IS 4972 (1968): Resistance spot welding electrodes [MTD 11: Welding General]

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Indian Standard

SPECIFICATION FOR RESISTANCE SPOT-WELDING ELECTRODES

(Second Reprint AUGUST 1984)

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INDIAN STANDARDS INSTITUTION
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 7

August 1969

Indian Standard

SPECIFICATION FOR RESISTANCE SPOT-WELDING ELECTRODES

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Indian Standard

SPECIFICATION FOR RESISTANCE SPOT-WELDING ELECTRODES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 31 December 1968, after the draft finalized by the Welding General Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The Sectional Committee responsible for the preparation of this standard felt the necessity for standardization of dimensional requirements for spot-welding electrodes in order to ensure the interchargeability of electrodes in the sockets of electrode holders and also to help in obtaining welds of uniform characteristics. This standard lays down suitable code numbers and dimensions for such electrodes so that the requirements for maximum number of applications are satisfied. However, these dimensions may be modified to suit the requirements for particular applications, if necessary. The requirements of the material recommended for these electrodes have also been included.

0.3 This standard has been prepared in two sections incorporating 'ISO taper' dimensions in one and 'Morse taper' dimensions in the other for spot-welding electrodes. It has been decided that both these tapers may continue for the manufacture of spot-welding electrodes until such time the country changes over to ISO taper.

0.4 This standard keeps in view the trade practices followed in the country in this field. Due regard has been taken of the Draft ISO Recommendation on taper dimensions of electrodes and holders in the formulation of Section 1 of the standard which deals with spot-welding electrodes incorporating the taper dimensions as suggested in the ISO Recommendation. It is felt that adoption of this taper will facilitate easy removal of electrodes from their holders. Morse taper being followed in the country for the manufacture of spot-welding electrodes has been incorporated in Section 2 of this standard.

0.4.1 In the formulation of this standard, assistance has also been derived from the following publications:

ISO/R 670:1968 Dimensions of straight resistance spot welding electrodes. International Organization for Standardization.

Draft ISO Recommendation No. 1161 Dimensions of straight spot welding electrodes (for loads greater than 1 500 kgf). September 1966. International Organization for Standardization.

NF A82-120 : 1946 Spot welding electric machines, male electrode points, couplings. Association Francaise de Normalization.

NF A82-121 : 1946 Spot welding electric machines, female electrode points, couplings. Association Francaise de Normalization.

B. S. 4215 : 1967 Spot welding electrode and electrode holders. British Standards Institution.

DIN 44750 Straight spot welding electrodes with taper shank. August 1961. Deutscher Normenausschuss.

Welding Handbook, Ed. 5, 1962. American Welding Society, New York.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

---

1. SCOPE

1.1 This standard lays down the code numbers (in metric units), dimensional requirements, and physical and mechanical properties for a series of spot-welding electrodes, cap electrodes and shanks, mainly intended for resistance spot welding of ferrous and non-ferrous metals.

1.1.1 This standard has been prepared in two sections. Section 1 covers standard ISO tapers and Section 2 Morse tapers.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 812-1957† shall apply.

3. MATERIAL

3.1 The recommended material for manufacture of spot-welding electrodes is given in Appendix A.

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*Rules for rounding off numerical values (*revised*).
†Glossary of terms relating to welding and cutting of metals.

SECTION 1

SPECIFICATION FOR SPOT-WELDING ELECTRODES WITH STANDARD ISO TAPERS

4. SIZE

4.1 The size of an electrode with taper engagement shall be defined by the number given in Table 1. Sizes 1 to 4 are for straight loading when the force does not exceed 1 500 kgf. If the line of force comes outside the engaged diameter at the datum or gauge plane, then the loading should be deemed to be eccentric and the sizes 5 to 8 shall be used. If the force exceeds 1 500 kgf for straight loading, then sizes 9 and 10 shall be used.

5. SHANKS

5.1 The shanks of electrodes shall conform to the dimensions shown in Table 1.

5.2 The form and dimensions of shanks shall be checked by means of a socket gauge as shown in Fig. 1 and Table 2 or 3. The surface of the shank shall be smooth and of such a contour that when tested with pigment the gauge shall leave a print over the whole area.

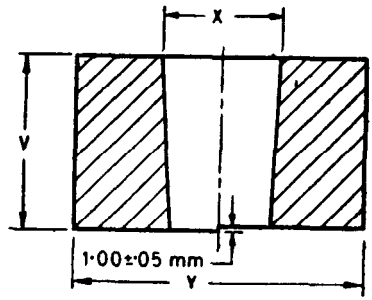


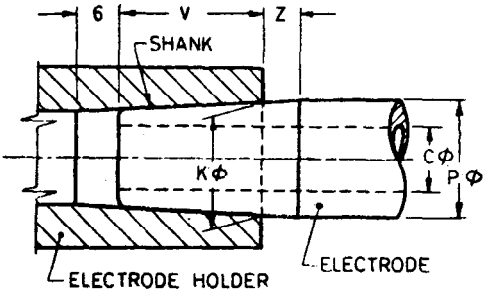
FIG. 1 SOCKET GAUGE FOR SHANKS

6. COOLING

6.1 If a circular hole is used, the diameter shall be as specified against each type.

TABLE 1 DIMENSIONS OF ELECTRODE SHANKS AND ELECTRODE HOLDERS WITH ISO TAPERS

(*Clauses* 4.1, 5.1 *and* 7.1)



Nominal Size	Major Dia P	Engage Dia K	V	Z	Cooling Hole Dia C	Taper (Inclusive)	Load
	mm	mm	mm	mm	mm		
01	13·0	12·7	16·0	3	7·0	1/10	For straight loads not over 1 500 kgf
02	16·0	15·5	20·0	5	8·5	1/10	
03	20·0	19·0	25·0	10	10·5	1/10	
04	25·0	24·5	31·5	5	13·5	1/10	
05	13·0	12·7	25·0	3	7·0	1/10	For eccentric loading
06	16·0	15·5	31·5	5	8·5	1/10	
07	20·0	19·0	40·0	10	10·5	1/10	
08	25·0	24·5	50·0	5	13·5	1/10	
09	31·5	31·0	40·0	5	14·0	1/5	For straight loading over 1 500 kgf
10	40·0	39·0	50·0	5	16·0	1/5	

TABLE 2 DIMENSIONS OF RING GAUGES FOR STRAIGHT THRUST SHANKS

(*Clause* 5.2)

NOMINAL SIZE	DIAMETER X*	V†	TAPER‡	DIAMETER Y APPROXIMATE
mm	mm	mm		mm
1	13·0	19·0	1/10	23
2	16·0	25·0	1/10	38
3	20·0	35·0	1/10	45
4	25·0	36·5	1/10	57
9	31·5	45·0	1/5	64
10	40·0	55·0	1/5	72

*Tolerance $^{+\ 0\cdot01}_{-\ 0}$ mm.

†Tolerance $\pm$ 0·02 mm.

‡Taper tolerance on diameter $\pm$ 0·003 per unit length of taper.

TABLE 3 DIMENSIONS OF RING GAUGES FOR ECCENTRICALLY LOADED SHANKS

(*Clause* 5.2)

NOMINAL SIZE	DIAMETER X*	V†	TAPER‡	DIAMETER Y APPROXIMATE
mm	mm	mm		mm
5	13·0	28·0	1/10	23
6	16·0	36·5	1/10	38
7	20·0	50·0	1/10	45
8	25·0	55·0	1/10	57

*Tolerance $^{+\ 0\cdot01}_{-\ 0}$ mm.

†Tolerance $\pm$ 0·02 mm.

‡Taper tolerance on diameter $\pm$ 0·003 per unit length of taper.

6.2 If a non-circular hole is used, the area shall be not less than 30 percent nor more than 40 percent of shank area at the datum or gauge plane (engage diameter R) and dimensions of the hole shall be such that they admit a cooling pipe of appropriate outside diameter as follows:

Nominal Size of Electrodes (*See* Table 1)	*Maximum Outside Diameter of Cooling Pipe*
mm	mm
1 and 5	6
3 and 7	8
4 and 8	10
9	10
10	12

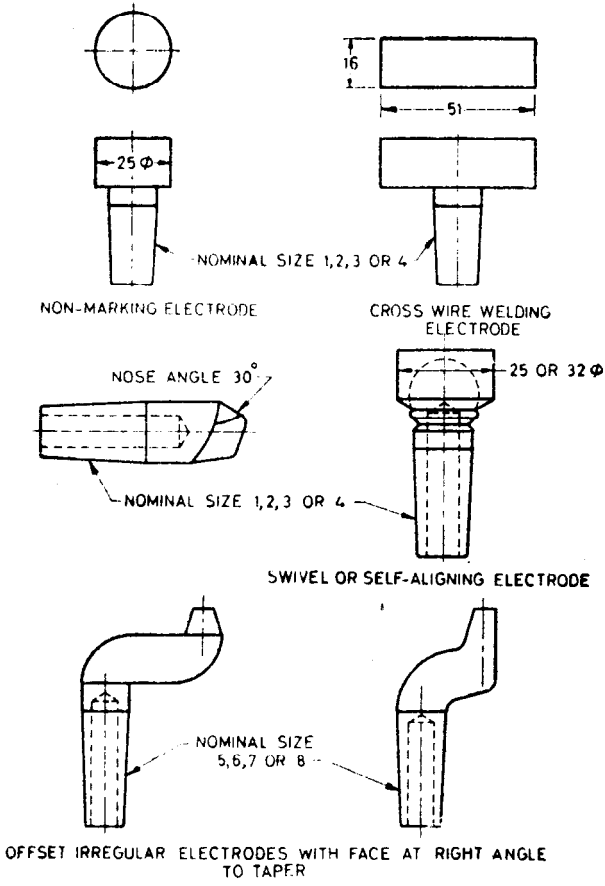
6.2.1 *Cooling Pipe* — The size of the cooling pipe shall be such that the cross-sectional area of its bore is approximately equal to the area of the annulus formed between its outside diameter and the bore of the electrode.

The cooling pipe shall be able to extend to within 4 mm from the blind end of the cooling hole in the electrode with the pipe and cut at 45°.

The cooling water should flow through the cooling pipe to the electrode and return via annulus between the outside of the pipe and the cooling holes.

7. ELECTRODES

7.1 Dimensions — Electrodes shall conform to the dimensions shown in Tables 1 and 4 to 8, and Fig. 2.

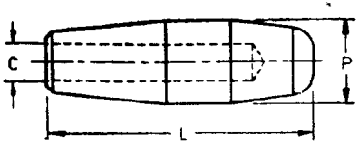


All dimensions in millimetres.

FIG. 2 IRREGULAR ELECTRODE NOMENCLATURE

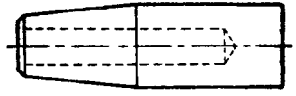
TABLE 4 STRAIGHT ELECTRODES WITH TAPERED SHANKS

(*Clause* 7.1)

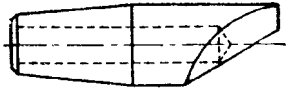


A-POINTED

B-DOME

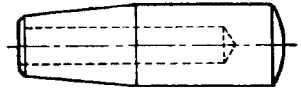


C-FLAT



D-OFFSET

E-TRUNCATED CONE



F- SPHERICAL

Electrode Designation with Class II Alloy* Pointed, Dome, etc	Overall Length (Tol ± 0·5)	Major Dia (Tol ± 0·05)	Nominal Size	Water Hole Dia (Tol ± 0·25)
	L	*P*		*C*
	mm	mm		mm
A, B, C, D, E or F201 038	38			
A, B, C, D, E or F201 044	44			
A, B, C, D, E or F201 051	51			
A, B, C, D, E or F201 057	57			
A, B, C, D, E or F201 064	64	13·0	1	7·0
A, B, C, D, E or F201 070	70			
A, B, C, D, E or F201 076	76			
A, B, C, D, E or F201 083	83			
A, B, C, D, E or F201 089	89			
A, B, C, D, E or F201 095	95			
A, B, C, D, E or F201 102	102			

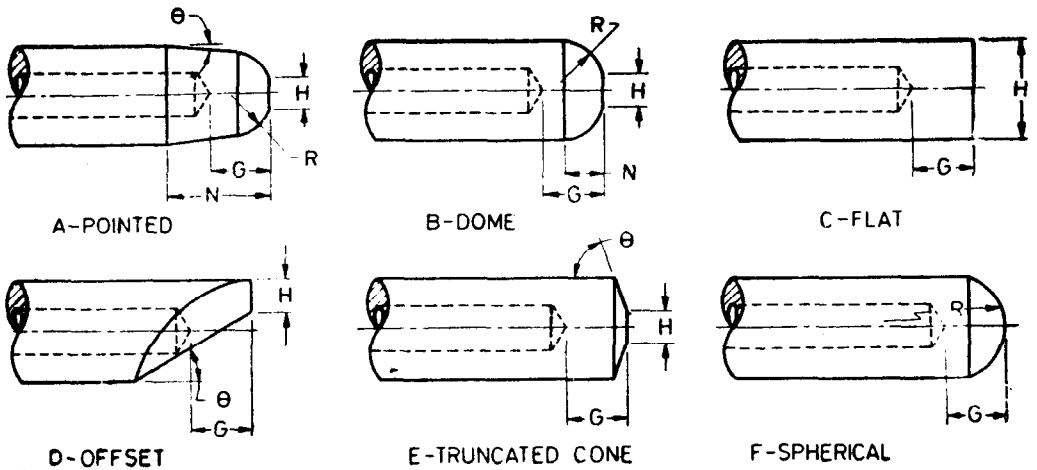
A, B, C, D, E or F202 038	38			
A, B, C, D, E or F202 044	44			
A, B, C, D, E or F202 051	51			
A, B, C, D, E or F202 057	57			
A, B, C, D, E or F202 064	64	16·0	2	8·5
A, B, C, D, E or F202 070	70			
A, B, C, D, E or F202 076	76			
A, B, C, D, E or F202 083	83			
A, B, C, D, E or F202 089	89			
A, B, C, D, E or F202 095	95			
A, B, C, D, E or F202 102	102			
A, B, C, D, E or F203 038	38			
A, B, C, D, E or F203 051	51			
A, B, C, D, E or F203 064	64	20·0	3	10·5
A, B, C, D, E or F203 076	76			
A, B, C, D, E or F203 089	89			
A, B, C, D, E or F203 102	102			
A, B, C, D, E or F204 064	64			
A, B, C, D, E or F204 076	76	25·0	4	13·5
A, B, C, D, E or F204 089	89			
A, B, C, D, E or F204 102	102			
A, B, C, D, E or F204 125	125			
A, B, C, D, E or F209 076	76			
A, B, C, D, E or F209 089	89	31·5	9	14
A, B, C, D, E or F209 102	102			
A, B, C, D, E or F209 125	125			
A, B, C, D, E or F210 089	89	40·0	10	16
A, B, C, D, E or F210 102	102			
A, B, C, D, E or F210 125	125			

*NOTE — First digit of electrode number (2) indicates Class II Alloy for Class I substitute number 1 and for Class III substitute 3.

CODE — Second two digit indicate nominal size and last 3 digits indicate length in mm.

TABLE 5 ELECTRODE NOSE CONFIGURATIONS

(*Clause* 7.1)



Nose Style	Nominal Size	Major Dia	Distance to Face ± 0·8	Flat Dia ± 0·4	Nose Length	Radius	Angle ± 30′
		*P**	*G*	*H*	*N*	*R*	θ
	mm	mm		mm	mm	mm	
A				5·0	19·0	4·0	6°
B				5·0	6·5	4·0	—
C				13·0	—	—	—
D	1, 5	13	12·5	5·0	—	—	30°†
E				5·0	—	—	20°
F				—	—	51·0	—

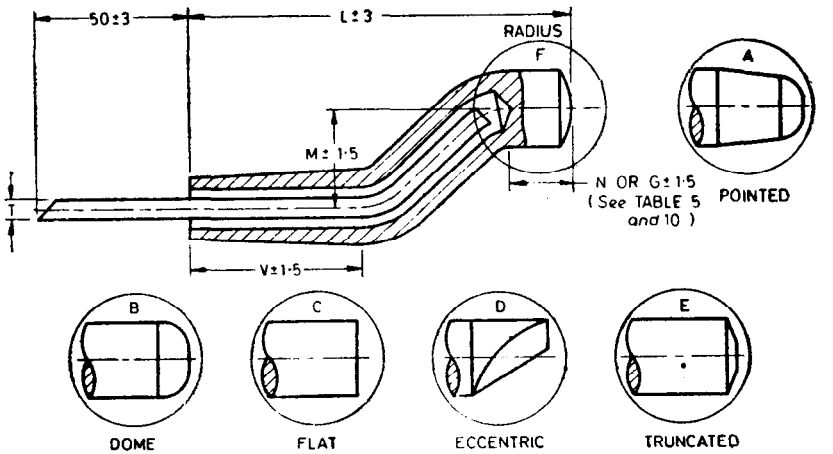
A				6·5	22·0	6·0	6°
B				6·5	10·0	6·0	—
C				16·0	—	—	—
D	2, 6	16	19·0	6·5	—	—	30°†
E				6·5	—	—	20°
F				—	—	51·0	—
A				8·0	28·5	8·0	6°
B				8·0	9·5	8·0	—
C				20·0	—	—	—
D	3, 7	20	19·0	8·0	—	—	30°
E				8·0	—	—	20°
F				—	—	51·0	—
A				8·0	28·5	8·0	6°
B				8·0	10·0	8·0	—
C				25·0	—	—	—
D	4, 8	25	19·0	8·0	—	—	30°
E				8·0	—	—	20°
F				—	—	75·0	—
A				10·0	32·0	13·0	6°
B				10·0	12·0	13·0	—
C				31·5	—	—	—
D	9	31·5	19·0	10·0	—	—	30°
E				10·0	—	—	20°
F				—	—	100·0	—
A				15·0	32·0	17·0	6°
B				15·0	12·0	17·0	—
C				40·0	—	—	—
D	10	40	20·0	15·0	—	—	30°
E				15·0	—	—	20°
F				—	—	150·0	—

**See* Table 1.

†Use 40° for electrodes under 38 mm.

TABLE 6 STANDARD SINGLE-BEND ELECTRODES; COLD-FORMED FROM STANDARD STRAIGHT ELECTRODES

(*Clause* 7.1)



NOTE — For dimensions of shanks *see* Table 1.

CODE

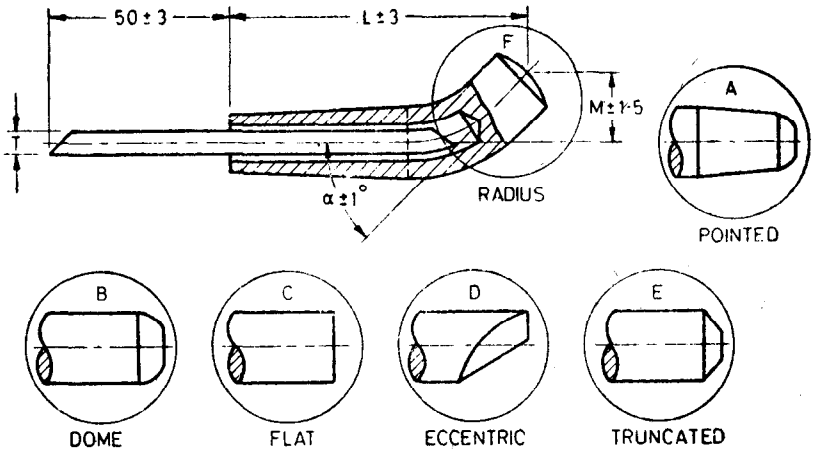
First 2 digits before letter indicate angle α
Letter indicates nose style (A, B, C, etc)
First digit following letter indicates alloy class (1, 2 or 3)
Second and third digits following letter indicate size (05, 06, 07 or 08)
Fourth, fifth and sixth digits following letter = overall length *L* after forming
2 digits following dash = offset distance *M*

Examples:

ELECTRODE DESIGNATION	ANGLE	NOSE STYLE	ALLOY CLASS	NOMINAL SIZE	OVERALL LENGTH	OFFSET	WATER TUBE DIA
	α				*L*	*M*	*T*
					mm	mm	mm
15B205 064-11	15°	B	2	5	64	11	4·62
25C306 070-12	25°	C	3	6	70	12	6·22
45F207 083-19	45°	F	2	7	83	19	6·22
45E308 083-19	45°	E	3	8	83	19	6·22

TABLE 7 STANDARD DOUBLE-BEND ELECTRODES; COLD-FORMED FROM STANDARD STRAIGHT ELECTRODES

(*Clause* 7.1)



NOTE — For dimensions of shanks *see* Table 1.

CODE

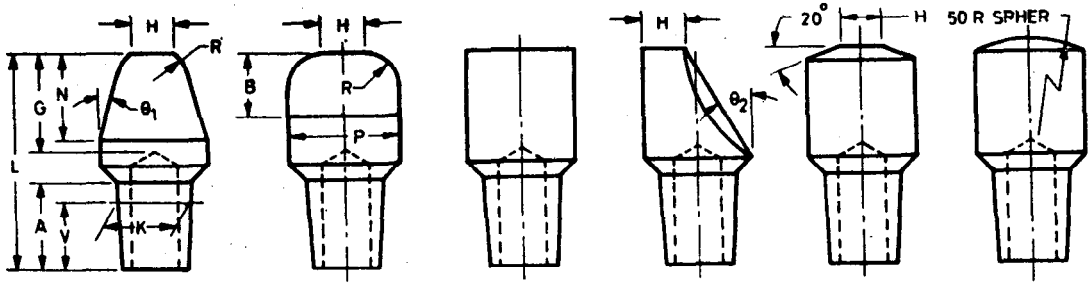
Letter indicates nose style A, B, C, etc (pointed, dome, flat, etc)
First digit indicates alloy class (1, 2 or 3)
Second and third digits indicate size (05, 06, 07, or 08)
Fourth, fifth and sixth digits = overall length *L* after forming
2 digits following dash = offset distance *M*

Examples:

ELECTRODE DESIGNATION	NOSE STYLE	ALLOY CLASS	NOMINAL SIZE	OVERALL LENGTH	OFFSET	WATER TUBE DIA
				L	*M*	*T*
				mm	mm	mm
B205 064-14	B	2	5	64	14	4·62
C306 070-19	C	3	6	70	19	6·22
F207 083-32	F	2	7	83	32	6·22
E208 083-32	E	2	8	83	32	6·22

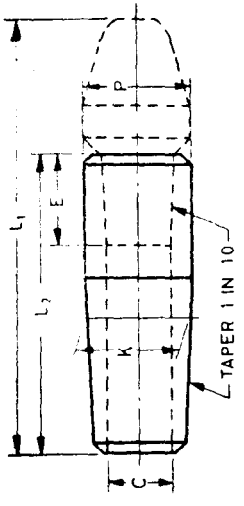
TABLE 8 CAPS AND ADAPTOR SHANKS

(*Clause* 7.1)



Cap Designation	Major Dia								Drill ± 0·25				
	P	*L* ± 0·25	*N*	*B*	*A*	*G* (± 0·8)	*V*	*K* + 0·000 − 0·02	*H* ±0·4	θ_1	θ_2	*R*	
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			mm
A, B, C, D, E or F21	13·0	28·6	9·5	6·35	9·5	12·7	7·24	10·0	6·14	4·76	18°15′	30°	3·8
A, B, C, D, E or F22	16·0	32·0	12·7	9·5	12·7	14·3	9·91	11·0	7·0	6·35	15°30′	30°	5·3
A, B, C, D, E or F23	20·0	41·3	19·0	9·5	15·0	15·0	12·0	12·0	8·0	7·14	13°30′	45°	6·35

ADAPTOR SHANKS



Shank Designation	L_1	L_2	Major Dia P	Nominal Size	E, Min	$C \pm 0{\cdot}25$	Engage Dia K
	mm	mm	mm		mm	mm	mm
G201 032	51	32					
G201 038	57	38					
G201 044	64	44					
G201 051	70	51					
G201 057	76	57					
G201 064	83	64	13·0	1	16·32	7·14	12·7
G201 070	89	70					
G201 076	95	76					
G201 083	102	83					
G201 089	108	89					
G201 095	115	95					
G201 102	120	102					
G202 032	51	32					
G202 038	57	38					
G202 044	64	44					
G202 051	70	51					
G202 057	76	57					
G202 064	83	64	16·0	2	13·5	9·50	15·5
G202 070	89	70					
G202 076	95	76					
G202 083	102	83					
G202 089	108	89					
G202 095	115	95					
G202 102	120	102					
G203 051	78	51					
G203 064	92	64					
G203 076	104	76	20	3	16·67	11·10	19·0
G203 089	117	89					
G203 102	130	102					

NOTE — In the shank designation letter G denotes adaptor shank; first digit indicates class of alloy (1, 2 or 3); second and third digits indicate size (01, 02 or 03); and fourth, fifth and sixth digits denote the overall length L_2.

SECTION 2

SPECIFICATION FOR SPOT-WELDING ELECTRODES WITH STANDARD MORSE TAPERS

8. SIZES

8.1 The size of an electrode with taper engagement shall be defined by the number of the taper of the shank (Fig. 3).

9. SHANKS

9.1 The shanks of electrodes shall conform to the dimensions shown in Fig. 3.

9.2 The form and dimensions of shanks shall be checked by means of ring and plug gauges as shown in Table 9. The surface of the shank shall be smooth and of such a contour that, when tested with pigment, the gauge shall leave a print over the whole area.

10. COOLING HOLE

10.1 If a circular hole is used, the diameter shall be as specified against each type.

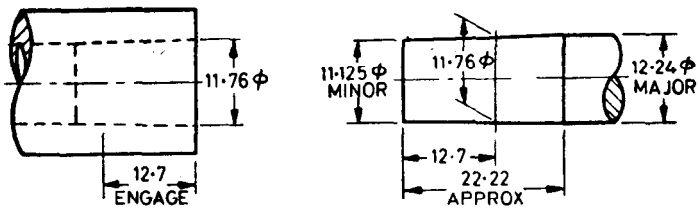
10.2 If a non-circular hole is used, the area shall be neither less than 30 percent nor more than 40 percent of shank area at the datum or gauge plane (engage diameter R) and dimensions of the hole shall be such that they admit a cooling pipe of appropriate outside diameter as follows:

Nominal Size of Electrodes (*See* Table 10)	*Maximum Outside Diameter of Cooling Pipe*
	mm
1	5
2	6·5
3	6·5

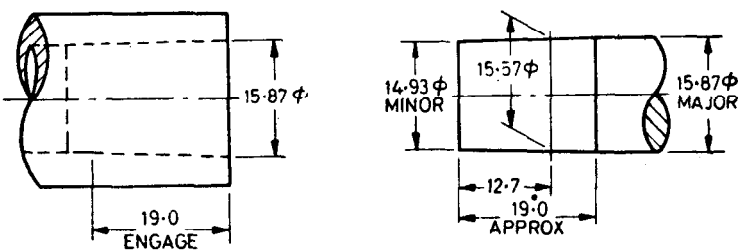
10.2.1 *Cooling Pipe* — The requirements of **6.2.1** shall apply.

11. ELECTRODES

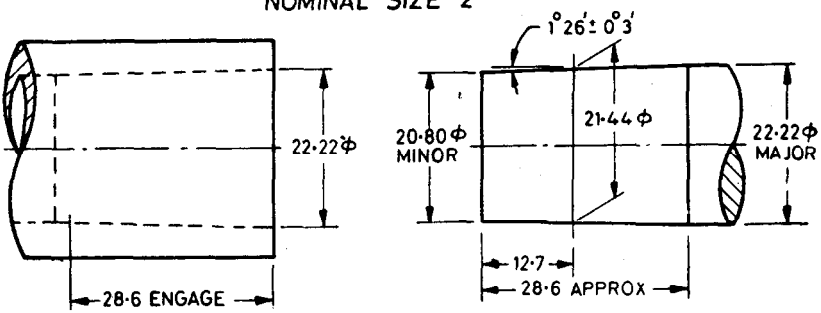
11.1 Dimensions — Electrodes shall conform to the dimensions shown in Fig. 4 and Tables 10 to 14.



NOMINAL SIZE 1



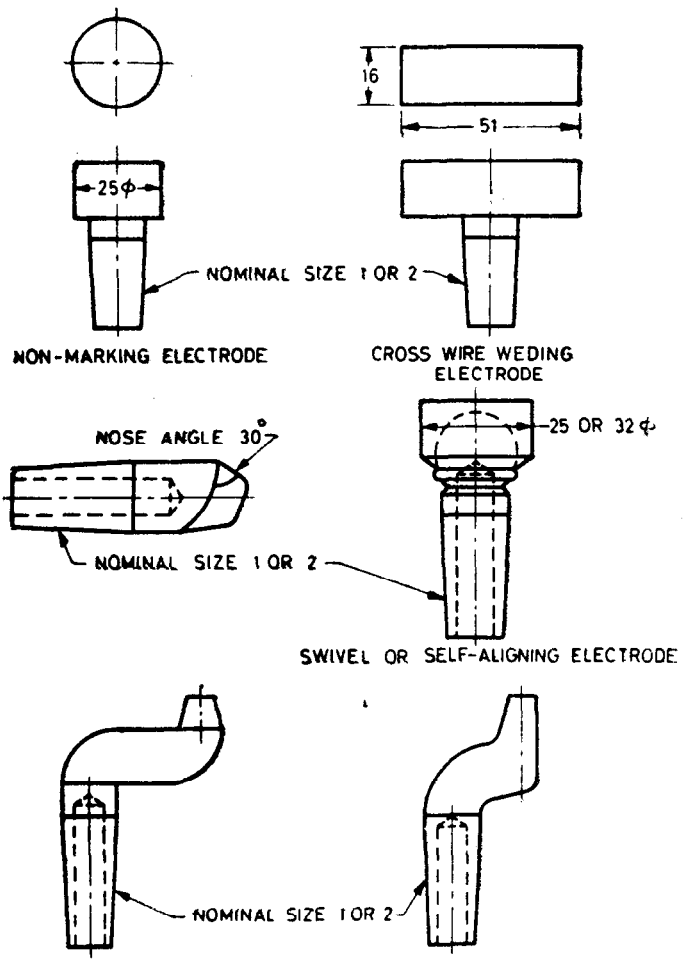
NOMINAL SIZE 2



NOMINAL SIZE 3

All dimensions in millimetres.

FIG. 3 DIMENSIONS OF ELECTRODE HOLDERS AND SHANKS WITH MORSE TAPER



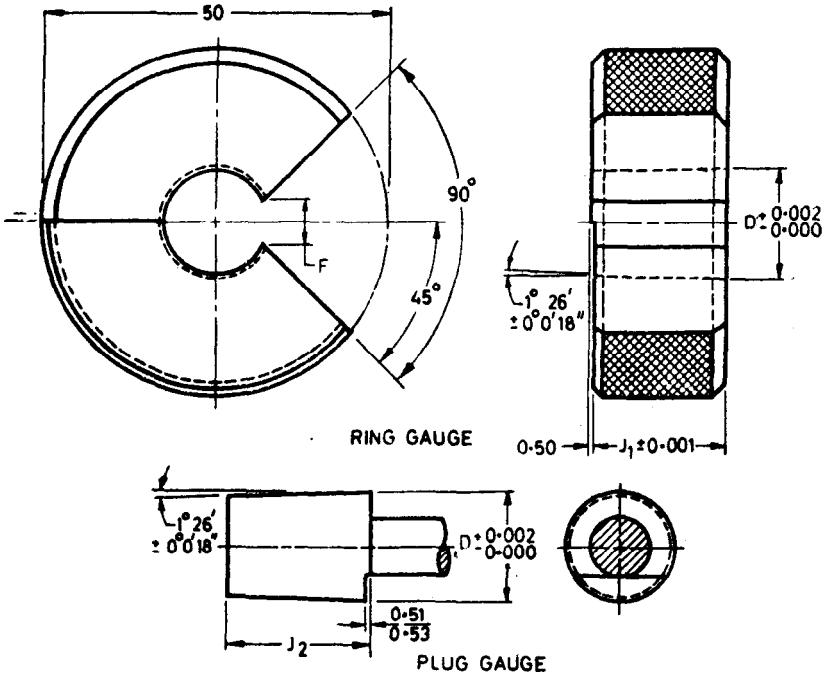
All dimensions in millimetres.

FIG. 4 MORSE IRREGULAR ELECTRODES

TABLE 9 TAPER RING AND PLUG GAUGES FOR ELECTRODE HOLDERS AND SHANKS

(*Clause* 9.2)

All dimensions in millimetres.

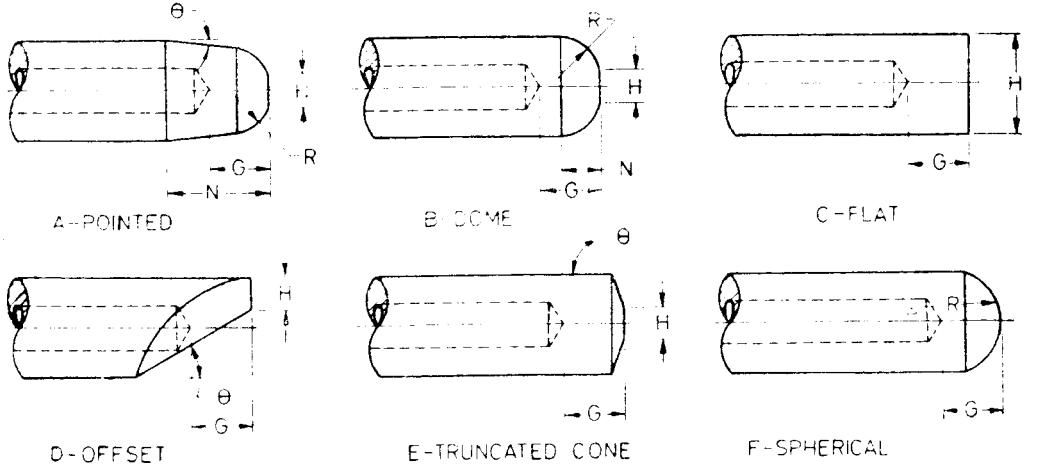


Nominal Size	Plug Gauge			
	D	J_1	J_2	F
	mm	mm	mm	mm
1	11·760	12·70	14·220	2·54
2	15·875	19·05	20·570	6·35
3	22·225	28·45	29·970	6·35

TABLE 10 MORSE ELECTRODE NOSE CONFIGURATIONS

(*Clause* 11.1)

All dimensions in millimetres



Nose Style	Nominal Size	Major Dia	Distance to Face ± 0·8	Flat Dia ± 0·4	Nose Length	Radius	Angle ± 30′
		*P**	*G*	*H*	*N*	*R*	θ
		mm	mm	mm	mm	mm	mm
A				5·0	19·0	4·0	6°
B				5·0	6·5	4·0	—
C	1	12·24	12·5	13·0	—	—	—
D				5·0	—	—	30°†
E				5·0	—	—	20°
F				—	—	51·0	—

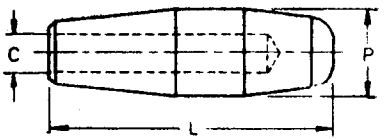
A				6·5	22·0	6·0	6°
B				6·5	10·0	6·0	—
C	2	15·87	19·0	16·0	—	—	—
D				6·5	—	—	30°†
E				6·5	—	—	20°
F				—	—	51·0	—
A				8·0	28·5	8·0	6°
B				8·0	10·0	8·0	—
C	3	22·22	19·0	22·0	—	—	—
D				8·0	—	—	30°
E				8·0	—	—	20°
F				—	—	51·0	—

*See Fig. 3.

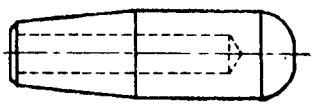
†Use 40° for electrodes under 38 mm.

TABLE 11 STRAIGHT ELECTRODES WITH TAPERED SHANKS

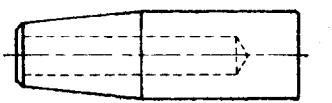
(*Clause* 11.1)



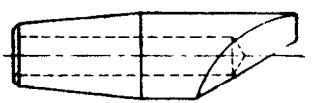
A-POINTED



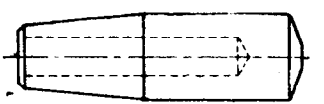
B-DOME



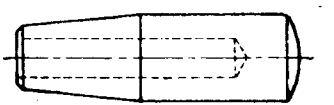
C-FLAT



D-OFFSET



E-TRUNCATED CONE



F-SPHERICAL

Electrode Designation with Class II Alloy, Pointed, Dome, etc	Overall Length Tol ± 0·10 *L* mm	Major Dia Tol ± 0·05 *P* mm	Nominal Size	Water Hole Dia Tol ± 0·25 *C* mm
A, B, C, D, E or F21 032	32			
A, B, C, D, E or F21 038	38			
A, B, C, D, E or F21 044	44			
A, B, C, D, E or F11 051	51			
A, B, C, D, E or F21 057	57			
A, B, C, D, E or F21 064	64	12·24	1	7·14
A, B, C, D, E or F21 070	70			
A, B, C, D, E or F21 076	76			
A, B, C, D, E or F21 083	83			
A, B, C, D, E or F21 089	89			
A, B, C, D, E or F21 095	95			
A, B, C, D, E or F21 102	102			

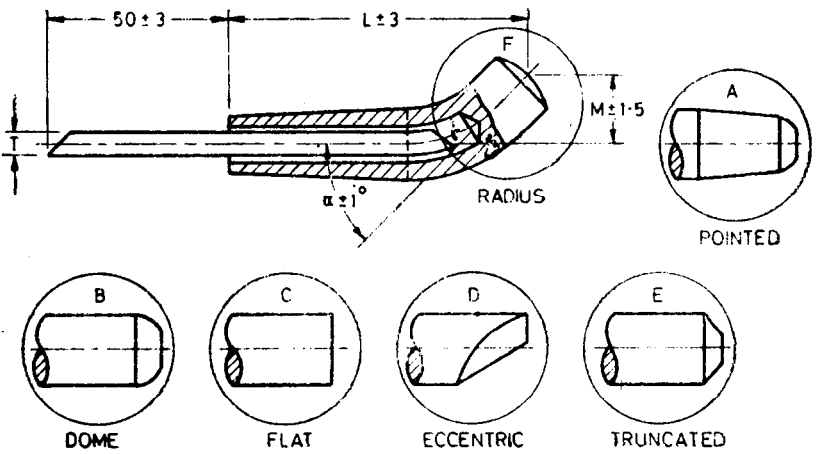
A, B, C, D, E or F22 032	32			
A, B, C, D, E or F22 038	38			
A, B, C, D, E or F22 044	44			
A, B, C, D, E or F22 051	51			
A, B, C, D, E or F22 057	57			
A, B, C, D, E or F22 064	64	15·87	2	9·5
A, B, C, D, E or F22 070	70			
A, B, C, D, E or F22 076	76			
A, B, C, D, E or F22 083	83			
A, B C, D, E or F22 089	89			
A, B, C, D, E or F22 095	95			
A, B, C, D, E or F22 102	102			
A, B, C, D, E or F23 038	38			
A, B, C, D, E or F23 051	51			
A, B, C, D, E or F23 064	64	22·22	3	12·7
A, B, C, D, E or F23 076	76			
A, B, C, D, E or F23 089	89			
A, B, C, D, E or F23 102	102			

NOTE — First digit of electrode number (2) indicates Class II Alloy, for Class I substitute number 1 and for Class III substitute 3; and second digit indicates nominal size and last 3 digits indicate length in mm.

TABLE 12 SINGLE-BEND ELECTRODES; COLD-FORMED FROM STANDARD STRAIGHT ELECTRODES

(*Clause* 11.1)

All dimensions in millimetres.



CODE

First two digits before letter indicate angle α
Letter indicates nose style (A, B, C, etc)
First digit following letter indicates alloy class (1, 2 or 3)
Second digit following letter indicates size (1, 2 or 3)
Third, fourth and fifth digits following letter = overall length L after forming
2 digits following dash = offset distance M

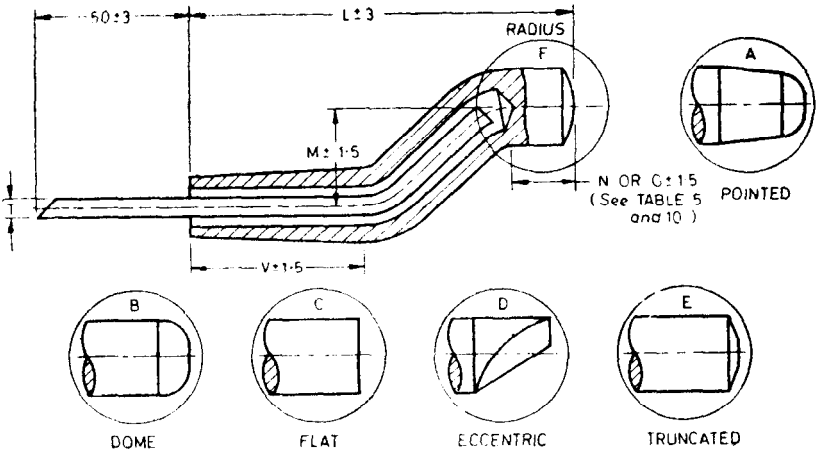
Examples:

Electrode Designation	Angle α	Nose Style	Alloy Class	Nominal Size	Overall Length L	Offset M	Water Tube Dia T
				mm	mm	mm	mm
15B21 064-11	15°	B	2	1	64	11	4·62
25C32 070-12	25°	C	3	2	70	12	6·22
45F23 083-19	45°	F	2	3	83	19	6·22

TABLE 13 DOUBLE-BEND ELECTRODES; COLD-FORMED FROM STANDARD STRAIGHT ELECTRODES

(*Clause* 11.1)

All dimensions in millimetres.



CODE

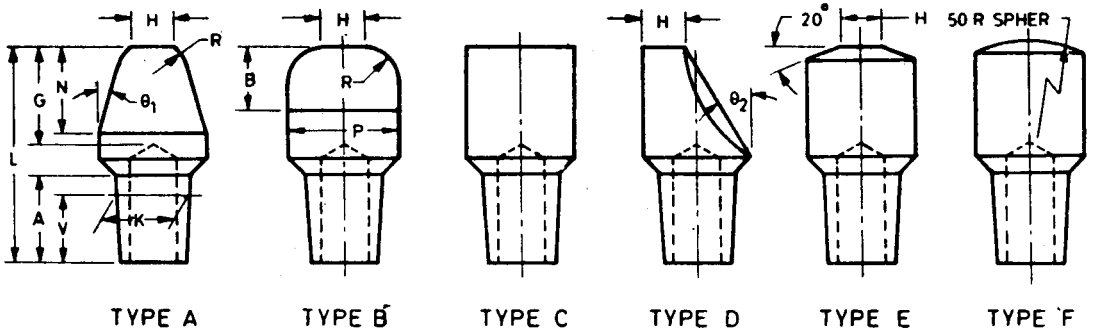
Letter indicates nose style A, B, C, etc (pointed, dome, flat, etc)
First digit indicates alloy class (1, 2 or 3)
Second digit indicates size (1, 2 or 3)
Third, fourth and fifth digits = overall length L after forming
2 digits following dash = offset distance M

Examples:

Electrode Designation	Nose Style	Alloy Class	Nominal Size	Overall Length	Offset	Water Tube Dia
				L	M	T
				mm	mm	mm
B21 064-14	B	2	1	64	14	4·62
C32 070-19	C	3	2	70	19	6·22
F23 083-32	F	2	3	83	32	6·22

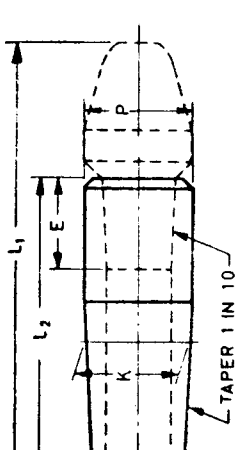
TABLE 14 MORSE CAPS AND ADAPTOR SHANKS

(*Clause* 11.1)



CAP ELECTRODES

Cap Designation	Major Dia								Drill ± 0·25				
	P	*L* ± 0·25	*N*	*B*	*A*	*G* ± 0·8	*V*	*K* + 0·000 − 0·02		*H* ±0·4	θ_1	θ_2	*R*
	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm			mm
A, B, C, D, E or F21	12·24	28·6	9·5	6·35	9·5	12·7	7·24	9·52	7·14	4·76	18°15′	30°	3·8
A, B, C, D, E or F22	15·87	32·0	12·7	9·5	12·7	14·3	9·91	10·54	8·0	6·35	15°30′	30°	5·3
A, B, C, D, E or F23	22·22	41·3	19·0	9·5	15·9	17·5	12·7	15·57	12·7	8·0	15°	45°	7·9



ADAPTOR SHANKS

Shank Designation	L_1	L_2	Major Dia P	Nominal Size	E,Min	$C \pm 0{\cdot}25$	Dia at 12·7 K
	mm	mm	mm	mm	mm	mm	mm
G21 032	51	32					
G21 038	57	38					
G21 044	64	44					
G21 051	70	51					
G21 057	76	57					
G21 064	83	64	12·24	1	10·32	7·14	11·76
G21 070	89	70					
G21 076	95	76					
G21 083	102	83					
G21 089	108	89					
G21 095	115	95					
G21 102	120	102					
G22 032	51	32					
G22 038	57	38					
G22 044	64	44					
G22 051	70	51					
G22 057	76	57					
G22 064	83	64	15·87	2	13·5	9·52	15·57
G22 070	89	70					
G22 076	95	76					
G22 083	102	83					
G22 089	108	89					
G22 095	115	95					
G22 102	120	102					
G23 051	76	51					
G23 076	102	76	22·22	3	16·67	12·7	21·44
G23 102	125	102					

NOTE — In the shank designation letter G denotes adaptor shank; first digit indicates class of alloy (1, 2 or 3); second and third digits indicate size (01, 02 or 03); and fourth, fifth and sixth digits denote the overall length L_2.

APPENDIX A

(*Clause* 3.1)

RECOMMENDED MATERIAL FOR SPOT-WELDING ELECTRODES

A-1. INTRODUCTION

A-1.1 Spot-Welding electrodes perform four functions, namely:

a) They conduct the welding current to the work and determine the current density in the weld zone;

b) They transmit the force to the area and determine the pressure in the weld zone;

c) They dissipate the heat from the weld zone, thus preventing surface fusion of the work; and

d) They maintain alignment of the work.

A-1.2 Spot-welding electrodes carry currents ranging from 800 to 11 000 A/cm^2. Since the quantity of heat developed is directly proportional to the square of the current, the time of current flow and the resistance of the path, it is obvious that the electrode materials should have a relatively high electrical conductivity to prevent electrodes from overheating. Also, the thermal conductivity should be sufficiently high to permit the heat generated at the work and electrode faces to be dissipated readily, thus preventing the surfaces from fusing.

A-1.3 The pressures on the electrodes may range from 7 to 42 kgf/mm^2. In addition, there may be considerable impact when the electrodes are brought together on the work. Therefore, in order to minimize deformation of the electrode face, the electrode should be of a material having high mechanical properties, particularly at elevated temperatures.

A-1.4 Thus, materials for spot-welding electrodes should possess high electrical and thermal conductivity and high resistance to compressive deformation. In general, higher the conductivity of an electrode material the lower is its strength. The best electrode to use for a given application is one which possesses conductivity sufficient to prevent overheating, but with the highest possible strength.

A-2. RECOMMENDED MATERIAL

A-2.1 Copper is the basis of all spot-welding electrodes because of its high electrical and thermal conductivities. High conductivity hard-drawn copper has a conductivity of over 90 percent of International Annealed Copper Standard (IACS) and is used in the welding of materials of high electrical conductivity, such as aluminium and its alloys.

A-2.2 The addition of a small percentage (0·5 to 1·0) of cadmium increases without much loss of conductivity the softening temperature of the alloy which is greater than that could be obtained with pure copper. Such alloys, with a conductivity of over 85 percent IACS are used for electrodes for welding tinplate and other coated material. Tellurium copper, containing about 0·5 percent tellurium is also a high conductivity material (90 percent IACS) used for making electrodes for the spot-welding of aluminium and its alloys.

A-2.3 Chromium copper containing about 0·5 to 0·8 percent of chromium may be hardened by heat-treatment and cold working and is one of the hardest and strongest high conductivity copper alloys (85 percent IACS); it is more resistant to wear and to softening at elevated temperatures than any materials of equivalent conductivity and is one of the most generally used material for spot-welding electrodes.

A-2.4 The addition of small quantities of cobalt and beryllium to copper provides an alloy with moderate conductivity and very high (higher than chromium copper) hardness and strength. It is particularly suitable for welding materials of high strength at elevated temperatures, such as stainless steel and the heat-resisting alloys used for jet engines.

A-2.5 Table 15 briefly summarizes the information regarding the material recommended for spot-welding electrodes.

TABLE 15 MATERIAL RECOMMENDED FOR SPOT-WELDING ELECTRODES

Class	Material	Conductivity Percent (that for Standard Annealed-Copper)	Vickers Pyramid Hardness *HV*	Application
I	Cadmium copper containing 0·5 to 1·0 percent cadmium	85	90	Spot-welding of coated steels, aluminium and its alloys
II	Chromium copper containing 0·5 to 0·8 percent chromium	80-85	110	Spot-welding of steels other than those coveredunder class II and III
III	Cobalt, beryllium copper	45-50	180	Spot-welding of stainless and heat-resisting alloys

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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