MATERIAL AND EQUIPMENT STANDARD

FOR

ARC WELDING EQUIPMENT AND ACCESSORIES

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PAGE No.

1. SCOPE

1.1 This Standard specifies minimum requirements for various types of arc welding machines (manual, semi-automatic and automatic), together with power sources and accessories, to be used in oil, gas and petrochemical industries. The machines may be employed for welding with several processes including Shielded Metal Arc Welding (SMAW), Gas Metal Arc Welding (GMAW or MIG)and Gas Tungsten Arc Welding (GTAW or TIG).

1.2 No exceptions or deviations from this Standard are permitted without prior written approval of purchaser. The intend deviations or exceptions shall be listed separately along with the reasons thereof for purchaser's consideration.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. Changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

BSI (BRITISH STANDARDISATION INSTITUTE)

BS 638 "Arc Welding Power Sources, Equipment and Accessories"

Part 1 "Specification for Oil Cooled Power Sources for Manual, Semi-Automatic and Automatic Metal-Arc Welding and for TIG Welding"

Part 2 "Specification for Air Cooled Power Sources for Manual Metal-Arc Welding with Covered Electrodes and for TIG Welding"

Part 3 "Specification for Air Cooled Power Sources for Semi-Automatic and Automatic Metal-Arc Welding and for TIG Welding"

Part 4 "Specification for Welding Cables"

Part 5 "Specification for Accessories"

Part 7 "Specification for Safety Requirements for Installation and Use"

Part 8 "Specification for Electrode Holders and Handheld Torches and Guns for MIG, MAG and TIG Welding"

ANSI/NEMA (AMERICAN NATIONAL STANDARD INSTITUTE/NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION)

CB1 "Brushes for Electrical Machines"

IEC (INTERNATIONAL ELECTROTECHNICAL COMMISSION)

245 "Rubber Insulated Cables of Rated Voltage Up to and Including 450/750 V"

501 "Safety Requirements for Arc Welding Equipment-Plugs, Socket-Outlets and Couplers for Welding Cables"

3. DEFINITIONS AND TERMINOLOGY

3.1 AC/DC Generator-Rectifier Arc Welding Power Source

An ac/dc generator-rectifier arc welding power sources is a combination of an alternating current generator and static rectifiers with the associated control and indicating devices required to produce either alternating or direct current suitable for arc welding.

3.2 AC/DC Transformer-Rectifier Arc Welding Power Source

An ac/dc transformer-rectifier arc welding power source is a combination of a transformer, having isolated primary and secondary windings, and static rectifiers with the associated control and indicating devices required to produce either alternating or direct current suitable for arc welding.

3.3 AC Generator Arc Welding Power Source

An ac generator arc welding power source is an ac generator with the associated control and indicating devices required to produce alternating current suitable for arc welding.

3.4 AC Transformer Arc Welding Power Source

An ac transformer arc welding power source utilizes a transformer having isolated primary and secondary windings with the associated control and indicating devices required to produce an alternating current suitable for arc welding.

3.5 Automatic Metal-Arc Welding

Metal-arc welding which the arc length and the travel of the electrode(s) or the workpiece(s) are automatically controlled.

3.6 Constant Current Arc Welding Power Source

A constant current arc welding power source is a power source that has means for adjusting the load current and that has a static volt ampere curve that tends to produce a relatively constant load current. The load voltage at a given load current, is responsive to the rate at which a consumable electrode is fed into the arc, except that, when a non-consumable electrode is used, the load voltage is responsive to the electrode to work distance.

3.7 Constant Current/Constant Voltage Arc Welding Power Source

A constant current/constant voltage arc welding power source is a power source that has the selectable characteristics of a constant current arc welding power source or constant voltage arc welding power source.

3.8 Constant Voltage Arc Welding Power Source

A constant voltage arc welding power source is a power source which has means for adjusting the load voltage and has a static volt ampere curve that produces a relatively constant load voltage. The load current, at a given load voltage, is responsive to the rate at which a consumable electrode is fed into the arc.

3.9 DC Generator Arc Welding Power Source

A dc generator arc welding power source is a dc generator with the associated control and indicating devices required to produce direct current suitable for arc welding.

3.10 DC Generator-Rectifier Arc Welding Power Source

A dc generator-rectifier arc welding power sources is a combination of an ac generator and static rectifiers with the associated control and indicating devices required to produce direct current suitable for arc welding.

3.11 DC Transformer-Rectifier Arc Welding Power Source

A dc transformer-rectifier arc welding power source is a combination of a transformer, having isolated primary and secondary windings, and static rectifiers with the associated control and indicating devices required to produce direct current suitable for arc welding.

3.12 Duty Cycle

Duty cycle, expressed in percent, is the ratio of arc time to total time. For the purpose of these standards, the time period of one complete test cycle shall be 10 minutes. (For example, in the case of a 60 percent duty cycle, load shall be applied continuously for 6 minutes and shall be off for 4 minutes.)

3.13 Efficiency

The efficiency of an arc welding power source is the ratio of the power output at the welding terminals to the total power input. Unless otherwise specified, the efficiency shall be given when the power source is operated at rated output.

3.14 Enclosure

An arc welding power source enclosure is the surrounding case or housing constructed to provide a degree of protection to personnel against incidental contact with energized and moving parts and to provide a degree of protection to the power source against damage that will adversely affect its operation.

3.15 Engine Generator Arc Welding Power Source

An engine generator arc welding power source is a power source that consists of an engine mechanically connected to, and mounted with, one or more arc welding generators.

3.16 High Frequency Stabilized Arc Welding Power Source

A high frequency stabilized arc welding power source is a constant current arc welding power source that includes a high-frequency arc stabilizer as an integral part of the power source and the suitable controls required to produce welding current. It is primarily intended for gas tungsten-arc welding.

3.17 Jack

A female contact device designed to mate with a jack plug to establish an electrical connection.

3.18 Jack Plug

A male device, usually associated with welding lead(s), that is inserted into a jack to establish an electrical connection of the welding circuit.

3.19 Load Current

The load current is the amperage flowing in the welding circuit when a load is applied to the welding terminals.

3.20 Load Voltage

Load voltage is the voltage between the welding terminals of the arc welding power source when load current is flowing in the welding circuit.

3.21 Manual Metal-Arc Welding (Hand Welding)

Metal-arc welding with consumable covered electrodes not exceeding 450 mm in length and applied by the operator without automatic or semi-automatic means of replacement. No protection in the form of a gas or mixture of gases from a separate source is applied to the arc or molten pool during welding.

3.22 Metal-Arc Welding Power Source

A power source with power supply and output regulating means, capable of supplying current for metal-arc welding.

3.23 MIG Welding

An electric arc welding process which produces coalescence of metals by heating them with an arc established between a continuous filler metal (consumable) electrode and the work. Shielding of the arc and molten weld pool is obtained entirely from an externally supplied gas or gas mixture.

3.24 Motor Generator Arc Welding Power Source

A motor generator arc welding power source is a power source that consists of an electric motor mechanically connected to and mounted with one or more arc welding generators.

3.25 Open Circuit Voltage

Open circuit voltage is the voltage, excluding high frequency stabilization voltage, between the welding terminals of the arc welding power source when no load current is flowing in the welding circuit.

3.26 Percent Ripple Voltage

Percent ripple voltage is the ratio, expressed as a percentage of the effective (root mean square) value of the ripple voltage to the average value of a pulsating unidirectional voltage. The root-mean-square value of the ripple voltage may be measured with a root-mean-square indicating meter in series with a capacitor having sufficiently low impedance so as not to affect appreciably the indication of the voltmeter. Rectifier type instruments should not be used.

3.27 Rating

A statement of limitations of performance parameters assigned by the manufacturer. These limitations, together with the associated conditions, which jointly constitute the rating, are marked on the rating plane, where applicable.

3.28 Ripple

An alternating component in a unidirectional.

3.29 Semi-Automatic Metal-Arc Welding

Metal-arc welding in which the arc length is automatically controlled but the positioning of the arc is manual.

Note:

MIG/MAG processes are common versions of semi-automatic welding.

3.30 Shielded Metal Arc Welding (SMAW)

An arc welding process that produces coalescence of metals by heating them with an arc between a covered metal electrode and the workpieces. Shielding is obtained from decomposition of the electrode covering. Pressure is not used, and filler metal is obtained from the electrode.

3.31 Static Volt Ampere Characteristics

The static volt ampere characteristics is the curve or family of curves which gives the steady state load voltage of an arc welding power source as ordinate, plotted against the steady state load current as abscissa.

3.32 TIG Welding

Arc welding in which the molten pool and the electrode are shrouded by an inert gas, the electrode being virtually non-consumable and made of pure tungsten or tungsten containing arc stabilizing additives.

4. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

5. CONFLICTING REQUIREMENTS

In case of conflict between this Standard and the inquiry or purchase order, the following will take precedence in the order of priority as indicated hereunder:

- **a)** Purchase order and variations
- **b)** Data sheet and drawings
- **c)** This Standard specifications

All conflicts requirements shall be submitted to the Purchaser in writing.

6. SPECIFICATION FOR ELECTRICAL ARC WELDING POWER SOURCES

6.1 Suitability of Operation

The characteristics of an arc welding power source conforming to these standards shall be such that a qualified operator or appropriate mechanically controlled equipment can, by following the manufacturer's recommended installation and operating procedures, weld satisfactorily.

6.2 Service Conditions

An arc welding power source constructed in accordance with these standards shall be capable of operation at the specified site conditions.

6.3 Construction Requirements-Mechanical Considerations

6.3.1 Frame and enclosure

An arc welding power source shall be so formed and assembled that it will have the strength and rigidity necessary to withstand the normal service to which it is likely to be subjected without increasing its shock, fire, or other hazard. An arc welding power source shall be provided with a case or cabinet that shall enclose all current carrying parts and hazardous moving parts (such as motors, pulleys, belts, fans, gears, and such except that the following need not be enclosed:

1) A flexible supply cord or cable and welding leads; and

2) Ungrounded output terminals for the connection of welding leads, jack plugs, jacks, or similar parts connected to the output circuit and limited in open circuit voltage in accordance with 6.6.3 if they are suitably protected against unintentional contact.

Protection of the output terminals will usually be afforded if:

a) Jacks and uninsulated current carrying parts of the power source, including the specified output terminal lugs in the case of threaded type connections, are recessed behind the vertical plane of the access opening,

b) an uninsulated current carrying part of the power source is recessed for a distance not less than one half of the minimum dimension of the opening behind which the current carrying part is located, or

c) a hinged cover, or a protective guard or cover, which is removable only by the use of tools, with smooth edged slots or openings for the cable is provided over the terminals.

6.3.2 Enclosure construction

6.3.2.1 An enclosure shall be constructed of either sheet metal or cast metal. If the enclosure is constructed from sheet metal, the thickness shall not be less than that given in Table 1 (see also 6.3.2.6). This table is based on a uniform deflection of the enclosure surface for any given load concentrated at the center of the surface regardless of metal thickness. The enclosure shall have a mechanical strength at least equivalent to a sheet metal enclosure constructed in accordance with Table 1.

TABLE 1 - MINIMUM THICKNESS OF SHEET METAL FOR ENCLOSURE-CARBON STEEL

without Supporting Frame (a)		With Supporting Frame or Equivalent Reinforcing (b)		Minimum Thickness	
Maximum Width (c), Inches (mm)	Maximum Length (d) of Supported Edge, Inches (mm)	Maximum Width (c) Inches (mm)	Maximum Length, Inches (mm)	Uncoated, Inches (mm)	Zinc Coated Inches (mm)
4.0 (102)	Not limited	6.25 (159)	Not limited		
4.75 (121)	5.75 (146)	6.75 (171)	8.25 (210)	0.020 (0.51)	0.023 (0.58)
6.0 (152)	Not limited	9.5 (241)	Not limited		
7.0 (179)	8.75 (222)	10.0 (254)	12.5 (318)	0.026 (0.66)	0.029 (0.74)
8.0 (203)	Not limited	12.0 (305)	Not limited		
9.0 (229)	11.5 (292)	13.0 (330)	16.0 (406)	0.032 (0.81)	0.034 (0.86)
12.5 (318)	Not limited	19.5 (495)	Not limited		
14.0 (356)	18.0 (457)	21.0 (533)	25.0 (635)	0.042 (1.07)	0.045 (1.14)
18.0 (457)	Not limited	27.0 (686)	Not limited		
20.0 (508)	25.0 (635)	29.0 (737)	36.0 (914)	0.053 (1.35)	0.056 (1.42)
22.0 (559)	Not limited	33.0 (838)	Not limited		
25.0 (635)	31.0 (787)	35.0 (889)	43.0 (1092)	0.060 (1.52)	0.063 (1.60)
25.0 (635)	Not limited	39.0 (991)	Not limited		
29.0 (737)	36.0 (914)	41.0 (1041)	51.0 (1295)	0.067 (1.70)	0.070 (1.78)
33.0 (838)	Not limited	51.0 (1295)	Not limited		
38.0 (965)	47.0 (1194)	54.0 (1372)	66.0 (1676)	0.030 (2.03)	0.084 (2.13)
42.0 (1067)	Not limited	64.0 (1626)	Not limited		
47.0 (1194)	59.0 (1499)	68.0 (1727)	84.0 (2134)	0.093 (2.36)	0.097 (2.46)
52.0 (1321)	Not limited	80.0 (2032)	Not limited		
60.0 (1524)	74.0 (1880)	84.0 (2134)	103.0 (2616)	0.108 (2.74)	0.111 (2.82)
63.0 (1606)	Not limited	97.0 (2464)	Not limited		
73.0 (1854)	90.0 (2286)	103.0 (2616)	127.0 (3226)	0.123 (3.12)	0.126 (3.20)

a) See 6.4.2.4.

b) See 6.4.2.3.

c) The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

d) Not limited applies only if the edge of the surface is flanged at least 0.500 inch (12.7 mm) or fastened to adjacent surface not normally removed in use.

6.3.2.2 The following factors shall be considered in determining the suitability of an enclosure:

a) Physical strength.

b) Resistance to impact.

c) Moisture absorptive properties.

d) Combustibility.

e) Resistance to corrosion.

f) Resistance to distortion at temperatures to which the enclosure may be subjected under conditions of normal or abnormal use.

g) Resistance to ignition from electrical sources.

6.3.2.3 With reference to Table 1 a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface and has sufficient torsional rigidity to resist the bending moments that may be applied to the surface of the enclosure when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels.

6.3.2.4 Construction considered to be without supporting frame includes:

a) Single sheet with single formed flanges (formed edges),
b) a single sheet that is corrugated or ribbed,
c) an enclosure surface loosely attached to a frame (for example, with spring clips),
d) an enclosure formed or fabricated from sheet metal.

6.3.2.5 The minimum thickness of an enclosure without supporting frame may be less than shown in Tables 1, 2 and 3 if the enclosure is so reinforced that if subjected to bending and torsion forces, its strength and rigidity are shown to be not less than the corresponding properties of an enclosure of the same maximum length and width having the required thickness of metal.

6.3.2.6 The thickness of sheet metal in an area where provision is made for connection of a wiring system in the field shall not be less than 1.35 mm (0.053 inch) if uncoated steel, 1.42 mm (0.056 inch) if galvanized steel and not less than 1.91 mm (0.075 inch) for aluminum, copper, and brass.

6.3.2.7 Construction of the power source enclosure shall be such that there are no sharp projections or edges on the exposed exterior surfaces of the enclosure that are likely to cause accidental injury to personnel.

6.3.2.8 Corrosion protection

All metallic parts shall be painted, plated, or otherwise protected against corrosion if the deterioration of such unprotected parts would be likely to result in a hazardous condition.

6.3.2.9 Brushes shall be in accordance with ANSI/NEMA Standards Publication No. CB1 "Brushes for Electrical Machines".

6.4 Construction Requirements-Electrical Considerations

6.4.1 Power supply connection

6.4.1.1 Where power supply conductors pass through an opening in a barrier or enclosure, the edges of the opening shall be smoothly rounded or shall be provided with a secured and smooth rounded bushing.

6.4.1.2 When a flexible cable is used for power supply connection, it shall comply with latest edition of standard IEC 245. The power source that has wheels, casters, or other obvious means of mobility shall be equipped with a flexible cord and attachment plug shall be provided on the flexible cord, it shall comply with requirements of latest edition of IEC 501.

6.4.1.3 If a power source is not provided with a flexible cord for power supply connection, it shall be provided with input wiring terminals or input terminal leads which shall be enclosed and accessible only by means of tools. A hole, knockout, or fitting shall be provided to facilitate connections to a permanent wiring system.

6.4.2 Grounding

6.4.2.1 All exposed noncurrent carrying conductive parts, which might become energized under the rigors of normal use and handling shall have metal-to-metal contact or shall be otherwise electrically bonded together and connected to a common grounding means.

The grounding means shall be:

1) A part of the power source,
2) used only for grounding purposes,
3) unlikely to be disassembled during operation or servicing,
4) of adequate size for the grounding conductor,
5) located in the vicinity of the supply connections.

The grounding means shall be a metal stud, binding post, pressure connector, binding screw, uninsulated or insulated leads, internally threaded boss, or equivalent means. Solder alone shall not be relied upon as a means for grounding connections. The grounding means shall comply with requirements of BS 638: Parts 5 and 7.

6.4.2.2 Ground clamp

The clamp shall be used for connecting the work lead or ground cable to the work. It shall produce a strong connection, yet be able to be attached quickly and easily to the work. For light duty, a spring-loaded clamp may be used. For high currents, a screw clamp should be used to provide a good connection without overheating the clamp. The clamp shall comply with latest edition of BS 638: Part 5.

6.4.3 Corrosion protection

When materials subject to corrosion, such as iron, steel, or aluminum, etc., are used as part of the wiring terminal or grounding means, such parts shall be plated or otherwise protected to maintain the integrity of the electrical connection.

6.4.4 Output provisions

6.4.4.1 Welding leads

Welding leads supplied with the power sources shall be of a size sufficient to limit the temperature to 85°C or to the temperature rating of the cable insulation, whichever is less, when operated at the rated load current and duty cycle of the power source.

6.4.4.1.1 Welding cables shall comply with latest edition of BS 638: Part 4.

6.4.4.1.2 At locations where a welding lead passes through an opening in a barrier, or enclosure, the opening shall be smoothly rounded or shall be provided with a secured and smoothly rounded bushing.

6.4.4.2 Welding terminals

Connectors and terminals shall be so designed and connected that they can not be unintentionally disconnected or work loose, it shall comply with safety requirements of latest edition of Standard BS 638: Part 7. The welding terminals shall not exceed 60°C temperature rise when the power source is operated at rated load current and duty cycle.

6.4.5 Internal wiring requirements

6.4.5.1 When internal wiring consists of insulated conductors, they shall be selected for the particular application with respect to the temperature, current, voltage, exposure to oil or grease, and other conditions of service to which they are likely to be subjected.

The wiring shall be so arranged or protected that no damage to the conductor insulation will occur from contact with any rough, sharp, or moving part.

All joints and connections shall be mechanically secured and shall provide electrical contact without mechanical strain on the conductor.

6.4.5.2 When uninsulated conductors are used within an enclosure, they shall be so supported that the spacings given in Table 4 shall be maintained.

6.4.5.3 Insulating washers, bushings, sheets, and such for the mounting of or insulation of live parts shall not be functionally damaged by the temperature to which they will be subjected during operation at rated load under usual service conditions.

6.4.5.4 The minimum spacing between any uninsulated live part and another live, grounded, or isolated conductive part shall not be less than those shown in Table 2.

6.4.5.5 Insulating materials in association with the conductors and the supporting structural parts of an arc welding power source shall have suitable thermal endurance when operating at the limiting temperature rise specified with considering of classification of insulation.

TABLE 2 - SPACINGS IN ARC WELDING POWER SOURCES [a)]

rms VOLTAGE BETWEEN PARTS INVOLVED [d,e)]	AT OTHER THAN WIRING TERMINALS					
	At Wiring Terminals [b,c)]		To other than Enclosure Walls		To Walls of a Metal Enclosure [f,g)]	
	Through Air mm	Over Surface mm	Through Air mm	Over Surface mm	Through Air mm	Over Surface mm
0 - 50	12.7	12.7	3.18	3.18	12.7	12.7
51 - 150	12.7	12.7	3.18	6.35	12.7	12.7
151 - 300	12.7	12.7	6.35	9.53	12.7	12.7
301 - 600	25.4	25.4	9.53	12.7	12.7	12.7

a) Values do not apply to a turn of wire on a coil or to spacings between:

1) Two conductors of a coil,
2) a coil and its core, and
3) a coil and any other part of opposite polarity including the crossover lead.

The spacings given in Table 4 do not apply to wiring devices (snap switches, lampholders, etc.), motors, printed circuit boards, potted circuits and devices, or other accessories for which there are standards established for such components.

b) Wiring terminals are considered to be terminals to which supply connections are made in the field.

c) The spacing between screw type terminals of opposite polarity shall be not less than 0.250 inch (6.35 mm) if the terminals are in the same plane.

d) When the repetitive peak voltage on which the device is used is more than 1.5 times the rms volts, the peak voltage shall be divided by 2 to obtain an equivalent rms rating in volts.

e) For grounded power systems, such as three phase four wire systems, the clearance and creepage distances to ground shall be governed by voltage to ground.

f) A metal piece attached to the enclosure is considered to be a part of the enclosure if deformation of the enclosure is likely to reduce clearance and creepage distances between the metal piece and uninsulated live parts or film coated wire.

g) For subassembly enclosures where clearance and creepage distances are rigidly maintained and when mounted inside another enclosure, the distances for "to other than enclosure walls" shall be permitted instead of "to walls of metal enclosure" but in no case shall they be less than 0.100 inch (2.54 mm).

6.4.6 Requirements for certain equipment and specific components

6.4.6.1 Transformers

A power source transformer supplying welding current shall have the secondary winding(s) electrically isolated from the primary winding(s) when the power source is designed to be operated from power supply lines. Transformers shall comply with requirements of latest edition of the Parts 1, 2 and 3 of BS 638 as applicable.

6.4.6.2 Generator type power sources

The generator sources convert mechanical energy into electrical power suitable for arc welding. The power may be obtained from an internal combustion engine, an electric motor, or from a power take-off from other equipment. The generator shall comply with latest edition of BS 638: Parts 2 and 3 as applicable.

6.4.6.3 Operating controls

A suitable means shall be provided for adjusting the output of an arc welding power source over the welding range specified by the manufacturer. Provision shall be made for indicating the approximate output setting(s) of the power source expressed as load voltage, load current, or by an arbitrary reference scale.

6.4.6.4 Marking of connections and operating controls

All welding terminal connections, tap connections, and operating controls shall be plainly and permanently marked to designate their purpose and correct usage.

6.4.6.5 Auxiliary power supply

6.4.6.5.1 Receptacles

A supply receptacle intended for providing power to 230 Volt auxiliary equipment such as wire feeders, drills, grinders, and such, shall be of the grounding type, and the grounding contact of the receptacle shall be electrically connected to the enclosure of the power source. The current and voltage rating of the auxiliary power supply shall be marked at the receptacle location.

6.4.6.5.2 Protection

When supplied, a fuse(s) or circuit breaker(s) that protects the auxiliary power supply circuit shall be capable of interrupting the auxiliary power supply circuit. The current rating of a fuse shall be marked at the fuseholder location.

6.4.6.5.3 Auxiliary power supply circuit

An auxiliary power supply circuit shall be electrically isolated from the input power supply.

6.4.6.5.4 Short circuit of welding circuit

An arc welding power source shall not become a fire or shock hazard as a result of a short circuit of the welding circuit.

6.4.6.5.5 Output regulating taps

When load voltage or load current regulating tap switches are provided, they shall have established contact positions. Switches, brushes, or sliding type contacts shall not, if left between two contact positions, short circuit any winding turns.

6.5 Rating and Performance

6.5.1 Input rating of arc welding power sources operating from electrical power supply

The input voltages and frequencies shall be as follows:

50 Hertz, 230/380.

The input current(s) of an arc welding power source operating from an electrical power supply shall be determined at the rated output when rated input voltage(s) and rated frequency(s) are applied.

For power sources with regulating taps, the input current(s) shall be determined under the conditions which result in the maximum input current when the output is the rated load current at the rated load voltage of the power source.

6.5.2 Power factor correction

When power factor correction is provided, the corrected value shall be measured at rated load, rated input voltage(s) and frequency(s). The corrected value shall not be less than 75 percent unless the corrected value is specified on the name-plate.

6.5.3 Open circuit voltage, conventional load voltage and the rated welding current shall comply with latest edition of BS 638: Parts 1, 2, and 3 as applicable.

6.6 Tests

6.6.1 Jerk test

If an eye or lug is provided for the purpose of lifting an assembled arc welding power source, such device shall be capable of withstanding a free fall jerk test. This test shall be made with the power source quipped with all associated attachments (excluding trailers, carts, and wheel running gears) that are likely to be installed and, in the case of engine driven power sources, completely serviced and ready for operation.

The unit shall be suspended from a rigid member by a chain or cable attached to the lifting eye or lug, and it shall be positioned for a direct free fall. The chain or cable suspension assembly shall be arranged to provide for a free fall of at least 6 inches (152 mm) before the unit is caught in suspension bringing the full force of the fall to bear on the lifting eye or lug. Three such falls shall be made.

6.6.2 Drop test

An assembled arc welding power source equipped with all associated attachments (excluding trailers, carts, and wheel running gear) that are likely to be installed and, in the case of engine driven power sources completely serviced and ready for operation, shall be capable of withstanding a drop test. This test shall consist of three drops onto a hard and rigid surface from a height of not less than 6 inches (152 mm). These drops shall be so arranged that each drop shall strike on a bottom edge different from that of any other drop.

6.6.3 Test conformance

After the above tests, the power source shall still conform to the provisions of this Standard, other than the foregoing 6.7.1 and 6.7.2 in all respects even though there may be some deformation of the structure parts of enclosure.

6.6.4 The following test shall be made at the manufacturers works according to the parts 1, 2 and 3 as applicable:

- Routine tests
- Type tests
- Conventional load voltage test
- Heating test
- High voltage test
- Instrument accuacies and test tolerances

6.7 Efficiency and Power Factor

6.7.1 Method of determining efficiency and power factor

6.7.1.1 Conditions for test

1) Input

The efficiency and input power factor of an arc welding power source shall be determined at rated input voltage, at rated frequency, and at measured input current.

2) Output

Efficiency and input power factor shall be determined at rated output when the power source is connected to resistance load having a power factor of 0.99 or higher.

3) Temperature

The efficiency and input power factor shall be measured just prior to the conclusion of the temperature test.

4) Miscellaneous losses

The power consumed by resistor, reactors, stabilizers, ventilating blowers, field and control rheostats, and other components, including separately excited fields and control windings, performing an essential function in the operation of the arc welding power source and included as in integral part of the power source shall be included in the determination of the efficiency and input power factor.

6.7.1.2 Efficiency

The efficiency of an arc welding power source shall be determined from simultaneous measurements of input power and output power.

6.7.1.3 Input power factor

The input power factor of an arc welding power source shall be determined from simultaneous measurements of input current, rated input voltage, and watts. Alternatively, a power factor meter shall be used.

6.8 Arc Welding Power Sources with High Frequency Arc Starting and/or Stabilizing

6.8.1 General

The maximum Open Circuit Voltage (OCV) given in 6.5.3 may not be sufficient for certain welding processes. A higher voltage may be required to maintain a stable arc, which is especially true for the ac GTAW welding processes.

Many processes use open circuit voltages sufficient to spark from the electrode to the work without making an intimate contact. In processes like the GTAW process, it may take several thousand volts to cause an electrical spark to jump this gap between the electrode and the work creating and initial path of ionization that the arc current can follow.

Thus arc stabilizing and starting may require open circuit voltages greater than the maximum values given in 6.6.3 of this Standard. In order to provide these higher voltages, it is common practice to superimpose a high open circuit voltage on the output of welding power sources by using high frequency techniques. The high frequency voltage is considered to be safer than the same voltage at line frequency or dc.

6.8.2 HF classification

6.8.2.1 HF as an integral part

When the HF is supplied as an integral part of the power source, the manufacturer shall furnish operation and installation instructions as necessary to minimize radiation and thus minimize possible radio frequency interference.

6.8.2.2 HF supplied as a separate unit

When HF units are supplied for attachment to power sources in general, the manufacturer of the HF unit shall supply operation and installation instructions as necessary to minimize radiation and thus minimize possible radio frequency interference, plus precautionary information regarding possible malfunctioning or overheating of the power source. HF attachments are to be used only on those power sources specified by the power source manufacturer.

6.8.2.3 Enclosure

The enclosure of the power sources with HF shall be metallic or metalized plastic of such nature as to provide a shield that can be grounded.

6.9 Additional Requirements for Gas Metal Arc Welding (GMAW) Power Sources

6.9.1 The GMAW process shall use a source of direct current, which may be supplied by a transformer-rectifier or a motor-generator power source. Power source ratings shall be based on either a 60 percent or 100 percent duty cycle.

6.9.2 Unless otherwise specified constant-voltage dc power sources with an adequate current rating shall be used for GMAW.

6.9.3 The constant voltage power supplies shall be equipped with a means of changing the slope of the volt-ampere characteristic to protect the molten electrode tip against the high short circuit current (Fig. 1).

The magnitude of the short-circuit current determines the amount of pinch force available on the electrode. The pinch force will eventually cause the molten electrode tip to "neck down" and finally separate from solid electrode material.

6.9.4 For short circuiting arc welding, inductance can be added to control the rate of current rise to minimize spatter (Fig. 2).

7. SPECIFICATION FOR SHIELDED METAL ARC WELDING ACCESSORIES

7.1 General

7.1.1 Shielded Metal Arc Welding process (SMAW) may be used for short welds in production, maintenance and repair, and field construction. The process can be used for most of the commonly used metals and alloys, and in areas of limited access. The typical welding circuit is shown in Fig. 3.

7.1.2 The filler metal, and the means of protecting it and the weld metal from harmful oxidation during welding, should be provided by the covered electrode (Fig. 4). The "reactive" metals, such as titanium, zirconium, tantalum, and columbium, shall be not welded with covered electrodes. These metals are very sensitive to oxygen contamination and the shielding obtained with covered electrodes is not adequate for them.

7.2 Electrode Holder

7.2.1 The holder must grip the electrode securely and hold it in position with good electrical contact.

7.2.2 Installation of the electrode must be quick and easy. The holder shall be light in weight and easy to handle, yet it must be sturdy enough to withstand rough use.

7.2.3 The holder shall have insulating material around the jaws to prevent grounding of the jaws to the work.

7.2.4 The holder shall be designed to carry the current required for the largest diameter electrode that it will hold.

7.2.5 The holder shall comply to latest edition of BS 638: Part 8.

8. SPECIFICATION FOR GAS TUNGSTEN ARC WELDING ACCESSORIES

8.1 General

8.1.1 Shielding of the electrode and weld zone of GTAW shall be provided from a gas or gas mixture. Filler metal may or may not be added. Fig. 5 shows the relative positions of the GTAW torch, the arc, the tungsten electrode, the gas shield, and the welding rode (wire) as it is being fed into the arc and weld pool. The welding rod guide shall be used only for mechanized or automatic welding. For manual welding the rod is hand held. A backing bar (as shown) may or may not be used depending on the joint design.

The gas tungsten arc welding process may be called "TIG" (Tungsten Inert Gas) Welding but the preferred designated letters are GTAW.

8.1.2 The basic features of the equipment used for the process are shown in Fig. 6. The major equipment components required for GTAW shall consist of:

1) The welding machine (power source),
2) the welding electrode holder and the tungsten electrode, and
3) the shielding gas supply and controls when specified.

Several optional accessories may be available. These include a foot rheostat which permits the welder to control current while welding, water circulating systems to cool the electrode holder, arc timers, and other accessories which may be required.

8.1.3 The hot tungsten electrode and the weld metal will oxidize rapidly during welding if exposed to air. Therefore, the shielding gas must be chiefly inert consisting of helium, argon, or a mixture which will protect both the electrode and the weld pool from oxidation.

8.1.4 Striking the arc may be done in the following ways:

1) By touching the electrode to the work momentarily and quickly withdrawing it a short distance.
2) By means of an apparatus that will cause a spark to jump from the electrode to the work.
3) By means of an apparatus that initiates and maintains a small pilot arc, which provides an ionized path for the main arc.

High frequency arc stabilizers, which are required when alternating current is used, will provide for the second type of arc starting. High frequency arc initiation occurs when a high frequency, high voltage signal is superimposed on the welding circuit. Arc initiating and maintaining devices, ac and dc shall comply with latest edition of BS 638: Part 5.

8.2 Methods of welding

The gas tungsten arc welding process may be used for continuous welds, intermittent welds, or for spot welds. It may be done manually, semiautomatically and automatically.

8.2.1 Manual welding

The required equipment for manual gas tungsten arc welding (Fig. 6) shall consist of:

a) An electrode holder with gas passages and a nozzle to direct the shielding gas around the arc and a gripping mechanism to energize and hold a tungsten electrode.

b) A supply of shielding gas.
c) A flowmeter and gas pressure reducing regulator.
d) A power source.

8.2.2 Semiautomatic welding

The required equipment for semiautomatic welding shall be similar to a manual electrode holder except that it must be equipped with an attachment that brings the filler metal wire into the arc area.

8.2.3 Automatic welding

Automatic welding shall have the same basic components that are shown in Figs. 5 and 6. Depending upon the application, other various devices and controls may be required. These may include an arc voltage control for constantly checking and adjusting the electrode position (arc length) to maintain a uniform arc voltage. Electrode positioning devices, seam tracking devices, and filler metal feeders also may be a part of an automatic installation.

8.3 Electrodes

Electrodes for gas tungsten arc welding may be classified as pure tungsten, tungsten with one or two percent thoria tungsten with 0.15 to 0.4 percent zirconia, and a tungsten electrode with an integral lateral segment or tungsten throughout its length which contains one to two percent thoria. Tungsten electrodes of 99.5 percent purity generally can be used on less critical operations than tungsten electrodes that contain thoria or zirconia.

8.3.1 Current carrying capacity

The current carrying capacity of all types of tungsten electrodes may be affected by the type of electrode holder, the position of welding, the shielding gas, and the type of welding current. Since the maximum current capacity of an electrode depends on a large number of factors, the typical current ranges shall be recommended by manufacturer.

8.3.2 Shape

With ac welding, a molten hemisphere shall be formed at the tip of a pure tungsten electrode at its minimum usable current, and it shall not become perceptibly larger as the current is increased to full usable capacity. The molten hemisphere tip is most desirable for welding.

Thoriated tungsten electrodes do not ball so readily and, therefore shall not be used for low currents without a tapered point.

8.4 Electrode Holder and Nozzle

The tungsten electrode holder must have sufficient welding current capacity to prevent overheating. Collets accommodate the correct sizes of tungsten electrodes. The direction and amount of inert gas covering the weld is controlled by gas nozzles threaded into the head of the electrode holder. The gas nozzles shall be made of various heat resistant materials in different diameters, shapes, and lengths. Length and shape are selected on the basis of joint accessibility and the required clearance between the nozzle and the work. The nozzle should be large enough to provide adequate inert gas coverage of the molten weld pool and adjacent hot base metal.

Specially designed gas nozzles may be provided to reduce gas turbulence at the end of the nozzle. With them, welding can be done with the nozzle as far as 25 mm (1 in.) from the work. This improves the welder's ability to see the weld puddle and allows him to reach difficult places, such as inside corners.

8.5 Arc Starting Means

If specified, retract starting may be used in automatic dc welding. The electrode is fed down until contact is made with the work, and it is then retracted to establish the arc.

High frequency starting may be used with dc or ac power sources for manual and automatic applications.

8.6 Filler Metal Feeders

Wire feeders shall be used to add filler metal during automatic welding. Either room temperature (cold) wire or pre-heated (hot) wire may be fed into the molten weld pool. The required system for the feeding of cold wire shall have three components:

1) A wire drive mechanism
2) A speed control
3) A wire guide attachment to introduce the wire into the molten weld pool

The equipment for a hot wire addition is similar to that for cold wire, except that the wire is electrically resistance heated to the desired temperature before it enters the molten weld pool (Fig. 7).

Preheated filler wire may be used for the joining of carbon and low alloy steels, stainless steels, and alloys of copper and nickel.

Preheated filler wire shall be not used for aluminum and copper because the low resistance of these filler wires requires high heating current, which results in excessive arc blow and uneven melting

8.7 Shielding Gases

The inert gases, argon and helium, may be used for gas tungsten arc welding. Of the reactive gases, only hydrogen and nitrogen have found limited use. Hydrogen may be added to argon or helium in small quantities for mechanized welding of stainless steel. Nitrogen sometimes may be added to argon for the joining of copper and copper alloy. A guide to the selection of gases is provided in Table 3.

TABLE 3 - SELECTION OF SHIELDING GASES AND POWER FOR GAS TUNGSTEN ARC WELDING

		Shielding gas[a] and power[b] used	
Material	Thickness[c]	Manual	Machine
Aluminum and its alloys	Under 3.2 mm	Ar (achf)	Ar (achf) or He (dcsp)
	Over 3.2 mm	Ar (achf)	Ar-He (achf) or He (dcsp)
Carbon steel	Under 3.2 mm	Ar (dcsp)	Ar (dcsp)
	Over 3.2 mm	Ar (dcsp)	Ar-He (dcsp) or He (dcsp)
Stainless steel	Under 3.2 mm	Ar (dcsp)	Ar-He (dcsp) or Ar-H_2 (dcsp)
	Over 3.2 mm	Ar-He (dcsp)	He (dcsp)
Nickel alloys	Under 3.2 mm	Ar (dcsp)	Ar-He (dcsp) or He (dcsp)
	Over 3.2 mm	Ar-He (dcsp)	He (dcsp)
Copper	Under 3.2 mm	Ar-He (dcsp)	Ar-He (dcsp)
	Over 3.2 mm	He (dcsp)	He (dcsp)
Titanium and its alloys	Under 3.2 mm	Ar (dcsp)	Ar (dcsp) or Ar-He (dcsp)
	Over 3.2 mm	Ar-He (dcsp)	He (dcsp)

a) Ar-He contains up to 75% helium; Ar-H_2 contains up to 15% hydrogen.

b) Abbreviations:

achf = alternating current, high frequency;
dcsp = direct current, straight polarity (electrode negative).

c) 3.2 mm = $^1/_8$ in

8.8 Gas Control Equipment

A combination regulator and flowmeter shall be used to control and measure the flow of shielding gas. High pressure in a cylinder or cylinder manifold shall be reduced to a safe working pressure. The lower pressure gas shall be metered through the flowmeter and controlled by manual adjustment of a throttle valve. The flow may be indicated on the flow-meter tube or dial that is calibrated for the particular gas being metered. In operations with high gas consumption, a centrally located cylinder manifold may be installed to store gas. The gas shall be piped from the storage containers to the welding stations. The pressure in the distribution line shall be regulated and individual flowmeters shall be mounted at each welding station.

When a shielding gas mixture must be used, standard proportions are commercially available in cylinders. Other desired mixtures can be obtained through the use of manually set mixers or automatic gas-ratio mixers, which can be operated from cylinders or bulk systems.

8.9 Foot and Hand Controls

Welding shall be stopped by shutting off the current with foot/hand-controlled switches. When specified foot and hand controls shall permit the welder to start, adjust, and stop welding current. They shall provide the welder with a means of controlling welding current as required to obtain good fusion and penetration.

9. SPECIFICATION FOR GAS-METAL ARC WELDING ACCESSORIES

9.1 General

9.1.1 Gas Metal Arc Welding (GMAW) uses the heat of an electric arc between a continuous filler metal electrode and the work. Shielding is obtained entirely from an externally supplied gas or gas mixture (Fig. 9). This can be a semiauto-matic (manual) and automatic process.

9.1.2 Unless otherwise specified GMAW shall use direct current reverse polarity (electrode positive). This type of electrical connection yields a stable arc, smooth metal transfer, relatively low spatter loss, and good weld bead charac-teristics for entire range of welding currents used.

9.1.3 As a minimum GMAW equipment shall consist of a welding gun, a power supply, a shielding gas supply, and a wire-drive system which pulls the wire electrode from a spool and pushes it through a welding gun. Also, a source of cooling water may be required for the welding gun. A system of accurate controls should be employed to initiate and terminate the shielding gas and cooling water, operate the welding contactor, and control the electrode feed speed as required. The basic features of GMAW equipment are shown in Fig. 10.

9.2 Welding Guns

The guns shall comply with latest edition of BS 638: Part 8. Because the electrode is fed continuously, a welding gun must have a sliding electrical contact (contact tube) to transmit the welding current to the electrode. The gun must also have a gas passage and a nozzle to direct the shielding gas around the arc and molten weld pool. Cooling is required to remove the heat generated within the gun, and also heat radiated from the welding arc and the molten weld metal. Shielding gas or internal circulating water, or both may be used for cooling. An electrical switch should be used to start and stop the welding current, electrode feed system, and shielding gas flow.

9.2.1 Semiautomatic guns

Semiautomatic, hand held guns may be in the form of a pistol, or shaped similar to an oxyacetylene torch (curved), with electrode wire fed through the barrel or handle. The gun shall comply with latest edition of BS 638: Part 8. Typical curved and pistol gun designs are shown in Fig. 11. The pistol grip handle shall permit easy manual loading of the holder against work.

9.2.1.1 Guns shall be equipped with metal nozzles of various internal diameters to insure adequate gas shielding. The orifice usually varies from approximately 10 to 22 mm ($^3/_8$ to $^7/_8$ inch) depending upon welding requirements. The nozzles shall be threaded to facilitate replacement.

9.2.1.2 Air-cooled guns can be used for applications where water is not readily obtainable as a cooling medium. These may be used for service up to 600 A, intermittent duty with CO_2 shielding gas. However, they should be limited to 200 A with argon or helium shielding. The holder should be a pistol-type construction and its operation parallels the water cooled type.

9.2.1.3 Water-cooled guns for manual GMAW with the addition of water cooling ducts may be used. The ducts shall circulate water around the contact tube and gas nozzle. Water cooling rate shall be such that permits the gun to operate continuously at rated capacity and at low temperatures. Water-cooled guns are used for applications requiring 200 to 750 A. However, the water in and out lines to the gun add weight and reduce maneuverability of the gun for welding.

9.2.1.4 The wire electrode drive mechanisms contained in hand-held (semiautomatic) guns shall be electric with adjustable speed.

In push-pull systems, the two drive motors shall be provided, the motors shall be synchronized to avoid damage to the wire electrode. Unless otherwise specified wire feeders shall be designed for use with constant voltage power sources. The welding current is adjusted by increasing or decreasing electrode speed for a given setting of the power source. Unless otherwise specified the wire feed motor shall be a dc type.

9.2.2 Automatic welding guns

Due to more severe service conditions the gun shall be water cooled and shall be designed to operate for long periods of arc time. The gun may be mounted directly below the electrode wire drive head which feeds the electrode wire through the gun. The electrode is fed by feed rolls into a guide assembly which supports and protects the electrode during the welding operation.

9.3 Welding Control Unit

The welding control unit may be a separate package for remote operation, or it may be integrated with the wire feed drive unit. The control unit shall regulate the speed of the wire feed motor. Motor speed regulation may be accomplished with an electronic governor in the control unit.

Electrode feed speed shall be capable of being set manually by the operator to obtain the desired welding current from a constant voltage power source.

The control also shall regulate the starting and stopping of electrode feed upon the appropriate manual or automatic switch operation. In addition, the control units shall contain the following:

1) An electrode feed jogging switch to feed the electrode through the Unit when not welding.
2) A shielding gas purging switch for manual control of shielding gas flow.
3) Electrode speed or arc voltage adjustment.
4) A braking system to prevent electrode stubbing into the molten weld pool when welding is stopped.
5) Timers for preweld and postweld gas and water flow.
6) A water pressure switch to insure coolant flow.
7) A meter to indicate the load on the drive motor.

9.4 Shielding Gas Equipment

9.4.1 Regardless of the type of gas supply system used, constant pressure and flow of the gas shall be maintained. The equipment shall be provided with gas pressure regulators to reduce the pressure from the source to a working pressure and to maintain a constant delivery pressure. The regulator shall be adjustable to provide gas at a desired pressure within its operating range.

9.4.2 Flowmeters shall be used to control the rate of gas flow to the welding gun. The inlet gas pressure to the flowmeter is specified by the manufacturer, and the pressure regulator shall be set accordingly. Gas flow shall be adjusted with a valve at the flowmeter outlet.

9.4.3 The delivery pressure to the flowmeter shall be adjusted and locked by the manufacturer. It should not be changed except for adjustment after repair.

9.4.4 Regulators and flowmeters shall only be used for the gases for which they are designed.

9.4.5 If specified, proportioners shall be used for mixing gases such as argon and carbon dioxide.

10. MANUFACTURER'S LIABILITY

10.1 The equipment shall be the product of a manufacturer regularly engaged in manufacturing of welding machines and shall be in regular production by the manufacturer for at least 3 years. These documents shall be submitted by manufacturer or supplier.

10.2 Compliance by the welding machine vendor with provisions of this Standard specification does not relieve him of the responsibility of furnishing properly designed equipment, mechanically suited to meet operating conditions specified.

10.3 Supplier/Manufacturer shall submit all necessary documents such as operating and maintenance instructions, spare parts list and etc., in the number of copies required by the Purchaser.

11. PREPARATION FOR SHIPMENT

11.1 The Vendor shall provide the Purchaser with the necessary instructions to preserve the integrity of the storage preparation after the equipment arrives at the job site.

11.2 Preparation for shipment shall be made after all testing and inspection of the equipment has been accomplished and the equipment has been approved by the Purchaser. The preparation shall include at least those specified in 11.2.1 through 11.2.8.

11.2.1 All exterior surfaces except machined surfaces shall be given a coat of the manufacturer's standard paint.

11.2.2 All exterior machined surfaces shall be coated with a suitable rust preventive.

11.2.3 The interior of the equipment shall be thoroughly cleaned.

11.2.4 All threaded openings shall be provided with steel caps or solid-shank steel plugs.

11.2.5 Lifting points and lifting lugs shall be clearly identified.

11.2.6 The equipment shall be identified with serial number.

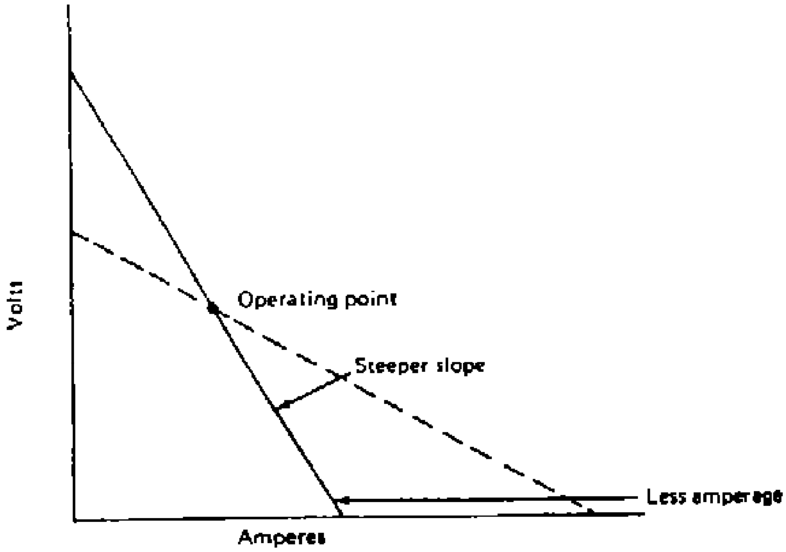
11.2.7 One copy of the manufacturer's standard instruction and packing list shall be packed and shipped with each equipment.

11.2.8 Separate shipment of materials is not allowed.

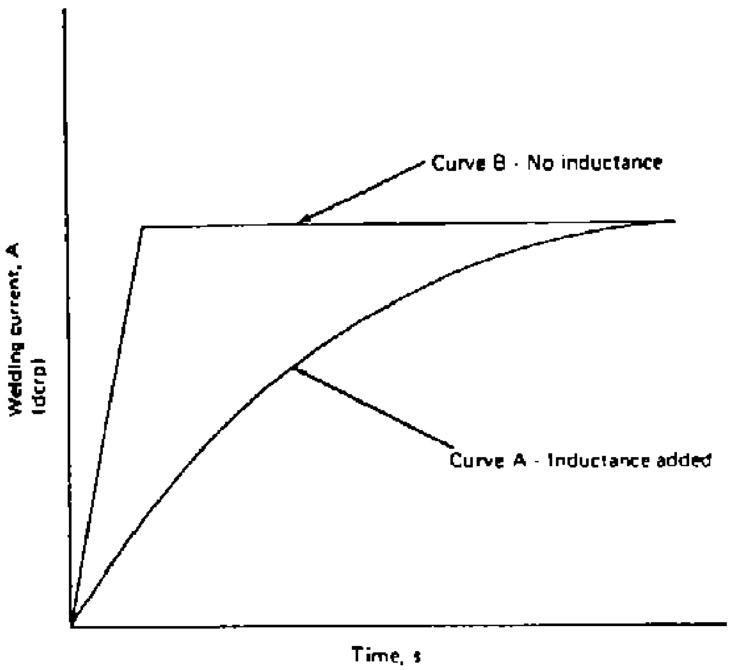
12. GUARANTEES AND WARRANTIES

All equipment and component parts shall be guaranteed by the Vendor against faulty design, defective or improper materials, poor workmanship, and failure due to normal usage for one year after being placed in the specified service, but not exceeding 18 months after the date of shipment. If any defects or malfunctions occur during the warranty period, the Vendor shall make all necessary or desirable alterations, repairs, and replacements free of charge.

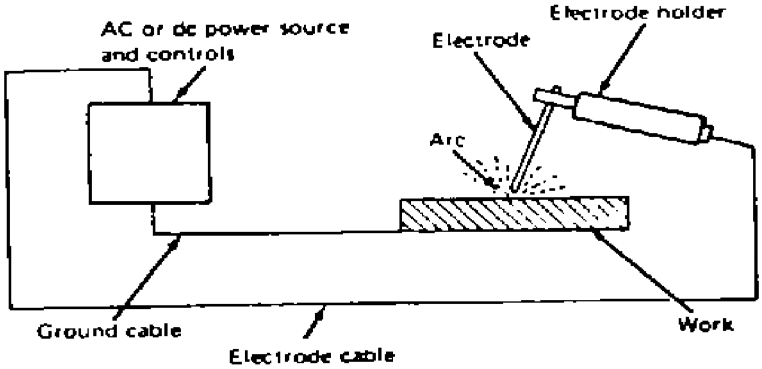
FIGURES



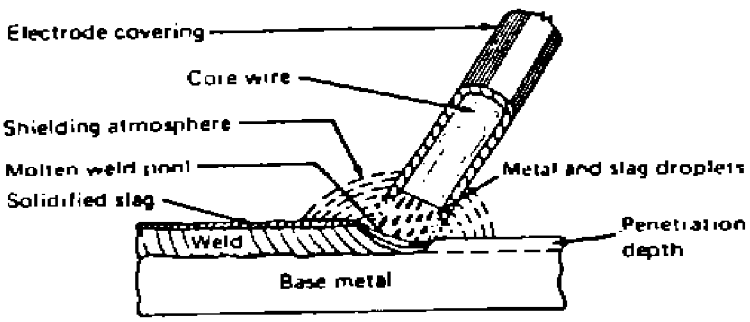
EFFECT OF CHANGING SLOPE ON SHORT CIRCUITING AMPERAGE
Fig. 1



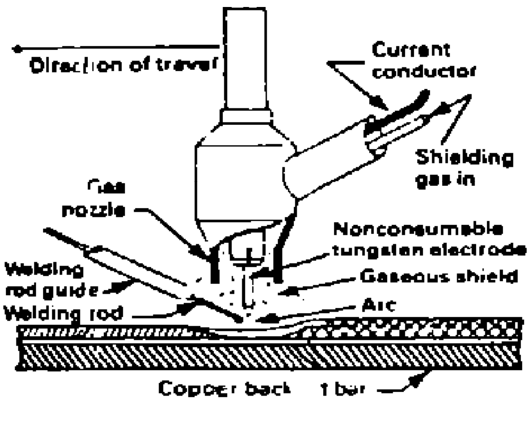
CHANGE IN WELDING CURRENT RISE DUE TO INDUCTANCE
Fig. 2



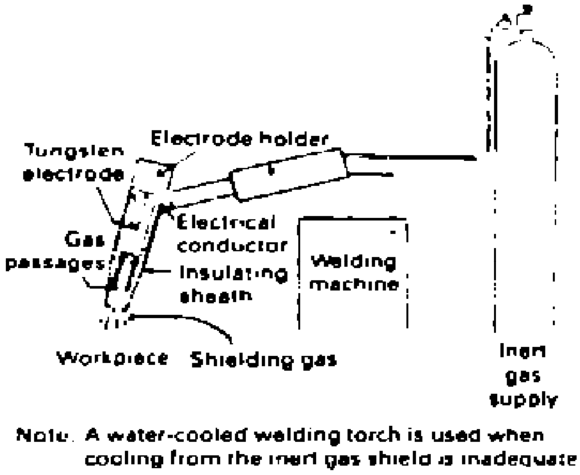
ELEMENTS OF A TYPICAL WELDING CIRCUIT FOR SHIELDED METAL ARC WELDING
Fig. 3



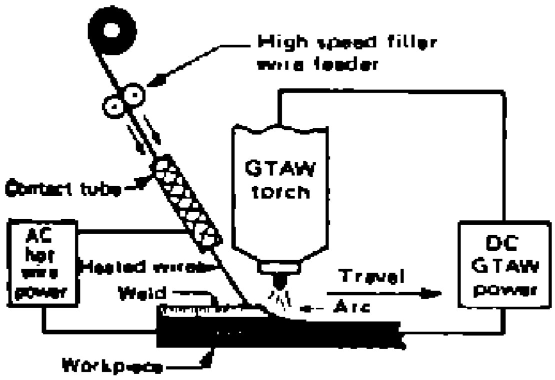
SHIELDED METAL ARC WELDING
Fig. 4



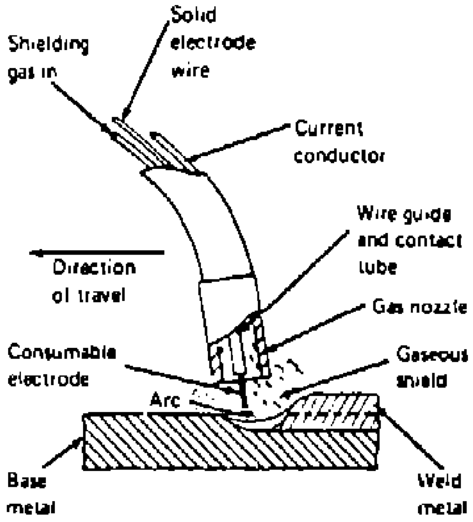
GAS TUNGSTEN ARC WELDING
Fig. 5



GAS TUNGSTEN ARC WELDING EQUIPMENT ARRANGEMENT
Fig. 6



GAS TUNGSTEN ARC HOT WIRE SYSTEM
Fig. 7



GAS METAL ARC WELDING PROCESS
Fig. 8

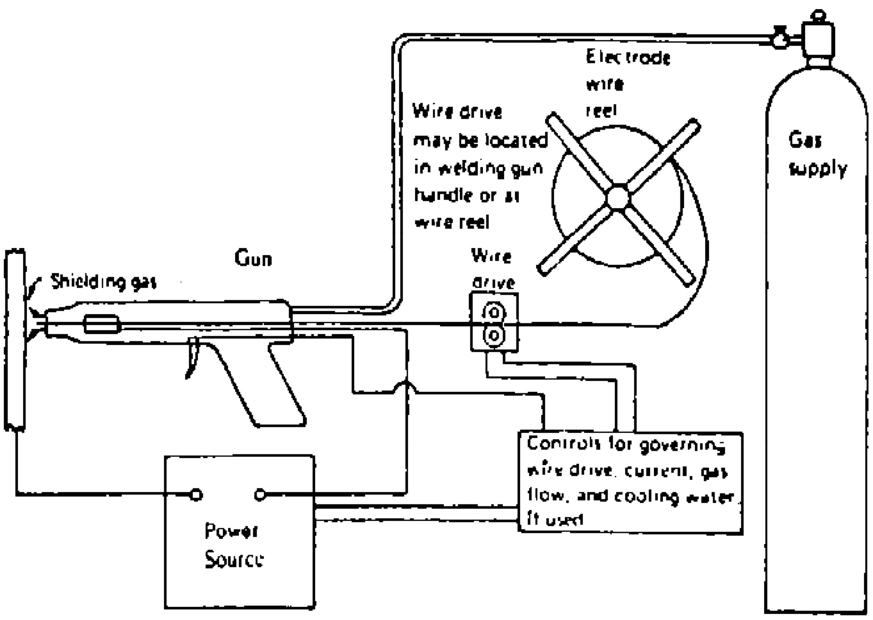
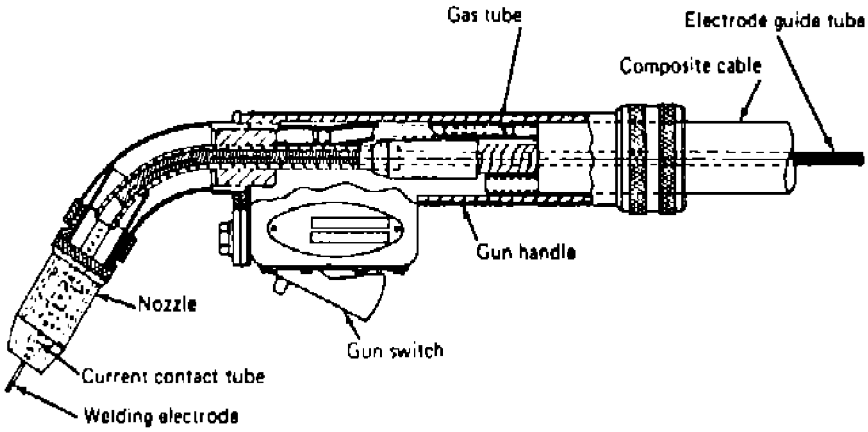
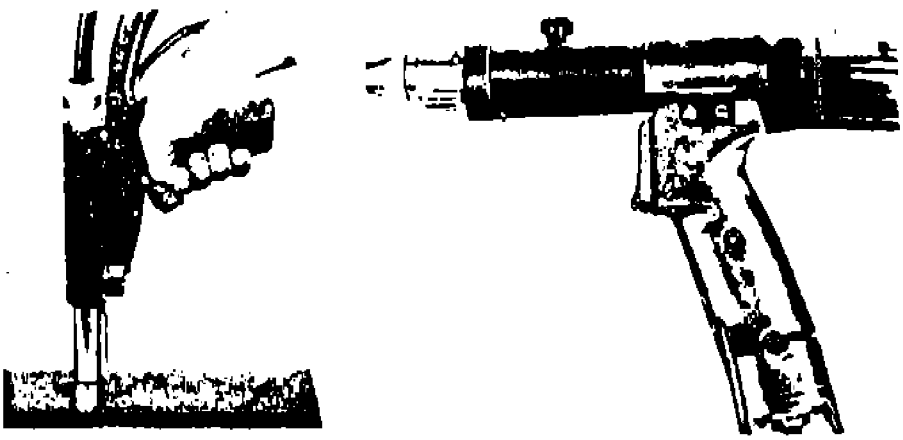


DIAGRAM OF GAS METAL ARC WELDING EQUIPMENT
Fig. 9



TYPICAL SEMIAUTOMATIC GAS - COOLED, CURVED-NECK GAS METAL ARC WELDING GUN
Fig. 10



TYPICAL SEMIAUTOMATIC GAS METAL ARC WELDING PISTOL GUN DESIGNS
Fig. 11