The QC checklist:
An essential tool for managing product quality of ceramics

By John Niggl

A quality control checklist clarifies product specifications for mass production and helps ensure the quality of manufactured ceramic products.

How might ceramics manufacturers be affected without the benefit of having a quality-control checklist for their products?

Ceramic knives, dishware, tile, and even disk brakes—common everyday products—would receive less oversight during production. Without the clarity that a quality control checklist provides, product inspection would be much less effective in finding quality issues and determining if ceramic products meet requirements. Put simply: Professionals in the ceramics industry would find it much harder to reliably manufacture their products.

When designers and product developers want to ensure that suppliers adhere to product dimensions and other specifications for mass production, the QC checklist helps them clarify these requirements. When manufacturers want their QC teams to follow a certain procedure when checking a product, they use a checklist as an outline of inspection criteria. And when a supplier or inspector wants to advise changes to a product or the standard used for evaluating a product, these changes are typically reflected in a checklist.

Let us take a closer look at the vital role QC checklists play in ensuring ceramic products are made to meet expectations.

What is a quality control checklist?

Sometimes called an "inspection criteria sheet," a QC checklist is a written guide that outlines requirements for manufacturing a product and the criteria for its inspection at the factory. Checklists typically include product specifications, such as dimensions, color, and appearance, as well as packaging, function, and special requirements.

The complete document can vary from several pages in length for a relatively simple consumer product to 10 or more pages for complex products. An effective checklist should be detailed enough to address all manufacturer's concerns about the product. But it also needs to be concise and organized so that suppliers and product inspectors can quickly find the information they need. Experienced QC professionals often use of tables and other visual elements, such as photographs or diagrams, when developing a prod-

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Capsule summary

ADDED VALUE

Quality control checklists help ensure that suppliers adhere to product specifications for mass production, guide manufacturers in product inspection procedures, and advise suppliers to product changes or evaluation standards.

MAKING A LIST

QC checklists outline requirements for manufacturing a product and criteria for its inspection at the factory, including product requirements, packaging requirements, on-site tests and checks, and defect classification.

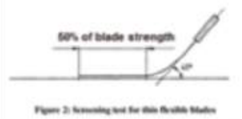
LET'S WORK TOGETHER

Manufacturers, suppliers, and inspectors must work together to ensure consensus and application of a QC checklist—because quality is built into a product, not added in after the fact.

uct checklist. These typically make the document easier for suppliers and inspectors to interpret, especially when there may be a language barrier.

Different QC checklists for similar products may have some of the same elements. But each checklist has requirements unique to the product. For example, consider a QC checklist for manufacturing ceramic kitchen knives. The checklist likely will have some points in common with that for manufacturing stainless steel knives, such as on-site testing to verify the strength of the blade and the blade tip. But strength tolerances and testing methods likely will differ between the two (Figure 1).

8.1. Section 5: On-site tests

No.	Checkpoint	Sample size	Checkpoint instruction	Tolerance	Result
1.	Knife strength test	2*	Apply a force shown to the item as shown in below tables. For thin flexible blades, always apply a force of 25 N ± 1 N regardless of length. • A thin flexible blade (e.g., slicing knife) is defined as a blade, which, when each side in turn is forced down at an angle of 45° on a plane until flat over 50% of its length, remains undamaged and does not acquire a permanent set in excess of 3°. Blade length (mm) / Bend test force (N): Up to 100 — 20 ± 1; > 100 — 30 ± 1 	No crack, break, or permanent deformation of >3°	
2.	Blade tip check	2*	Apply bending force in vertical position (10° arc each side of vertical position, N/A to heavy knives).	No evidence of permanent deformation	

Credit: InTouch

Figure 1. Example checklist for manufacturing ceramic kitchen knives.

How do QC checklists limit quality defects and other problems with manufacturing ceramics?

Experienced manufacturers and importers know their supplier must clearly understand all facets of their product before beginning mass production, whether working with ceramics or other materials. They also realize the need for any QC staff to have clear criteria and instructions for inspecting the product.

An effective QC checklist clarifies expectations and addresses product requirements and inspection criteria by

- Outlining quality standards and product requirements the supplier is expected to meet; and
- Providing objective criteria for inspecting the product to ensure it meets customers' expectations.

Imagine manufacturing ceramic distribution boxes for transferring molten metal. The product functions as a mold used in air and vacuum casting for steel. It is vital that factory staff manufacturing the product are familiar with dimensional requirements. It also is important that inspectors who check the product know how to measure it and its tolerances. Like many industrial products, a distribution box with a dimension measuring more than 0.1 mm out of tolerance may be unusable.

Manufacturers can minimize the risk of errors in manufacturing or inspection by clearly stating dimensions, measuring methods, and tolerances in a QC checklist. The conse-

Figure 2. Comparing an approved sample to a mass-produced product.

quence of omitting these or other important considerations from a checklist could be unsellable finished goods or an unreliable inspection report.

Four important sections to include in a QC checklist

Most product QC checklists contain four important sections. Although we can include some smaller sections, such as desired sample size to be pulled during product inspection, a typical checklist contains

- Product requirements;
- Packaging requirements;
- On-site tests and checks; and
- Defect classification.

It may seem initially that some of these points are important only for the product inspector. But, as many QC professionals can attest, quality is built into a product. It is important for suppliers to know the standard that will be used to evaluate the product, so they can take this into account when selecting raw materials and components, producing the product, and packaging it for shipping.

Product requirements

Manufacturers often find product requirements are the most obvious point to include in their QC checklist. After all, quality defects and issues related to the product itself are more likely to cause customer dissatisfaction and returns than problems related to packaging, for example. QC checklists should include requirements for product material, construction, weight, dimensions, color, markings, and labeling.

Material composition can be a major concern for manufacturers of certain ceramic products. The ceramic material used in thermocouple protection tubes, for example, often contains a certain percentage of alumina (Al_2O_3) used for its thermal conductive properties. Tubes subjected to higher temperatures generally must contain a higher content of alumina. A deficiency in this constituent could lead to product failure in service. Therefore, manufacturers must address material and construction in their QC checklist and to ensure their supplier understands requirements before starting mass production.

For many ceramics manufacturers, verifying color and dimensions often is vital. Dimensional tolerances and measuring methods should be included directly in the QC checklist, if not in a supplemental table or drawing. Inspectors often use a Pantone swatch to verify product color—if there are particular color requirements, the checklist should include a Pantone code for reference.

Markings and labeling can be a very important consideration for certain products, and it is an aspect of inspection that manufacturers sometimes neglect to consider. For example, the U.S. Food and Drug Administration[1] and some European governments[2] limit use of certain toxic metals in ceramicware. Legislation compels manufacturers to meet certain guidelines for use of the term "lead-free" and similar claims in product labels. Ceramics manufacturers may be prohibited from distributing their products if they do not meet labeling requirements mandated in the markets they sell.

In addition to stating clear product requirements in a QC checklist, manufacturers may benefit from establishing an approved "golden" sample.[3] Before mass production begins, manufacturers can ask suppliers to send a product sample and then have them revise the sample as needed until one perfectly meets the manufacturing requirements. With this approved sample in hand, the supplier has a model to follow for mass production, and QC staff have a model for comparison during inspection (Figure 2).

Packaging requirements

Packaging a ceramic product using the proper method and materials can be a critical part of the manufacturing process. Although often discarded after the product reaches consumers, packaging protects the product during transit and can greatly influence consumers' perception of its quality, because it often is the first part of the product they see.

A QC checklist that adequately addresses packaging requirements typically contains all of the following:

- Packaging weight and dimensions;
- Carton labeling requirements;
- Carton material;
- Packing and assortment method; and
- Retail packaging graphics and labeling.

The weight and size of packaging can greatly impact shipping. Suppose a manufacturer plans to ship 1,500 porcelain sinks in a single, 40-ft shipping container. The manufacturer requires the factory to package each sink in a carton that is 0.5-m wide. If the factory mistakenly uses packaging that is 0.55-m wide, the whole order may not fit in one container as planned. What may seem like a minor discrepancy could cause shipping delays and significantly increase costs.

Carton labeling can affect salability of a product in the same way as labeling on the product itself. But cartons tend to have more labeling and markings, and distributors often have their own standards they impose on suppliers. For example, Amazon.com requires sellers to use shipment labels measuring 3-1/3 in. × 4 in., along with many other requirements.[4] Ensuring the right barcodes are printed on a product is very important for tracking goods throughout the supply chain.

Section 1: Shipper carton packaging							
No.	**Checkpoint**	**Sample size**	**Checkpoint instruction**			**Tolerance**	**Result**
1.1	Shipper dimensions	2*	Measure shipper carton dimensions and compare against claimed values on carton; otherwise, record actual measurement result.			Conform to specification or ±5% tolerance.	
1.2	Shipper weight	2*	Measure shipper carton weight and compare against claimed values on carton; otherwise, record actual measurement result.			Conform to specification or ±5% tolerance.	
1.3	Shipper markings/ labeling	ASD	According to specification.			N/A	
1.4	Shipper details	ASD	Material	☐ Br. cardboard	☐ White cardboard	☐ Color export box	☐ Other:
			Layers	☐ Single	☐ Double	☐ Triple	☐ Other:
			Sealing	☐ Transparent tape	☐ Opaque tape	☐ Paper tape	☐ Other:
			Strapping	☐ Nylon band	☐ Metal band	☐ None	☐ Other:
			Binding	☐ Glue	☐ Staples	☐ None	☐ Other:

Credit: InTouch

Figure 3. QC checklists should provide explicit packaging details to avoid product damage during shipping and handling.

Manufacturers should explicitly state carton material and packing method in QC checklists (Figure 3). Glass and porcelain, for example, tend to be delicate products that must be packed with materials that protect against damage during shipping and handling. Some manufactures require factory workers to add small, silica desiccant packets to shipper cartons to limit the amount of moisture inside. Others may want to specify details, such as glue or staples used for binding or double- or single-ply cardboard cartons. Inadequate packaging strength can lead to damaged goods when multiple cartons are packed on top of each other, crushing those near the bottom.

Points related to retail packaging often are similar to those for outer carton packaging. But, retail packaging requirements typically will include any artwork and a breakdown of assortment. For example, suppliers often ship ceramic dinnerware and stoneware for cooking in sets of three, five, or more pieces. The QC checklist may specify what quantities of various pieces or components the factory should pack in each shipper carton, retail carton, polybag, etc.

On-site product tests and checks

Although many manufacturers carefully specify detailed requirements for their product and its packaging in a checklist, far fewer adequately address on-site testing. These are tests QC staff can perform at the factory to identify any issues with product functionality, safety, and performance. Neglecting on-site testing can lead to serious issues, often putting consumers at risk.

A QC checklist includes three key points regarding on-site testing:

- Procedures and testing criteria for any on-site testing;
- Required equipment for tests; and
- Who will provide the required equipment.

Many manufacturers assume there are uniform and widely accepted testing standards and procedures for their products. This is true in some cases. The procedure for crosshatch adhesion testing of enamel-coated cookware, for example, is simple and generally does not vary depending on the item. But, there are other tests common for the same type of product, such as the hotplate shock test, that vary depending on the item and its unique quality standards. A procedure may call for each sample to be tested on the surface of a hotplate heated to 280°C, whereas another manufacturer of a similar product may want the hotplate surface heated to 320°C. Regardless of whether a manufacturer suspects the QC team and supplier are familiar with the testing method, it is always wise to include this information in the QC checklist to avoid errors.

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Figure 4. Example of a pinhole defect in a finished ceramic product.

Failure to clarify equipment needed for on-site testing can result in inspectors' inability to conduct the test or to conduct it accurately. In the earlier example of hotplate shock testing, the inspector likely needs a temperature gun to reliably measure surface temperature of the hotplate. Another common test for enamel-coated products is an impact test to measure strength of the enamel coating using a steel ball with specific weight requirements. Without having a working temperature gun and the proper steel ball on hand during inspection, these tests will not provide reliable outcomes.

The last main point about testing concerns what party will be responsible for making the testing equipment available at the inspection site. It may seem like a minor detail—but leaving this point out of the checklist often leads to a situation where the inspector mistakenly thinks the factory will provide the needed equipment and vice versa. Going back again to the enamel-coated product, a coating thickness gauge is needed to accurately measure enamel thickness on-site. But there is no guarantee that either factory or QC staff will know to provide the gauge unless notified before inspection. The best place to clarify these details is the QC checklist.

Classifying quality defects

One of the least understood aspects of creating an effective QC checklist for a product is how to define and classify quality defects. Most QC professionals rely on an international standard known as acceptable quality limits (AQL) for conducting product inspection.[5] Inspectors and manufacturers apply the AQL standard to a sampling method and to reporting various types of defects during inspection. The ultimate result of an inspection is largely governed by this standard.

Quality defects are typically sorted into one of three categories (Figure 4):

- "Minor" defects—those found in relatively small quantities that typically do not affect the salability of a product and are not normally noticed by customers;
- "Major" defects—those that do not pose a threat to user safety, but do not match product specifications or the golden sample; and
- "Critical" defects—those that present a safety hazard to the user, might cause property damage, or otherwise harm the end user.

Depending on tolerance for particular quality issues—the acceptable quality limit—manufacturers can determine the maximum number of minor, major, and critical defects allowed in a sample of goods using the AQL standard.

Without delving too deeply into determining a specific tolerance, which tends to vary from one manufacturer to another, individual manufacturers should recognize the importance of clarifying which defects should be reported as minor, major, and critical in the QC checklist (Figure 5). For example, manufacturers might consider crazing, or fine cracks on the surface of the material, to be a minor defect, whereas crazing beyond a certain length might constitute a major defect. Pinholes, dents, chips, scratches, and discolorations are other examples of defects commonly found in certain types of ceramics. But each manufacturer must decide which defects, and in what frequency, it is willing to accept in finished goods. Inspectors will

8.2. Individual product						Critical	Major	Minor
1.	Use of any unverified paint, marker, or other substrate to cover an imperfection.					X		
2.	Craze under glaze	XL	L	M	S		X	
		>6 mm	>5 mm	>4 mm	>3 mm			
		Any visual craze under glaze with less severity than above.						X
3.	Pinhole	XL	L	M	S		X	
		A surface: Any pinhole >1 mm, or more than 7 pinholes ≤1 mm; *B surface*: Any pinhole >1.5 mm, or more than 7 pinholes ≤1.5 mm at 1 side.	*A surface*: Any pinhole >1 mm, or more than 5 pinholes ≤1 mm; *B surface*: Any pinhole >1.5 mm, or more than 5 pinholes ≤1.5 mm at 1 side.	*A surface*: Any pinhole >1 mm, or more than 3 pinholes ≤1 mm; *B surface*: Any pinhole >1 mm, or more than 5 pinholes ≤1 mm at 1 side.	*A surface*: Any pinhole >1 mm, or more than 3 pinholes ≤1 mm; *B surface*: Any pinhole >1 mm, or more than 5 pinholes ≤1 mm at 1 side.			

Credit: InTouch

Figure 5. Example of defect specifications from a product checklist.

look for this standard in the QC checklist to guide them in how to report results.

Collaboration is the best approach to creating a QC checklist

Having an effective QC checklist will go a long way in helping a manufacturer maintain the right standards for its products. But outlining requirements in the checklist is only part of the equation. It is important that manufacturers, suppliers, and inspectors understand and agree with the expectations before the manufacturer can be confident that the QC checklist will be followed. Collaboration and consensus on the requirements in the checklist is best reached as early as possible—well before mass production begins, if not during product development. Again, quality is built into a product, not added in after the fact.

In addition, suppliers need the opportunity to provide feedback on manufacturers' requirements. If a manufacturer has unreasonable expectations or a requirement the supplier cannot reasonably meet, it typically is less costly in time and money to find out earlier, rather than be surprised later.

Remember the earlier example of thermocouple protection tubes? Can you imagine a supplier manufacturing the product with only 80% aluminum oxide because the manufacturer did not clarify a requirement of 90%? At worst, the supplier might lie about the material composition, and the manufacturer might not know until receiving the finished goods. At best, suppliers would directly tell the manufacturer about the misunderstanding when they finally see the checklist, but they likely would need to discard any tubes already produced and restart production. By letting suppliers review the manufacturer's checklist beforehand, they have the opportunity to ask questions and manage expectations.

Just as it is important to work with a supplier to develop a checklist, input from any QC staff who will ultimately inspect the product can be invaluable. Most professional inspectors specialize in a limited number of product categories. An inspector may be able to advise what quality issues tend to affect the product type, what testing should be performed during inspection, and more. Even for experienced manufacturers that have worked with a particular product for many years, having an open discussion with the QC team about checklist requirements ensures there is a mutual understanding about how the product should be inspected.

Often a forgotten aspect of QC checklist development, collaboration helps manufacturers avoid costly mistakes and surprises. No individual checklist is a one-size-fits-all solution. Product requirements, packaging, on-site testing, and quality defects can differ vastly between ceramic products. And approaching the process of setting product standards alone, or forgoing a QC checklist entirely, is a mistake most manufacturers cannot afford to make.

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