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## Program Document WLDBOK

PD 6103

WLDBoK-001/PL-2 REV. A

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### BODY OF KNOWLEDGE:

**ROLE DESCRIPTION:** PLANNER

**SPECIAL PROCESS:** Welding

**METHOD:** Performance of Resistance Spot and Seam Welding Requirements

All PRI Qualification<sup>SM</sup> program examinations are created using the applicable PRI Qualification<sup>SM</sup> program 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 BoKs are created by subject matter experts who participate in the PRI Qualification<sup>SM</sup> Body of Knowledge Review Boards. All BoKs are updated periodically according to the latest revision of PRI Qualification<sup>SM</sup> program documentation (PD6100: Industry Managed Special Process Bodies of Knowledge) to ensure consistency with current industry practice.

## 1. INTRODUCTION

This document has been created by the PRI Qualification<sup>SM</sup> program Welding Body of Knowledge Review Board (WLD-BoKRB) according to the requirements of PD6100.

This document constitutes the PRI Qualification<sup>SM</sup> program 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 revision 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 PRI Qualification<sup>SM</sup> program examination candidate preparation
- Welding Examination Review Board (WLD-ERB) for the development of PRI Qualification<sup>SM</sup> program examinations
- Candidates taking PRI Qualification<sup>SM</sup> program examinations who wish to prepare in advance

## 2. REFERENCES

PRI Qualification<sup>SM</sup> program documents:

PD6000	Governance & Administration of PRI Qualification <sup>SM</sup> 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 PRI Qualification<sup>SM</sup> 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 PRI Qualification<sup>SM</sup> program examination candidates are recommended to read all documents referenced in section 2 of this document.

As stated in PRI Qualification<sup>SM</sup> program document PD6200, every 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 Approved Training Providers can be found at <https://p-r-i.org/>)

Records of all qualified personnel shall be maintained and include:

- Date of Qualification
- Results of Written Exam
- Results of Practical Exam (if applicable)
- Summary of Experience (Owner level only)

5. LEVELS

Level			
Descriptors	Operator/Technician (OP/T) <i>For descriptions, please refer to current version of PD6000</i>	Planner (PL) <i>For descriptions, please refer to current version of PD6000</i>	Owner (OW) <i>For descriptions, please refer to current version of PD6000</i>
<b>Welding Process Specific Criteria</b>	No additional criteria for the Welding process.	No additional criteria for the Welding process.	No additional criteria for the Welding process.
<b>Technical Knowledge</b>	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.  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.  Able to contribute to set externally recognized standards.  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.
<b>Experience</b>	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.
<b>Personal Attributes</b>		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.	
<b>Skills</b>		Describes the activities necessary to perform each level of job function to comply with the Body of Knowledge	
<b>Non-Special Process Related Requirements</b>		Health & Safety, Environmental, Quality System Requirements, RCCA, Contract Review.	

6. TABLE 1

**ROLE DESCRIPTION:** Resistance Seam and Spot Welding

**SPECIAL PROCESS:** Welding

**METHOD:** Performance of Resistance Welding Requirements

**REFERENCE GUIDELINES:** *Addendum 1 is a list of the International Standards and References Documents applicable to Welding Processes*

Row #	COMPETENCE	Weight (1,3,7,10)	Exam Type Gen/Specific /Practical	Reference Guidelines
	<b>KNOWLEDGE:</b> The basic knowledge of the special processes, methods and tools			
	<b>GENERAL KNOWLEDGE</b>			
1.	Fundamentals of resistance welding process.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
2.	Overview of resistance welding processes, advantages and limitations.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
3.	Basic resistance welding variables including the relationship of welding current, pressure, resistance and time and the effect of welding parameters on weld quality.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
4.	Commonly welded materials and their individual properties.	10	Gen	AWS C1.1M/C1.1, AWS WHB-3.9
5.	Standard terms and definitions	10	Gen	AWS A3.0M/A3.0, AWS D17.2/D17.2M, AWS C1.1M/C1.1, ISO 17677-1
6.	Welding symbols – drawing interpretation	10	Gen	AWS A2.4
	<b>MACHINES</b>			
7.	Basic resistance welding equipment including press-type and rocker-arm type machines.	10	Gen	AWS RWMA BULLETIN 16, AWS WHB-3.9
8.	Current power sources (SCR, Inverter, Single- and Three-Phase).	10	Gen	AWS RWMA BULLETIN 5, AWS WHB-3.9
9.	Welding cycles/schedules - terms (preheat current, impulse, hold time, forging force etc.), types (single-impulse, complex)	10	Gen	AWS RWMA RWM, ISO 17677-1
10.	Machine qualification - purpose of machine qualification	10	Gen	AWS D17.2/D17.2M, ISO 16338
11.	Test specimens - material groups, weld class, thickness, specimen size, number of test specimen	10	Gen	AWS D17.2/D17.2M, ISO 16338
12.	Testing requirements - test methods (visual, NDT, mechanical tests, metallography), acceptance criteria, machine qualification test reports	10	Gen	AWS D17.2/D17.2M, ISO 16338
13.	Laboratory testing and inspection equipment requirements	10	Gen	AWS D17.2/D17.2M, ISO 16338
14.	Machine qualification scope - weld class, thickness range	10	Gen	AWS D17.2/D17.2M, ISO 16338
15.	Machine re-qualification - conditions requiring re-qualification	10	Gen	AWS D17.2/D17.2M, ISO 16338
16.	Calibration - devices requiring calibration (pressure and/or force gages)	10	Gen	AWS D17.2/D17.2M, ISO 16338
17.	Equipment maintenance - importance of an effective machine maintenance program	10	Gen	AWS C1.1M/C1.1, AWS RWMA RWM
18.	General maintenance - e.g. lubrication, housekeeping	10	Gen	Equipment manufacturer's manual, AWS C1.1M/C1.1, AWS RWMA RWM
19.	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 J1.2M/J1.2, AWS D17.2/17.2M, AWS WHB-3.9
20.	Maintenance records	10	Gen	AWS J1.2M/J1.2, 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
	<b>ELECTRODES</b>			
21.	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
22.	Contact tip geometry effect on weld nugget shape.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
23.	Electrode alignment effect on resulting surface indentation and weld nugget shape.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
24.	Electrode cooling and methods used for cooling.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
25.	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
26.	Control of electrode identification, purchasing and receiving inspection.	10	Gen	Electrode manufacturer's specifications
	<b>FIXTURES AND TOOLING</b>			
27.	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
28.	How to prevent shunting.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
29.	That magnetic materials must not be located in the magnetic field of the welding machine.	10	Gen	AWS RWMA RWM, AWS WHB-3.9
30.	Maintenance of fixtures and tools.	10	Gen	AWS RWMA RWM, AWS D17.2/D17.2M, ISO 16338
	<b>PRE-WELD PREPARATION</b>			
31.	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
32.	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
33.	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
34.	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
35.	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
36.	Effect of time laps between cleaning and welding.	10	Gen	AWS RWMA RWM, AWS WHB-3.9, AWS D17.2/D17.2M
37.	Process sequence between welding and heat treatment when welding heat treatable alloys.	10	Gen	AWS D17.2/D17.2M, ISO 16338
38.	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
	<b>WELDING SCHEDULE CERTIFICATION</b>			
39.	Purpose of welding schedule certification	10	Gen	AWS D17.2/D17.2M, ISO 16338
40.	Standard certification versus Design allowable certification	10	Gen	AWS D17.2/D17.2M, ISO 16338
41.	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
42.	Schedule 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
43.	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
44.	Schedule certification test reports requirements - examination data and results	10	Gen	AWS D17.2/D17.2M, ISO 16338
45.	Conditions requiring re-certification of welding schedule	10	Gen	AWS D17.2/D17.2M, ISO 16338
	<b>PRODUCTION VERIFICATION TESTING</b>			
46.	Purpose of production verification testing (production witness specimens)	10	Gen	AWS D17.2/D17.2M, ISO 16338
47.	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
48.	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
49.	Acceptance criteria	10	Gen	AWS D17.2/D17.2M, ISO 16338
50.	Test records - logbook maintenance	10	Gen	AWS D17.2/D17.2M, ISO 16338
	<b>INSPECTION OF PRODUCTION PARTS</b>			
51.	Test methods used to evaluate weld quality on production parts - Visual, NDT	10	Gen	AWS D17.2/D17.2M, ISO 16338
52.	Inspection equipment requirements.	10	Gen	AWS D17.2/D17.2M, ISO 16338
53.	Weld classes and the differences in the acceptance criteria.	10	Gen	AWS D17.2/D17.2M, ISO 16338
54.	Calibration of dimensional measurement equipment.	10	Gen	AWS D17.2/D17.2M, ISO 16338
55.	Understanding of qualification requirements for Visual Weld Inspectors	10	Gen	AWS D17.2/D17.2M
56.	Rework – conditions permitting rework, approval of rework welding schedules	7	Gen	AWS D17.2/D17.2M
	<b>TESTING</b>			
57.	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
58.	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
59.	Coring in nickel-base alloys	7	Gen	AWS RWMA RWM, AWS C1.1M/C1.1
60.	Heat affected zone in commercially-pure titanium, metallographic nugget size measurement	7	Gen	AWS RWMA RWM, AWS C1.1M/C1.1
61.	Weld defects and possible causes	10	Gen	AWS RWMA RWM, AWS C1.1M/C1.1
62.	Laboratory testing and inspection equipment requirements.	10	Gen	AWS D17.2/D17.2M, ISO 16338
63.	Calibration of laboratory testing equipment.	10	Gen	AWS D17.2/D17.2M, ISO 16338
64.	Lab and NDT personnel qualification - general knowledge	10	Gen	AWS RWMA RWM, AWS C1.1M/C1.1, AWS D17.2/D17.2M
	<b>OPERATOR QUALIFICATION</b>			
65.	Welding operator training program - experience (OJT), training, testing, and oversight	10	Gen	AWS C1.5, AWS RWMA RWM, AWS C1.1M/C1.1, AWS D17.2/D17.2M
66.	Re-qualification requirements	10	Gen	AWS C1.5, AWS D17.2/D17.2M
67.	Vision test – requirements, frequency	10	Gen	AWS D17.2/D17.2M
	<b>SAFETY</b>			
68.	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
69.	Local safe working requirements.	10	Gen	Local requirements

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

**7. DOCUMENT REVISION HISTORY**

REVISION DATE	SUMMARY
25 May 2018	Added new logo
9 August 2018	Reviewed and updated by eQualified Content Developer
25 January 2019	Incorporated changes of AWS D17.2/D17.2M:2019
4 December 2019	Editorial revision to update program name from eQualified to PRI Qualification <sup>SM</sup> .



Addendum 1

LIST OF INTERNATIONAL STANDARDS & REFERENCE DOCUMENTS FOR WELDING

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
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
Resistance Spot & Seam Welding	Specification for AWS Certification of Resistance Welding Technicians	AWS QC20
Resistance Welding – Spot and Seam	Resistance Welding Manual	AWS RWM
Resistance Welding	Welding Handbook 9th Edition, VOL. 3 – Welding Processes, Part 2	AWS WHB-3.9
Resistance Welding	Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying	AWS A3.0M/A3.0
Resistance Welding	Safety in Welding, Cutting, and Allied Processes	ANSI Z49.1
Resistance Welding – Spot and Seam	Recommended Practices for Resistance Welding	AWS C1.1M/C1.1
Resistance Spot & Seam Welding	Specification for Resistance Welding Controls	AWS J1.1M/J1.1
Resistance Welding	Standard Symbols for Welding, Brazing, and Nondestructive Examination	AWS A2.4
Resistance Spot & Seam Welding	Guide to Installation and Maintenance of Resistance Welding Machines	AWS J1.2M/J1.2
Resistance Welding – Spot and Seam	Specification for the Qualification of Resistance Welding Technicians	AWS C1.5
Resistance Welding – Spot and Seam	Specification for Resistance Welding for Aerospace Applications	AWS D17.2/D17.2M
Resistance Welding – Spot and Seam	Resistance Welding Control Standards	AWS RWMA BULLETIN 5
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 Spot & Seam Welding	Electrode taper fits for spot welding equipment - Dimensions	ISO 1089
Resistance Spot & Seam Welding	Resistance welding equipment — Transformers — General specifications applicable to all transformers	ISO 5826:2014
Resistance Spot & Seam Welding	Resistance welding — Procedures for determining the weldability lobe for resistance spot, projection and seam welding	ISO 14327
Resistance Spot & Seam Welding	Quality requirements for welding — Resistance welding of metallic materials — Part 2: Elementary quality requirements	ISO 14554-2
Resistance Spot & Seam Welding	Quality requirements for welding — Resistance welding of metallic materials — Part 1: Comprehensive quality requirement	ISO 14554-1
Resistance Spot & Seam Welding	Specification and qualification of welding procedures for metallic materials — Welding procedure test - Spot, seam and projection welding	ISO 15614-12
Resistance Spot & Seam Welding	Welding for aerospace applications - Resistance spot and seam welding	ISO 16338
Resistance Welding – Spot and Seam	Resistance welding - Vocabulary - Part 1: Spot, projection and seam welding	ISO 17677-1