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WELDING SAFETY BY USING A NEW MODEL OF WELDERS' RECERTIFICATION IN THE OIL AND GAS INDUSTRY

BEZBEDNOST U ZAVARIVANJU KORIŠĆENJEM NOVOG MODELA RESERTIFIKACIJE ZAVARIVAČA ZA POTREBE NAFTNE I GASNE INDUSTRIJE

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Keywords
- safety
- certification
- welded joints
- welding processes
- competence in welding

Abstract

The paper presents a solution applied for determining the quality of the welding process in oil and gas industrial plants, as well as reliable verification of professional qualification of welding personnel. By applying the solution, welded joint quality can increase and thus the safety (especially in the field of high-pressure gas plants) and the reliability of the process in oil and gas-, petrochemical and nuclear plants, as a whole. The paper analyses safety aspects in the welding process, depending on the competence in welding and an appropriate qualification, taking into account that high levels of skill and competence are required where safety-critical items are fabricated. The results in the application of the new recertification model are presented and analysed, and it is emphasized that the areas of application of the new solution are wide, mainly applied in the oil and gas-, petrochemical industry, and the construction of nuclear plants. The application of the new model of Welders Recertification enables project savings, but also safety at work since the employer has a constant insight into the qualifications and welding capabilities of each welder.

Ključne reči
- bezbednost
- sertifikacija
- zavareni spojevi
- postupci zavarivanja
- stručnost u zavarivanju

Izvod

U radu je predstavljeno rešenje koje se primenjuje za određivanje kvaliteta procesa zavarivanja u industrijskim postrojenjima nafte i gasa, kao i pouzdana verifikacija profesionalne kvalifikacije zavarivačkog osoblja. Primenom ovog rešenja može se povećati kvalitet zavarenih spojeva, a samim tim i bezbednost (posebno u oblasti gasnih postrojenja visokog pritiska) i pouzdanost procesa, postrojenja za naftu i gas, petrohemijskih i nuklearnih postrojenja u celini. U radu se analiziraju aspekti bezbednosti tokom procesa zavarivanja u zavisnosti od kompetencije u zavarivanju i odgovarajuće kvalifikacije, uzimajući u obzir da su potrebni visoki stepeni stručnosti i kompetentnosti tamo gde se proizvode predmeti kritične bezbednosti. Predstavljeni su i analizirani rezultati primene novog modela resertifikacije, te je naglašeno da su područja primene novog rešenja široka, uglavnom za naftnu i gasnu industriju, petrohemijsku industriju i izgradnju nuklearnih postrojenja. Primena novog modela resertifikacije zavarivača omogućava uštedu na projektu, ali i bezbednost i zaštitu na radu, jer poslodavac ima stalan uvid u kvalifikacije i mogućnosti zavarivanja svakog zavarivača.

INTRODUCTION

Welding is considered to be a risky occupation due to well-known and subtle hazards to health and safety that occur in the short or long term. If sufficient protection measures are not taken, many potential hazards show up, and they can be rapidly fatal or have delayed effects, /1-3/. Welders may encounter many dangers if safety measures are ignored, such as burns, electric shock, overexposure to gases and fumes, explosions and fires, overexposure to toxic gases and hazardous substances, arc radiation, overexposure to vibration and noise, and heat stress, as shown in Table 1, /2, 3/. There are also many health problems connected to manual handling and ergonomics, so the welding profession can be classified as one of the riskiest ones.

Table 1. General hazards associated with welding.

	Welding process			
Hazard	PAW/PAC air carbon arc	SMAW GTAW GMAW FCAW	SAW	Oxyfuel
Heat, fire and burns	●	●	●	●
Electric shock	●	●	●	
Toxic fumes and gases	●	●	●	●
Ultraviolet radiation	●	●	●	
Vibration and noise	●			
Ergonomic	●	●	●	●

The welders' health can be jeopardized due to various factors, and major dangers involve exposure to heat, gases, fumes, radiation, and noise. Consequences can be fatal and permanent, like eye injury, burns, hearing impairment, and

even death. It is most important that sufficient safety measures are taken to protect the welder from potential hazards, including the mandatory use of personal protective equipment (PPE), as well as detailed checks on the ability and classification of the welders themselves.

Welding is generally considered to be a dangerous profession, but it involves a variety of working conditions and a wide range of processes. It should be noticed that different level of skill and competency is required due to different working conditions and processes. A high level of welders' skill and competency is always needed for the fabrication of safety-critical products, i.e., welding pressure vessels, but in general-purpose welding, it may not be so critical, /4-6/.

The personnel with relevant skill levels and competence should do welding; they must know the right procedure for doing the job, the potential dangers of the job, and how to prevent them and protect the welder from potential hazards. It should be emphasized that welders should not use the equipment they are not certified to handle, /2, 3/. The appropriate level of competence of welders is proven by an appropriate qualification, issued by a certified organisation for training welders, or based on relevant welding standards, /7-11/.

In the US, welder qualification is performed following ASME Section IX, ASME-Section II-ad AWS D1.1, API 582 and API 1104 standards /7, 12-17/, also used in some other countries in Africa and Asia, and even in Europe where plants or parts of plants are constructed following the requirements of ASME Section VIII-1 /18/. Some states have welding qualifications that exceed AWS qualifications, but most are committed to AWS, ASME, or APIs. In Canada, welder qualification is done according to CSA standards and ASME, /7, 19/. The ASME code is commonly used for the application of pressure vessels and pressure pipes, and the CSA standards are used for structural, general production and non-pressure applications. There are four main CSA standards by which welders can qualify: CSA W47.1 /19/ for steels (including stainless steels); CSA W47.2 /20/ for aluminium; CSA W186 /21/ for reinforcing bars; CSA W55 .3 for welding of steel and aluminium, /22/. According to these CSA standards, the Canadian Welding Bureau conducts a qualification test of welders every two years to ensure continuing competence. In Europe, the European Committee for Standardization (CEN) has adopted ISO standards on the qualification of welders (ISO 9606) /9/, which are a replacement for the old European series EN 287, /11/. Operators of automated welding systems are certified following EN 1418, /15/. In Europe, welders are often certified by third-party personnel certification, such as the Welding Institute (TWI/CSWIP). Welders involved in the production of equipment falling within the scope of the Pressure Equipment Directive must be approved by a competent third party which may be either a notified body or a third party organisation recognized by the Member State. Once a welder passes a test (or series of tests), their employer or the third party involved will confirm their ability to pass the test and the limits, or degree for which they are qualified to weld, as a written document (welder qualification record, or WKTR). This document is usually valid for a limited time (usually two years) after which the welder must be tested again. However, some qualifications are valid for only one project, while others are unlimited until welders pass a certain time without performing a certain type of welding (this period is usually 6 months). Welders must keep records to prove that they have maintained their qualifications.

This paper analyses the solution for rapid recertification of welders to ensure safe handling of equipment during welding and ensure the safety of the welded joint, all to ensure safety both during the welding process and during further operation of the system and plant. This solution can be applied to the work of the welders who will be engaged in company projects and that are performed outside the European Union, especially in African and Asian countries, where time constraints and urgency of work do not allow such frequent recertification as required by EN 9606 or BS287-1 /11/ and, on the other hand, it is necessary to check the professional competence of welders, which are not the requirements of the ASME standard because it is based on the certificate of the employer. The application of such a solution is presented and analysed, and a proposed procedure is a flexible solution according to which welders would be certified in a short period of time and without the presence of a certification body, which would make additional savings on company projects and provide safe and secure execution of the project.

WELDING HEALTH AND SAFETY DUE TO WELDERS' TRAINING, QUALIFICATIONS AND COMPETENCY

Inspections of welding equipment should be carried out periodically, which should be performed by qualified maintenance personnel who will issue certified inspection reports, within which it is necessary to define identifiers for inspection equipment, such as a serial number, /1, 4/.

Welders should be trained to use all protective equipment and taking into account the frequent dangers of heat, welders must be trained in adequate use of fire extinguishers and hot work permits if they are used.

To ensure all aspects of safety and health during the welding process, welders must have extensive knowledge, which is primarily provided by adequate training. However, given the fact that the welding process is a complex and hazardous operation, all aspects of safety cannot be fully provided by training alone, but experience, skill, and practice are of paramount importance for safe work practice, /6/.

Since experience and practice are extremely important in ensuring a safe and secure welding process, it is necessary to emphasize that welding safety is provided by teamwork. Especially, team leaders and experienced team members should actively train other team members for proper health and safety practices. This practice is extremely important when teams are faced with complicated or new tasks. Adequate detailed instructions for equipment adjustment, safe use, and maintenance are most often given by the manufacturer or supplier of the equipment and must be followed to ensure safe welding operation. For different welding processes, standard personal protective equipment (PPE) must always contain:

– eye protection,

– welding helmet with a suitable arc flash filter,
– flameproof overalls with long sleeves and neck fastenings,
– occupational protective gloves,
– respiratory protection.

The principles of health and safety at work require the employer to take all protective measures, in terms of adequate training and the provision of the necessary protective equipment, to prevent possible hazards and injuries to employees. Employers need to provide:
– necessary protective equipment,
– training and supervision of employee's,
– to carry out health monitoring (with employee's consent) when employees are exposed to significant hazards,
– involve employees in health and safety issues if possible.

In this sense, employers must have an accurate insight into the qualifications and level of competence of welders, ensured by the certification and recertification of welders. Training and certification of welders must be provided adequately, and must include information on appropriate ways to do the job, but also on possible hazards and ways to prevent them, incident, or damage reporting procedures, and how to use PPE. It is necessary to provide supervision until the competence of the welder is achieved, although sometimes supervision is always needed, i.e., confined space entry. After the competence of welders is ensured, recertification of welders is necessary in an adequate period.

Welder certification (also known as welder qualification) is a process that examines and documents the professional ability of welders to produce welded joints of the required quality level after a well-defined welding procedure, /1, 8/. The welders' certificate is based on specially designed tests to determine the skill and ability of the welder. The main part of the welders' test consists of welding one or more test specimens which are then tested by destructive and non-destructive methods. The scope of certification is described by the number of variables which include the specific welding process, the type of metal applied, the thickness, the construction of the joints, the position, and others.

Depending on the product's needs, the test can be conducted under the auspices of a national or international organisation, such as the American Welding Society (AWS) or the American Association of Mechanical Engineers (ASME), but manufacturers can also set their standards and requirements. Most certificates expire after a certain period of time and have different requirements for the renewal or extension of the certificate.

Certificates obtained according to ASME-Section IX /7/ or API standards /8/ do not require special recertification, but it is based on confirmation from the employer that the welder has worked on the welding of certain joints in the past. The most common problems in the application of this type of certification occur when the welder has done welding on structures and facilities of lower levels of danger (structures that require virtually no type of inspection other than visual inspection) or has made longer breaks and then when starting welding work in demanding plants such as welding gas and oil pipelines operating at high pressures, frequent errors occur. On the other hand, certificates according to European standards, EN 9606-1-4, /9, 10/, require professional qualification checks and recertification every six months, and in special cases, it can be extended to 2 or 3 years. The scope and short deadlines for completion of work, very often the urgency, especially in the oil and gas industry, requiring the continuous operation of the plant, fail to meet such stringent requirements, so outside the European Union welder certificates are not required according to EN 9606 /9-10/.

NEW WELDER RECERTIFICATION METHODOLOGY

Performance qualification tests aim to determine the ability of welders to make satisfactory welds. Any welder wishing to perform welding activities must be qualified following the latest editions of relevant welding standards. Welder qualification is performed for appropriate positions and appropriate welding processes, given in ASME and EN standards.

Each organisation must qualify each welder or welding operator for each welding process to be used in production welding. The performance qualification test includes welding following a qualified specific welding procedure (WPS) or standard welding procedure (SWPS), unless the performance qualification is performed in accordance with a WPS or SWPS requiring preheating or heat treatment after welding, where these may be omitted. A welder or welding operator preparing WPS qualification coupons is also qualified within the qualification limits for the specified performance and positions specified in the relevant document.

Each qualified welder and welding operator is assigned an identification number, letter, or symbol of the organisation to be used to identify the welder or welding operator. The record of welder qualification or welding work (WPQ) should contain essential variables from the latest edition of ASME Section IX, the type of test and test results and the ranges qualified according to the parameters, for each welder.

Required types of tests

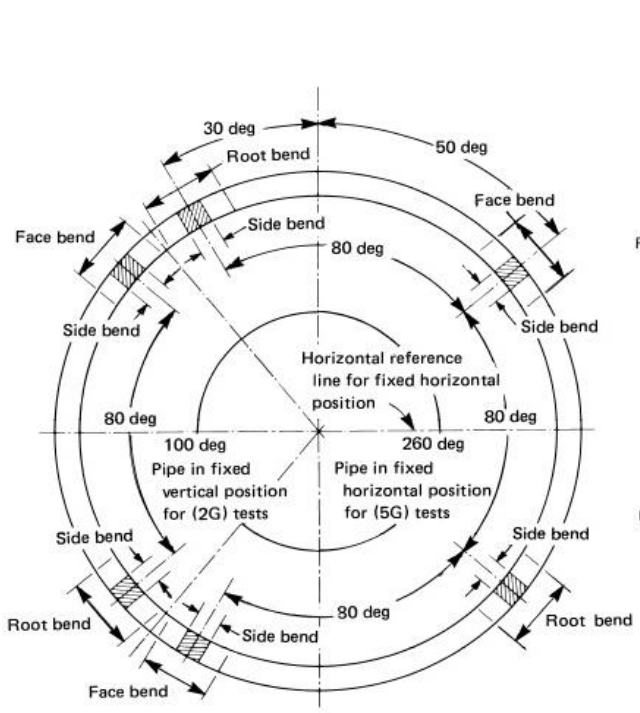
Except as specified for special welding procedures, type and number of test specimens required for mechanical testing shall follow the recommendations. Samples for testing welds are removed in a precisely defined manner, examples are shown in Fig. 1, /8/. All mechanical tests must meet the requirements prescribed in QW-160- or QW-180 of the latest edition of ASME Section IX, as appropriate.

Special welding positions

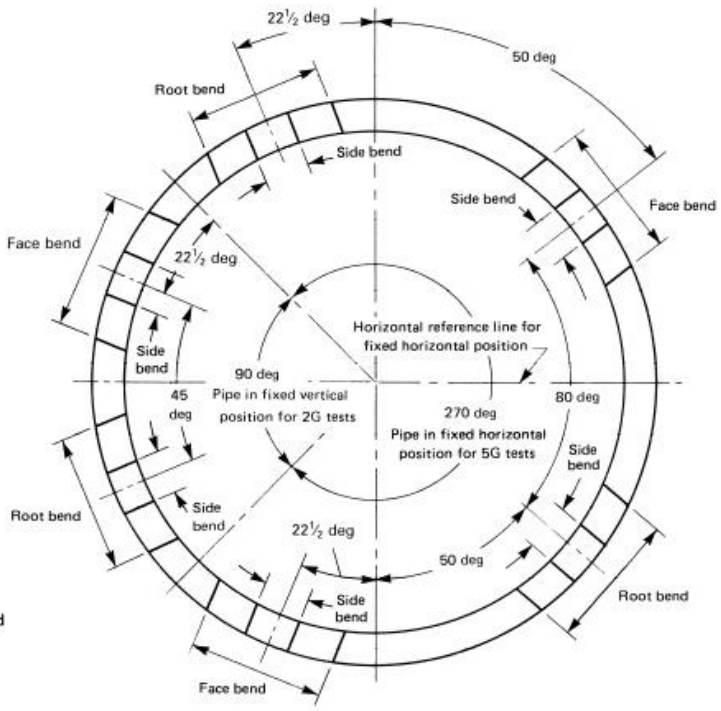
An organisation that produces welds in special positions can perform performance qualification tests for these specific positions. Such qualifications apply only to straight positions and to specially tested positions, where the angular deviation is allowed to be ±15 degrees in the inclination of the welding axis, by turning the face of the metal seam, as defined in Fig. 2, /8/.

Revalidation of welder qualification

The qualifications of the welder for the welding process should be confirmed every 6 months by the person responsible for welding or the tester/certified body. This confirms that the welder worked with the qualification range and extended the validity period of the qualification for another 6 months.



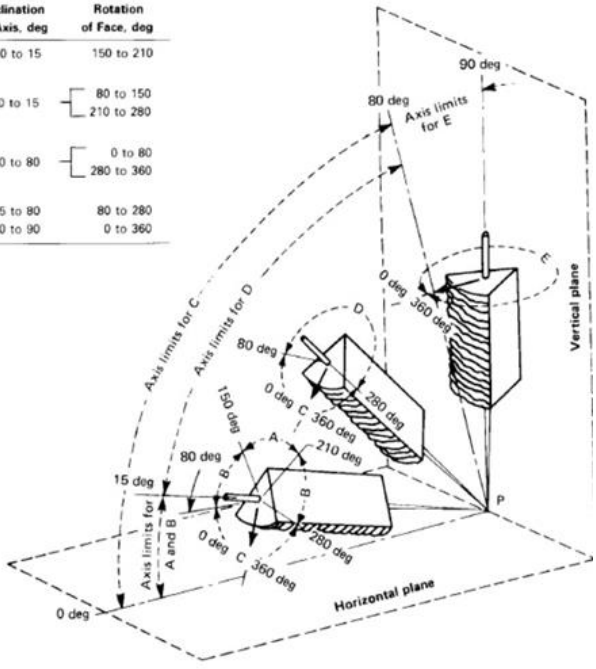
Pipe-NPS 10 (DN250) Performance qualification



NPS 6 (DN150) or NPS 8 (DN200) Assembly Performance qualification

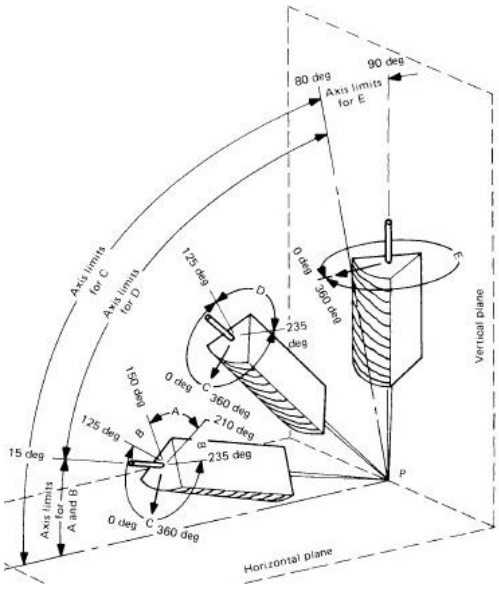
Figure 1. Performance qualification.

Position	Diagram Reference	Inclination of Axis, deg	Rotation of Face, deg
Flat	A	0 to 15	150 to 210
Horizontal	B	0 to 15	80 to 150 210 to 280
Overhead	C	0 to 80	0 to 80 280 to 360
Vertical	D E	15 to 80 80 to 90	80 to 280 0 to 360



Positions of welds-groove welds

Position	Diagram Reference	Inclination of Axis, deg	Rotation of Face, deg
Flat	A	0 to 15	150 to 210
Horizontal	B	0 to 15	125 to 150 210 to 235
Overhead	C	0 to 80	0 to 125 235 to 360
Vertical	D E	15 to 80 80 to 90	125 to 235 0 to 360



Positions of welds-Fillet welds

Figure 2. Positions of welds.

Revalidation of welder qualification is performed by the appropriate examiner/designated body for the qualification of welders. The skill of the welder will be periodically carried out according to one of the following methods:

(a) the welder is retested every 3 years;

(b) every two years, two welded joints made during the last 6 months of the validity period are tested by radiographic or non-destructive testing and registered. Levels of acceptance of imperfections must be specified according to ISO 9606-1: 2013 (for steels) or other relevant welding standards. Tested welds must reproduce the original test conditions, except for the thickness and outer diameter.

These tests confirm the qualifications of the welder for an additional two years. The following conditions must also be met:

- the welder works for the same manufacturer for which he qualified and who is responsible for the production of appropriate products;
- the manufacturer's quality program has been checked following ISO 3834-2 or ISO 3834-3;
- the manufacturer has documented that the welder has produced welded joints of acceptable quality, based on the application of the standard; the tested welds must confirm the following conditions; welding position (s) type of welding (FW, BW), substrate material (mb) or no substrate material (nb).

The welder's qualification mark contains the following items in the given order:

(a) the number of this part of ASME Section IX or ISO 9606 -2013;

(b) essential variables:
- welding procedures,
- product type: plate, pipe, etc,
- type of weld: butt welding (BW), fillet welding (FW),
- filling material or parent material group,
- types of filling materials,
- dimensions: thickness of sample, s or of material t, and outer diameter, D,
- welding places 1G, 2G, ...

Welding details: the type of protection and gas will not be included in the label but will be included in the welder's qualification test certificate.

RESULTS AND DISCUSSION

It is verified whether the welder has successfully passed the qualification test. All basic variables are recorded on the certificate. If the tested piece(s) do not pass any of the required tests according to the standard, the certificate is not given. The certificate is given under the sole responsibility of the examiner or the designated body that conducts the personnel qualification test in the field of welding. The examiner or the designated body for the verification of welding personnel is responsible for verifying that all major variables are addressed in this certificate.

Table 2 contains a list of samples specially made for the certification-recertification processes of welders according to the new model. Figures 3 and 4 show some of the developed samples for specific welding processes and welding carbon steels with carbon steels (CS-CS), stainless steels with stainless steels (SS-SS) as well as the case of combined welding of carbon steels with stainless steels (CS-SS). The test results of welded joints according to the new recertification methodology were conducted successfully in one company in the Republic of Tunisia and are presented in Figs. 5-8.

The most common problems in the application of the current type of certification in the countries of Asia and Africa and Indonesia, based on ASME Section IX and API, and also in the countries of the European Union where the plants are built in accordance with ASME standards (Section VIII and B31.3, B31. 4) occurred when the personnel who performed welding on structures and facilities of lower levels of danger (those types of structures that require only visual inspection after completion of welding) or ruled a long break and then when welding was performed in demanding plants

Table 2. Characteristics of test specimens.

TEST COUPON	DESCRIPTION
#1	CS-CS, PIPE DIA 3" (Thk=5.97mm), Welding position 6G Root pass (GTAW) – filler wire 70S6-CS, Ø2.4mm Hot pass (SMAW) – electrode E7016, Ø2.5mm Filling/capping (SMAW) – electrode E7016, Ø3.2mm
#2	CS-CS, PIPE DIA 10" (Thk=13.0mm), Welding position 6G Root pass (GTAW) – filler wire 70S6-CS, Ø2.4mm Hot pass (SMAW) – electrode E7016, Ø3.2mm Filling/capping (SMAW) – electrode E7016, Ø3.2mm
#3	SS(316L)-SS(316L), PIPE DIA 3" (Sch.10S), Welding position 6G Root pass (GTAW) – filler wire 316L, Ø2.4mm Hot pass (GTAW) – filler wire 316L, Ø2.4mm Filling/capping (GTAW) – filler wire 316L, Ø2.4mm
#4	SS(316L)-SS(316L), PIPE DIA 10" (Sch.80S), Welding position 6G Root pass (GTAW) – filler wire 316L, Ø2.4mm Hot pass (GTAW) – filler wire 316L, Ø2.4mm Filling/capping (GTAW) – filler wire 316L, Ø2.4mm
#5	CS(API5L)-SS(316L), PIPE DIA 2" (Sch.40-Sch.40S), Welding position 6G Root pass (GTAW) – filler wire 309L, Ø2.4mm Hot pass (GTAW) – filler wire 309L, Ø2.4mm Filling/capping (GTAW) – filler wire 309L, Ø2.4mm
#6	CS(API5L)-SS(316L), PIPE DIA 10" (Sch.80-Sch.80S), Welding position 6G Root pass (GTAW) – filler wire 309L, Ø2.4mm Hot pass (SMAW) – electrode 309L, Ø3.2mm Filling/capping (SMAW) – electrode 309L, Ø3.2mm

such are welding of gas and oil pipelines (especially main) that work at high pressures, there were frequent errors in welded joints, on the one hand, while on the other hand the existing employer or new employer (if certain welders changed jobs) did not have clear insight into the actual expertise of the staff as the information on the qualification of the welder was based only on certain types and employer certificates. Such approaches have led to a large number of side effects, especially in the oil and gas industry, primarily because welded joints where the aforementioned defects were found in the welded joints required subsequent repair welding, additional inspections, increased project costs, and of course safety was in a high-risk category in these cases.

Figure 3. Butt weld joint SS-SS.

Figure 4. Butt weld joint CS-SS, CS-CS and SS-SS.

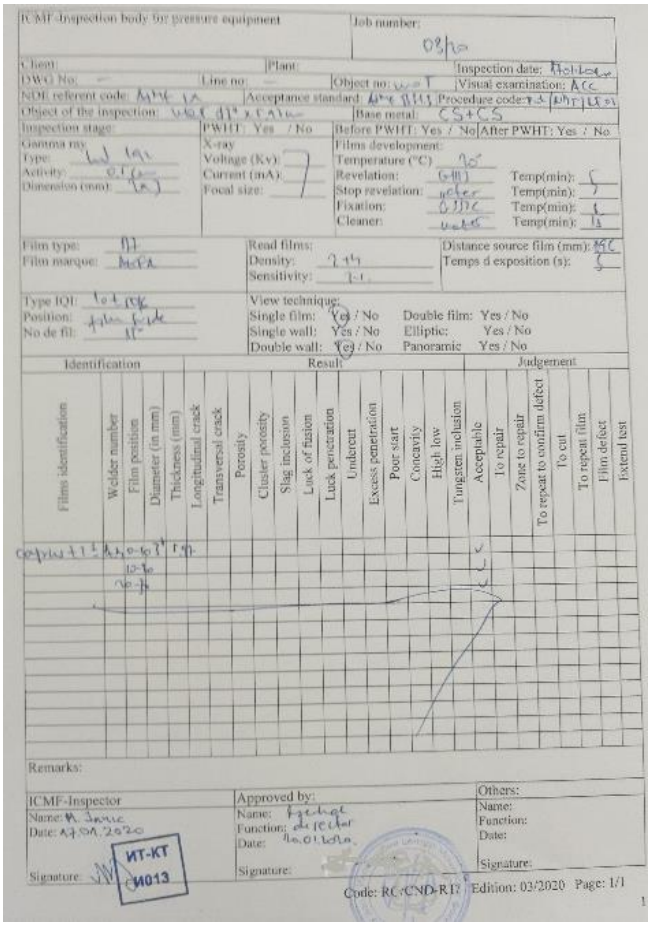


Figure 5. Results of examination of butt weld joint CS-CS.

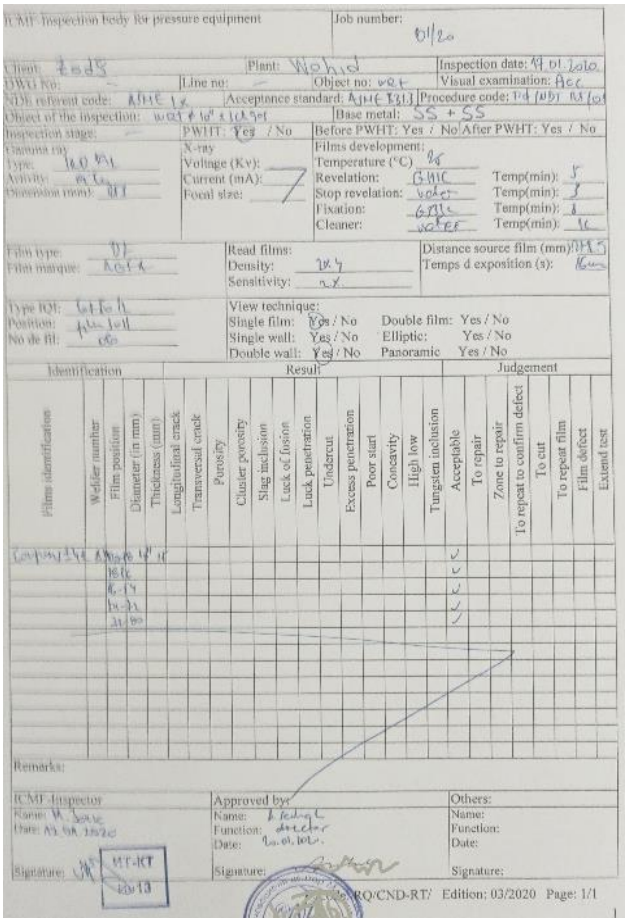


Figure 6. Results of examination of butt weld joint SS-SS.

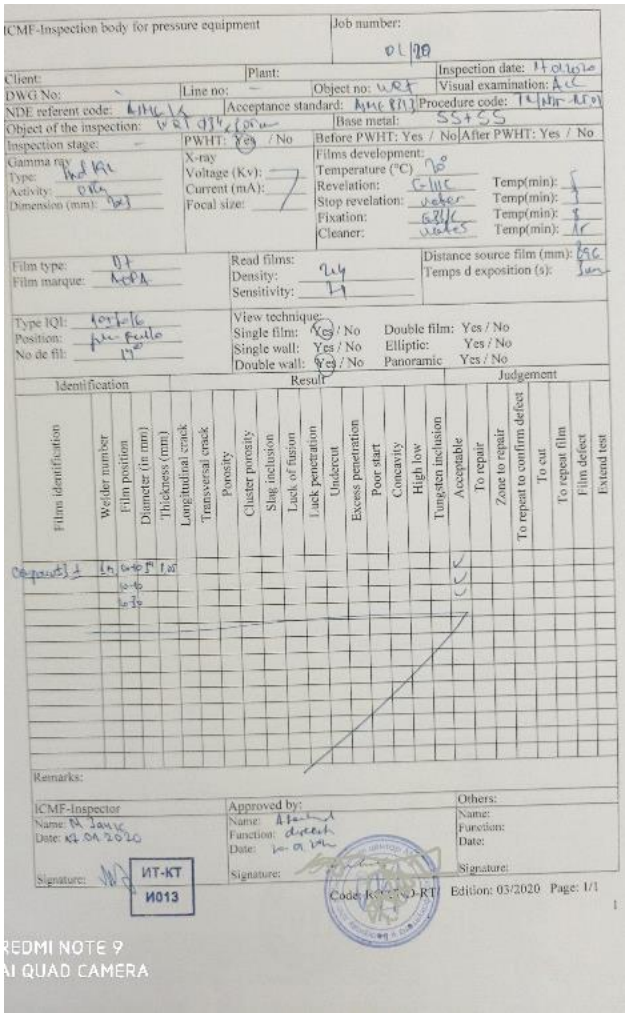


Figure 7. Results of examination of butt weld joint SS-SS.

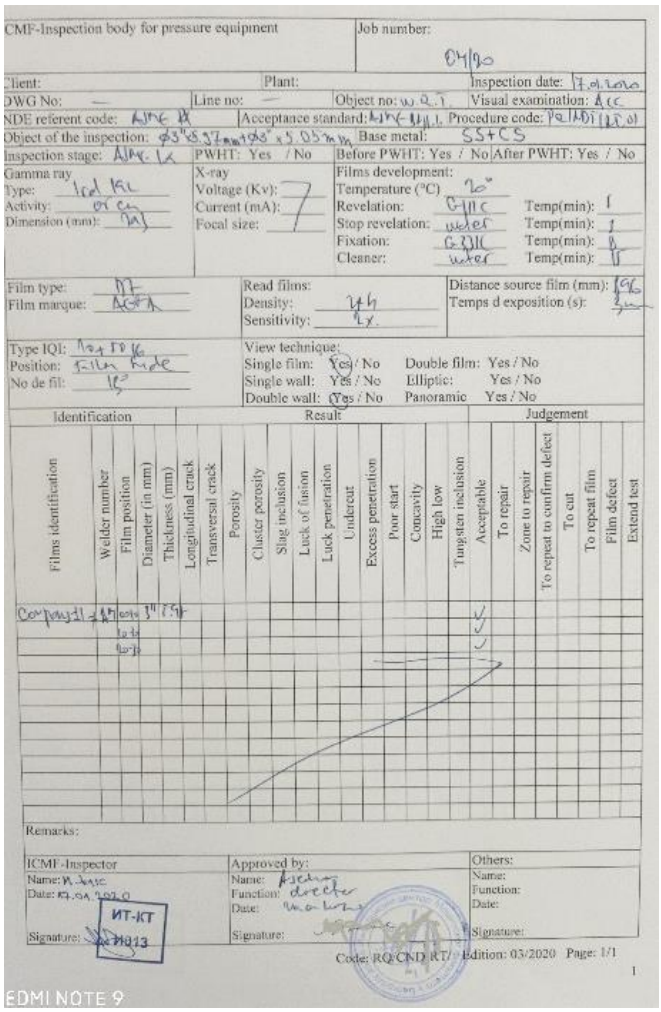


Figure 8. Results of examination of butt weld joint SS-CS.

CONCLUSIONS

This paper presents a very flexible variant and a unique solution to the previously described problem which, with relatively low financial resources and practical workshop conditions, allows employers who manufacture pressure equipment to check the professional qualifications of welding personnel on-site and at any time and with minimal financial resources, especially before starting the production of high-level equipment.

The results of this solution are applied to check the professional competence of welding personnel in oil and gas plants when it is necessary in the shortest possible time and at the lowest possible cost to check the ability of welding personnel before performing welding work on demanding facilities and especially high-pressure equipment, with high levels of danger.

The application of this solution enables the certification of welding personnel without the presence of appropriate certification bodies (certification of personnel practically in workshop conditions and with minimal costs) thus the user of the solution achieves significant savings on their projects on the one hand, and on the other hand has available information welding at all times, thus increasing safety.

By applying this methodology, the user of the solution achieves additional savings on their projects on the one hand because this approach allows him to see the actual professional skills of welders at any time, which allows proper delegation of personnel for certain welding jobs in accordance with their professional skills and thus reducing repair costs. i.e. welding and additional costs for the needs of repair welding (hiring cranes and cranes and additional means of transport, additional hiring of highly qualified welding engineers and inspectors and inspectors for welded joints) and thus lowering the project cost and ensuring a high level of safety as a whole.

ACKNOWLEDGEMENTS

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REFERENCES

1. Harris, M.K., Welding Health & Safety: A Field Guide for OEHS Professionals, Virginia: American Industrial Hygiene Association, 2002.
2. Blunt, J., Balchin, N.C., Health and Safety in Welding and Allied Processes, 5th Ed., Woodhead Publishing, 2002.

3. Safety in Welding and Cutting: Safety in Welding, Cutting, and Allied Processes, Supersedes ANSI Z49.1:2012, American Welding Society, 2012.
4. Veljić, D., Sedmak, A., Rakin, M., et al. (2015), *Advantages of friction stir welding over arc welding with respect to health and environmental protection and work safety*, Struct. Integ. and Life, 15(2): 111-116.
5. Olsen, F.O. (ed.), Hybrid Laser-Arc Welding, Woodhead Publishing, 2009.
6. Timings, R., Fabrication and Welding Engineering, Routledge, Elsevier, Oxford, 2008.
7. ASME-Boilers and pressure vessels code-Section IX-Welding, brazing and fusing qualifications, ASME, 2017.
8. API 577 - Welding processes inspection and metallurgy, API, 2013.
9. EN9606, Qualification testing of welders - Fusion welding - Part 1: Steels, IOS, 2012.
10. EN9606, Qualification testing of welders - Fusion welding - Part 2: Aluminium and aluminium alloys, IOS, 2012.
11. BS287-1, Qualification testing of welders - Fusion welding - Part 1: Steels, BSI, 2012.
12. API 1104 - Welding of Pipelines and Related Facilities, API, 2013.
13. ASME-Boilers and pressure vessels code-Section II: materials - part A Ferrous material specifications, ASME, 2017.
14. ASME-Boilers and pressure vessels code-Section II: materials - part B Non-ferrous material specifications, ASME, 2017.
15. ASME-Boilers and pressure vessels code - Section II: materials - C Specifications for welding rods, electrodes, and filler metals - materials, ASME, 2017.
16. ASME-Boilers and pressure vessels code - Section II: materials - D Properties - (customary), ASME, 2017.
17. API-RP-582 Welding Guidelines for the Chemical, Oil, and Gas Industries, ASME, 2016.
18. ASME-Boilers and pressure vessels code - Section VIII - Division 1 - Rules for construction of pressure vessels division 1, ASME, 2017.
19. Canadian standard - CSA W47.1 Certification of Companies for the fusion welding of steel, CWB Group, 2019.
20. Canadian standard - CSA W47.2 Certification of Companies for the fusion welding of aluminium, CWB Group, 2019.
21. Canadian standard - CSA W186-Welding of reinforcing bars, CSA Group, 2021.
22. Canadian standard - CSA W55.3- Certification of companies for resistance welding of steel and aluminium, CWB Group, 2008.

ESIS ACTIVITIES

CALENDAR OF CONFERENCES, TC MEETINGS, and WORKSHOPS

September 8-10, 2021	ESIAM21 Virtual Conference – 2nd European Conference on the Structural Integrity of Additively Manufactured Materials	ESIS - TC15	https://esiam.eu/
September 21-24, 2021	CP2021 - The 7th International Conference on Crack Paths *online and on-demand*	ESIS - TC3	link - flyer
September 26-30, 2021	1st Virtual ESIS TC4 Conference on Fracture of Polymers, Composites and Adhesives	Elsevier	link
June 25–26, 2022	7th Summer School on 'Fracture Mechanics and Structural Integrity'	Funchal, Madeira, Portugal	link
June 27–July 01, 2022	23rd European Conference on Fracture - ECF23	Funchal, Madeira, Portugal	link