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RECOMMENDATIONS FOR DESIGN AND FABRICATION OF ENCLOSED ARC WELDED JOINTS IN REINFORCING BARS

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SYNOPSIS

The Committee on Concrete in the Japan Society of Civil Engineers (JSCE) organized Subcommittee on Joints of Reinforcing bars in 1979. After extensive researches the subcommittee proposed Recommended Rules for Joints of Reinforced Concrete published on the Concrete Liabrary International, Vol.1, 1983.

The subcommittee continued to investigate about the enclosed arc welded joint of reinforcing bars according to the trust of research from Nippon Kokan koji K.K. The recommendations for design and fabrication of enclosed arc welded joints in reinforcing bars here proposed is the result of the activity of the subcommittee.

The enclosed arc welded joints mentioned here refer to the joints executed by arc welding process in which the molten pool is enclosed with backing metal to prevent the fusion metal from flowing out.
The manual operations and the semi-automatic operations are prescribed in the recommendations.

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RECOMMENDATIONS FOR DESIGN AND FABRICATION OF ENCLOSED ARC WELDED JOINTS IN REINFORCING BARS
(9, 1984)

CHAPTER 1 GENERAL

Section 1 Extent of applicability

This Recommendation shall apply as a basis to design and fabrication of enclosed arc welded joints in reinfrocing bars to be used in reinforced concrete structures in general.

The enclosed arc welded joints mentioned here refer to the joints executed by arc welding process in which the molten pool is enclosed with backing metal to prevent the fusion metal from flowing out. There are an enclosed arc welding by manual operation (hereinafter to be called the manual enclosed arc welding) and an enclosed gas shielded metal arc welding by semi-automatic operation (hereinafter to be called the semi-automatic enclosed arc welding).

the mattes not specified in this Recommendation shall be ruled by JSCE "Recommendation for fundamentals in design and fabrication of joints in reinforcing bars" (hereinafter to be called "Recommendations for fundamentals").

CHAPTER 2 MATERIALS

Section 2 Reinforcing bars

(1) Reinforcing bars to be used for enclosed arc welded joints shall conform to SD30, SD35 or SD40 specified under JIS G 3112-1975 "Reinforcing bars for concrete", with diameters generally conforming to D32-D51.

(2) Reinforcing bars shall possess high joint-weldability and shall be free from any defect which is detrimental to service of reinforcing bars.

Section 3 Welding materials

(1) Covered electrode to be employed for manual enclosed arc welding shall be equivalent to or better than D5816 under JIS Z 3212-1982 (Covered Electrodes for High Tenisile Strength Steel) or DL 5016 under JIS Z 3241-1981 (Covered Electrodes for Low Temperature Service Steels).

(2) Kinds of wires and shield gases to be employed for semi-automatic enclosed arc welding and mechanical properties of deposited metal obtained under different combinations of wires and shield gases shall conform to Table 1.

Table 1 Wire and Shield gases

Wire code (note)	Shield gas kinds	Values of tension test			Values of Charpy impact test	
		Yield point kgf/mm^2 (N/mm^2)	Tensile strength kgf/mm^2 (N/mm^2)	Elongation (%)	Test temperature (°C)	Absorbed energy kgf.m (j)
YGW 21	CO_2	50	58	19	-5	4.8
YGW 23	80Ar-20CO_2	(490)	(570)		-20	(47)

(note) According to JIS Z 3312-1983 (Solid Wires for MAG Welding of Mild Steel and High Strength Steel)

(3) Backing metal to be employed for joining bars in vertical direction by semi-automatic enclosed arc welding shall be equivalent to or higher than the bars to be welded together in strength and chemical composition.

CHAPTER 3 DESIGN OF JOINT PORTIONS

Section 4 Locations of joints

(1) Cross sections subjected to high stresses shall be avoided if possible as the locations of bar joints.

(2) In principle the bar joints shall be staggered and shall not be concentrated in the same cross section. Thereby the staggering shall be more than 25 times the bar diameter.

(3) When the joints are concentrated in the same cross section, the allowable stresses in joints shall be reduced according to Section 9 of Recommendations for fundamentals.

Section 5 Spacing of bars

When enclosed arc welding is done after assembly of reinforcing bars, a central spacing of bars shall be secured in advance which is wide enough to allow installation of an enclosed arc welding jig.

Section 6 Concrete cover

Concrete cover for joint portion shall meet the requirements in Section 4 of Recommendations for fundamentals.

Section 7 Joints of bars of dissimilar steels or of different diameters

When bars with widely different diameters, qualities or surface configurations are to be joined by enclosed arc welding, testing shall be done preliminarily to check the joint performance.

CHAPTER 4 FABRICATION

Section 8 Welding engineers and welding operators

(1) Persons to control the welding job shall be Class 1 or Class 2 welding engineers qualified under WES 8103-1981 (Standard for Qualification and Certification of Welding Engineers).

(2) Welding operators to be engaged in manual enclosed arc welding shall be qualified under JIS Z 3801-1979 (Standard Qualification Procedure for Welding Technique) and well-skilled in execution of manual enclosed arc welding.

(3) Welding operators to be engaged in semi-automatic enclosed arc welding shall be qualified under JIS Z 3841-1979 (Standard Qualification Procedure for Semi-Automatic Arc Welding Technique) and well-skilled in execution of semi-automatic enclosed arc welding.

Section 9 Processing of reinforcing bars

(1) Reinforcing bars shall be cut or processed such that their welded length may meet the design. Thereby a specified gap shall be allowed in advance between the bar ends.

(2) Bar ends as received shall normally be taken, but when they are heavily distorted, deformed or corrugated, such portions shall be corrected.

(3) In vertical welding of bars, either of the bar ends shall be submitted to edge preparation. In semi-automatic enclosed arc welding for bars smaller than D35, however, edge preparation a may be omitted.

Section 10 Constitution of welding equipment

(1) Manual enclosed arc welding equipment consists of an arc welding machine (with a remote-controller of the current), an enclosed arc welding jig and accessories such as an electrode holder, cables, an electrode drier and an ammeter.

(2) Semi-automatic enclosed arc welding equipment consists of semi-automatic arc welding machine, a power source, a wire feeder, a welding torch, an enclosed arc welding jig, a shield gas feeder (cylinder and pressure regulator) and accessories such as cables and an ammeter.

Section 11 Welding machine and accessories

(1) A welding machine for manual enclosed arc welding shall be one capable of supplying adequate current and voltage conforming to JIS C 9306-1981 (Rectifier Type DC Arc Welding Machines with Drooping Characteristic) when a rectifier type DC is employed; conforming to JIS C 9301-1981 (AC Arc Welding Machines) when AC is employed; and conforming to WES 6101-1974 (Engine-drive Arc Welding Machines) when the machine is engine-driven.

(2) A semi-automatic arc welding machine for semi-automatic enclosed arc welding shall meet the following requirements;

a) Welding power supply is such that it possesses the necessary current capacity and electric characteristics suitable for welding and it can smoothly regulate the welding current and the arc voltage.

b) Wire feeder can stably and smoothly feed the wire.

c) The welding torch possesses the required current capacity and endurance as well as high workability.

d) Pressure regulator for shield gas assures the necessary flow rate and full safety.

(3) Accessories for welding meet the following JIS specifications;

JIS C 9302-1976	Welding Electrode Holders
JIS C 3404-1978	Welding Cables
JIS C 3327-1982	600V Rubber Insulated Flexible Cables
JIS B 6803-1977	Pressure Regulator for Gas Cutter
JIS C 1102-1975	Indicator-Ammeter

Section 12 Welding Jig

(1) Enclosed arc welding jig consists of a copper strap and its holder and a bar-support.

(2) The copper strap shall be of such quality and performance that it is free form deposition or melt down in welding operation.

(3) The holder shall be one which is so designed as to embrace the copper strap and hold it to the bars and is easy to handle.

(4) The semi-automatic enclosed welding jig shall be one which is equipped with a gas hood designed to shield the equipment from the influence of wind.

(5) The bar-support shall be one capable of firmly holding butted ends of bars and adjusting the eccentricity and distortion of bars as well as adjusting the root opening of butted ends of bars.

Section 13 Finished state of weld

(1) The surface of weld shall be as flat as possible, the diameter of weld being normally 1.1 to 1.3 times the nominal diameter of bar.

(2) The surface of weld shall be free from such harmful defects as crack, undercut or overlap and the joint portion shall be free from harmful eccentricity or bend.

Section 14 Welding operation

Enclosed arc welding shall be done using a specified welding equipment in accordance with a specified procedure with reliability so that the quality of work may meet the requirement.

CHAPTER 5 INSPECTION

Section 15 Inspection of joint apperance

(1) In principle the inspection of joint apperance shall be 100% sampling by visual inspection.

(2) Detailed inspection of the apperance shall be done using slide calipers or other adequate instruments, the sampling rate thereby being normally more than 5%.

(3) Detailed inspection of the apperance shall be done to check the weld for presence of undercut, overlap, eccentricity, bend or crack. Welded joint shall be free from supposedly harmful undercut or overlap. Heavy eccentricity or bend shall be absent, the allowable eccentricity being normally less than 1/10 of the bar diameter.

(4) Qualified or disqualified in the detailed inspection of the appearance shall be agreed upon in the work specification or shall be entrusted to discretion of the responsible engineer.

Section 16 Nondestructive inspection of joints

(1) Nondestructive inspection of joint shall be done by ultrasonic flaw detection method, using a finished joint.

(2) Sampling rate in nondestructive inspection shall be set by the work specification. A joint disqualified in this inspection shall be cut off and submitted to a destructive test specified in Section 17 to check its strength, and the cut off portion shall be rewelded.

(3) Matters other than (1) and (2) in the nondestructive inspection shall be entrusted to discretion of the responsible engineer.

Section 17 Destructive inspection of joints

(1) Destructive test of joint shall be a tension destructive one.

(2) For the test of a joint for strength, a destructive test shall be done using model test specimens which are prepared under the same conditions during the fabrication of the joint. However, when the responsible engineer finds it necessary, a piece may be cut off from a finished joint and submitted to a failure test.

(3) Frequency of destructive inspection shall be instructed by the responsible engineer.

(4) A disqualified lot or disqualified joints shall be disposed in accordance with agreement in the work specification or instructed by the responsible engineer.

COMMENTARY ON RECOMMENDATIONS FOR DESIGN AND FABRICATION OF ENCLOSED ARC WELDED JOINTS IN REINFORCING BARS (9. 1984)

CHAPTER 1 GENERAL

Section 1 Extent of applicability

This Recommendation deals with standards about design and fabrication of enclosed arc welded joints in reinforcing bars to be used in reinforced concrete structures in general. Therefore in the case of designing and fabricating the reinforcing bar joints for a special structure or structure subjected to a special load or environmental conditions, the matters specified in this Recommendation shall be referred to with appropriate consideration of special conditions in the structure concerned.

Enclosed arc welding can be executed by covered arc welding or gas shielded arc welding. From the standpoint of welding operation, the former is a manual process, while the latter is a semi-automatic or an automatic process.

Covered arc welding is a welding process to be executed with use of covered electrode, while gas shielded arc welding is a kind of arc welding to be executed with arc and weld metal shielded from the atmosphere by means of CO_2 gas or argon gas. Welding equipment for these processes are illustrated in Fig. 1 and 2 in Commentary to Chapter 10.

In writing this Recommendation, the test results about the manual and semi-automatic enclosed arc weldings (NKE Process) and the welded joints executed by these processed have been taken into consideration.

About the matters not specified in this Recommendation, JSCE "Recommendations for fundamentals in design and fabrication of joints in reinforcing bars" which lays down general rules on the design and fabrication of joints in reinforcing bars shall be referred to.

Section 2 Reinforcing bars

1.- There are five types of hot-rolled deformed bars as specified under JIS G 3112 "Reinforcing bars for concrete": Class 1 SD24, Class 2 SD30, Class 3 SD35, Class 4 SD40 and Class 5 SD50. Among these, ones which have so far been tested and proved their availability as enclosed arc welded joints are SD30, SD35 and SD40, their diameters ranging from D32 to D51. Thus Class 2 SD30, Class 3 SD35 and Class 4 SD40 with diameters D35 to D51 are designated as ones acceptable to this Recommendation.

This is, however, not to say that other types and diameters than specified here are not available for enclosed arc welding. Enclosed arc welding may be applied to any other reinforcing bar than specified here, provided it is submitted to a preliminary test and confirmed about its joint-weldability.

2.- It is stated in Remark 1 to Table 2 chemical composition of JIS G 3112 that the chemical composition of reinforcing bar shall assure joint-weldability and gas pressure weldability of the bar. These weldabilities are defined as "weldability of metal and its performance satisfying the service requirements when an adequately designed structure is welded under specified engineering conditions". Weldable or non-weldable of metal, i.e., reinforcing bar depends on its weld crack sensitivity (at low or high temperature), weld-hardenbility, notch brittleness or weld ductility. It should be borne in mind that these factors are variously affected by the properties of the reinforcing bar.

Defects which are detrimental to use of the reinforcing bar include surface defects such as crack or burr; internal defects such as shrinkage cavity, slag inclusion or segregation; end warp; deformed end face; poor angularity; heavy rusting.

Reinforcing bars for concrete as specified under JIS G 3112 are made of steel produced in blast furnace or electric furnace and no conspicuous difference in joint-weldability is recognized between bars produced under appropriate control.

It should be noted, however, that electric furnace-produced bars may contain large quantities of such elements as P, S, Zn, Cu, Sn which detract from the weldability, because the material for these bars is mainly scrapped steel. This fact should be borne in mind when purchasing the reinforcing bars.

Adverse effect of impurities contained in reinforcing bars on the enclosed arc welded joint is not so serious as on the gas pressured welded joint. It is recommendable in making an order for electric furnace-produced bars to state explicitly that the bars are to be enclosed arc welded. The bars should be preliminarily checked for their satisfactory performance by welding tests.

Section 3 Welding materials

1.- Covered electrode shall be selectively used depending on the type and performance of the bars to be joined.

In manual enclosed arc welding with a large welding heat input, the strength of weld metal tends to be lower than in the conventional build-up welding with the same covered electrode employed.

Among the bars to which the manual enclosed arc welding is applicable, SD30 with a specified tensile strength of 49 - 63 kgf/mm^2 should have a tensile strength of its weld metal which is virtually equal to about 60 kgf/mm^2. Therefore D5816 under JIS Z 2312 should be employed for reinforcing bar joints in general. For joints in structures which are required to serve at low temperatures, adoption of DL5016 under JIS Z 3241 is desirable.

When welding is done with an electric current beyond the range recommended by electrode manufacturers, it is likely that the impact value and other properties will be unsatisfactory; and in such a case it would be necessary to confirm the performance of welded joint portion by a preliminary test. The same can be said about 2.

2.- YGW21 in Table 1 is a wire intended for CO_2 welding having a tensile strength in the order of 60 kgf/mm^2, and it can be employed for common reinforcing bar joints.

YGW23 is a wire intended for 80Ar-20CO_2 welding and it can give a satisfactory joint performance not only for general purpose but also for low temperature service.

Shield gages should be any of the gases specified under JIS K 1106-1978 (Liquid Carbon Dioxide) or a carbon dioxide gas for welding with less than 0.005 % of water content mass ratio for (1) CO_2 welding and should be one conforming to WES 5401-1983 "Argon-CO_2 mixture for Arc Welding" for (2) 80Ar-20CO_2 gas welding.

3.- Backing metal is employed exclusively for joining the bars in vertical direction by semi-automatic welding and it should be equivalent to or higher than bars to be welded with respect to strength and chemical composition.

Backing metal is rectangular or elliptic in section, and being applied in a semi-circle around the bar, it forms a part of the joint after welded.

CHAPTER 3 DESIGN OF JOINT PORTIONS

Section 4 Locations of joints

1. and 2.- Refer to Section 2 or Recommendations for fundamentals.

Section 5 Spacing of bars

When bars assembled which do not permit a atemporary enlargement of the spacing are to be enclosed arc welded, it may sometimes be impossible to install a welding jig; in that case it would become necessary to provide in advance a specified central spacing of bars. In the case of enclosed arc welding mentioned in commentary to Section 1, the following table 1 shall be referred to for selection of the central spacing;

Table 1 Central spacing of bars for enclosed arc welding

Diameter of bar	D32	D32	D38	D41	D51
Central spacing of bars (mm)	100	115		120	140

The central spacing of bars is identical for both manual and semi-automatic enclosed arc welding. In manual enclosed arc welding, said spacing can be reduced to the dimensional limit of copper backing, if the work efficiency is left out of consideration.

When it is inevitable to set said spacing narrower than specified in Table 1, it would be necessary to provide in advance for modification of the welding jig.

Section 6 Concrete cover

The diameter at the widest portion of an enclosed arc welded joint is about 1.1 times the bar diameter. The comparable value of a vertical welded joint in semi-automatic enclosed arc welding with use of a backing metal will, however, be about 1.3 times the bar diameter.

Generally speaking, the influence of a swelling due to use of a backing metal is not so predominant as in bars arranged in horizontal direction; and accordingly it seldom happens that the concrete cover for main bars must be made especially thick.

Section 7 Joints of bars of dissimilar steels or of different diameters

In enclosed arc welded joint, the configuration of weld can be easily changed depending on the configuration of a copper strap, therefore in enclosed arc welding of bars with different surface configurations and different diameters, welding can be done under normal welding conditions, provided a copper strap appropriate for the purpose is employed.

For instance, D35 and D51 are easy to join by enclosed arc welding; in a tension test of their welded joint a rupture takes place at the base metal of D35, i.e., on the side of a smaller diameter.

When the qualities of bars to be joined are widely different, the joint performance is likely to be affected. In such a case, the joint performance should be checked by testing. Otherwise, the welding should be done in conformity to Sections 5 and 6 of Recommendations for fundamentals.

CHAPTER 4 FABRICATION

Section 8 Welding engineers and welding operators

1.- It is stipulated that welding engineers to control the welding job should be ones qualified under WES 8103. Engineers thus qualified are allowed to execute and control the welding of steel structures and it is desirable that they be well-informed on the assembling of bars.

2. and 3.- Workers to be engaged in manual or semi-automatic enclosed arc welding should be well-informed on arc welding; skilled and experienced in manual arc welding or semi-automatic welding; and moreover well-skilled in enclosed arc welding.

Welding enginners and welding operators should submit their names, protraits, and certificate numbers in writing to the responsible engineers to be approved by them. Welding operators should always carry their certificates on their person while they are engaged in an operation.

Section 9 Processing of reinforcing bars

1.- In enclosed arc welding a specified gap is taken between butted ends of bars and the gap is filled with a molten metal. As the result, welded bars will be longer by this gap. Therefore, a gap of about 10 mm per one joint should be considered so that the welded length may meet the design.

2. and 3.- It is desirable that the bar ends to be welded be approximately normal to the axis and flat, but they may be taken as received, provided there is no serious distortion. When a cutting is needed, the work may be done either by machine or by gas. When a local unevenness (about equal to the diameter of less then 7 mm in width and more than 2 mm in depth) is left on the end face, it should be removed by grinder or the like.

Edge preparation for bars to be welded vertically should be done in conformity to the procedure specified in Section 14; generally the recommendable angle is about 20 degrees for manual enclosed arc welding and about 10 degrees for semi-automatic enclosed arc welding.

Section 10 Constitution of welding equipment

In this section the basic constitution of enclosed arc welding equipment is specified.

1.- The constitution of manual enclosed arc welding equipment is illustrated in Fig. 1.
2.- The constitution of semi-automatic enclosed arc welding equipment is illustrated in Fig. 2.

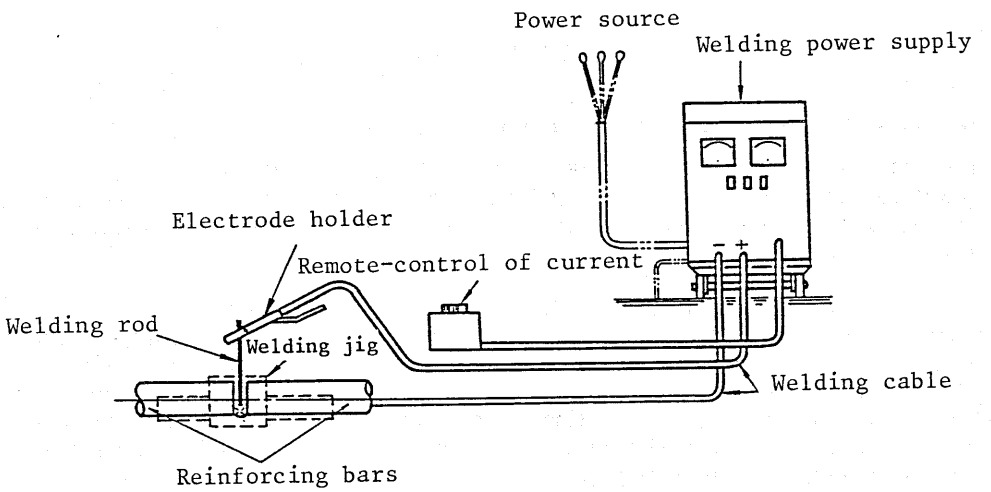


Fig. 1 Example of manual enclosed arc welding equipment

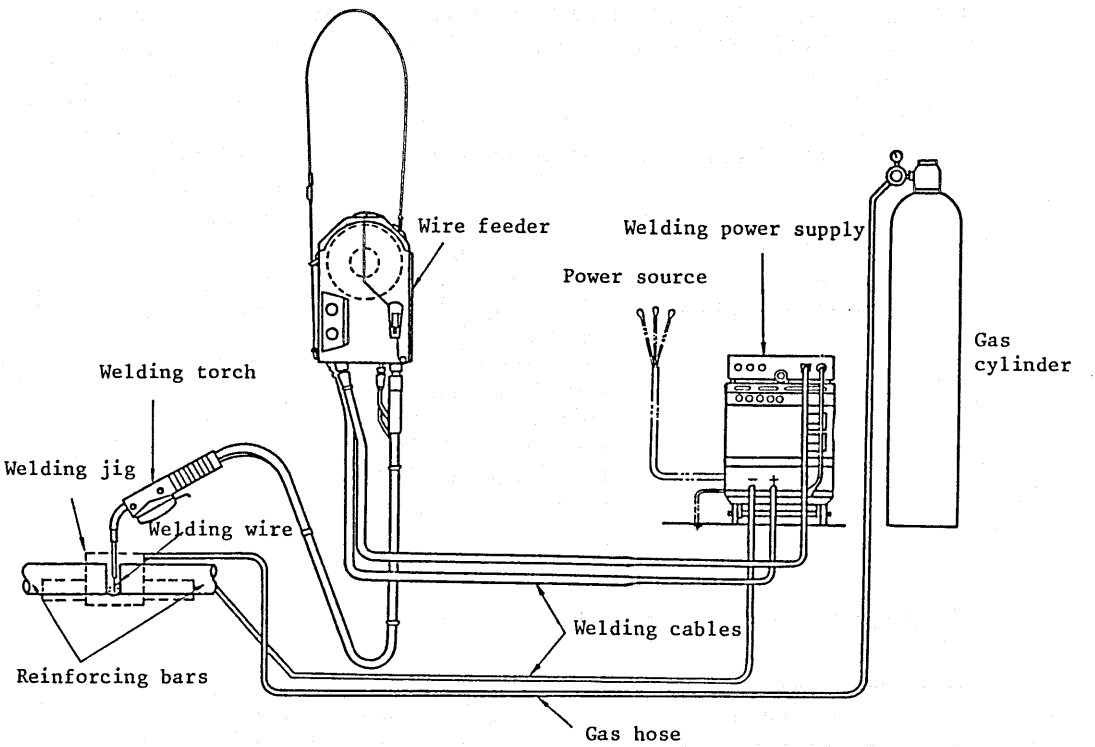


Fig. 2 Example of semi-automatic enclosed arc welding equipment

Section 11 Welding machine and accessories

This Section specifies the standards for welding machines and accessories. 1. and 2.- Examples of specifications are given in Tables 2 and 3.

Table 2 Example of manual enclosed arc welding machine

Items	Specifications
Welding machine	DC 300A, with remote control, input 3ϕ, 200V, 23KVA
Electrode drier	400°C max, can hold 100kg input 2ϕ, 200V, 4.4KVA
Ammeter	DC 300A, Class 2.5, portable

Table 3 Example of semi-automatic enclosed arc welding machine

Items		Specifications
Welding machine	Welding power supply	DC 350A-36V input 3ϕ, 200V, 18KVA
	Wire feeder	Wire diameters 0.9 1.2
	Welding torch	350A
Shield gas feeder	Gas cylinder	Co_2 or 80Ar-20CO_2
	Pressure regulator	120 ℓ/min
Ammeter		DC 300A, Class 2.5, portable

Section 12 Welding jig

Examples of welding jigs for manual and semi-automatic enclosed arc weldings are shown in Figs. 3 and 4.

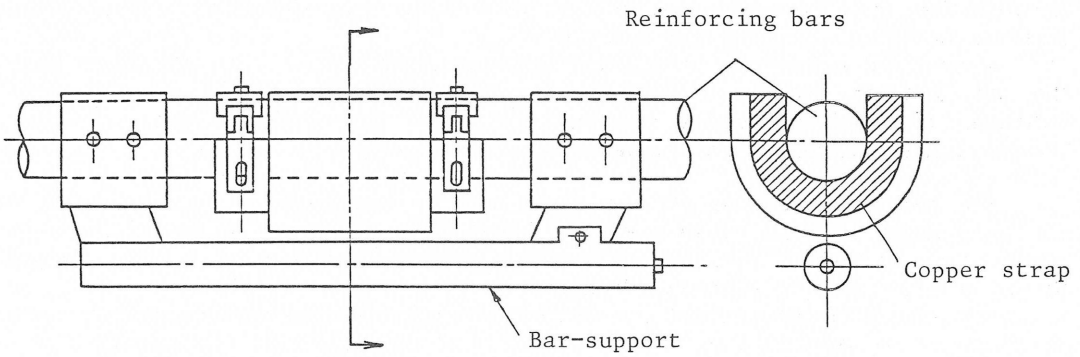


Fig. 3 Example of manual enclosed arc welding jig

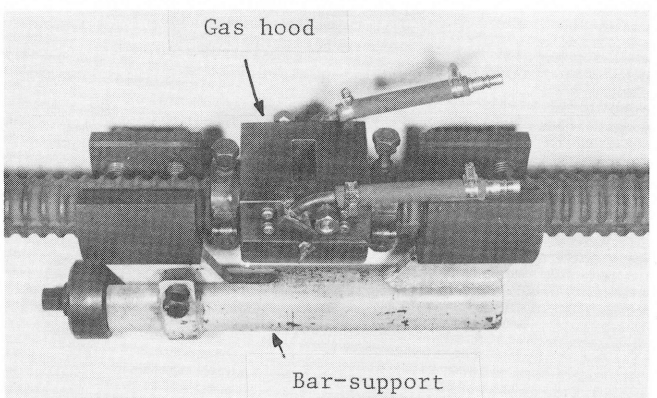


Fig. 4 Example of semi-automatic enclosed arc welding jig

Section 13 Finished state of weld

1.- Flatness and reinforcement of weld surface depend mainly on the distance between the surface of the base metal of bar and the copper strap as well as on the internal configuration of the copper strap.

In enclosed arc welded joint, the reinforcement is normally slightly larger than the bar diameter (about 1.1 times the bar diameter). In vertical joint of semi-automatic enclosed arc welding, however, the widest part of weld is about 1.3 times the bar diameter on account of the backing metal employed.

2.- The heat-affected zone of base metal and the weld metal should be free from cracks. Slight undercut or overlap will have little influence on the static joint performance, but when the fatigue strength is deemed important, even such a defect should be corrected by a grinder or the like.

Normally finished enclosed arc welded joint is said to possess a fatigue strength which meets the specification in Section 5 of Recommendations for fundamentals. Eccentricity of less than 1/10 of the bar diameter and bend of less than 1/10 gradient will have no adverse effect on the static strength. When the joint is likely to suffer fatigue, eccentricity or bend is undesirable, the less of them, the better; and therefore the adverse effect of these defects should be studied.

Section 14 Welding operation

Details of the working procedure should be decided before starting on an enclosed arc welding job and the job should be executed reliably.

The following conditions should be considered in the working procedure;

(1) Inspection and maintenance of welding equipment and adoption of adequate power source

Welding equipment and tools should be reliably maintained and used. Power supply facilities should have sufficient capacity. Cabtyre cables and welding cables should have adequate sectional area and length for use.

(2) Storage of welding materials

Welding materials should be stored always in dry place and, if necessary, a drier should be employed to keep them dry.

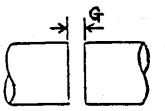
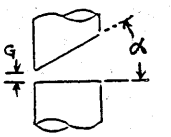
(3) Treatment of bar ends

Supposedly harmful deposits on bar ends or their vicinity such as grease, cement paste, rust should be removed in advance.

(4) Groove preparation

Groove is normally I-type. In vertical welding of bars, a single bevel groove may be used when the bar diameter is more than 38 mm. Groove profile and size for manual and semi-automatic enclosed arc welding are illustrated in Table 4.

Table 4 Example of groove profile and size for enclosed arc welding

Items		Bar direction	
		Horizontal	Vertical
Profile			
Root bap (G)	manual	53∿13mm	4∿8mm
	semi-automatic	8∿11mm	6∿8mm
Groove angle (α)	manual	——	15∿25°
	semi-automatic	——	10∿15°

(5) Weather

The following conditions are specified for work in wind, rainfall or snowfall;

a) In principle the work should be stopped in heavy wind, rain or snow, but it may be permitted if a reliable shielding is provided.

b) When rain or snow is not so heavy as to need rain cover for normal work (diurnal precipitation less than 10 mm), the work may be done if a reliable shielding is provided.

c) Wind is liable to disturb the arc and cause defects like blowholes, therefore the allowable wind velocity to the joint portion is set at 10 m/s for manual enclosed arc welding and at 5 m/s for semi-automatic enclosed arc welding. When these limits are exceeded, the wind to the joint portion should be abated by use of, say, an anti-wind board.

(6) Measures to be taken when the welding is interrupted

When the arc is stopped in mid-welding, rewelding should be done after preheating is done to such an extent that no hardened zone is left in the heat-affected zone of base metal.

(7) Safety and accident prevention

a) Welding operation should be done with full care for safety in accordance with the Industrial Safety and Sanitation Law, the Pressurized Gas Control Law and other related regulations.

b) If the inflammable substance around the weld is likely to burn by ignition in arc welding, gas cutting or grinder operation, appropriate measure for protection should be taken.

CHAPTER 5 INSPECTION

Section 15 Inspection of joint appearance

2.- In a detailed inspection of the appearance to be done using an appropriate instrument for confirmation of the inspection in (1), the sampling rate is set at over 5%.

3.-

a) The joint should be free from harmful undercut or overlap. Harmful undercut mentioned here refers to one which is more than 0.8 mm deep.

The outer diameter of joint is usually about 1.1 times the bar diameter. In a vertical joint of semi-automatic enclosed arc welding, on account of a portion of the backing metal which is left on the joint the outer diameter is slightly increased, being about 1.3 times the bar diameter. In this case weld of reinforcement should not be so insufficient that the diameter of weld part turns out smaller than that at the dent between lugs.

As for details about undercut or overlap, Commentary (2) to Section 13 of Chapter 4 should be referred to.

b) Enclosed arc welding is a so-called "place and join" process in which pressure application is not done during welding and accordingly no eccentricity happens in welding. Considering various conditions of work at the site, the eccentricity of joint is set at 1/10.

Inspection of bars of different diameters for their appearance should be similarly done.

4.- Disposal of joints disqualified in the inspection of appearance should be entrusted to discretion of the responsible engineer.

Section 16 Nondestructive inspection of joints

1.- Procedure of ultrasonic flaw detection should conform to NAKS-0001-1977 Recommendations for Ultrasonic Flaw Detection of Gas Pressure Welds in Reinforcing Bars.

2.- In principle, samples should be taken for nondestructive inspection. The sampling rate is normally over 10%, but depending on the significance of a structure or its test results, the responsible engineer may set the rate othewise. A joint disqualified should be cut off and submitted to a destuctive test to check its strength. The cut-off portion should be rewelded.

3.- Matters other than the above should be entrusted to discretion of the responsible engineer.

Section 17 Destructive inspection of joints

1.- Destructive inspection is done to make an overall estimate about the adequateness of the equipment, conditions and operation of enclosed arc welding executed. For this reason, a joint is submitted to a failure test for qualification of the joint strength. In principle, as-welded joints are put to tension test for destructive inspection. Tension tests are done in accordance with JIS Z 2241-1980 Metallic Materials Tension Test Procedure. In seeking a tensile strength of a joint, the nominal sectional area specified under JIS G 3112 Steel Bars for Concrete Reinforcement is taken as the sectional area.

2.- Performance of joints executed by enclosed arc welding in accordance with the instruction of a welding engineer with use of adequate materials and equipment by a qualified welding operator may be deemed approximately identical if the conditions are identical. Therefore in principal model test specimens should be submitted to a tension destructive test to confirm the performance of a finished joint.

For strength inspection, two joint specimens should be tested at a time. The two specimens are qualified when their strength meets Class A specified in (1) of Section 3 of Recommendations for fundamentals. When the responsible engineer recongnizes the necessity, for instance when the results of inspection specified in Section 15 or 16 and of strength test using model test specimens are doubtful, a specimen should be cut off from a finished joint and submitted to a strength test.

3.- About the frequency of destructive inspection, whether the specimen is model or a piece taken from a finished joint, the responsible engineer should instruct it.

4.- A disqualified lot may be put to 100% sampling destructive test or sorted out as good and bad joints or may have the bad joints corrected. The last method is recommendable for disposal of enclosed arc welded joints. To be more specific, all the joints in the disqualified lot are sorted out by nondestructive inspection and the disqualified ones are rewelded in accordance with an instruction of the responsible engineer.