# Present status of Indian standards in SMAW

## —*A few current topics*

By D. S. HONAVAR*

**Theme**

The three current topics of importance, which are engaging the attention of SMDC : 14 of the Indian Standards Institution are :

(a) Revision of IS : 814-1974 and IS : 815-1974, based on the experience already gained ;

(b) Methods for measurement of diffusible hydrogen in weld metal ;

(c) Use of non-rimming steel for core wire of electrodes in welding mild and low alloy steels.

Use of alcohol displacement method in preference to glycerine displacement method has been discussed with regard to its relative advantages of greater accuracy and shorter duration in collecting diffusible hydrogen. Use of non-rimming steel as core wire for the rutile type and the lime-fluoride type has been discussed with reference to the recent investigations made in India and future course of action suggested.

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This paper was presented in the National Welding Seminar, WELDING '84 Tiruchirapalli.

**Introduction**

The problems confronting the standardisation body in India are not different from those in other developing countries. The factors which have to be kept in mind are ;

(a) Rapid technological advancement ;

(b) Yet, a wide technological gap (which tends to widen further) between India and the highly industrialised countries ;

(c) need to blend well with the standards and practices existing in developed countries ; and

(d) keen desire, born out of a sense of patriotism and realism to establish our own identity even while drawing liberally from existing international and national standards.

This is the situation Indian Standards Institution had to face when it embarked on its ambitious programme of standardisation several decades ago. Commendable progress has been made since then in the field of standardisation at national level, and over 12500 standards have already been prepared. Among these are a total of 77 standards pertaining to the field of welding. In this group are 30 standards relating to arc welding, including 19 on MMA Welding, and these, in turn, include 8 on consumables for MMA Welding. With over 90% weld metal deposited even to-day being by MMAW, the thrust of a discussion on standards has to be directed at MMAW. The calendar of development of Indian Standards in welding consumables is given in Table 1.

**Overseas Standards**

To start with we shall see how the few highly industrialised countries stand with regard to the number of standards on MMAW (or SMAW) consumables. Table 2 has been prepared to show the comparison of various standards. It clearly brings out the fact that our country has done well in the field of national standards for welding consumables. Welding personnel in India often face a problem in identification and selection of consumables in projects which have foreign collaborations. The industrial consultants or collaborators indicate the coding as per the respective national standards. The countries which have a lot to

**Table 1. Calender of Development of Indian Standards in Welding Consumables**

| Sl. No. | Year | Spec. Number | Title of Standard Specification | Remarks |
|---|---|---|---|---|
| 1. | 1956 | IS-815 | Classification and coding of covered electrode for metal arc welding of structural steel | Adopted from HDC (Building Divisional Council) of ISI |
| 2. | 2957 | IS-814 | Covered electrodes for metal arc welding of structural steel | —do— |
| 3. | 1958 | IS-1278 | Filler rods and wires for gas welding (ferrous & non ferrous) | Year of Adoption |
| 4. | 1959 | IS-1395 | Low and medium alloy steel covered electrodes for manual metal arc welding | Year of Adoption |
| 5. | 1963 | IS-814 | — | First revision |
| 6. | 1964 | IS-1395 | — | First revision |
| | | IS-2927 | Specification for brazing alloys | Year of Adoption |
| 7. | 1966 | IS-815 | — | First revision |
| 8. | 1967 | IS-814 | — | Second revision |
| | | IS-1278 | — | First revision |
| 9. | 1969 | IS-5206 | Covered electrodes for manual metal arc welding of stainless steel and other similar high alloy steels | Year of Adoption |
| | | IS-5511 | Covered electrodes for manual metal arc welding of cast iron | —do— |
| 10. | 1970 | IS-814 | — | Third revision |
| | | IS-5856 | Corrosion and heat resisting Cr-Ni steel solid welding rods and bare electrodes | Year of adoption |
| | | IS-5857 | Nickel and Nickel alloy bare solid welding rods and electrodes | —do— |
| | | IS-5897 | Al and Al alloy welding rods and wires and Mg alloy welding rods | Year of Adoption |
| | | IS-5898 | Cu & Cu alloy bare solid welding rods and electrodes | —do— |
| 11. | 1971 | IS-1395 | — | Second revision |
| | | IS-6419 | Welding rods and bare electrodes for gas shielded arc welding of structural steel | Year of Adoption |
| 12. | 1972 | IS-1278 | — | Second revision |
| | | IS-6560 | Mo & Cr-Mo low alloy steel welding rods and bare electrodes | Year of Adoption |
| 13. | 1974 | IS-814 (Part I) | For welding products other than sheets | Fourth rivision |
| | | IS-814 (Part II) | For welding sheets | —do— |
| | | IS-815 | — | Second revision |
| | | IS-7303 | Covered electrodes for surfacing of metal by manual arc welding | Year of Adoption |
| | | IS-7280 | Bare wire electrodes for SAW of structural steels | —do— |
| | | IS-3630 | Acceptance tests for wire flux combination for SAW | First revision |
| 14. | 1975 | IS-2927 | — | First revision |
| 15. | 1976 | IS-8363 | Bare wire electrodes for electroslag welding of steels | Year of Adoption |
| 16. | 1977 | IS-8666 | Cu & Cu alloy covered electrodes for MMAW | Year of Adoption |
| | | IS-8736 | Ni & Ni alloy covered electrodes for MMAW | —do— |
| 17. | 1980 | IS-9495 | Test for brazeability of brazing alloy | Year of Adoption |
| 18. | 1982 | IS-1395 | — | Third revision |
| 19. | 1983 | IS-5206 | — | First revision |
| 20. | 1984 | 1. | Revision of IS 5206 | Standard under print |
| | | 2. | Method of sampling and preparation of weld pad for chemical analysis of weldmetal for covered electrodes for MMAW | —do— |
| | | 3. | Revision of IS 5511 | Draft standard formulated |
| | | 4. | Commentary to IS 814 (Part I) | —do— |
| | | 5. | Method of determination of diffusible $H_2$ content of deposited weld metal from covered electrodes in welding mild and low alloy steels | —do— |
| | | 6. | Tungsten electrodes for inert gas shielded arc welding and for plasma cutting and welding | —do— |
| | | 7. | Classification and codification of filler wires and fluxes for SAW | —do— |
| | | 8. | Redrying of covered electrodes before use | Draft standard under preparation |
| | | 9. | Revision of IS 814 (Part I) | —do— |
| | | 10 | Revision of IS 814 (Part II) | —do— |
| | | 11. | Revision of IS 815 | —do— |
| | | 12. | Commentary to IS 815 | —do— |

**Table 1. Calender of Development of Indian Standards in Welding Consumables (*Coutd.*)**

| Sl. No. | Year | Spec. Number & Title of Standard Specification | | | Remarks |
|---|---|---|---|---|---|
| 13. | | Covered electrodes determination of efficiency, metal recovery and deposition coefficient | — | — | —do— |
| 14. | | Revision of IS 5856, IS 6419, IS 6560, IS 7280 | | — | —do— |
| 15. | | Flux cored wires | — | — | —do— |
| 16. | | Classification and codification of filler wires and fluxes for SAW Part III wire-flux combination | — | — | —do— |
| 17. | | Revision of IS 5897 | — | — | Draft standard approved for wide circulation |
| 18. | | Comparison of Indian and Overseas Classification and coding of welding filler materials | — | — | —do— |
| 19. | | Acceptance tests for combination of filler wires and shielding gases for MIG welding | — | — | Work in hand |

**Table 2. Comparison of Standards (Approximate)**

| | Subject | AWS | IS | ISO | BS | DIN | AFNOR | JIS |
|---|---|---|---|---|---|---|---|---|
| 1. | Carbon Steel covered arc welding electrodes | A 5.1–81 | 814/815–75 | 2560–73<br>544–75<br>547–75 | 639–76 | 1913–76 | A 81-300–80<br>A 81–304–69<br>A 81–309–75 | Z 3210–76<br>Z 3211–78 |
| 2. | Iron & Steel bare gas welding rods | A 5.2–80 | 1278–72 | 544–75, 546–75, 545–75, 636–75, 708–68 | 1453–72 | 8554–76 | — | Z 3201–76 |
| 3. | Al & Al alloy covered arc welding electrodes | A 5.3–80 | — | — | — | 1732–77 | — | — |
| 4. | Stainless steel covered arc welding electrodes | A 5.4–81 | 5206–69 | 3581–76 | 2926–70 | 8556–76 | A 81–343–79<br>A 81–344–79 | Z 3221–76 |
| 5. | Low alloy steel covered arc welding electrodes | A 5.5–81 | 1395–71 | 546–75<br>2560–73<br>3580–75 | 2493–71 | 8529–81<br>8575–70 | A 81–345–79<br>A 81–346–79<br>A 81–309–75<br>A 81–340–79<br>A 81–341–79<br>A 81–347–79<br>A 81–348–79 | Z 3212–76,<br>Z 3223–77,<br>Z 3213–77,<br>Z 3241–77 |
| 6. | Cu & Cu alloy covered arc welding electrodes | A 5.6–76 | 5898–70 | — | — | 1733–79 | — | Z 3231–76 |
| 7. | Cu & Cu alloy bare rods & electrodes | A 5.7–77 | 5898–70 | — | 2901–83 Part 3 | 1733–79 | — | Z 3202–76 |
| 8. | Brazing filler metals | A 5.8–81 | 2927–64 | — | — | — | — | — |
| 9. | Stainless steel bare, cored and stranded electrode and welding rods | A 5.9–81 | 5856–70 | — | 2901–83 Part 2 | 8556–76 | — | Z 3321–74 |
| 10. | Al & Al alloy bare welding rods & electrodes | A 5.10–80 | 5879–70 | — | 2901–83 Part 4 | 1732–77 | — | Z 3232–79 |
| 11. | Ni & Ni alloy covered arc welding electrodes | A 5.11–83 | — | — | — | 1736–80 | — | Z 3224–76 |
| 12. | Tungsten electrodes for arc welding | A 5.12–80 | — | — | — | 32528–77 | — | Z 3233–76 |
| 13. | Surfacing electrodes & welding rods | A 5.13–80 | 7303–74 | — | — | 8555–78 | A 81–381–79 | Z 3251–81 |
| 14. | Ni & Ni alloy bare electrodes welding rods | A 5.14–83 | 5857–70 | — | 2901–83 Part 5 | 1736–80 | — | — |
| 15. | Welding rods and covered electrodes for welding cast iron | A 5.15–82 | 5511–69 | 1071–1969 | — | 8573–78 | — | Z 3252–76 |

Table 2. Comparison of Standards (Approximate) (*Contd.*)

| | Subject | AWS | IS | ISO | BS | DIN | AFNOR | JIS |
|---|---|---|---|---|---|---|---|---|
| 16. | Ti & Ti Alloy bare welding rods and electrodes | A 5.16-70 | — | — | — | 1737-82 | — | Z 3331-77 |
| 17. | Carbon steel electrodes and fluxes for submerged arc welding | A 5.17-80 | 3613-74<br>7280-74 | — | 4165-71 | 8557-81<br>32522-81 | A 81-316-80 | Z 3311-76 |
| 18. | Carbon steel filler metals for gas shielded arc welding | A 5.18-79 | — | 864-75 | 2901-83<br>Part I | 8559-76 | A 81-312-79 | A 3312-77 |
| 19. | Magnesium alloy bare electrodes and welding rods | A 5.19-80 | 5897-70 | — | — | — | — | — |
| 20. | Carbon steel flux cored arc welding electrodes | A 5.20-79 | — | — | — | 8559-76 | — | — |
| 21. | Composite surfacing electrodes and welding rods | A 5.21-80 | — | — | — | — | — | — |
| 22. | Stainless steel flux cored arc welding electrodes | A 5.22-80 | — | — | — | — | — | — |
| 23. | Low alloy steel and composite electrodes and fluxes for submerged arc welding | A 5.23-80 | — | — | — | 32522-81<br>8557-81 | A 81-316-80<br>A 81-318-80 | —<br>— |
| 24. | Zirconium & Zirconium alloy bare electrodes and welding rods, | A 5.24-79 | — | — | — | — | — | — |
| 25. | Consumables for electro-slag welding | A 5.25-78 | — | — | — | 8574-78 | — | — |
| 26. | Consumables for electro-gas welding | A 5.26-78 | — | — | — | — | — | — |
| 27. | Copper and copper alloy gas welding rods | A 5.27-78 | — | — | — | — | — | — |
| 28. | Low alloy steel filler metals for gas shielded arc welding | A 5.28-79 | 6560-72 | — | 2901-83<br>Part I | — | A 81-312-79 | — |
| 29. | Low alloy steel flux cored welding electrodes | A 5.29-80 | — | — | — | — | — | — |
| 30. | Consumable inserts | A 5.30-79 | — | — | — | — | — | — |
| 31. | Electrode wires and fluxes for SAW of stainless Steel | — | — | — | 5465-77 | — | A 81-318-80 | — |

do with India in the industrial development are the U.S.A., U.K., U.S.S.R., West Germany, France and Japan. Table 3 has been prepared to show a comparison of the various national standards.

The International Organisation for Standardisation devised a "universal" designation system for electrode codings and this was published as ISO Standard 2560 in the hope that it would be adopted by individual member countries. This standard became the basis in the U.K. for BS 639 : 1976, and in India for IS : 815-1974. The standard in West Germany (DIN) was already close to ISO Standard.

**Standards Revised**

Two important standards revised in the last two years after prolonged deliberations are now under print. These are

(1) IS : 5206-1969—Corrosion resisting chromium and chromium-nickel steel covered electrodes for manual metal arc welding.

(2) IS : 1395-1971—Molybdenum and chromium-molybdenum-vanadium low alloy steel electrode for metal arc welding (second revision)

The revised versions are based on the ISO document—General Scheme for the Classification of Filler Material, and the corresponding draft international standard of ISO.

The standard which is at an advanced stage of revision is

IS : 5511-1969—Covered electrodes for manual metal arc welding of cast iron

The two standards most widely required by both the fabrication industry and electrode manufacturer are

IS:814—1974 and IS:815-1974

**Table 3. Equivalent Electrode Designations of Various Countries—*mild steel Electrodes***

| Specification No. | AWS-SFA 5.1 | AS-1552 1973 | NF-A 81-309-1975 | BS-639 1976 | CSA-W 48.1-M 1980 | DIN-1913 Pt 1 1913 | IS-815 1974 | ISO 2560 1973 | JIS 23211 23213(Re-affiirmed 1980) | O NORM-M7820 Teil 1 | ONE 14003 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Country | USA | Australia | France | U.K. | Canada | Germany | India | International | Japan | Austria | Italy |
| Equivalent Electrode Designation | E 6010 | E 4110 | E434/OC10 | E4340CC10 | E41010 | E4340C4 | E100414 | E434C10 | — | E4340C10* | E434C10 |
| | E 6011 | E 4111 | E434/OC16 | E4340C16 | E41011 | E4340C4 | E104414 | E434C16 | D 4311 | E4340C14 | E434C16 |
| | E 6012 | E 4112 | E431/OR12 | E4310R12 | E41012 | E4310R(C) | E212411 | E431R12 | — | E4310R(C)15 | E431R12 |
| | E 6013 | E 4113 | E431/OR11 | E4310R14 | E41013 | E4310R2 | E316411 | E431R11 | D 4313 | E4310R11 | E431R11 |
| | E 6020 | E 4120 | E432/OA32 | E4310A32 | — | E4310A5 | E442412 | E432A32 | — | E4310A32 | E432A32 |
| | E 6022 | E 4120 | E430/OA41 | E4300A44 | — | E4300A5 | E436410 | E430A41 | — | E4300A41 | E430A41 |
| | E 6027 | E 4127 | E434/OA32 | E4340A32 | E41027 | E4340A5 | E546414 | E434A32 | D 4327 | E4340A32 | E434A32 |
| | E 7014 | E 4814 | E511/OR11 | E5113RR11 | E48014 | E5110RR8 | E205511 | E511R11 | — | E5110RR11 | E511R11 |
| | E 7015 | E 4815 | E514/OB10 | E5140B10 | E48015 | E5140B9 | E600514 | E514B10 | — | E5140B10* | E514B10 |
| | E 7016 | E 4816 | E514/OB16 | E5140B16 | E48016 | E5140BR9 | E604514 | E514B16 | D 6216 | E5140B16 | E514B16 |
| | E 7018 | E 4818 | E514/OB16 | E5140B16 | E48018 | E5140BR9 | E604514 | E514B16 | D 6218 | E5140B16 | E514B16 |
| | E 7024 | E 4824 | E511/OR31 | E5140RR31 | E48024 | E5110RR11 | E246511 | E511RR31 | — | E5110RR31 | E511RR31 |
| | E 7027 | E 4827 | E514/OA31 | E5140A31 | E48027 | E5140A5 | E546514 | E514A31 | — | E5140A33 | E514A31 |
| | E 7028 | E 4828 | E513/OB36 | E5130B32 | E48028 | E5130B12 | E642513 | E513836 | — | E5130B36 | E513B36 |
| | E 7048 | — | — | E5140B93 | E48048 | — | E614514 | — | — | — | — |

These have been taken up for revision. In doing so, it has been decided to combine the two standards as was done by BSI in respect of BS 639-1976. It must be noted in this connection that BS 639 itself has been taken up for revision. Similarly, ISO 2560-1973—Covered Electrodes Manual Arc Welding of Mild Steel and Low Alloy Steel—Code of Symbols for Identification, is also in the process of revision. Inasmuch as IS:815 and IS:814 were prepared after adopting ISO 2560, we have to take into account the proposed changes. It is noteworthy that the BSI in revising BS 639 will keep in mind the trend of changes proposed for ISO 2560. In the light of this development on the international scene, the proposed revision of IS : 814 and IS:815 can be done after a study of the proposed revision of BS 639.

Chart No. 1 serves to explain the system of coding in IS:815-1974 which is currently in force. Chart No. 2 is meant to be a guide to proposed electrode coding in revision of BS 639-1976. The salient features of the proposed revision of BS 639 are

(a) to shorten the designation the initial letter E has been dropped ;

(b) one single table for impact strength has been included and the lower level of requirements relating to the ISO 2560 standard has been omitted ;

(c) to take account of the development in welding electrodes over recent years the table of impact strength has been extended to cover lower test temperatures down to-90°C ; and

(d) in the preparation of weld assembly for tensile and impact tests, the method is based on the two beads per layer, which is in line with that adopted by both AWS and ISO systems.

(e) Sub-Committee SMDC 14.1 is engaged in preparing a standard on comparison of Indian and Overseas classification and coding of MMA electrodes. Table 3 gives such a comparison and it should prove a useful guide to welding engineers associated with projects having foreign collaboration.

**Certification Mark and Export of Electrodes**

While the ISI has strived hard and published various standards, their adoption and implementation has left a lot to be desired. This arises from the fact that the code of construction is of ASME. Even so there exists lot of scope at least with reference to M.S. types and it must

| TYPE OF COVERING | |
|---|---|
| 1 | High Cellulose Content |
| 2 | High content of Titatia - fairly viscous slag |
| 3 | Appreciable amount of Titania - fairly fluid slag |
| 4 | High content of oxides, silicates or both of iron & manganese - inflated slag |
| 5 | High content of iron oxide or silicate or both - heavy solid slag |
| 6 | High content of Calcium Carbonate & Fluoride - basic slag |
| 7 | Any other type not classified above |

| WELDING POSITION | |
|---|---|
| 0 | F, H, V, D, O |
| 1 | F, H, V, O |
| 2 | F, H |
| 3 | F |
| 4 | F, $H_f$ (horizontal fillet) |
| 9 | Any other position not classified above |

| CURRENT CONDITION | |
|---|---|
| 0 | D + |
| 1 | D + A90 |
| 2 | D - A70 |
| 3 | D - A50 |
| 4 | D + A70 |
| 5 | D ± A90 |
| 6 | D ± A70 |
| 7 | D ± 50 |

Typical Example

| E | 6 | 1 | 4 | 5 1 | 4 | HJ |
|---|---|---|---|---|---|---|

| METHOD OF MANUFACTURE | |
|---|---|
| E | Extruded solid |
| R | Extruded with reinforcement |

| ELECTRODE CLASSIFICATION | MECHANICAL PROPERTIES | | | |
|---|---|---|---|---|
| | Tensile Strength Range N/mm² | Yield Stress minimum N/mm² | Elongation on gauge length of $6.65\sqrt{S_o}$ percent | *Impact value of 47J(4.8 kgf.m) minimum at °C |
| EXXX - 410 | 410-510 | 330 | - | - |
| EXXX - 411 | 410-510 | 330 | 20 | +27 |
| EXXX - 412 | 410-510 | 330 | 22 | 0 |
| EXXX - 413 | 410-510 | 330 | 24 | -20 |
| EXXX - 414 | 410-510 | 330 | 24 | -30 |
| EXXX - 415 | 410-510 | 330 | 24 | -40 |
| EXXX - 510 | 510-610 | 360 | - | - |
| EXXX - 511 | 510-610 | 360 | 18 | +27 |
| EXXX - 512 | 510-610 | 360 | 18 | 0 |
| EXXX - 513 | 510-610 | 360 | 20 | -20 |
| EXXX - 514 | 510-610 | 360 | 20 | -30 |
| EXXX - 515 | 510-610 | 360 | 20 | -40 |

| SPECIAL PROPERTIES | |
|---|---|
| H | Hydrogen controlled |
| J | Metal recovery 110-130% |
| K | Metal recovery 130-150% |
| L | Metal recovery above 150% |

* Note

When impact test is carried out at -30° and -40° the average minimum shall be 27J (2.8 Kgf.m)

*CHART 1 IS:815 Codification for MMAW Electrodes.*

be stated that a number of fabrication units have based their testing and approval of welding electrodes on IS:814 and IS:815. The Certification Marks scheme for welding electrodes which did not fare well, for various reasons, until about 1980, has now been tightened up and loopholes plugged, particularly with regard to small scale units. The earlier attempt to give the benefit of saving to SSI by exempting them from installation of standard mechanical testing equipment seemed to have caused a setback, and the image of ISI did suffer a great deal. Based on such experience that quality control without the minimum standard mechanical testing equipment cannot be meaningful, ISI have now stopped giving any concession in this regard. This is a welcome step in the interests of quality, as the proliferation of small scale units for manufacture of electrodes has already led to dilution of quality standards in the product reaching the consumer. The three-fold effort through (a) insistence on the installation of the requisite equipment within each electrode manufacturing unit, small scale or large scale, (b) stricter process control, and (c) more vigorous inspection by ISI personnel, has already started yielding the desired results. Faith of user industry in the Certification Mark for electrodes seems to have been restored. This is in our national interest, and it casts a heavy responsibility on the ISI to live up to the expectations and to prove worthy of the faith reposed in it by the welding fraternity in particular and standards engineers in general.

With the rapid growth in export of welding electrodes, it is necessary to propagate knowledge of, and aim at acceptance of, Indian Standards in the developing countries. ISI has to make a planned publicity drive for this purpose on the same lines as it is doing in India. The advertisement inserted by the ISI in their bulletin, can be considered very apt and effective and it is worth having a look at it.

## Measurement of Diffusible Hydrogen

Influence of hydrogen and its manifestation in welds has continuously engaged the attention of researchers during the last forty five years. Starting around 1935, the intensive and extensive research work has dealt with the various facets of the subject and led to progressively better understanding of the role of hydrogen, its behaviour in producing defects in welds, the need for its control and method of control. Certainly, for nearly half-a-century, hydrogen in welds has remained a lively topic of discussion and deliberations, not only with regard to its adverse effects and its control, but also its measurement. Even after we have stepped into the eighties, no one can say with any degree of certainty that the last word has been uttered on this remarkable damaging and intriguing and hence to a researcher challenging and fascinating, element in welds.

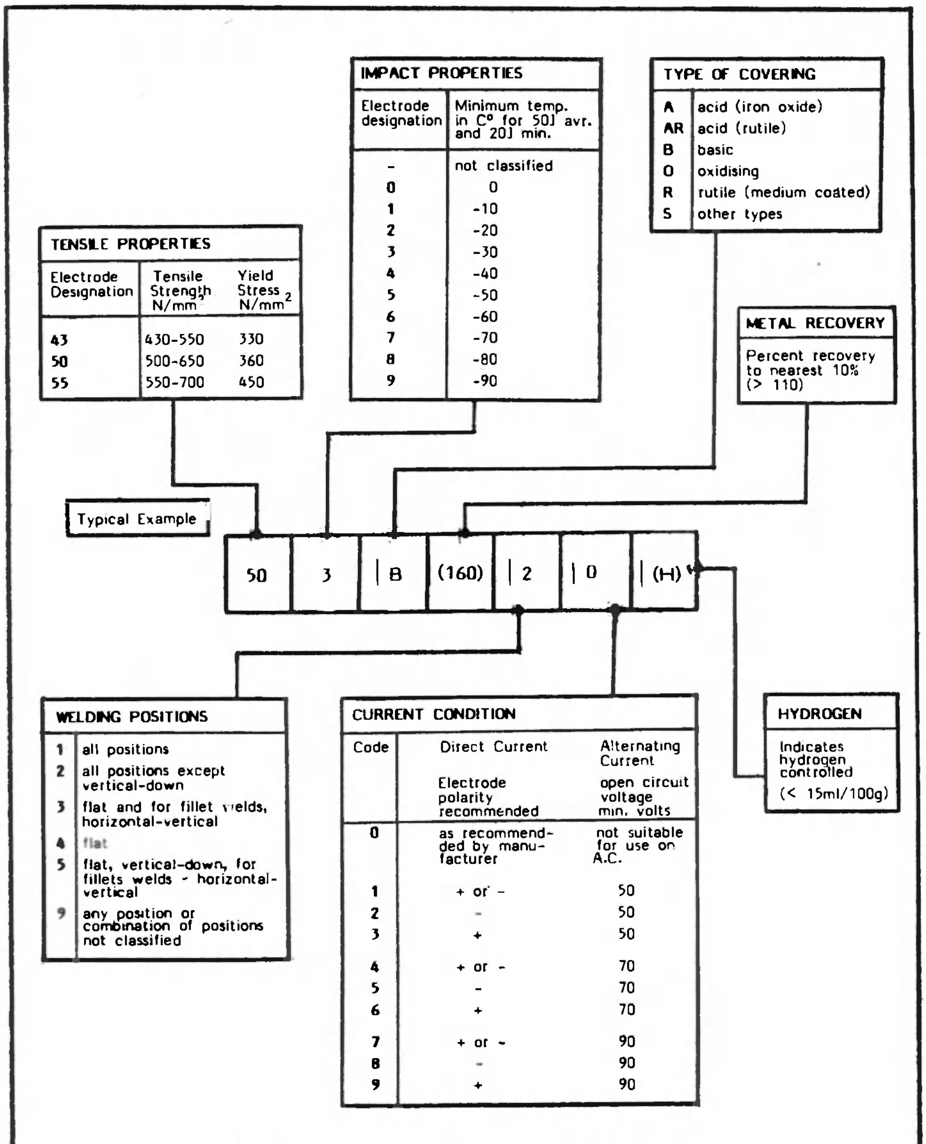



*CHART 2 Proposed Revision of BS:639-1976 - codification of MMAW electrodes.*

While its role in cold cracking and the means of controlling the same have been thoroughly investigated and its damaging effect curbed to a very large extent, we today find ourselves in a position where the very measurement of diffusible hydrogen in welds seems to be eluding a final solution. The mercury method for measurement of diffusible hydrogen was standardised after years of work and co-operation among members of International Institute of Welding. ISO 3690:1977 is already in use in several countries. Methods prescribed in BS 639:1976 and in IS: 815-1974 are similar.

Recent investigations by Dr. T. Boniszewski and Mr. A.G.C. Morris have cast doubts on the reliability of the ISO mercury method. The latest work in this series is that of Mr. A.G.C. Morris of ESAB, which established that complete evaluation of hydrogen takes as long as 21 days. In any case, all the recent investigations lead to the conclusion that the 72 hours period stipulated in the ISO and BS standards is not adequate. Thus, this important issue has once again been thrown open for further deliberations. We, in India, are equally interested for two reasons—

(a) The mercury method has been incorporated in IS: 815-1974, and

(b) The glycerine method is still used by LRS, BV, ABS etc.

It is already known that glycerine method is very much simpler, though the measurement of hydrogen by this method gives lower values than those obtained by the mercury method. The solubility of hydrogen in glycerine being high, the results obtained may have to be raised by a factor of upto 1.5. It is also known that Japan has not yet adopted the ISO method and continues to use the glycerine method, as laid down in the Japanese Standard JIS Z 3113-1970. Comparison of various standard is shown in Chart 3.

## Glycerine Methods

The glycerine displacement method has been in use over the last thirty years and more. This is the method used by electrode manufacturers in India, and it has served the industry well, particularly for the purpose of quality control in manufacture of electrodes. It came to be introduced in India as a part of regulations of LRS for hydrogen controlled class of electrodes. Limitations of the method are the lower values of hydrogen because of (a) solubility of $H_2$ in glycerine, and (b) bubbles of $H_2$ in the surface tayer of glycerine even at the end of the prescribed period of 48 hours. For this very reason Lloyds Register of Shipping stipulates foı hydrogen controlled electıodes, the upper limit of 10 ml for the glycerine method and 15 ml for the mercury method (Fig. 1).

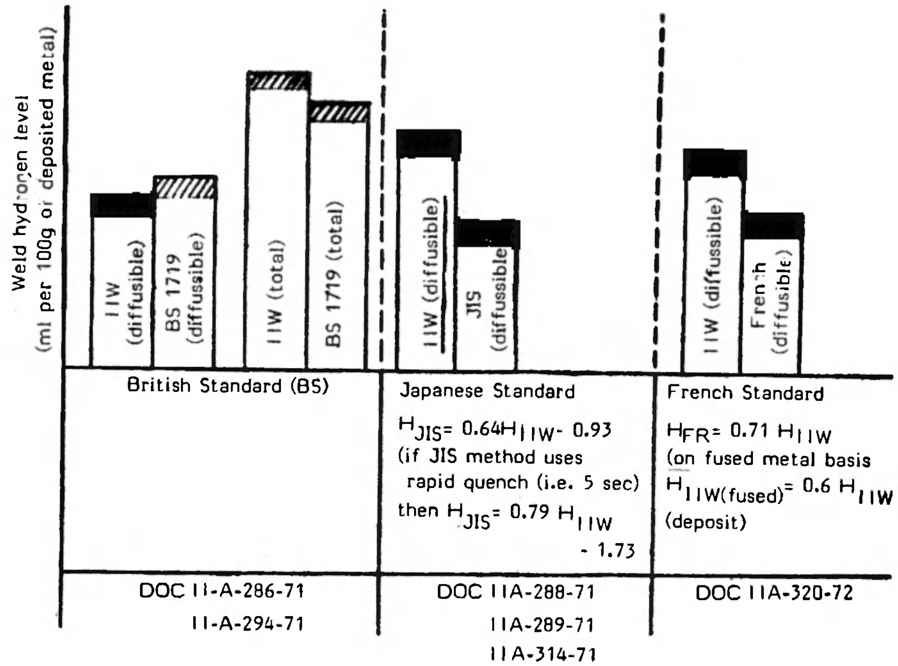



*CHART 3 Comparison of IIW procedure with those of various national standards for measuring weld hydrogen level.*

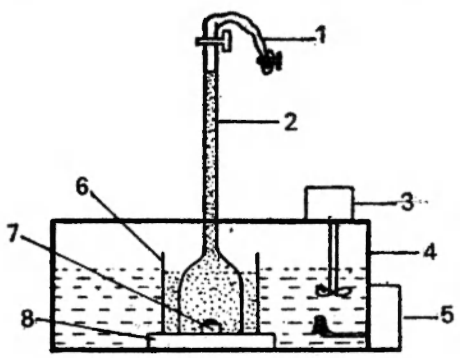



*Fig. 1 Apparatus for Glycerine Method*

1. *Rubber tube with pinch cock*
2. *Inverted glass trough with 0—10 ml. burette*
3. *Stirrer motor*
4. *Thermobath 600×510×300mm*
5. *Temp. Control unit*
6. *Glycerine trough 105×155mm dia*
7. *Specimen*
8. *Perforated grill metal stand 400×400×50 mm*

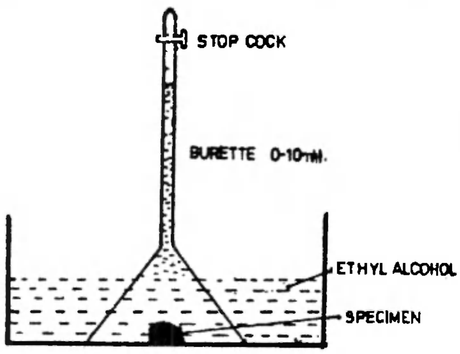



*Fig. 2 Apparatus for Ethyl Alcohol Method*

**Ethyl Alcohol Method**

Replacing glycerine by alcohol seems to offer a greater degree of accuracy as alcohol has the advantage of lower solubility of $H_2$ and lower density. In fact, this is the method prescribed in GOST specification and is employed in the USSR (The method is described in Annexure 1). Noteworthy is the shorter period of 24 hours for the collection of hydrogen, and that too at room temperature. (Fig. 2).

A number of comparative tests carried out in the Laboratories of D & H Secheron have yielded interesting results and brought out the advantage of alcohol over glycerine. Results of comparative tests are as under :

| | | | |
|---|---|---|---|
| Glycerine Method | 4.38 m'. | 0.82 ml. | 0.44 ml. |
| Alcohol Method | 5.66 ml. | 1.54 ml. | 1.45 ml. |

As is evident the results of glycerine method tend to become unreliable as the level of hydrogen drops below 5ml, and particularly below 2 ml.

Thus, the alcohol method is of great interest to us in India, and we ought to consider it for a satisfactory compromises between mercury method and glycerine method, with the additional advantage of faster collection (24 hours) and higher degree of reliability at values below 5 ml. per 100 gm. weld metal. Further tests are in progress and the findings will be submitted to SMDC 14.1 in due course.

**Gas Chromatograph Method**

This method was evolved in Japan about 5 years ago with a view to match the accuracy of mercury method without having to face the hazard of handling mercury. Apparatus for this method is now available in Japan and also in Europe however, the cost is high at present. The method is described in Annexure II.

A comparison of the IIW method and the GC (Gas Chromatograph) method has been made in the Fig. 3. The total time for collection is only 48 hours and the temperature to be maintained is 45°C. In terms of the IIW method the total time for collection is 72 hours and the temperature to be maintained is 25°C. Fig. 4 shows the relation between the results obtained by the two methods

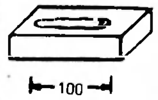
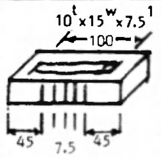
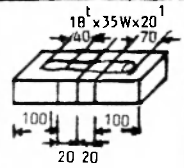
| Feature | Ethyl Alcohol Method (Russian) | Glycerine Method (Lloyds) | Mercury Method (11W) | G.C. Method |
|---|---|---|---|---|
| Test piece details | Same as Glycerine Method but on cu-plate Only bead is tested | 12t x25w x125l  | 10t x15w x7.5l  | 18t x35Wx20l  |
| Collector vessel | Glass burette | Glass burette | Glass tube | Metal tube |
| Collecting condition | 24 hours at RT | 48 hours at 45°C | 72 hours at 25°C | 48 hours at 45°C |
| Substituant material for measurement | Ethyl Alcohol | Glycerine | Mercury | Dry argon gas |

*Fig. 3. Comparison of various methods of diffusible hydrogen measurement.*

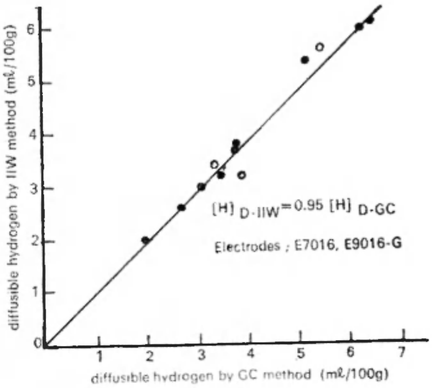



*Fig 4. Relation between GC method and IIW method (SMAW)*

using E 7016 and E9016G electrodes. It is observed that the two results are almost identical.

**IS: 2879 and Use of non-rimming quality steel**

Grant of ISI Certification Mark is based on conformance of the electrodes of IS:814 for the various properties, in addition to use of a dependable quality control system as laid down in the Certification Mark Scheme.

Clause V of IS:814-1974 states that mild steel for core wire shall conform to IS.2879 (specification for mild steel for metal arc welding electrode core wire).

IS:2879 stipulates that the steel shall be of rimming quality.

The combined effect of abovementioned inter-relations is that use of ISI Certification Mark is valid for electrodes manufactured with rimmed steel only. That is why there is no problem in using the steel produced by Bhilai Steel Plant and Tata Iron & Steel Co. The steel produced in the open hearth furnaces at Bhilai Steel Plant and Tata Iron & Steel Co is of rimming quality. On the other hand, steel produced in electric arc furnaces, as in the case of mini steel plants, with or without continuous casting method, is not of rimming quality. Furthermore, use of steel scrap as raw material would yield some quantities of trace elements, in the final product. There are also chances of occurrence of tramp elements depending on the nature of the scrap used. Furthermore, control of silicon below the limit of 0.03% (as laid down in IS:2879) calls for special care. Added to all this is the risk of residual aluminium, when aluminium is used as a deoxidiser.

Efforts to produce non-rimming steel for electrode core wire were started about five years ago. During the period 1979-81, the scarcity prevailing in respect of supplies from Tata Iron & Steel Co and Bhilai Steel Plant gave an impetus to such efforts of producing non-rimming steel in electric arc furnaces. Substantial quantities of such steel were consumed particularly by the small scale units.

However, in terms of IS:814, electrodes manufactured with such non-rimming steel core wire do not qualify for approval under the ISI Certification Mark Scheme. That is why the ISI was approached by the parties concerned with a proposal to amend IS:2879 to include non-rimming steel for electrode core wire.

While the non-rimming steel wire can be safely used for hardfacing electrode, use of such wire in electrodes of classifications E 212411 and E 312412 was known to produce adverse effect on (a) operating characteristics, particularly in positional welding, and (b) all weld elongation and impact strength. In this connection it is noteworthy that a detailed investigation was taken up in 1946 in the U.S.A. under the auspices of the Welding Research Council on "Study of Core Wire for Electrode". The results were published in the June 1950 issue of the Welding Journal. The findings were not conclusive for or against non-rimming steel, but seemed to favour use of rimming quality steel for the E 6012 class. Surprisingly, there has been hardly any follow-up investigations in this direction published during the last 30 years. It is, however, well-known that in all the industrially advanced countries, the specification for M.S. core wire is a matter mutually settled between the electrode manufacturer and steel producer. No attempt was made to formulate a standard for electrode core wire in any of these countries, with the exception of Japan. Japanese Standard JIS : G 3525 was published in 1954 and covered four grades :

Thus, there is hardly any published literature over a period of almost 30 years, 1951 to 1980, which could

**Japanese Standards : JIS : G 3525—Electrode Core Wire**

| Designation | CHEMICAL COMPOSITION(%) | | | | | |
|---|---|---|---|---|---|---|
| | C | Si | Mn | P | S | Cu |
| SWY 11 | 0.10 max | 0.03 max | 0.35-0.65 | 0.020 max | 0.020 max | 0.20 max |
| SWY 12 | 0.10 max | 0.03 ,, | 0.35-0.65 | 0.030 ,, | 0.030 ,, | 0.20 ,, |
| SWY 21 | 0.10-0.15 | 0.03 ,, | 0.35-0.65 | 0.020 ,, | 0.020 ,, | 0.30 ,, |
| SWY 22 | 0.10-0.15 | 0.03 ,, | 0.35-0.65 | 0.030 ,, | 0.030 ,, | 0.30 ,, |

prove useful to the ISI on this particular issue. The Welding Institute, U.K., took in hand a detailed investigation sometime after 1980. Once again the findings of a very extensive study proved inconclusive. This only serves to highlight two points : (a) the problem is not so simple in deciding for or against use of non-rimming steel, and (b) we in India have to depend on ourselves in taking a decision one way or the other.

The initial tests carried out by a few leading electrode manufacturers with indigenous non-rimming steel revealed adverse effect on operating characteristics, elongation and/or impact strength. That is why SMDC : 14.1 did not favour amendment of IS:2879 without an indepth study of the behaviour of electrodes having non-rimming steel core wire as compared to the electrodes having rimmed steel core wire. After elaborate discussions in the meetings of the Sub-Committee SMDC:14.1, followed by discussions in the Committee SMDC:14, it was decided to undertake detailed investigation in the laboratories of four leading electrode manufacturers using core wire from non-rimming steel rods which would be supplied by a leading mini-steel plant. The set of tests was decided upon to permit a proper evaluation of the effect of the core wire on the various properties of both the rutile as well as lime-fluoride type. The findings based on various results obtained in the laboratories of the four electrode manufacturers are presented in a tabular from in Annexure IIIA & B.

It is evident that the results, by and large, are unsatisfactory, particularly in respect of impact values at O°C for the rutile type (E317412) and at -30°C for the lime-fluoride type (E 616 513H). Inasmuch as the detailed investigation was undertaken with the specific objective of ascertaining the suitability of the particular non-rimming steel, the unsatisfactory results necessitated a decision against amendment of IS: 2879 to accommodate non-rimming steel.

The Sub-Committee SMDC: 14.1 of the ISI rightly felt that further investigations would be necessary by using two or more heats of non-rimming steel produced by the same Steel Plant. All the four electrode manufacturers expressed that they had an open mind on the issue and were willing to undertake further investigations. Further tests are in progress and it is hoped that efforts of the mini steel plants will yield tangible results in terms of quality acceptable to electrode manufacturers and will lead to amendment of IS:2879 to permit use of steel produced by the concast route. Such tests will probably reveal as to what had gone wrong in the first heat and caused the results in all four laboratories with their respective coating formulations to be unsatisfactory.

It is at once clear that the very nature of raw material, viz., steel scrap, demands the chemical specification for wire rods to be broad-based, unlike the specification in IS:2879, to include upper limits for Cr, Ni, Mo, Al & Sn as also $O_2$ & $N_2$. But, then, it has to be based on experience of using several heats or a few hundred tonnes. It is known that several leading steel producers abroad are marketing for electrode manufacture wire rods. from non-rimming concast steel, e.g. OVAKO of Finland. Perhaps some assistance can be derived from such producers, directly through collaboration or indirectly through close scrutiny of their records of chemical analysis covering all possible elements. Such a scrutiny may serve to reveal the "trick of the trade" and put indigenous steel producers on the right track.

While on this subject, it is pertinent to mention about the ISO document ISO/TC17/WGI N28 of August 1981, which is :

"First Working Group Proposal for Steel Wire Rod—Part 3 : Wire Rods for the Manufacture of Welding Electrodes—Quality Requirements".

The proposed specification for product analysis of wire rods is given hereunder :

In fact this document was discussed in a meeting of SMDC 14.1 and SMDC 14, and a letter was addressed to ISO Secretariat, seeking certain clarifications with regard to trace elements. That happened about 1 1/2 years ago, but no reply has been received so far, despite reminder. This only underlines the need for us to be self-reliant by generating data based on our own experience in producing and using non-rimming steel, through close cooperation between steel producers and electrode manufacturers.

**Conclusion**

In concluding this paper, I consider it appropriate to reproduce the editorial from one of the recent issues of ISI Bulletin. It

**Product analysis of wire rod for the production of covered electrodes (Non-alloy steels)**

| Designation | Chemical Composition (product analysis) % | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C (1) | | Si | Mn | | P | S | Cr | Cu | Ni |
| | min | Max | Max | min | Max | Max | Max | Max | Max | Max |
| CE 8 | 0.04 | 0.12 | (2) | 0.40 | 0.65 | 0.030 | 0.030 | 0.15 | 0.20 | 0.15 |
| CE 9 | 0.04 | 0.12 | (2) | 0.40 | 0.65 | 0.020 | 0.020 | 0.15 | 0.20 | 0.15 |

**Note :**

(1) By agreement at the time of ordering, the maximum carbon content can be limited to 0.10%.

(2) By agreement, 0.10 percent max. silicon allowable for other than rimmed steels and 0.05 percent max. for rimmed steels.

touches on the very core of the process of standardization at the national level.

"Standards provide the basic framework for the production and marketing of quality goods. To be useful and effective they must represent the widest cross-section of information and opinion in the concerned area. This can come about only through a process which depends mainly on the consensus principle. This, in turn, determines the very procedure and inputs that must go into the making of a standard.

The inputs for standards can be broadly categorized into human and information elements. At the human level, the input comes in the form of technical institutions and inspection authorities who freely give their expertise and experience in meeting of various committees, sifting and analyzing the available information and scientific data to determine the optimum requirements essential for the manufacture of a quality product. The permanent staff of a standards body provides the necessary support required for administering the committee process, preparing drafts of the concerned standards and incorporating committee decisions at different stages.

The information element comprises the technical know-how derived from a variety of sources. This may include manufacturers' knowhow, purchasers' knowledge and Government view point, especially in cases where health and safety of the consumer are involved. Another important input is the experience of other standards bodies at the national and international levels as reflected in the standards and specifications prepared by them. Then there are the research and testing inputs. These include investigations of specific standards interest carried out by the concerned standards bodies as also by national laboratories and other research institutions. Also significant in this context is the feedback from field-authentic data on various aspects of production during the course of operation of the certification scheme and the behaviour of a product during use.

A standard, once prepared, is however not absolute ; it only represents the state of technology prevailing at the time of its formulation in its particular area of operation. With the passage of time the particular technology specified in a standard may become obsolete or the materials prescribed may no more be available or, may be, an indigenous substitute of an imported item has meanwhile been evolved. That is why standards are constantly reviewed and revised at both national and international levels to take note of the latest trends in technology. The success of the voluntary consensus standards process thus essentially hinges on inputs from a variety of sources. In fact, the quality of a standard very much depends on the extent to which these inputs are made freely available to a standards formulating body."

**Cooperation from various qnarters**

The last point clearly highlights the need for welding technologists, the major Organizations engaged in welded fabrication, research institutions—be it WRI, CMERI, Indian Institutes of Technology, or in-house R & D Laboratories of manufacturers and users, inspection agencies, and engineering consultants, to respond to the call of the Indian Standards Institution to associate themselves actively with the national effort at standardisation in welding. Such participation can be through membership of the relevant committee or through offering data and comments on proposed draft standards. After all, it is our duty, and also is a necessity, for technological advancement as a nation.

The author wishes to thank Mr P Dakshinamurthy, Senior Dy. Director (Metals) and Mr K Raghavendran, Director (Structural and Metals), ISI, for their help in compiling the calendars of development of standards.

**References**

1. Allen, J. S., Metal Construction, March 1983.

2. ISI Bulletin.

*ANNEXURE I*

**Determination of Diffusible Hydrogen in Weld Metal—Alcohol Displacement Method (As Per GOST Specification)**

The diffusible hydrogen shall be determined by the apparatus as shown in Figure-2 over ethyl alcohol.

The electrodes shall be subjected to the rebaking process as suggested by the manufacturer and the welding carried out on a copper plate, the chamber of which is cooled by water circulation. The weld metal is chipped out of the plate, quenched in water and the slag is removed thoroughly. The weld metal is then flushed with ethyl alcohol, and kept in a beaker filled with ethyl alcohol. The time gap between the completion of welding and insertion of the sample in alcohol should not be more than 3 minutes. The initial reading of alcohol in the burette is noted. The liberated hydrogen slowly displaces the alcohol in the burettee. The final reading of the burette is noted after 24 hours. The volume of hydrogen liberated is reduced to N.T.P. by the formula

$$\text{Hydrogen evolved (ml/100 gm)} = \frac{2.09\,(13045-h) \times V_2}{T_2 \times W}$$

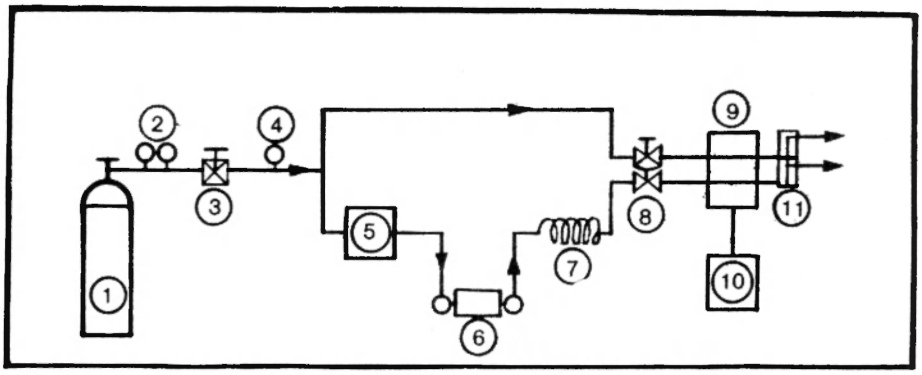
Where h = height of alcohol from the surface in beaker to the lower level of burette reading in mm

$V_2$ = Volume of hydrogen evolved in ml.

W = Weight of the weld metal in gms.

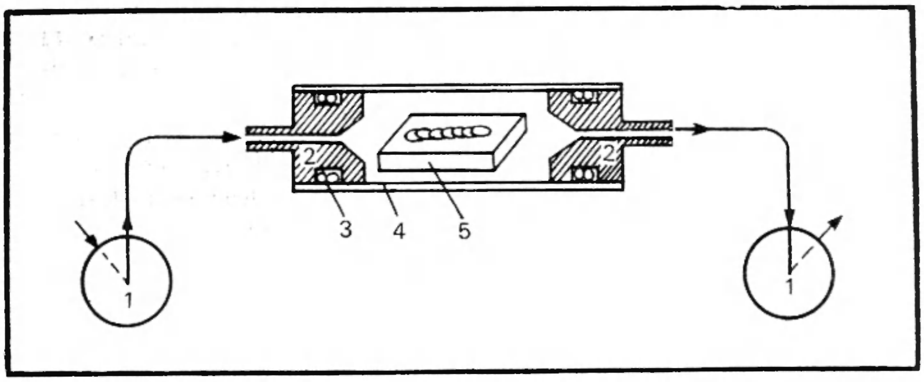
$T_2$ = Room temperature °C.

**Note** : The test specimen consists of only weld metal and not of bead on plate.



*1. Argon 2. Valve 3. Pressure Regulator 4. Pressure gauge 5. Gas doser 6. Gas tight Collector Vessel 7. Column 8. Flow Controllers 9. TCD 10. Integrator 11. Flow meters*

*Fig 5. Schematic diagram of gas chromatograph apparatus*



*1. Valve 2. Plunger 3. O-ring 4. Cylinder 5. Test piece*

*Fig 6. Gas light collector Vessel.*

*ANNEXURE II*

**Gas Chromatograph Apparatus for Measuring Diffusible Hydrogen in Welds**

The gas chromatograph apparatus consists of gas-tight collector vessel and gas chromatograph. The gas tight collector vessel can be separated and kept inside thermostat for the collection of diffusible hydrogen. Figure-5 shows a schematic diagram of this equipment. Figure 6 shows the gas chromatograph for quantifying a large volume of hydrogen containing gas.

In essence the principle of this method involves initially calibrating the equipment by introducing a known volume of hydrogen using argon as carrier gas and using the same for measurement of unknown volumes of hydrogen. An example of the chart obtained from the chromatograph is shown in Figure-7 where the area of each peak corresponds to the hydrogen volume evolved from a test specimen.

*ANNEXURE IIIA*

**Rimming vs. Non-rimming steel for electrode core wire—Summary of findings**

| Manufacturer A | Manufacturer B | Manufacturer C | Manufacturer D |
|---|---|---|---|
| *Core Wire*<br>*Macro studies*<br>— | 1. Light segregation.<br>2. Thin sulphide, silicate, alumina inclusions.<br>3. Heavy alumina inclusion compared to rimming type. | 1. Blackening on etching observed.<br>2. Inclusions distributed all over matrix.<br>3. Distribution of inclusions uneven.<br>4. Inclusions more at the periphery to the core.<br>5. Inclusion count 4-5 nos. per mm² at 50x. | — |
| *Running Characteristics.*<br>1. Non-rimming electrode getting red hot on A.C.<br>2. Arc interruptions more with a non-rimmed core wire in OH position on A.C.<br>3. This behaviour was common to E-6013 as well as E-7018. | 1. Severe spatter in both the types.<br>2. Slight lack of fusion in E-6013.<br>3. Bead appearance slightly rough.<br>4. Positional welding showed slag and porosity in E-6013 and the same was extensive in E-7018. | 1. In E-6013 positional welding, few slag inclusions and some porosity.<br>2. In OH butt joint, slag and porosity are considerable.<br>3. In E-7016, butt joints of positional welding showed severe slag and porosity clusters.<br>4. OH butt joint found full of slag and porosity. | 1. Operating characteristics in V & OH position found inferior in both types. |
| *Conclusions*<br>1. Silicon content in weld found higher with non-rimmed steel<br>2. CVN values are highly reliable for rimming quality in comparison to non-rimming, specially at sub zero conditions.<br>3. In the case of E-7018 rimmed core wire electrodes show higher CVN values than the non-rimmed ones. | 1. E-6013 class electrode below standard in performance and weldability with non-rimming core.<br>2. E-7018 class fares poorly in rediography test.<br>3. Overall performance of both types with non-rimming grade core NOT satisfactory. | 1. Non-rimming core wire may lead to problem in cutting due to its higher U.T.S.<br>2. In E-6013 as well as E-7016 class with non-rimming core, lowering of ductility and CVN values observed with increase in yield strength.<br>3. Fillets demonstrate poor penetration with non-rimming core upto medium current.<br>4. Positional butt joints show decrease in arc force indicated by slag, porosity in both the types. | 1. Higher Sulphur and phosphours content creates limitations on usability of non-rimming core.<br>2. Toughness and ductility of welds impaired with non-rimming core.<br>3. Non-rimming core wire appears to be inferior for operating characteristics. |

Comments of WRI:
1. Trace elements such as Cu, Cr, Ni, Sn, and Co the levels between 0.02-0.17% show no perceptible effect in the weld, though the effect of Sn is still a matter of consideration.
2. The quality of the weld metal being the more important criterion, killed could logically substitute rimming quality, considering E7018 Class gives highly deoxidised weld metal.
3. Al as metal being harmful for ductility and impact strength in the weld metal, controlled Al to the extent of 0.03% could be suggested with an option to accept upto 0.05% max. in view of the related steel making problems. WI, UK concurs with the view that Al in welds upto 0.05% is harmless.

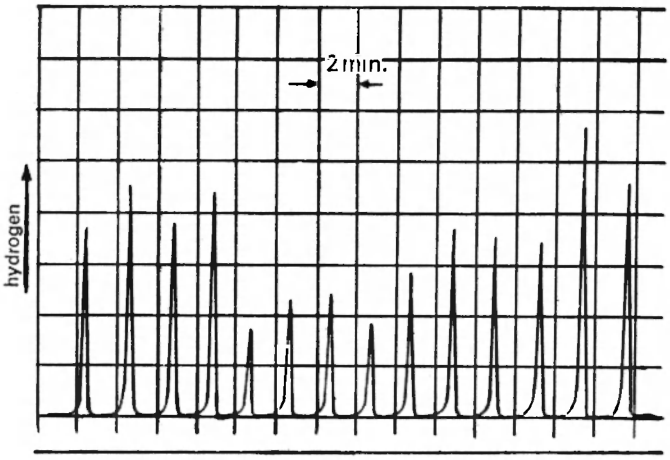



*Fig 7. Example chart of gas chromatograph*

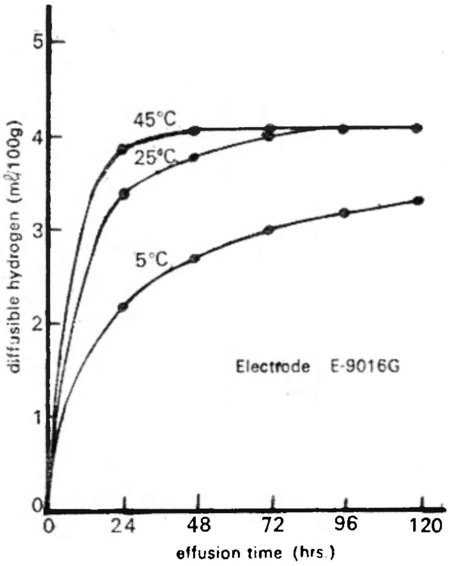



*Fig 8. Effusion curves of diffusible hydrogen (SMAW)*

## GC method for measuring diffusible hydrogen in welds

Figure-3 compares the gas chromatograph method and the IIW method. The test piece size, in accordance with the JIS method is larger than that of IIW method and so a stable bead and penetration are obtained. Both the methods follow the same procedure for preparation, welding condition, quenching condition and storing condition for the specimen. The specimen stored in dry ice alcohol is taken out and washed with ether and inserted into the vessel. Innert gas of the vessel is exhausted and substituted by the pure argon at about 1 atm. The collecting vessel assembly is stored in a thermostat maintained at the collecting conditions indicated in Figure-3. Since the temperature is higher in this method than that of the IIW method, the effusion rates are higher. Figure-8 shows the effusion curves for manual arc welding electrodes.

*ANNEXURE IIIB*

**Supporting data on Mechanical Properties**

| Mechanical Properties | | A Non-Rimming | A Rimming | B* Non-Rimming | C Non-Rimming | C Rimming | D* Non-Rimming |
|---|---|---|---|---|---|---|---|
| **Tensile** | | | | | | | |
| E6013 | UTS kg/mm² | 50.52 | 50.20 | — | 53.8 | 47.87 | 53.10 |
| | Elong. % | 29.75 | 28.50 | — | 19.0 | 23.0 | 13.0 |
| E7016 | UTS kg/mm² | — | — | — | 62.30 | 58.51 | 64.4 |
| | Elong. % | — | — | — | 22.0 | 24.0 | 29.3 |
| E7018 | UTS kg/mm² | 55.23 | 52.40 | — | — | — | — |
| | Elong. % | 29.6 | 32.35 | — | — | — | — |
| **CVN** | | | | | | | |
| E6013 | at R.T. | 8.0 | 8.5 | 9.6 | — | — | — |
| | „0°C | 5.20 | 7.46 | 6.5 | 3.35 | 6.35 | 4.0 |
| E7016 | „ —20°C | — | — | — | 7.2 | 9.32 | 7.4 |
| E7018 | „ —30°C | 3.65 | 10.83 | 4.0 | — | — | — |

Electrode Manufacturers: A, B*, C, D*

*B and D had not reported values for rimming core.