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Program Document WLDBOK

PD 6103

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BODY OF KNOWLEDGE:

ROLE DESCRIPTION: Planner
SPECIAL PROCESS: Welding
METHOD: Performance of Electron Beam Welding Requirements

All PRI Qualification[SM] program examinations are created using the applicable PRI Qualification[SM] 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[SM] Body of Knowledge Review Boards. All BoKs are updated periodically according to the latest revision of PRI Qualification[SM] 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[SM] program Welding Body of Knowledge Review Board (WLD-BoKRB) according to the requirements of PD6100.

This document consitutes the PRI Qualification[SM] program BoK for (Welding, Electron Beam, 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[SM] program examination candidate preparation
- Welding Examination Review Board (WLD-ERB) for the development of PRI Qualification[SM] program examinations
- Candidates taking PRI Qualification[SM] program examinations who wish to prepare in advance

2. REFERENCES

PRI Qualification[SM] program documents:

PD6000	Governance & Administration of PRI Qualification[SM] 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[SM] Dictionary.

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

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.

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

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 revision 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[SM] program examination candidates are recommended to read all documents referenced in section 2 of this document.

As stated in PRI Qualification[SM] program document PD6200, every exam question shall relate directly to and be derived from the information as detailed in the current revision of the BoK.

Re-assessment of candidates 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 (OP)/Technician(T)*** ***For descriptions, please refer to current version of PD6000***	***Planner (PL)*** ***For descriptions, please refer to current version of PD6000***	***Owner (OW)*** ***For descriptions, please refer to current version of PD6000***
Welding 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. 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.
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.		

6. TABLE 1

ROLE DESCRIPTION: Planner
SPECIAL PROCESS: Welding
METHOD: Performance of Electron Beam Welding Requirements
REFERENCE GUIDELINES: ***Addendum 1 is a list of the International Standards and Reference Documents applicable to Electron Beam Welding processes.***

Row #	COMPETENCE	Weight (1,3,7,10)	Exam Type Written/ Practical	Reference Guidelines
	KNOWLEDGE: The basic knowledge of the special processes, methods and tools			
1.	Definition & fundamentals of fusion welding including EBW	10	W	AWS WHB-1.9, AWS C7.1
2.	Fundamentals of electron beam welding processes including heat source, power density, focal point, focal spot size, keyhole vs melt-in, power curves, vacuum level, etc.	10	W	AWS WHB-1.9, AWS C7.1
3.	Electron beam equipment including electron gun design, vacuum mode (high, medium, low vacuum), high vacuum level & vacuum leak rate, outgassing, voltage mode (high vs. low voltage.) beam focus, beam deflection & resulting characteristics of each.	10	W	AWS WHB-1.9, AWS C7.1
4.	Safety including radiation safety	7	W	AWS WHB-1.9, AWS WHB-3.9, ANSI Z49.1, AWS C7.1
5.	Advantages and limitations of Electron Beam Welding (EBW) process	7	W	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1
6.	Basic process variables and qualitative effect on weld including current voltage, working distance, travel speed, beam focus, beam upslope/downslope, preheat, method of preheat, etc.	10	W	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1
7.	Commonly welded materials and their properties	7	W	AWS WHB-1.9, AWS WHB-4.9, AWS WHB-5.9, AWS C7.1
8.	Basic (Qualitative) Weld Metallurgy including parts of weld, terms such as HAZ, general effects of heat & effect on properties including defects	7	W	AWS WHB-1.9, AWS WHB-4.9, AWS WHB-5.9, AWS C7.1
9.	Standard terms and definitions	7	W	AWS A3.0, AWS WHB-1.9, AWS C7.1
10.	Welding symbols – drawing interpretation	7	W	AWS WHB-1.9, AWS A2.4
11.	Basic joint configurations	7	W	AWS WHB-1.9, AWS C7.1, AWS D17.1, AWS A2.4
12.	Monitoring & Control of EBW including beam control, beam electrical characteristics, beam oscillation, beam movement, etc.	7	W	AWS WHB-1.9, AWS C7.1
13.	Basics of Mechanized, Semi-Automated, Automated, and Robotic Welding (workpiece/gun movement, seam trackers, wire feeders, alignment, rotation, fixturing, etc.)	3	W	AWS WHB-1.9, AWS C7.1
14.	Procedure for calibration of equipment	3	W	AWS D17.1, AWS C7.1
15.	Procedures & practice for equipment preventive maintenance including tooling, fixtures, demagnetization, inspection for suitability of use, alignment inspection, rotational acceptability, records, leak rate for vacuum systems, chamber cleanliness etc.	7	W	AWS WHB-4.9, AWS C7.1
16.	Fixturing	3	W	AWS WHB-1.9, AWS D17.1, AWS C7.1
	WELDING OPERATOR QUALIFICATION			
17.	Performance qualification requirements, including equipment operation, visual acuity, record keeping, acceptance criteria, experience (OJT), training, testing, and oversight, etc.	7	W	AWS WHB-1.9, AWS WHB-3.9, AWS D17.1, AWS C7.1, AMS2680, AMS2681
18.	Welding operator qualification – test weld conditions (position, thickness, base metal groups, procedure qual. variables, etc.) vs. qualified scope	7	W	AWS WHB-1.9, AWS WHB-3.9, AWS D17.1, AWS C7.1, AMS2680, AMS2681
19.	Welding operator qualification – special applications, inspection requirements, other welding conditions	7	W	AWS WHB-1.9, AWS WHB-3.9, AWS D17.1, AWS C7.1, AMS2680, AMS2681

20.	Welding Operator qualification test records	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS D17.1, AWS C7.1, AMS2680, AMS2681
21.	Re-qualification requirements	**3**	**W**	AWS D17.1, AWS C7.1, AMS2680, AMS2681
22.	Disqualification criteria	**3**	**W**	AWS D17.1, AWS C7.1, AMS2680, AMS2681
	PRE-WELD PREPARATION			
23.	Joint design	**7**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1
24.	Part and tooling surface preparation (including cleanliness and effect on weld quality	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1
25.	Selection of cleaning materials, methods, cleaning tool types & materials of tools used to remove contaminants and oxides on the part and weld wire	**7**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1
26.	Part surface fit-up/gaps and effect on weld quality	**7**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1
27.	Effect of time lapse between cleaning and welding	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1
28.	Process sequence between welding and heat treatment when welding heat treatable alloys	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1
	WELDING PROCEDURE QUALIFICATION			
29.	Purpose & process of welding procedure qualification including data to be recorded such as current, voltage, speed, tooling/fixtures, degaussing, preheat, post heat, vacuum level etc.	**7**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
30.	Classification of welds	**7**	**W**	AWS D17.1, AMS2680, AMS2681
31.	Procedure qualification testing - test methods	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
32.	Acceptance criteria	**10**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
33.	Procedure qualification test reports (WPQR) - examination data and test results	**3**	**W**	AWS WHB1.9, AWS WHB-3.9, AWS C7.1, AMS2680, AMS2681
34.	Conditions requiring procedure re-qualification	**3**	**W**	AWS WHB-1.9, AWS WHB-3.9, AWS D17.1, AMS2680, AMS2681
	FABRICATION			
35.	Tack welds including qualified vs. unqualified procedures, etc.	**3**	**W**	AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
36.	Preheat and Interpass heating & type of preheat including with beam or external, extent, need, material requirements, etc.	**10**	**W**	AWS WHB-3.9, AWS C7.1
37.	Weld start and run-off tabs including purpose, control, allowed material, size, attachment mechanism, cleanliness, qualification if needed, etc.	**3**	**W**	AWS C7.1, AWS D17.1, AMS2680, AMS2681
38.	Filler materials if used: reason for use, form, selection/specification, etc.	**7**	**W**	AWS WHB-3.9, AWS D17.1, AMS2680, AMS2681
39.	Filler materials control if used: purchasing, storage, use, and disposal	**3**	**W**	AWS WHB-3.9, AWS C7.1, AWS D17.1,
40.	Weld settings – Welding Procedure Specification (WPS) Ranges or parameter listings	**7**	**W**	AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
41.	Post-weld cleaning including removal of colored surfaces, material compatibility of tools, etc.	**10**	**W**	AWS WHB-3.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
42.	Post-weld processing, including weld metal removal, heat treatment, documentation with respect to weld procedure, etc.	**10**	**W**	AWS WHB-3.9, AWS C7.1, AMS2680, AMS2681
43.	Rework vs. Repair	**3**	**W**	AWS D17.1, AMS2680, AMS2681

44.	Record requirements	**7**	**W**	AWS D17.1, AMS2680, AMS2681
	WELD INSPECTION AND TESTING			
45.	Test methods used to evaluate weld quality - Visual, other NDE methods, mechanical, metallography	**10**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
46.	Common EBW defects and cause including lack of fusion, missed joint, porosity, cracking, etc.	**10**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681
47.	Inspection equipment requirements including calibration, inspection for viability, timing of inspections, record, etc.	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
48.	Calibration of dimensional measurement equipment	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
49.	Weld classes and the differences in the acceptance criteria	**7**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1, AMS2680, AMS2681,
50.	Understanding of qualification requirements for Visual Weld Inspectors	**7**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
51.	NDT – understanding of principles and advantages & limitations of Penetrant Inspection of electron beam welds	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
52.	NDT – understanding of principles and advantages & limitations of Magnetic Particle Inspection of electron beam welds	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
53.	NDT – understanding of principles and advantages & limitations of Radiographic Inspection of Electron beam welds	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
54.	NDT – understanding of principles and advantages & limitations of Ultrasonic Inspection of fusion welds	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
55.	Measurement of electron beam weld features including reinforcement, underfill, penetration, misalignment, etc.	**7**	**W**	AWS WHB-1.9, AWS C7.1
56.	Laboratory testing and inspection equipment requirements as applicable to EBW	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
57.	Calibration of laboratory testing equipment	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
58.	Lab and NDT personnel qualification - general knowledge	**3**	**W**	AWS WHB-1.9, AWS C7.1, AWS D17.1
	SKILLS Defined within these roles describes the range of skills. The skills required to perform a particular special process task			
59.	Ability to read, understand and interpret drawings, specifications and customer flown-down requirements			
60.	Ability to convey complete and through work instructions and procedures			
61.	Ability to verify, validate, and certify the qualification and witness test results			
62.	Apply technical knowledge when solving problems			
63.	Ability to identify training needs and coordinate the training			
64.	Good communicator at all levels			
	PERSONAL ATTRIBUTES: Are statements that will enable judgment of the person's personal attributes			
65.	Be able to work independently with a minimum of supervision	**NA**	**NA**	
66.	Must have a high degree of integrity	**NA**	**NA**	
67.	Be attentive to details	**NA**	**NA**	
68.	Be flexible	**NA**	**NA**	
69.	Tolerate stress	**NA**	**NA**	
70.	Exhibit conflict resolution	**NA**	**NA**	
71.	Decision making ability	**NA**	**NA**	
72.	Team Worker	**NA**	**NA**	
73.	Ethical Behavior	**NA**	**NA**	
74.	Exhibit Leadership	**NA**	**NA**	
	EXPERIENCE: Are the minimum experience requirement expected to demonstrate their competence.			
75.	High School Diploma or GED or Secondary Education	**NA**	**NA**	
76.	Apprenticeship	**NA**	**NA**	
77.	Industry Training or Courses	**NA**	**NA**	
	NON-SPECIAL PROCESS RELATED REQUIREMENTS: Defined within these rolls are other general or pre-requisite needed			
78.	Thorough understanding of Quality Systems per AS9100 or equivalent			

79.	Thorough understanding of Control of Non-Conformance for equipment and product including Containment, Customer notification and disposition			
80.	Thorough understanding of Root Cause and Corrective Action (RCCA) tool			
81.	Responsible for conducting periodic self-audits			

7. DOCUMENT REVISION HISTORY

REVISION DATE	SUMMARY
4 December 2019	Editorial revision to update program name from eQualified to PRI Qualification[SM.]

ADDENDUM 1

LIST OF INTERNATIONAL STANDARDS & REFERENCE DOCUMENTS FOR ELECTRON BEAM WELDING

SPECIAL PROCESS	DOCUMENT TITLE	DOCUMENT NUMBER
Welding	Electron-Beam Welding for Fatigue Critical Applications	AMS2680
Welding	Welding, Electron-Beam	AMS2681
Welding	Standard Symbols for Welding, Brazing, and Nondestructive Examination	AWS A2.4
Welding	Standard Welding Terms and Definitions	AWS A3.0M/A3.0
Welding	Recommended Practices for Electron Beam Welding and Allied Processes	AWS C7.1
Welding	Specification for Fusion Welding for Aerospace Applications	AWS D17.1/D17.1M
Welding	Welding Handbook - Volume 1, Welding Science and Technology	AWS WHB-1.9
Welding	Welding Handbook - Volume 3, Welding Processes,	AWS WHB-3.9
Welding	Welding Handbook - Volume 4, Materials and Applications, Part 1	AWS WHB-4.9
Welding	Welding Handbook - Volume 4 Materials and Applications, Part 12	AWS WHB-5.9
Welding	Safety in Welding, Cutting and Allied Processes	AWS Z49.1

ADDENDUM 2

SUPPLEMENTAL READING LIST

*****Documents listed in the Supplemental Reading Addendum are not required documents and will not be the basis of any questions on the PRI Qualification[SM] Theory Assessment associated with this Body of Knowledge. Documents listed below are only included as they may be of interest to individuals who perform Electron Beam Welding processes. *****

SPECIAL PROCESS	SPECIAL PROCESS	DOCUMENT NUMBER
Welding	Guide for the Nondestructive Examination of Welds	AWS B1.10M/B1.10
Welding	Guide for the Visual Examination of Welds	AWS B1.11M/B1.11
Welding	Specification for Welding Procedure and Performance Qualification	AWS B2.1/B2.1M
Welding	Specification for the Qualification of Weld Inspector Specialists and Welding Inspector Assistants	AWS B5.2
Welding	Process Specification for Electron Beam Welding	AWS C7.3
Welding	Guide for Components of Robotic and Automatic Arc Welding Installations	AWS D16.2M/D16.2
Welding	Recommended Safe Practice for Electron Beam Welding and Cutting	AWS F2.1
Welding	Standard for AWS Certification of Welding Inspectors	AWS QC1
Welding	Mechanized, Automated, and Robotic Welding	AWS WHB-1.11