

BY BOB COHEN

Mastering CLASS A ALUMINUM Resistance Welding

An aerospace-grade Sciaky resistance welding machine with the WeldComputer® adaptive control used to produce Class A aluminum spot welds.

Using the right equipment, control, and monitoring system are the keys to quality welds

Welding aluminum can be challenging because of its unique properties, but it's not impossible. Class A quality aluminum welds can be produced with the right equipment, technique, and process settings.

Common Challenges

Class A welds are defined by AWS D17.2, *Specification for Resistance Welding for Aerospace Applications*, as welded joints “whose failure during any operating condition would cause loss of the equipment or system or one of its major components.” Class A welds are free of cracks and expulsion. There are also limitations to the allowable linear dimension of a pore and how far it may extend beyond the central axis of the weld.

Electrode material and geometry, variations in surface and electrical conductivity, current delivery and forge timing from the control, machine responsiveness, the adhesive being used, and thermal conductivity can all impact the welder's ability to achieve a Class A quality weld.

Material Surface Resistance

Aluminum's surface resistance varies significantly, causing problems with conventional welding controls. This leads to inconsistent heat generation and varying weld size, sometimes causing surface burning, cracks, porosity, or expulsion.

Consistent Current Delivery

Aluminum exhibits higher electrical conductivity than most materials when resistance welded. Consequently, generating sufficient current is critical. Lower-than-optimum current delivery throughout the welding process can cause a larger heat-affected zone, leading to an unfavorable change in metallurgical properties. Manufacturers must ensure their machine/control combination has the current capacity to avoid these issues.

Machine Responsiveness

Aluminum's coefficient of thermal expansion is higher than that of other materials, causing it to grow thicker as temperature increases. Therefore, welding machines used

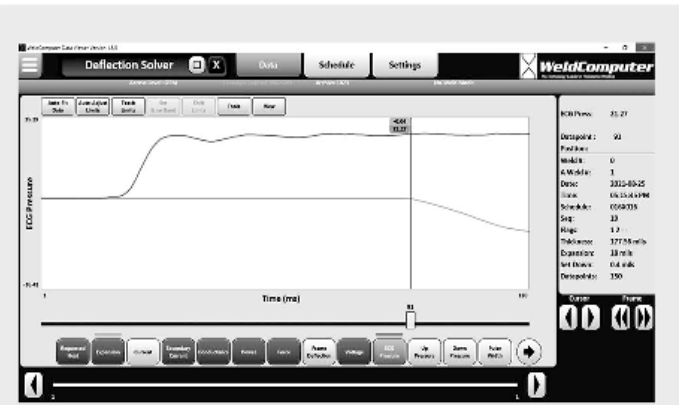


Fig. 1 – Welding data from a commercial welding machine with a ram mechanical problem. The dark-green curve measures differential cylinder pressure during forging. The light-green curve measures ram movement.

for aluminum parts must have low-friction rams, allowing electrodes to move easily with the thermally expanding and contracting part. Variable friction or binding of the ram will cause inconsistent electrode force, resulting in poor and inconsistent welds. Most commercial grade welding machines lack the necessary mechanical precision to handle these demands when welding aluminum.

Figure 1 presents data from an attempt to weld and forge aluminum on a commercial-grade welding machine. The operational breakaway force of the machine's ram was more than 100% of the applied forging force. As depicted by the dark-green graph of cylinder pressure change during the forging operation, the machine applied a forging force of more than twice the welding force. None of that force was transferred to the electrodes, as evidenced by the lack of ram motion response, depicted by the light-green curve.

To achieve Class A forging results, the forging force should be transmitted to the electrodes within the first 10 ms. However, the machine in its current state cannot produce Class A aluminum welds because the ram remains motionless and no force is transmitted to the electrodes even after 75 ms of initiating the forging operation. This machine cannot produce the Class A quality aluminum welds because of a ram/cylinder assembly with a breakaway force higher than its forging force.

Critical Weld Stages for Achieving Class A Welds

Two key stages directly impact Class A aluminum welds:

NUGGET FORMATION STAGE As the weld nugget forms, heat dissipates outward, affecting the surrounding area. This reduces heat at the weld site and emphasizes the use of higher current for shorter periods. However, higher current can generate disturbances from magnetic fields as well as material expansion and contraction, leading to machine vibration. Effective management of these forces is needed to contain molten material and form nuggets without unexpected expulsions.

FORGING STAGE During cooling, the material changes state from liquid to plastic to solid. To prevent cracks and porosity, the timing of the right increase in electrode force is vital. Applying force during the molten state impacts nugget formation and reduces forging effectiveness, while force applied after solidification has little effect. A quick force rise (within 40 ms) during the time the nugget is in a plastic state is crucial for preventing cracking and porosity during cooling.

Using the Right Equipment and Controls

Producing Class A welds requires the right equipment, techniques, and process settings. Not all controls meet aerospace-grade standards for consistent heat and precise timing of forging operations, and not all machines can produce Class A welds to standard.

Class A welding machines are rare compared to those found in the automotive and general appliance markets, contributing to frequent issues among commercial-grade welding machines. Let's compare aerospace-grade welding machines to commercial-grade welding machines.

Aerospace-Grade Welding Machines Require Specific Mechanical Performance

Aerospace welding machines use a low-friction pneumatic cylinder and moving ram to control the applied force of electrodes against the material being welded. The force from electrodes is linked to the differential pressure in the welding cylinder. The pressure rapidly increases during forging, rising in less than 40 ms.

By analyzing electrode force and motion responses, we can pinpoint why welding machines with piston-type pneumatic cylinders or servo-actuated mechanisms often lack the required responsiveness to produce defect-free Class A aluminum welds.

Pneumatically Operated Machines

If the proportion of static friction or breakaway force of the ram controlling the electrode force gets too high, inconsistent weld production becomes an issue for manufacturers. This problem primarily arises in machines that rely on piston-type pneumatic cylinders as opposed to rolling-diaphragm-type cylinders.

Servo-Operated Machines

Servo-operated machines may experience hysteresis in mechanisms surpassing breakaway force with pneumatic cylinders. The servos have a slow response to force changes against electrodes caused by thermal expansion during welding. The excessive response delay will cause inconsistent process performance and produce welds that lack repeatability. Consistency is a key factor to producing high-quality welds free from expulsion, cracks, and porosity.

Impact of a Reliable Class A Machine

Forge response was measured to compare a commercial-grade welding machine to an aerospace-grade welding machine across two key metrics:

- Rise time of differential cylinder pressure transition, and
- Response time to transfer changing differential cylinder pressure to electrode force.

The results are summarized in Table 1.

The slower commercial-grade welding machine's response reduces plastic-state force rise, limiting its ability to prevent cracking and porosity when the nugget cools.

Conclusion

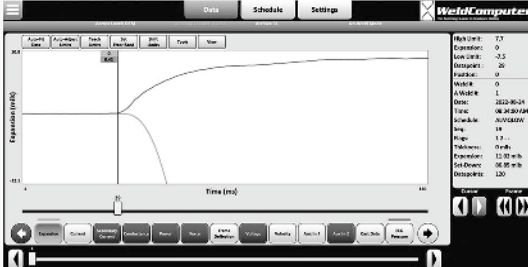
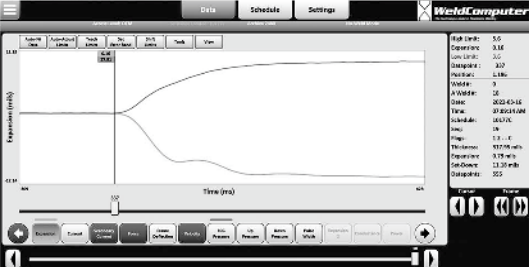
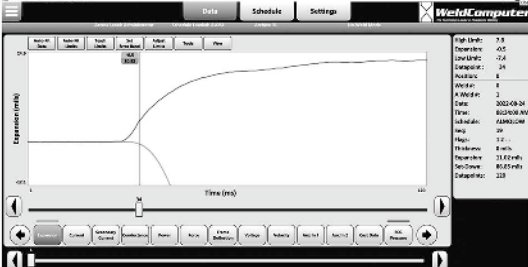
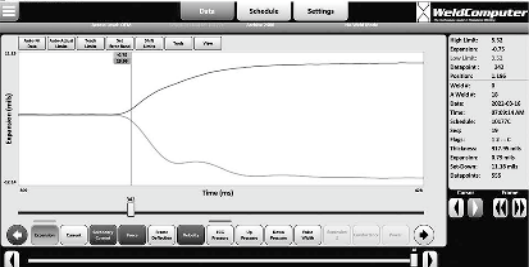
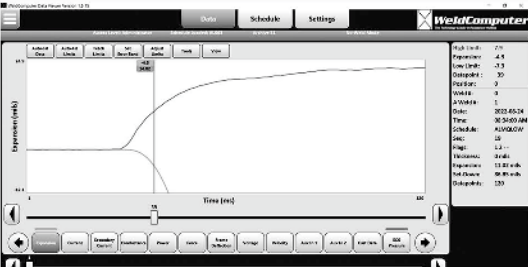
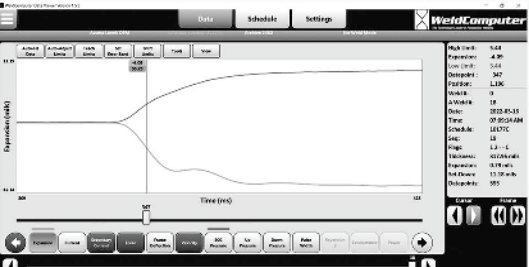
To ensure optimal results, it is important to address variations in surface resistance and metal expansion as the temperature increases. The nugget formation and forging stages are crucial to the process that significantly impacts weld quality. Therefore, it is essential to have a machine/control system that can optimize this process.

Consistent, repeatable Class A aluminum welds can be achieved by utilizing an aerospace-grade machine with a good ram free of friction and binding, a control capable of delivering consistent heat and accurate timing of the forging operation, and a monitoring system to ensure weld forming process variables deliver repeatable performance. **WJ**

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Table 1

Comparison of Commercial Welding Machines and Aerospace Welder Forge Response

Commercial Welding Machine	Aerospace-Grade Welding Machine
 <p>Lower arm deflection has a delayed response to increasing differential cylinder pressure.</p>	 <p>Lower arm deflection is responsive to increasing differential cylinder pressure.</p>
 <p>At 5 ms after the start of the forge, 2% of differential cylinder pressure transfers to electrode force.</p>	 <p>At 5 ms after the start of the forge, 66% of differential cylinder pressure transfers to electrode force.</p>
 <p>At 10 ms after the start of the forge, 10% of differential cylinder pressure transfers to electrode force.</p>	 <p>At 10 ms after the start of the forge, 100% of differential cylinder pressure transfers to electrode force.</p>



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- Quality System ► Plant certified ISO 9001, in process to be certified EN 9100
- Product Approvals ► BV ► CWB ► Lloyd's Register ► TUV ► ATG (Brazing)



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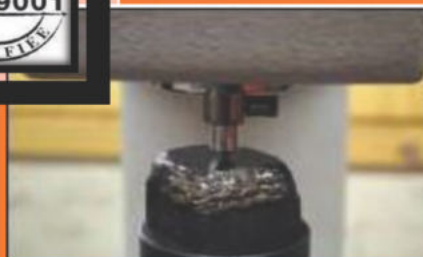
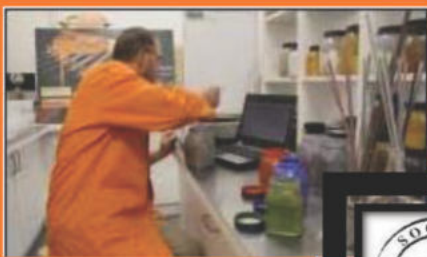
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THE INDIAN INSTITUTE OF WELDING

Authorised Nominated Body - ANB

Information Brochure for Enrolment

INTERNATIONAL WELDER



A Division of The Indian Institute of Welding has been accredited by IIW as its only 'Authorised Nominated Body' (ANB) in India (referred to as ANB-India) to operate its international schemes and award International Diplomas on Welding to personnel at various responsibility and job levels including International Welder for different processes at three skill levels. The Indian Institute of Welding in turn can appoint welder training Institutes in different parts of the country as Approved Training Bodies (ATBs) to impart the practical and theoretical training programmes. Prospective candidates are required to undergo training in these ATBs in the welding course of their choice following a prescribed theory and practical curriculum.

1.0 Benefits

Career for Welders: Welding is a widely used skill offering opportunities to build careers in fabrication & construction. People starting out through practical welding qualifications can achieve high level welding skills which are greatly sought after and they need not stagnate in welder's jobs if they wish to further develop their careers. There is enormous scope to obtain overseas appointment at all levels for IIW Diploma holders apart from within India. 'International Welder' Diploma includes additional certification for practical skill qualification as per ISO 9606.

2.0 International Welder Curriculum

The detailed course content & eligibility form part of the guideline **IAB-089r5-2014** or latest edition (Part 1) of the **IIW-International Authorisation Board (IAB)**.

For the International Welder course: The Diploma Certificate issued specifies 3 levels of increasing knowledge & skill as **International Fillet Welder (IFW), International Plate Welder (IPW), International Tube (Pipe) Welder (ITW)** taking into account the welding process and material to be welded. A person having completed all the three levels in a process and passed the ANB conducted examination in written & practical test is entitled for a Comprehensive Level Diploma Certificate. For details visit website link: <https://iiwindia.com/personnel-qualification-certification/certification/welder/>

2.1 Theoretical:

The theoretical education and training programme consist of 3 theory modules **A, B** and **C** (for ITW only) The candidates also have to undergo an additional module '**S**' depending on the welding process of their choice (MMA, MIG/MAG, TIG) as offered at the ATB and may also select an optional module 'P' for base material (Aluminium, Stainless Steel) other than carbon steel & low alloy steel, which are the normal materials used for welding training.

2.3 Practical:

There are 6 practical training and tests modules or processes covering the various welding processes and materials which are listed to the requirements of ISO: 9606 standards for approval testing of welders.

Process 111	(MMAW)	:	MMA welding of Ferritic & Stainless Steel
Process 135,136,138	(GMAW)	:	MAG welding of Ferritic & Stainless Steel
Process 141	(GTAW)	:	TIG welding of Ferritic & Stainless Steel,
Process 131	(GMAW)	:	MIG welding of Aluminium (if offered by ATB)

3.0 International Welder (Eligibility for Admission in an ATB)

Eligibility Criteria for Module-1 (Access Condition - Entry Level)

- Must have completed Secondary Education (Class X) from a State or Central Board, or equivalent with ability to comprehend written/oral instructions in English.
- Must possess appropriate health, physical and mental capability i.e. no physical or mental disability that precludes safe operation of welding equipment or interferes with full performance of duties in industry.
- Minimum age requirements prescribed in the State and Indian Central Labour Laws applicable in the state in which the ATB is located.
- Must have some background experience / knowledge in industry. Basic skill in metal working is required as a pre-qualification.

4.0 Procedure For Enrolment, Registration & Training

- **ANB India** controls admission to all IIW courses as per eligibility requirements of the "Access Conditions" and subsequent registration process, examination, testing and final award of International Welder Diploma and Certification on practical welding skill.
- The actual theoretical lesson and practical training is conducted by the Approved Training Body (ATB). For convenience, the application/registration Forms are available with the ATB and may be submitted through them. After successful theoretical and practical examination, the Authorized National Body awards an 'International Welder' Diploma to the candidate specifying the process, level and material (if applicable).
- Prospective candidates are advised to refer to ATB for details of course fees including practical training fees to be paid to the ATB and other charges payable to ANB for Registration and conduct of Examination and practical test for IW Diploma.
- Presently Don Bosco Technical at Kochi is the only ATB for this Diploma and interested candidates may contact directly as below:
Principal - Fr. Raju Philip sdb, Mob: +91 9483360106, [E Mail: unnaramkallel@gmail.com](mailto:unnaramkallel@gmail.com)
Other Contact: Preethy James (+91 9446029120), [E Mail: dbprojectsvaduthala@gmail.com](mailto:dbprojectsvaduthala@gmail.com)

5.0 International Welder Examinations, Diploma & Certification

After completion of the modules A, B and C, there is a final theoretical examination set under the authority & supervision of the ANB. In addition to the examination of the modules A, B and C, the examination of the specific welding process (S) module and – if applicable – the appropriate material (P) module (Aluminium/SS) is required other than carbon steel & low alloy steel at all levels.

Welding skill is tested as per requirements of the IAB guideline and also certified as per ISO 9606-1 under ANB authorised Examiner to ensure compliance. The appropriate level of Diploma as **(IFW)** or **(IPW)** or **(ITW)** with mention of additional Process (S) & Optional material chosen (P) is awarded after successful finish of Module 2, 4 & 6 respectively or a **Comprehensive Level Diploma** once all the levels are completed in a particular process. The diploma at any level of 'International Welder' also includes an additional renewable certification for practical skill tests as per ISO 9606 appropriate part.



The Indian Institute Of Welding - ANB

Authorised Nominated Body of the International Institute of Welding in India

IIW-INDIA HOUSE, PLOT 38, GEETANJALI PARK
200, KALIKAPUR MAIN ROAD, P.O. MUKUNDAPUR, KOLKATA - 700 099, INDIA
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BE A WORLD CLASS MANUFACTURER IN FABRICATION

The Indian Institute of Welding - ANBCC

Introduces to Welding Related Industries The Survival Strategy for the 21st Century



In a globalised business environment where the cost and quality competitiveness are increasingly playing the dominant roles, the Indian fabricators using welding should not only be prepared to face more challenges at home from Imports of finished fabricated products but also be able to compete overseas in order to grow and sustain their viability.

Manufacturer Certification Scheme - The Quality Requirement for the 21st Century

Many companies have achieved certification to ISO:9001 for their quality management systems. But where significant use of it towards the **special process** (a process where the conformity to the resulting product cannot be readily or economically verified is referred to as a special process) like welding, such certification is unlikely to provide the required demonstration of company capability to manufacture products with the 'required' product quality. In such cases compliance to ISO:3834 is the recommended solution. The International Institute of Welding (IIW), as a tool for achieving substantial quality, has introduced a specific **Manufacturers Certification Scheme (MCS)** referring to ISO:3834 for world wide implementation.

Introduction to ISO : 3834

Processes such as fusion welding are widely used to manufacture many products. In some companies, they are the key process of production. Products may range from simple assemblies to complex fabrication. Examples include pressure vessels, domestic and agricultural equipment, cranes, bridges, transport vehicles, construction of plants and many such other items. It is important, therefore, to ensure that the operational processes are carried out in the most effective way and that appropriate control is exercised on overall aspects of the operation. Quality cannot be inspected in to a product; it has to be built in. Even the most extensive and sophisticated non-destructive testing does not improve the quality of the product.

It is emphasized that ISO:3834 entitled "Quality requirements for fusion welding of metallic materials" is not a quality management system standard replacing ISO:9001, but supplements this. ISO:3834 identifies measures that are applicable for different situations for fusion welding application.

IIW Manufacturer Certification System Benefits - By Compliance to ISO:3834

Benefits for Certified Organizations

- Clear, high profile, independent verification of compliances by the world's leading authority on Welding.
- Confirmation of welding and fabricating capability and staff competence,
- Improved client confidence leading to a reduction in external audits.
- Entry of the company's details on well-publicised International Web site register.
- Quality management and fabrication capability assessment are carried out by IIW recognized assessors.
- Increased national and international business potential.

- Cost savings through reduction of rejection/rework in production.
- Improved delivery with "first time right" approach.
- For many products, mandatory requirement for suppliers to EU and many other countries, and also for the sub-suppliers. Namely the EU Directives and the Harmonised Product Standards.
- Establish the base for implementation of other relevant standards like EN:15085, EN:1090, EN:13445 etc. & CE making

Authorisation as per certification body

International Institute of Welding (IIW) appoints an Authorised National Body for Company Certification (ANBCC) under its Manufacturers Certification Scheme (MCS) for Compliances to ISO:3834.

IIW-India has obtained accreditation as ANBCC from the International Institute of Welding through its International Authorisation Board (IAB) for the exclusive rights within India to operate its MCS for certification of companies for compliance to the requirements if ISO:3834.

Specific Advantages of IIWs MCS

- Beside ensuring compliance with the requirements of ISO:3834, it also covers the welding related aspects of
 - a) Environment as per ISO:14001 and
 - b) Health & Safety as per OHSAS
- Under MSC of IIW, the certificate is valid for 5 years. Renewal of Certificate are carried out after 4 years of surveillance audits, while as per the certification schemes by competitors the Renewal of Certificate are carried out after 2 years of surveillance audits as the new certificate's validity is 3 years.
- As per MCS, it is a mandatory requirement to assess the competence of WCs, which is also a requirement as per new version of ISO:14731:2019

Levels of Certification

ISO:3834 certification can be achieved in 3 levels of quality requirements.

ISO:3834-2 Comprehensive quality requirements

ISO:3834-3 Standard quality requirements

ISO:3834-4 Elementary quality requirements.

Steps towards Certification as per ISO:3834

- Gap Analysis
- Awareness Program, including suppliers
- Documentation as per code requirement
- Finalization of RWC from human resource within the organization or otherwise from external source
- Review, decision on new approved suppliers
- Arrange or identify welding related personnel qualification as per code requirement
- Certification of Welders, Certification of Inspectors
- Qualification of Welding Procedures
- Review and upgrade present systems
- International Audit/ Review of systems as per code requirement
- Invitation to Certification Body for Certification

How is ISO:3834 Certification Achieved ?

Steps to be followed

Pre-application Stage

- **Step 1** - The intending client sends an enquiry to IIW-India ANBCC
- **Step 2** - IIW-India sends to the client a letter explaining the pre-application stage, information brochure on ISO:3834, a preliminary form (RFQ)
- **Step 3** - The client sends back the filled-in RFQ form and request for awareness programme (optional)
- **Step 4** - Based on the data provided by the client, the ANBCC sends to the client a formal techno-commercial offer/agreement for certification, the exact scope of work, technical requirements and contract, requirements. For implementation of other relevant standard like EN:15085, EN:1090, EN:13445 etc. and CE making. The client sends back the formal acceptance of the contract.
- **Step 5** - The customer sends back filled-in detailed application form and the quality documents along with the applicable fees to ANBCC.
- Establish the base for implementation of other relevant standards like EN:15085, EN:1090, EN:13445 etc. & CE making.

Document Audit

The basic documents such as manuals, work instructions etc. which are submitted along with the application, are reviewed for adequacy. At this stage, more documents may be asked by the auditor as necessary. Only after satisfying about the adequacy of documentation, site audit will start.

Undertake adequacy audit at the discretion of the auditor and if agreed to by the manufacturer.

Corrective Action requests

The applicant will be required to take corrective actions within the committed and mutually agreed time for any minor non-conformance found before certification can be granted.

The certification can be granted only after satisfactory closure NCs, as verified by auditor, which may require additional site visit by auditor. If there is any major non-conformance, additional site audit may be required. It is also possible that the audit process will be terminated and the manufacturer has to start the process all over again from application. In case of more than one major non-conformance the case may be closed and fresh application process from client shall start.



IIW-India is committed to the cause of supporting the Indian Fabricating Industry, a key player in projecting India's manufacturing sector as world class with ability to compete on equal terms with global competitors.



The Indian Institute Of Welding - ANBCC

Authorised Nominated Body of Company Certification of International Institute of Welding

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Tel : +91 33 4006 1837

E-mail : anbcc@iiwindia.com

oprn.mktg.anbcc@iiwindia.com

IIW India Website : <http://www.iiwindia.com>

Certification

ANBCC will issue a certificate of registration to the applicant once the corrective actions have been accepted and / or implemented. The certificate carries a validity of upto five years (max.) from the date of issue.

Surveillance

During the certificate validity period, surveillance assessments are carried out at an interval of 12 months (max.) at the end of first, second, third and fourth year of the certificate validity.

Renewal

The client's quality system is required to be re-assessed for the renewal of certificate. The re-assessment is carried out before the end of the validity period of certificate. The process steps are same as Certification process.

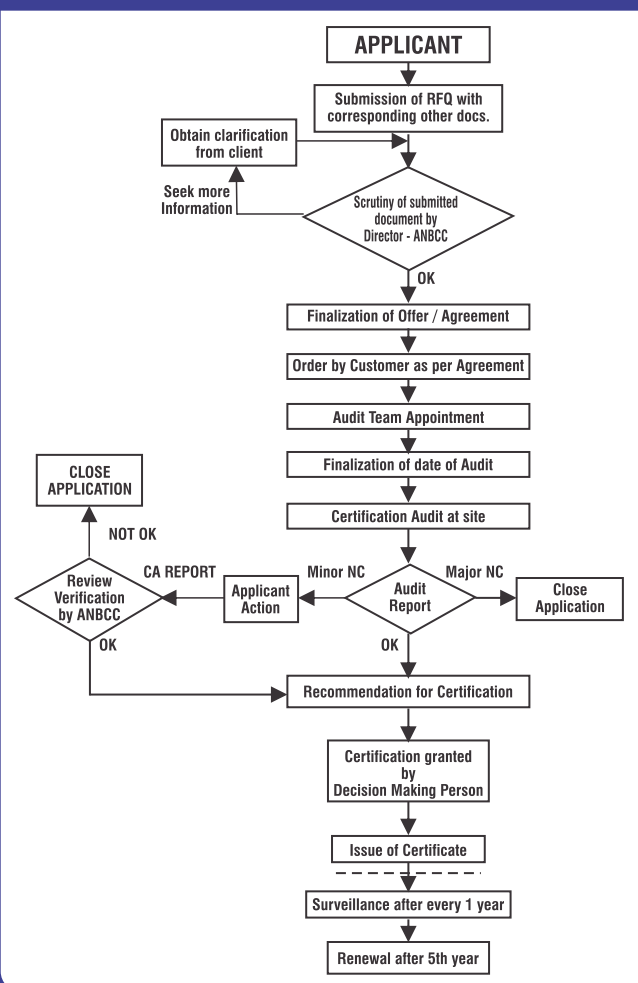
Other Services -

Direct or through empanelled experts

At the discretion of the Client, Training can be offered by IIW-India - ANBCC in the following areas :

- Awareness program on ISO:3834 : 1 day
- Internal Auditor Training on ISO:3834 : 2 days
- Auditing of suppliers : 2-3 days
- Comprehensive Training on Implementation of ISO:3834 including the above and gap analysis : 4-5 days
- Customized modules to suit manufacturers requirement.

ISO:3834 CERTIFICATION PROCESS FLOW CHART : STEPS TO CERTIFICATION



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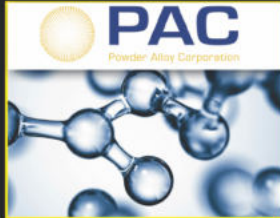
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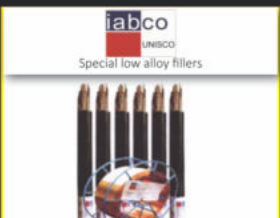
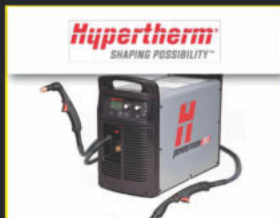
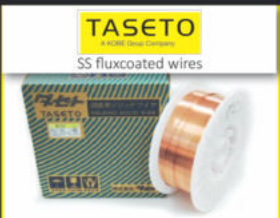
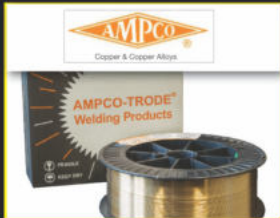
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