

INCH-POUND

MIL-STD-403C

30 June 1992

SUPERSEDING

MIL-STD-403B

14 June 1968

MILITARY STANDARD
PREPARATION FOR AND INSTALLATION OF
RIVETS AND SCREWS, ROCKET,
MISSILE, AND AIRFRAME STRUCTURES



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FOREWORD

1. This military standard is approved for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, U.S. Army Missile Command, ATTN: AMSMI-RD-SE-TD-ST, Redstone Arsenal, AL 35898-5276 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Purpose. The purpose of this standard is to establish acceptable limitations applicable to preparation for, and installation of rivets and screws for rocket, missile and airframe structures.

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2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATION

MILITARY

MIL-P-116	-	Preservation, Methods of
MIL-S-8802	-	Sealing Compound, Temperature-Resistant, Integral Fuel Tanks and Fuel Cell Cavities, High Adhesion
MIL-S-11030	-	Sealing Compound, Single Component, Non-Curing, Polysulfide Base

SPECIFICATION

FEDERAL

TT-P-1757	-	Primer Coating, Zinc Chromate, Low-Moisture Sensitivity
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STANDARD

MILITARY

MIL-STD-171	-	Finishing of Metal and Wood Surfaces
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(Unless otherwise indicated, copies of the federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Bldg. 4D, 700 Robbins Ave., Philadelphia, PA 19111-5094.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document,

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however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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3. DEFINITIONS

3.1 Definitions. For the purposes of this standard, the following definitions shall apply.

3.2 Cocked head. The seating of either the manufactured head or the upset head at an angle other than perpendicular to the shank of the rivet parallel to the surface.

3.3 Manufactured head. The head formed at the time the rivet is manufactured.

3.4 Upset head (shop formed). The head formed during the riveting operation.

3.5 Dimpling. Stretching a relatively small shallow indentation into sheet metal. Stretching metal into a conical flange for use of a countersunk rivet or screw. Dimpling is substantially stronger than countersinking and should be performed on relatively thin panels.

3.5.1 Draw dimpling. Dimpling that is produced by utilizing a male and female die without first preparing a pilot hole. The dimple dies punch the hole and form the dimple in a single operation. (NOTE - Draw dimpling shall not be permitted without written approval of the procuring activity.)

3.5.2 Modified-radius dimpling. Dimpling which is produced by utilizing a male and female die where the contour of the dies results in a dimple with the top and bottom sides of the dimple non-parallel.

3.6 Countersinking (machine countersinking). Chamfering a conical depression around the top of a hole for receiving the head of a fastener.

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4. GENERAL REQUIREMENTS

4.1 Hole formation.

4.1.1 Hole sizes. Unless otherwise specified, pilot holes shall be drilled before dimpling. The final hole size shall be drilled or reamed after dimpling, or countersinking. Hole tolerance shall be in accordance with tables I, II, III, or IV.

4.2 Dimpling. Where flush applications of rivets and screws are specified, both sheets to be joined shall be dimpled when each sheet is within the thickness specified in tables I, II, III, or IV. All parts shall be dimpled separately with the following exceptions:

a. Parts cemented together with a total thickness not greater than the greatest thickness for dimpling.

b. Parts, spot or seam welded, with a total thickness greater than the greatest thickness for dimpling.

4.2.1 Modified-radius dimpling. Modified-radius dimpling shall be used when dimpling by form countersinking is not possible with the following exceptions:

a. A modified-radius dimple shall not nest into another modified-radius dimple.

b. The greatest material thickness for modified-radius dimpling shall be 0.064 inch.

c. The greatest size of modified-radius dimple shall be 0.188 inch diameter rivet.

4.2.2 Cracked dimples. Cracked dimples shall be rejected. Any repairs shall be subject to engineering approval.

4.3 Countersinking. Countersinking shall be used when the outer sheet is within the limits specified in tables I, II, III, or IV, or when dimpling is not permitted by engineering drawings or by this standard.

4.4 Combination dimple and countersinking for rivets and screws. This method shall be used only when specified on the engineering drawings or when the outer sheet is less than the least

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thickness for countersinking and the inner sheet is greater than the greatest thickness for dimpling.

4.5 Cleaning and protective coatings.

4.5.1 Finishing sequence. Parts shall be cleaned (see 4.5.2), surface treated or electroplated, and primed in detail prior to assembly as specified on applicable drawings.

4.5.1.1 Sealing. Rivets, buck bolts, blind rivets and threaded fasteners shall be assembled with wet, unthinned zinc chromate primer conforming to TT-P-1757. If the fasteners are dissimilar to and can result in a direct contact with magnesium, a washer of 5052 aluminum alloy with not less than an over-lap of 0.125 to 0.25 inch shall be used in addition to TT-P-1757 primer. Other sealing compounds, such as materials conforming to MIL-S-11030 and MIL-S-8802, may be used as substitute for TT-P-1757 when approved by the procuring activity.

4.5.2 Cleaning of mating surfaces. All chips, burrs, and foreign material shall be removed from the mating surfaces prior to surface treating.

4.5.2.1 Removal of strippable coating. The temporary strippable coatings must be removed from all joints and from under the heads of all fasteners before installations.

4.5.3 Materials to be stored. Materials which are to be stored after drilling, countersinking, or dimpling prior to finishing shall be protected against corrosion in accordance with the applicable methods of MIL-P-116. In cases where drilling, countersinking, or dimpling is accomplished after finishing, the damaged areas of the protective finish shall be repaired with a suitable surface treatment meeting the requirements of MIL-STD-171 and reprimed.

4.5.4 Gap limitations between joined sheets. Gap limitations between joined sheets shall be in accordance with figures 1 and 6 and tables I, II, III and IV.

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5. DETAILED REQUIREMENTS

5.1 Dimpled holes. When dimpling is performed, pilot holes shall be drilled, the material dimpled, then the hole drilled or reamed to the final size noted in tables I, II, III, or IV. Both sheets to be joined shall be dimpled when each sheet is within the thickness limits specified in figures 1 or 6 and tables I, II, III, or IV.

5.1.1 Dimpling. Aluminum, magnesium and titanium alloy sheet stock shall be dimpled in accordance with temperature requirements of 5.1.1.1.

5.1.1.1 Dimpling temperatures. The following temperatures must be obtained at the bend radii during the dimple cycle:

2024-T3 or T4	Ambient Temperature
*6061-T4	Ambient Temperature
*6061-T6	Ambient Temperature
7075-T6	Not less than 149° Celsius (C) - Not greater than 204°C
2024-T6	Not less than 149°C - Not greater than 204°C
Magnesium	Not less than 149°C - Not greater than 204°C
Titanium	Not less than 316°C - Not greater than 426°C

* If cracking occurs, heat to not less than 149°C - not greater than 204°C. Dimpling of 7075-T6, interrupted-aged, material may be done at room temperature with the written approval of the procuring agency.

5.1.1.2 Hot dimpling precaution. The method of hot dimpling shall be controlled to prevent loss of sheet strength. When thermocouple controlled temperature heater blocks are used, the heater blocks shall be tight on the dies at operating temperature. The thermocouple location shall be near the dies and approximately the same location in all heater blocks. Any protective finish or

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treatment must be removed around the area contacted by the dimpling tools.

5.2 Rivets.

5.2.1 Conventional rivets. The application of conventional rivets shall be in accordance with table I, unless otherwise specified on the engineering drawing.

5.2.2 Pull-through and self-plugging blind rivets. Pull-through and self-plugging blind rivets shall be installed as in accordance with table II and the manufacturers recommended practices except as modified by the engineering drawing or by this standard.

5.2.2.1 Acceptable and unacceptable limits of upset heads. Acceptable and unacceptable limits of upset heads shall be as shown in Figure 4. Choice of the proper rivet size and grip length will be the controlling factor to meet these conditions.

5.2.3 Chemically expanded rivets. Chemically expanded rivets shall be installed in accordance with table III and the manufacturer's recommended practices except as modified by the engineering drawing or by this standard.

5.2.4 Rivet hole tolerance. Unless otherwise specified, holes shall be prepared for rivets in accordance with the tolerances specified in tables I, II, or III. Oversize holes shall be corrected by the use of one size larger rivet with the following restrictions:

a. Not more than 10 percent (%) of the rivets in the pattern shall be affected.

b. The least required edge distance and sufficient head clearance for the replacement rivet shall be obtainable. NOTE - Edge distance is the distance from the center line of the rivet to the edge of the sheet or joint. This dimension should not be less than two times the rivet diameter in sheet stock, three times the rivet diameter in non-ferrous castings. Generally, rivet spacing is called out on all drawings in accordance with stress requirements.

c. The hole shall not have a dimension greater than the allowable diameter for the next larger size rivet.

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d. When countersinks are oversize the skin thickness shall permit the use of the next larger size rivet.

5.2.5 Countersinking. Unless otherwise specified on the engineering drawing, countersinking sizes and dimensional limitations shall be in accordance with figure 2 and table I, III, or III.

5.2.6 Combination dimple and countersinking. Combination dimple and countersinking sizes and dimensional limitations shall be in accordance with figure 3 and tables I, II, or III.

5.2.7 Rivet heads.

5.2.7.1 Manufactured rivet head height. Manufactured heads of countersunk rivets shall not be below the skin of exposed or critical surfaces either before or after driving. Unless otherwise specified on the engineering drawing, the projection height of countersunk heads shall be not greater than 0.004 inch (see figure 1). A maximum of 0.006 inch may be shaved from a protruding head in order to meet this requirement.

5.2.7.2 Cocked heads. Cocking of either head (manufactured or upset) shall not be allowed, except where one or more joined surfaces are angular. When only one side of the material to be joined is in an angular position, the upset head shall be formed on the angular side of the material.

5.2.7.3 Upset heads. The diameter and height of upset heads shall be determined in accordance with figure 5 and table V or VI.

5.2.7.4 Malformed upset heads. The mean height of malformed upset heads shall be not less than one-third of the rivet-shank diameter. The mean height shall be within the limits specified in tables V or VI.

5.2.7.4.1 Cracked upset heads. Very fine radial cracks located on or around the periphery are not acceptable if they are wedge shaped or permit chips to fall out. Radial shear cracks shall be not greater than 0.125 inch of nominal shank diameter in depth or 0.063 of nominal shank diameter in width. There shall be no cracks within a circle concentric with and 1.10 times the under shank diameter. The crack criteria for upset rivet heads does not apply to barrel sections of rivets.

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5.2.7.5 Marring of the manufactured head. A cut or ring caused by the riveting equipment used shall be acceptable on non-flush rivets providing the depth of the cut is not greater than one-fourth of the head height. Cut or ringed flush rivets shall not be acceptable.

5.2.7.6 Head gap. Gaps under the manufactured head of non-flush rivets installed on a flat surface shall not be acceptable. Heads of non-flush rivets installed on convex surfaces shall seat flat longitudinally only.

5.2.8 Rivet lengths. The rivet length shall be selected to allow sufficient material to form the correct size driven head. Table VII shows the nominal shank projection before the driving for rivets up to 0.375 inch in length. Rivet length shall be selected so that the finished rivet will meet the requirements of this standard and applicable specification and drawings.

5.3 Screws.

5.3.1 Hole sizes. Unless otherwise specified on the engineering drawings, hole sizes for screw installation shall be in accordance with table IV.

5.3.2 Oversize holes. Oversize holes may be corrected when approved by the procuring agency.

5.3.3 Countersinking. Countersinking sizes and dimensional limitations shall be in accordance with figure 7 and table IV, unless otherwise specified on the engineering drawings.

5.3.4 Combination dimple and countersinking. Combination dimple and countersinking sizes and dimensional limitations shall be in accordance with figure 6 and table IV.

5.4 Skin damage. Damage or deformation of the skin from the riveting equipment or flushhead shaver shall not be acceptable.

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6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. This standard is intended to establish acceptable limitations applicable to preparation for, and installation of rivets, and screws for rocket, missile, and airframe structures.

6.2 Issue of DODISS. When this standard is used in acquisition, the applicable issue of the DODISS must be cited in the solicitation (see 2.1.1 and 2.2).

6.3 Metrication. Metric equivalents in accordance with FED-STD-376 are acceptable for use in this specification.

6.4 Subject term (key word) listing.

Bolts
Couplings
Fasteners
Pins

6.5 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Custodian:
Army - MI

Preparing activity:
Army - MI

Review activities:
Army - AR, EA, ME
AF-99

Project No. 1410-8117

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TABLE I. Holes for conventional rivets.

Rivet size		0.0625	0.0938	0.125	0.156	0.188	0.25	0.313	0.375
Hole size before dimpling	Min.	0.064	0.096	0.128	0.159	0.191	0.250	0.312	0.375
Final hole size	Min. Max.	0.067 0.071	0.098 0.106	0.129 0.139	0.161 0.172	0.191 0.204	0.257 0.266	0.320 0.330	0.386 0.404
Sheet thickness for dimpling	Min. Max.	0.016 0.040	0.016 0.051	0.016 0.064	0.016 0.072	0.016 0.091	0.016 0.125	0.016 0.156	0.016 0.188
Sheet thickness for countersinking	Min.	0.032	0.040	0.051	0.064	0.072	0.102	0.125	0.156
Countersink diameter ¹	Min. Max.	0.095 0.105	0.160 0.170	0.206 0.216	0.267 0.277	0.334 0.344	0.457 0.467	0.545 0.555	0.675 0.685
Countersink diameter ²	Min. Max.	0.117 0.127	0.167 0.177	0.215 0.225	0.285 0.293	0.349 0.359	0.471 0.481		
"G" gap (see Fig. 1)Max.		0.005	0.010						

¹Countersink dimensions to be used when countersinking is the only method of hole preparation used.

²Countersink dimensions to be used when combination predimple and countersink method of hole preparation is used.

TABLE II. Holes for pull-through and self-plugging rivets.

Rivet size	0.125	0.156	0.188	0.25	0.134	0.172	0.203
Hole size before	Min.	0.128	0.161	0.234	0.120	0.159	0.193
Final hole size	Min.	0.160	0.192	0.256	0.137	0.177	0.206
	Max.	0.164	0.196	0.261	0.141	0.181	0.210
Sheet thickness for dimpling	Min.	0.016	0.016	0.016	0.016	0.016	0.016
	Max.	0.051	0.091	0.125	0.051	0.072	0.091
Sheet thickness for countersinking	Min.	0.051	0.072	0.102	0.051	0.064	0.072
Countersink diameter ¹	Min.	0.206	0.267	0.334	0.206	0.267	0.334
	Max.	0.216	0.277	0.344	0.216	0.277	0.344
Countersink diameter ²	Min.	0.215	0.283	0.349	0.215	0.283	0.349
	Max.	0.225	0.293	0.359	0.225	0.293	0.359
"G" gap (see fig. 1)	Max.	0.010					

¹Countersink dimensions to be used when countersink is the only method of hole preparation used.

²Countersink dimensions to be used when combination predimple and countersink method of hole preparation is used.

TABLE III. Holes for chemically expanded rivets.

Rivet size		0.125	0.156	0.188
Hole size before dimpling	Min.	0.128	0.157	0.189
Final hole size	Min.	0.136	0.173	0.204
	Max.	0.139	0.176	0.207
Sheet thickness for dimpling	Min.	0.016	0.016	0.016
	Max.	0.051	0.072	0.091
Sheet thickness for countersinking	Min.	0.051	0.064	0.072
Countersink diameter ¹	Min.	0.206	0.267	0.334
	Max.	0.216	0.277	0.344
Countersink diameter ²	Min.	0.206	0.267	0.334
	Max.	0.216	0.277	0.344
"G" gap (see fig. 1)	Max.	0.010		

¹Countersink dimensions to be used when countersinking is the only method of hole preparation used.

²Countersink dimensions to be used when combination predimple and countersink method of hole preparation is used.

TABLE IV. Hole for screws (See fig. 6 & 7).

Screw size	4	6	8	10	0.25	0.313	0.375	0.438	0.5	0.563	0.625
Hole size before dimpling	Min. 0.098	0.098	0.106	0.128	0.166	0.205	0.261				
Final hole size	Min. 0.112 Max. 0.116	0.138 0.142	0.166 0.170	0.191 0.194	0.250 0.254	0.312 0.316	0.375 0.379	0.437 0.442	0.500 0.505	0.562 0.567	0.625 0.630
Sheet thickness for dimpling	Min. 0.016 Max. 0.051	0.016 0.064	0.016 0.081	0.016 0.091	0.016 0.125	0.016 0.156	0.016 0.188	0.016 0.204	0.016 0.231	0.016 0.251	0.016 0.286
Sheet thickness for countersinking	Min. 0.064 Max. 0.051 outer inner	0.072 0.294	0.081 0.342	0.091 0.395	0.125	0.156	0.188	0.204	0.231	0.251	0.286
Countersink diameter ¹	Min. 0.220 Max. 0.230	0.284 0.294	0.332 0.342	0.385 0.395	0.507 0.517	0.635 0.645	0.762 0.772	0.890 0.900	1.017 1.027	1.145 1.155	1.272 1.282
Countersink diameter ²	Min. 0.215 Max. 0.225	0.283 0.293	0.333 0.343	0.386 0.396	0.513 0.523	0.639 0.649	0.767 0.777	0.940 0.950	1.067 1.077	1.195 1.205	1.322 1.332
"G" gap (see fig. 6)	Max.	0.010									

¹Countersink dimensions to be used when countersinking is the only method of hole preparation used.

²Countersink dimensions to be used when combination predimple and countersink method of hole preparation is used.

TABLE V. For 2017-T rivets driven hard (see fig. 5).

Size	Tolerance of upset rivet heads		
	Diameter max. 1.5D	Height min. 0.5D	Diameter min. 1.25D
0.0938	0.140	0.047	0.125
0.125	0.187	0.062	0.156
0.156	0.234	0.078	0.203
0.188	0.281	0.093	0.234
0.25	0.375	0.125	0.312
0.313	0.469	0.156	0.391
0.375	0.562	0.187	0.469
			0.250

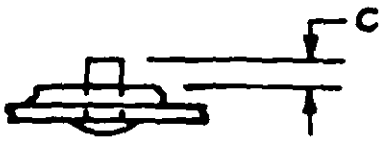
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TABLE VI. For all rivets except 2017-T rivets driven hard (see fig. 5).

Size	Tolerance of upset rivet heads			
	Diameter max. 1.66D	Height min. 0.33D	Diameter min. 1.25D	Height Max. 0.66D
0.0938	0.156	0.031	0.125	0.062
0.125	0.203	0.047	0.156	0.078
0.156	0.264	0.047	0.203	0.109
0.188	0.312	0.063	0.234	0.125
0.25	0.423	0.078	0.312	0.172
0.313	0.515	0.108	0.391	0.203
0.375	0.625	0.125	0.469	0.250

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TABLE VII. Average nominal projection before driving.

Rivet Diameter	Dimension C	
0.0625	.094	
0.938	.141	
0.125	.188	
0.156	.234	
0.188	.281	
0.25	.375	
0.313	.469	
0.375	.562	

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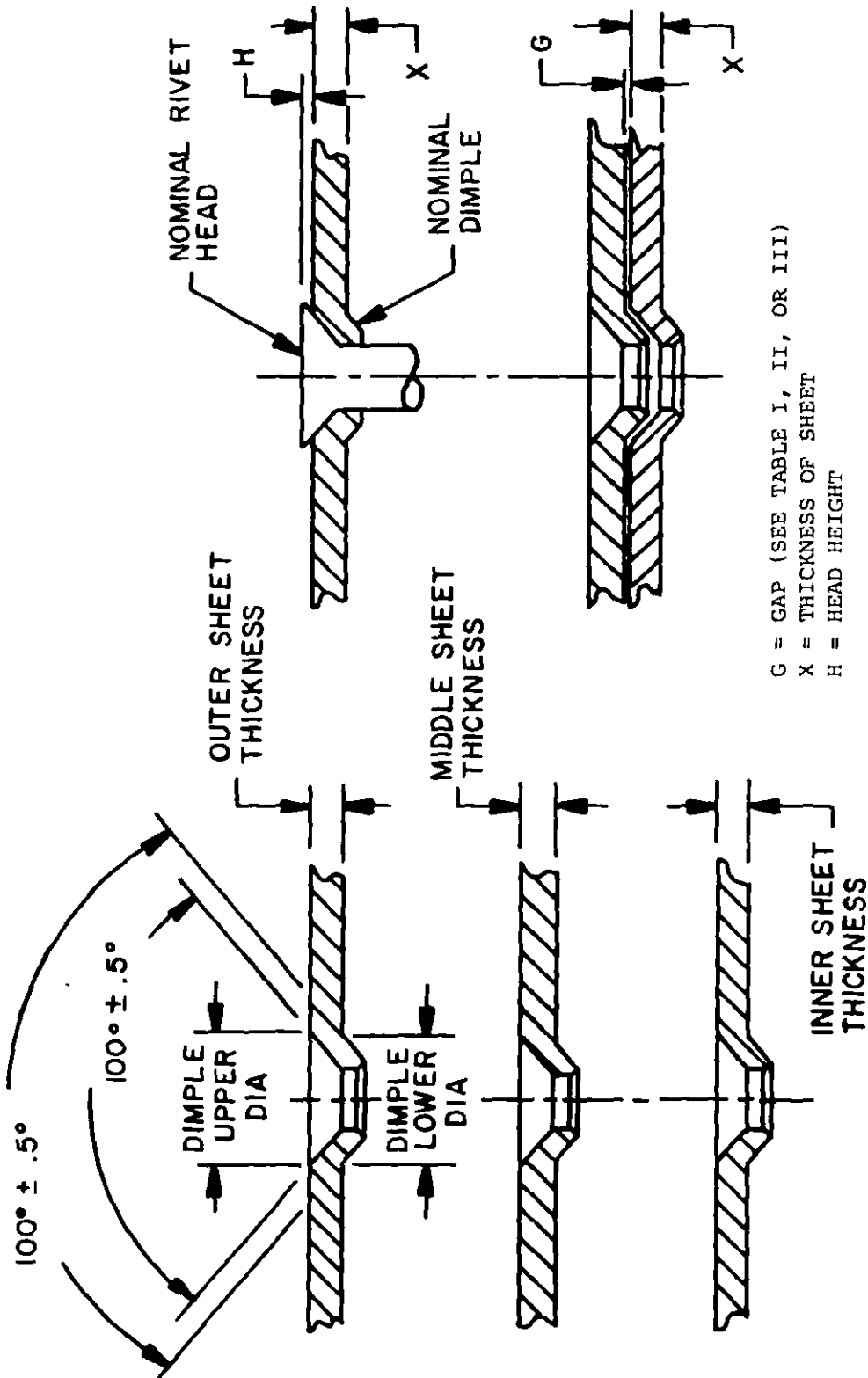
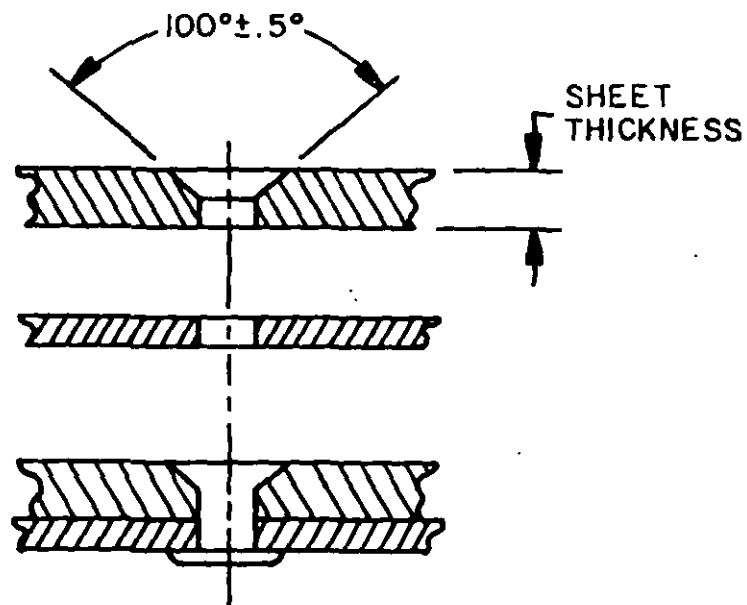


FIGURE 1. Dimple size dimensions for rivets (see table I, II or III).

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NOTE: COUNTERSINK DIMENSIONS ARE CHOSEN SO THAT MANUFACTURED RIVET HEAD WILL BE "FLUSH" TO "HIGH" AFTER DRIVING. THIS MAY NECESSITATE SHAVING DEPENDING UPON SURFACE REQUIREMENTS.

FIGURE 2. Countersink dimensions for rivets.

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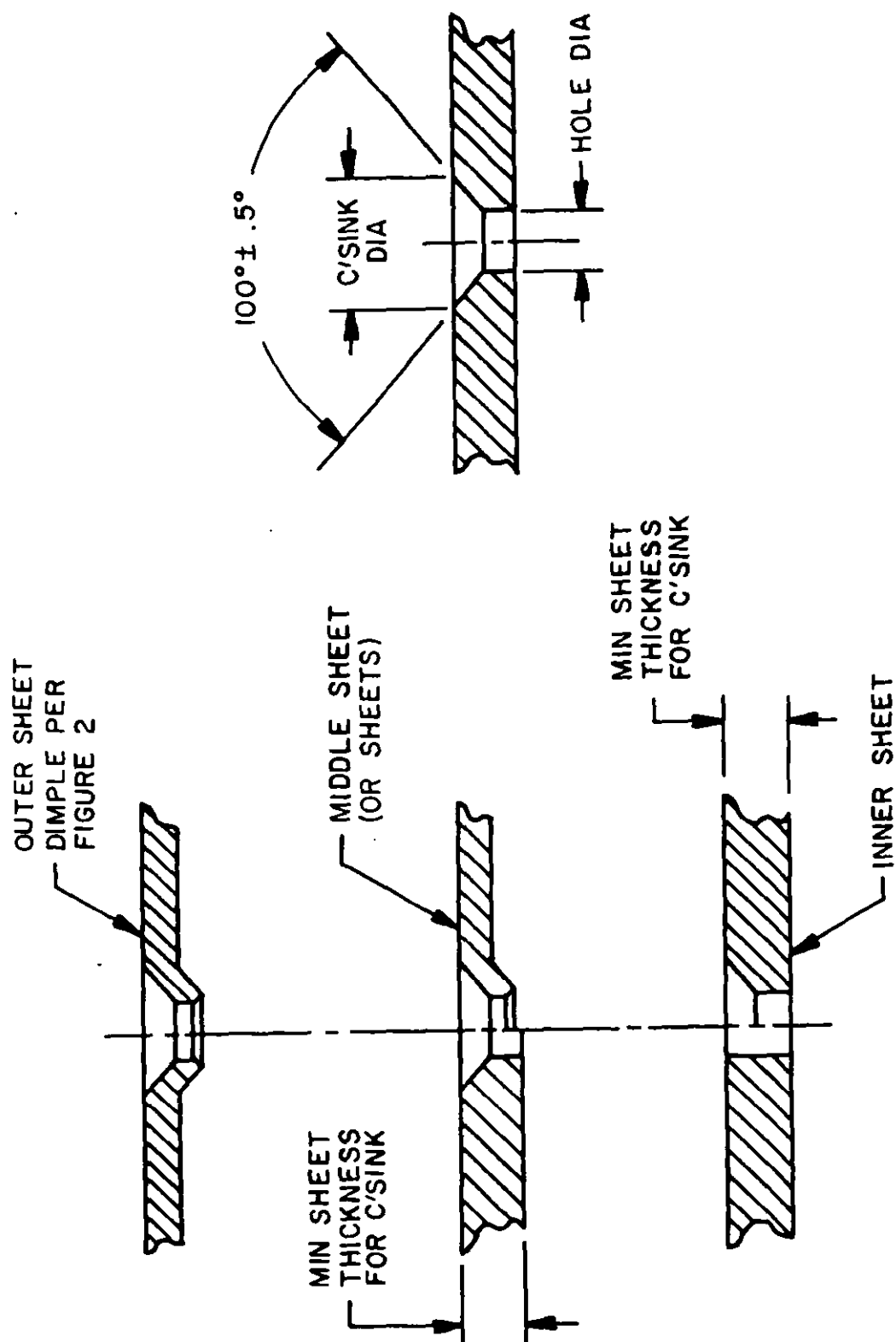
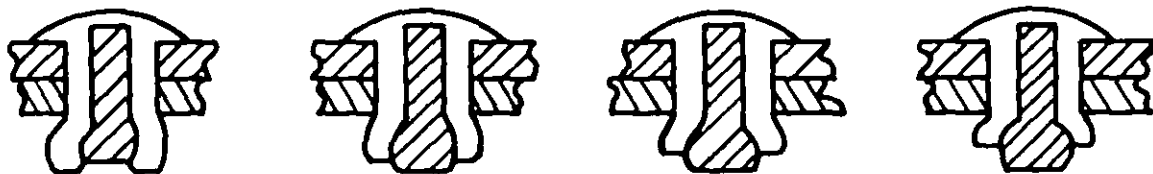


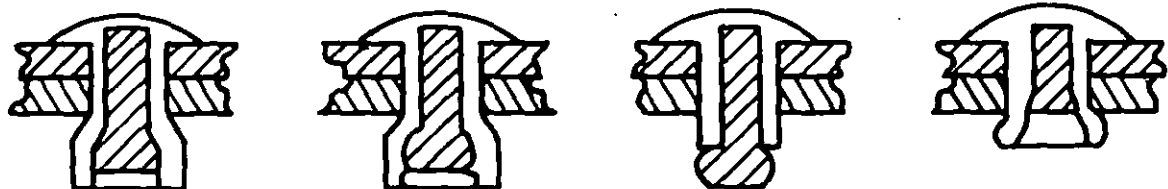
FIGURE 3. Combination dimple and countersink dimensions for rivets (see table I, II or III).

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ACCEPTABLE CONDITIONS



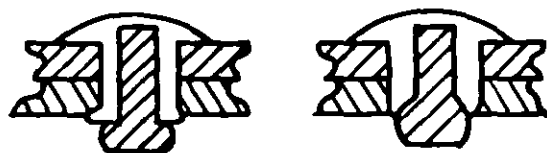
UNACCEPTABLE CONDITIONS



GRIP LENGTH TOO LONG
FOR MATERIAL THICKNESS

UNDERSIZED
HOLE

OVERSIZED
HOLE



GRIP LENGTH TOO SHORT
FOR MATERIAL THICKNESS

FIGURE 4. Acceptable and unacceptable conditions for pull-through and self-plugging rivets.

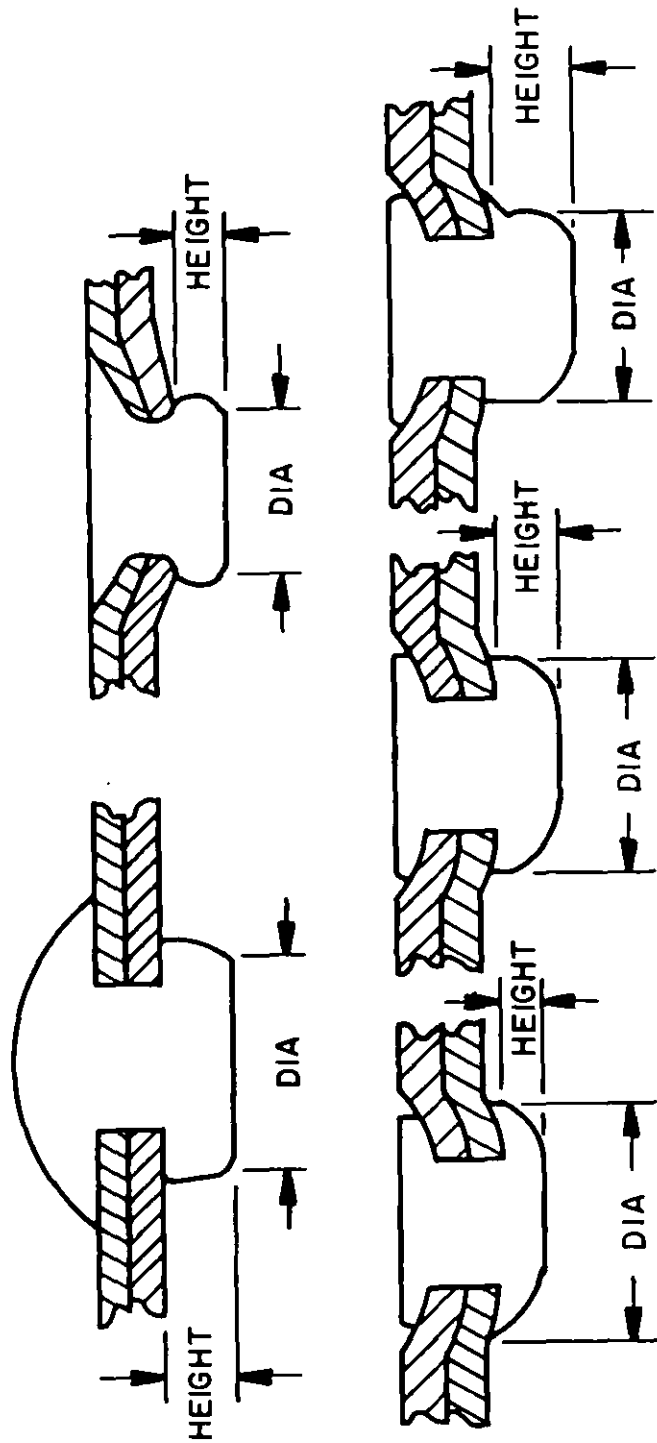


FIGURE 5. Upset head diameters (see tables V and VI).

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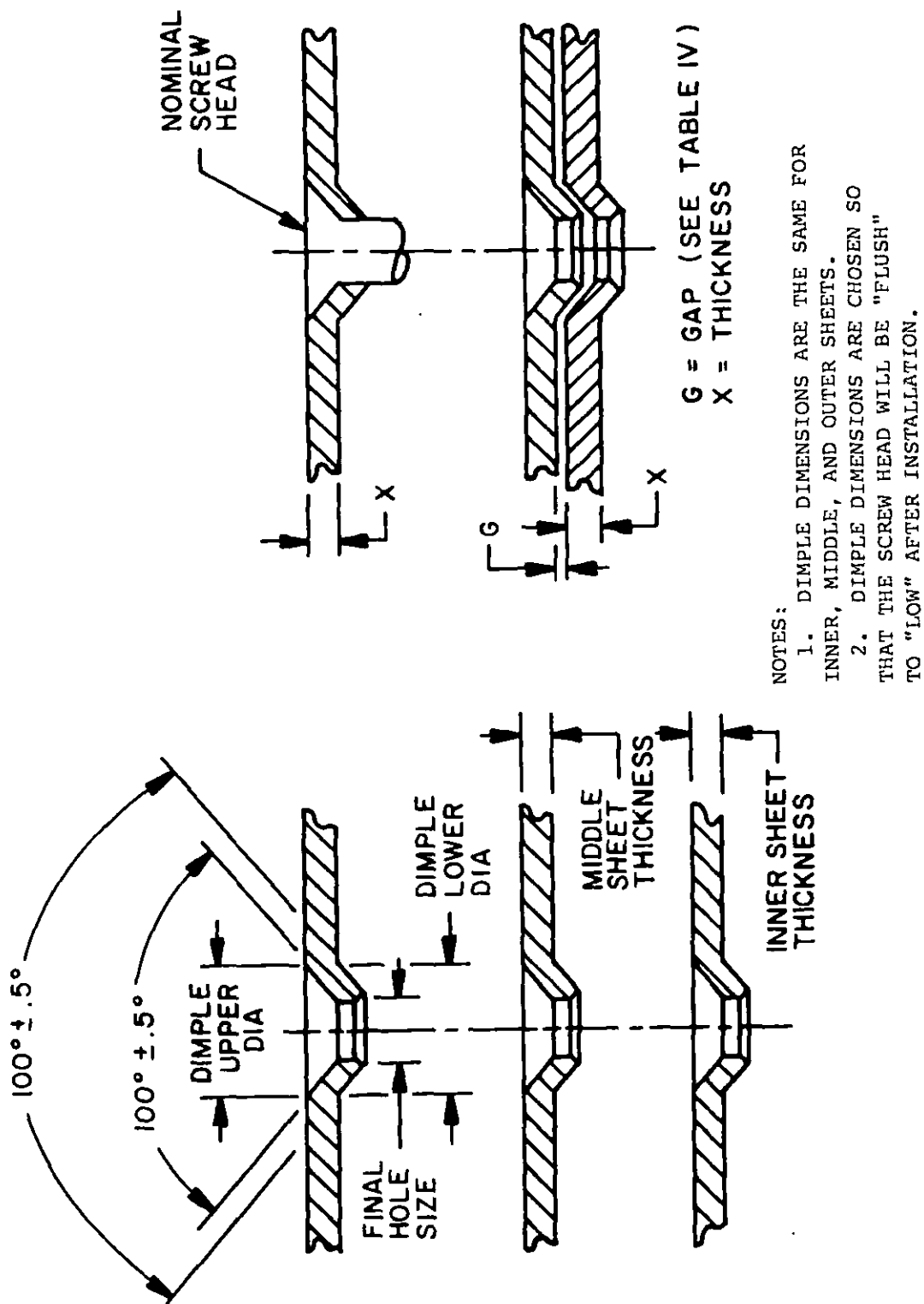
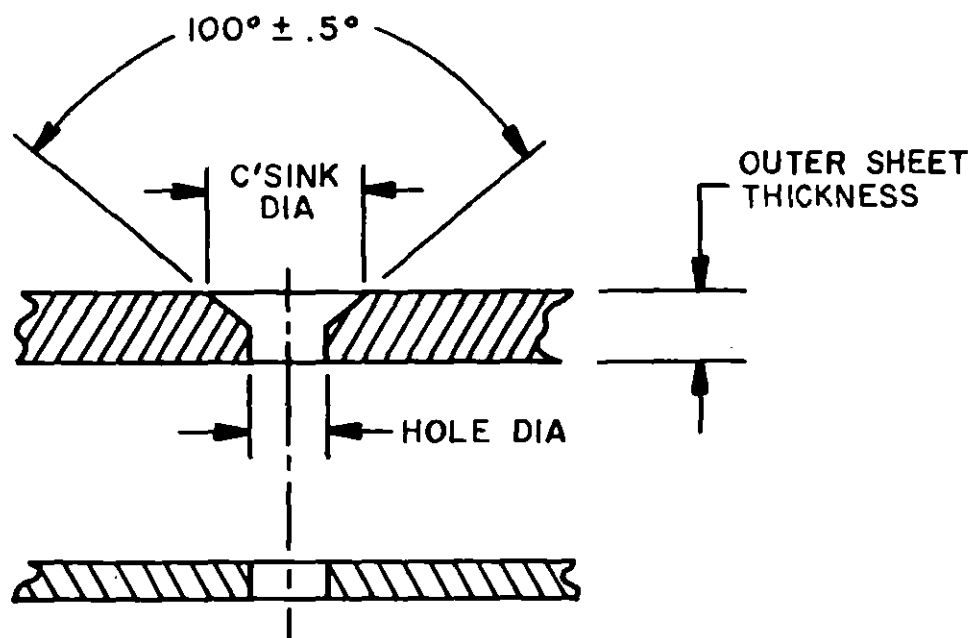


FIGURE 6. Dimple dimensions for screws.

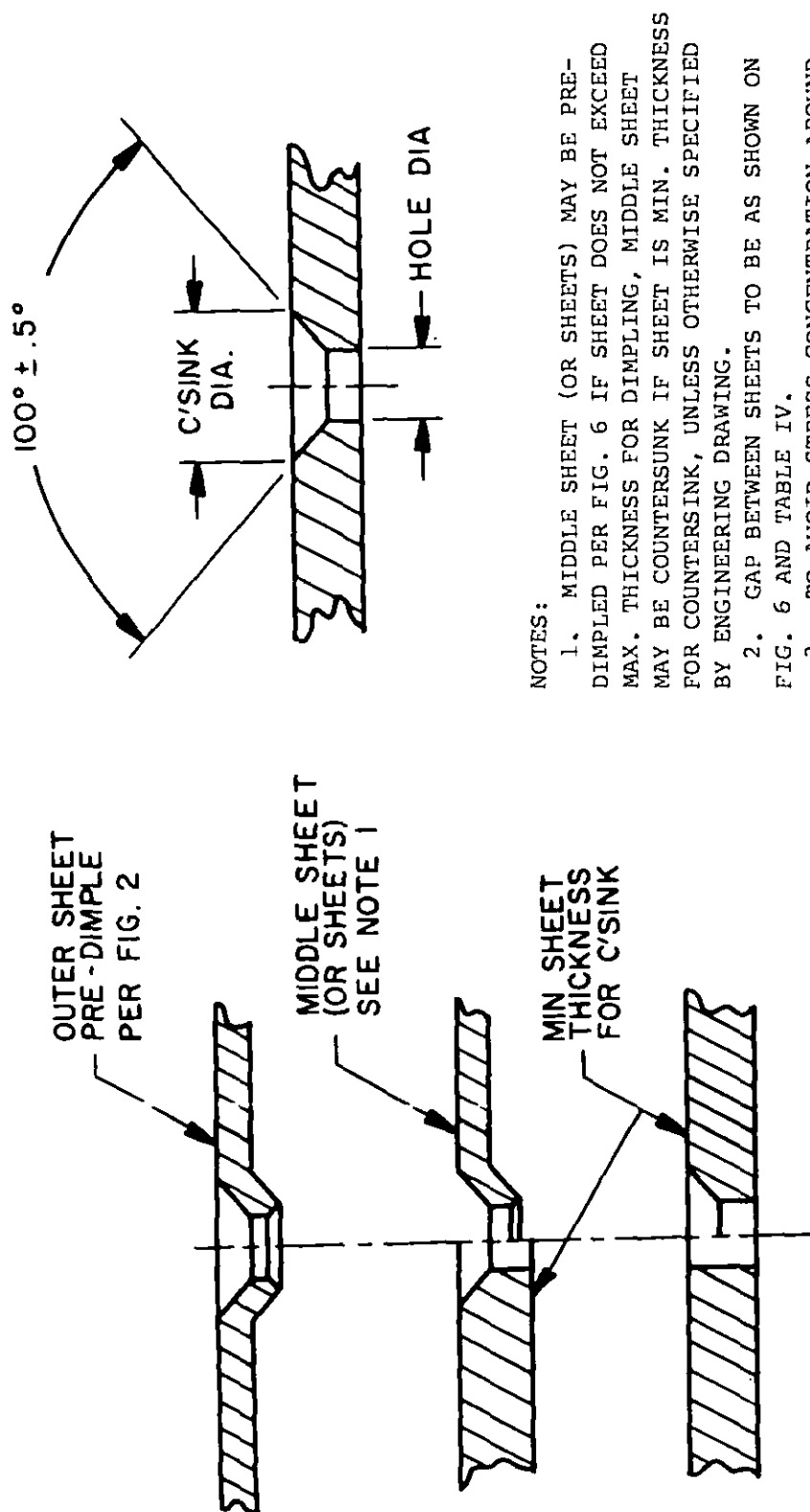
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NOTE: COUNTERSINK DIMENSIONS ARE CHOSEN
SO THAT THE SCREW HEAD WILL BE "FLUSH"
TO "LOW".

FIGURE 7. Countersink dimensions for screws (see table IV).

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NOTES:

1. MIDDLE SHEET (OR SHEETS) MAY BE PRE-DIMPLED PER FIG. 6 IF SHEET DOES NOT EXCEED MAX. THICKNESS FOR DIMPLING, MIDDLE SHEET MAY BE COUNTERSUNK IF SHEET IS MIN. THICKNESS FOR COUNTERSINK, UNLESS OTHERWISE SPECIFIED BY ENGINEERING DRAWING.
2. GAP BETWEEN SHEETS TO BE AS SHOWN ON FIG. 6 AND TABLE IV.
3. TO AVOID STRESS CONCENTRATION AROUND HOLES, PUNCHES MUST BE MAINTAINED IN A SHARP CONDITION.

FIGURE 8. Combination dimple and countersink dimensions for screws.

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3. DOCUMENT TITLE PREPARATION FOR AND INSTALLATION OF RIVETS AND SCREWS, ROCKETS, MISSILE, AND AIRFRAME STRUCTURES			
4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)			
5. REASON FOR RECOMMENDATION			
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