"}}$

Post Embedment in Grout	SHT F2

Chk conc. grout:

$\phi := 0.65$

$R_{max} := 300$ lb

$f'_{c1} := 6000$ psi *Grout Strength*

$M := 12600$ lb·in

$f'_{c2} := 4000$ psi *Conc. Strength*

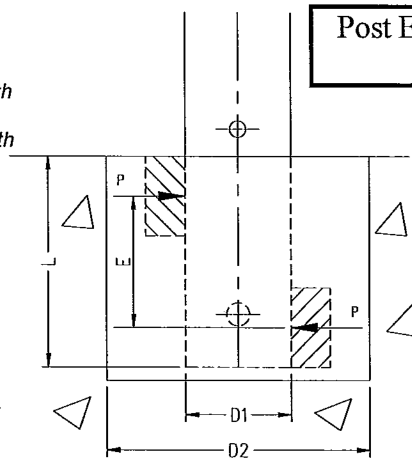
$LF := 1.6$ *(Load Factor)*

$L := 5$ in

$D_1 := 1.9$ in *(Post Width)*

$c := \frac{L}{2}$

$D_2 := 3$ in *(Grout Pocket Width)*



Assume Whitney stress block for bearing distribution:

$$\beta_1 := \max\left(\begin{pmatrix} 0.85 - .05 \cdot \frac{f'_{c1} - 4000}{1000} \\ 0.65 \end{pmatrix}\right) \qquad \beta_1 = 0.75 \qquad a_1 := \beta_1 \cdot c \qquad a_1 = 1.88$$

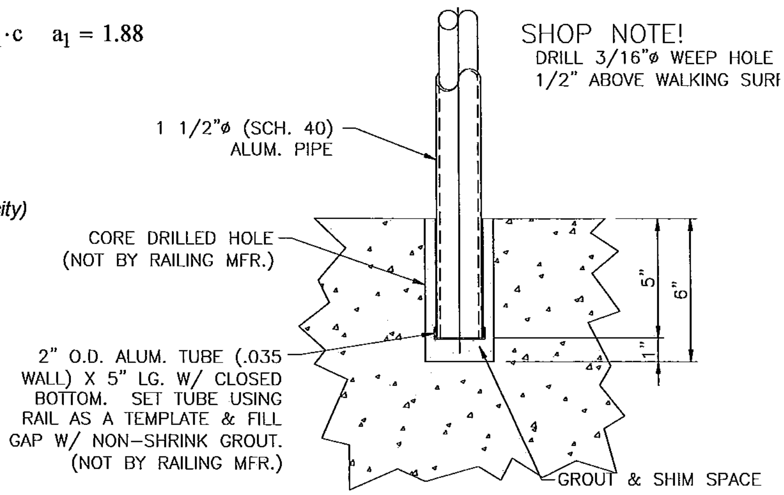
$A_1 := a_1 \cdot D_1$ $\quad A_1 = 3.56$ in *(Bearing Area)*

$E_1 := L - a_1$ $\quad E_1 = 3.13$ in *(Load Eccentricity)*

$P_1 := \frac{M}{E_1} + \frac{R_{max}}{2}$ $\quad P_1 = 4182$ lb *(Bearing Load)*

$\phi F_{p1} := \phi \cdot 0.85 \cdot A_1 \cdot f'_{c1}$ $\quad \phi F_{p1} = 11810$ lb *(Allowable Bearing Load)*

$I_1 := \frac{LF \cdot P_1}{\phi F_{p1}}$ $\quad \boxed{I_1 = 0.57}$



REMOVABLE SLEEVE

25KD-30A

Chk concrete (for reference only):

$$\beta_2 := \max\left(\begin{pmatrix} 0.85 - .05 \cdot \frac{f'_{c2} - 4000}{1000} \\ 0.65 \end{pmatrix}\right) \qquad \beta_2 = 0.85 \qquad a_2 := \beta_2 \cdot c \qquad a_2 = 2.13$$

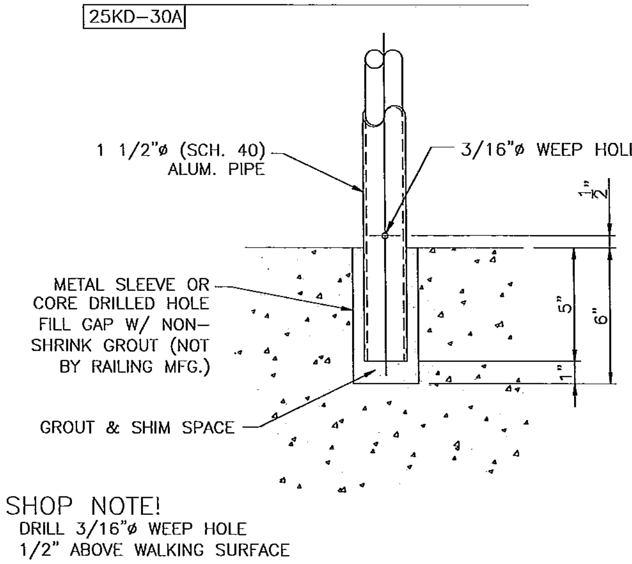
$A_2 := a_2 \cdot D_2$ $\quad A_2 = 6.38$ in *(Bearing Area)*

$E_2 := L - a_2$ $\quad E_2 = 2.88$ in *(Load Eccentricity)*

$P_2 := \frac{M}{E_2} + \frac{R_{max}}{2}$ $\quad P_2 = 4533$ lb *(Bearing Load)*

$\phi F_{p2} := \phi \cdot 0.85 \cdot A_2 \cdot f'_{c2}$ $\quad \phi F_{p2} = 14089$ lb *(Allowable Bearing Load)*

$I_2 := \frac{LF \cdot P_2}{\phi F_{p2}}$ $\quad \boxed{I_2 = 0.51}$



FIXED SLEEVE

25KD-29A

Use 6,000 psi, non-shrink Grout
-Design of Bearing on Concrete by others
-Design of Concrete Breakout and point loads By others

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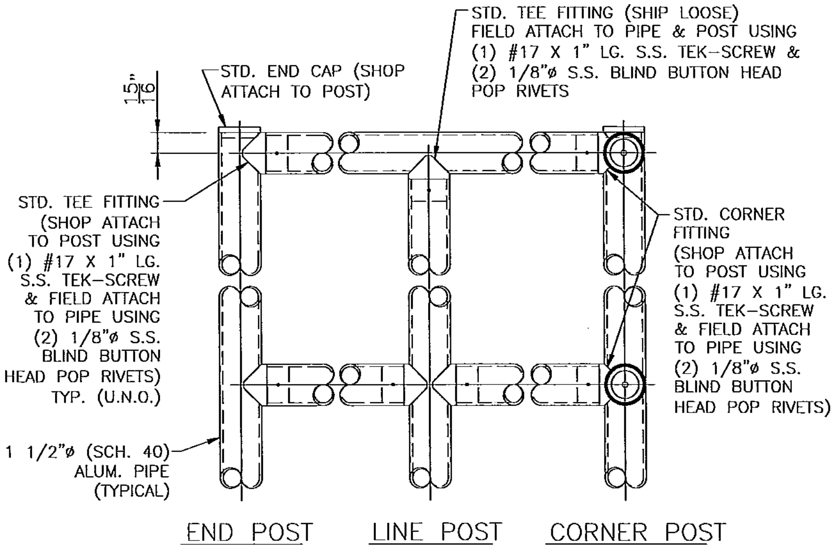
		R0001 - RMR Standard Calcs	Engineer: JDB	Sheet No: F2
			Date: 2/23/11	Rev:
Template: REI-MC-5740			Chk By:	Date:

Miscellaneous Connections	SHT M1

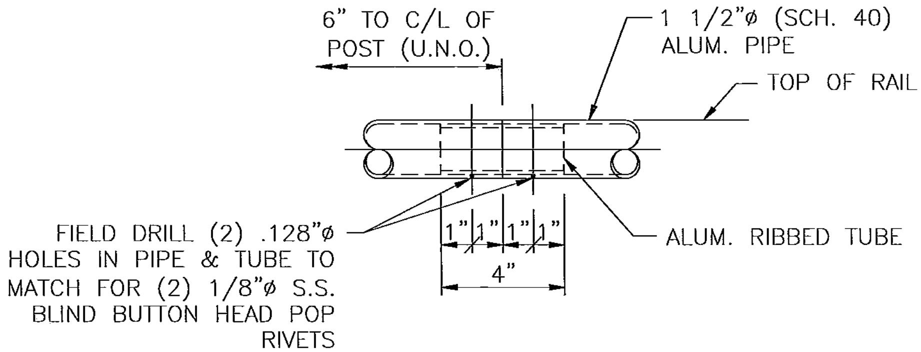


TYPICAL LEVEL RAIL CONNECTIONS

25KD-2

$R_{max} := 300$ lb

$M_{max} := 1680$ lb·in



Chk 1/4-20 Screws @ Tee/Rail:

$V := \frac{R_{max}}{2}$ $\quad V = 150$ lb

$V_{all} := 520 \cdot 0.33$ $\quad V_{all} = 172$ lb

Use (2) - 1/8 S.S. Blind Button Head Rivets (Pop Rivets)
(Safety Factor = 3)

Chk Splice Piece:

$S_x := 0.104$ in^3

$f_b := \frac{M_{max}}{S_x}$ $\quad f_b = 16154$ psi

$F_b := 21000$ psi

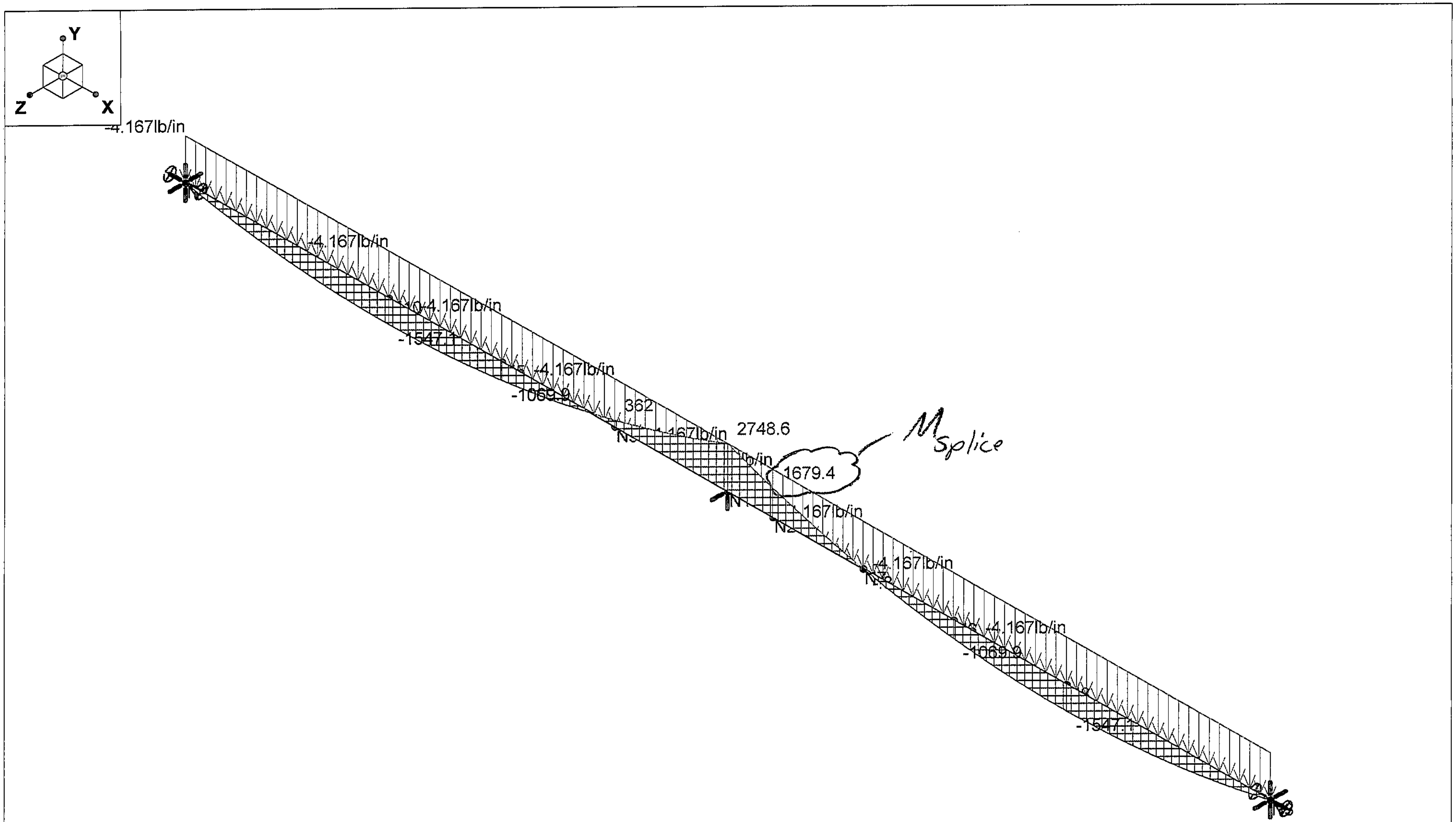
Use Ribbed Tube Aluminum Splice Piece
6105-T5 Alloy

Chk #17 S.S. TEK Screw @ Tee/Post :

$V_2 := R_{max}$ $\quad V_2 = 300$ lb

$V_{all2} := 2184 \cdot 0.33$ $\quad V_{all2} = 721$ lb

Use (1) #17 S.S. TEK Screw per "Tee"
300 Series S.S.



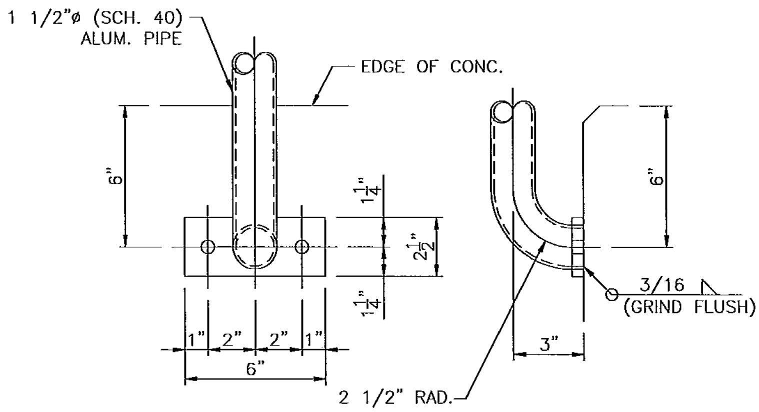
Loads: BLC 1, 50 PLF
Results for LC 1, 50 PLF
Member z Bending Moments (lb-in)

Rice Engineering	R0001 - RMR Standard Calcs	SK - 1
Joe Bauer		Feb 23, 2011 at 3:13 PM
R11-02-15H		6 ft Splice Loads.r3d

MIA

ASSUME GROUT FILLED CMU
DESIGNED BY OTHERS

Wall Rail Post Bracket Analysis	SHT M2



CUSTOMER NOTE!
FILL VOID CAVITY IN CMU WITH GROUT @ ALL RAIL MOUNTING LOCATIONS.

WALL RAIL LINE POST

25KD-35A

(Reaction From RISA Model)

$R_{max} := 113$ lb

$M_{max} := 2287$ lb·in

Chk weld to base plate:

$t_w := 0.1875$ in (thickness of weld)

$d := 1.9$ in (stub depth)

$A_w := t_w \cdot (\pi \cdot 0.5 \cdot d)$ $\quad A_w = 0.56$ in^2

$T := \frac{M_{max}}{d}$ $\quad T = 1204$ lb

$f_w := \frac{T}{A_w}$ $\quad f_w = 2151$ psi

$F_w := 6500$ psi

Use 3/16" weld all around as noted
5356 filler alloy

Chk Aluminum Base Plate:

$L1 := 6$ in $\quad D1 := 1$ in

$L2 := 2.5$ in $\quad D2 := 2.5$ in

$t := 0.5$ in

$L := L1 - (2 \cdot D1)$ $\quad L = 4$ in

$P := \frac{M_{max}}{d}$ $\quad P = 1204$ lb

$M_{p1} := 0.5 \cdot P \cdot 1$ $\quad M_{p1} = 602$ in·lb

$M_{pl2} := 0.5 \cdot P \cdot (1.05)$ $\quad M_{pl2} = 632$ in·lb

$t_{req1} := \sqrt{\frac{M_{p1} \cdot 6}{(12000) \cdot L2}}$ $\quad t_{req1} = 0.347$ in

$t_{req2} := \sqrt{\frac{M_{pl2} \cdot 6}{(28000) \cdot L2}}$ $\quad t_{req2} = 0.233$ in

$I_2 := \frac{\max(t_{req1}, t_{req2})}{t}$ $\quad I_2 = 0.69$

Use 1/2" x 6" x 2-1/2" AL Plate
6061-T6 alloy

Note! Anchor Type Size + Embedment

Chk Bolts to Grout Filled CMU:

$V_b := \frac{R_{max}}{2}$ $\quad V_b = 57$ lb

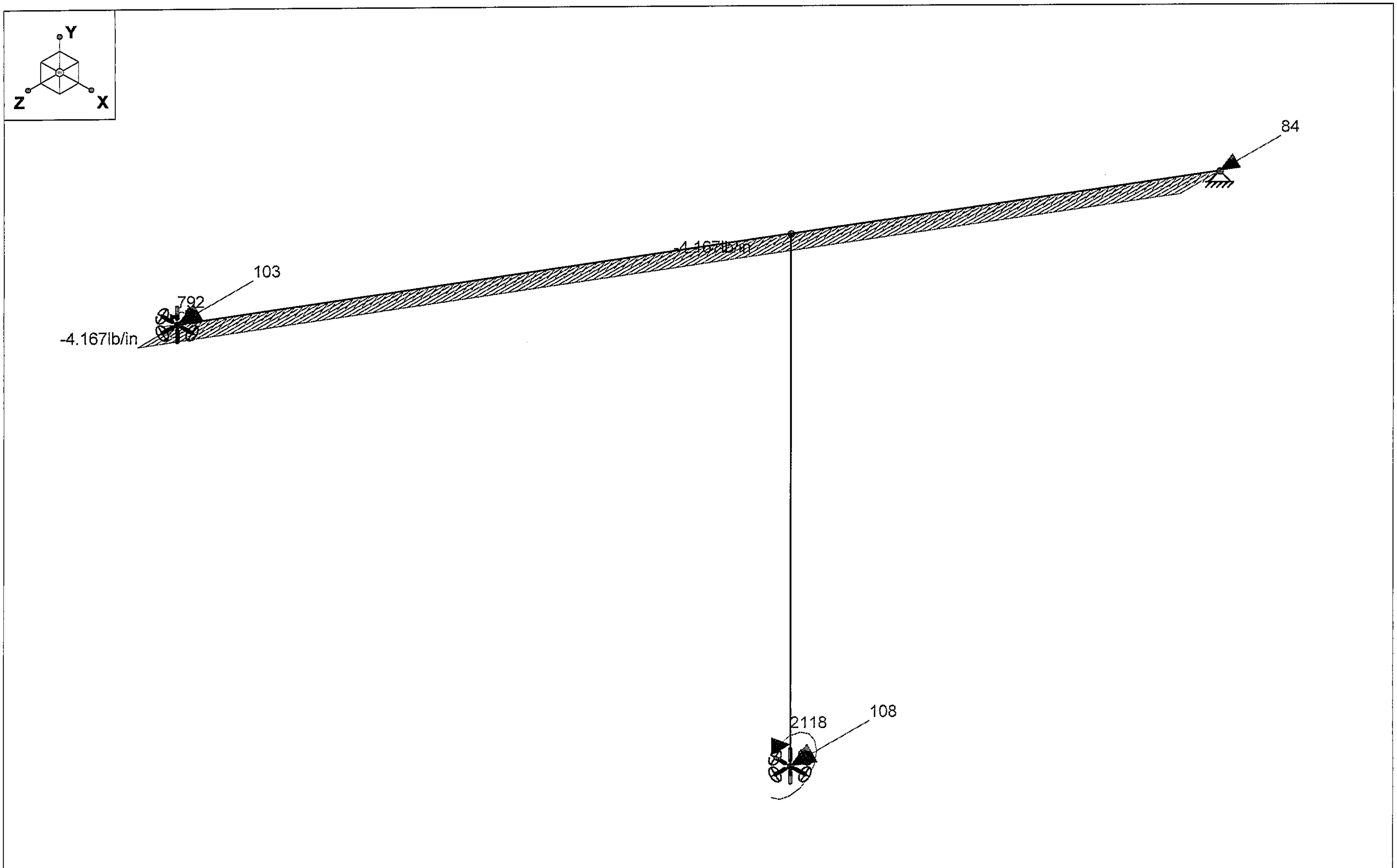
$T_b := \frac{M_{max}}{2 \cdot (0.5 \cdot D2)}$ $\quad T_b = 915$ lb

$T_{all} := \min(1100, 1975 \cdot 0.5)$ $\quad T_{all} = 988$ lb

$V_{all} := \min(1419, 2756 \cdot 0.5)$ $\quad V_{all} = 1378$ lb

$I_b := \left(\frac{T_b}{T_{all}}\right)^{1.67} + \left(\frac{V_b}{V_{all}}\right)^{1.67}$ $\quad I_b = 0.88$

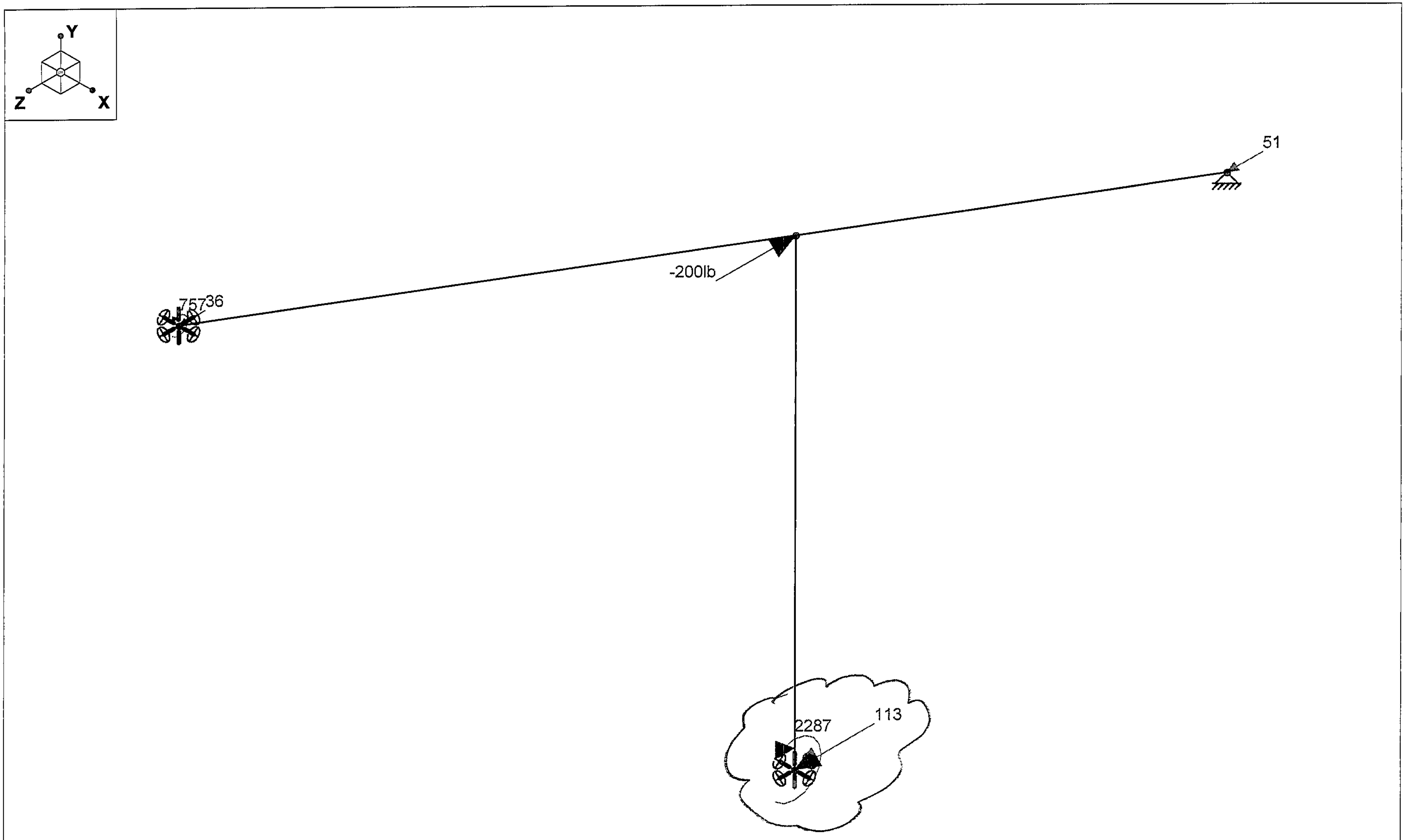
Use (2) - 3/8" Dia. S.S. Threaded Rods
W/ Hilti HIT-HY 150 MAX Adhesive
Edge Distance: 4"
End Distance: 4"
Embedment: 3-3/8"



Loads: BLC 1,
Results for LC 1, Dist 1
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 2
Joe Bauer		Feb 23, 2011 at 3:23 PM
R11-02-15H		Handrail Post Bracket.r3d

M2A



Loads: BLC 2,
Results for LC 2, Point
Z-moment Reaction units are lb and lb-in

Rice Engineering	R0001 - RMR Standard Calcs	SK - 3
Joe Bauer		Feb 23, 2011 at 3:24 PM
R11-02-15H		Handrail Post Bracket.r3d

M2B

Pipe Handrail

These calculations are based on emperical test data performed by Julius Blum & Co., Inc.

Wall or Grab Rail Analysis	SHT M3

Input Variables:

$F_H := 50$ $\frac{lb}{ft}$ Load Case 1 (Uniform Load)

$F_V := 0$ $\frac{lb}{ft}$ Simultaneous Vertical Uniform Load

$P := 200$ lb Load Case 2 (Point Load)

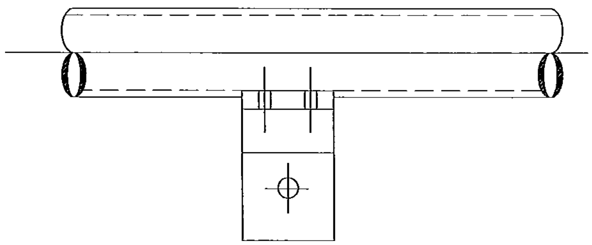
$L := 60$ in ***MAX BRACKET SPACING (cl to cl)***

Number of Railing Spans:

- [x] 1 span
- [x] 2 span
- [x] 3 or more spans

Railing Section:

- [ ] 1 1/4" Schd. 40
- [ ] 1 1/4" Schd. 80
- [x] 1 1/2" Schd. 40
- [ ] 1 1/2" Schd. 80
- [ ] 1 1/2" tube
- [ ] 2" Schd. 40
- [ ] 2" Schd. 80



Railing Temper:

- [x] 6105-T5 or 6061-T6
- [ ] 6063-T5
- [ ] *4/3 increase allowed*

All calculations below this line are automatic

Railing Properties

Ixr=	0.31
Iyr=	0.31
Sxr=	0.326
Syr=	0.326
R=	0.95
t=	0.145

Computational Factors

$K_1 := (8 \cdot q1) + (8 \cdot q2) + (9.5 \cdot q3)$ $K_1 = 8$

$K_2 := (4 \cdot q1) + (5 \cdot q2) + (5 \cdot q3)$ $K_2 = 5$

$K_3 := (48 \cdot q1) + (66 \cdot q2) + (87 \cdot q3)$ $K_3 = 66$

$E_r := 10100000$ psi

$I_{xtotr} := I_{xr}$ $\boxed{I_{xtotr} = 0.31}$ in^4

$I_{ytotr} := I_{yr}$ $\boxed{I_{ytotr} = 0.31}$ in^4 $S_{R1} := \frac{R_r}{t_r}$ $S_{R1} = 6.55$

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			Date: 2/23/11	Rev:
Template: REI-MC-5702			Chk By:	Date:

Railing Analysis:

$W_h := \frac{F_H}{12}$ $W_v := \frac{F_V}{12}$

Wall or Grab Rail Analysis	SHT M3 A

Case 1 Uniform Load:

$\Delta_{yr1} := \frac{5 \cdot W_h \cdot L^4}{384 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr1} = 0.225$ in   Modeled as a simple span

$\Delta_{xr1} := \frac{5 \cdot W_v \cdot L^4}{384 \cdot E_r \cdot I_{xtotr}}$ $\Delta_{xr1} = 0$ in

$\Delta_{allr} := \frac{L}{96}$ $\Delta_{allr} = 0.63$ in   Per ASTM E985

$M_{yrmax} := \frac{W_h \cdot L^2}{K_1}$ $M_{yrmax} = 1875$ lb·in

$M_{xrmax} := \frac{W_v \cdot L^2}{K_1}$ $M_{xrmax} = 0$ lb·in

---

$f_{bry1} := \frac{M_{yrmax}}{S_{yr}}$ $f_{bry1} = 5752$ psi

$f_{brx1} := \frac{M_{xrmax}}{S_{xr}}$ $f_{brx1} = 0$ psi

Case 1 Point Load:

$\Delta_{yr2} := \frac{P \cdot L^3}{K_3 \cdot E_r \cdot I_{ytotr}}$ $\Delta_{yr2} = 0.209$ in

$M_{yrmax2} := \frac{P \cdot L}{K_2}$ $M_{yrmax2} = 2400$ lb·in

$f_{bry2} := \frac{M_{yrmax2}}{S_{yr}}$ $f_{bry2} = 7362$ psi

$F_{bry} := \begin{cases} (F_{bry1} \cdot 1.34) & \text{if } IBC = 1 \\ F_{bry1} & \text{otherwise} \end{cases}$ $F_{bry} = 25000$ psi

Calculation Results:

$Int_{r1} := \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right)$ $Int_{r1} = 0.23$

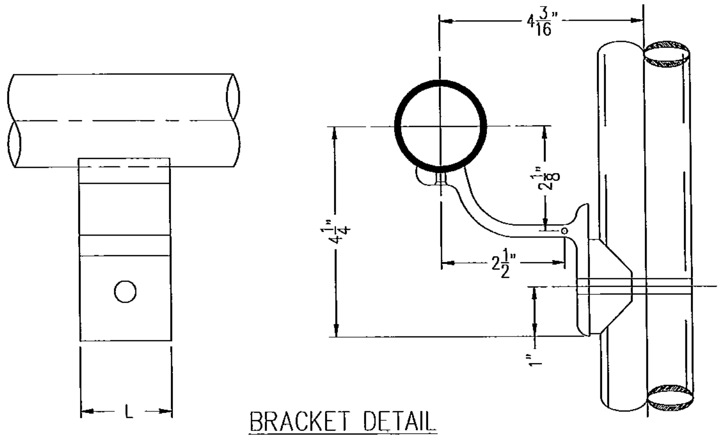
$Int_{r2} := \frac{f_{bry2}}{F_{bry}}$ $Int_{r2} = 0.29$

$RAILS := \begin{cases} \text{"OK"} & \text{if } \frac{\max(\Delta_{yr1}, \Delta_{xr1}, \Delta_{yr2})}{\Delta_{allr}} \le 1 \wedge \left(\frac{f_{brx1}}{F_{bry}}\right) + \left(\frac{f_{bry1}}{F_{bry}}\right) \le 1 \wedge \frac{f_{bry2}}{F_{bry}} \le 1 \\ \text{"FAIL"} & \text{otherwise} \end{cases}$ RAILS = "OK"

Grab Rail Bracket Analysis	SHT M4

Inputs:

$L_s := 60$	in	(bracket span)	$A := 3.0$	in
$w_h := 0$	plf	(horiz uniform load)	$B := 2.125$	in
$w_v := 50$	plf	(vert uniform load)	$C := 2.5$	in
$P := 200$	lb	(conc. load)	$D := 1.0$	in
$F_b := 28000$	psi	(Allowable Stress)	$H := 4.25$	in
			$L := 2$	in
☐ 4/3 Stress Increase Allowed			$t := 0.25$	in



5' 0" Max Bracket Spacing

Horizontal Uniform Loading:

$R_1 := \frac{w_h \cdot L_s}{12}$ $R_1 = 0$ lbs

$M_1 := B \cdot R_1$ $M_1 = 0$ in-lb

Vertical Uniform Loading:

$R_2 := \frac{w_v \cdot L_s}{12}$ $R_2 = 250$ lbs

$M_2 := C \cdot R_2$ $M_2 = 625$ in-lb

$M_{b1} := M_1 + M_2$ $M_{b1} = 625$ in-lb

Concentrated Loading:

$M_{b2} := P \cdot B$ $M_{b2} = 425$ in-lb

$M_b := \max(M_{b1}, M_{b2})$ $M_b = 625$ in-lb

$F_{b1} := \begin{cases} (F_b \cdot 1.34) & \text{if } IBC = 1 \\ F_b & \text{otherwise} \end{cases}$

$t_{req} := \sqrt{\frac{6M_b}{F_{b1} \cdot L}}$ $t_{req} = 0.26$ in

Interaction:

$I := \frac{t_{req}}{t}$ $I = 1.04$ <u>< 5% Over OK</u>

Use Aluminum Rail Bracket, 6105-T5 or 6061-T6 Alloy, 2" Long

Anchorage to Post *(Horizontal Load Case)*:

$M_3 := H \cdot P$ $M_3 = 850$ in-lb

$T_p := \frac{M_3}{0.85D} + P$ $T_p = 1200$ lbs

$V := \max(R_2, 200)$ $V = 250$ lbs

$T_{all} := 3100 \cdot \frac{0.145}{0.341}$ $T_{all} = 1318$ lbs

$V_{all} := 1614$ lbs

$I_b := \left(\frac{T_p}{T_{all}}\right)^2 + \left(\frac{V}{V_{all}}\right)^2$ $I_b = 0.85$

<u>Use (1) - 3/8" Dia. S.S. Thru Bolts</u>
Cond "CW", Fy= 65 ksi

Bracket to Grab Rail Screws:

Use (2) #1/4-20 S.S. Fasteners "OK" per inspection

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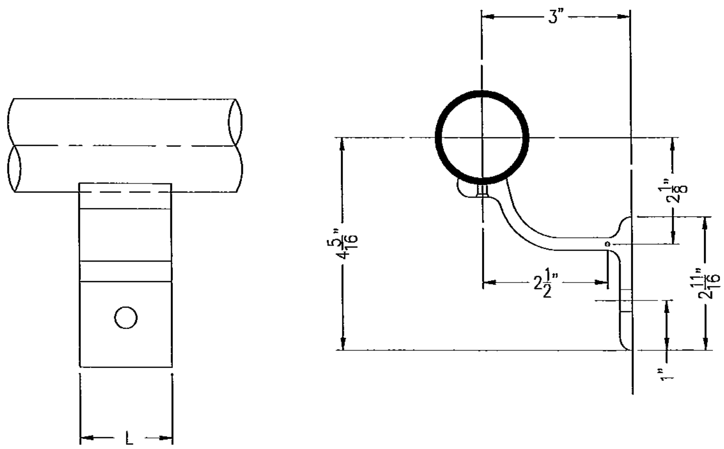
			Date: 2/23/11	Rev:
Template:			Chk By:	Date:

Wall Rail Bracket Analysis	SHT M5

Inputs:

$L_s := 60$	in	(bracket span)	$A := 2.5$	in
$w_h := 0$	plf	(horiz uniform load)	$B := 2.125$	in
$w_v := 50$	plf	(vert uniform load)	$C := 2.5$	in
$P := 200$	lb	(conc. load)	$D := 1.0$	in
$F_b := 28000$	psi	(Allowable Stress)	$H := 4.313$	in
			$L := 2$	in
☐ 4/3 Stress Increase Allowed			$t := 0.25$	in

ASSUME GROUT FILLED CMU DESIGNED BY OTHERS



BRACKET DETAIL

5' 0" Max Bracket Spacing

Horizontal Uniform Loading:

$R_1 := \frac{w_h \cdot L_s}{12}$ $\quad R_1 = 0$ lbs

$M_1 := B \cdot R_1$ $\quad M_1 = 0$ in-lb

Vertical Uniform Loading:

$R_2 := \frac{w_v \cdot L_s}{12}$ $\quad R_2 = 250$ lbs

$M_2 := C \cdot R_2$ $\quad M_2 = 625$ in-lb

Concentrated Loading:

$M_3 := P \cdot \max(B, C)$ $\quad M_3 = 500$ in-lb

$M_b := \max(M_1, M_2, M_3)$ $\quad M_b = 625$ in-lb

$F_{b1} := \begin{cases} (F_b \cdot 1.34) & \text{if IBC} = 1 \\ F_b & \text{otherwise} \end{cases}$

$t_{req} := \sqrt{\frac{6 \cdot M_b}{F_{b1} \cdot L}}$ $\quad t_{req} = 0.26$ in

Note: Anchor Size, Type & Embedment

Interaction:

$I := \frac{t_{req}}{t}$ $\quad I = 1.04$ $\quad$ < 5% OK

Use Aluminum Wall Bracket, 6105-T5 or 6061-T6 Alloy, 2" Long

Wall Anchorage *(Horizontal Load Case)*:

$M_4 := \max(P \cdot H, R_1 \cdot H, R_2 \cdot A)$ $\quad M_4 = 863$ in-lb

$T_p := \frac{M_4}{D \cdot 0.85} + P$ $\quad \boxed{T_p = 1215}$ lbs

$V := \max(R_2, 200)$ $\quad \boxed{V = 250}$ lbs

$T_{all} := 1319$ lbs

$V_{all} := 2181$ lbs

$I_b := \left(\frac{T_p}{T_{all}}\right)^{1.67} + \left(\frac{V}{V_{all}}\right)^{1.67}$ $\quad I_b = 0.9$

<u>Use (1) - 1/2" Dia. S.S. Threaded Rod</u>
W/ Hilti HIT-HY 150 MAX Adhesive
Edge Distance: 4"
End Distance: 4"
Embedment: 4-1/2"

Bracket to Grab Rail Screws:

Use (2) #1/4-20 S.S. Fasteners "OK" per inspection

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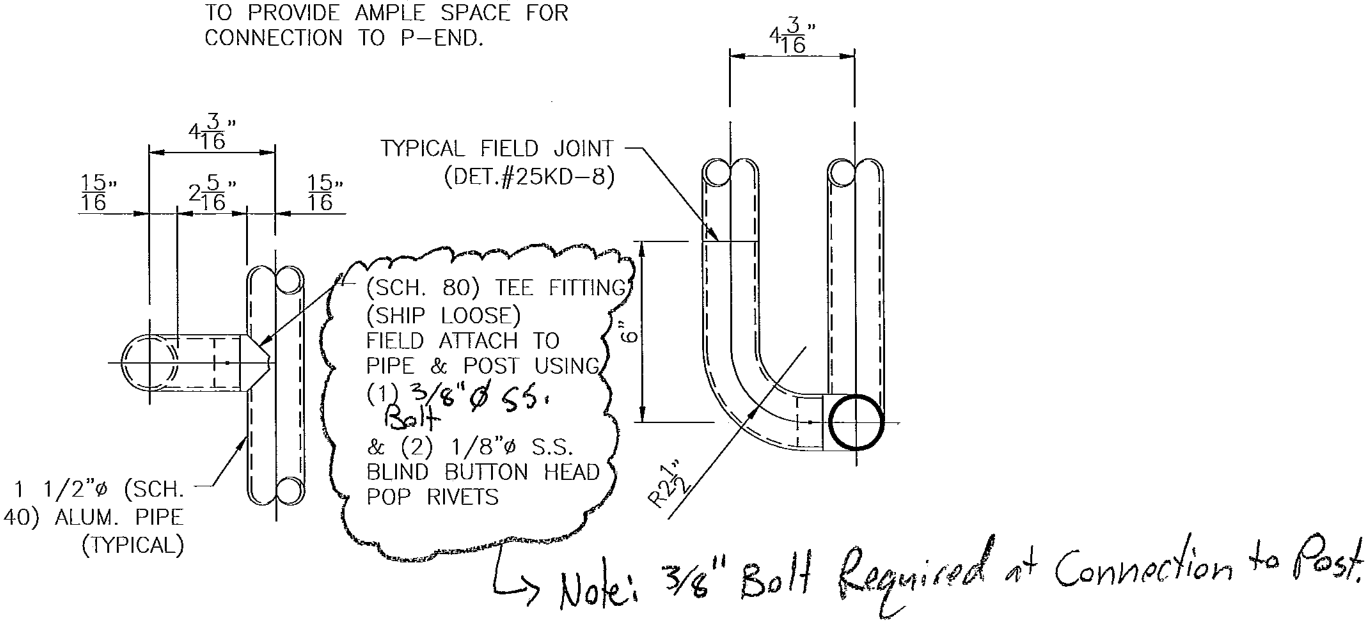
		R0001 - RMR Standard Calcs	Engineer: JDB	Sheet No: M5
			Date: 2/23/11	Rev:
Template:			Chk By:	Date:

$R_{max} := 200$ lb

$M_{max} := R_{max} \cdot 3.25 = 650$ lb·in

ARCH/ENG NOTE:
HANG-OFF RAIL CORNER NEEDS TO BE ATTACHED WITH A (SCH. 80) TEE FITTING RATHER THAN A (SCH. 40) TEE FITTING TO PROVIDE AMPLE SPACE FOR CONNECTION TO P-END.



SPECIAL OFFSET RAIL CONNECTION

25KD-35E

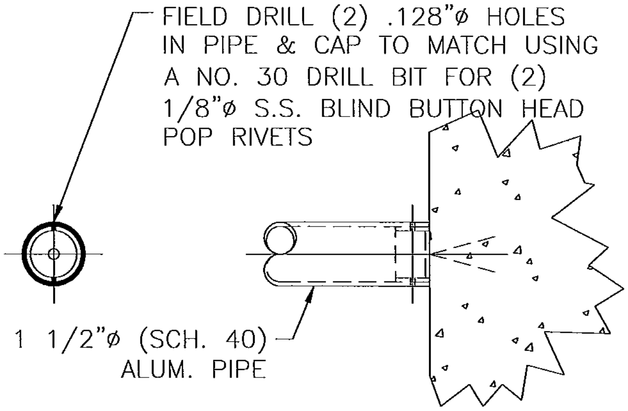
Chk Thru-Bolts @ Tee:

$$T := \frac{M_{max}}{1.9 \cdot 0.5} \qquad \boxed{T = 684} \text{ lb}$$

$$T_{all} := 3100 \cdot \frac{0.145}{0.553} \qquad \boxed{T_{all} = 813} \text{ lb}$$

Use (1) - 3/8" Dia. S.S. Bolt
Drill & Tap or Thru-Bolt
Cond "CW", Fy= 65 ksi
0.145" min. Thread Engagement

Wall Mount End Cap	SHT M7



CUSTOMER NOTE!
FILL VOID CAVITY IN CMU WITH GROUT @ ALL RAIL MOUNTING LOCATIONS.

WALL MOUNT END CAP

25KD-33

Chk Fasteners:

Use (2) 1/8" Dia. S.S. Blind Buton Head Pop Rivets
(OK By Inspection)

Chk End Cap:

Use End Cap as shown
(OK By Inspection)

Chk Anchors: (Assume Grout Filled CMU)

$R_{max} := 200$ lb

$V := \frac{R_{max}}{1}$ $V = 200$ lb

$V_{all} := 1419 \cdot 0.5$ $V_{all} = 710$ lb $V_{all2} := 380$ lb

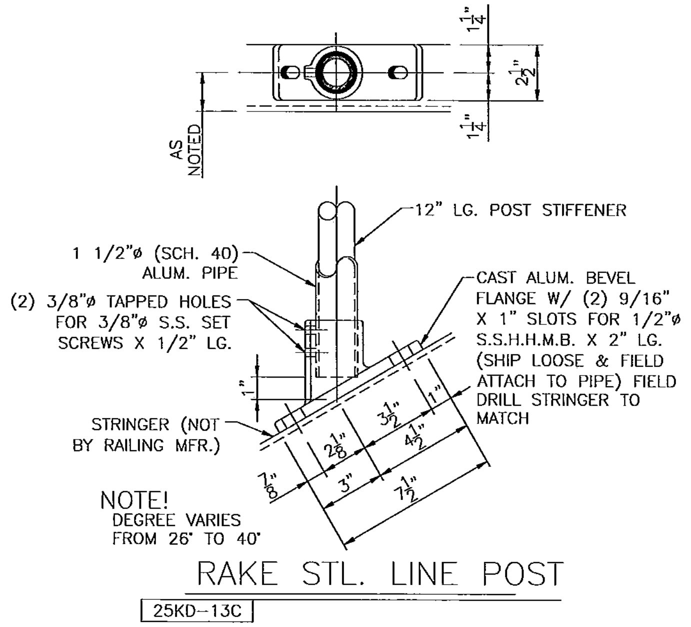
Use (1) - 3/8" Dia. S.S. Threaded Rod w/ Hilti HIT-RE 500 MAX Adhesive
3-3/8" Min. Embedment
4" Min. Edge Distance

OR

Use (1) 1/4" Dia. S.S. Hilti Kwik Bolt 3
(300 Series S.S.)
1-1/8" Min. Embedment
4" Min. Edge Distance

Note: Values for HIT-RE 500 Epoxy Adhesive Based on HIT-HY 150 MAX Adhesive with a Safety Factor of 8

2-Bolt Raked Base Plate	SHT M8



$R_{max} := 250$ lb

$M := R_{max} \cdot 42 = 10500$ lb·in

$M_{max} := \cos(32deg) \cdot M = 8905$ lb·in

$d := 2.5$ in (sleeve dia.)

Note: Model based on 5'-0" max post spacing (measured along rail) and a post height of 3'-6" above bottom of base

Note: 6'-0" max post spacing (measured along rail) along rail and a post height of 2'-10" above bottom of base

$\frac{M}{34} = 309$ lb $>$ $4.167 \cdot 72 = 300$ lb

Chk shear on shoe wall:

$P := \frac{M_{max}}{0.67 \cdot (2.375)}$ $P = 5596$ lb

$f_v := \frac{(P + R_{max})}{2 \cdot (0.315) \cdot (2)}$ $f_v = 4640$ psi

$F_v := \frac{0.57 \cdot (18000)}{1.65}$ $F_v = 6218$ psi

$I := \frac{f_v}{F_v}$ $I = 0.75$ <u>Shear Stress "OK"</u>

Chk Aluminum Base Plate:

$L1 := 7.5$ in $D1 := 1$ in

$L2 := 2.5$ in $D2 := 1.25$ in

$t := 0.5$ in

$L := L1 - (2 \cdot D1)$ $L = 5.5$ in

$P := \frac{M_{max}}{d}$ $P = 3562$ lb

$\sigma_{max} := 14182$ psi *See Next Sheet For Model*

$\sigma_{all} := \frac{1.3 \cdot (18000)}{1.65}$ $\sigma_{all} = 14182$ psi

$I_2 := \frac{\sigma_{max}}{\sigma_{all}}$ $I_2 = 1$

Note: Model based on 5'-0" max post spacing measured along rail and a post height of 3'-6"

<u>Use Cast Aluminum Base, as shown</u>
535 casting alloy, Fu= 35 ksi min.

Chk Bolts to Steel Stringer:

$V_b := \frac{R_{max}}{2}$ $V_b = 125$ lb

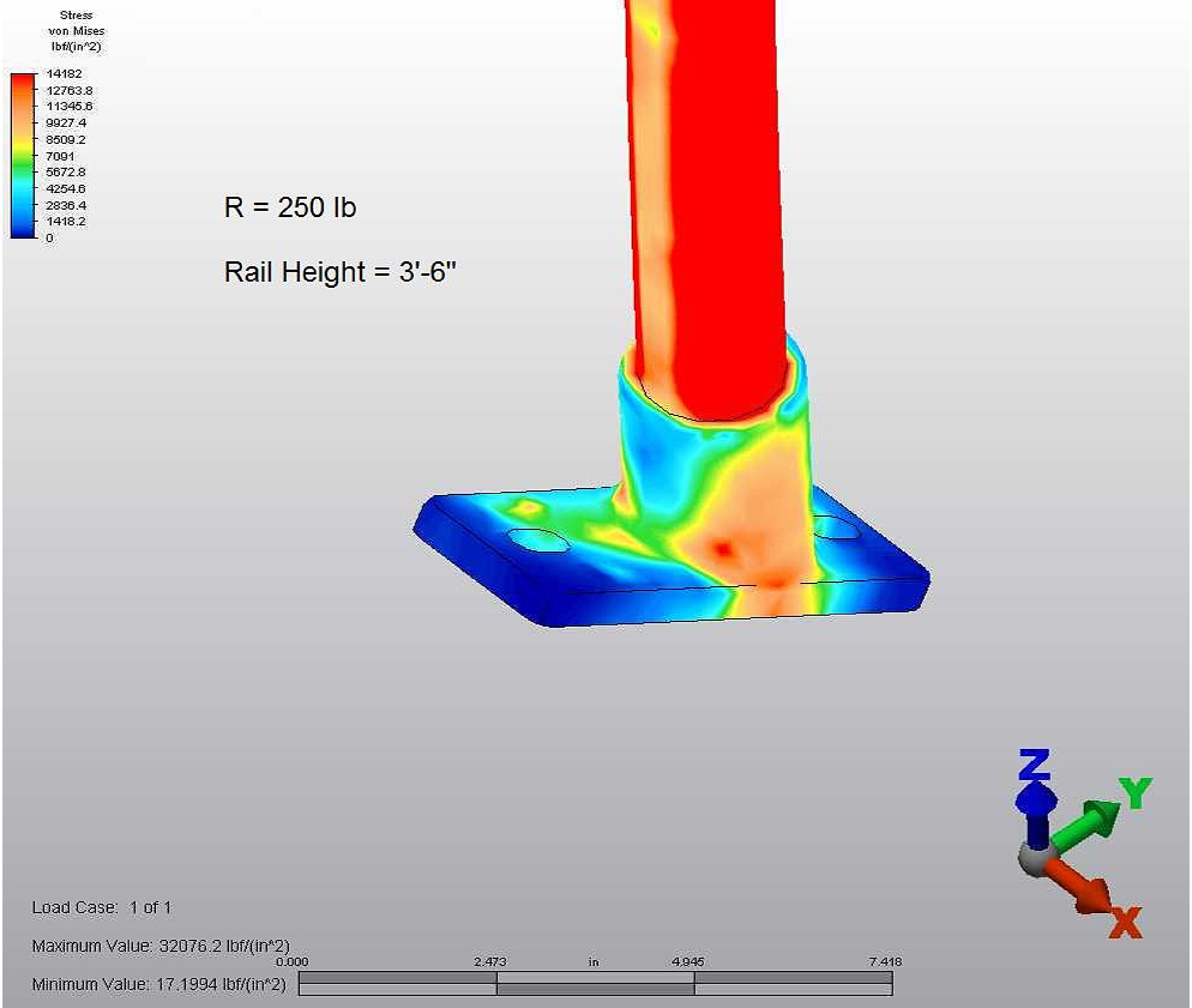
$T_b := \frac{M_{max}}{2 \cdot 1.25}$ $T_b = 3562$ lb

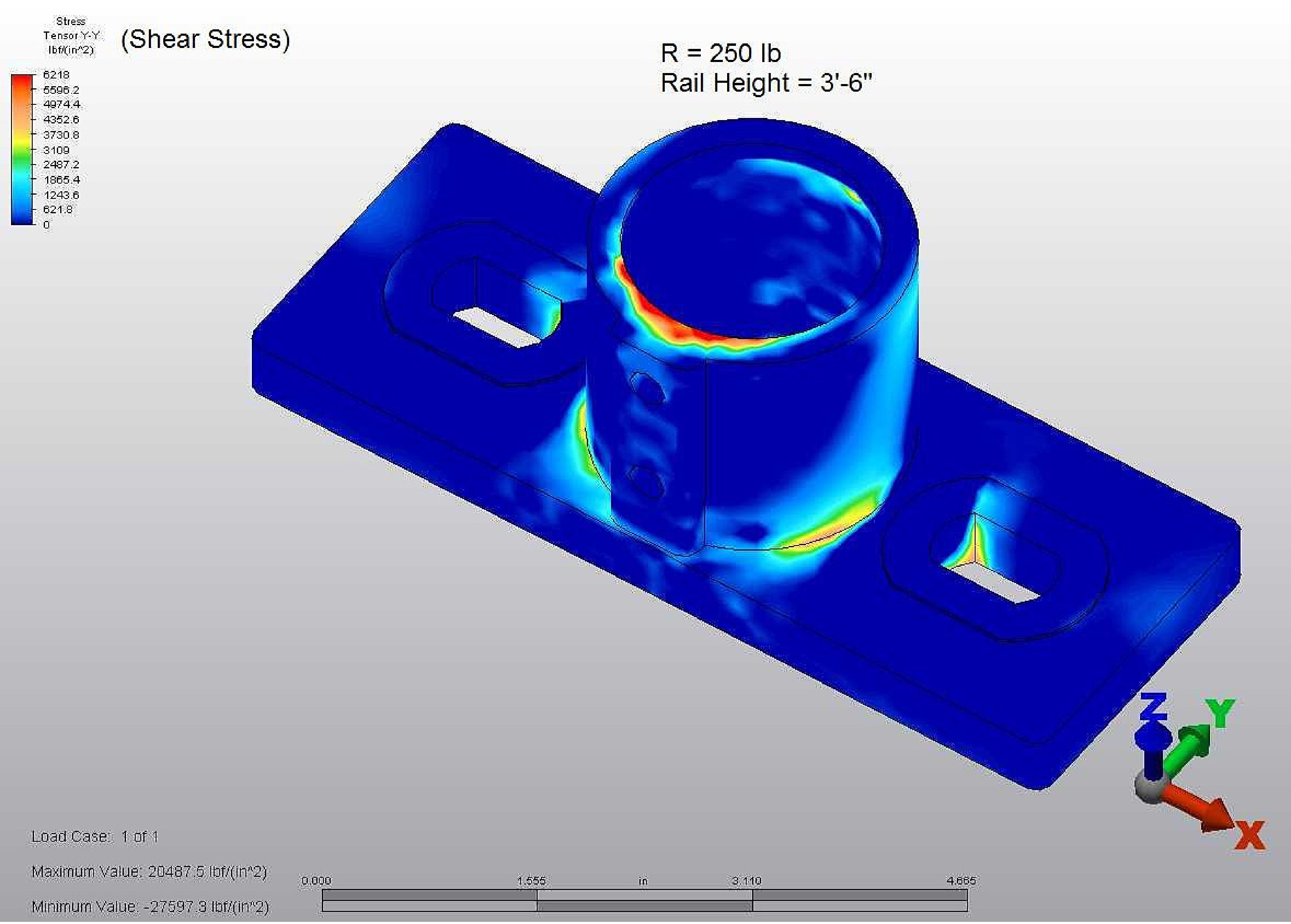
$V_{all} := 0.196 \cdot 23094$ $V_{all} = 4526$ lb

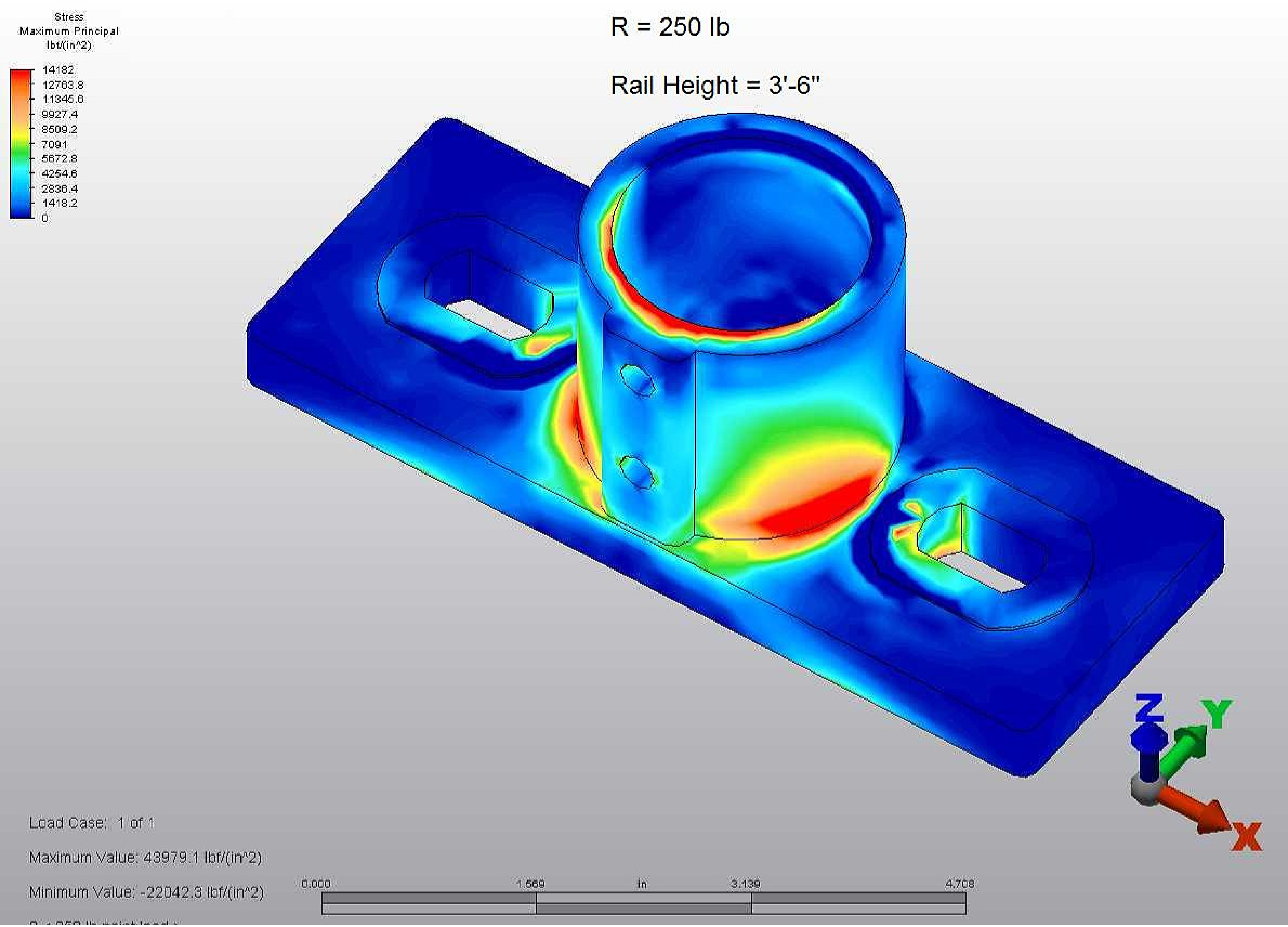
$T_{all} := 0.142 \cdot 40000 \cdot \frac{0.375}{0.456}$ $T_{all} = 4671$ lb

$I_3 := \left(\frac{V_b}{V_{all}}\right)^2 + \left(\frac{T_b}{T_{all}}\right)^2$ $I_3 = 0.58$

<u>Use (2) - 1/2" Dia. S.S. Thru-Bolts</u>
<u>or Drill & Tap w/ 3/8" Min. Thread Engagement</u>
Condition "CW"


Stress
von Mises
lbf/(in^2)
14182
12763.8
11345.6
9927.4
8509.2
7091
5672.8
4254.6
2836.4
1418.2
0
R = 250 lb
Rail Height = 3'-6"
Z
Y
X
Load Case: 1 of 1
Maximum Value: 32076.2 lbf/(in^2)
Minimum Value: 17.1994 lbf/(in^2)
0.000
2.473
in
4.946
7.418


Stress
Tensor Y-Y
lbf/(in^2)
(Shear Stress)
6218
5596.2
4974.4
4352.6
3730.8
3109
2487.2
1865.4
1243.6
621.8
0
R = 250 lb
Rail Height = 3'-6"
Z
Y
X
Load Case: 1 of 1
Maximum Value: 20487.5 lbf/(in^2)
Minimum Value: -27597.3 lbf/(in^2)
0.000
1.555
in
3.110
4.665


R = 250 lb
Rail Height = 3'-6"
Stress
Maximum Principal
lbf/(in^2)
14182
12763.8
11345.6
9927.4
8509.2
7091
5672.8
4254.6
2836.4
1418.2
0
Z
Y
X
Load Case: 1 of 1
Maximum Value: 43979.1 lbf/(in^2)
Minimum Value: -22042.3 lbf/(in^2)
0.000
1.569
in
3.139
4.708

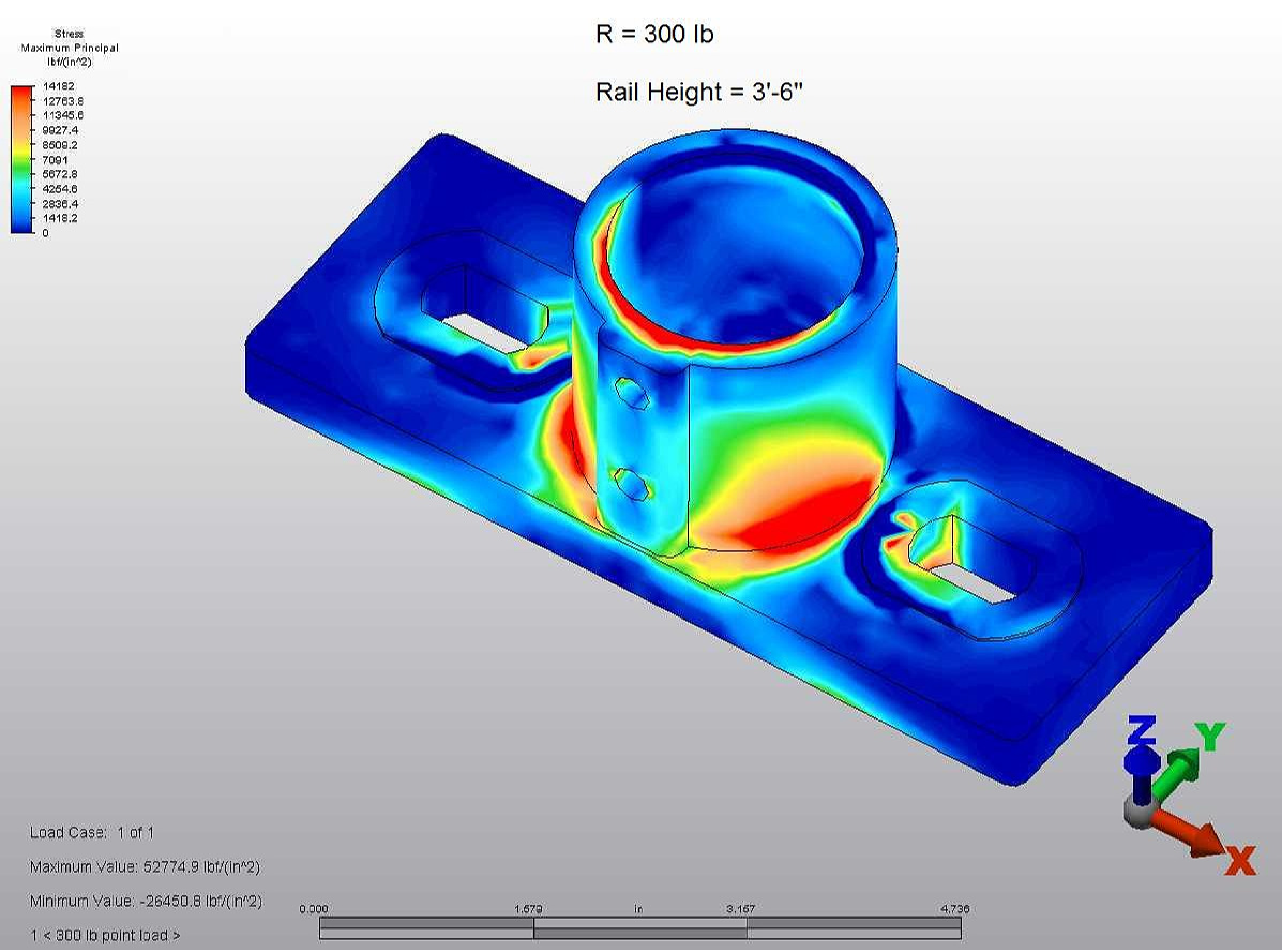

R = 300 lb
Rail Height = 3'-6"
Stress
Maximum Principal
lbf/(in^2)
14182
12763.8
11345.6
9927.4
8509.2
7091
5672.8
4254.6
2836.4
1418.2
0
Load Case: 1 of 1
Maximum Value: 52774.9 lbf/(in^2)
Minimum Value: -26450.8 lbf/(in^2)
1 < 300 lb point load >
0.000
1.579
in
3.157
4.736
Z
Y
X

TABLE 11

Nominal Thread Diameter & Thread/Inch	D Nominal Thread Diameter (Inch)	A(S) Tensile Stress Area (Sq. In.)	A(R) Thread Root Area (Sq. In.)	Allowable Tension (Pounds)	Allowable Shear: Single (Pounds)	Allowable Shear: Double (Pounds)	Bearing (Pounds): 1/8" St. A36	Bearing (Pounds): 1/8" Al. 6063-T5	Bearing (Pounds): 1/8" Al. 6063-T6	Minimum Material Thickness to Equal Tensile Capacity of Fastener (In.): A36	6063-T5	6063-T6
STAINLESS STEEL - Alloy Groups 1, 2 and 3, Condition CW												
#6-32	0.1380	0.0091	0.0078	364	180	360	1201	276	414	0.126	0.274	0.198
#8-32	0.1640	0.0140	0.0124	560	286	573	1427	328	492	0.162	0.368	0.251
#10-24	0.1900	0.0175	0.0152	700	351	702	1653	380	570	0.170	0.372	0.287
#12-24	0.2160	0.0242	0.0214	968	494	988	1879	432	648	0.200	0.450	0.321
1/4-20	0.2500	0.0318	0.0280	1272	647	1293	2175	500	750	0.225	0.541	0.360
5/16-18	0.3125	0.0524	0.0469	2098	1083	2166	2719	625	938	0.284	***	0.459
3/8-16	0.3750	0.0775	0.0699	3100	1614	3229	3262	750	1125	0.341	***	0.553
7/16-14	0.4375	0.1063	0.0961	4252	2219	4439	3806	875	1313	0.395	***	0.642
1/2-13	0.5000	0.1419	0.1292	5676	2984	5967	4350	1000	1500	0.456	***	0.745
9/16-12	0.5625	0.1819	0.1664	7276	3843	7686	4894	1125	1688	0.510	***	0.836
5/8-11	0.6250	0.2260	0.2071	9040	4783	9566	5437	1250	1875	0.563	***	0.923
3/4-10	0.7500	0.3345	0.3091	11280	6023	12046	6525	1500	2250	0.590	***	0.963
7/8-9	0.8750	0.4617	0.4286	15582	8352	16703	7612	1750	2625	0.686	***	1.123
1-8	1.0000	0.6057	0.5630	20442	10970	21941	8700	2000	3000	0.778	***	1.276

	DIAMETER Up Thru 5/8"	3/4" and Over
F_u (Min. Ultimate Tensile Strength)	110,000 psi	85,000 psi
F_y (Min. Tensile Yield Strength)	65,000 psi	45,000 psi
F_t (Allowable Tensile Stress)	40,000 psi	33,750 psi
F_v (Allowable Shear Stress)	23,094 psi	19,486 psi

$$A(R) = 0.7854\left(D - \frac{1.2269}{N}\right)^2$$

$$A(S) = 0.7854\left(D - \frac{0.9743}{N}\right)^2$$

For Diameters Up Thru 5/8":

$$F_t = 0.40F_u$$

$$\text{Allowable tension} = 0.40F_u[A(S)]$$

$$F_v = \frac{0.40}{\sqrt{3}}F_u$$

$$\text{Allowable shear (Single)} = \frac{0.40}{\sqrt{3}}F_u[A(R)]$$

For Diameters 3/4" and Over:

$$F_t = 0.75F_y$$

$$\text{Allowable tension} = 0.75F_y[A(S)]$$

$$F_v = \frac{0.75}{\sqrt{3}}F_y$$

$$\text{Allowable shear (Single)} = \frac{0.75}{\sqrt{3}}F_y[A(R)]$$

In Tables 9 thru 15, for Group Type and Condition Definitions see pages 22 and 23.

TABLE 27 TEKS –

Nominal Thread Diameter & Thread/Inch	D Nominal Thread Diameter (Inch)	K Basic Minor Diameter (Inch)	A(R) Thread Root Area (Sq. In.)	Allowable Tension (Pounds)	Allowable Shear: Single (Pounds)	Allowable Shear: Double (Pounds)	Bearing (Pounds): 1/8" St. A36	Bearing (Pounds): 1/8" Al. 6063-T5	Bearing (Pounds): 1/8" Al. 6063-T6	Minimum Material Thickness to Equal Tensile Capacity of Fastener (In.): A36	6063-T5	6063-T6
STAINLESS STEEL - Alloy Groups 1, 2 and 3, Condition CW												
#6-20	0.1380	0.0997	0.0078	312	180	360	1201	276	414	0.112	0.240	0.174
#8-18	0.1640	0.1257	0.0124	496	286	573	1427	328	492	0.147	0.329	0.235
#10-16	0.1900	0.1389	0.0152	608	351	702	1653	380	570	0.153	0.328	0.238
#12-14	0.2160	0.1649	0.0214	856	494	988	1879	432	648	0.182	0.403	0.289
1/4-14	0.2500	0.1887	0.0280	1120	647	1293	2175	500	750	0.205	0.439	0.323
5/16-12	0.3125	0.2443	0.0469	1876	1083	2166	2719	625	938	0.260	0.627	0.416
3/8-12	0.3750	0.2983	0.0699	2796	1614	3229	3262	750	1125	0.313	0.763	0.505

F_u (Minimum Ultimate Tensile Strength)	100,000 psi
F_y (Minimum Tensile Yield Strength)	65,000 psi

$$A(R) = 7854K^2$$

Where: A(R) = Thread Root Area, sq. in.
K = Basic Minor Diameter, in.

$$F_t = 0.40F_u$$

$$\text{Allowable tension} = 0.40F_u[A(R)]$$

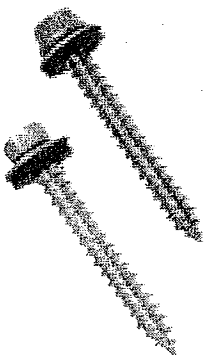
$$F_v = \frac{0.40}{\sqrt{3}}F_u$$

$$\text{Allowable shear (Single)} = \frac{0.40}{\sqrt{3}}F_u[A(R)]$$

304 SS & CARBON TAPPERS

PRODUCT REPORT NO. 040601

Selector Guide



Carbon Steel Electro Zinc Part #	304 Series Electro Zinc Part #	Description	Carbon Steel Box Qty.	304 SS Box Qty.
1874200	1863000	14 x 3/4" HWH W/ BD Type A Tappers	2,500	2,500
1875200	1864000	14 x 1" HWH W/ BD Type A Tappers	2,500	2,500
1877200	1866000	14 x 1-1/2" HWH W/ BD Type A Tappers	2,000	2,000
1879200	--	14 x 2" HWH W/ BD Type A Tappers	1,500	1,500
1880200	--	14 x 2-1/2" HWH W/ BD Type A Tappers	1,000	1,000
1881200	--	14 x 3" HWH W/ BD Type A Tappers	1,000	750
1886200	--	17 x 3/4" HWH W/ BD Type A Tappers	2,500	2,000
1887200	--	17 x 1" HWH W/ BD Type A Tappers	--	2,000

Performance Data

with Bonded Washer		PULLOUT VALUES (avg. lbs ultimate)						
		Gauge	26	24	22	20	18	16	14
Fastener		Thickness	0.018	0.024	0.030	0.036	0.048	0.060	0.075
14	Type A	Drill Size	1/8"	5/32"	5/32"	3/16"	3/16"	#7	#7
			191	252	336	371	545	694	884
Fastener		Gauge	26	24	22	20	18	16	14
		Thickness	0.018	0.024	0.030	0.036	0.048	0.060	0.075
17	Type A	Drill Size	1/8"	5/32"	5/32"	3/16"	#2	#2	1/4"
			263	307	425	475	559	791	

with Bonded Washer		PULLOVER VALUES (avg. lbs ultimate)							
		Gauge	26	24	22	20	18	16	14
Fastener		Thickness	0.018	0.024	0.030	0.036	0.048	0.060	0.075
14	Type A	Drill Size	1/8"	5/32"	5/32"	3/16"	3/16"	#7	#7
			595	827	1093	1341	1931	2229	2696
Fastener		Gauge	26	24	22	20	18	16	14
		Thickness	0.018	0.024	0.030	0.036	0.048	0.060	0.075
17	Type A	Drill Size	1/8"	5/32"	5/32"	3/16"	#2	#2	1/4"
			565	792	970	1100	1556	1813	2065

with Bonded Washer		SHEAR VALUES (avg. lbs ultimate)					
Fastener		Gauge	26-14	24-14	22-14	20-14	18-14
14	Type A	Drill Size	#7	#5	#2	#2	0.234"
			534	704	863	1245	2120
Fastener		Gauge	26-18	24-18	22-14	20-14	18-14
17	Type A	Drill Size	#2	1/4"	1/4"	1/4"	1/4"
			454	1013	1264	1544	1294

304 SS FASTENER VALUES (avg. lbs ultimate)			
Fastener (dia-tpi)	Tensile (lbs min.)	Shear (avg. lbs ult.)	Torque (min. in lbs)
14-10	2684	2148	127
17-9	N/A	N/A	229

CARBON STEEL FASTENER VALUES (avg. lbs ultimate)			
Fastener (dia-tpi)	Tensile (lbs min.)	Shear (avg. lbs ult.)	Torque (min. in lbs)
14-10	4060	2600	150
17-9	5000	2750	173

Tools and Techniques

- A standard screwgun with a depth sensitive nosepiece should be used to install Tappers. For optimal fastener performance, the screwgun should be a minimum of 6 amps and have an RPM range of 0-2500.
- Adjust the screwgun nosepiece to properly seat the fastener.
- New magnetic sockets must be correctly set before use. Remove chip build-up as needed.
- The fastener is fully seated when the head is flush with the work surface.
- Overdriving may result in torsional failure of the fastener or stripout of the substrate.
- The fastener must penetrate beyond the metal structure a minimum of 3 pitches of thread.

ITW Buildex

1349 West Bryn Mawr Avenue
Itasca, Illinois 60143
630-595-3500 Fax: 630-595-3549
www.itwbuildex.com