# Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations

(Revised in June 2020)

## Introduction

Welding Engineering and Technology is the backbone of varied industries such as construction, fabrication, ship building, power generation, pressure vessels, underwater piping, desalination plants, automobile, etc. Only few institutions are offering undergraduate and post graduate courses in Welding Engineering and Technology. The professionals working in industries, having a diploma or degree in traditional engineering branches have few avenues for improving their knowledge and expertise in the area of welding and joining to keep pace with the continued developments taking place.

Keeping the above points in view, a scheme of Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations was prepared by The Indian Institute of Welding, and Enrollment to the first batch of candidates for the Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations was started in 1988.

Subsequently, The Indian Institute of Welding has forwarded a scheme of Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations to the Ministry of Human Resource and Development (MHRD) in 1996 seeking its recognition. This case was referred to the AICTE by the MHRD, and based on the comments from the experts of the AICTE, New Delhi in 1997, some revisions in the Curriculum and Syllabus were incorporated and the matter was reconsidered by the AICTE on September 27 2000 and the MHRD accorded recognition to AM-IIW Examinations, and a Gazette Notification was made to this effect on November 18 2000. The Gazette Notification states:

"On the recommendations of the High Level Committee for Educational Qualifications, the Government of India have decided that Associate Membership Examination of the Indian Institute of Welding Calcutta is to be treated as a recognized qualification for the purpose of employment under the Central Government to the posts and service for which Bachelor's degree in Engineering in the appropriate field is a prescribed qualification."

However, in December 06 2012, MHRD decided that

"(ii) All those students who are enrolled with the institutions with permanent recognition upto 31.05.2013 would be eligible for consideration in accordance with MHRD office memorandum/ order in force pertaining to their course for equivalence in Central Government jobs. However, these concerned orders will cease to have effect from 01.06.2013 onwards.

(iii) After 31.05.2013, based on the review by the regulator i.e. AICTE, a decision on continuation of the certification of equivalence of degree/ diploma shall be taken by statutory regulator."

The Indian Institute of Welding has presented the detail of Associate Membership of The Indian Institute of Welding (AM-IIW) Examination before the committee constituted by the AICTE to review Professional Bodies/ Institutions in the field of Technical Education on July 04 2017 at the AICTE Head Quarters, New Delhi as invited by the AICTE. The final recommendation from the AICTE is awaited.

Meanwhile, The Indian Institute of Welding has decided to reframe course and curriculum of the Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations of its own, and from June 2020 onwards, new enrollment of candidates to this AM-IIW Examination would commence. The candidates who have passed, or would pass, the AM-IIW Examination, will be awarded as a 'National Welding Engineer'.

# AM-IIW Examination System

AM-IIW Examination system is an educational programme and certification examination in the field of Welding Engineering. The course curriculum, syllabi and the examination have been so designed that a candidate passing out these examinations may be considered to have enough knowledge in the field of welding and joining. The Indian Institute of Welding, under its consideration, is holding this qualifying professional examination having the same standard as that of a Bachelor degree in Engineering offered by a recognised Indian or foreign University.

The Institute conducts AM-IIW examination all over India based on its own course designed to meet industry need. Examination is conducted twice a year, i.e. in Summer and Winter.

AM-IIW has been recognized by the International Institute of Welding (HQ at Paris, France/ Jenoa, Italy) as the entry qualification for the International Diploma like International Welding Technologist (IWT), or International Welding Engineer (IWE), etc. after fulfilling some eligibility criterion, attending a course and passing an examination conducted by IIW-India ANB under the authority of International Institute of Welding with guidelines from 'International Authorisation Board' (IAB).

Engineering Diploma students in a 3-year course will be allowed to register for AM-IIW Examinations in the final year, and 4-year engineering degree students studying in the 3rd and 4th year are eligible to register. Registration will be valid for six years.

A Bachelor of Engineering candidate is exempted from appearing in examinations of some papers that one has passed during their regular course. Any candidate may also seek exemption from appearing in a paper if one passes a similar paper through Massive Online Open Courses (MOOCs) such as NPTEL, etc. The decision on exemption will be taken based on one individual's claim for exemption with relevant documents related to the detailed course content and that a candidate has passed the paper successfully.

After one passes all non-exempted papers and completing an approved Project work on a welding related case study/ problem and Viva Voce as per IIW-India rule, one becomes eligible to become The Associate Member of The Indian Institute of Welding. He will also be awarded as a 'National Welding Engineer'.

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# Associate Membership of The Indian Institute of Welding (AM-IIW) Examinations

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## Course Details

| Sl. No. | Course Name | Part | No. of Papers | Exemption for Degree Engineers |
|---|---|---|---|---|
| 1 | Theory Papers | PART A | 6 | Papers already covered in a Degree Course OR through MOOCs (such as NPTEL, etc.) except Welding Metallurgy papers |
| | | PART B | 6 | |
| 2 | Practical, Project and Comprehensive Viva Voce | PART C | 3 | Compulsory Papers |

## Curriculum Structure of AM-IIW Examination System

| Part-A | Part-B | Part-C |
|---|---|---|
| 1. Material Science (AME-101) | 7. Testing & Quality Assurance (AME-201) | 13. Practical (AME-301) |
| 2. Strength of Materials (AME-102) | 8. Welding Metallurgy of Non Ferrous Alloys, Dissimilar Welding and Cladding (AME-202) | 14. Project (AME-302) |
| 3. Production Engineering (AME-103) | 9. Welding and Allied Processes-II (AME-203) | 15. Comprehensive Viva Voce (AME-303) |
| 4. Welding & Allied Processes-I (AME-104) | 10. Weldment Design, Welding Procedure and Its Applications (AME-204) | |
| 5. Welding Metallurgy of Steels (AME-105) | 11. Occupational Health, Safety and Environmental Issues in Welding and Related Areas (AME-205) | |
| 6. Economics of Welding and Fabrication (AME-106) | 12. Advanced Welding Technology (AME-206) | |

# Part – A

## AME-101 : Materials Science

**Atomic Structure and Types of Bonding between Atoms** : Bohr's atomic model– electronic configuration of atoms, periodic classification of elements. Binding energy; ionic bonds, covalent bonds, material properties having these bonds. Electronegativity. Metallic bond– materials properties having this bond. Intermolecular forces.

**Concepts of Crystal Geometry** : Space lattice– cubic (simple cubic, BCC and FCC), tetragonal, orthorhombic, rhombohedral, hexagonal, monoclinic and triclinic. Unit cell parameters to specify each crystal system. Crystal directions and planes, Miller indices.

**Bonding and Defects in Solids :** Crystal symmetry and structure. Crystalline imperfections. Point imperfections and line imperfections or dislocations, edge and screw dislocations, slip planes. Surface imperfections. Polymorphism in metal and ceramics; Amorphous materials– glass and polymer.

**Alloys** : Phase rule, thermodynamic principles of mixing, binary phase diagrams of important alloy systems, solidification, lever rule, solid solutions and governing rules, isomorphous system, eutectic, peritectic, eutectoid and peritectoid reactions. Intermetallic compounds, sigma & other phases.

**Mechanical Deformation of Materials** : Elastic and Anelastic deformation; plastic deformation, stress-strain curve, slip and twin, dislocation theory, critical resolved sheer stress, strengthening mechanisms, precipitation hardening, deformation in polycrystalline material, slip systems. Bauschinger's effect and elastic after effect. Work hardening; recovery, recrystallisation and grain growth, preferred orientation.

**Fracture in Metals and Alloys** : Ductile and brittle fracture, impact test, Griffith's theory, fracture toughness, ductile-brittle transition, fatigue, creep. Mechanical testing of metals.

**Ceramic Materials** : Structure in silica and silicates, Polymorphism, fracture in glass, electrical properties of ceramic phases, refractoriness, Engineering ceramics, Functional ceramics.

**Polymers** : Classification; degree of polymerization. Formability; addition polymerization, copolymerization, condensation polymerization. Molecular structure; linear, branched, cross linked polymers. Thermoplastic and thermosetting polymers. Structure-property correlation, crystallinity, mechanical properties, applications.

**Composites** : General characteristics, dispersion/ particulate strengthened composites, rule of mixture, fibre reinforced composites, laminated composites- fabrication techniques.

## Recommended Text Books and References


- Material Science and Metallurgy for Engineers, V.D. Kodgire and S.V. Kodgire, Everest Publishing House, Pune (2003).
- Material Science and Engineering, 7th Edition, W.D. Callister Jr., John Willey & Sons (2006).
- Material Science and Engineering– A First Course, V. Raghavan, 4th Edition, Prentice Hall of India, New Delhi (2004).
- Material Science, S.L. Kakani and A. Kakani, 1st Edition, New Age International.
- Principles of Engineering Metallurgy, L. Krishna Reddy, New Age International, (1996).

## AME–102 : Strength of Materials

**Simple Stress and Strain :** Stress – strain Diagram for ductile, brittle and plastic materials, concept of true modulus of elasticity, yield stress ultimate stress, working stress, proof stress, and engineering stress, factor of safety, stress concentration, simple problems of thermal stresses and statically indeterminate problems.

**Elastic Constants :** Poisson's ratio; bulk modulus; relation between bulk modulus and Young's modulus ; modulus of rigidity and shear modulus, relation between modulus of rigidity and Young's modulus.

**Plane Stress and Strain :** Basic concepts; principal and principal strains; Mohr's circle of stresses. Stress tensors, Von mises stress, Equivalent stress and equivalent strain, von Mises and Tresca criteria.

**Bending of Beams:** Types of beams, supports and loads; concentrated load, uniformly distributed load, gradually varying load; bending moment and shear force diagrams.

**Stresses in Beams :** Theory of simple bending; neutral axis, moment of resistance, section modulus flexural equations. Bending stress distribution in beams.

Shear stress distribution in beams of rectangular, solid circular, and I– section beams.

**Deflection of Beams :** Differential equation of the Elastic Curve; relation between deflection, shape, shear force and bending moment; simple problems of deflection of beams.

**Buckling of Columns :** Euler's theory ; critical loads; short and long columns.

**Torsion of Circular Shafts :** Torsional stress and strain, polar moment of inertia, power transmitted by a shaft. Shear stress distribution across solid and hollow shafts.

**Thin Cylinder under Internal Pressure:** Circumferential and longitudinal stress; change in volume due to internal pressure; simple problems.

### Recommended Text Books and References


- Elements of Strength of Materials, 5th Edition, S. Timoshenko and D.H. Young, Affiliated EWP (1968).
- Strength of Materials, S.S. Rattan, McGraw-Hill Publication (2008).
- Strength of Materials, G.H. Ryder, Macmillan (1969).
- Strength of Materials, B.S. Basavarajaiah and P. Mahadevappa, Taylor & Francis (2010).
- Mechanics of Materials, E.P. Popov, Prentice Hall (1952).

## AME–103 : Production Engineering

**Metal Casting :** Types of patterns and core boxes; metal flow in a mould; gating and risering; casting processes; green and dry sand, other sand casting processes, metal mould casting processes, precision casting processes. Melting furnaces; casting defects, inspection and rectification. , Solidification of metals and alloys, cast structure.

**Metal Forming : Principles of metal forming,** Cold and hot working processes; principles of processing maps, dynamic recrystallization, various metal forming processes; Rolling, forging, extrusion, punching, blanking, coining, drawing, bending, production of pipes, tubes, plates etc. machine and drop forging, dies for drop forging, forging hammers and presses, rolling mills, extrusion press, etc., formability testing.

**Machining and Machine Tools :** Definition of Machining and Machine Tools. Elements of Mechanics of metal cutting, types of chips, cutting tools, tool geometry in ASA, ORS and NRS systems, shear angle and shear strain, tool materials and their properties, forces on cutting tool, Merchant's circle diagram, tool failure, tool life, cutting fluid, speed, feed and depth of cut, power requirements. Various machining operations, turning, milling, shaping, planing, drilling, thread cutting, gear cutting, grinding, superfinishing. Machine tools used for these operations, motions needed for machining on respective machine tools and their structures.

**Elementary Ideas on Fabrication Processes :** Brief introduction to welding, brazing, soldering, and other semi-permanent/ temporary joining processes used for fabrication, fitment of components, assembly sequence, shell forming, heat treatment.

**Surface Modification Technology :** Case hardening by flame, case carburizing, nitriding, carbunitriding; Coating- PVD and CVD techniques; Cladding; thermal spraying.

**Metrology :** Limit, fit and tolerance, Tolerancing Grade as per IS standard, Use of comparators, Measurement of flatness and surface finish, Use of gauges- GO and NOT GO gauges, thickness gauge, thread pitch gauge, radius gauge.

**Production Planning and Control :** Process and Production Planning and control; Production planning, Gantt chart, inventory control, inventory policies, EOQ; Method and work study; Time study, systems of rating, time standard.

### Recommended Text Books and References


- Production Technology, Vol. I and Vol. II, R.K. Jain, Khanna Publication (2001).
- A Text Book of Production Engineering, P.C. Pandey, C.K. Singh and Balbir Singh, Standard Publishers Distributors (1972).
- Production Technology Manufacturing Processes, Vol. I and Vol. II, O.P. Khanna and G.K. Lal, Dhanpat Rai Publications, New Delhi.
- Materials and Manufacturing Processes, E.P. Degarmo, J.T. Black and R.A. Kohser, Pearson.

## AME–104 : Welding & Allied Processes - I

**Introduction :** Historical evolution of welding ; classification of welding processes; flame, arc, resistance, solid state, etc., oxy-gas and related welding processes; characteristics of flames produced by different fuel gases, combustion chemistry of Acetylene, flame types and their applications, methods of safe handling and working, hazards and their prevention.

**Electrical Power in Welding :** Direct current & polarity, alternating current. Magnetism in welding; use of capacitor & condenser, welding transformers, rectifying bridge; half wave and full wave rectification; uses of transistor, rectifiers, thyristor, microprocessors and inductors, welding generators, invertors. Hazards associated with welding power sources.

**Welding Arc** : Physics of arc, Ionization of gases, Open Circuit Voltage, Arc stabilitiy, AC and DC Arc: types, structure, mechanism, stability and characteristics. Temperature distribution across the Arc. Mechanism of Arc Blow, its effects and remedies; Types of Metal Transfer – short circuit transfer, types of globular transfer; Forces affecting types of Metal Transfer.

**Power Sources for Arc Welding** : Static and dynamic characteristics, flat and drooping characteristics, short circuit current, duty cycle; sine wave and square wave A.C., and D.C. power sources. Introduction to waveform controllable rectifier-inverter power sources, microprocessor control, Pulse welding; Arc striking methods, Classification of power sources based on insulation, environmental protection (water ingress).

**MMAW :** Equipment and power source characteristics; Covered electrodes; types and functions of coating, slag metal and gas metal reactions influence of coating on weld metal transfer, handling and storage, joint design, advantages and disadvantages of MMAW.

**TIG Welding :** Physical phenomena, operating principles of TIG, TIG welding; arc ignition methods, choice of type of current, polarity, shielding gas and electrodes type according to application, joint preparation, equipment and accessories, Autogenous welding, variants of TIG welding, orbital welding, tube to tube sheet welding, internal bore welding, pulsed TIG welding, AC and DC TIG welding.

**MIG/MAG (GMAW) and Flux Cored Arc Welding :** MIG/MAG (GMAW) and Flux Cored Arc Welding Processes, inert and active gases and their effects on arc characteristics, filler materials. metal transfer modes– dip, globular, spray, pulsed and rotating; consumables, welding equipment, Voltage and current characteristics. Effect of shielding gas on metal transfer, pulsed and synergic MIG welding, MIG welding equipment, flux cored and metal cored arc welding, consumables for MIG welding, joint preparation.

**Submerged Arc Welding :** Principles, arc striking methods, selection of current, polarity and consumables according to application, fluxes in SAW; types– agglomerated, sintered, neutral and active fluxes, basic fluxes; joint design, single and multi wire techniques, slag–metal and gas–metal reactions.

## Recommended Text Books and References


- Welding Engineering and Technology, R.S. Parmar, Khanna Publishers, New Delhi.
- A Textbook of Welding Technology, O.P. Khanna, Dhanpat Rai Publication, New Delhi (1980).
- Welding Handbook, American Welding Society, Section-II : Gas Arc and Resistance.
- The Science and Practice of Welding, Vol-1 : Welding Science and Technology, Cambridge University Press.
- The Science and Practice of Welding, Vol-2 : The Practice of Welding : A.C. Davies, Cambridge University Press.
- Principles of Welding, Messler R.W., John Wiley & Sons (1999).
- Welding Technology for Engineers, 3rd Reprint, Eds. Baldev Raj, V. Shankar, A.K. Bhaduri, Narosa Publishing House, New Delhi (2009).

## AME–105 : Welding Metallurgy of Steels

**Physical Metallurgy of Steels:** An introduction to iron and steel making, ingot metallurgy and continuous casting, solid state transformations in iron and steel, Fe-C diagram. Time temperature transformation (TTT) diagram, pearlite, bainite and martensite phases and their influence on properties of steel, annealing, normalizing, quenching and tempering. Effect of alloying elements in steels on Fe-C diagram and TTT diagram, Continuous cooling transformation (CCT) diagram, hardenability of steels.

**Physical Metallurgy of Fusion Zone and Heat Affected Zone:** Weld thermal cycle, slag-metal and gas-metal interaction in the fusion zone, Solidification of the weld fusion zone, segregation, constitutional supercooling, microstructural evolution in the fusion zone of steel weld metal during cooling, Definition of Heat Affected Zone and different parts of the Heat Affected Zone, Effect of heat input and thermal diffusivity on the size and shape of fusion zone and HAZ, Solid state transformations in the HAZ, Effect of multi-pass welding in fusion zone and HAZ microstructure, Concept of carbon equivalent for steel welds, Generation of residual stresses in the welds, Stress relieving and post weld heat treatment of the steel welds.

**Weldability of Steels:** Concept and definition of weldability, weldability of steels, Hydrogen Assisted Cracking, low hydrogen consumables. Preheating and post heating. Carbon equivalent and prediction of preheat and post heating conditions.

**Different Steels and Their Weldability:** C-Mn steels, Effect of alloying elements on weldability of steels, Steels for high strength applications, low temperature applications, high temperature applications, HSAL steels, High strength steels, Maraging steels, armour steels. Reheat Cracking in alloyed steels,

**Stainless Steels:** Different type of stainless steels; austenitic stainless steels, duplex stainless steels, hot cracking and weldability of austenitic stainless steels and role dof delta ferrite, Sensitization, intergranular corrosion and stress corrosion cracking,

**Welding Consumables:** Welding consumables for C-Mn, Cr-Mo, and Ni steels, consumables for high strength steels, welding consumables for austenitic stainless; considerations for welding consumables for different arc welding processes.

### Recommended Text Books and References


- Welding Handbook, American Welding Society, Part-I: Fundamentals of Welding.
- Metallurgy of Welding, J.L. Lancaster, Woodhead Publishing Ltd.
- Metals and Their Weldability, Welding Handbook, Part-IV, American Welding Society.
- Welding Metallurgy, 2nd Edition, S. Kou, John Wiley & Sons (2003).
- A Textbook of Welding Metallurgy, O.P. Khanna, Dhanpat Rai & Sons (1980).
- Welding Metallurgy and Weldability of Stainless Steels, Asian Edition, J.C. Leopold and D. Kotecki, John Wiley & Sons Ltd., New Delhi.

## AME–106 : Economics of Welding and Fabrication

**Consumer Behaviour and Demand:** Concept and definition of demand; types of demand; demand schedule, demand curve and demand function; Laws of demand, elasticity of demand– price elasticity, income elasticity, cross elasticity; demand forecasting for welded or fabricated products, methods of demand forecasting.

**Microeconomics :** Consumer behaviour, production, cross curves, types of industry and profit maximization.

**Macroeconomics :** Macroeconomics data, measuring National income, simple income determination, Government policy, major macro-economics problems.

**Estimation of Welding and Fabrication Cost:** Estimation of costs for preparation of jobs for welding, cutting, machining, edge preparation etc, estimation of amount of welding consumable to be used. Cost of estimation for inspection and testing of the welds, Cost of qualification of welders, consumables and procedures. Total estimation of fabrication cost. Requirements for setting up welding and fabrication shops.

**Production Functions:** product function, period in production; total, average and marginal product, types of production function; laws of increasing, constant and diminishing returns, economies of scale.

**Cost Analysis:** opportunity cost, past and future cost, avoidable and unavoidable cost, replacement cost, historical cost, incremental and sunk cost, controllable cost, production and short run cost, relationship between various costs.

**Break Even Analysis:** limitations, formulae for break even analysis.

**Market:** classification on the basis of competition, perfect competition, monopoly, bilateral monopoly, forms of price discrimination, imperfect competition, monopolistic competition, oligopoly, duopoly; determination of equilibrium price, price control, price support and minimum price fixation, pricing strategy.

**Sources of Finance:** financial accounts and management of finance; cost of capital, working capital management, capital market and money market.

### Recommended Text Books and References


- Managerial Economics and Financial Analysis, S. A. Siddiqui and A.S. Siddiqui, New Age International (2005).
- Engineering Economics, S.K. Poddar, The Association of Engineers, India Publication, Kolkata.

# Part – B

## AME–201 : Testing, Inspection and Quality Assurance

**Mechanical Properties:** Tensile properties of weld joints, Hardness of weld metal, HAZ and hardness profile across the welds, Vickers, Brinell, Rockwell Hardness testing, Microhardness testing, Tensile testing of all weld metal and transverse weld joint, preparation of weld joint specimens for tension testing, Preparation of specimens for impact testing of weld metal and HAZ, Impact testing at sub zero temperatures, Estimation of Ductile Brittle transition temperatures.

**Tests under Cyclic Stress :** Principles of Fatigue damage, Testing for Low cycle and high cycle fatigue, S–N curves, endurance limit, fatigue fracture.

**Other Destructive Tests :** Principles of creep, standard creep curve, Creep Test Stress rupture tests, Stress corrosion testing, Hydro static testing and pneumatic testing of components Proof testing.

**Weld Defects :** Classification, origin and identification. Type of cracking welds (Cold cracking, Hot cracking, Reheat Cracking, Lamellar tearing), Assessment of susceptibility to cracking from chemical composition and welding parameters, Estimation of preheat and post heat condition to prevent HAC, Assessment of hot cracking susceptibility using Scheffler diagram.

**Weldability Tests :** Self restraint and external restraint tests, Weldability tests to assess different forms of cracking, Assessment of cracking susceptibility from the test results.

**Non destructive Testing and Inspection :** Surface inspection, Visual Inspection, Leak Testing, Liquid Penetrant inspection, magnetic particle inspection, eddy current inspection;

**Volumetric Inspection:** Radiographic inspection; X-ray and gamma ray, Radiographic inspection of pipes and tubes; use of image quality indicators, principles of digital and microsfocal radiography, X-ray generators and gamma sources for radiographic inspection, Ultrasonic inspection, pulse echo mode, Effect of frequency angle of ultrasonic wave propagation on inspection, A-Scan, B-Scan and C-Scan modes, Reference defects for calibration of the signals, acoustic emission inspection;

Field Techniques to identify base metal and weld metal: positive material identification (PMI) principle through X-ray fluorescence (XRF), optical emission spectrometry (OES).

**Concept of Quality Assurance and Quality Control :** Inspection, quality control quality assurance and total quality management, roles and responsibilities Continuous improvement, quality manual, Introduction to ISO standards and ASME pressure vessel and piping code.

**Quality Assurance in Welding :** Welder qualification, consumable qualification and Procedure qualification, Essential, non-essential and supplementary essential variables, Grouping of base metals and filler wires for the purpose of weld qualification as per ISO specification and ASME pressure vessel and piping code. Preparation of Procedure Qualification Report writing, quality control procedures, and quality plans for welded fabrication.

**Introduction to Statistical Quality Control :** Process control and process improvement, Shewart control charts; construction and interpretation of X bar and R charts; P– chart, C-chart.

**Acceptance Sampling :** Single, double and sequential sampling plans; O–C curves. Producer's risk and consumer's risk.

## Recommended Text Books and References


- Introduction to Non Destructive Testing, P.E. Mix, John Wiley & Sons, New Jersey (2005).
- Practical Non Destructive Testing, Baldev Raj, T. Jaya Kumar and M. Tavasimuthu, Narosa Publishing House, New Delhi (1997).
- Introduction to Non Destructive Testing of Weld Joints, R. Halmshaw, Woodhead Publishing Ltd., Cambridge (1996).
- Metals Handbook, Vol.17, Non Destructive Evaluation and Quality Control, ASM International (1989).
- Fundamentals of Quality Control and Improvement, 3rd Edition, A. Mitra, John Wiley.
- Statistical Quality Control: A Modern Introduction, 6th Edition, D.C. Montgomery, Wiley India.
- Total Quality Management, 3rd Edition, P.M. Charantimath, Pearson India.

## AME–202 : Welding Metallurgy of Non Ferrous Alloys, Dissimilar Welding and Cladding

**Introduction to Aluminium and Magnesium Alloys and Their Welding :** Introduction to physical metallurgy of Al alloys, principles of precipitation hardening, heat treatable and non-heat treatable alloys, Choice of welding processes for welding of Al alloys, Cracking in Al alloys, selection of welding consumables for Al alloys, post weld heat treatment to Al alloys, Friction stir welding of Al alloys. An introduction to welding of Mg and Mg alloys.

**Welding of Nickel, Copper and Titanium Base Alloys :** Solid solution strengthened and precipitation hardened Ni base alloys, Susceptibility of the alloys to hot cracking and reheat cracking, Microstructural changes during ageing on these alloys. Welding of Cu and Cu alloys. Welding of Ti and its alloys, effect of oxygen contamination on properties of these alloys, welding processes for welding of Ti alloys, Heat treatable and non-heat treatable Ti alloys.

**Dissimilar Welding :** Welding of steels to stainless steels, Shaffler, Delong and WRC 92 diagrams for selection of welding consumables, Buttering during dissimilar welding,

Welding of stainless steels to Ni base alloys, selection of welding consumables.

**Metallurgy and Welding of Cast Iron :** Welding of Al/Al alloys and Ti/Ti alloys to steel: Difficulty in fusion welding, non fusion techniques, friction welding, explosive welding etc.

**Surfacing and Hardfacing :** Purpose of surfacing, welding processes employed for surfacing, Dilution during surfacing, Alloys used for surfacing, consumables available for surfacing, Welding of plates with surfacing.

**Hardfacing:** Purpose of hardfacing, alloys and consumables available for hardfacing, Controlling dilution and cracking during hardfacing, stress relieving heat treatment after hardfacing, concept of wear plate, the prefabricated plates for wear resistance application

**Repair Welding :** Difference between welding defects detected during fabrication and the defects formed in service, Problems of repair and maintenance welding, welding repair procedures to avoid post weld heat treatment, welding repair procedure qualification. Use of austenitic stainless steel and Ni base alloy consumable for repair of defects formed during service, NDT of weld repair, welder qualification to be applied to repair welds.

### Recommended Text Books and References


- Metallurgy of Welding, J.F. Lancaster, Woodhead Publishing Ltd.
- Metals and Their Weldability, Welding Handbook, Part-IV, American Welding Society.

- Welding Metallurgy, 2nd Edition, S. Kou, John Wiley & Sons (2003).
- A Text book of Welding Metallurgy, O.P. Khanna, Dhanpat Rai & Sons, New Delhi (1980).
- Welding Metallurgy and Weldability of Stainless Steels, Asian Edition, J.C. Leopold and D. Kotecki, John Wiley & Sons, New Delhi.

## AME–203 : Welding and Allied Processes – II

**Resistance Welding :** Principles of resistance welding process, the concept of weld lobe, Pressure resistance, spot resistance and flash resistance welding, Overview of spot, projection, butt, seam welding; equipment and accessories, temperature distribution, control of welding parameters, current, pressure, time, pulse etc., typical joint preparation. Evaluation of quality of the resistance welds.

**High Energy Beam Welding Processes :** Concept of key hole welding, Principles Laser beam welding, Type of lasers used for welding and cutting, Pulsed laser welding, Advantages of laser beam welding, Estimation of laser power, pulsed lasers for welding, Laser welding in conductive and key hole modes, Laser surfacing.

Electron Beam welding, details of the equipment, requirement of vacuum, relationship between beam energy, material and thickness that can be joined; Preparation of jobs for laser and electron beam welding.

Plasma Welding; A variant to TIG process, Key hole plasma welding, microplasma welding and Plasma transferred Arc surfacing, Gases for plasma welding,

A comparison of advantages, limitations and application of these processes,

Other fusion Welding Processes: Electroslag Welding, Electrogas welding, Thermit welding, principles and Applications

**Solid State Welding Processes :**, friction welding, principles, equipments, , testing, Applications for dissimilar metal welding, friction stir welding, principles, equipment, advantages of continuous welding without fusion, importance of tool material and design, properties of the weld joints, applications for dissimilar joining, microstrurcture of the stirred zone, deformed zone and heat affected zone, applications and limitations magnetic pulse welding, ultrasonic welding, explosive welding, diffusion bonding , , high frequency, stud and cold pressure welding processes.

**Cutting and Other Edge Preparation Processes :** Mechanical cutting, oxygen cutting and oxy–fuel gas cutting, principles of arc cutting processes– arc air, carbon and metal arc, oxy–arc cutting processes. Plasma cutting and gouging, laser cutting, electron beam drilling, arc and flame gouging, water jet cutting.

**Thermal Spraying** : Spraying with powder, flame spraying, arc spraying, plasma spraying. Spraying materials, cold and fusion techniques.

**Joining of Polymers, ceramics and composites:** Joining of polymers: Hot plate welding, hot gas welding, extrusion welding, induction welding, resistance welding, implant welding, high frequency welding, friction welding, electro–fusion, ultrasonic and vibration welding, adhesive bonding.

Joining of Ceramics and composites: Brazing of ceramics, Transient liquid phase bonding, Adhesive bonding, Plasma Spark Sintering.

**Brazing and Soldering** : Bonding mechanisms, surface tension, wetting and capillary, survey of brazing and soldering techniques, consumables and fluxes for brazing and soldering, braze welding; soldering techniques– dip, vapour phase. brazing alloys for different applications and temperatures, product forms of brazing alloys, vacuum brazing, Active brazing alloys to join metals to ceramics, different soldering alloys, lead free soldering alloys, Evaluation of the joint integrity.

## Recommended Text Books and References


- Welding Engineering and Technology, R.S. Parmar, Khanna Publishers, New Delhi.
- A Textbook of welding Technology, O.P. Khanna, Dhanpat Rai & Sons, New Delhi (1980).
- Welding Handbook, American Welding Society, Section-II: Gas, Arc and Resistance.
- The Science and Pratice of Welding, Vol.1: Welding Science and Technology, Cambridge University Press..
- The Science and Practice of Welding, Vol.2: The Practice of Welding: A.C. Davies, Cambridge University Press.
- Principles of Welding, R.W. Messler, John Wiley & Sons (1999).
- Welding Technology for Engineers, 3rd Reprint, Baldev Raj, V. Shankar and A.K. Bhaduri, Narora Publishing House, New Delhi (2009).

## AME–204 : Weldment Design, Welding Procedure and Its Applications

**Applications of Welding :** Tubular joints; T,Y, X and K joints. Stress concentration factor, concept of hot spot stress. Pipes; welding processes for pipe joining. Pressure vessels; classification, typical shell to shell and plate connections, head and closure design. Pressure vessel cladding. Pressure piping; materials and welding processes.

**Types of Welded Joints :** Butt Joint, Lap Joint, T-Joint, Cruciform Joint, Corner Joint and Edge Joint. Fillet and groove welds. Complete and Partial Joint penetration.

**Grove Welds:** Classification and types of grove welds, single and double fillet welds, combined partial joint penetration grove and fillet welds, size of fillet and grove welds.

**Weld Symbols :** Standard system of representation of welded joints, brazed and soldered joints.

**Design of Welded Joints** : Joint design based on stresses in the structure; Joint design for structural elements such as bars, beams, plates, slabs, columns, trusses, plate girders, cylindrical shells and pressure vessels and pipe lines. Design for flanged connections.

**Structural Hollow Sections and Branch Connections** : Welding joint design to control distortion and shrinkage, residual stresses and cracking.

**Residual Stress :** Definition, effects on the welded fabrication; measurement and control of residual stress. Methods to bring down the residual stresses.

**Distortion in Welding :** Transverse, longitudinal and angular. Factors responsible for distortion. Distortion control in the design, fabrication and post fabrication stages **Fitness for Purpose :** Principles of fracture toughness, effect of imperfection size, morphology and position on structural integrity, concept of leak before break Typical methods of conducting an engineering critical assessment of a welded structure.

### Recommended Text Books and References


- Welding Technology and Design, V.M. Radhakrishnan, 2nd Edition, New Age International.
- A Guide to Designing Welds, J.G. Hicks, Woodhead Publising Ltd.

## AME–205 : Occupational Health, Safety and Environmental Issues in Welding and Related Areas

**Introduction :** Occupational Health and Safety Risks at Work– Basics Principles.

**Risks in Welding and Their Control :** Occupational Health and Safety Risks in various types of welding and control measures, Health hazards of Welding Fumes (Combination of metals and gases) and factors affecting welding fumes. Typical particulate matter in welding fumes, Effect of flux coating on welding fumes, Carcinogenic p articulate matter in welding fumes (hexavalent Cr and Mn particulate matter), Electrical Safety in Welding. Environmental Hazards of Welding activities and Mitigation strategies. Welding helmets, shade levels for glasses used for different welding processes, requiurement for design of welding booth, use of curtains to shield ultraviolet radiation.

**Safety and Health Hazards of Welding in Confined Spaces :** Fire and Explosion, Oxygen Deficiency while carrying out TIG welding or MIG welding in confined spaces, Exposure to Toxic Substances.

**Safety in Areas Related to Welding :** Safety in Surface Preparation Activities and Material Handling. Safety in Quality related Processes such NDT, usage of aerosol-based and radioactive materials.

**Selection and Usage of Personal Protective Equipment :** Specification, method of usage, limitations, up keep, etc. Hygiene, Health Monitoring and Training. Fire prevention and fighting. First-Aid and Emergency response.

**Applicable Standards & Legislations Related to Occupational Health & Safety.**

### Recommended Text Books and References


1. Welding Health & Safety: A Field Guide for OSHE Professionals, M.K. Harris, AIHA Press Publication, USA (2002).
2. Health and Safety in Welding and Allied Processes, J. Blunt and N.C. Balchin, Elsevier Publication (2002).
3. Welding, D. Geary and R. Miller, 2nd Edition, McGraw Hill (2011).
4. Welding and Metal Fabrication, L. Jeffus, Cengage Publication (2006).
5. How to Weld, T. Bridigum, Motorbooks Publication (2008).
6. Welding Principles and Application, L. Jeffus, Cengage Publication (1984).
7. Safety for Welders, L. Jeffus, Cengage Publication (1980).
8. Welding Essentials, Question and Answers, W. Galvery and F. Marlow, Industrial Press (2001).
9. Welding Processes Handbook, 2nd Edition, K. Weman, Woodhead Publishing (2003).
10. Hazardous Substances in Welding and Allied Processes (IIW Collection), V.E.S. Ciobanu, L. Costa and W. Zschiesche, Springer Publication (2020).
11. Factories Act and BOCW Act- Relevant Sections.

## AME–206 : Advanced Welding Technology

**Advances in Arc Welding Processes:** Narrow Gap TIG welding, K-TIG Welding, CMT-MIG, Surface Tension Transfer MIG and Regulated Metal Transfer MIG, Narrow Gap Submerged Arc Welding, Tandem Submerged Arc Welding, Laser Hybrid TIG Welding and Laser Hybrid MIG welding.

**Digital Power Sources for Arc welding:** Power sources with automatic data acquisition systems, provision for online modification of the welding parameters, Power sources which continuous acquisition and storage of the welding data, Power sources with Ethernet connection for data transmission and cloud storage.

**Welding Automation:** System Automation and Robotic Automation, Instrumentation and control systems for system automation in welding power source, integrated controls systems, for arc start, wire feed, torch or job movement, gas flow, Arc Gap Controls, Seam tracking etc. Devices and sensors for welding automation.

Robotic welding, principles of robotic engineering, sensors, actuators, programming, software, Five axis and six axes controls, interfacing robot with power sources, safely locks, Interfacing engineering drawing with robotic welding.

**Mathematical Modeling of Welding Process:** Knowledge of various models available for modeling welding process, Heat source modeling for different welding processes, preparation of material data base for modeling, Modeling of weld thermal cycles, Use of standard finite element packages for modeling, Inclusions of convective and radiation heat losses in the model, Prediction of fusion zone and heat affected zone dimensions from the thermal models, Inclusion of phase transformations during weld thermal cycles in the models, Combining heat transfer model to stress analysis to predict residual stress distribution in the weld, Preliminary knowledge on prediction of weld microstructure.

**Additive Manufacturing Using Welding :** Basic methodology, Laser enhanced net shaping (laser bed additive manufacturing, Laser Powder additive manufacturing), Wire arc additive manufacturing using advanced welding processes, Other techniques for additive manufacturing, Microstructure of components produced by additive manufacturing, defects in products formed by additive manufacturing, Applications of additive manufacturing

### Recommended Text Books and References


- Welding Engineering and Technology, R.S. Parmar, Khanna Publishers, New Delhi.
- A Textbook of Welding Technology, O. P. Khanna, Dhanpat Rai & Sons, New Delhi (1980).
- Welding Handbook, American Welding Society, Section-II: Gas, Arc Resistance.
- The Science and Practice of Welding, Vol.1: Welding Science and Technology, Cambridge University Press.

- The Science and practice of Welding, Vol.2: The Practice of Welding: A.C. Davies, Cambridge University Press.
- Principles of Welding, R.W. Messler, John Wiley & Sons (1999).
- Welding Technology for Engineers, Baldev Raj, V. Shankar and A.K. Bhaduri, Narora Publishing House, New Delhi, 3rd Reprint (2009).

# Part – C

**AME–301 : Practical**

Ten Practicals from the list of practical experiments/ practices covering different welding processes, testing (destructive and NDT) techniques, edge preparation, surfacing techniques, etc. would have to be undertaken at a recommended organization.

**Group A (Any Two)**

1. Tension and Compression Test in a Universal Testing Machine
2. Bend-Rebend Test in a Universal Testing Machine
3. Shear Test in a Universal Testing Machine

**Group B (Any Five)**

4. Practice module on SMAW for bead on plate welding and butt joining
5. Practice module on GMAW for bead on plate welding and butt joining
6. Practice module on GTAW for bead on plate welding and butt joining
7. Practice module on Resistance welding and observation of weld bead cut section to observe nugget diameter under different welding conditions
8. Practice module on gas welding and cutting
9. Practice module on gas brazing
10. Investigation on the effect of varying welding conditions on weld bead geometry in arc welding
11. Investigation on the effect of varying welding conditions on weld bead geometry in a welding process other than arc welding

**Group C (Compulsory)**

12. Hardness Test of two different materials in Brinell/ Vickers Hardness Tester and Rockwell Hardness Testing Machine and Impact Test

13. NDT on welded samples in terms of DP test/ magnaflux test and study of radiography films and ultrasonic test results to find out flaws present in a weld

**Group D (Any One)**

14. Preparation of edge by machining/ grinding and welding using multi-passes
15. Metallographic sample preparation to observe bead profile, microstructure of weld metal, HAZ and base metal and to measure width of HAZ and observation of microhardness or Rockwell hardness in C scale across the weldment

## AME–302 : Project

A Project may be carried out on fabrication/ experimental investigation/ testing/ quality control or assurance related to welding and joining. A candidate will do the project individually under the guidance of a teacher/ an experienced engineer. The candidate needs to prepare a comprehensive project report after completing the work to the satisfaction of the supervisor and it should contain the following:

i) A Title page describing the tilte of the project, Detail of the candidate, Name, Designation and Affiliation of the Supervisor(s) and at the bottom of the page, AM-IIW Examination, The Indian Institute of Welding and its full address.
ii) Certificate page by the Supervisor(s)
iii) Acknowledgement by the candidate
iv) Abstract (It should summarize the work done)
v) Contents
vi) Chapter I: Introduction (It should briefly introduce the topic, importance of the area of work done and the Objective of taking the project)
vii) Chapter II: Literature Review (It should give an overview of the works done in the chosen area of work and the present status of known methods/ technology followed by Gap in Literature and aim of the Work to do.)
viii) Chapter III: Materials and Methods (It should contain the detail of the work done mentioning detail of Equipment/ Methodology used, experiment/ test done, etc.)
ix) Results and Discussion
x) Conclusion
xi) References (It should list reference literatures, such as published Research article in a Journal/ Conference article/ Book/ Handbook/ Internet Source, etc. in the following format:


[1] Khanna P and Maheshwari S (2020); Development of a mathematical model for predicting angular distortion in butt welded stainless steel 409M plates in GMAW process, Indian Welding Journal, 53(1), pp.57-66.
[2] Badheka VJ and Albert SK (2009); Improving the weld penetration by application of oxide coating in GTAW of P91 steel, Proceedings of the National Welding Seminar, Kolkata, India, p.18.
[3] Lippold J, DuPont JC, DuPont JN, Kiser SD (2009); Welding Metallurgy and Weldability of Nickel Base Alloys, John Wiley and Sons, Inc., New Jersey.
[4] https://www.nickelinstitute.org/~/Media/Files/TechnicalLiterature/Copper_Nickel Alloys Properties andApplications_12007_.pdf


The project report is to be submitted to the Controller of Examinations, AM-IIW Examinations, The Indian Institute of Welding for its examination. If the project report is found by the examiner not up to the standard, the same would have to be resubmitted after incorporation of necessary corrections as suggested by the examiner.

## AME–303 : Comprehensive Viva Voce

The Comprehensive Viva-Voce will be conducted by a Committee consisting of few experts to assess the understanding of the candidate on welding and allied areas with regard to the papers he/ she passed in AM-IIW Examinations including Practical and Project.

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# COURSE FEES

## AM–IIW Examination & Other Fees

| Sl No. | Revised Rates | Rs. |
|---|---|---|
| a) | Registration Fee ……. | 1000.00 |
| b) | Enrolment Fee …….. | 700.00 |
| c) | Examination Fee …… (Part-A,B,C per subject) | 500.00 |
| d) | Enrolment Fee for ……. Part 'D' Exam. | 700.00 |
| e) | (1) Evaluation of Project Report …… (2) Vova Voce …… | 1000.00 1000.00 |
| f) | Re-examination of Project Report (earlier Report rejected or extensive Revision recommended)…… | 1000.00 |
| g) | Re-examination of Project Report (minor revision recommended …… | 750.00 |
| h) | Re-examination in Viva Voce (failed Candidate) …….. | 1000.00 |
| i) | Issue of Duplicate Mark Sheet of Summer / Winter Exam. (lost by Candidate) ……... | 500.00 |
| j) | Issue of Consolidated Mark Sheets …….. | 700.00 |
| k) | Re-totalling and Re-scrutiny of Marks in a Subject …… | 400.00 |
| l) | Fees for Practical ……. | 5000.00 |