The Role of The IIW in the Field of Mannual Arc Welding

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Mr. President, Ladies and Gentlemen,

It is my pleasure to present to you today, on behalf of the International Institute of Welding, a review of the work of the technical commission dealing with manual metal arc welding, namely Commission II. Although predictions have been made that welding with stick electrodes will eventually be forced to give way to gas metal arc and submerged arc, the process is still very much alive and there are good reasons to assume that it will be with us for a long time to come. The main advantages, which are particularly relevant to any developing industry, are :

1. The capital investment is low.
2. The process is flexible and enables on-site welding and repair.
3. There is a large range of electrode types to choose from.
4. Special compositions can be made easily and quickly in small quantities.

Before considering the tasks and achievements of Commission II, it is expedient to first consider the activities of the IIW as a whole.

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The number of member countries has increased progressively since inception of the IIW in 1948 and presently totals 36. Members from the Afro-Asian continents now include South Africa, China, India, Iran, Israel, Japan and Turkey. Each country is represented by one or more member Societies, India —for example—having two : the Welding Research Institute and The Indian Institute of Welding.

The IIW has sixteen Technical Commissions and one special study group. The Commissions exist on a permanent basis and provide means for the collection and dissemination of information, the development and co-ordination of research programmes and the compilation of findings contributed by the member countries. The subjects covered by the Commissions range from the welding processes through the effects of welding on material and design to the inspection of welds, terminology, health, safety and education. The Commissions are listed in Table 1 to enable an appreciation of the scope of the activities to be made.

Each commission has a working programme, progress on which must be reported once a year at an Annual Assembly. The objectives of these programmes in many of the commissions are often to agree to the technical bases upon which international standards and specifications shall be formulated.

Table—1

Technical Commissions

Commission	*Title*
I	Gas welding, brazing and cutting
II	Arc welding
III	Resistance welding
IV	Special welding processes
V	Testing, measurement and control of welds
VI	Terminology
VII	Documentation and standardization
VIII	Hygiene and safety
IX	Behaviour of metals subjected to welding
X	Residual stresses and stress-relieving
XI	Pressure vessels, boilers and pipelines
XII	Flux-and gas-shielded electrical welding
XIII	Fatigue testing
XIV	Welding instruction
XV	Fundamentals of design and fabrication
XVI	Welding of plastics
S. G. 212	Physics of the welding arc and other high energy sources.

Although it is not the purpose of the IIW to prepare standards as such, one of its stated objectives is to assist in the formulation of standards in collaboration with the International Organization for Standardization. The Institute has done this since its inception, in some cases offering documents to ISO which it considered could be used as a basis for international standardization, and in other cases responding to appeals from ISO for information required in the elaboration of an international standard.

Over the years, more than 500 documents have been approved by the IIW for publication. Many of these have appeared in the Institute's own bimonthly journal "Welding in the World" which was first published in 1963. In addition, a number of books, booklets, films and reference radiographs of welds have been made available.

Having briefly considered the activities of the IIW, we can now turn our attention to the Commission which deals with manual metal arc welding.

Commission II

The Commission is subdivided into four Sub-Commissions having the following titles :

Sub-Commission A The Metallurgy of Weld Metal

B Testing and Measurement of Welding Equipment

C Testing and Measurement of Weld Metal

E Classification of Electrodes.

In order to review the activities of the Sub-Commissions it is convenient to draw attention to the working programme and the main publications issued. A list of the published documents is given in the Appendix.

Sub-Commission A (The Metallurgy of Weld Metal)

This Sub-Commission was previously entitled "Hydrogen in weld metal" and serves primarily as a technological back-up group for the other Sub-Commissions. In addition to hydrogen, the other fields of interest are the constitution of weld metal, gas metal reactions, weld metal cracking and the study of methods for collecting and analysing fumes and gases.

The work on hydrogen spans a period of over twenty years and has culminated in a series of publications as well as ISO 3690 (Determination of hydrogen in weld metal). A recommendation has also been issued for the determination of water in electrode coatings. An acceptance level for defining hydrogen controlled electrodes has been agreed upon and recommendations have been made for reporting hydrogen contents. Currently, the expertise gained is being extended to other processes, in particular to submerged arc welding.

Hydrogen induced embrittlement of weld metal has been studied extensively and a recommended method for the assessment of microfissures has been proposed. Similarly, the effects of hydrogen on the heat-affected zone has been studied, using the implant test as well as conventional weldability tests. The role of hydrogen is reassessed continuously, the most recent literature review having been issued in 1975.

Attention has been directed towards the contitution of weld metal, with particular emphasis on oxygen and nitrogen contents. Also, the detection

of non-metallic inclusions has been reported upon. In the last two years, a joint programme has been launched to study the microstructure of C-Mn steel weld metal. Almost twenty laboratories world-wide, which include the National Metallurgical Laboratory in India, are co-operating and preliminary results indicate the microstructural components, i.e. pro-eutectoid ferrite, bainite and acicular ferrite, can be described in the same quantitative terms. A further current point of interest is the chemical reactions occurring during welding and particular emphasis is being placed on the effect of pressure during hyperbaric welding on metal chemistry. Also, information on methods for determining fume emission rates of electrodes is being collected and liaison is being maintained with other interested groups.

Sub-Commission B (Testing and Measurement of Welding Equipment)

This Sub-Commission is primarily concerned with the suitability of different welding equipment. Also analytical studies are being carried out on the effect of electrode movement and of arc voltage and current fluctuations during welding with covered electrodes. Methods of measuring arc welding currents and voltages are also under study. A project for the determination of fusion constants is being drafted and in the field of welding safety close co-operation is being maintained with the International Electrotechnical Commission (IEC). In addition, liaison is being maintaind with Sub-Committee 4 of ISO/TC 44 with regard to national standards related to welding rectifiers. Problems associated with connections to the main power supply of single-phase equipment are also being considered. Another field of interest is stud-welding and a continuous watch is being kept on developments. A number of documents have been published by the Sub-Commission, as can be seen from the Appendix. A relevant ISO recommendation is R 700, concerned with the rating of manual arc welding equipment.

Sub-Commission C (Testing and Measurement of Weld Metal)

For a number of years, this Sub-Commission has dealt with the measurement of delta ferrite in austenitic weld metal. Collaborative programmes have been carried out and a final report, shortly to be released as a Welding Research council bulletin, was issued in 1974. Furthermore, a recommended method for the metallographic determination of delta ferrite exists and an atlas has been made available. Work is currently being carried out on calibration methods for instruments to determine the ferrite number of Cr-Ni stainless steel weld metal and it is envisaged that a standard can eventually be released.

Another collaborative programme to have spanned a number of years is a study to evaluate the performance of hot cracking test methods. The work has now been completed and a final report is awaiting publication. The conclusion drawn was that simple self-restraining tests are quite capable of distinguishing between the hot cracking tendencies of different electrodes when a suitable root gap is used.

Data collection is an important aspect of the work of the Sub-Commission and a current subject is information on various conventional and electro-chemical tests to determine the corrosion resistance of weld metal and welded joints. A review of methods for hardness measurements of hardsurfaced components is also an item on the working programme. In addition, attention, is being devoted to creep testing of weldments and to the testing of primer coated steels. The welding of cast iron is a further topic and contact is being maintained with other IIW commissions.

A method of testing for determining the efficiency, metal recovery and deposition of covered electrodes was published and this led subsequently to ISO 2401.

The ductile/brittle behaviour of weld metal has also been a major item over the years and the subject of several co-operative studies. A proposed method of Charpy-V impact testing has been published and work is currently continuing on the scattering of impact values of high tensile steel weld metal. Other brittle fracture test methods are under constant review, with the object of evaluating their suitability for electrode classification.

Considerable emphasis has been placed on notch toughness and this is difficult, in some cases, to understand. In IIW work, it can be followed that from an original criterion for operating conditions, notch toughness has developed into a quality test procedure, since impact values are sensitive to small changes in impurities and electrode coating formulations. Although other approaches for ductile and brittle behaviour, such as COD, have developed, the Charpy test is still a valuable means of verifying whether electrodes once offered are of consistent quality—even if there is no direct relationship, as such, between crack opening displacement and the absorbed energy.

Sub-Commission E (Classification of Electrodes)

Sub-Commission E deals with the classification of electrodes and thus presents the end product of the work of other Sub-Commissions.

A code of symbols for mild steel and low alloy steel electrodes was first prepared and after transmission finally led to ISO 2560. The code includes a method for the mechanical testing of weld metal and this is described separately in ISO recommendation R 615. A standard for these electrodes has recently been submitted to ISO and thus includes an all-weld-metal tensile test, a butt weld test and a hydrogen test. The standard supersedes IIW 56/60, which was the first document to be published in Welding in the World and classes electrodes according to two Charpy-V levels, namely 27 and 47 Joules.

A code of symbols for electrodes destined for the welding of high tensile steels and steels for low temperature applications has been drawn up (ISO TC 44 SC 3-189) together with a related standard for the determination of chemical analysis (S3 C-187). The Sub-Commission is currently working on a standard for these electrodes.

Two further codes of symbols have been prepared, namely ISO 3580 and ISO 3581, the electrodes being intended for creep resistant and foi stainless steels, repectively. Codes for hardfacing electrodes and for cast iron electrodes are currently being considered by ISO. A future commitment is to prepare standards in these cases also.

The classification of electrodes as regards to welding fume is being considered in co-operation with Commission VIII (Hygiene and Safety). The Sub-Commission has decided in the first instance to prepare a recommendation based on experience gained within the Scandinavian countries, using the Swedish fume box to determine total fume emission. In some countries it is felt that the classification of electrodes into fume classes is premature at this stage. In other quarters, preference has been expressed for specification which gives an indication of the amount of ventilation needed to ensure the threshold limit values prescribed by the authorities for the substances contained in the welding fume. Emphasis has been placed on the ventilation aspect since it is not only the consumable which contributes to fume but also the presence of primers, paint and grease, etc. on the surface of the plate.

Concluding Remarks

In my address today, I have outlined the activities of Commission II which is concerned with manual metal arc welding, a process which is an extension of artisan skills and of considerable importance to rapid industrial expansion. Similar work is being conducted by the other Commissions and I feel humble in attempting to describe an association built up by the combined efforts of so many people over the last thirty years.

The Institute is a non-profit organization and membership is the means by which a large amount of information can be obtained at, incidentally, relatively low cost. Thus non-member countries could well consider whether participation at this stage is feasible and of benefit to their national economies. India, our host at this Conference, has been a welcome member for a number of years and actively participates in both the Governing Council and the technical commissions. A consequence of membership is a broadening of knowledge and it is probably true to say that there is no equivalent organization in the world where chemical, physical, mechanical and metallurgical engineers can meet to discuss and solve common problems. Finally, and of greater importance, the IIW is a meeting place of people from many different countries, thus leading to friendship and better understanding.

APPENDIX

(Documents published by Comm. II)

IIS/IIW 5-58 The effect of storage time on the hydrogen content and mechanical properties of arc welds made with covered electrodes.

8-58 Determination of total hydrogen contents of weld metal.

10-59 The formation of fish-eyes in weld metal as a result of stressing.

11-59 Dynamic behaviour of D.C. generators for arc welding—Proposal for a definition of "Stability for welding".

21-59 Measurement of the flexibility of welding cables.

31-59 Soudage a l'arc electrodes enrobees a forte penetration.—Resultats d'etudes faites a l'Institut de Soudure (Paris).

56-60 Method of testing and approval of electrodes for welding mild and low alloy high tensile steels.

59-60 Tests to determine current strengths admissible in welding cables, proposed values.

60-60 Memorandum on low voltage safety devices.

120-63 Calculation of the power of a multi-operator welding set.

126-64 Code of good practice for deep penetration welding.

153-64 Determination of total hydrogen contents in weld metal.

206-66 Non-metallic inclusions in weld metal.

253-67 Proposed method of Charpy V impact testing at low temperatures for approval of electrodes for use on mild steel and low alloys structural steels.

268-67 Dynamic behaviour of arc welding transformers. —Draft proposal for a definition of the suitability to weld.

290-68 Appreciation of the quality of welding transformers.

314-68 Recommended procedure for the determination of total water contents of electrode coating by combustion (potential hydrogen contents).

315-68 Tentative procedure for the determination of hydrogen in mild and low-alloy steel weld metal.

339-69 Method of testing for determining the efficiency, metal recovery and deposition constant of covered electrodes.

352-70 A survey of research on the dynamic behaviour of welding transformers.

361-71 Measurement of hydrogen in weld metal.

449-74 Final report on the cooperative testing programme (1971-1972) on the measurement of ferrite in austenitic stainless steel weld metal.

452-74 Weld metal hydrogen levels and the definition of hydrogen controlled electrodes.

477-75 Recommended method of testing for the assessment of the microfissuring tendency of mild and low alloy steel weld metal deposited by manual arc welding covered electrodes.

482-75 Recommended method for the metallographic determination of ferrite in Cr-Ni austenitic weld metal by means of normal optical microscopy and visual comparison with an atlas.

491-75 Hydrogen diffusion in welding. —An assessment of current knowledge.

812-76 Recommended methods of reporting single bead weld metal hydrogen contents.