Construction Product Approval Process

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CONSTRUCTION INNOVATION HUB

UK Research and Innovation

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Use of this Handbook

The Construction Product Quality Planning (CPQP) process is a structured methodology aimed at supporting the development and introduction of new construction products.

This Construction Product Approval Process (CPAP) handbook is part of the CPQP process and should be used in conjunction with the CPQP Guide and the nine supporting CPQP tools, published by the Construction Innovation Hub.

This document is intended to be a guideline to aid the CPAP, providing the basic principles and a suggested methodology. The templates provided can be changed and modified to suit individual companies.

It is intended for use by companies manufacturing offsite construction products largely using the CPQP process with their customers and suppliers.

For a list of the acronyms and abbreviations used in this document, refer to Appendix B – List of Abbreviations.

For the various terms used in this document, refer to Appendix C – Glossary of Terms.

For further information about the CPQP Guide and its toolset please contact: **cpqp@constructioninnovationhub.org.uk.**

Introduction

Background

The Construction Product Approval Process (CPAP) helps organisations to gain confidence in their supplier's processes and products.

Aligned with the Construction Product Quality Planning (CPQP) process, CPAP is aimed at those enterprises that design and manufacture construction products through manufacturing-led construction approaches.

The CPAP defines a structured process that helps manufacturers and suppliers communicate the approval of production designs and processes before, during and after manufacturing alongside CPQP activities. CPQP is an adaptation of the Advanced Product Quality Planning (APQP), which is employed throughout the manufacturing sector on a global scale to effectively 'build in' quality when developing new products. APQP ensures that quality is factored into the entire product development cycle from concept design through to the full-scale implementation of a manufacturing strategy [1]. The APQP process is then validated through a Production Part Approval Process (PPAP). This standardised approach to APQP and PPAP remained during its adaptation for the construction sector. The Construction Innovation Hub has developed this guide and uses analogous terminology; Construction Product Quality Planning (CPQP) and Construction Production Approval Process (CPAP).

Purpose

The Construction Product Approval Process (CPAP) handbook provides guidance to approve the activities described in the Construction Product Quality Planning (CPQP) guide. The CPAP adds oversight and accountability to quality management at every step of the CPQP process and ensures that defects are identified proactively and not processed along the New Product Introduction (NPI) journey. The main purpose of the Construction Product Approval process is:

- To provide evidence that the CPQP process has been completed and all engineering, design record and specification requirements are fulfilled by the supplier or manufacturer organisation; and
- To demonstrate that the manufacturing process has the potential to produce and deliver products and assemblies that meet all requirements at the required production rate.

How does CPAP fit in with Construction Product Quality Planning?

The Construction Product Approval Process (CPAP) documents the proof or evidence collected through the CPQP process, therefore, CPAP and CPQP are linked elements as shown in Figure 1. CPAP provides evidence that the CPQP has been successfully performed and the CPAP document relies on the activities and deliverables of the CPQP activities. CPAP provides an interim submission at every CPQP phase and the final sign-off of the process is done through the Part Submission Warrant (PSW) at Gate 5 of the CPQP.

The information collected and the records kept through the CPAP enable the golden thread of information. The information can be recorded digitally and transferred along with project information into BIM models digital twins and asset management tools.

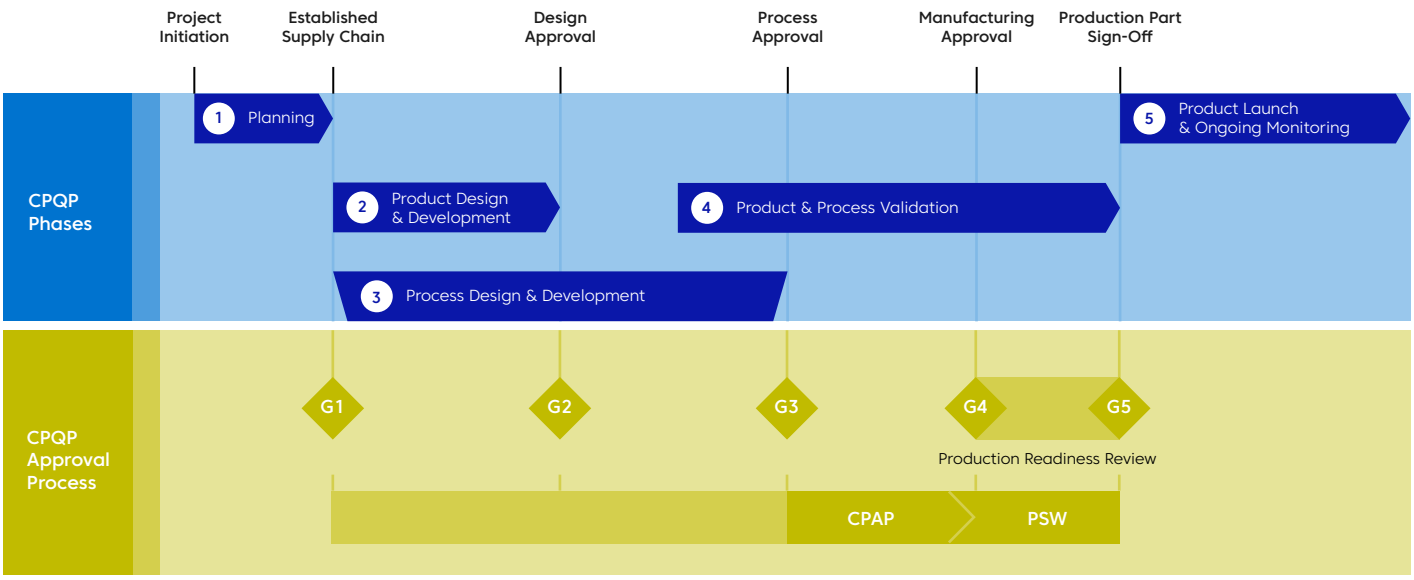

Figure 1. CPQP and CPAP overview

Methodology

Methodology

The steps to follow when completing the CPAP activities within the CPQP process are shown in Figure 2 and will be discussed in detail in this handbook.

It should be noted that the timeframe for completing the CPAP and the entire CPQP process or individual phases is dependent upon the complexity of the product, the detail of the client requirements, and the experience of the development team. However, the adoption of the CPQP process and the CPAP are not expected to significantly increase the product development time when compared to other adopted approaches. It requires up-front planning and an early effort that would offset the time and cost associated with resolving issues and addressing quality defects later in the development and production processes.

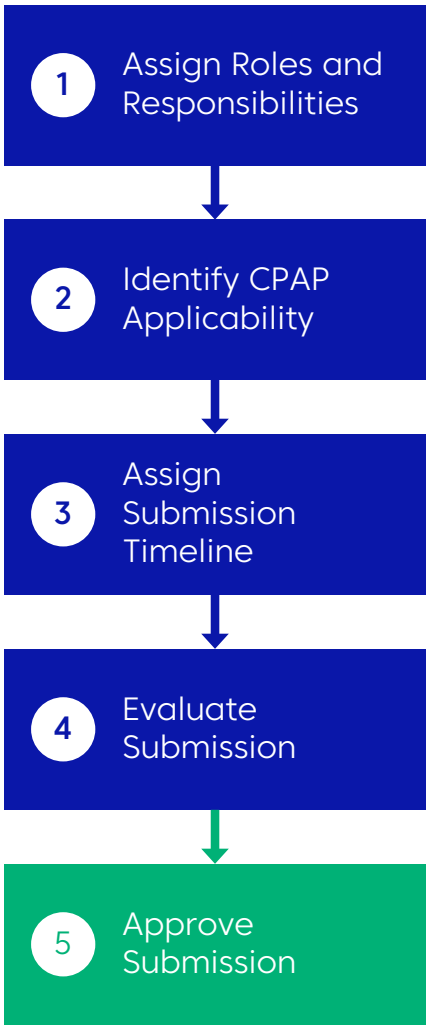

Figure 2. CPAP timeline

Roles and Responsibilities

The successful completion of the Construction Product Approval Process (CPAP) requires the collaboration of customers (external or internal) and suppliers along with other relevant stakeholders involved in the development of the product.

In the context of the CPQP process and this CPAP handbook, the customer is the organisation or department (in the case of internal customers) that leads the implementation of the CPQP process and is responsible for the overall quality of the project. The customer, through a representative, defines the initial requirements and signs off the CPAP document. Therefore, depending on the product delivery strategy, the customer could sit within an organisation representing the client (e.g. main contractors, contract management organisation) or an internal representative acting as product owner for internal product development projects.

The supplier or manufacturer is the organisation that manufactures and delivers the actual product to meet customer requirements. The manufacturer shall engage with its supply chain and ask the major suppliers to follow the CPQP process.

The CPAP activities require the outline of at least two main roles within the organisations, namely Client Representative (CRe) and Product Approval Coordinator (PAC).

Client Representative (CRe)

The CRe is the responsible and accountable person for monitoring the overall progress associated with the CPQP process and the submission of the CPAP. The final submission of the CPAP relies on the successful completion of the CPQP and the key elements to be delivered in the CPAP are directly linked to the deliverables in the CPQP process. This role sits within the organisation that is responsible for the overall quality requirements of the project, i.e., is accountable to the client.

The CRe provides the final signature to approve the supply chain as production ready for the project or future projects through the completion of the CPAP. Table 1 describes the different responsibilities that the CRe shall hold for implementing the CPQP process.

The CRe ensures that the CPQP Project Plan has been kicked off and the supply chain is on track to complete the CPQP process. It would also be the CRe's responsibility to ensure that any risks encountered by the cross-functional project team are alleviated or mitigated. The CRe assigns the type of submission required by providing the Product Approval Checklist and assigning the submission level. This ensures the supply chain is made aware if any elements of the CPQP which are not applicable. The submission levels that can be assigned for the CPQP are specified in Table 5.

The CRe also ensures that the delivery of the CPQP milestones and gates are as per the original plan and proactively communicates any bottlenecks to the client. If any design, manufacturing or validation issues are encountered during the later phases of CPQP, the CRe would ensure that the relevant technical authorities are involved in additional risk analysis.

If the product is not produced as per the engineering definition, but acceptable to the internal project customer, the CRe shall ensure that any concessions are granted only after consultation with the relevant project technical authority.
In such a case, the CRe shall also ensure that the CPQP submission is only granted an interim approval on the PSW until a conforming product can be produced at required demand rate by the manufacturer, or an engineering definition change is granted by the design consultants to accept the non-conformance as formal product definition (only in cases where the risk is deemed extremely low).
The different approval levels, which can be granted by the CRe, are summarised in Table 6 and Figure 5.

Kick off	Supervise	Maintain	Sign Off
• CPQP Project Plan • Product Approval Checklist • Multi-functional project team creation	• Flow down CPQP requirements to supply chain • Provide expertise, best practices and resolve bottlenecks • Ensure correct procedures are being followed • Multi-functional team sessions and gate approvals	• Clear and consistent communication with the client throughout the project life-cycle • Check progress with the supply chain • Lessons learnt document	• Customer specific requirements. • Part Submission Warrant (PSW) • On-site assembly sample fit out • Customer concession

Table 1. Responsibilities assigned to CRe

Product Approvals Co-ordinator (PAC)

The Product Approvals Co-ordinator (PAC) is responsible for preparing the CPAP submission pack for review and sign-off by the CRe. The PAC is a role defined for a competent person within the organisation to ensure the communication, preparation and submission required for the CPAP activities. Table 2 describes the different responsibilities of the PAC required during the different phases of the CPQP.

The CRe sets out the initial requirements for the different CPQP elements and customer-specific requirements. It is then the responsibility of the PAC to flow down the relevant requirements internally to the designers, manufacturers and sub-tier suppliers.

Assigning the Roles

The roles for the implementation of the CPQP and the completion of the CPAP may be delegated to different organisations depending on the nature of the product development project, procurement contracts and delivery model.

The adoption of the CPQP process in the construction industry can lead to multiple scenarios for completion of the CPAP. Two of the early envisioned scenarios are described in this section for illustrative purposes. However, the implementation details need to be defined in collaboration with customers, manufacturers and suppliers.

Kick off	Supervise	Maintain	Sign Off
• Internal Project Plan (This could also include Task Information Delivery Plan (TIDP) in instances where Building Information Modelling level 2 is being incorporated) • Initial requirements capture for submission level from CRe • Requirements flow down to sub-tiers	• Requirements flow down to further sub-tiers • Completion of all CPQP elements • Setting up error proofing (Poka-Yoke) devices • 8D Problem Solving and Root Cause Analysis	• Internal project charter • Formal communication with the CRe throughout the CPQP project including gate approvals • Production readiness status • Lessons learnt log	• Production control results • Process Flow and Failure Mode and Effects Analysis (FMEAs) • Control Plan & Reaction Plan • Dimensional results • Material results and lab control documentation • PSW from sub-tiers

Table 2. Responsibilities assigned to Product Approvals Co-ordinator

Contractor Delivering a Pipeline of Off-site Projects for a Public or Private Developer

The client should ideally delegate the implementation of the CPQP and the completion of the CPAP to the main contractor or a contract management organisation. This is the organisation responsible for the overall quality requirements of the project (i.e. is accountable to the client) and takes the role of customer for the CPQP and the CPAP completion.

The main contractor or the contract management organisation in representation of the client assign the Client Representative (CRe). The CRe will be the responsible and accountable person for monitoring the overall CPAP progress associated with the CPQP process. Through the CRe, the main contractor or the contract management organisation cascades the Voice of the Customer and initial requirements to the manufacturer and suppliers.

The manufacturer organisation still bears the responsibility for the design and development of the products and manufacturing processes. The manufacturer appoints a Product Approval Coordinator, PAC, who is responsible for coordinating the completion of the CPAP following the CPQP process. The manufacturer through the PAC should ensure the engagement of their supply chain and make sure requirements are cascaded down so that the entire chain is aware of the CPQP requirements and the information they need to deliver for the completion of the CPAP.

If the procurement contract entails a supply route, where the product (or system) is designed by an organisation separate from the manufacturer, then the two bodies may appoint their respective PACs to promote cross-functional communication between the organisations. This example is shown in Figure 3.

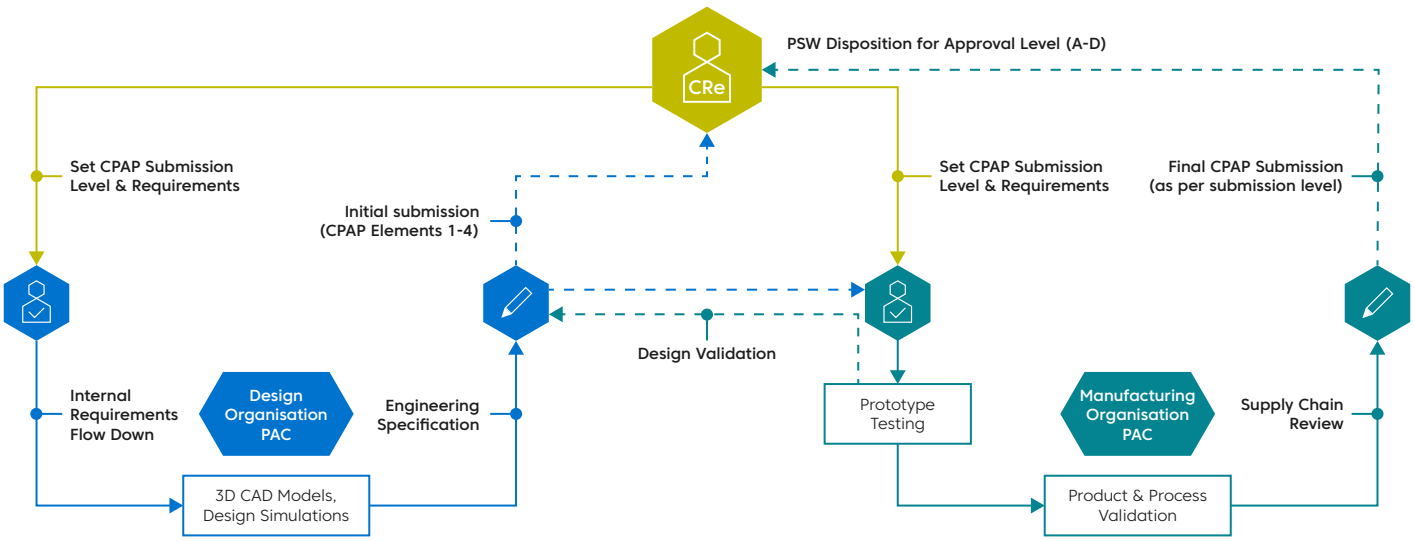

Figure 3. Diagrammatic flow for sample CPAP responsibilities – multiple PACs

Through the implementation of the CPQP and the CPAP, the main contractor or the contract management organisation would then be able to foresee any issues with the products to be delivered by the supplier at early stages of the product design and thus ensure they meet the customer requirements. The CRe signs-off the final submission of the CPAP provided that the product meets the defined customer requirements.

Through this sign-off, the main contractor is confirming to the supplier and manufacturer the suitability of the product for the project based on the defined requirements.

The manufacturer bears sole responsibility for the products they manufacture and supply. The sign-off from the main contractor or contract management organisation does not imply any legal relief from their obligations and liability.

Manufacturer Developing a Product in Response to an Identified Market Need

This scenario corresponds to an internal product development process within an organisation. The manufacturing organisation is interested in developing a product for a specific market need.

The product is expected to be manufactured at scale in a production line. The implementation of the CPQP is led by the internal customer that is driving the development of the product. The role of Client Representative should be assigned to the product owner or a person appointed by the internal customer. The CRe will be the responsible and accountable person for monitoring the overall CPAP progress associated with the CPQP process. Through the CRe, the organisation cascades the Voice of the Customer and initial requirements to the development team.

The development team is responsible for the design and development of the products and the manufacturing processes. The Product Approval Coordinator, PAC, should sit within that development team. The PAC is responsible for coordinating the completion of the CPAP following the CPQP process. The development team, through the PAC, should ensure the engagement with other relevant departments in the organisation as well as with the supply chain to make sure requirements are cascaded down.

Through the implementation of CPQP and CPAP, the internal customer and the product owner would be able to foresee any issues in the product development process from the early stages and work alongside the

development team to overcome them.

The CRe signs-off the final CPAP submission provided that the product meets the defined customer requirements. Through this sign-off the internal customer is confirming to the development team that the product and its manufacturing process meets the requirements. This sign-off declares the product delivers to the Voice of the Customer and can be handed over to the production team.

CPAP Applicability

The CPAP is initiated from the client representative organisation and forms the formal evidence for approval through the CPQP process. As a first step of the CPQP, the cross-functional team identifies and classifies the product into one of three categories; critical, significant, or unclassified as defined in Table 3 (and covered in the CPQP Guide).

Critical	Non-conformance would result in loss of primary function of the product resulting in catastrophic or hazardous failures without any warning. These are failures that would potentially lead to the loss of lives and/or irreparable damage. Products with any critical features are automatically classified as critical products.
Significant	Non-conformance would result in loss of primary function of the product resulting in major failures without any warning. These are failures that cause significant disruption and costs to the client. Products with any significant features are automatically classified as significant products.
Unclassified	Non-conformance would result in the loss of a functionality that causes only minor disruption to the end-user. These are failures that can be repaired with relative ease and cause only minor disruptions. Products with all unclassified features are unclassified products.

Table 3. Classification of Products and Features

Classifying features and products using this methodology ensures that appropriate quality tools can be used and the CRe can provide the required oversight during their approval using the CPAP approval checklist. As the CPQP does not apply to products that are unclassified, any Commercial Off-The-Shelf (COTS) material or products are considered unclassified and out of scope for this process as well. Some examples of the different classifications of products are available in the Construction Product Quality Planning Guide.

The CPAP details the oversight for the implementation of the Construction Product Quality Planning (CPQP) process. CPQP describes the process for the introduction of new products, but its applicability is not only limited to brand new and complex products but also covers exiting products where relevant changes are expected (e.g. design changes, materials choices, etc.). The applicability matrix in Table 4 has been described in the CPQP guide and it also is relevant for the CPAP.

Applicable	Non Applicable
The introduction of significant and critical products on new or existing projects.	The introduction of unclassified products.
Re-introduction of an outdated significant or critical product with no continuity of supply for more than 2 years.	Purchase of standard Commercial Off-The-Shelf (COTs) products.
Change to the production process for an existing significant or critical product (only certain elements of CPQP apply).	Products purchased only for supporting the construction process but those that will not be included in the final built asset.
A modification to an existing significant or critical product being procured through the same supplier (only certain elements of CPQP apply).	Modification considered low risk by CRe or customer.
Change of supply source, change of facility within existing source or change to production process (only certain elements of CPQP apply).	Only volume ramp up within existing source without any change to the production process. (In this instance, a simple load and capacity report should be sufficient).

Table 4. CPAP applicability matrix

In summary, CRe oversight is limited to only significant and critical products, for which a PSW is signed at the first-off delivery and thereby giving authorisation to ramp up to future production schedules.

Submission and Approval Levels

Submission Process

The requirements for the overall CPAP submission flows down from the CRe to the different tiers of manufacturers providing (significant or critical) products, as shown in Figure 4. These requirements are initially supplied in the Construction Product Approval Checklist (CPAC). Further information is explained in the CPAP Submission Timeline section. A template for the CPAC checklist can be found in the appendix.

These manufacturers in turn have their own supply chains from which they may be receiving unclassified products. In such a case the responsibility for the overall CPAP submission lies with the top tier manufacturer, as they in turn are responsible for overlooking their own supply chains on behalf of the CRe. Successfully completing CPAP activities results in a submission flow from sub-tier suppliers to the CRe as shown in Figure 4.

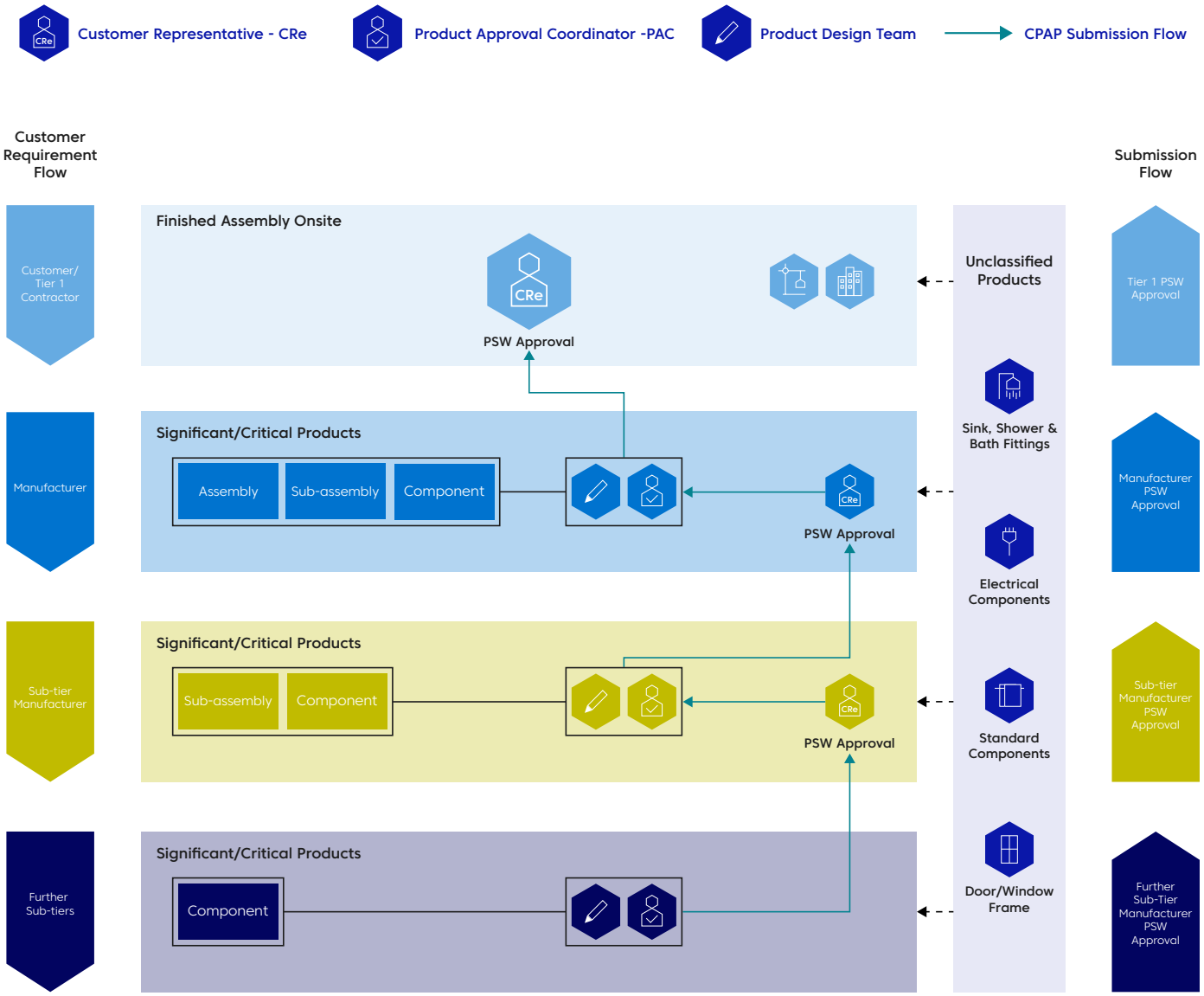

Figure 4. Customer requirements cascade and submission flow for CPAP

Submission Levels

The submission level defines the level of oversight that the CRe would exercise over the implementation of the CPQP and the completion of the CPAP. The CRe assigns a submission level required for approval, once Phase 1 of the CPQP has been commenced.

The submission levels are assigned based on the maturity of the supply route. If a supply chain is relatively new for the product mix being procured, it is recommended to have a more stringent submission level, i.e., level 3. Table 5 summarises the different submission levels, which may be assigned for the CPAP activities.

CPAP Submission Level	Type	Definition
1	Consult	The organisations involved in the CPQP process may consult the CRe on which of the 15 elements need to be submitted for approval. The CRe may tailor the CPQP element submission requirements and specify this on the Product Approval Checklist. This submission level is appropriate to use when working with a procurement route that has been validated previously and has extensive experience in delivering representative products. Document retention requirements to be defined by the CRe.
2	Submit	The organisations involved in the CPQP process are required to submit all 15 elements outlined in this handbook. This submission level is appropriate to use when working with a procurement route with design practices and suppliers that have previously been delivering similar products. All documents to be retained by the organisations submitting the respective elements, unless otherwise specified by the CRe.
3	Witness	The CRe may request witnessing any of the elements of CPQP as specified on the Product Approval Checklist as they are being carried out by any of the organisation involved. Submission for all the elements may still be required. This submission level is appropriate to use when working with a new procurement route with design practices and suppliers that have not delivered similar systems previously. All documents to be retained by the organisations submitting the respective elements.

Table 5. Submission levels defined by the CRe at Project Kick-off

Approval Levels

The goal of the CPAP is to achieve a final and full approval of the process that ensures that the supply chain can meet all the system and level requirements to deliver a fully conforming product at the expected customer demand rate. However, interim approvals are often required in instances when the supply chain has faced exceptional circumstances and production readiness has not been achieved by the CPAP due date.

These are often special situations where due to either design complexities or manufacturing constraints, the product is unlikely to achieve production readiness status within the project timeframe. The approval levels in Table 6 define the different levels of interim approval to ensure continuity of supply while the supplier may still be in the development phase. This classification, which is assigned by the CRe to the CPAP submission, also provides clarity to the client about the production readiness levels of their supply chain.

CPAP Approval Level	Type	Definition
A – Final Approval	Production ready	The supply chain can meet all system level and product level requirements to deliver a fully conforming product at the expected customer demand rate.
B – Interim Approval	Quality ready	The supply chain can fulfil all the quality requirements of the customer, but the process is not fully production ready. This may be due to lack of capacity or fixed production volumes.
C – Interim Approval	On-site rework	The supply chain cannot fulfil all the quality requirements of the customer and the process is not production ready. There is on-site rework required to install the sample product on site.
D – Interim Approval	Impaired quality	The supply chain cannot fulfil the quality requirements of the customer and the process is not production ready. The product needs customer concession to be shipped to site as the manufacturer is unable to meet engineering definition. There may be further on-site rework required to install the sample product. This level should be granted only if the defective product is still acceptable to the internal customer receiving it.

Table 6. Approval levels disposition by the CRe at CPAP Submission

The different approval levels assigned on the PSW help in monitoring the overall progress and reporting any issues to the client. Figure 5 illustrates the criteria to consider for granting the different approval levels.

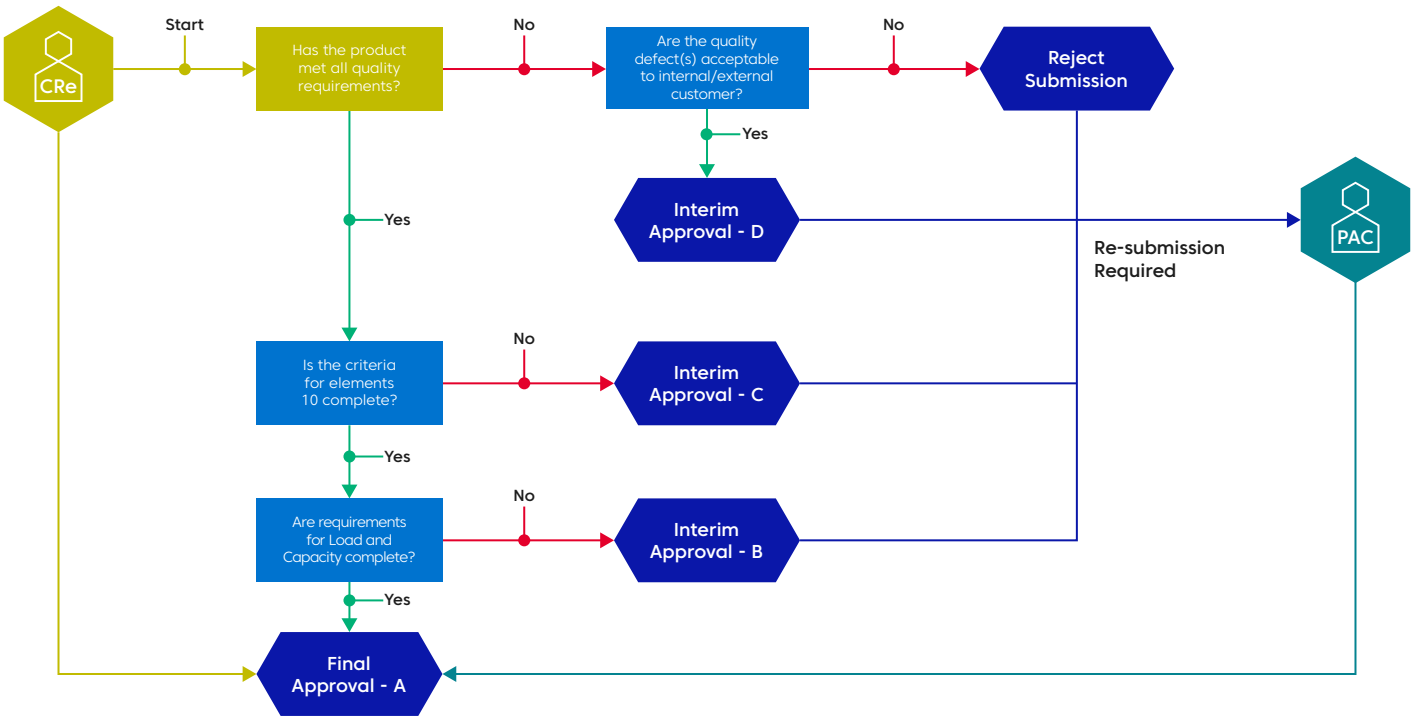

Figure 5. CRe oversight for disposition of the CPAP submission

CPAP Submission Timeline

CPAP Submission Timeline

The Construction Product Approval Process should be initiated by the CRe after completion of the CPQP gate 1 activities as shown in Figure 6.

The CPAP pack is submitted at the end of phase 4 of the CPQP. However, CPAP provides an interim submission at every CPQP phase in order to ensure that the activities are being carried out as required. If the design and manufacturing supply chain have significant demonstrable experience, the CRe may provide exemptions for certain elements which may have previously been completed. The list below summarises the 15 CPAP elements and the recommended submission timeline.

1. Planning Phase (gate 1) – CRe to initiate CPAP activities. At this stage, the CRe completes the Construction Product Approval Checklist (CPAC) and assigns a required submission level.

2. Product Design and Development (gate 2, CPAP elements 1-3) – PAC for the design organisation to submit Design Specifications, Customer Engineering Approvals and Design Failure Mode and Effects Analysis.

3. Process Design and Development (gate 3, CPAP elements 4-7) – PAC for the manufacturer to submit Process Flow Chart, Process Failure Mode and Effects Analysis, Control Plans and Qualified Laboratory Documentation and Records of Material / Performance Test Results.

4. Product and Process Validation (gate 4, CPAP elements 8-9) – PAC for the manufacturer to submit Product Sustainability Documentation and Packaging Instructions.

5. Product and Process Validation (gate 5, CPAP elements 10-15) – After successfully obtaining the Sample Product On-Site Approval and Production Readiness Approval, the PAC for the manufacturer should submit the remaining CPAP elements and obtain full PSW level A approval from the CRe.

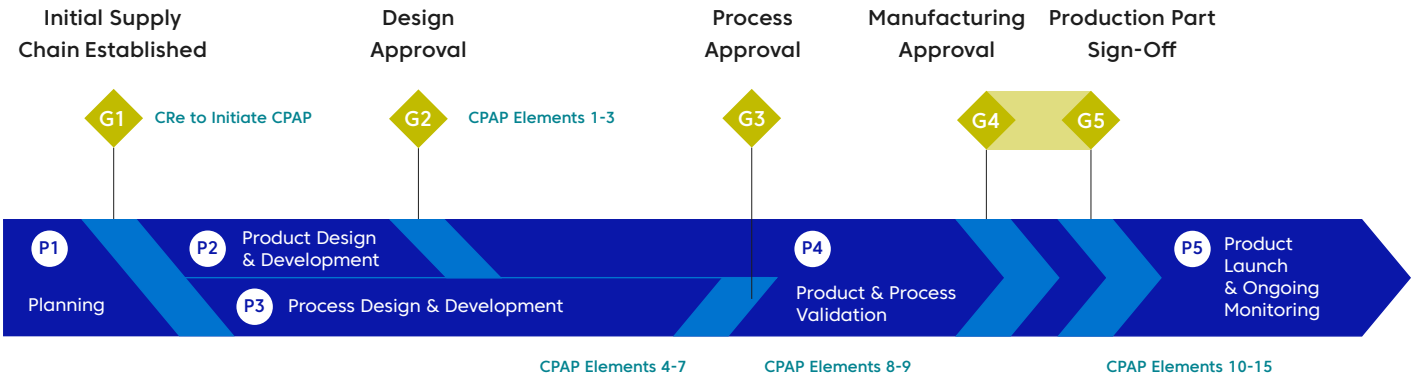

Figure 6. CPAP element submission timeline

CPAP Acceptance Criteria

CPAP Acceptance Criteria

The evaluation of the submission requires the definition of a set of clear criteria and questions that can be used by the CRe and PAC to assess if the CPAP documents and files have achieved the required standard that will result in a successful Part Submission Warrant (PSW) submission.

The checklists in the next section provide audit questions and criteria for each of the 15 CPAP elements. The same questions can also be used during the CPQP process and gates as an aid to assess progress.

The final step in the timeline is to complete the Part Submission. The Part Submission Warrant (PSW) checklist (Table 21) outlines the evaluation for the completion of the submission and the template found in the guide provides the format for it to be completed.

CPAP Deliverables Checklists

Tables 7 to 21 provide some guidance for the checklist of relevant elements of the CPAP submission pack. The checklists should be adapted to the needs of the projects and agreed upon by the Client representative CRe, the Product Approval Coordinator PAC and the wider CPQP team during Phase 1 of the CPQP.

	Audit Question and Criteria	Y	N
1	Have the Product Design Requirements been clearly defined in a document(s) translated from the customer wants, expectations, requirements and design goals into design features and a measurable set of engineering and quality targets for the product?		
2	Are all engineering, construction, regulatory and customer specifications confirmed? Are they documented (in a list) and referenced in the associated product and component drawings?		
3	Are the drawings, CAD models and any specification documentation at the correct revision level and are they referenced with the correct part names and numbers?		
4	Are the drawings and CAD models at the correct level and status for production, i.e., released?		
5	When there are hierarchies of assemblies, sub-assemblies and components and/or there are different configurations of finished product: • Are there matching levels of engineering drawings? • Is there a configuration tree document?		
6	Is the Bill of Materials up to date, at the same level as the drawings, does it match the hierarchy of assemblies and is it released for production?		
7	Have all engineering changes been approved and implemented prior to the PSW submission?		

Table 7. CPAP checklist - Design Specifications

Customer Engineering Approvals

	Audit Question and Criteria	Y	N
1	Is there evidence that the customer has given engineering approval? (i.e., signed drawings, design review sign off, specification sign off)		
2	If there is a concession or deviation applicable to the product or process, is there an appropriate document signed off from the customer?		
3	Where a Design Verification Plan exists, has it been completed and signed off by the customer? (see Table 20 - Final Product Validation Test checklist)		

Table 8. CPAP checklist - Customer Engineering Approvals

Design Failure Mode and Effects Analysis (DFMEA)

	Audit Question and Criteria	Y	N
1	Are product and DFMEA references correct? (i.e., process and facility location, product details, part number, latest drawing revision, latest DFMEA revision, its date and list of participants involved up to date)		
2	Does the DFMEA include and evaluate all the functional requirements of the design?		
3	Was the DFMEA developed with a cross-functional team covering all disciplines including operators and where appropriate the customer?		
4	Have DFMEAs for similar products been considered and reviewed?		
5	Has historical performance data for similar products been considered when creating and scoring the DFMEA? (i.e., quality, warranty, product performance data with cross checks on severity ratings and occurrences from known past failures)		
6	Is the DFMEA maintained as a live document, i.e. • Is it in line with the latest drawings and specifications and is there evidence that the DFMEA has been updated through change control management as the design has evolved? • Have corrective actions been set with dates? • Have the actions been closed out ready for the CPAP submission at the end of Phase 4? • Have Risk Priority Number (RPN) scores been updated as actions have been completed or design changes been made?		
7	Does the DFMEA identify all Critical Characteristics and Significant Characteristics?		
8	Are the identified potential failure modes clearly defined? (i.e., if the failure mode was fastener pilot hole wrong size, it could be oversized or undersized)		
9	Do the identified effects of failure modes consider the impact on higher-level systems (sub-assemblies being fitted to a larger assembly) and on the “customer” (including the end users)?		
10	Are the causes described in terms of something that can be controlled or fixed with the product design and point to the root cause? (e.g. “poor design” is an ambiguous cause whereas stating “Pilot for fastener too big allowing panel to be pulled out” is much more concise)		
11	Are the scoring criteria used consistent with the DFMEA guideline?		
12	Have appropriate actions been identified and taken for failure modes with high severity (>7)?		

Table 9. CPAP checklist - DFMEA

Process Flow Chart

	Audit Question and Criteria	Y	N
1	Are product and process references correct? (i.e. process and facility location, product details, part number, latest drawing issue)		
2	Was the Process Flow Chart developed with a cross-functional team covering all disciplines including operators?		
3	Were the appropriate DFMEAs used to develop the process flow?		
4	Does the Process Flow Chart or set of flow charts cover the end-to-end process from Goods Received to Goods Despatched and does it show the actual process where each step is clearly defined?		
5	Do the Process Flow Charts show links to other internal manufacturing processes, i.e., where sub-assemblies feed in/out and do they link to external outsourced manufacturing processes?		
6	Does the Process Flow Chart show how material is moved within the process, i.e. forklift truck, auto transfer etc?		
7	Does the process flow show inspection processes?		
8	Does the flow chart show rework and reject flows?		
9	Does the process identify manual and machine operations and where qualified operators are required?		
10	Is the Process Flow Chart maintained as a live document? (i.e., is it in line with the latest drawings and specifications and is there evidence the flow has been updated through change control management as the design and process has evolved)		

Table 10. CPAP checklist - Process Flow Chart

Process Failure Mode and Effects Analysis (PFMEA)

	Audit Question and Criteria	Y	N
1	Are product and PFMEA references correct? (i.e., process and facility location, product details, part number, latest drawing issue, latest PFMEA level, its date and list of participants involved up to date)		
2	Does the PFMEA align with the latest revision of the process flow and cover all the operations?		
3	Was the PFMEA developed with a cross-functional team covering all disciplines including operators and where appropriate the customer?		
4	Have PFMEAs for similar products and processes been considered and reviewed?		
5	Has historical performance data for similar product and processes been considered when creating and scoring the PFMEA? (i.e., quality, warranty, process performance data with cross checks on severity ratings and occurrences from known past failures)		
6	Is the PFMEA maintained as a live document: • Is it in line with the latest drawings and specifications and is there evidence that the PFMEA has been updated through change control management as the design and process has evolved? • Have corrective actions been set with dates? • Have RPN scores been updated as actions have been completed or design changes been made?		
7	Are the identified potential failure modes clearly defined? (i.e. if the process was to fit 3 bolts to a specified torque the failure modes would be: no bolts fitted, not enough bolts fitted, bolts over tightened, bolts under tightened, wrong bolt fitted)		
8	Do the identified effects of failure modes consider the impact on the “customer” in terms of the subsequent operations? (i.e., on the product, equipment, tooling, people, end user)		
9	Are the causes and corresponding control method functionally explicit, verifiable and actionable? (i.e., operator error with an action of operator training is not the root cause of failure or a corrective action that will reduce RPN)		
10	Is the scoring criteria used consistent with the PFMEA guideline?		
11	Have appropriate actions been identified and taken for failure modes with high severity (>7)		
12	Does the PFMEA link with the drawings, DFMEA and Control Plan, with traceability for the source of Critical Characteristics and Significant Characteristics?		
13	Where detection is the major factor in a high RPN, have provisions been made in the process to control the cause prior to the next operation?		
14	Has the RPN scoring for severity used the highest value from both the DFMEA and PFMEA?		

Table 11. CPAP checklist - PFMEA

Control Plan

	Audit Question and Criteria	Y	N
1	Does Control Plan identify Key Characteristics and Critical Items?		
2	Does the Control Plan include the high RPN items identified in the PFMEA?		
3	Where Key Characteristics and Critical Items have been identified, are appropriate process controls in place to minimise variation?		
4	Does the Control Plan include all process steps for the product manufacture?		
5	Does the Control Plan include all high-risk items identified in the PFMEA?		
6	Are the Control Methods identified and Poka-Yoke measures in place?		
7	Where Statistical Process Control (SPC) has been used, is process monitoring being implemented to identify special cause variation?		
8	Does the Control Plan specify inspection frequency and sampling plan?		
9	In cases where sample and reduced inspection is being carried out, is appropriate evidence available showing customer approval?		
10	Does the Control Plan specify appropriate reaction plan?		

Table 12. CPAP checklist - Control Plan

Qualified Laboratory Documentation and Records of Material/Performance Test Results

	Audit Question and Criteria	Y	N
1	Has the organisation carrying out the laboratory tests gained required accreditation?		
2	Are all laboratory approvals up to date?		
3	Does the Material and or Performance Test comply with the overall validation required?		
4	Is the material traceable on the manufacturer's batch card with a unique identification number?		
5	Are the product references on material validation certificates clearly identified?		
6	Does the supplier use MRP/ERP systems to monitor and store historical data for materials supplied?		

Table 13. CPAP checklist - Qualified Laboratory Documentation and Records of Material / Performance Test Results

Sustainability Documentation

	Audit Question and Criteria	Y	N
1	Do all construction products have an Environmental Product Declaration (EPD) compliant with EN 15804?		
2	Has there been a Life Cycle Cost (LCC) analysis for the manufacturing and production of building products? (e.g. modules A1-A3 of the building assessment information described in BS EN 16627)		
3	Has there been any consideration for the social performance of building components, such as adaptability to people's use, accessibility or health and comfort?		
4	Have the relevant construction products been assessed and certified by Responsible Sourcing Certification Schemes (RSCS)?		
5	Has the manufacturer/designer had any consideration for Design for Disassembly (DfD) of the building products? (i.e. decommissioning manual, reuse potential)		
6	Has the manufacturer/designer provided any information on the maintenance cycles and/or service life of the building products?		

Table 14. CPAP checklist - Sustainability Documentation

Packaging and Labelling Standards and Documentation

	Audit Question and Criteria	Y	N
1	Is the packaging and labelling of the product compliant with relevant specification/regulation?		
2	Does the product marking provide traceability?		
3	Are product markings clear and legible?		
4	Is the finished product free from any contamination/debris?		
5	Are digital MRP/ERP being used and scanning systems ensuring that product has correct labelling prior to despatch?		

Table 15. CPAP checklist - Packaging and Labelling Standards and Documentation

Sample Production Product - On Site Approval

	Audit Question and Criteria	Y	N
1	Has the sample product been delivered free of any visual defects?		
2	Does the product documentation clearly identify any non-conformance?		
3	Does the product documentation include all relevant validation reports?		
4	Has the product been certified by an UKAS approved body?		
5	Have all specifications been satisfied? If they have not been satisfied has an appropriate concession been raised to allow supply documenting the corrective actions and dates for close out when the product will be supplied to specification?		
6	Does the product fulfil its design intent during assembly in an error proof manner?		
7	Does the product or system require any on-site rework during assembly operation?		
8	Has the assembly of the product or system resulted in any snagging defects?		

Table 16. CPAP checklist - Sample Production Product - On Site Approval

Measurement System Analysis (MSA) Studies and Dimensional Results

	Audit Question and Criteria	Y	N
1	Is there evidence to show that the measurement systems being used in manufacture are being validated to measure the customer specifications?		
2	Are all measurement gauges and sensors being calibrated at regular intervals and calibration stickers displayed on all equipment used?		
3	Does the data show meaningful results, for example: bias, linearity, Type 2 gauge R&R, attribute agreement analysis?		
4	In cases where validation studies have been carried out, are correct specifications being adhered to for quantifying and accepting errors as per required guidelines?		
5	In cases where validation studies have been carried out, are correct number of operators, parts and measurement repeats being established?		
6	Does the metrology department deem any features to be thermally sensitive for dimensional control and if so, have appropriate inspection methods been put in place?		
7	Has any specialist software been used to validate the gauges or sensors used during manufacture or product assembly? Is the software fit for the intended use?		
8	Has the assembly of the product or system resulted in any snagging defects?		
9	In cases where the supplier hasn't checked all features on the drawing, are customer approvals in place to carry out sample or reduced inspection?		
10	Have appropriate number of products been used to prepare dimensional conformance report?		
11	Have all validation results been deemed complete and signed off by the responsible technical authority at the manufacturer?		

Table 17. CPAP checklist - MSA Studies and Dimensional Results

Process Capability and Surveillance

	Audit Question and Criteria	Y	N
1	Has the supplier used highly repeatable manufacturing processes resulting in acceptable documented tolerances or product of the tool features?		
2	Has the supplier demonstrated process capability to required levels for key characteristics and critical items?		
3	In cases where the engineering specification contains key characteristics and critical items, have appropriate process control parameters been identified?		
4	In cases where the engineering specification contains key characteristics and process capability data is unavailable, has the supplier included relevant examples of error proofing mechanisms in the manufacturing process?		
5	Has the manufacturing process been deemed stable and fixed by the client representative?		
6	Are results from the sub-tier suppliers and contractors conforming to the required specification?		
7	Have all responsible technical authorities approved the process control document?		
8	Are any Factory Production Control (FPC) Audits scheduled at regular intervals for further 3rd party approvals?		

Table 18. CPAP checklist - Process Capability and Surveillance

Quality, Load and Capacity Report (QLC)

	Audit Question and Criteria	Y	N
1	Have trial production process runs been conducted with all run time, down time and cycle times recorded? Were the total number of parts made with number of rejects and reworks recorded? Were the run duration times recorded?		
2	Have all issues raised during the trial production process runs been logged on the QLC form, actioned and closed out?		
3	Has the QLC report been completed using the production run data?		
4	Are product and the Quality and Capacity Report (QCAR) references correct? (i.e., process and facility location, product details, part number, latest drawing issue level and date)		
5	Does the QCAR show that given the shift patterns and available time to run the process and the demonstrated data from the trial runs, that the process will meet customer demand? (i.e. is there enough capacity to meet demand)		
6	Does the quality level achieved in the production trial run meet the quality target?		
7	Does the combined production rate and quality output meet the required capacity?		
8	Has the report been internally approved and signed off by the appropriate operational and manufacturing managers responsible for the production process?		

Table 19. CPAP checklist - QLC Report

Final Product Validation Test

	Audit Question and Criteria	Y	N
1	Are the Design Verification Plan and Report (DVP&R) references correct? (i.e., product details, part number, latest drawing issue)		
2	Have all design verification tools and tests been recorded and does the DVP&R tie up with the DFMEA, product Design Specifications, customer specific and regulatory requirements?		
3	Do the tests cover all the product characteristics that need to be tested identified in the engineering and product specifications?		
4	Is all the testing information complete on the DVP&R?		
5	Have all tests been completed and passed? Status shown on the DVP&R?		
6	Where tests have failed is there evidence that corrective actions have been recorded, actioned and closed out?		
7	Are all the results recorded in the DVP&R?		
8	Are reports available for each test (either internal or external)?		
9	Has the customer signed off the test results?		

Table 20. CPAP checklist - Final Product Validation Test

Part Submission Warrant (PSW)

	Audit Question and Criteria	Y	N
1	Has the documentation been submitted to the correct submission level?		
2	Have the required number of parts been produced as a part of the production process run?		
3	Does the PSW identify the technical authority from the production organisation responsible for the submission?		
4	Where additional customer requirements have been identified, have all of them been satisfied?		
5	Are records available to show that sub-tiers are production ready?		
6	Have all requirements been satisfied for the 15 elements to grant full approval?		

Table 21. CPAP checklist - PSW

References and Appendices

References

[1] Automotive Industry Action Group. (2008). Advanced product quality planning (APQP) and control plan reference manual (2nd ed.). Southfield, MI: AIAG.

[2] British Standards Institution. (2018). Aerospace Series – Requirements for advanced product quality planning and production part approval process. BS EN 9145. UK: BSI.

[3] Tanner, S. & Bailey, M. (2014). The business improvement handbook, fourth edition, London, UK: BSI Group.

Appendices

Appendix A – Tool Templates

Templates to be use within the context of this guideline are available, please contact: **cpqp@constructioninnovationhub.org.uk**

Appendix B – List of Abbreviations

The following is a list of initialisations and acronyms used in this guideline.

A	**APQP**	Advanced Product Quality Planning
C	**COTS**	Commercial Off-The-Shelf
	CPAC	Construction Product Approval Checklist
	CPAP	Construction Product Approval Process
	CPQP	Construction Product Quality Planning
	CRe	Client Representative
D	**DfD**	Design for Disassembly
	DFMEA	Design Failure Mode and Effects Analysis
	DVP&R	Design Verification Plan and Report
E	**EPD**	Environmental Product Declaration
F	**FMEA**	Failure Mode and Effects Analysis
	FPC	Factory Production Control
L	**LCC**	Life Cycle Cost
M	**MSA**	Measurement System Analysis
N	**NPI**	New Product Introduction
P	**PAC**	Product Approvals Co-ordinator
	PFMEA	Process Failure Mode and Effects Analysis
	PPAP	Production Part Approval Process
	PSW	Part Submission Warrant
Q	**QCAR**	Quality and Capacity Report
	QLC	Quality, Load and Capacity
R	**RPN**	Risk Priority Number
	RSCS	Responsible Sourcing Certification Schemes
S	**SPC**	Statistical Process Control
T	**TIDP**	Task Information Delivery Plan

Appendix C – Glossary of Terms

The following is a list of commonly utilised quality, manufacturing and construction specific terms and their definitions within this context used within this guideline.

A **Advanced Product Quality Planning (APQP)**

A quality framework used for developing new products. It was developed by the automotive industry but can be applied to any industry and is similar in many respects to the concept of design for six sigma; see AIAG Reference [1].

C **Construction Product Approval Process (CPAP)**

An adaptation of Production Part Approval Process (PPAP) that is aimed at those enterprises that will feed construction with new componentry for off-site builds.

Commercial Off-The-Shelf (COTS)

BS EN 9145: "Commercially available products, defined by industry recognized specifications and standards, sold through public catalogue listings."

Construction Product Quality Planning (CPQP)

An adaptation of Advanced Product Quality Planning (APQP] that is aimed at those enterprises that will feed construction with new componentry for off-site builds.

Critical Item (CI)

BS EN 9145 [2]: "Those items (e.g., functions, parts, software, characteristics, processes) having significant effect on the product realization and use of the product; including safety, performance, form, fit, function, producibility, service life, etc.; that require specific actions to ensure they are adequately managed."

Customer Representative (CRe)

The CRe is the responsible and accountable person for monitoring the overall progress associated with the CPQP process. This role sits within the organisation that is responsible for the overall quality requirements for the project i.e., is accountable to the client. Depending on the nature of the procurement contract, different organisations may be delegated to have this responsibility. The CRe provides the final signature to approve the supply chain as production ready for the project or future projects. This term is synonymous to 'Client Representative'.

D **Design Failure Mode Effects Analysis (DFMEA)**

An application of Failure Mode Effects Analysis (FMEA) for product design.

Design for Manufacture and Assembly (DfMA)

Product design with design priority given to ease of both assembly and manufacture.

Design Verification Plan and Report (DVP&R)

A planning tool for the systematic determination that a product or process meets its design specifications and performance requirements. Closely tied to FMEA; FMEA determines the 'what' in anticipating potential failures while DVP&R focuses on the 'how'.

F **Failure Mode Effects Analysis (FMEA)**

"A tool for facilitating the process of predicting failures, planning preventative measures, estimating the cost of the failure, and planning redundant systems or system responses to failures [3]."

"The FMEA assists in the identification of CIs as well as key design and process characteristics, helps prioritize action plans for mitigating risk and serves as a repository for lessons learned [2]."

K **Key Characteristic (KC)**

BS EN 9145 [2]: "An attribute or feature whose variation has a significant influence on product fit, performance, service life or producibility; that requires specific action for the purpose of controlling variation."

M **Measurement Systems Analysis (MSA)**

A tool that is used to validate measurement systems; this can range from subjective, manual measuring equipment to automated sensor equipment that outputs measured values. MSA looks not only at the equipment being used but also the human factors, environment, location and inspection process. A complete MSA study can provide confidence to all parties involved in the construction process that the data has been validated through a comprehensive process.

N **New Product Introduction (NPI)**

NPI programs aim to introduce new and usually complex products to markets through a standardised process. The phases typically covered are concept planning, design & manufacture, final validation & production launch. This is usually achieved in other sectors through application of process such as the APQP process.

P **Poka-Yoke**

Based on the Japanese term for "mistake proofing" it more broadly refers to any mechanism within a product or process designed to prevent errors.

Process Failure Mode Effects Analysis (PFMEA)

An application of Failure Mode Effects Analysis (FMEA) for process design and implementation.

Production Part Approval Process (PPAP)

A process, standardised by both the automotive and aerospace industries, that outlines the steps and requirements for approval of production designs and/or manufacturing processes throughout the product development cycle. It also ensures that the entire supply chain understands these steps when procuring externally manufactured parts.

Part/Product Submission Warrant (PSW)

The PSW is the final approval form that the Customer Representative has to sign off indicating that all the requirements for the CPQP process have been completed and production readiness status has been achieved.

Q **Quality, Load and Capacity Report (QLC)**

The Quality, Load and Capacity Report contains all relevant information regarding the quality of the production batch of components along with any constraints within capacity. The QLC report forms a key part of the overall CPQP submission.

S **Statistical Process Control (SPC)**

ISO 3534-2: "Activities focused on the use of statistical techniques to reduce variation, increase knowledge about the process, and steer the process in the desired way. SPC operates most efficiently by controlling variation of a process characteristic or an in-process product characteristic that is correlated with a final product characteristic and/or by increasing the robustness of the process against this variation. A supplier's final product characteristic can be a process characteristic to the next downstream supplier's process."

T **Task Information Delivery Plan (TIDP)**

According to the BIMe Initiative, "This document sets out the information delivery responsibilities of each Task Team. TIDPs are submitted in accordance with the Master Information Delivery Plan (MIDP) and aggregate team information deliverables, project tasks, formats, dates and related responsibilities [3]."

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mtc Manufacturing Technology Centre

cdbb Centre for Digital Built Britain

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