Key Performance Indicators to describe production activity with QTS-2 equipment

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Abstract: *New equipment's development involves a multidisciplinary approach and also risks associated with expected outcomes. Monitorization from incipient steps using KPIs could bring improvements and defensive strategies of preventions. This article presents the evaluation of production activities with QTS-2 equipment, using Key Performance Indicators (KPIs). In order to identify weaknesses and mitigation actions, performance monitoring was performed. The production activities of the QTS-2 (Quick Thermal Shock) equipment were analyzed using delivery metrics definition guidance from IAQG - International Aerospace Quality Group, section 5.1.2.*

Key Words: *metrics definition, key performance indicator, EN 9100:2018/ AS 9100D, IAQG*

1. INTRODUCTION

The International Aerospace Quality Group [1] proposes metrics definitions for Key Performance Indicators used to describe on-time and on-conformity deliveries of services and products.

Unique definitions aim to harmonize the way customers and suppliers assess together delivery characteristics.

In this article, we evaluate the QTS-2 Quick thermal Shock equipment for 24 months, [4]. In aeronautics and space it is important that aircraft and missiles can withstand both positive temperatures and high negative temperatures.

If we analyze the stratification of the atmosphere from the ground up to about 500 km, we can see that there are two zones of interest with negative temperatures, areas through which the aircraft and /or missiles must pass.

From the analysis of the graphical representation of temperature variation with altitude (aeronautical meteorology) it can be observed that the minimum temperature of -90°C is in the altitude range of 80-90 km and positive temperatures of about 1000°C start at the altitude of 500 km (Thermosphere area).

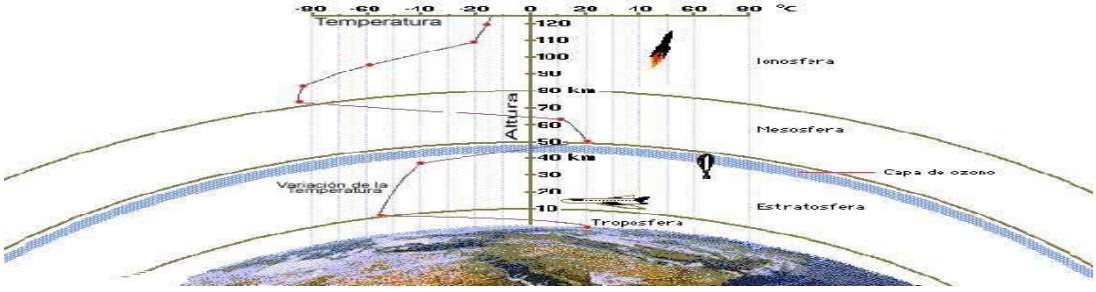

Figure 1. - Temperature variation with altitude [4]

The QTS-2 Quick thermal Shock allows testing ceramic materials at temperatures below 0°C when cooling.

The testing of materials intended for use in aeronautics and space and especially the thermal shock behavior at temperatures between -100°C and + 1200°C are of particular interest.

If some positive temperature solutions are used for positive temperatures, they will need to be cooled with CO_2 carbon dioxide and N_2 nitrogen.

So far, two systems have been used for rapid cooling:

- the first is air cooling at a maximum pressure of 8 bar, through a nozzle or two nozzles, on one face or another of a spear-lipid specimen;
- the second one is water-cooled cooling at ambient temperatures (about 21°C).

Increasing the cooling gradient will require cooling with solid or liquid materials at temperatures below 0°C. Two materials widely used in the technique, namely carbon dioxide (CO_2) and nitrogen (N_2), will be considered.

Figure 2. - QTS-2 Rapid Heat Shock equipment

2. PRESENTATION OF METRICS [3]

The metrics should be used by suppliers for measuring performance, driving internal continuous improvement and for communication with their customers.

2.1 Escape

Escape is a non-conforming item that has reached a customer of the company. This metric represents the conformity delivered to the customer from delivery to the end of the operation phase. It is split into two metrics: Conformity for Items, which is the "Item Escape rate" and conformity for Systems, which is the "Defects per Unit". Concession and Product Quality Escape differ with respect to the point in time when a non-conformance is detected during the product life cycle: Concession is relevant before delivery to the customer; while Product Quality Escape is applicable after delivery to the Customer [3].

2.1.1 Item Escape Rate (Above 1000 items delivered per year use PPM in IER indicator)

$$IER = \frac{Number\ of\ non-conforming\ items\ under\ company\ liability}{Number\ of\ items\ delivered\ by\ the\ company\ during\ the\ period}$$

Rate expressed in parts per million (PPM) by multiplying the ratio by 1 000 000.

- **Items**: components (specimens of ceramic materials).
- **Items delivered**: all the items delivered to a specific customer in case of a one to one assessment.

All the items delivered by one supplier to several customers and averaged for a global assessment.

- **Non-conforming items**: an item that has one or more characteristics that do not fulfill the requirements.

Items can be: rejected by customer, called back by the company, scrapped by customer with the company agreement, reworked by the company in customer plant, or refused by customer during an onsite acceptance inspection. Returned items for check or upgrade to the last standard, are not to be regarded as non-conforming items.

- **Items under company liability**: items rejected by customer after investigation.

2.1.2 Defects per Unit (For low volume deliveries (below 1000) use DPU for systems, or use only number of escapes for non-systems)

This metric is used for Systems; it could be used in the delivery phase, integration phase or the operation phase.

$$DPU = \frac{Number\ of\ systems\ defects,\ under\ company\ liability}{Number\ of\ systems\ delivered\ by\ the\ company\ during\ the\ period}$$

Rate expressed in unit.

- **Systems*:*** assembly of products(specimens of ceramic materials), operating in a common way and in a permanent interaction, which could not normally be rejected / returned by customer in its entirety (e.g. engines, Aircraft Electrical/Electronic Distribution Sub-Systems, seats, etc);
- **Systems delivered**: all the systems delivered to a specific customer in case of a one to one assessment. All the systems delivered by one supplier to several customers and averaged for a global assessment;
- **System Defects*:*** one or more characteristics that do not fulfill the system requirements [2]

Systems can be: rejected by the customer, called back by the company, scrapped by the customer with the company agreement, reworked by the company in customer plant, or refused by customer during an onsite acceptance inspection. Returned systems for check or upgrade to the last standard, are not to be regarded as non conforming systems.

- **Defects under company liability*:*** defects identified by customer after investigation. Evaluation where liability is unclear (e.g. No Fault Found, damage by customer or transporter) are not to be included in the calculation.

Table 1. – Calculation of DPU

Month	Number of systems defects	Number of systems delivered	DPU
VI	2	6	0,33
XII	1	5	0,2
XVIII	1	10	0,1
XXIII	1	9	0,11

2.2 Concessions

Written authorization to use or release a product that does not conform to the specified requirements. A concession authorizes the internal/ external supplier or subcontractor to ship a product that has specific non-conforming characteristics [2].

Concession and Product Quality Escape differ with respect to the point in time when a non-conformance is detected during the product life cycle: Concession is relevant before delivery to the Customer while Product Quality Escape is applicable after delivery to the Customer [2].

The metric refers to the production rather than the development phases of a project.

2.2.1 Concession Rate (Above 1000 items delivered per year use PPM in CR indicator**)**

$$CR = \frac{Number\ of\ \ concessed\ items\ delivered}{Number\ of\ items\ delivered\ by\ the\ company\ during\ the\ period}$$

Rate expressed in parts per million (PPM) by multiplying the ratio by 1 000 000.
Detailed explanations:

- **Items**: assembly of products(specimens of ceramic materials), as defined in the purchase order.
- **Items delivered**: all the items delivered to a specific customer in case of a one to one assessment. All the items delivered by one supplier to several customers and averaged for a global assessment.It refers to production and spare parts, not indirect services.
- **Concessed items*:*** a non-conforming item that is then accepted by the design authority, or external regulator, or customer.

2.2.2 Concession per System (For low volume deliveries (below 1000) use CPS for systems, or use only number of concessions for non-systems)

$$CPS = \frac{Number\ of\ concessions\ raised\ on\ systems}{number\ of\ systems\ delivered\ by\ the\ company\ during\ the\ period}$$

Rate expressed in unit. Detailed explanations:

- **Systems**: assembly of products(specimens of ceramic materials), which could not normally be rejected/ returned by customer in its entirety.

- **Systems delivered**: all the systems delivered to a specific customer in case of a one to one assessment or delivered to a customer's sample group in case of global assessment.
- **System Defect**: one or more characteristics that do not fulfill the system requirements [2].

Systems concessions can be driven by: customer rejects, systems called back by the company, systems reworked by the company in customer plant, or after refusal by customer during an onsite acceptance inspection.

Table 2. – Calculation of CPS

Month	Number of concessions raised on systems	Number of systems delivered by the company during the period	CPS
VI	0	6	0
XII	0	5	0
XVIII	0	10	0
XXIII	0	9	0

2.3. Punctuality

2.3.1. On Time Delivery

$$OTD = \frac{Number\ of\ Purchase\ order\ items\ due\ and\ delivered\ on\ time\ in\ the\ period}{Number\ of\ Purchase\ order\ items\ due\ in\ the\ period}$$

Indicator expressed in percentage (%) by multiplying the ratio by 100.

Detailed explanations:

- **Items**: assembly of products(specimens of ceramic materials).
- **Purchase Order (PO) lines**: all purchase order lines regarding items, for a specific customer, in case of a one to one assessment or for a customer's sample group, in case of global assessment, are taken into account.
- **PO lines/ items due:** all purchase order lines/ items due to a specific customer in case of a one to one assessment or due to a customer's sample group in case of global assessment.
- **On time**: PO lines/ items delivered early or on time as defined in the agreed PO (Supplier Promised Date - SPD). Transportation is to be taken into account according to the PO clauses. That means: "Departure date" + "transportation duration" ≤ "Supplier Promised Date".

Table 3. – Calculation of OTD

Month	Number of purchase order lines/items due and delivered on time in the period	Number of purchase order lines/items due in the period	OTD
VI	1	16	0,0625
XII	1	5	0,2
XVIII	1	10	0,1
XXIII	1	9	0,11

2.3.2 Delay Average

$$DV = \frac{Cumulative\ number\ of\ days\ for\ all\ late\ deliveries\ in\ the\ period}{Number\ of\ late\ deliveries\ \ in\ the\ period}$$

Indicator expressed in unit. Detailed explanations:

- **Items**: assembly of products(specimens of ceramic materials), as defined in the purchase order.
- **Purchase Order (PO) lines**: all purchase order lines regarding items, as defined here-above, for a specific customer, in case of a one to one assessment, or for a customer's sample group, in case of global assessment, are taken into account.
- **Deliveries**: all purchase order lines /items (as defined here-above) for a specific customer in case of a one to one assessment or for a customer's sample group in case of global assessment, delivered during the period.
- **Late**: PO lines /items delivered late as defined in the agreed PO (Supplier Promised Date - SPD).

Transportation is to be taken into account according to PO clauses. That means that a delivery is late if: "Departure date" + "transportation duration" > "Supplier Promised Date".

Table 4. – Calculation of DV

Month	Cumulative number for all late deliveries in the period	Number of late deliveries in the period	DV
VI	1	1	1
XII	1	5	0,2
XVIII	1	10	0,1
XXIII	1	9	0,11

3. CONCLUSIONS

Unless otherwise specified by contractual requirements, this delivery metrics material is proposed to all International Aerospace and Defense companies and their suppliers worldwide. The document can be used for self-assessment and for measuring industrial performance to assist in driving continuous improvement.

The objective of this delivery metrics material is to provide a mutually agreed definition of the Key Performance Indicators (KPIs) recommended for use at all levels of the supply chain to ensure the consistency of provided data. It allows clear communication between at all levels of the supply chain. This understanding helps to improve benchmarking between customer and supplier, ultimately creating a common measurement system.

The metrics should be used by suppliers for measuring performance, driving internal continuous improvement and for communication with their customers.

The use of the KPIs will allow for the detection of possible issues as soon as they occur in order to anticipate mitigation and improvement actions and reduce the probability of poor on-time and on-quality performance originated in production.

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