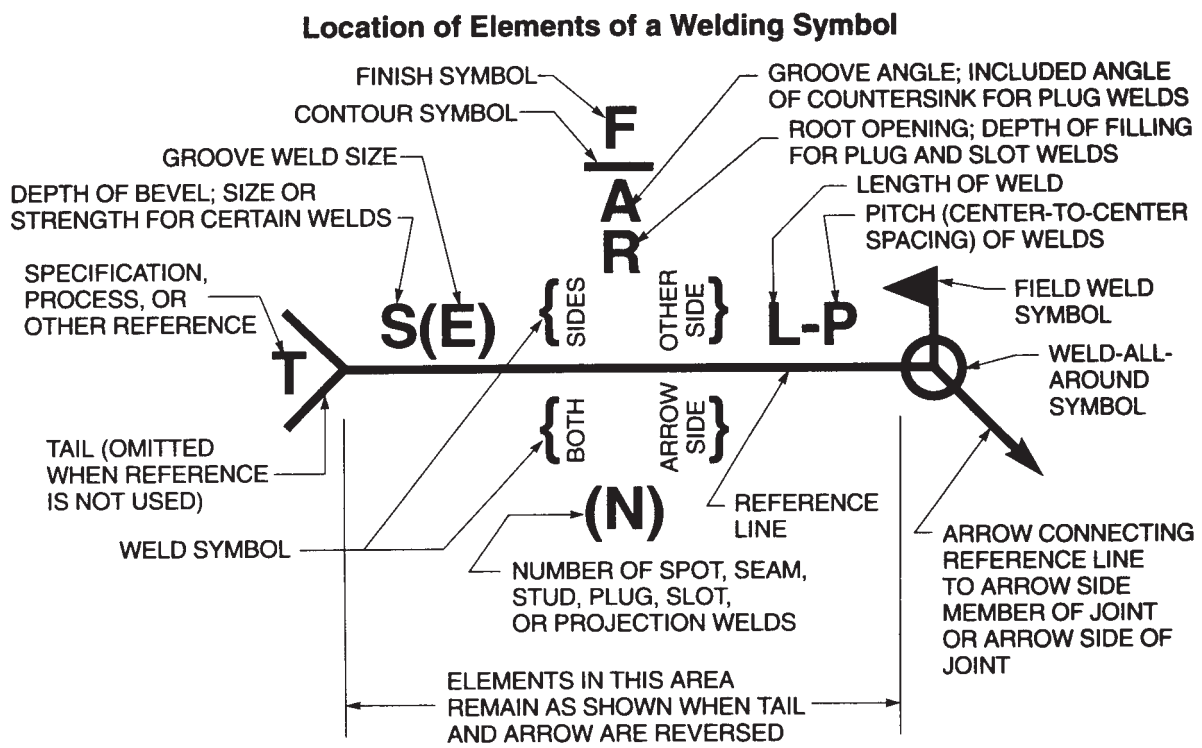
GASES & TECHNICAL

SECTION Part 6 - Appendixes

APPENDIX A
Recommended Copper Cable Sizes

Cable Sizes for Combined Lengths of Electrode and Work Cables					
Amperes	**Percent Duty Cycle**	**0 to 50 ft.**	**50 to 100 ft.**	**100 to 150 ft.**	**150 to 200 ft.**
100	20	8	4	3	2
150	40	6	5	3	2
225	20	4	3	2	1
250	40	2	2	1	1
300	60	1/0	1/0	1/0	2/0
350	60	1/0	1/0	2/0	2/0
400	60	2/0	2/0	2/0	3/0
500	60	2/0	2.0	3/0	3/0

APPENDIX B
Location of Elements of a Welding System



APPENDIX C

Material Indentification

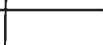
Test	Low Carbon Steel	Med. Carbon Steel	High Carbon Steel	High Sulphur Steel
Appearance Test	Dark Grey	Dark Grey	Dark Grey	Dark Grey
Magnetic Test	Strongly Magnetic	Strongly Magnetic	Strongly Magnetic	Strongly Magnetic
Chisel Test	Continuous Chip Smooth Edges Chips Easily	Continuous Chip Smooth Edges Chips Easily	Hard to Chip Can Be Continuous	Continuous Chip Smooth Edges Chips Easily
Fracture Test	Bright Grey	Very Light Grey	Very Light Grey	Bright Grey Fine Grain
Flame Test	Melts Fast Becomes Bright Red Before Melting	Melts Fast Becomes Bright Red Before Melting	Melts Fast Becomes Bright Red Before Melting	Melts Fast Becomes Bright Red Before Melting
*Spark Test**  *For best results, use at least 5,000 surface feet per minute on grinding equipment. $\left(\frac{\text{Cir.} \times \text{R.P.M.}}{12}\right)$ = S.F. per Min.	 Long Yellow Carrier Lines (Approx. 20% Carbon or Below)	 Yellow Lines Sprigs Very Plain Now (Approx. 20% to 45% Carbon)	 Yellow Lines Bright Burst Very Clear Numerous Star Burst (Approx. 45% Carbon and Above)	 Swelling Carrier Lines Cigar Shape

Test	Manganese Steel	Stainless Steel	Cast Iron	Wrought Iron
Appearance Test	Dull Cast Surface	Bright, Silvery Smooth	Dull Grey Evidence of Sand Mold	Light Grey Smooth
Magnetic Test	Non Magnetic	Depends on Exact Analysis	Strongly Magnetic	Strongly Magnetic
Chisel Test	Extremely Hard to Chisel	Continuous Chip Smooth Bright Color	Small Chips About 1/8 in., Not Easy to Chip, Brittle	Continuous Chip Smooth Edges, Soft & Easily Cut & Chipped
Fracture Test	Coarse Grained	Depends on Type Bright	Brittle	Bright Grey Fibrous Appearance
Flame Test	Melts Fast Becomes Bright Red Before Melting	Melts Fast Becomes Bright Red Before Melting	Melts Slowly Becomes Dull Red Before Melting	Melts Fast Becomes Bright Red Before Melting
*Spark Test**  *For best results, use at least 5,000 surface feet per minute on grinding equipment. $\left(\frac{\text{Cir.} \times \text{R.P.M.}}{12}\right)$ = S.F. per Min.	 Bright White Fan-Shaped Burst	 1. Nickel-Black Shape Close to Wheel. 2. Moly-Short Arrow Shape Tongue (only). 3. Vanadium-Long Spear-point Tongue (only)	 Red Carrier Lines (Very Little Carbon Exists)	 Long, Straw Color Lines (Practically Free of Bursts or Sprigs)

APPENDIX D

Basic Welding Symbols and Their Location Significance

Location Significance	Fillet	Plug or Slot	Spot or Projection	Stud	Seam	Back or Backing	Surfacing	Flange Corner	Flange Edge
Arrow Side									
Other Side				Not Used			Not Used		
Both Sides		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
No Arrow Side or Other Side Significance	Not Used	Not Used		Not Used		Not Used	Not Used	Not Used	Not Used

Location Significance	Groove							Scarf for Brazed Joint
	Square	V	Bevel	U	J	Flare-V	Flare-Bevel	
Arrow Side								
Other Side								
Both Sides								
No Arrow Side or Other Side Significance		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used

APPENDIX E

General Troubleshooting - Mig Welding

Problem	Possible Cause	Remedy
Porosity	Contamination from dirt on plate or wire	Clean base metal Keep filler metal clean and dry
	Contaminated shielding gas	Shield weld area from drafts Check hoses for leaks
Poor arc starting	Bad workpiece connection	Reconnect workpiece cable
Weld cracking	Wrong filler metal	See filler metal selection guide
Electrode burnback	Insufficient wire feed	Increase wire feed speed
	Worn or dirty conduit liner	Replace liner
Color mismatch after anodizing	Use of 4XXX filler metal	See filler metal selection guide

APPENDIX F

Troubleshooting Mechnical Problems in GMAW and FCAW-G

Problem	Possible Cause	Remedy
Irregular wire feed and burnback	Insufficient drive roll pressure Contact tube plugged or worn Kinked electrode wire Coiled gun cable Conduit liner dirty or worn Conduit too long	Adjust Clean or replace Cut out, replace spool Straighten cables, hang the wire feeder Clean or replace Shorten or use push-pull drive system
Electrode wire wraps around drive roll ("birdnesting")	Excessive feed roll pressure Incorrect conduit liner or contact tip Misaligned drive rolls or wire guides Restriction in gun or gun cable	Adjust Match liner and contact tip to electrode size Check and align properly Remove restriction
Heavily oxidized weld deposit	Air/water leaks in gun and cables Restricted shield gas flow	Check for leaks and repair or replace as necessary Check and clean nozzle
Electrode wire stops feeding while welding	Excess or insufficient drive roll pressure Wire drive rolls misaligned or worn Liner or contact tube plugged	Adjust Realign and/or replace Clean or replace
Wire feeds but no gas flows	Gas cylinder is empty Gas cylinder valve closed Flow meter not adjusted Restriction in gas line or nozzle	Replace and purge lines before welding Open cylinder valve Adjust to give flow specified in the procedure Check and clean

Problem	Possible Cause	Remedy
Porosity in the weld bead	Failed gas valve solenoid Gas cylinder valve closed Insufficient shielding gas flow Leaks in gas supply lines (including the gun)	Repair or replace Turn valve on Check for restrictions in gas line or nozzle and correct Check for leaks (especially at connections) and correct
Wire feed motor operates but wire does not feed	Insufficient drive roll pressure Incorrect wire feed rolls Excessive pressure on wire spool brake Restriction in the conduit liner or gun Incorrect liner or contact tube	Adjust Match feed rolls to wire size and type Decrease brake pressure Check liner and contact tip Clean and/or replace Check and replace with correct size
Welding gun overheats	Pinched or clogged coolant line Low coolant level in pump reservoir Water pump not functioning correctly	Check and correct Check and add coolant as necessary Check and repair or replace

APPENDIX G

Troubleshooting Electrical Problems in GMAW and FCAW-G

Problem	Possible Cause	Remedy
Difficult arc starting	Wrong polarity Poor work lead connection	Check polarity; reverse leads if necessary Secure work lead connection
Irregular wire feed and burnback	Power circuit fluctuations Polarity wrong	Check line voltage Check polarity; reverse leads if necessary
Welding cables overheating	Cables are too small or too long Cable connections loose	Check current carrying requirements—replace or shorten if necessary Tighten
No wire feed speed control	Broken or loose wires in control circuit Bad P.C. board in governor	Check and repair if necessary Replace P.C. board
Unstable arc	Cable connections are loose	Tighten connections
Electrode won't feed	Control circuit fuse blown Fuse blown in power source Defective gun trigger switch or broken wire leads Drive motor burned out	Replace fuse Replace fuse Check connections; replace switch Check and replace

Problem	Possible Cause	Remedy
Wire feeds but no gas flows	Failure of gas valve solenoid Loose or broken wires to gas valve solenoid	Replace Check and repair if necessary
Electrode wire feeds but is not energized (no arc)	Poor workpiece connection Loose cable connections Primary contactor coil or points defective Contactor control leads broken	Tighten if loose; clean work of paint, rust, etc. Tighten Repair or replace Repair or replace
Porosity in weld	Loose or broken wires to gas solenoid valve	Repair or replace

APPENDIX H

Tips to Make the Aluminum Welding Job Easier

- Use the proper welding power source. A constant current unit is best for welding aluminum because it does not permit the high current surges produced by constant voltage machines. These surges cause arcing inside the guide tube which results in deposits that impede wire feed.
- If the torch cables are more than 12 ft (3.6 m) long, a push-pull wire feed system should be considered.
- Feed rolls with a U-groove rather than a V-groove or knurled surface should be used. Make sure that drive roll pressure isn't excessive, because that will tend to distort the wire.
- A straight barrel torch should be used rather than a goose-neck torch to minimize friction in the wire feed system.
- Teflon or nylon wire feed conduits should be used to reduce friction in the wire feed system. When aluminum particles from the wire feed rolls accumulate in the conduits, the conduits should be replaced. Some users report improved operation by blowing the particles out using argon, but usually it is best to replace the worn parts.
- After a burnback, it is best to replace the whole length of electrode in the conduit. Otherwise, the slightest kink in the wire left in the conduit may cause another jam.

APPENDIX I

Steel Hardness Numbers

Rockwell C-Scale Hardness Number	BRINELL HARDNESS NUMBER 10-MM. BALL, 3000-KG. LOAD			ROCKWELL HARDNESS NO.		
	Standard Ball	Hultgren Ball	Tungsten Carbide Ball	A-Scale 60-kg. Load Brale Penetrator	B-Scale 100-kg. Load 1 16 in. Dia. Ball	D-Scale 100-kg. Load Brale Penetrator
68				85.6		76.9
67				85.0		76.1
66				84.5		75.4
65			739	83.9		74.5
64			722	83.4		73.8
63			705	82.8		73.0
62			688	82.3		72.2
61			670	81.8		71.5
60		613	654	81.2		70.7
59		599	634	80.7		69.9
58		587	615	80.1		69.2
57		575	595	79.6		63.5
56		561	577	79.0		67.7
55		546	560	78.5		66.9
54		534	543	78.0		66.1
53		519	525	77.4		65.4
52	500	508	512	76.8		64.6
51	487	494	496	76.3		63.5
50	475	481	481	75.9		63.1
49	464	469	469	75.2		62.1
48	451	455	455	74.7		61.4
47	442	443	443	74.1		60.8
46	432	432	432	73.6		60.0
45	421	421	421	73.1		59.2
44	409	409	409	72.5		58.5
43	400	400	400	72.0		57.7
42	390	390	390	71.5		56.9
41	381	381	381	70.9		56.2
40	371	371	371	70.4		55.4
39	362	362	362	69.9		54.6
38	353	353	353	69.4		53.8
37	344	344	344	68.9		53.1
36	336	336	336	68.4	109.0	52.3
35	327	327	327	67.9	108.5	51.5
34	319	319	319	67.4	108.0	50.8
33	311	311	311	66.8	107.5	50.0
32	301	301	301	66.3	107.0	49.2
31	294	294	294	65.8	106.0	48.4
30	286	286	286	65.3	105.5	47.7
29	279	279	279	64.7	104.5	47.0
28	271	271	271	64.3	104.0	46.1
27	264	264	264	63.8	103.0	45.2
26	258	258	258	63.3	102.5	44.6
25	253	253	253	62.8	101.5	43.8
24	247	247	247	62.4	101.0	43.1
23	243	243	243	62.0	100.0	42.1
22	237	237	237	61.5	99.0	41.6
21	231	231	231	61.0	98.5	40.9
20	226	226	226	60.5	97.8	40.1
18	219	219	219		96.7	
16	212	212	212		95.5	
14	203	203	203		93.9	
12	194	194	194		92.3	
10	187	187	187		90.7	
8	179	179	179		89.5	
6	171	171	171		87.1	
4	165	165	165		85.5	
2	158	158	158		83.5	
0	152	152	152		81.7	

TEMPERATURE CONVERSION (Fahrenheit and Centigrade)

°F	°C	°F	°C
32	0	1000	538
50	10	1050	566
100	38	1100	593
150	66	1150	621
200	93	1200	649
250	121	1250	677
300	149	1300	704
350	177	1350	732
400	204	1400	760
450	232	1450	788
500	260	1500	816
550	288	1550	843
600	316	1600	871
650	343	1650	899
700	371	1700	927
750	399	1750	954
800	427	1800	982
850	454	1850	1010
900	482	1900	1038
950	510	1950	1066

CONVERSIONS TO METRIC MEASURES

In this Guide, wire, rod and electrode diameters are frequently shown in metric measures, in addition to the customary U.S. units. However, in instances where only the U.S. units appear in the Guide (or when you need a handy reference), the conversions are as follows:

in.	mm	in.	mm
0.030	0.8	3/32	2.4
0.035	0.9	1/8	3.2
0.045	1.2	5/32	4.0
1/16	1.6	3/16	4.8
5/64	2.0	1/4	6.4

APPENDIX J

Temperature Data

Color Scale A	Color Scale B	Degrees Celsius	Melting Points
		1600	Pure Iron Low-Carbon Steel
		1500	
White	White	1400	18-8 Stainless Steel
	Yellow White	1300	
Light Yellow	Orange Yellow	1200	Cast Iron
Lemon	Orange Red	1100	
Orange	Bright Cherry Red	1000	Brasses and Bronzes
Bright Red	Cherry Red	900	
Cherry Red	Dull Cherry Red	800	
Dark Cherry	Dark Red	700	
		600	Aluminum Alloys
Blood Red Faint Red		500 400 300 200	 Lead Lead Alloys

NOTE: Color scale A is an approximation of what the naked eye will see in dim light. Color scale B is close to what a welder will see through his goggles. Neither should be considered precise.

APPENDIX K

Tests for Identifying Metals

Chip Test. If a high-speed grinder is not available, or the results of a spark test seem inconclusive, a chip test with a small cold chisel and hammer will often reveal striking differences between metals of similar surface appearance. The table below summarizes the chipping characteristics of five types of ferrous metals.

	Appearance of Chip	Size of Chip	Facility of Chipping
Gray Cast Iron	Small partially broken chips	1/8 in.	Not easy
Malleable Iron	Noticeably longer than those from gray cast iron	1/4 to 3/8 in.	Very tough; harder to chip than gray iron
Low Carbon Steel and Cast Steel	Can be made continuous; chisel leaves smooth groove	Almost any length	Very easy
High Carbon Steel	Fine grain fracture noticeable, although chip may be continuous	Almost any length	Difficult, due to hard ness of metal
Nickel or Monel Metal	Chipping characteristics are so similar to those of low-carbon steel that chip test cannot distinguish one from the other.		

APPENDIX L

Physical Properties of Metals

A. Chemical symbol. (Many of the symbols are derived from Latin names for the elements; for example, "Pb" from "plumbum", "Au" from "aurum", and "Sn" from "stannum".)
B. Specific gravity; the relative mass of the metal by comparison with water. Since one cubic meter of water has a mass of 1000 kilograms, the density of any of the metals, in terms of kg/m^3, is 1000 times the figure shown. To arrive at density in terms of pounds per cubic foot, multiply specific gravity by 62.5.
C. Melting point, degrees Celsius.
D. Melting point, degrees Fahrenheit.
E. Coefficient of thermal expansion, per degree°C, X one million. To illustrate use of these figures: An unrestrained bar of aluminum, one meter long, will change its length 23.6 millionths of a meter (or 23.6 thousandths of a millimeter) for each 1°C change in temperature. Rate of expansion is not constant at all temperatures; data given represent coefficients at room temperature.
F. Thermal conductivity. Specifically, the figures shown represent calories per square centimeter cross-section, per centimeter length, per degree°C. (Cal/cm^2 /cm/°C). Data provided primarily to emphasize the wide variation in thermal conductivity, and fact that there is no general relationship between rate of expansion and rate of heat conductivity.

	A	B	C	D	E	F
Aluminum	Al	2.70	658	1216	23.6	.57
Chromium	Cr	7.14	1615	2939	6.2	.16
Copper	Cu	8.94	1083	1981	19.6	.94
Gold	Au	19.3	1063	1945	14.2	.71
Iron	Fe	7.86	1535	2795	11.7	.18
Lead	Pb	11.35	328	622	29.3	.08
Magnesium	Mg	1.74	651	1204	25.2	.37
Nickel	Ni	8.90	1452	2646	13.3	.22
Platinum	Pt	21.5	1755	319	1 8.9	.16
Silver	Ag	10.5	960	1760	19.7	1.0
Tin	Sn	5.75	232	450	23	.15
Titanium	Ti	4.5	1800	3272	8.4	.04
Tungsten	W	19.3	3370	6098	4.6	.40
Zinc	Zi	7.14	419	787	39.7	.27

APPENDIX M

Steel Pipe Specifications

This table is extracted from ASTM Standard A-53-73, " Standard Specifications for Welded and Seamless S Pipe." It covers most sizes from 1/2-in. through 6-in., Schedules 40 (Standard) and 80 (Extra Strong).

Size (in.)	Schedule	Outside Diameter (in.)	Wall Thickness (in.)	Weight per foot (lb.)
1/2	40	0.840	0.109	0.86
	80	0.840	0.147	1.09
3/4	40	1.050	0.113	1.14
	80	1.050	0.154	1.48
1	40	1.315	0.133	1.68
	80	1.315	0.179	2.18
11/2	40	1.9	0.145	2.72
	80	1.9	0.200	3.64
2	40	2.375	0.154	3.66
	80	2.375	0.218	5.03
3	40	3.5	0.216	7.58
	80	3.5	0.300	10.3
4	40	4.5	0.237	10.8
	80	4.5	0.337	15.0
5	40	5.563	0.258	14.7
	80	5.563	0.375	20.8
6	40	6.625	0.280	19.0
	80	6.625	0.432	28.6

APPENDIX N

Pressure Drop in Fitted Hose Assemblies

The table on the facing page shows the approximate pressure drop for which allowance should be made when using various lengths and sizes of fitted hose assemblies. For hose lengths of 12-1/2 and 25 feet, pressure drop through the nipples at each end of the hose assembly accounts for the major part of the drop shown. All figures assume that hose nipples have hole diameters as follows:

3/16-in. nipple 0.125 in. (3.2 mm)
1/4-in. nipple 0.1405 in. (3.5 mm)
5/16-in. nipple 0.1935 in. (4.9 mm)
3/8-in. nipple 0.250 in. (6.3 mm)

Not all commercially-available nipples have hole diameters equal to those given above, although industry-wide standardization is expected within a few years. In some cases, actual pressure drop through a fitted hose assembly may be substantially greater than that indicated in the table. Because pressure drop through the fittings is such a significant part of the total pressure drop, when two lengths of hose are coupled together, calculate the drop for each piece separately, and make some additional allowance for pressure drop through the hose connection coupling. For example: If you need a 50-ft. run of hose for a cutting job which calls for an oxygen flow of 250 cfh at 50 psi delivery pressure, and to get that run you must couple two 25-ft. lengths of 1/4-in. fitted hose, the pressure drop will not be 8 psi (as shown in table for 50 ft. of 1/4-in. hose at 250 cfh and 50 psi delivery) but more than 10 psi (5 plus 5 plus an allowance for drop through coupling). Figures shown for delivery pressures of 5 psi and 10 psi are based on acetylene data; for equivalent oxygen flows assume pressure drops about 20% greater. Figures shown for delivery pressures of 25, 50, and 100 psi are based on oxygen flow data. Pressure drops greater than 5 psi are not shown for delivery pressures of 5 and 10 psi, since maximum acetylene pressure at the regulator outlet must be limited to 15 psi. If you wish to estimate pressure drops for oxygen at flow rates of 100-250 cfh through 3/16-in. and 1/4-in. hose, with 10 psi delivery pressure, use drops about one-third higher than those shown for corresponding flow rates at delivery pressure of 25 psi.

Pressure Drop Through Fitted Hose

Del. Press. (psi)	Gas Flow (cfh)	3/16-in. Hose Length in Feet				1/4-in Hose Length in Feet				5/16-in Hose Length in Feet				3/8-in. Hose Length in Feet			
		12-1/2	25	50	100	12-1/2	25	50	100	12-1/2	25	50	100	12-1/2	25	50	100
5	25	*	*	1	2	*	*	*	1	*	*	*	*	*	*	*	*
	50	1	2	4	•	*	1	2	3	*	*	*	1	*	*	*	*
	75	3	4	•	•	1	2	3	5	*	*	1	2	*	*	*	1
	100	5	•	•	•	2	3	5	•	*	1	2	3	*	*	1	2
10	25	*	*	1	2	*	*	*	1	*	*	*	*	*	*	*	*
	50	1	2	3	5	*	1	1	2	*	*	*	*	*	*	*	*
	75	2	3	5	•	1	1	2	4	*	*	*	*	*	*	*	*
	100	3	5	•	•	2	2	4	•	*	*	1	1	*	*	*	1
	150	•	•	•	•	3	5	•	•	1	1	2	4	*	1	1	2
	250	•	•	•	•	•	•	•	•	2	4	•	•	1	2	3	4
25	100	4	6	8	13	**	**	3	4	**	**	**	**	**	**	**	**
	250	13	18	28	•	6	8	12	17	**	2	3	7	**	**	**	4
	500	•	•	•	•	22	26	•	•	6	9	12	20	3	5	7	12
50	100	2	3	6	9	**	**	2	3	**	**	**	**	**	**	**	**
	250	8	13	19	30	3	5	8	11	**	**	2	4	**	**	**	3
	500	26	31	•	•	14	18	26	•	3	6	8	13	**	3	5	8
	750	•	•	•	•	29	37	•	•	9	12	18	27	4	6	10	11
100	100	**	**	3	5	**	**	**	**	**	**	**	**	**	**	**	**
	250	5	7	10	17	2	3	4	6	**	**	**	2	**	**	**	**
	500	14	21	32	•	8	11	15	21	2	3	5	7	**	**	2	5
	750	29	•	•	•	18	23	32	•	5	7	10	15	**	3	5	9
	1000	•	•	•	•	31	37	•	•	9	12	17	25	3	5	9	14

*Drop is lessthan 1 psi ** Drop is less than 2 psi

•Drop is greater than 5 psi(for 5 and 10 psi delivery) or greater than 37 psi (for 25, 50 or100 psi delivery).

All data given in "English" measure, rather than metric, because currently (1976) all U.S. regulator gauges are calibrated in "psi" and virtually all flow data are presented in "cfh". To convert to metric measurement, multiply figures by 6.9 to arrive at kPa; multiply cfh figures by 0.028 to arrive at m^3/h or by 0.472 for L/min.

APPENDIX O

Twist Drill Sizes

Drill No.	Diam., In.	Diam., mm	Drill No.	Diam., In.	Diam., mm	Drill No.	Diam., In.	Diam., mm
80	0.0135	0.343	44	0.0860	2.184	9	0.1960	4.978
79	0.0145	0.368	43	0.0890	2.261	8	0.1990	5.055
78	0.0160	0.406	42	0.0935	2.375	7	0.2010	5.105
77	0.0180	0.457	41	0.0960	2.438	6	0.2040	5.182
76	0.0200	0.508	40	0.0980	2.489	5	0.2055	5.220
75	0.0210	0.533	39	0.0995	2.527	4	0.2090	5.309
74	0.0225	0.572	38	0.1015	2.578	3	0.2130	5.410
73	0.0240	0.610	37	0.1040	2.642	2	0.2210	5.613
72	0.0250	0.635	36	0.1065	2.705	1	0.2280	5.791
71	0.0260	0.660	35	0.1100	2.794	A	0.234	5.94
70	0.0280	0.711	34	0.1110	2.819	B	0.238	6.04
69	0.0293	0.743	33	0.1130	2.870	C	0.240	6.16
68	0.0310	0.787	32	0.1160	2.946	D	0.246	6.25
67	0.0320	0.813	31	0.1200	3.048	E	0.250	6.35
66	0.0330	0.839	30	0.1285	3.264	F	0.257	6.53
65	0.0350	0.889	29	0.1360	3.454	G	0.261	6.63
64	0.0360	0.914	28	0.1405	3.569	H	0.266	6.76
63	0.0370	0.940	27	0.1440	3.658	I	0.272	6.91
62	0.0380	0.965	26	0.1470	3.734	J	0.277	7.04
61	0.0390	0.991	25	0.1495	3.797	K	0.281	7.14
60	0.0400	1.016	24	0.1520	3.861	L	0.290	7.37
59	0.0410	1.041	23	0.1540	3.912	M	0.295	7.49
58	0.0420	1.067	22	0.1570	3.988	N	0.302	7.67
57	0.0430	1.092	21	0.1590	4.039	O	0.316	8.03
56	0.0465	1.181	20	0.1610	4.089	P	0.323	8.20
55	0.0520	1.321	19	0.1660	4.216	Q	0.332	8.43
54	0.0550	1.397	18	0.1695	4.305	R	0.339	8.61
53	0.0595	1.511	17	0.1730	4.394	S	0.348	8.84
52	0.0635	1.613	16	0.1770	4.496	T	0.358	9.09
51	0.0670	1.702	15	0.1800	4.572	U	0.368	9.35
50	0.0700	1.778	14	0.1820	4.623	V	0.377	9.57
49	0.0730	1.854	13	0.1850	4.699	W	0.386	9.80
48	0.0760	1.930	12	0.1890	4.801	X	0.397	10.1
47	0.0785	1.994	11	0.1910	4.851	Y	0.404	10.3
46	0.0810	2.057	10	0.1935	4.915	Z	0.413	10.5
45	0.0820	2.083	--	--	--	--	--	--

APPENDIX P

Decimal Equivalents of Common Fractions

8ths	16ths	32nds	64ths	Decimal Equivalent In.	Decimal Equivalent mm
			1	.016	0.397
		1	2	.031	0.794
			3	.047	1.191
	1	2	4	.063	1.587
			5	.078	1.984
		3	6	.094	2.381
			7	.109	2.778
1	2	4	8	.125	3.175
			9	.141	3.572
		5	10	.156	3.969
			11	.172	4.366
	3	6	12	.188	4.762
			13	.203	5.159
		7	14	.219	5.556
			15	.234	5.953
2	4	8	16	.25	6.350
			17	.266	6.747
		9	18	.281	7.144
			19	.297	7.541
	5	10	20	.313	7.937
			21	.328	8.334
		11	22	.344	8.731
			23	.359	9.128
3	6	12	24	.375	9.525
			25	.391	9.922
		13	26	.406	10.319
			27	.422	10.715
	7	14	28	.438	11.112
			29	.453	11.509
		15	30	.469	11.906
			31	.484	12.303
4	8	16	32	.50	12.700
			33	.516	13.097
		17	34	.531	13.494
			35	.547	13.890
	9	18	36	.563	14.287
			37	.578	14.684
		19	38	.594	15.081
			39	.609	15.478
5	10	20	40	.625	15.875
			42	.641	16.272
		21	43	.656	16.669
			43	.672	17.065
	11	22	44	.688	17.462
			45	.703	17.859
		23	46	.719	18.256
			47	.734	18.653
6	12	24	48	.75	19.050
			49	.766	19.447
		25	50	.781	19.844
			51	.797	20.240
	13	26	52	.813	20.637
			53	.828	21.034
		27	54	.844	21.431
			55	.859	21.828
7	14	28	56	.875	22.225
			57	.891	22.622
		29	58	.906	23.019
			59	.922	23.415
	15	30	60	.938	23.812
			61	.953	24.209
		31	62	.969	24.606
			63	.984	25.003

APPENDIX Q

Glossary

Arc blow - The deviation of an arc from its normal path because of magnetic forces.

Arc force - The axial force developed by an arc plasma.

Arc length - The distance from the tip of the electrode or wire to the workpiece.

Arc welding deposition efficiency - The ratio of the weight of filler metal deposited to the weight of filler metal melted. (%)

Arc welding electrode - A part of the welding system through which current is conducted that ends at the arc.

As-welded - The condition of the weld metal, after completion of welding, and prior to any subsequent thermal or mechanical treatment.

Automatic - The control of a process with equipment that requires little or no observation of the welding, and no manual adjustment of the equipment controls.

Backhand welding - A welding technique where the welding torch or gun is directed opposite to the direction of welding.

Brazing (B) - A welding process where the coalescence of materials is produce by heating them in the presence of a filler metal having a melting point above 450 ºC (840 ºF) but below the melting point of the base metal. The filler metal is distributed between the closely fitted surfaces of the joint by capillary action.

Buttering - A process that deposits surfacing metal on one or more surfaces of a joint to provide metallurgically compatible weld metal for the subsequent completion of the weld.

Cold lap - Incomplete fusion or overlap.

Constant current power source - An arc welding power source with a volt-ampere output characteristic that produces a small welding current change from a large arc voltage change.

Constant voltage power source - An arc welding power source with a volt-ampere output characteristic that produces a large welding current change from a small arc voltage change.

Contact tube - A system component that transfers current from the torch gun to a continuous electrode.

Cryogenic - Refers to low temperatures, usually -200 ºF or below.

Density - The ratio of the weight of a substance per unit volume; e.g. mass of a solid, liquid, or gas per unit volume at a specific temperature.

Deposited metal - Filler metal that has been added during welding, brazing or soldering.

Dew point - The temperature and pressure at which the liquefaction of a vapor begins, usually applied to condensation of moisture from the water vapor in the atmosphere.

Direct current electrode negative (DCEN) - The arrangement of direct current arc welding leads in where the electrode is the negative pole and workpiece is the positive pole of the welding arc.

Direct current electrode positive (DCEP) - The arrangement of direct current arc welding leads in where the electrode is the positive pole and workpiece is the negative pole of the welding arc.

Duty cycle - The percentage of time during a time period that a power source can be operated at rated output without overheating.

Electrode extension - The length of electrode extending beyond the end of the contact tube.

Filler material - The material to be added in making a welded, brazed, or soldered joint.

Fillet weld - A weld of approximately triangular cross section which joins two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint.

Flammable Range - The range over which a gas at normal temperature (NTP) forms a flammable mixture with air.

Flat welding position - A welding position where the weld axis is approximately horizontal, and the weld face lies in an approximately horizontal plane.

Forehead welding - A welding technique where the welding torch or gun is directed toward the direction of welding.

Gas Metal Arc Welding (GMAW) - An arc welding process where the arc is between a continuous filler metal electrode and the weld pool. Shielding from an externally supplied gas source is required.

Gas Tungsten Arc Welding (GTAW) - An arc welding process where the arc is between a tungsten electrode (nonconsumable) and the weld pool. The process is used with an externally supplied shielding gas.

Heat-affected zone - That section of the base metal, generally adjacent to the weld zone, whose mechanical properties or microstructure have been altered by the heat of welding.

Hot crack - A crack formed at temperatures near the completion of weld solidification.

Incomplete fusion - A weld discontinuity where fusion did not occur between weld metal and the joint or adjoining weld beads.

Incomplete joint penetration - A condition in a groove weld where weld metal does not extend through the joint thickness.

Interpass temperature - In a multipass weld, the temperature of the weld area between passes.

Kerf - The width of the cut produced during a cutting process.

Manual welding - A welding process where the torch or electrode holder is manipulated by hand.

Mechanized welding - Welding with equipment where manual adjustment of controls is required in response to variations in the welding process. The torch or electrode holder is held by a mechanical device.

Metal cored electrode - A composite tubular electrode consisting of a metal sheath and a core of various powdered materials, producing no more than slag islands on the face of the weld bead. External shielding is required.

Molecular Weight - The sum of the atomic weights of all the constituent atoms in the molecule of an element or compound.

Pilot arc - A low current arc between the electrode and the constricting nozzle of a plasma torch which ionizes the gas and facilitates the start of the welding arc.

Plasma Arc Cutting (PAC) - An arc cutting process using a constricted arc to remove the molten metal with a high-velocity jet of ionized gas from the constricting orifice.

Plasma Arc Welding (PAW) - An arc welding process that uses a constricted arc between a nonconsumable electrode and the weld pool (transferred arc) or between the electrode and the constricting nozzle (nontransferred arc). Shielding is obtained from the ionized gas issuing from the torch.

Plasma Spraying (PSP) - A thermal spraying process in which a nontransferred arc is used to create an arc plasma for melting and propelling the surfacing material to the substrate.

Porosity - A hole-like discontinuity formed by gas entrapment during solidification.

Preheat temperature, welding - The temperature of the base metal immediately before welding is started.

Pull gun technique - Same as backhand welding.

Pulsed spray welding - An arc welding process variation in which the current is pulsed to achieve spray metal transfer at average currents equal to or less than the globular to spray transition current.

Push angle - The travel angle where the electrode is pointing in the direction of travel.

Root opening - A separation at the joint root between the workpieces.

Self-shielded Flux Cored Arc Welding (FCAW-S) - A flux cored arc welding process variation in which shielding gas is obtained exclusively from the flux within the electrode.

Shielded Metal Arc Welding (SMAW) - An arc welding process where the arc is between a covered electrode and the weld pool. Decomposition of the electrode covering, provides the shielding.

Spatter - Metal particles expelled during welding that do not form a part of the weld.

Standard Temperature and Pressure (STP) - An internationally accepted reference base where standard temperature is 0 ^{o}C and standard pressure is one atmosphere, or 14.6960 psia.

Stress-relief heat treatment - Uniform heating of a welded component to a temperature sufficient to relieve a major portion of the residual stresses.

Thermal conductivity - The quantity of heat passing through a plate.

Underbead crack - A crack in the heat-affected zone generally not extending to the surface of the base metal.

Undercut - A groove melted into the base plate adjacent to the weld toe or weld root and left unfilled by weld metal.

Vapor Pressure - The pressure exerted by a vapor when a state of equilibrium has been reached between a liquid, solid or solution and its vapor. When the vapor pressure of a liquid exceeds that of the confining atmosphere, the liquid is commonly said to be boiling.

Viscosity - The resistance offered by a fluid (liquid or gas) to flow.

Welding leads - The workpiece lead and electrode lead of an arc welding circuit.

Welding wire - A form of welding filler metal, normally packaged as coils or spools, that may or may not conduct electrical current depending upon the welding process used.

Weld metal - The portion of a fusion weld that has been completely melted during welding.

Weld pass - A single progression of welding along a joint. The result of a pass is a weld bead or layer.

Weld pool - The localized volume of molten metal in a weld prior to its solidification as weld metal.

Weld reinforcement - Weld metal in excess of the quantity required to fill a joint.

Wetting - The phenomenon whereby a liquid filler metal or flux spreads and adheres in a thin continuous layer on a solid base metal.

Wire feed speed - The rate at which wire is consumed in welding.

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