The Special Importance of Personnel Competence in Welding Fabrication

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Background

The safety, reliability and cost effectiveness of welded products requires the welds to be of adequate quality. Welding is a special process which needs unique controls in order to achieve the required quality. Such processes are recognised in the quality management systems standard, ISO 9001 [1], which requires them to be treated in a particular way. Ignoring the need for special, competent control of welding can result, in the worst cases, in catastrophic failure and loss of life. Whilst such occurrences are rare these days, they are not unknown. More commonly companies that do not adequately ensure competent control of welding may find themselves suffering from cost overruns, delays, contractual problems, etc, arising from the need to make repairs to bad welds. The cost penalties can be significant: it has been established that repairing a faulty weld incurs more than five to six times the cost of doing it correctly the first time.

The importance of competence in welding was recognised a long time ago. As an example, on 28 November 1918, the Technical Committee of Lloyd's Register of Shipping reviewed a report [2] on the application of arc welding to shipbuilding. This report was generally positive about the introduction of the process and proposals regarding additional regulations were made. These included the following:

• *The Committee must be satisfied that the operators engaged are specially trained, and are experienced and efficient in the use of the welding system proposed to be employed.*

• *Efficient supervisors of approved ability must be provided, and the proportion of supervisors to welders must be submitted for approval.*

These proposals were adopted and appeared in the 1920 issue of Lloyd's Rules.

Therefore, when we talk about competence in welding today, we are not talking about anything new! Our predecessors' opinion on the matter is evident from the above quotations; although it is only by viewing these statements through the prism of history that we can see how prescient they were.

In the years that followed, specifications and standards on welder approval (or “qualification” as it is now called) emerged from a number of countries. In the UK, a new professional body, the Institute of Welding (now part of The Welding institute - TWI) was formed in 1923.

Later on, in the 1960s and beyond, specifications dealing with the competence of non-destructive testing (NDT) and welding inspection personnel emerged.

Nowadays, controlling welding as a special process is dealt with in ISO 3834 [3], quality requirements for fusion welding (which was first published as ISO 3834, and as EN 729, in 1995). This standard sets specific requirements for the competence of people with welding responsibilities and this includes: welders, NDT personnel, welding inspectors and welding coordinators. In other words, it is clear that anyone and everyone who can have an impact on the final quality of the welds in the product must have the required competence. It is like a chain - a 'welding quality chain' - if only one link is missing or faulty, the chain will break and the kinds of problems highlighted above may occur. This is recognised in ISO 14731 [4], welding coordination - tasks and responsibilities (first published in1994 as EN 719) which is referred to in ISO 3834.

The correct implementation of these two standards, ISO 3834 and ISO 14731, is the key to the cost-effective manufacture of safe and reliable welded products.

Definitions

The subject of competence is emotive because it is a personal attribute. In order to analyse and deal with the subject objectively, it is important in the first instance to be clear about the definition of words and phrases that are used in the context of competence. In the English language, this is not a straightforward matter and therefore considerable difficulties arise when attempting to transfer competence concepts into different languages. However, in order to make a start, the following definitions are offered, although they may not be the true 'Oxford Dictionary' definitions:

Competence - the state of being competent; that is, being adequately capable of performing certain defined tasks.

Education - the processes of imparting a general level of knowledge in a subject or range of subjects.

Training - the process of imparting knowledge and/or a set of skills which is narrowly defined and usually employment related. The emphasis is generally on the attainment of practical skills together with relevant underpinning knowledge.

It should be noted that a person who undergoes a course of education or training does not automatically acquire the knowledge and/or skill that the course was designed to impart. Therefore it is common to have some kind of test at the end of a course.

Qualification - confirmation that a person has been successful in a test (usually theoretical) to confirm the attainment of knowledge. A university degree is an example of an academic or professional qualification. Qualifications may help in determining the competence of a person but they do not normally, in themselves, give adequate assurance of competence.

Experience - working in a job in such a way as to make use of any education, training and qualifications gained. The type of experience can be determined from the person's job specification and of particular importance for people with professional qualifications is the level and type of decision-making authority that the person has been given.

Certification - a testimony that a person has proved an ability to carry out certain defined tasks and has the underpinning knowledge necessary to perform those tasks. Certification usually requires the prior achievement of specific qualifications, training and experience; and practical testing that is in addition to the qualification testing mentioned above. In cases where the scope of certification matches the requirements of the job to be carried out, certification is the best way of demonstrating competence.

Authority to work - the authority to carry out a job of work can only be granted by the employer according to the employment law of most countries. This implies that the employer is also responsible for the competence of the person to do the job that he/she has been engaged to do. Employers are encouraged to use personnel with relevant certification, where available and appropriate, in order to help with this.

Continuing Professional Development (CPD) - this is a process through which professionally qualified or certified people can keep up to date in the areas in which they are qualified and employed, thereby keeping their competence 'current' and not 'historical'. This is important in technical fields because of the regular advances that are made. Best practice CPD requires the employee and the employer to agree upon a personal development plan which is regularly reviewed. Evidence of CPD is often required for certification and for renewal of certification.

Competence in welding and related fields

As mentioned above the special importance of competence in welding has been recognised for many years. Since the 1980s a great deal of effort has gone in to the development of an internationally harmonised education, training, qualification and certification system [5]. The system is now maturing, and is implemented and recognised widely throughout the world. Over 150,000 diplomas have been awarded. Some of these harmonised qualifications are also mentioned in ISO 3834 and ISO 14731.

The system is a valuable tool for individuals seeking wide recognition of their knowledge and skills and for employers seeking to employ competent people. Qualification and certification that are widely recognised inspire confidence in holders, in employers and in clients who purchase welded products. However, the system continues to be misunderstood in some quarters and therefore it may be helpful to remind ourselves what these qualifications mean.

The harmonised system is largely focused on education and examination leading to the issue of a 'Diploma'. In the definition above this is clearly a qualification. The key thing is that these qualifications do not require any experience at all and therefore they do not, in themselves, provide any assurance of competence. For example, a person can achieve the European/International Welding Engineer (E/IWE) Diploma at the age of about 22, on the basis of having completed a three year university degree in an engineering or materials subject, and the 14 week E/IWE course and examination. Such a person possesses a valid E/IWE Diploma but without any understanding of how to apply the knowledge in a real working environment. Unfortunately some employers are not aware of this and assume that a person with an International/European Diploma is a competent person.

An International/European personnel certification scheme is in place and available [5]. This uses the International/European Diplomas as proof of knowledge but sets additional requirements in terms of experience and CPD. It is unfortunate that the scheme is much less popular than the qualification scheme with only around 1500 certificates having been awarded world-wide. More must be done to inform employers about the value of this certification scheme.

ISO 14731 requires the manufacturing organisation to appoint at least one Responsible Welding Coordinator (RWC). It is useful that the standard makes reference to the International/European qualification system as a way of dealing with the technical knowledge requirements for RWCs; but what about RWCs who do not possess an International/European qualification? EWF/IIW have developed guidance on this for certification bodies conducting compliance assessments of manufacturers to ISO 3834, see Appendix 1. Routes (a) and (b) in Appendix 1 are straightforward because of the presence of the international harmonised certification/qualification. Route (c) is more complicated because it deals with RWCs without such certification/qualification. Some experience of implementing route (c) in the UK is given in the section below.

Welding Coordination as described in ISO 14731 covers many different welding and welding related tasks covering the entire 'welding quality chain' mentioned in above. This includes:

- Review of requirements
- Technical review
- Sub-contracting
- Welding personnel
- Equipment
- Production planning
- Qualification of welding procedures
- Welding procedure specifications
- Work instructions
- Welding consumables
- Materials
- Inspection and testing before, during and after welding
- Post-weld heat treatment
- Non-conformance and corrective actions
- Calibration and validation of measuring, inspection and testing equipment
- Identification and traceability
- Quality records.

In order to comply with the standard, the manufacturer must be able to show that employees with any of the tasks listed in ISO 14731 possess appropriate competence. EWF/

IIW have developed a wide range of so-called 'guidelines' that describe courses of training designed to underpin different welding related jobs, see Appendix 2. Therefore for many of the activities covered by welding coordination in ISO 14731, a harmonised and recognised International/ European course is available. However, these courses are not widely used at present and, again, more must be done to convince industry of their value.

In the field of non-destructive testing (NDT) there is a European and an International standard [6], [7] that deal with the independent certification of NDT personnel. These standards have not resulted in the harmonised approach to NDT like the one that has been adopted in the international welding community. However, they do provide a measure of assurance of competence of NDT practitioners in possession of certificates that are in accordance with one of the standards, especially if the certificates are backed by a recognised national accreditation body. ISO 3834 requires NDT personnel to be qualified in accordance with ISO 9712 or an equivalent standard.

There is no European or International standard for welding inspectors at present. However, there is an International/ European qualification scheme, see Appendix 2, and IIW has recently approved a document that deals with the certification of welding inspectors. National certification schemes for welding inspectors have existed for many years, some of which are available internationally [8], [9]. ISO 3834 requires welding inspectors to be competent but does not require any particular qualification or certification. However, the take up of the welding inspector certification schemes has generally been extraordinarily high (many tens of thousands) reflecting the fact that certified welding inspectors is a common feature in the specification of manufacturing or construction contracts world-wide.

Experience in assessing competence

It can be argued that welding is one of the most regulated occupations in the world. As we have seen from the historical evidence above, the importance of welding skill was recognised over 90 years ago; and today, for all "serious" welding, the welders are subject to a strict regime of testing and re-testing in accordance with national, European and/or International standards. These standards are, in many respects, similar; and it is a pity that attempts to achieve a single harmonised international standard for the testing of welders have not been successful. Nevertheless, for the manufacturer, a reasonable assurance of competence of welders is achieved by adopting an appropriate standard, and welder testing has become embedded in the culture of today's manufacturing by welding.

Similarly, manufacturers usually take measures to ensure the competence of personnel involved in NDT and welding inspection often by using one of the schemes mentioned above.

For all the other welding activities and related tasks and responsibilities identified in ISO 3834 and ISO 14731 there is no such culture of competence assessment. In recent years, TWI has been involved in the assessment of a number of companies against the requirements of ISO 3834 and this has led to a number of interesting issues with regard to competence assurance.

One manufacturer challenged the link between ISO 3834 and ISO 14731. The view of EWF/IIW (and TWI) is that, in order to comply with ISO 3834 Part 2 ("comprehensive" quality requirements) or Part 3 ("standard" quality requirements), the manufacturer must also comply with ISO 14731. It is interesting that neither Part 2 nor Part 3 refers to ISO 14731 directly: the issue is covered only by reference to Table 2 of Part 5 (normative references). This table does indicate the need to comply with ISO 14731 but, in the general section of Part 5, in section 2.1 (according to a corrigendum) it is stated that 'other documents' or 'different supporting standards' can be used in certain circumstances. Unfortunately this provides a basis for a manufacture to challenge the need for compliance with ISO 14731.

Once the manufacturer has accepted the need for compliance with ISO 14731, the first issue to deal with is the competence of the appointed RWC. As mentioned above IIW/ EWF have issued guidance on this (see Appendix 1) and, in dealing with route (c) people, TWI has also found it beneficial to follow the requirements of document EA-6/02 [10] which state:

- *Special care should be taken by the EN ISO 3834 Assessment Team in evaluating the competence of the manufacturer's welding coordinators in accordance with EN ISO 14731. The Certification Body should have procedures, which demonstrate that this important aspect of ISO 3834 is properly evaluated.*
- *Such procedures should include a peer review and challenge process* in which the company's Responsible Welding Coordinators are interviewed and their work examined. The EN ISO 3834 Assessment Team should be able to demonstrate complete evaluation of welding co-ordination (functions and individuals) in the company. Records of this process should be maintained.*

  ** This means that technical discussions must take place between each Responsible Welding Coordinator and the relevant Assessor about the detailed technical scope of the Responsible Welding Coordinator's responsibilities. This process will require the Assessor to examine evidence of completed work done by each Responsible Welding Coordinator and to investigate his/her knowledge and understanding of it.*
- *The peer review process should involve the examination of specific contract(s) to assess compliance with the customer's specification in, for example, the following areas:*

  i) selection/development of welding procedures

  ii) welding sequences

  iii) NDT and heat treatment

  iv) approval of personnel

  v) traceability

  vi) quality control and acceptance

  vii) sub-contracting

In TWI's experience there have been several instances where the appointed RWC has fallen short of the requirements in terms of technical knowledge requirements of ISO 14731. In the UK, RWCs are often people who started their careers in practical welding and, over a number of

years, have been successively developed their careers away from practical welding, for example into welding inspection, quality assurance, etc, until they become the most senior welding person in the company. These people are often perfectly competent to follow the procedures and systems that have proved successful in the company over a period of time, but often they do not have the underlying knowledge as to why things are done in the way that they are. This can be a serious problem if there are changes, for example to the materials, welding processes or products used by the company, or if something runs outside of the applicable specification. The person could tell you, for example, what the preheat temperatures are for the all the joints to be welded and how those temperatures are achieved, but may be completely ignorant as to why preheat is necessary. In such cases, TWI recommends that the person attend the relevant European/International Diploma modules in order to acquire the important underlying technical knowledge.

ISO 14731 does allow 'acceptable national qualifications', as alternatives to the European/International ones, to confirm technical knowledge. In the UK, we are fortunate to have had a system for assessing and assuring competence in welding for many years. This is called Professional Membership of The Welding Institute and it is directly related to the UK national system for registering engineers and technicians in all fields [11]. Possession of one of these qualifications can be a convenient way of satisfying the route (c) requirements for RWCs.

If it is clear that there is no one in the company with the capability to meet the ISO 14731 requirements regarding the RWC, the company can engage an external consultant to fulfil this role. In such cases, TWI advises that additional control measures are applied:

i) there must be a contract between the company and the external RWC which includes a clear description of the RWC's role and responsibilities

ii) the RWC must visit the company regularly (at least once per month) and there must be record of the work carried out by the RWC in each visit

(iii) the RWC must have the right to visit the company anytime unannounced.

Anyone with welding responsibilities, no matter how narrow is categorised by ISO 14731 as a welding coordinator and must be able to demonstrate competence in the allocated tasks. TWI recommends that the manufacturer draws up a matrix of all the welding tasks identified in ISO 14731, together with the names of the people who are responsible for each one. As an example, a storekeeper may be responsible for the correct storage of a wide range of equipment, tools, etc, and this may include welding consumables. In such a case, the storekeeper would be expected to know about the importance of correct storage of welding consumables and to ensure that correct procedures are adhered to. If the storekeeper does not possess the competence to fulfil these tasks, there is a weak link in the 'welding quality chain' and, even if the company has the best welders and the best RWC in the world, problems may arise. The storekeeper is a welding coordinator according to ISO 14731 and should be trained and recognised as such by the company.

The final example is competence in NDT. As indicated above, ISO 3834 is clear about the need for some kind of independent assessment of competence in accordance with ISO 9712 or an equivalent standard. But is it really necessary? In one company visited by TWI, a person was found performing magnetic particle inspection on a steel framework component for a fork lift truck. The person appeared to be using appropriate techniques but on questioning him it was found that he had been shown what to do by a colleague and did not know anything about the principles of the NDT method he was using. Furthermore, when asked what action was required if indications appeared the answer was that he did not know because he had never found anything! The lesson to be learned from this is that, like welding, NDT is a special process and care is needed to ensure that operators are trained and competent.

Recommendations for improvement

The competence requirements in ISO 3834 and ISO 14731 are a major step forward in recognising the special importance of welding and in ensuring that welding production is under competent control. What is important now is for standards writing bodies to call up the standards in applications standards and for client organisations to specify the standards in their contracts. Where possible it would also be beneficial to write in the need for some kind of recognised third party assessment of compliance. Certification bodies are free to offer ISO 3834 assessment and certification services, but these are only likely to bring value of they are under national accreditation in accordance with EA-6/02. Even so there is evidence that accredited certification to ISO 3834 is being carried out that is not in compliance with EA-6/02. The accreditation bodies should address this: EA-6/02 is their document and they should be more rigorous in controlling its implementation.

EWF/IIW has developed and implemented a system for ISO 3834 certification which fully embraces EA-6/02 together with additional controls to ensure that certificates issued to manufactures follow both the letter and the spirit of ISO 3834. This is exemplified by the special requirements for RWC assessments as indicated in Appendix 1. Furthermore, assessing the competence of RWCs can be facilitated by adopting the EWF/IIW personnel certification scheme. All sides of industry should be made aware of the added value offered by these certification schemes.

EWF/IIW have issued a wide range of training and qualification guidelines in addition to the main ones that deal with the knowledge requirements for RWCs. Adoption of these guidelines, where relevant to the tasks required, can also facilitate the assessment of competence in more specialist welding and related areas of work. Further promotion of this is required.

With regard to the standards themselves, the link between ISO 3834 and ISO 14731 should be made more solid. There should be no scope for challenging the applicability of ISO 14731 in the case of compliance with ISO 3834 Part 2 or Part 3.

In the case of welding manufacture, health and safety, and environmental management are especially important but neither of them is mentioned in ISO 3834 or in ISO 14731. It is

recommended that this is addressed by the bodies responsible for these standards. The omission has been recognised by EWF and documents have been published about how to take care of heath, safety and the environment from the welding point of view [12]. Manufacturers have the option to undergo assessments against these requirements as part of their EWF ISO 3834 assessment.

Conclusions

1. Competence in welding is key to the safety, reliability and cost effectiveness of welded products. This applies to all personnel to whom welding, or welding related, tasks have been assigned.

2. Assuring a person's competence is a complicated matter and requires and understanding of education, training, qualifications, experience, certification and continuing professional development.

3. Compliance with ISO 3834 and ISO 14731 is a way for manufacturers to ensure that they deal with welding competence in a proper way.

4. EWF/IIW have developed qualification and certification systems which facilitate the adoption of best practice in terms of competence demonstration.

5. More effort should be made to raise industry awareness of the importance of welding competence and of the routes to achieve it.

6. ISO 3834 and ISO 14731 should be more widely specified in applications standards and in contract documents.

7. In the light of recent experience some improvements to ISO 3834 and ISO 14731 with regard to competence should be considered, particularly:

- *Strengthening the link between the two standards*
- *Adding requirements for health and safety competence*
- *Adding requirements for competence in environmental management*

8. Accreditation bodies should do more to ensure that certification bodies fully satisfy the accreditation bodies' requirements in relation to ISO 3834 assessment and certification.

References

[1]. ISO 9001:2000, Quality management systems - Requirements.

[2]. Lloyd's Register of Shipping, London. Remarks submitted by the chief ship surveyor on the application of electric arc welding to shipbuilding. Document appended to the minutes of a meeting of the Technical Committee, 28 November 1918.

[3]. ISO 3834:2005, in five parts, Quality requirements for fusion welding of metallic materials.

[4]. ISO 14731:2006, Welding coordination - Tasks and responsibilities.

[5]. Quintino, L; Ferraz, R; and Fernandes, I; "International education, qualification and certification systems in welding". 5/2008. European Welding Federation web site: www.ewf.be.

[6]. BS EN 473:2008 Non-destructive testing. Qualification and certification of NDT personnel. General principles.

[7]. ISO 9712:2005, Non-destructive testing - Qualification and certification of personnel.

[8]. CSWIP Welding Inspector certification scheme. TWI Certification Ltd, web site: www.cswip.com.

[9]. AWS Certified Welding Inspector scheme. American Welding Society, web site www.aws.org.

[10]. EA Guidelines on the Use of EN 45 011 and ISO/IEC 17021 for Certification to EN ISO 3834. EA-6/02. July 2007 rev 1. EA web site: www.european-accreditation.org.

[11]. UK-SPEC 2008, UK Standard for Professional Engineering Competence, Engineering Technician, Incorporated Engineer and Chartered Engineer Standard. Engineering Council UK web site: www.engc.org.uk.

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Appendix 1

Extract from IAB document IAB-340-08 (and EWF document 639-07) about assessment of RWCs (www.iiw-iis.org)

Concerning the welding coordination personnel according to ISO 3834..... the following criteria shall be considered:

(a) Certification according to IIW Personnel Certification Scheme (CIWE, CIWT, CIWS and CIWP) shall be accepted provided the schedule of the person's certificate is consistent with the type of products being manufactured.

(b) If an IIW qualification is available (IWE, IWT, IWS and IWP) the welding coordinator(s) could be accepted provided there is an adequate experience and competence in the products being manufactured to be verified by means of a professional interview and curriculum vitae.

(c) If no certifications or qualifications are available, the ANBCC shall verify compliance by means of a professional interview covering knowledge, experience and competence of the welding coordinators with particular emphasis on welding technology, materials and their behavior during welding, design fundamentals of welded construction, as well as fabrication and inspection aspects (including knowledge of standards). If such a professional interview is satisfactory, the welding coordinator(s) can be recognized by the ANBCC for this role and for the products and processes consistent with the current production.

Due to the principle of mutual recognition between IIW and EWF whenever IIW qualification and/or certification of welding coordination personnel is mentioned, the correspondent EWF qualification and/or certification is considered equivalent.

The manufacturer shall define tasks and responsibilities of the welding coordination team, based on ISO 14731 "Welding Coordination personnel - Tasks and responsibilities".

Appendix 2

List of all IIW/EWF education/training guidelines (www.ewf.be)

1. IAB-252-07, Personnel with responsibility for welding coordination. Includes European/International Welding Engineer, European/International Welding Technologist, European/International Welding Specialist, and European/International Welding Practitioner
2. IAB-041r3-08, International Welding Inspection Personnel
3. IAB-201-06, International Welded Structures Designer
4. IAB-089-03/EWF-452-467-480-481 Rev 3, International Welder
5. EWF-459r1-06, European Thermal Spraying Specialist
6. EWF-592-01, European Thermal Spraying Practitioner
7. EWF-507r1-06, European Thermal Sprayer
8. EWF-517-01, European Adhesive Engineer
9. EWF-516-01, European Adhesive Specialist
10. EWF-515-01, European Adhesive Bonder
11. EWF-525-01, European Welding Specialist for Resistance Welding
12. EWF-621-06, European Welding Practitioner for Resistance Welding
13. EWF-570-01, European MMA Diver Welder
14. EWF-581-01. European Plastics Welder
15. EWF-635-07, European Aluminothermic Welder
16. EWF-494-01, Special Course in Laser Welding (Engineer, Technologist and Specialist levels)
17. EWF-544-01, Special Course for Welding Reinforcing Bars at the Specialist level
18. EWF-623r1-04, Special Course on Weld Imperfections for Non-Destructive Testing Personnel
19. EWF-627-07, Special Course on Personnel with responsibility for Macroscopic and Microscopic Metallographic Examination
20. EWF-628-08, Special Course on Personnel with Responsibility for Heat Treatment of Welded Joints
21. EWF-640-07, Special Course on Risk Management in Welding Fabrication

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