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## Program Document HTBOK

**PD 6103**

HTBoK-005/OP/T-1 REV. A

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### BODY OF KNOWLEDGE:

**ROLE DESCRIPTION:** PYROMETRY PROCESS OPERATOR / CALIBRATION AND TEST  
TECHNICIAN

**SPECIAL PROCESS:** Pyrometry

**METHOD:** Performance of Pyrometry Requirements for Thermal Processing  
Equipment

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 who participate in the eQualified Body of Knowledge Review Boards. All eQualified BoKs are updated periodically according to the latest revision of eQualified PD6100 to ensure consistency with current industry practice.

## 1. INTRODUCTION

This document has been created by the eQualified Heat Treating Body of Knowledge Review Board (HT BoKRB) according to the requirements of eQualified Program Document PD6100 Industry Managed Special Process Bodies of Knowledge.

This document constitutes the eQualified BoK for Pyrometry Process Operator and Calibration and Test Technician. It defines the baseline knowledge and experience required to be considered competent to perform this role.

Unless otherwise stated, the HT 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 eQualified examination candidate preparation
- Heat Treat Examination Review Board (HT-ERB) for the development of eQualified examinations
- Candidates taking eQualified examinations who wish to prepare in advance

## **2. REFERENCES**

eQualified documents:

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.

**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.

**IN-HOUSE (or IN-SOURCING):** Keeping responsibility and control of key or critical processes inside an organization by using available internal resources in-house control (in-sourcing) is often preferred to ensure compliance of critical with specific customer or statutory requirements – the opposite of out-sourcing

**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 Planner. Please refer to the current revision of PD 6000 for definitions of these levels.

**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.

**OUT-SOURCED:** is the contracting out of a business process to a third-party (external) supplier. It relates to both product and services

**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.

**SERVICE PROVIDER:** A company or individual that provides a service or product. Service provider is generally used to refer to external or outsourced (third party) suppliers of services and product although large organizations may have Internal Service Providers for example IT.

Examples may include Instrument calibration, Periodic Tests (TUS, SAT), analysis or testing which is outside the capability of internal resources. Service providers may also be suppliers of goods for example thermocouples pure gases etc.

**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 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 eQualified approved providers can be found at [www.eQualified.org](http://www.eQualified.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

5. LEVELS

Descriptors	Level		
	Operator (OP) / Technician (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>Pyrometry Specific Criteria</b>	<p><i>Basic understanding of Heat Treating processes, Pyrometry Testing and Calibration.</i></p> <p><i>Authorized to performing Temperature Uniformity Surveys, System Accuracy Tests, Calibrations of Controlling, Monitoring and Recording Instruments.</i></p> <p><i>Responsible for reporting results of Pyrometry Tests and Calibrations, and capable of detecting non-conforming results.</i></p>	<p><i>In addition to knowing the roles of the Operator, the Planner:</i></p> <p><i>Provides work instructions/procedures for Pyrometry Tests and Calibrations performed by the Operator.</i></p> <p><i>Provides forms for recording the results of Pyrometry Tests and Calibrations.</i></p> <p><i>Maintains records of Pyrometry Tests and Calibrations.</i></p> <p><i>Is authorized to define, assign or perform actions related to Pyrometry Test and Calibrations results.</i></p>	<p><i>In addition to knowing the roles of the Operator and Planner, the Owner:</i></p> <p><i>Manages, oversees and trains Planners and Operators.</i></p> <p><i>Approves Pyrometry Test and Calibration work instructions/procedures.</i></p> <p><i>Approves Purchase Orders for performing Pyrometry Test and Calibrations.</i></p> <p><i>Is authorized to review and approve Pyrometry Tests and Calibration results.</i></p> <p><i>Approves actions taken by Planner or Operator related to Pyrometry Test and Calibration results.</i></p> <p><i>Is responsible for the conformance of heat treating equipment to customer requirements and provisions.</i></p>
<b>Technical Knowledge</b>	<p>Basic knowledge of the special process, its main processes, methods and tools.</p>	<p>Good level of knowledge in all aspects of the special process, all its processes, methods and tools.</p> <p>Ability to coach others on contents and methods in the context of their workplace.</p>	<p>High or extensive knowledge in all aspects of the special process, all its processes, methods and tools to assess and validate improvements.</p> <p>Able to contribute to set externally recognized standards.</p> <p>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.</p>
<b>Experience</b>	<p>Sufficient experience to deal with recurrent activity.</p>	<p>Has enough experience to deal with unforeseen issues.</p>	<p>Wide proven experience of the subject. Is recognized specialist within the special process?</p>
<b>Personal Attributes</b>	<p>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.</p>		
<b>Skills</b>	<p>Describes the activities necessary to perform each level of job function to comply with the Body of Knowledge</p>		
<b>Non-Special Process Related Requirements</b>	<p>Health &amp; Safety, Environmental, Quality System Requirements.</p>		

(1) Important to be aware that the special process provider is ultimately responsible for the compliance of his Pyrometry Service Providers compliance

6. TABLE 1

**ROLE DESCRIPTION: PYROMETRY PROCESS OPERATOR / CALIBRATION AND TEST TECHNICIAN**

**SPECIAL PROCESS: PYROMETRY**

**METHOD: Performance of Pyrometric Requirements for Thermal Processing Equipment**

**REFERENCE GUIDELINES: All Paragraph references are applicable to AMS2750 (latest rev) unless otherwise identified. Addendum 1 is a list of the international Standards and Reference Documents applicable to Pyrometry processes.**

Row #	COMPETENCE	Weight (1,3,7,10)	Exam Type Written / Practical	Reference Guidelines (See description above)
	<b>Understands:</b> <b>The basic knowledge of the special processes, methods and tools</b>			
<b>1</b>	<b>GENERAL QUALITY SYSTEMS KNOWLEDGE:</b>			
<b>2</b>	A general understanding of Aerospace Quality Systems and the need for compliance	7	W	AS9100; AC7102/8 2.1, 8.0
<b>3</b>	A fundamental understanding of the need to follow Internal Work Instructions (Job Sheet /Traveler/Data Card etc.).	7	W	AS9100; AC7102/8 2.1, 8.0
<b>4</b>	A general understanding of the relationship between work instruction / customer requirements / requirements of external standards.	7	W	AS9100; AC7102/8 2.1, 8.0
<b>5</b>	A general understanding of the cause and effect of Nonconformances and the importance of having an effective process to identify Root Cause and Corrective Action.	7	W	AMS2750 3.4.5.4, 3.4.5.5, 3.5.16.1 AC7102/8 2.1, 8.0
<b>6</b>	Knowledge and understanding of Safety requirements as applicable	7	W	ISO14001 & OHSAS 18001
<b>7</b>	A general understanding of the importance of the linkage between the thermal process being carried out and the pyrometry controls required by AMS2750 to ensure compliance.	7	W	AMS2750 AC7102/8 2.1; 8.0
<b>8</b>	Awareness and general understanding of temperature sensors, instrumentation, thermal processing equipment, system accuracy tests, and temperature uniformity surveys.	7	W	AMS2750 AC7102/8 2.1; 8.0
<b>9</b>	General understanding of the need for traceability of customer product through each process step and that this must not be affected by any pyrometry activities.	7	W	AMS2750 4.1 AC7102/8 2.1; 8.0
<b>10</b>	General understanding of the need for traceability of calibration to NIST or equivalent national agencies.	7	W	AMS2750 3.1.2.2.6, 3.2 AS9100 AC7102/8 2.1.2; 8.0
<b>11</b>	Sufficient knowledge and understanding to be able to recognize and report in real time deviations from process parameters or other events which may have a negative impact on product quality.	7	W	AMS2750 4.1 AC7102/8 2.1; 8.0
<b>12</b>	Basic understanding of the metallurgy of the processes carried out and how these are affected by compliance.	10	W	AMS2750 4.1 AC7102/8 2.1; 8.0
<b>13</b>	Knowledge and understanding of the need for compliance with internal and external process requirements and that these must not be affected by any pyrometry activities.	7	W	AMS2750 4.1 AC7102/8 2.1; 8.0
<b>14</b>	<b>SENSORS (THERMOCOUPLES):</b>			
<b>15</b>	Basic knowledge and understanding of sensor types and their proper applications.	10	W	AMS2750 3.1, Table 1 AC7102/8 3.0
<b>16</b>	Basic knowledge and understanding of temperature range recommendations, atmosphere effects, and usage restrictions.	7	W	AMS2750 3.1.1.4 AC7102/8 3.0
<b>17</b>	Basic understanding that there are specific requirements controlling recalibration, reuse, salvage and replacement, calibration and reporting.	7	W	AMS2750 3.1 AC7102/8 3.0
<b>18</b>	Basic understanding that there are specific requirements for proper connection including use of extension wires and wireless transmitters.	7	W	AMS2750 3.1.1.5, 3.1.1.5.1 AC7102/8 3.0
<b>19</b>	Understanding of how to recognize temperature sensor (thermocouple) failures and the subsequent actions which must be taken to minimize impact on product.	7	W	AMS2750 3.1.2.3 AC7102/8 3.0
<b>20</b>	Basic understanding of correction factors and their application and when their application is required.	10	W	AMS2750 3.4.5.1, 3.5.16, 3.5.17.1.1 AC7102/8 3.10, 6.7.2
<b>21</b>	<b>INSTRUMENTATION:</b>			
<b>22</b>	Basic knowledge and understanding of the variety of instrumentation functions (standard, test, controlling, monitoring and recording) and the differences in calibration accuracy and frequency requirements for specific types (digital, electromechanical, mechanical or thermal element).	7	W	AMS2750 3.2, Table 3 AC7102/8 4.2.1, 4.2.2; 4.2.4
<b>23</b>	General understanding of when and how offsets are permitted to be used (or not), limitations for use, and recording of their use when required.	7	W	AMS2750 3.2.4, Fig 6, 3.4.5.6, Table 6, Table 7

				AC7102/8 6.6
24	Basic understanding of software (Electronic Program Control and Data Acquisition) in use and how they control and document the processes being carried out.	7	W	AMS2750 3.2.7, Table 4, Table 5 AC7102/8 4.3
25	General knowledge of programming and program verification where process cycles are run under computerized systems.	7	W	AS9100
26	Understanding of requirements for verification prior to production use when changes are made to automated programs.	10	W	AS9100
27	<b>INSTRUMENT CALIBRATION</b>			
28	General knowledge and understanding of instrumentation hierarchy and the relationships between test instruments and other instruments	10	W	AMS2750 3.2, Table 3
29	General knowledge and understanding of test and other instrument calibration and reporting requirements	10	W	AMS2750 3.2, Table 4, Table 5 AC7102/8 4.1; 4.2
30	Understanding that all Test Instruments must be digital, must be readable to 1°F or 1°C, and must meet calibration frequency and accuracy requirements of other specifications if these are more stringent.	10	W	AMS2750 3.2.2, Table 3 AC7102/8 4.1.1, 4.1.2
31	General knowledge and understanding of Instrument Sensitivity	10	W	AMS2750 2.2.58, Table 3 AC7102/8 4.2.3
32	<b>THERMAL PROCESSING EQUIPMENT:</b>			
33	Basic understanding of how to identify or verify Furnace Class and Instrumentation Type and how this relates to processing.	7	W	AMS2750 3.3 AC7102/8 4.4
34	Understanding that the combination of Furnace Class and Instrumentation Type must be known to determine the correct frequencies for TUS and for SAT	7	W	AMS2750 Tables 6 to 9
35	Basic understanding of the different types of Thermal Processing Equipment (including ovens, furnaces, HIP units, quench baths, Autoclave and refrigeration equipment, etc.) and their basic function and usage related to the metallurgy of the treatments carried out and alloy type being treated.	7	W	AMS2750 3.3.1 through 3.3.6.1 AC7102/8 4.4
36	<b>SYSTEM ACCURACY TESTS:</b>			
37	Knowledge, understanding and ability to demonstrate practically how to perform a System Accuracy Test (SAT).	10	W/P	AMS2750 3.4 AC7102/8 5.0
38	Understanding of the requirements for relative location of the SAT sensor to the sensor being checked and how that is verified for the particular equipment configuration.	10	W/P	AMS2750 3.4.5.2
39	Knowledge and understanding that the SAT must be performed to assure the accuracy of the furnace control and recording system in each control zone and any other sensors required for a particular Instrumentation Type.	7	W	AMS2750 3.4; 3.4.1; 3.4.2 AC7102/8 5.1; 5.3
40	Knowledge and understanding of the records that must be included in the System Accuracy Test report.	7	W	AMS2750 3.4.8, 3.7 AC7102/8 5.4.2
41	Basic understanding of any limitations to use of different temperature sensor types (E, K, N, R etc.).	7	W	AMS2750 3.4.2
42	Basic knowledge and understanding of how to verify compliance with requirements when resident SAT thermocouples are used.	7	W	AMS2750 3.4.5.2.1 AC7102/8 5.5
43	Knowledge and understanding of the difference in System Accuracy Test interval requirements for processing parts vs. raw material as well as the application of more stringent customer requirements in addition to the requirements.	10	W	AMS2750 Table 6 and Table 7 AC7102/8 5.3.2
44	Demonstration of the ability to perform the SAT difference calculations, including application of correction factors and offsets when required, and to compare the results to specification requirements	10	W	AMS2750 3.4.5.3, Figure 6 AC7102/8 5.4.1
45	Knowledge and understanding of SAT Data Collection and requirements for reporting.	7	W	AMS2750 3.4.8 AC7102/8 5.4.2
46	<b>TEMPERATURE UNIFORMITY SURVEYS:</b>			
47	General understanding of what a TUS is measuring and why it is important.	7	W	AMS 2750 3.5 AC7102/8 6.0
48	Knowledge and understanding of how to set up, program, load and monitor a Temperature Uniformity Survey (TUS).	7	W	AMS2750 3.5 AC7102/8 6.0
49	Knowledge and understanding of how an Initial TUS shall be performed in accordance with more stringent customer requirements.	7	W	AMS2750 3.5.5 AC7102/8 6.1.2, 6.3
50	General understanding of the difference between modifications and repairs to the degree necessary to determine whether maintenance may require a new Initial TUS be performed	7	W	AMS2750 3.5.3, 3.5.4 AC7102/8 6.1.2
51	General understanding of the requirements for TUS conditions (furnace operating parameters, load, atmosphere, etc.) to the degree necessary to determine whether there have been any changes since the last TUS that may require a new Initial TUS be performed	7	W	AMS2750 3.5.8, 3.5.10 AC7102/8 6.2.2, 6.2.4
52	Knowledge and understanding of how Periodic TUS shall be performed in accordance with the interval shown in AMS2750 or more stringent customer requirements including the difference in furnace test interval requirements for processing parts vs. raw material.	7	W	AMS2750 3.5.6 AC7102/8 6.4.3
53	Knowledge and understanding of issues which may arise during a survey which may 'fail' the survey (Overshoot, Temperature Sensor Failure) and what is the appropriate action to take in response.	7	W	AMS2750 3.5.16; 3.5.19 AC7102/8 6.5

54	Basic knowledge of the requirements for number and location of thermocouples in order to follow planning requirements and verify whether they are appropriate for the equipment being tested	7	W	AMS2750 3.5.14.1 AC7102/8 6.2.6
55	Knowledge and understanding of the information that must be collected during the TUS to permit compliance with reporting and documentation requirements	7	W	AMS2750 3.5.21.1 AC7102/8 6.7
<b>SKILLS:</b>				
<b>The skills required to perform a particular special process task</b>				
56	<b>READ AND UNDERSTAND WRITTEN INSTRUCTIONS:</b>			
57	Understand internal instructions related to Pyrometry and Processes being carried out at the specific location.	10	W	General Industry
58	Has knowledge and understanding to be able to recognize and report in real time deviations from process parameters or other events which may have a negative impact on product quality.	10	W	General Industry
59	Knowledge and understanding of the specific equipment types to be tested and calibrated. i.e. access to specs, manuals and details procedures.	10	W	Job Knowledge
<b>Sequencing</b>				
60	Has an appropriate understanding of where this process falls in the sequence of events.	10	W	
<b>PERSONAL ATTRIBUTES:</b>				
<b>Are statements that will enable judgment of the person's personal attributes</b>				
613	Willingness to train and mentor co-workers	7	P	
624	Good communicator at all levels	7	P	
635	Takes responsibility to challenge work instructions that do not appear to conform to specification or customer requirements.	10	P	
646	Personal integrity	10	P	
657	Attentive to details	7	P	
<b>EXPERIENCE:</b>				
Are the minimum experience requirement expected to demonstrate their competence.				
<p><b>NOTE:</b> ARP 1962 (Aerospace Recommended Practice -Training and Approval of Heat-Treating Personnel) requires that suppliers have a documented personnel training program including documented training to an established outline and initial and periodic evaluation of competency.</p> <p>While it does not specifically address pyrometry, it does speak to maintenance. The following are recommendations and would be superseded by the supplier's specific documented program. The supplier program may define alternative criteria, waivers and equivalences.</p>				
66	<b>Education</b>			
67	As determined by supplier's procedures Recommended minimum - High School Graduate / GED	5		
68	<b>Recommended Minimum Classroom Training</b>			
69	Paperwork – 40 hours Test, Inspection, Maintenance – 40 hours	7		ARP1962 Table 1
70	<b>Recommended Minimum On-the-Job-Training</b>			
71	There is no specific minimum requirement but documentation of training in the functions being performed is required.	5		ARP1962 Table 2 3.3.2
72	<b>Testing and Evaluation</b>			
73	Initial and periodic evaluation of personnel is required. The type of frequency of the evaluation shall be determined by the company employing the individual, except that each individual shall be evaluated at least every 5 years. This shall be defined in the formal written program. Evaluation may consist of any combination of written or oral examination or testing, structured checklist review, employee performance appraisal, company employee specific audit program or other appropriate methodology defined in the formal written program.	10	W/P	ARP1962 3.3.1.4
<b>NON-SPECIAL PROCESS RELATED REQUIREMENTS:</b>				
<b>Defined within these rolls are other general or pre-requisite needed</b>				
74	Must have a thorough understanding of general Quality Systems principles (AS9100) or equivalent.	10	W	General Industry
75	Must have a thorough understanding of customer specific requirements.	10	W	General Industry
76	Must have a thorough understanding of Control of Non Conformance for equipment and product including containment, customer notification and disposition.	10	W	General Industry

7. DOCUMENT REVISION HISTORY

REVISION DATE	SUMMARY
03 Oct 14	Editorial change to formatting and definitions
03 Jun 15	Name change from Pyrometry Service In-House to Pyrometry Service Processor
08 Feb 16	Name change from Pyrometry Service Processor to Pyrometry Process
17 Jun 16	Editorial change made to update BoK with new template revisions
26 Jan 17	Reworded Pyrometry Specific Criteria – all levels Added additional line items and weights to Weight Column Added ARP 1962 to Addendum 1



ADDENDUM 1

LIST OF INDUSTRY STANDARDS FOR PYROMETRY

<b>SPECIAL PROCESS</b>	<b>DOCUMENT TITLE</b>	<b>DOCUMENT NUMBER</b>
Heat Treating	Nadcap Audit Criteria for Heat Treating Pyrometry	AC7102/8
Pyrometry	Pyrometry	AMS2750
Training	Training and Approval of Heat-Treating Personnel	ARP1962
Quality	Quality Management Systems - Requirements for Aviation, Space and Defense Organizations	AS9100
Quality	Quality Standards	ISO9001