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# Program Document WLDBOK

**PD 6103**

**WLDBoK-001/PL-2 REV. N/A**

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BODY OF KNOWLEDGE:

ROLE DESCRIPTION: RESISTANCE SPOT AND SEAM WELDING
SPECIAL PROCESS: Welding
SCOPE: Resistance Welding
METHOD: Performance of Resistance Spot and Seam Welding Requirements
LEVEL: Planner

All eQuaLified examinations are created using the applicable eQuaLified Body of Knowledge (BoK), which defines the baseline knowledge and experience required to be considered competent to perform the specified job role in aerospace special process manufacturing.

All eQuaLified BoKs are created by subject matter experts through an exhaustive job analysis process as detailed in the eQuaLified Program Document 6100: Industry Managed Special Process Bodies of Knowledge. All eQuaLified BoKs are updated periodically according to the requirements of the current eQuaLified PD6100 document to ensure they are consistent with current industry practice.

## 1. INTRODUCTION

This document has been created by the eQuaLified Welding Body of Knowledge Review Board (WLD BoKRB) according to the requirements of eQuaLified Program Document PD6100 Industry Managed Special Process Bodies of Knowledge.

This document consitutes the eQuaLified BoK for (Welding, Resistance Spot and Seam, Planner). It defines the baseline knowledge and experience required to be considered competent to perform this role.

Unless otherwise stated, the WLD BoKRB has followed guidelines as detailed in the current version of International Aerospace Quality Group (IAQG) Guidance PCAP 001 (Competence Management Guideline) to develop this BoK.

The information in this BoK will provide guidance for the following:

- Training providers who wish to develop training courses intended to support eQuaLified examination candidate preparation
- Welding Examination Review Board (WLD-ERB) for the development of eQuaLified examinations
- Candidates taking eQuaLified examinations who wish to prepare in advance

## 2. REFERENCES

eQuaLified documents:


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| | |
|---|---|
| PD6000 | Governance & Administration of eQuaLified Program |
| PD6100 | Industry Managed Special Process Bodies of Knowledge |
| PD6200 | Industry Managed Special Process Examinations System |

IAQG documents: IAQG Guidance PCAP 001 Competence Management Guideline

## 3. DEFINITIONS

**Definitions described within are specific to the Special Process BoK. For program-specific definitions, please refer to either the PD 6000 or the eQuaLified Dictionary.**

BODY OF KNOWLEDGE (BoK): Baseline knowledge and experience required to be considered competent for a target position.

EXPERIENCE: The accumulation of knowledge or skill that results from direct participation in events or activities over a period of time.

GENERAL EXAMINATION: The General Examination is designed to ascertain the candidate's general knowledge required for a particular job, role or activity. All of the questions will be derived from the corresponding BoK.

KNOWLEDGE: Information / understanding acquired over a period of time. Information acquired through study and retained over that period of time (education, training, experience etc.) The combination of data and information, to which is added expert opinion, skills and experience, to result in a valuable asset which can be used to aid decision making and problem solving.

LEVEL: A class or division of a group based on education, training and experience. There are **3** levels: Operator/Technician, Planner and Owner. Please refer to the current version of PD 6000 for definitions

METHOD: A well-defined division of a SPECIAL PROCESS widely recognised by industry. A specific area of a special process for example anodizing within Chemical Processing

NON-SPECIAL PROCESS RELATED REQUIREMENTS: Miscellaneous requirements such as Health and Safety, Environmental, etc.

PERSONAL ATTRIBUTES: A quality or characteristic expected and required for a particular job, role or activity.

PRACTICAL EXAMINATION: The Practical Examination shall consist of a demonstration of proficiency in performing tasks that are typical of those to be accomplished in the performance of the candidate's duties. The examination content is derived from the corresponding BoK.

SKILL: Ability to perform a particular task. The quality of being able to do something that is acquired or developed through training or experience.

SPECIFIC EXAMINATION: The Specific Examination shall cover requirements and use of the specifications, codes, equipment, operating procedures and test techniques the candidate may use in the performance of his/her duties with the employer. Examination content will be derived from the corresponding BoK where applicable.

WEIGHTING: The "weighting" of each line item, using a scale of 1, 3, 7, 10, (1 being least important; 10 being most important) indicates the relative importance of that aspect of the BoK and will determine the likelihood and frequency of a question on that topic appearing in the examination

## 4. GUIDANCE TO EXAMINATION CANDIDATES

All eQuaLified examination candidates are recommended to read all documents referenced in section 2 of this document.

As stated in eQuaLified PD6200, every eQuaLified exam question shall relate directly to and be derived from the information as detailed in the current version of the BoK.

Re-assessment to this BoK is required every 5 years, unless otherwise specified.

Candidates are therefore advised to ensure familiarity with all aspects of the BoK as detailed in Table 1. This can be done through:

- Self-study
- Completion of internal training
- Completion of external training (a list of eQuaLified approved providers can be found at www.eQuaLified.com)

Records of all qualified personnel shall be maintained and include:

- Date of Qualification
- Results of Written
- Results of Practical (if applicable)
- Results of Experience

## 5. LEVELS

| | Level | | |
|---|---|---|---|
| **Descriptors** | **Operator/Technician (OP/T)**<br>*Understand and perform the hands-on operations of the special process for which qualification is sought.* | **Planner (PL)**<br>*Capable of selecting manufacturing processes and creating the process procedures to conform to customer specification and requirements.*<br><br>*Capable of problem solving and resolving day to day issues.* | **Owner (OW)**<br>*Capable of writing, reviewing and approving processes, procedures and qualifications of Operators and Planners. Capable of designing new processes and resolving issues among other levels.* |
| **Welding Process Specific Criteria** | No additional criteria for the Welding process. | No additional criteria for the Welding process. | No additional criteria for the Welding process. |
| **Technical Knowledge** | Basic knowledge of the special process, its main processes, methods and tools. | Good level of knowledge in all aspects of the special process, all its processes, methods and tools.<br><br>Ability to coach others on contents and methods in the context of their workplace. | High or extensive knowledge in all aspects of the special process, all its processes, methods and tools to assess and validate improvements.<br><br>Able to contribute to set externally recognized standards.<br><br>Ability to define contents and methods for using knowledge effectively in influencing and developing international processes. Ability to influence the process with one's knowledge. |
| **Experience** | Sufficient experience to deal with recurrent activity. | Has enough experience to deal with unforeseen issues. | Wide proven experience of the subject. Is recognized specialist within the special process. |
| **Personal Attributes** | Takes into consideration behavioral characteristics such as but not limited to: team working, communication, direction and purpose, innovation and problem solving, mutual trust and respect, confidentiality and trustworthiness. | | |
| **Skills** | Describes the activities necessary to perform each level of job function to comply with the Body of Knowledge | | |
| **Non-Special Process Related Requirements** | Health & Safety, Environmental, Quality System Requirements, RCCA, Contract Review. | | |

**TABLE 1**

**ROLE DESCRIPTION: Resistance Seam and Spot Welding**
**SCOPE: Resistance Welding**
**METHOD: Performance of Resistance Welding Requirements**
**LEVEL: Planner**

| Row # | COMPETENCE | Weight (1,3,7,10) | Exam Type Gen/Specific /Practical | Reference Guidelines |
|---|---|---|---|---|
| | **KNOWLEDGE:** The basic knowledge of the special processes, methods and tools | | | |
| **1** | **GENERAL KNOWLEDGE** | | | |
| 2 | Fundamentals of resistance welding process. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 3 | Overview of resistance welding processes, advantages and limitations. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 4 | Basic resistance welding variables including the relationship of welding current, pressure, resistance and time and the influence of welding parameters on weld quality. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 5 | Commonly welded materials and their individual properties. | 10 | Gen | AWS C1.1M/C1.1, AWS WHB-3.9 |
| 6 | Standard terms and definitions | 10 | Gen | AWS A3.0M/A3.0, AWS D17.2/D17.2M, AWS C1.1M/C1.1, ISO 17677-1 |
| 7 | Welding symbols – drawing interpretation | 10 | Gen | AWS A2.4 |
| **8** | **MACHINES** | | | |
| 9 | Basic resistance welding equipment including press-type and rocker-arm type machines. | 10 | Gen | AWS RWMA BULLETIN 16, AWS WHB-3.9 |
| 10 | Current power sources (SCR, Inverter, Single- and Three-Phase). | 10 | Gen | AWS RWMA BULLETIN 5, AWS WHB-3.9 |
| 11 | Welding cycles/schedules - terms (preheat current, impulse, hold time, forging force etc.), types (single-impulse, complex) | 10 | Gen | AWS RWMA RWM, ISO 17677-1 |
| 12 | Machine qualification - purpose of machine qualification | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 13 | Test specimens - material groups, weld class, thickness, specimen size, number of test specimen | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 14 | Testing requirements - test methods (visual, NDT, mechanical tests, metallography), acceptance criteria, machine qualification test reports | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 15 | Laboratory testing and inspection equipment requirements | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 16 | Machine qualification scope - weld class, thickness range | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 17 | Machine re-qualification - conditions requiring re-qualification | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 18 | Calibration - devices requiring calibration (pressure and/or force gages) | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 19 | Equipment maintenance - importance of an effective machine maintenance program | 10 | Gen | AWS C1.1M/C1.1, AWS RWMA RWM |
| 20 | General maintenance - e.g. lubrication, housekeeping | 10 | Gen | Equipment manufacturer's manual, AWS C1.1M/C1.1, AWS RWMA RWM |
| 21 | Preventive maintenance program - maintenance procedure and schedule (daily, weekly, monthly, etc.), responsibilities, equipment monitoring techniques. | 10 | Gen | Equipment manufacturer's manual, AWS C1.1M/C1.1, AWS RWMA BULLETIN 14, AWS D17.2/17.2M, AWS WHB-3.9 |
| 22 | Maintenance records | 10 | Gen | AWS RWMA BULLETIN 14, AWS RWMA RWM, AWS C1.1M/C1.1, AWS WHB-3.9, AWS D17.2/D17.2M |

| Row # | COMPETENCE | Weight (1,3,7,10) | Exam Type Gen/Specific/ Practical | Reference Guidelines |
|---|---|---|---|---|
| **23** | **ELECTRODES** | | | |
| 24 | Electrode alloys (RWMA classification) and alloy selection for combinations of different base materials and/or thicknesses used for resistance welding. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338, RWMA RWM, AWS RWMA BULLETIN 34 |
| 25 | Contact tip geometry effect on weld nugget shape. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 26 | Electrode alignment effect on resulting surface indentation and weld nugget shape. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 27 | Electrode cooling and methods used for cooling. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 28 | Electrode maintenance to control contamination and shape changes of electrode tip dimensions including criteria for electrode dressing and frequency of changes. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 29 | Control of electrode identification, purchasing and receiving Inspection. | 10 | Gen | Electrode manufacturer's specifications |
| **30** | **FIXTURES AND TOOLING** | | | |
| 31 | The need to use non-conducting and non-magnetic materials in the design of fixtures/tools. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 32 | How to prevent shunting. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 33 | That magnetic materials must not be located in the magnetic field of the welding machine. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| 34 | Maintenance of fixtures and tools. | 10 | Gen | AWS RWMA RWM, AWS D17.2/D17.2M, ISO 16338 |
| **35** | **PRE-WELD PREPARATION** | | | |
| 36 | Part surface preparation (cleanliness) and effect on weld quality. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M, ISO 16338 |
| 37 | Selection of cleaning materials and methods used to remove contaminants and oxides. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M, ISO 16338 |
| 38 | Part surface fit-up/gaps and effect on weld quality. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M, ISO 16338 |
| 39 | Control of tack welding (fusion and resistance) and effect on weld quality. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M, ISO 16338 |
| 40 | Measurement and control of surface resistance (aluminum and magnesium alloys) | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M, ISO 16338 |
| 41 | Effect of time laps between cleaning and welding. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M |
| 42 | Process sequence between welding and heat treatment when welding heat treatable alloys. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 43 | Effect of different material thicknesses and dissimilar materials on nugget location and methods to locate the nugget at the faying surface. | 10 | Gen | AWS RWMA RWM, AWS WHB-3.9 |
| **44** | **WELDING PROCEDURE CERTIFICATION** | | | |
| 45 | Purpose of welding procedure certification | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 46 | Standard certification versus Design allowable certification | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 47 | Test specimens, test versus production conditions - material, thickness, size, heat treat condition, surface condition, sample shape, overlap, edge distance, tack welds, spot spacing | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 48 | Procedure certification testing - test methods, number of test specimens for welding process (spot, seam) and weld class. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 49 | Acceptance criteria | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |

| Row # | COMPETENCE | Weight (1,3,7,10) | Exam Type Gen/Specific/ Practical | Reference Guidelines |
|---|---|---|---|---|
| 50 | Procedure certification test reports requirements - examination data and results | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 51 | Conditions requiring procedure re-certification | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| **52** | **PRODUCTION VERIFICATION TESTING** | | | |
| 53 | Purpose of production verification testing (production witness specimens) | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 54 | Test specimens - test versus production conditions: material, thickness, heat treat condition, surface condition, sample shape, overlap, edge distance, tack welds (both resistance or fusion), spot spacing | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 55 | Testing requirements - number of test samples, frequency of testing, test methods (visual, metallography, shear test, etc.) | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 56 | Acceptance criteria | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 57 | Test records - logbook maintenance | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| **58** | **INSPECTION OF PRODUCTION PARTS** | | | |
| 59 | Test methods used to evaluate weld quality on production parts - Visual, NDT | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 60 | Inspection equipment requirements. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 61 | Weld classes and the differences in the acceptance criteria. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 62 | Calibration of dimensional measurement equipment. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 63 | Understanding of qualification requirements for Visual Weld Inspectors | 10 | Gen | |
| **64** | **TESTING** | | | |
| 65 | Test methods involved in resistance welding process control - visual, NDT, mechanical, metallography, and electrical (surface resistance) | 10 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1, AWS D17.2/D17.2M, ISO 16338 |
| 66 | Measurement of resistance spot and seam weld features including nugget size, minimum penetration, maximum penetration, indentation, sheet separation, clear zone, expulsion, surface imperfections, and internal imperfections. | 10 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1, AWS D17.2/D17.2M, ISO 16338 |
| 67 | Coring in nickel-base alloys | 7 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1 |
| 68 | Heat affected zone in commercially-pure titanium, metallographic nugget size measurement | 7 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1 |
| 69 | Weld defects and possible causes | 10 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1 |
| 70 | Laboratory testing and inspection equipment requirements. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 71 | Calibration of laboratory testing equipment. | 10 | Gen | AWS D17.2/D17.2M, ISO 16338 |
| 72 | Lab and NDT personnel qualification - general knowledge | 10 | Gen | AWS RWMA RWM, AWS C1.1M/C1.1 |
| **73** | **OPERATOR QUALIFICATION** | | | |
| 74 | Welding operator qualification procedure - experience (OJT), training, testing, and oversight | 10 | Gen | AWS C1.5, AWS RWMA RWM, AWS C1.1M/C1.1 |
| 75 | Re-qualification requirements | 10 | Gen | AWS C1.5 |
| **76** | **SAFETY** | | | |
| 77 | Health and safety related to resistance welding equipment. | 10 | Gen | AWS C1.1M/C1.1, ANSI Z49.1, Equipment manufacturer Operating Manuals, AWS WHB-3.9, AWS RWMA RWM |
| 78 | Local safe working requirements. | 10 | Gen | Local requirements |

| Row # | COMPETENCE | Weight (1,3,7,10) | Exam Type Gen/Specific/ Practical | Reference Guidelines |
|---|---|---|---|---|
| **79** | **SKILLS:** Defined within these rolls describes the range of skills. The skills required to perform a particular special process task | | | |
| 80 | Ability to read, understand and interpret drawings, specifications and customer flown-down requirements | | | |
| 81 | Ability to convey complete and through work instructions and procedures | | | |
| 82 | Ability to verify, validate, and certify the qualification and witness test results | | | |
| 83 | Apply technical knowledge when solving problems | | | |
| 84 | Must be able to set-up equipment | | | |
| 85 | Ability to identify training needs and coordinate the training | | | |
| 86 | Good communicator at all levels | | | |
| **87** | **PERSONAL ATTRIBUTES:** Are statements that will enable judgment of the person's personal attributes | | | |
| 88 | Be able to work independently with a minimum of supervision | | | |
| 89 | Must have a high degree of integrity | | | |
| 90 | Be attentive to details | | | |
| 91 | Be flexible | | | |
| 92 | Tolerate stress | | | |
| 93 | Exhibit conflict resolution | | | |
| 94 | Decision making ability | | | |
| 95 | Team Worker | | | |
| 96 | Ethical Behavior | | | |
| 97 | Exhibit Leadership | | | |
| **98** | **EXPERIENCE:** Are the minimum experience requirement expected to demonstrate their competence. | | | |
| 99 | EDUCATION | | | |
| 100 | High School Diploma or GED or Secondary Education | | | |
| 101 | Apprenticeship | | | |
| 102 | Industry Training or Courses | | | |
| **103** | **NON-SPECIAL PROCESS RELATED REQUIREMENTS:** Defined within these rolls are other general or pre-requisite needed | | | |
| 104 | Thorough understanding of Quality Systems per AS9100 or equivalent | | | |
| 105 | Thorough understanding of Control of Non-Conformance for equipment and product including Containment, Customer notification and disposition | | | |
| 106 | Thorough understanding of Root Cause and Corrective Action (RCCA) tool | | | |
| 107 | Responsible for conducting periodic self-audits | | | |

**ADDENDUM 1**

**LIST OF INTERNATIONAL STANDARDS FOR WELDING**

*NOTE: The standards below are listed as reference only, and may not be directly linked to the requirements in Table 1 above.*

| SPECIAL PROCESS | DOCUMENT TITLE | DOCUMENT NUMBER |
|---|---|---|
| Resistance Welding | Safety in Welding, Cutting, and Allied Processes | ANSI Z49.1 |
| Resistance Welding | Specification for Calibration and Performance Testing of Secondary Current Sensing coils and Weld Current Monitors Used in Single-Phase AC Welding | AWS A10.M:2007 |
| Resistance Welding | Standard Symbols for Welding, Brazing, and Nondestructive Examination - 7th Edition | AWS A2.4 |
| Resistance Welding | Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying - 12th Edition | AWS A3.0M/A3.0 |
| Resistance Welding – Spot and Seam | Recommended Practices for Resistance Welding - 5th Edition | AWS C1.1M/C1.1 |
| Resistance Welding – Spot and Seam | Specification for the Qualification of Resistance Welding Technicians - Second Edition | AWS C1.5 |
| Resistance Welding – Spot and Seam | Specification for Resistance Welding for Aerospace Applications | AWS D17.2/D17.2M |
| Resistance Spot & Seam Welding | Specification for Resistance Welding Controls | AWS J1.1M/J1.1:2013 |
| Resistance Spot & Seam Welding | Specification for AWS Certification of Resistance Welding Technicians - 1st Edition | AWS QC20 |
| Resistance Welding – Spot and Seam | Resistance Welding Control Standards | AWS RWMA BULLETIN 5 |
| Resistance Welding – Spot and Seam | Maintenance Manual for Resistance Welding Machines | AWS RWMA BULLETIN 14 |
| Resistance Welding – Spot and Seam | Resistance Welding Equipment Standards | AWS RWMA BULLETIN 16 |
| Resistance Welding – Spot and Seam | Manufacturer's Cross References of Standard Resistance Welding Electrode Numbers and Alloys | AWS RWMA BULLETIN 34 |
| Resistance Welding – Spot and Seam | Resistance Welding Manual - 4th Edition | AWS RWMA RWM |
| Resistance Welding | Welding Handbook 9th Edition, VOL. 3 – Welding Processes, Part 2 | AWS WHB-3.9 |
| Resistance Spot & Seam Welding | Electrode taper fits for spot welding equipment - Dimensions | ISO 1089:1980 |
| Resistance Spot & Seam Welding | Resistance welding — Procedures for determining the weldability lobe for resistance spot, projection and seam welding | ISO 14327:2004 |
| Resistance Spot & Seam Welding | Quality requirements for welding — Resistance welding of metallic materials — Part 1: Comprehensive quality requirement | ISO 14554-1:2013 |
| Resistance Spot & Seam Welding | Quality requirements for welding — Resistance welding of metallic materials — Part 2: Elementary quality requirements | ISO 14554-2:2013 |
| Resistance Spot & Seam Welding | Specification and qualification of welding procedures for metallic materials — Welding procedure test - Spot, seam and projection welding | ISO 15614-12:2014 |
| Resistance Spot & Seam Welding | Welding for aerospace applications - Resistance spot and seam welding - First Edition | ISO 16338 |
| Resistance Welding – Spot and Seam | Resistance welding - Vocabulary - Part 1: Spot, projection and seam welding | ISO 17677-1 |
| Resistance Spot & Seam Welding | Resistance welding equipment — Transformers — General specifications applicable to all transformers | ISO 5826:2014 |