INSPECTION OF RIVETED BOILERS

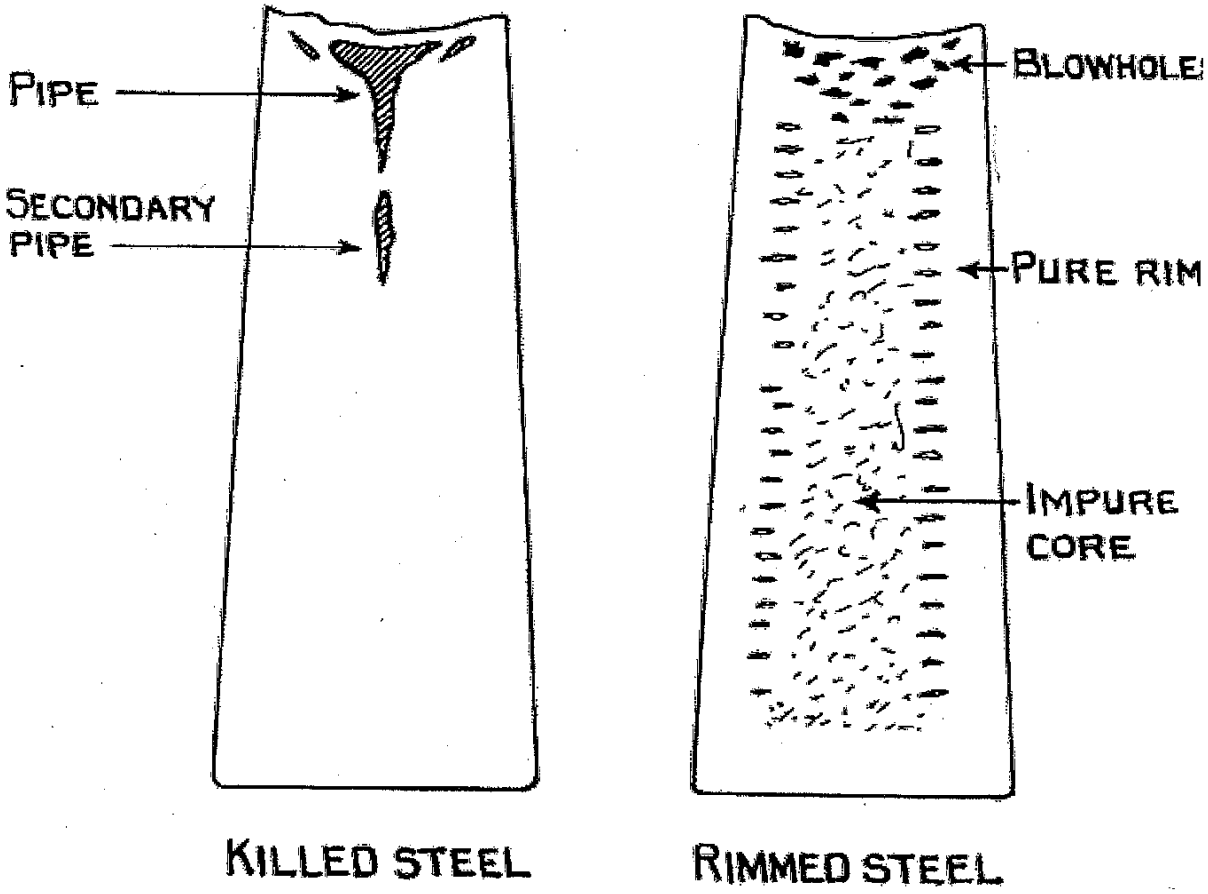
Typical Plate Steel

- S-1-Firebox or flange quality, minimum strength 55,000 psi (1914 ASME code).
- Equivalent to A70 (in 1931)
- SA 212 B split into 516 (fine grain and greater toughness) and 515 (course grain) in 1967

Types of steel ingots

- Rimmed steel - ingots have a rim of pure iron material free of defects. Conversely impurities tend to concentrate in the middle section of the ingot. This feature persists through the rolling of a plate. Therefore, the core is less pure than the superficial layers. This provides an advantage for fillet welds, cold forming and rivetting.
- Semi-Killed and Killed steels have no rimming and are homogeneous in nature.

Comparing Ingots



Limitations of Longitudinal Joints (from ASME Sect I 1971)

- Joints of a shell or drum greater than 36”ID shall be butt or double-strap.(PR-16.1)
- Joints of a shell or drum less than or equal to 36”ID may be lap-riveted when MAWP does not exceed 100psi.(PR-16.2)
- Some jurisdictions have a time limit on the life of a riveted lap joint.

Minimum Thickness of Buttstraps as per 1971 ASME Section I and 2017 Sect I PR -9

Required Thickness	Min. Thickness of Buttstraps
1/4, 9/32, 5/16, 11/32	1/4
3/8, 13/32	5/16
7/16, 15/32	3/8
1/2, 17/32, 9/16	7/16
5/8, 3/4	1/2
7/8	5/8
1	11/16
1-1/8	3/4
1-1/4	7/8
1-1/2	1

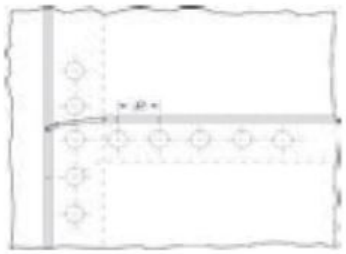
Tables in NBIC Part 2 Supplement S2.10

TABLE S2.10.3.1

MAXIMUM ALLOWABLE WORKING PRESSURE FOR CYLINDRICAL COMPONENTS (BARREL)

For Single-Riveted Lap Joint

TS x t x E/R x FS



	0.43	0.44	0.45	0.46	0.47	0.48	0.49	0.5
42	381	390	399	408	416	425	434	443
2	352	360	368	376	384	393	401	409
4	327	334	342	349	357	365	372	380
9	305	312	319	326	333	340	347	354
8	286	292	299	306	312	319	326	332
9	269	275	281	288	294	300	306	313
3	254	260	266	272	278	284	289	295
8	241	246	252	257	263	269	274	280
5	229	234	239	245	250	255	261	266
3	218	223	228	233	238	243	248	253
3	208	213	218	222	227	232	237	242
3	199	203	208	213	217	222	227	231
4	191	195	199	204	208	213	217	222
6	183	187	191	196	200	204	208	213
9	176	180	184	188	192	196	200	204
2	169	173	177	181	185	189	193	197
5	163	167	171	175	178	182	186	190
0	158	161	165	169	172	176	180	183
4	152	156	160	163	167	170	174	177
9	147	151	154	158	161	165	168	172
4	143	146	150	153	156	160	163	166
0	139	142	145	148	151	155	158	161
5	134	138	141	144	147	150	153	156
1	131	134	137	140	143	146	149	152
8	127	130	133	136	139	142	145	148
4	124	126	129	132	135	138	141	144
1	120	123	126	129	132	134	137	140
8	117	120	123	125	128	131	134	136
5	114	117	120	122	125	128	130	133
2	112	114	117	119	122	124	127	130
9	109	111	114	116	119	122	124	127
6	106	109	111	114	116	119	121	124
4	104	106	109	111	114	116	118	121
2	102	104	106	109	111	113	116	118

R = Radius of Shell (inside diameter/2)

FS = Factor of Safety (6)

TS= tensile strength (55,000)

FS= Factor of Safety (6)

E= joint eff of 58%

R= inside radius of shell

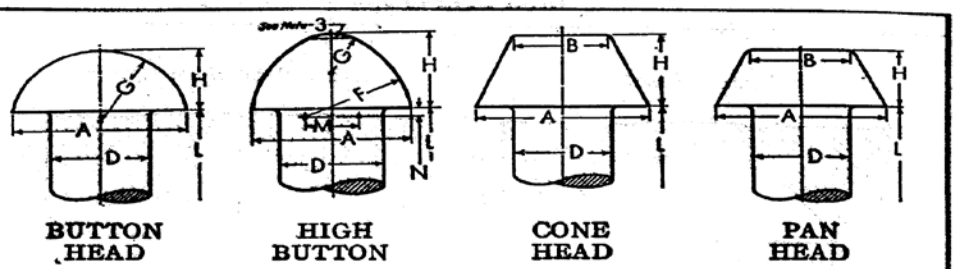
Types of rivet steel

- SA-31(dropped by ASME for a time but back by popular demand) This spec has better expansion/ductility characteristics than SA-36
- SA-36 created after 1960. ASME Section I 2005 Add. Requires this material to meet all test requirements for SA 31.
- NBIC allows SA 675 as alternative

RIVETS

ASME B18.1.2 also provides acceptable forms of finished heads
This chart is also in NBIC Part 3 Figure S2.13.13.4-a

American Standard Large Rivets — 1 (ASA B18.4-1960)



BUTTON HEAD | HIGH BUTTON | CONE HEAD | PAN HEAD

Nom. Body Diam. *D*†	Head Diam. *A*		Height *H*		Head Diam. *A*		Height *H*	
	M'f'd Note 1	Driven Note 2	M'f'd Note 1	Driven Note 2	M'f'd Note 1	Driven Note 2	M'f'd Note 1	Driven Note 2
	BUTTON HEAD				HIGH BUTTON HEAD (ACORN)			
½	0.875	0.922	0.375	0.344	0.781	0.875	0.500	0.375
⅝	1.094	1.141	0.469	0.438	0.969	1.062	0.594	0.453
¾	1.312	1.375	0.562	0.516	1.156	1.250	0.688	0.531
⅞	1.531	1.594	0.656	0.609	1.344	1.438	0.781	0.609
1	1.750	1.828	0.750	0.688	1.531	1.625	0.875	0.688
1⅛	1.969	2.062	0.844	0.781	1.719	1.812	0.969	0.766
1¼	2.188	2.281	0.938	0.859	1.906	2.000	1.062	0.844
1⅜	2.406	2.516	1.031	0.953	2.094	2.188	1.156	0.938
1½	2.625	2.734	1.125	1.031	2.281	2.375	1.250	1.000
1⅝	2.844	2.969	1.219	1.125	2.469	2.562	1.344	1.094
1¾	3.062	3.203	1.312	1.203	2.656	2.750	1.438	1.172
	CONE HEAD				PAN HEAD			
½	0.875	0.922	0.438	0.406	0.800	0.844	0.350	0.328
⅝	1.094	1.141	0.547	0.516	1.000	1.047	0.438	0.406
¾	1.312	1.375	0.656	0.625	1.200	1.266	0.525	0.484
⅞	1.531	1.594	0.766	0.719	1.400	1.469	0.612	0.578
1	1.750	1.828	0.875	0.828	1.600	1.687	0.700	0.656
1⅛	1.969	2.063	0.984	0.938	1.800	1.891	0.788	0.734
1¼	2.188	2.281	1.094	1.031	2.000	2.094	0.875	0.812
1⅜	2.406	2.516	1.203	1.141	2.200	2.312	0.962	0.906
1½	2.625	2.734	1.312	1.250	2.400	2.516	1.050	0.984
1⅝	2.844	2.969	1.422	1.344	2.600	2.734	1.138	1.062
1¾	3.062	3.203	1.531	1.453	2.800	2.938	1.225	1.141

† Tolerance for diameter of body is plus and minus from nominal and for ½-in. size equals +0.020, −0.022; for sizes ⅝ to 1-in., incl., equals +0.030, −0.025; for sizes 1⅛ and 1¼-in. equals +0.035, −0.027; for sizes 1⅜ and 1½-in. equals +0.040, −0.030; for sizes 1⅝ and 1¾-in. equals +0.040, −0.037.

Note 1. Basic dimensions of head as manufactured.

Note 2. Dimensions of manufactured head after driving and also of driven head.

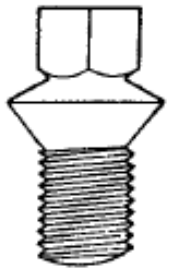
Note 3. Slight flat permissible within the specified head-height tolerance.

The following formulas give the basic dimensions for manufactured shapes: *Button Head Rivets:* $A = 1.75D$; $H = 0.75D$; $G = 0.885D$. *High Button Head:* $A = 1.50D + 0.031$; $H = 0.75D + 0.125$; $F = 0.75D + 0.281$; $G = 0.75D - 0.281$; $M = 0.50$; $N = 0.094$. *Cone Head:* $A = 1.75D$; $H = 0.875D$; $B = 0.938D$. *Pan Head:* $A = 1.60D$; $B = D$; $H = 0.70D$. The length (L), in all cases, is measured from the largest diameter of the bearing surface of the head, to the point in a line parallel with the axis of the rivet.

Patch Bolts

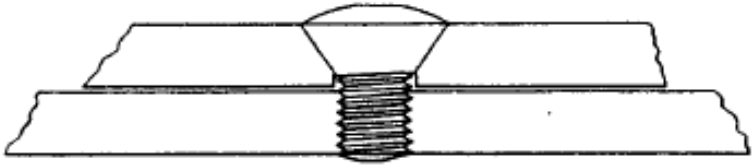
Part 3 Figures
S1.2.8 and
S2.13.6

— **Patch Bolts**



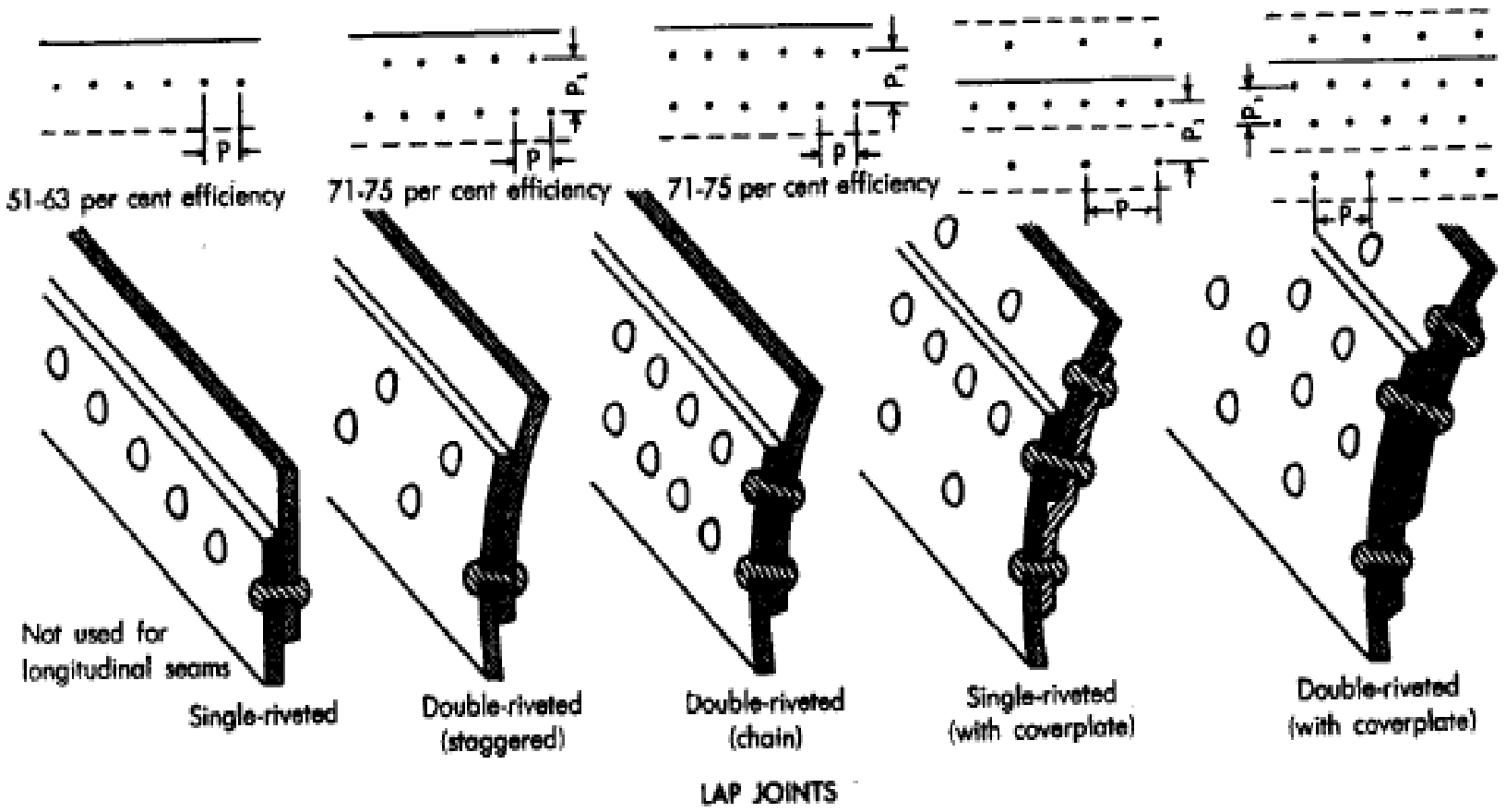
Typical Patch Bolts

Typical Patch Bolt Application



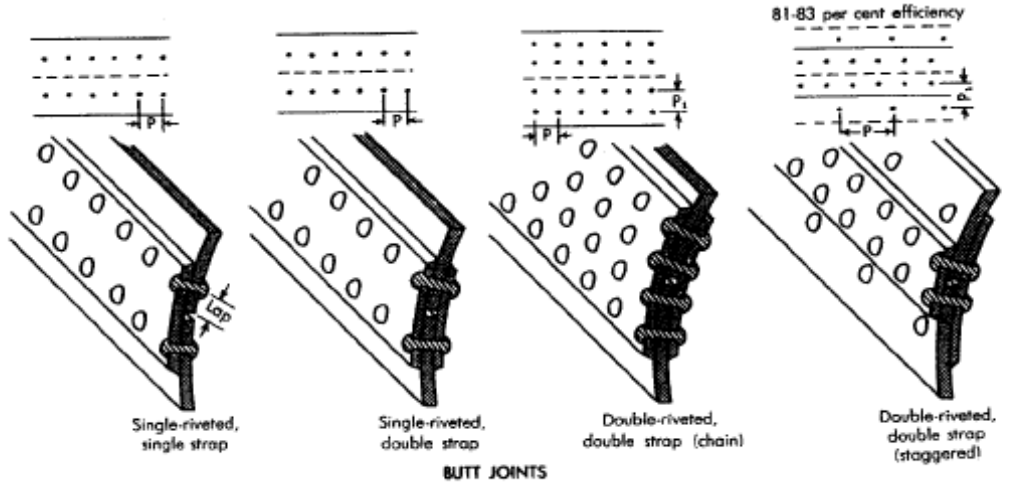
Types of Lap joints

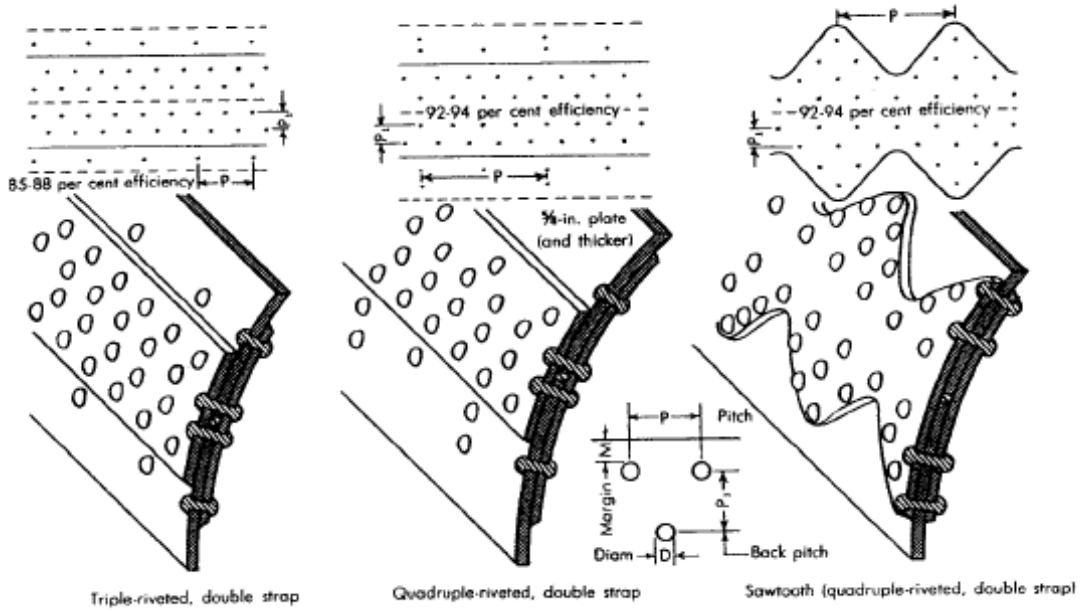
RIVETING



LAP JOINTS

Types of Buttstrap joints





Mud rings

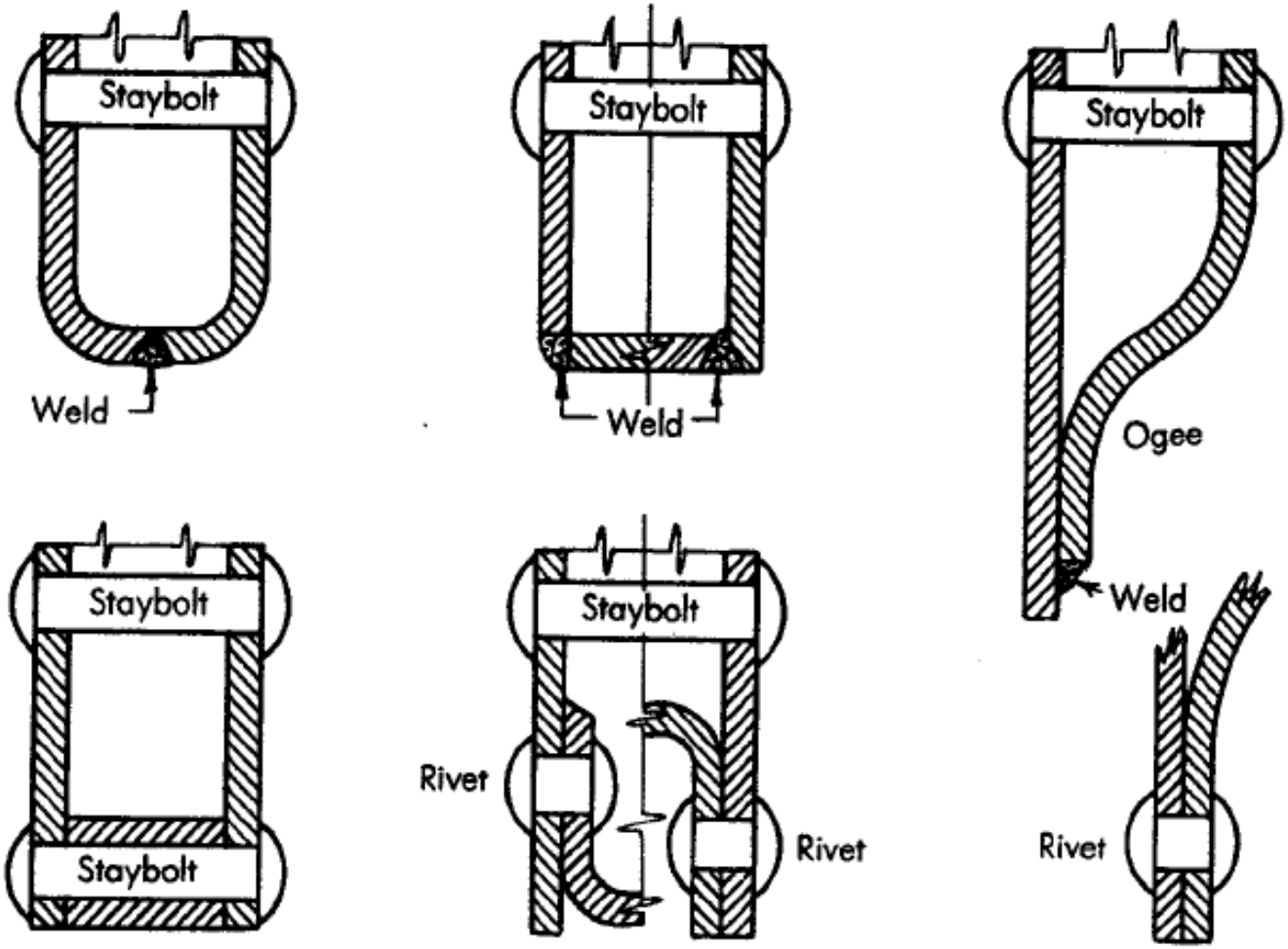
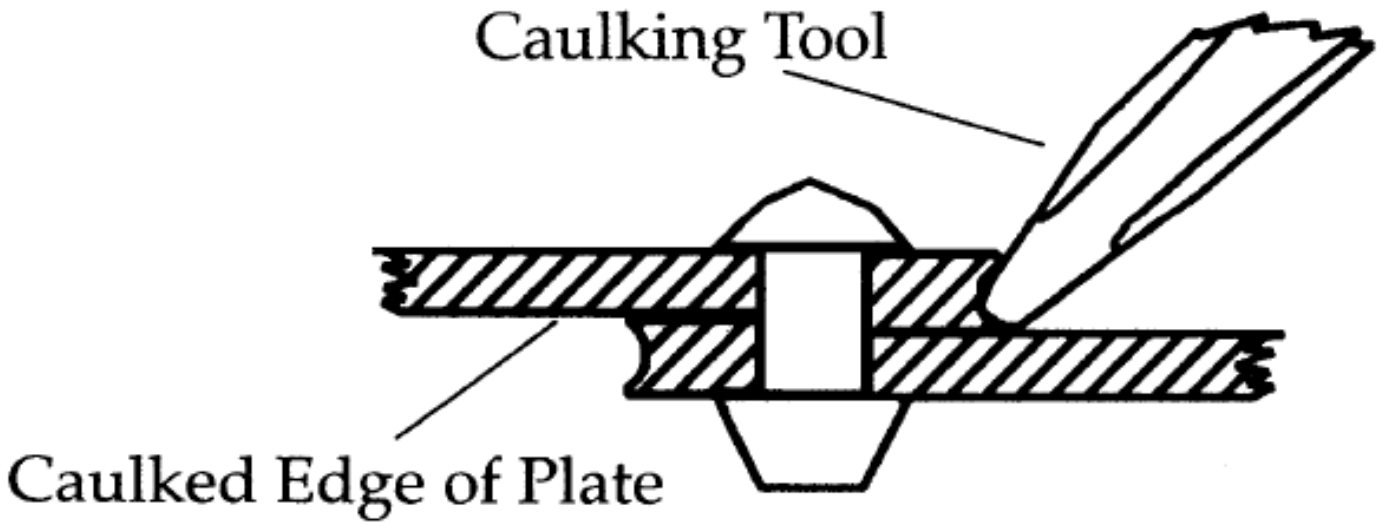


Fig. 22.14 Staybolting, riveting, and welding at firebox boiler mud ring

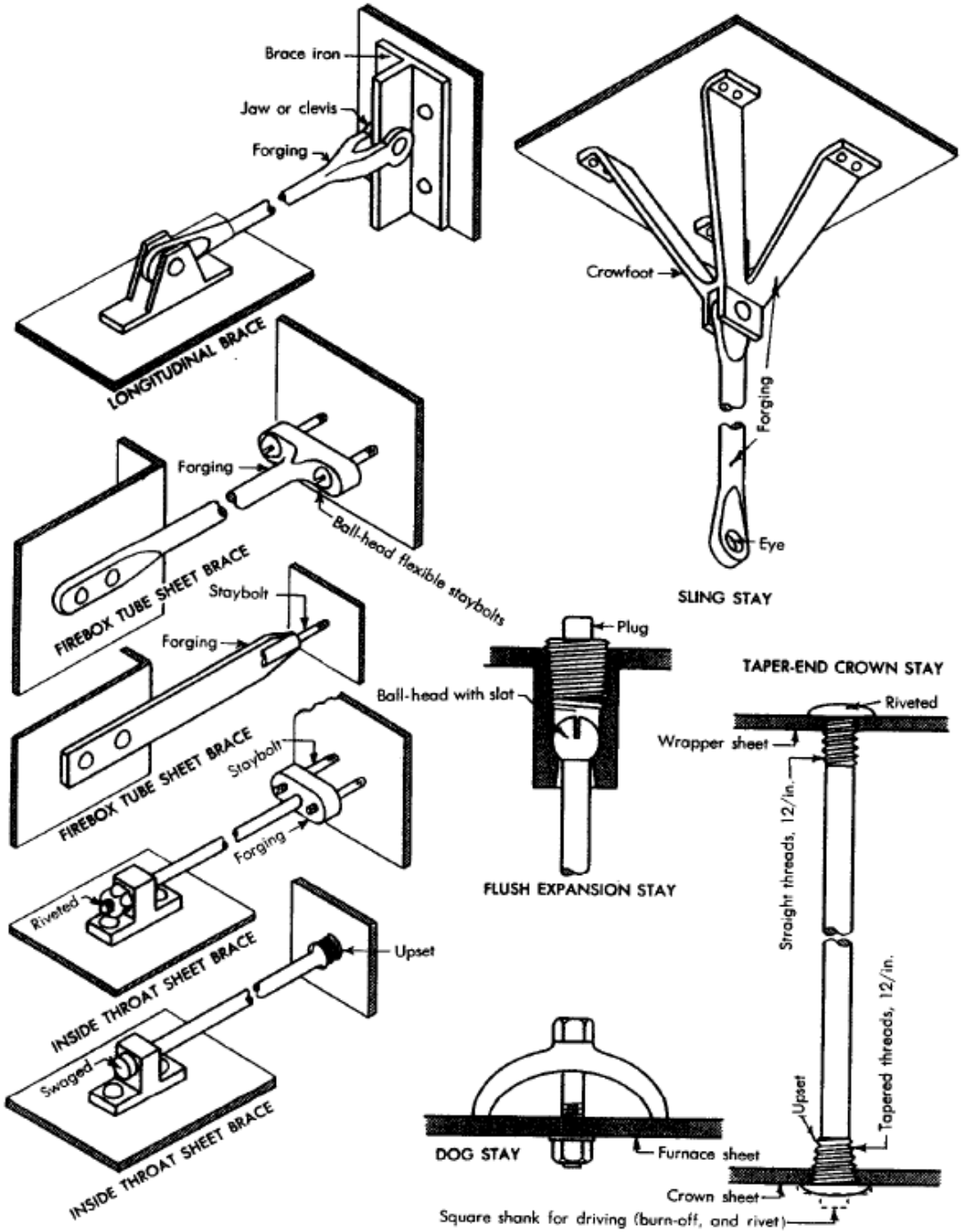
Caulking tool

Used to seal the joint from a corrosive atmosphere. This important to prevent crevice corrosion cracking.

Part 3 fig S2.13.13.1



Stays and Braces



More stays

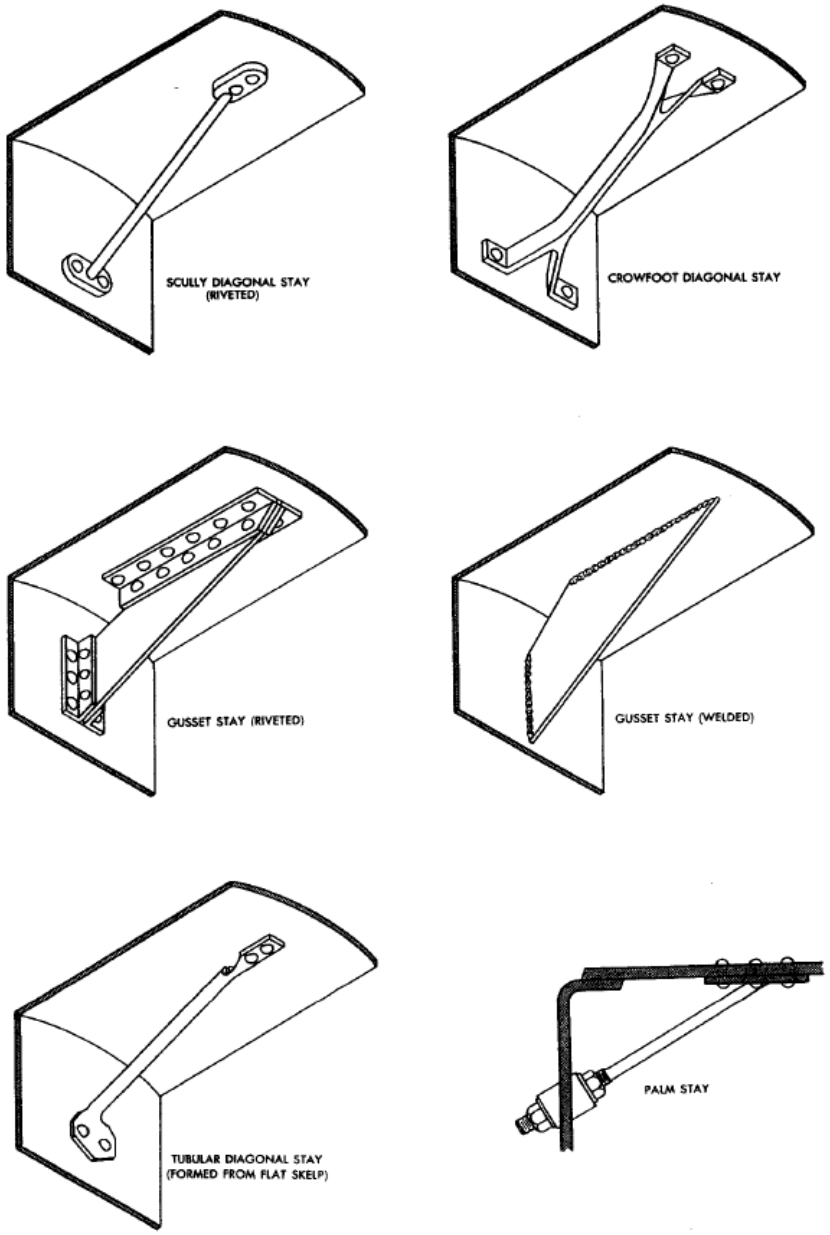


Fig. 22.10 Diagonal-stays

Stay Brace

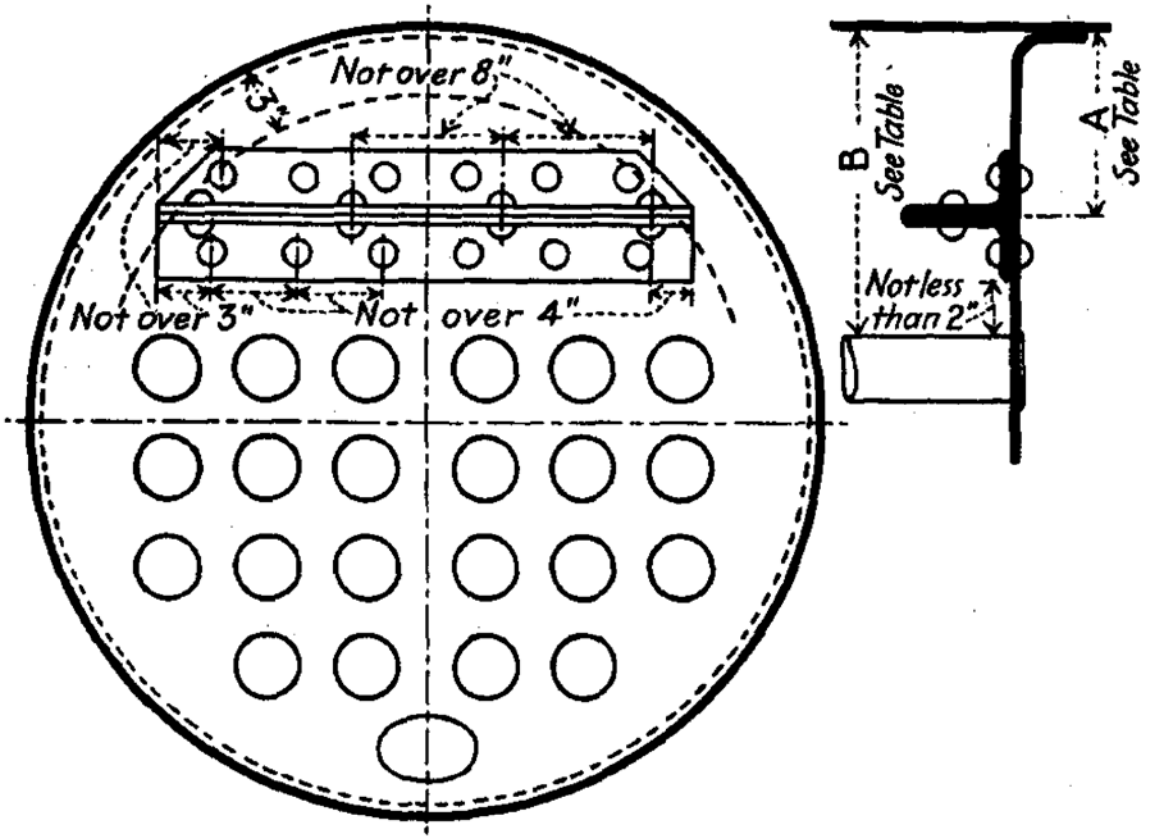
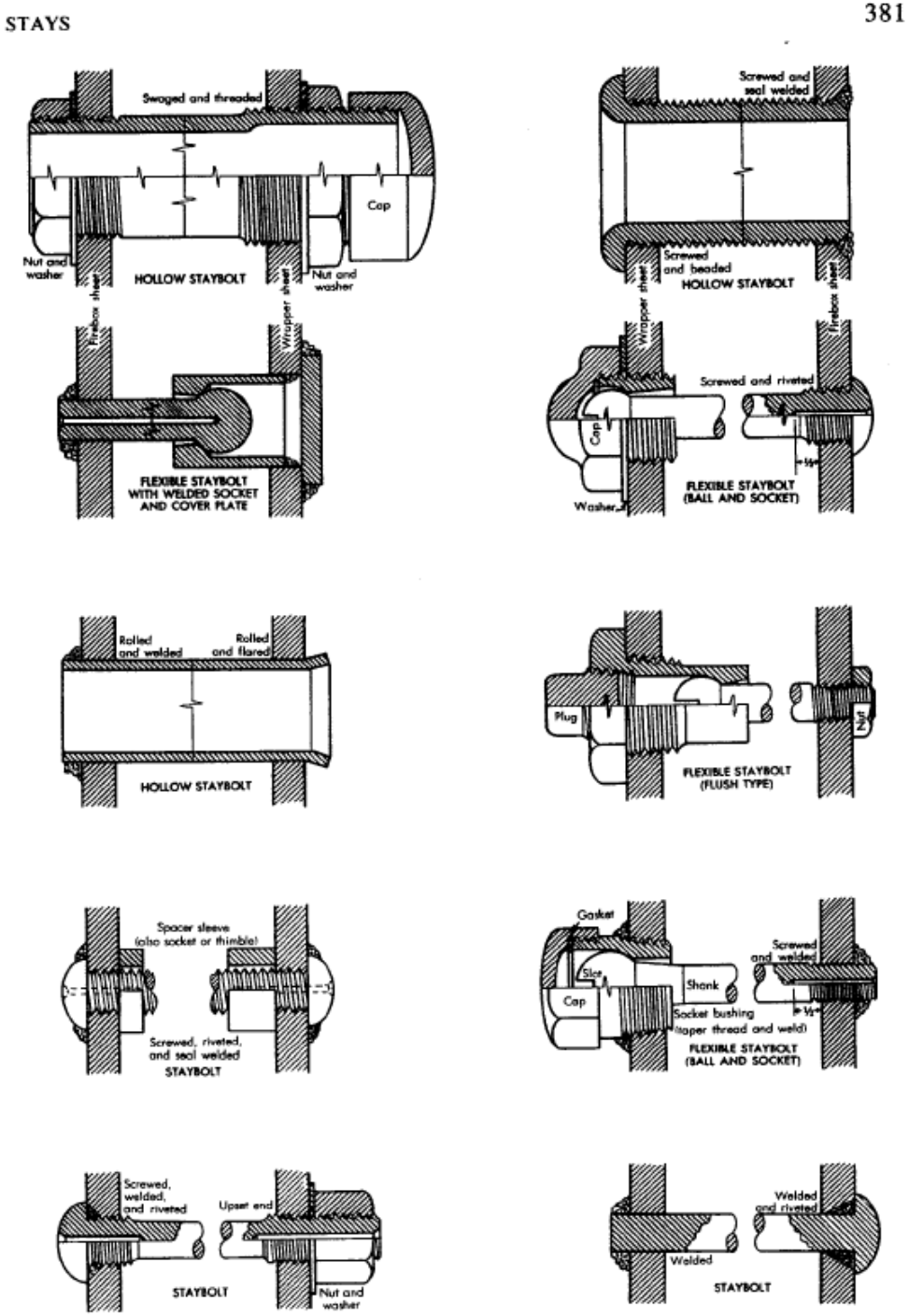
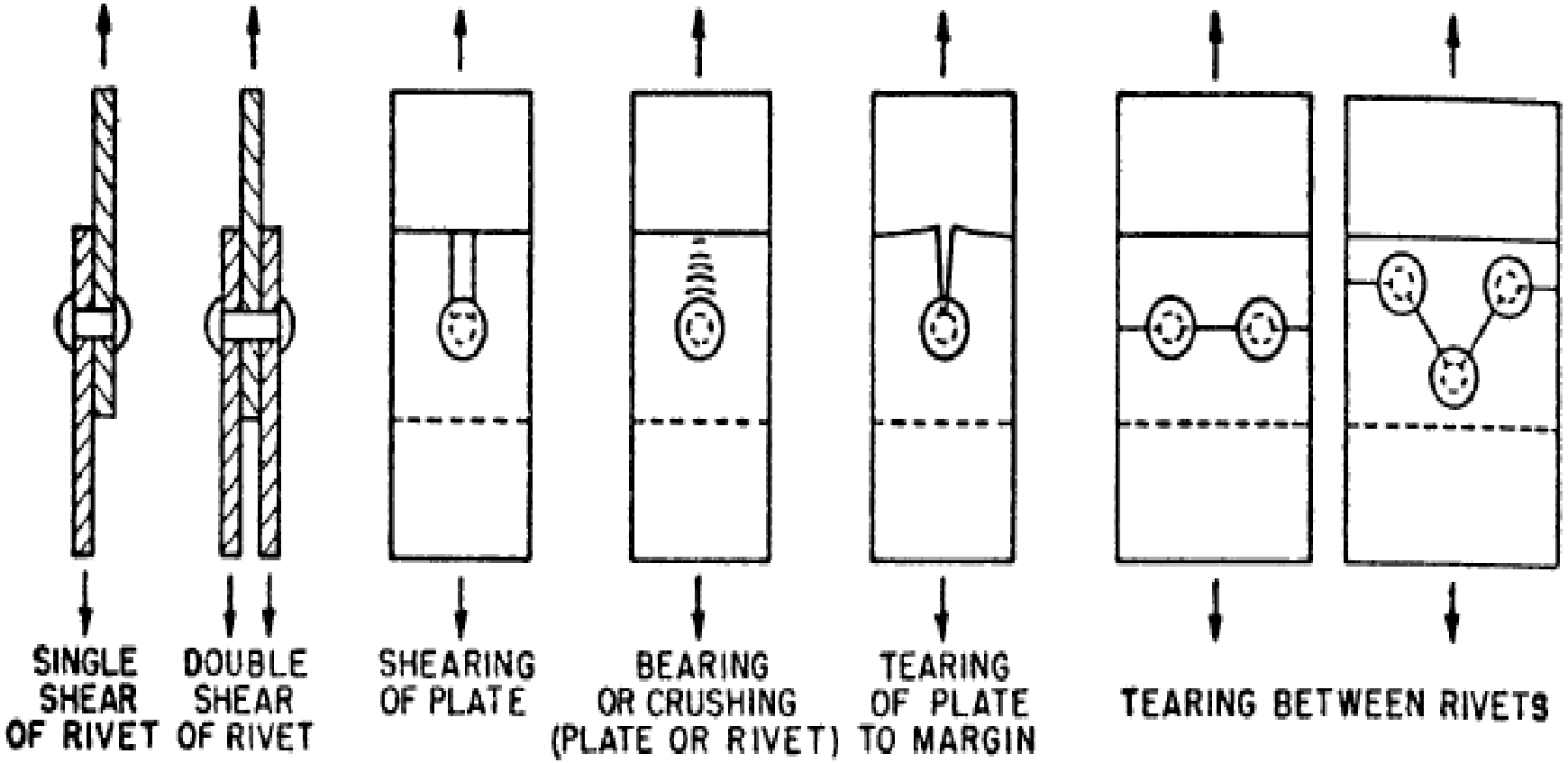


FIG. 16 · STAYING OF HEAD WITH STEEL ANGLES IN TUBULAR BOILER

Staybolts


STAYS
381
Swaged and threaded
Cap
Nut and washer
HOLLOW STAYBOLT
Nut and washer
Firebox sheet
Wrapper sheet
FLEXIBLE STAYBOLT WITH WELDED SOCKET AND COVER PLATE
Screwed and seal welded
Screwed and beaded
HOLLOW STAYBOLT
Wrapper sheet
Firebox sheet
Screwed and riveted
Cap
Washer
FLEXIBLE STAYBOLT (BALL AND SOCKET)
Rolled and welded
Rolled and flared
HOLLOW STAYBOLT
Plug
Nut
FLEXIBLE STAYBOLT (FLUSH TYPE)
Spacer sleeve (also socket or thimble)
Screwed, riveted, and seal welded
STAYBOLT
Gasket
Slot
Shank
Cap
Socket bushing (taper thread and weld)
Screwed and welded
FLEXIBLE STAYBOLT (BALL AND SOCKET)
Screwed, welded, and riveted
Upset end
STAYBOLT
Nut and washer
Welded and riveted
Welded
STAYBOLT

Types of Rivet & Plate Failure



Intergranular corrosion cracking at rivet holes also.

Bulges

FIGURE S2.10.4.2-a

POINT OF TANGENCY OF THE CURVE IN A BULGE WITHIN 't' OF THE EDGE OF THE STAYBOLT

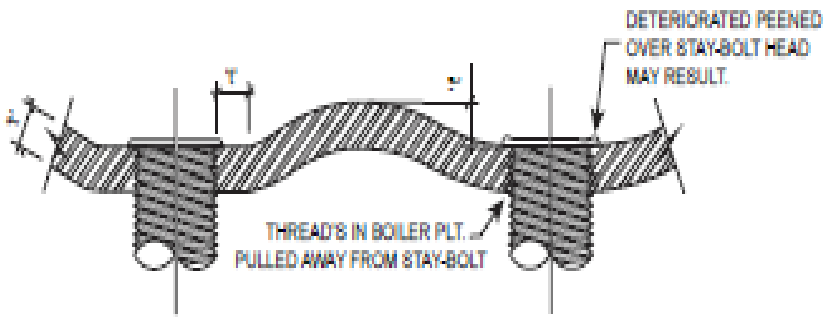
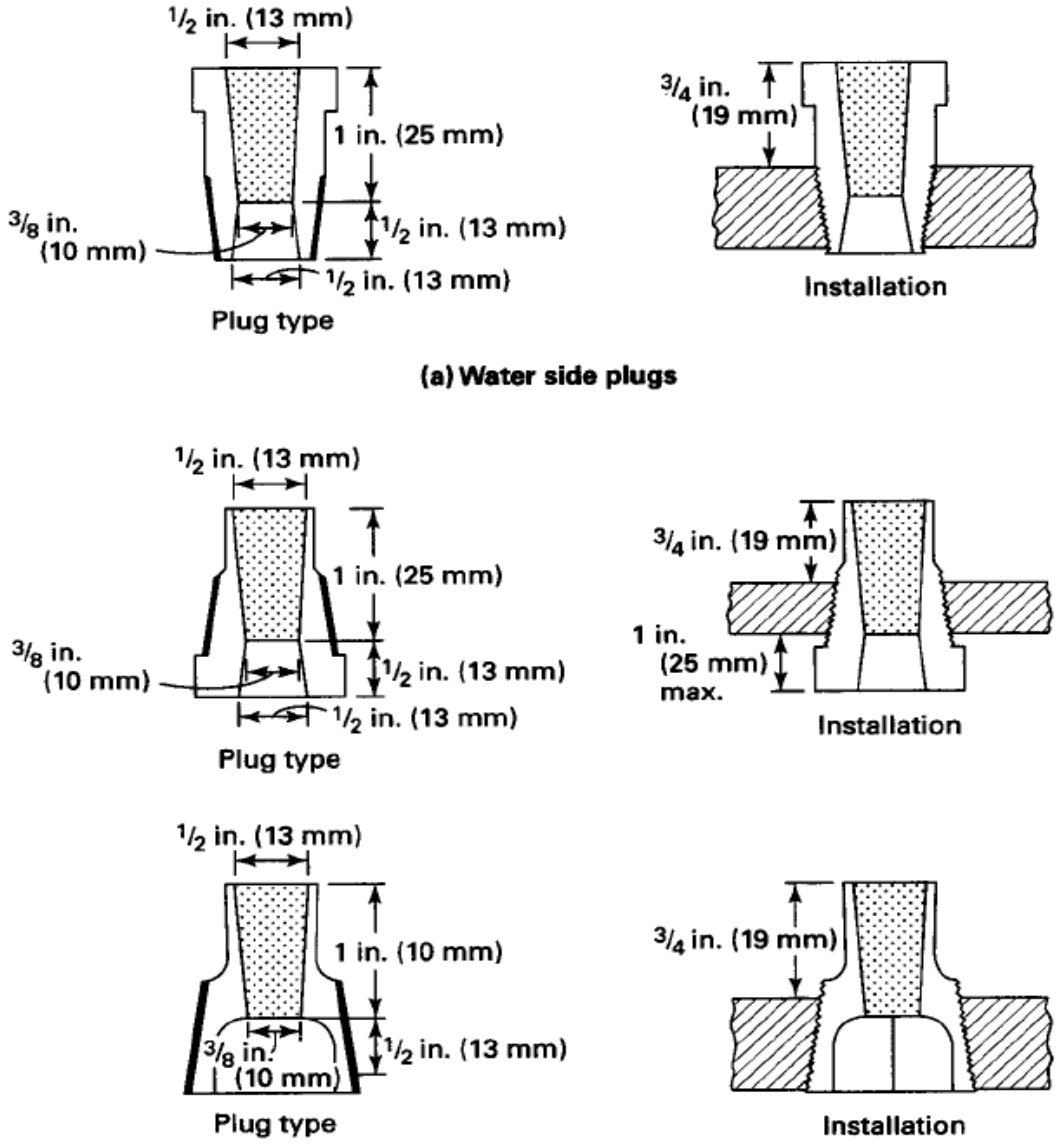


FIGURE S2.10.4.2-b

CONTINUOUS BULGING WHERE ONLY SOME BULGES EXCEED ALLOWABLE DEFORMATION

Fusible plugs



GENERAL NOTE: All dimensions minimum unless otherwise specified

FIG. A-10 TYPICAL FORMS OF FUSIBLE PLUGS

Leaks

- *Leaking rivets should be re-caulked.
- *Small cracks are drilled at each end and patched (or welded).
- *Joints should be re-caulked (welding should be a last resort and should be minimized).
- Leaking tell tale holes in stays indicate a broken stay
- *All of these methods should be approved by the jurisdiction before work begins.

Weld repairs

- Small seal welds instead of caulking are OK with a qualified welder and procedure. However, heat treatment may be required.
- Full penetration welds should be monitored closely because of the potential of welding to rimmed steel.
- Dye penetrant exam before welding is recommended

Before welding the riveted lap joint

After welding the riveted lap joint