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Applications of statistical and related methods to new technology and product development process —

Part 6:
Guidance for QFD-related approaches to optimization

Application des méthodes statistiques et des méthodes liées aux nouvelles technologies et de développement de produit —

Partie 6: Lignes directrices pour QFD et approches reliées pour l'optimisation

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Contents

Page

Foreword v
Introduction vi
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
4 Basic concepts of QFD 1
5 Integration of QFD and robust parameter design 2
5.1 Quality engineering 2
5.1.1 General 2
5.1.2 Loss function 2
5.1.3 Types of factors which affect variability 3
5.2 When to use quality engineering 4
5.3 Robust parameter design, QFD, and TRIZ 4
6 Types of QFD and robust design projects 5
7 QFD and robust parameter design team membership 6
7.1 QFD uses cross-functional teams 6
7.2 Core team membership 6
7.3 Subject matter experts 6
7.4 QFD team leadership 6
8 Robust parameter design 6
8.1 General 6
8.2 Signal-to-noise ratio 6
8.2.1 General 6
8.2.2 Signal 6
8.2.3 Noise 7
8.2.4 Three types of SN ratios 7
8.3 Assessing robustness 8
8.4 Two-step optimization 8
8.4.1 General 8
8.4.2 Design of experiments (DOE) 8
8.5 Steps to robust parameter designed experiments 8
8.5.1 General 8
8.5.2 Step 1. Clarify the system's ideal function 9
8.5.3 Step 2. Select signal factor and its range 9
8.5.4 Step 3. Select measurement method of output response 9
8.5.5 Step 4. Develop a noise strategy, and select noise factors and levels 9
8.5.6 Step 5. Select control factors and their levels from design parameters 10
8.5.7 Step 6. Assign experimental factors to inner or outer array 10
8.5.8 Step 7. Conduct experiment and collect data 10
8.5.9 Step 8. Calculate the SN ratio (η) and sensitivity (S) 10
8.5.10 Step 9. Generate factorial effect diagrams on SN ratio and sensitivity 10
8.5.11 Step 10. Select the optimum condition 11
8.5.12 Step 11. Estimate the improvement in robustness by the gain 11
8.5.13 Step 12. Conduct a confirmation experiment and check the gain and reproducibility 11
8.5.14 Conclusions 11
8.6 Case studies in robust parameter design 11
Annex A (informative) **Integration of robust parameter design (RPD) with quality function deployment (QFD) and theory of inventive problem solving (TRIZ)** 12
Annex B (informative) **Other optimization methods** 13

Bibliography 14

Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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A list of all parts in the ISO 16355 series can be found on the ISO website.

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Introduction

Quality function deployment (QFD) is a method to assure customer or stakeholder satisfaction and value with new and existing products by designing in, from different levels and different perspectives, the requirements that are most important to the customer or stakeholder, and ensuring their quality throughout the downstream activities of design, development, supply, building, commercializing, support and retiring from the market. These requirements are well understood through the use of quantitative and non-quantitative tools and methods to improve confidence of the design and development phases that they are working on the right things. In addition to satisfaction with the product, robust parameter design improves the process by which new products are developed and produced.

Reported results of using QFD include improved customer satisfaction with products at time of launch, improved cross-functional communication, systematic and traceable design decisions, efficient use of resources, reduced rework, reduced time-to-market, lower life cycle cost, improved reputation of the organization among its customers or stakeholders.

This document demonstrates the dynamic nature of a customer-driven approach. Since its inception in 1966, QFD has broadened and deepened its methods and tools to respond to the changing business conditions of QFD users, their management, their customers, and their products. Those who have used older QFD models will find these improvements make QFD easier and faster to use. The methods and tools shown and described represent decades of improvements to QFD; the list is neither exhaustive nor exclusive. Users should consider the applicable methods and tools as suggestions.

Robustness assessment is performed as a consideration of overall loss during the product's life cycle. The overall loss is composed of costs and losses at each stage of the product's life. It includes all costs incurred during not only the production stage, but also the disposal stages. When a product is not robust, the product causes many environmental and socioeconomic losses (including losses to the manufacturer and the users) due to poor quality caused by functional variability throughout its usable lifetime from shipping to final disposal. Product suppliers have responsibilities and obligations to supply robust products to the market to avert losses and damages resulting from defects in the products. The role of robust parameter in the QFD process is presented with examples and references to other ISO documents and related materials.

The topics in this document are not exhaustive and vary according to industry, product, and markets. They are considered a guide to encourage users of this document to explore activities needed to accomplish the same goal for their products.

Users of this document include all organization functions necessary to assure customer satisfaction, including business planning, marketing, sales, research and development (R&D), engineering, information technology (IT), manufacturing, procurement, quality, production, service, packaging and logistics, support, testing, regulatory, business process design, and other phases in hardware, software, service, and system organizations.

Applications of statistical and related methods to new technology and product development process —

Part 6: Guidance for QFD-related approaches to optimization

1 Scope

This document provides guidance for QFD-related approaches to optimization through robust parameter design to ensure customer satisfaction with new products, services, and information systems. It is applicable to identify optimum nominal values of design parameters based on the assessment of robustness of its function at the product design phase.

NOTE Some of the activities described in this document can be used at earlier and later stages. Other approaches to solve optimization problems in new technology and product development processes are listed in Annex B.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16336:2014, *Applications of statistical and related methods to new technology and product development process — Robust parameter design (RPD)*

ISO 16355-1:2015, *Application of statistical and related methods to new technology and product development process — Part 1: General principles and perspectives of Quality Function Deployment (QFD)*

3 Terms and definitions

For the purposes of this document, the terms, definitions and symbols given in ISO 16336 and ISO 16355-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Basic concepts of QFD

The basic concepts of QFD are described in ISO 16355-1:2015, Clause 4.

5 Integration of QFD and robust parameter design

5.1 Quality engineering

5.1.1 General

Dr. Genichi Taguchi, a pioneer in Japanese quality methods, developed a philosophy of quality engineering based more on technology than theory in order to measure loss, maintain quality in production, and improve quality continuously. The goal is to create high quality, low cost goods and services that satisfy customer needs, a goal shared with quality function deployment (QFD)[3].

5.1.2 Loss function

Measuring loss can be explained by the concept of the loss function; any variability from the ideal function of a product creates a loss:

a) to the customer, who is unable to fully enjoy their intended use for the expected life of the product)[8];

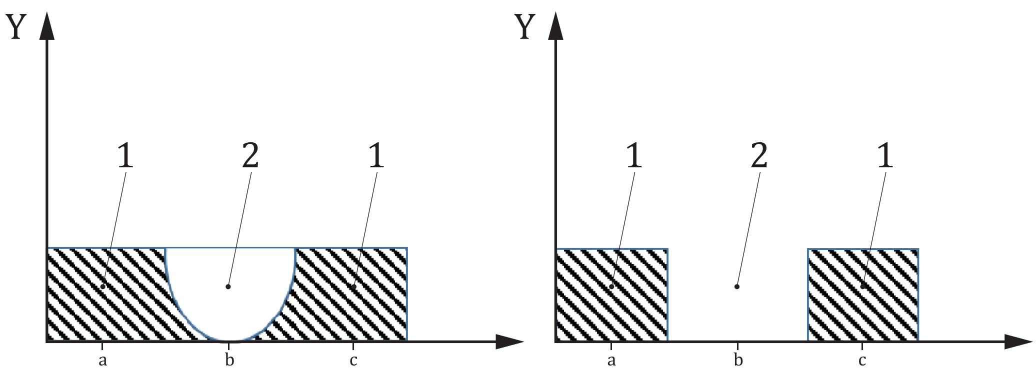
NOTE Robust parameter design focuses on the customer's quality loss due to variability in the function or performance of the product. This has alternatively been called the cost of inferior quality[2].

b) to the organization, which can result from wasted activity, wasted materials, wasted time, rework, scrap, warranty replacement, maintenance[12];

c) to society, which can result from regulation, disposal, recovery, safety, hazards[7].

5.1.2.1 Taguchi's loss function vs. specification loss function

Measuring loss can be performed by calculating the cost to the customer, organization, and society due to variability from the target design specification set to fully satisfy the customer. Defining this target specification level is described in ISO 16355-5:2017, Clause 9, in the maximum value table, and in ISO 16355-5:2017, 10.3.4.1 in both the unweighted and weighted design planning tables. Taguchi's loss function considers any deviation from the target specification to be a loss to the customer, organization, and society, and it can be quantified in terms of cost. Traditional loss function is a step function in that as long as the product or component performance is within the lower and upper specification limits of the nominal target value, there is no loss recognized, as shown in Figure 1.



Key

Y cost
1 loss
2 no loss

a Lower specification limit.
b Target specification.
c Upper specification limit.

Figure 1 — Taguchi (left) and specification (right) loss function

5.1.2.2 Calculating the loss function

The farther from the nominal target specification the product or component performance varies, the greater the Taguchi loss function is. Monetizing the average loss allows the QFD team to consider different design alternatives with different costs and loss. The average loss can be calculated with a quadratic formula[13]:

$$\bar{L} = k\left[\sigma^2 + (\bar{y} - T)^2\right]$$

where

$\bar{L}$ is the loss to the customer, organization, or society,

k = money/Δ^2,

where Δ is the tolerance, difference between the designed nominal value and the tolerance limit, and "money" is loss when characteristic exceeds the tolerance Δ,

T is the target value of performance,

σ^2 is the variance of performance, and

$\bar{y}$ is the average performance.

The determination of tolerance Δ is described in ISO 16337: —1), 4.3.

NOTE 1 The above Taguchi loss function quadratic equation is commonly used in QFD when the target specification is a nominal-the-best functional or non-functional requirement. Different equations for larger-the-better and smaller-the-better specifications can also be used[11].

NOTE 2 In QFD applications, the value of k can be set to 1 since the monetary loss to customers would be the same for all competitors[13].

NOTE 3 Competitive benchmarking of performance can be done in real-life environments (called gembas in QFD) that represent key applications of key customers that were defined in the customer segments table described in ISO 16355-2:2017, 9.2.2.2, and prioritized in the business goals - customer segments prioritization matrix described in ISO 16355-2:2017, 9.2.3. If not possible, laboratory or computer simulations can be used as a proxy. The results can be recorded in the maximum value table described in ISO 16355-5:2017, Clause 9, and in either the unweighted and weighted design planning tables described in ISO 16355-5:2017, 10.3.4.1.

NOTE 4 The loss function for dynamic characteristic cases is defined as $\bar{L} = k\sigma^2 = k/\eta$, as described in ISO 16337:—1), 4.3.

5.1.3 Types of factors which affect variability

The goal of robust parameter design is to minimize loss due to variation[5]. There are different types of factors to be considered on minimizing loss due to variation, as shown in Figure 2:

a) shifts in mean (B2 has higher mean than B1);

b) changes in variability (C2 has less variability than C1);

c) changes in costs, same mean or variability, but can lower cost by picking cheaper alternative (D1 or D2);

d) trade-off between mean and variability (A1 versus A2).

1) Under preparation. Stage at the time of publication: ISO/DIS 16337:2019.

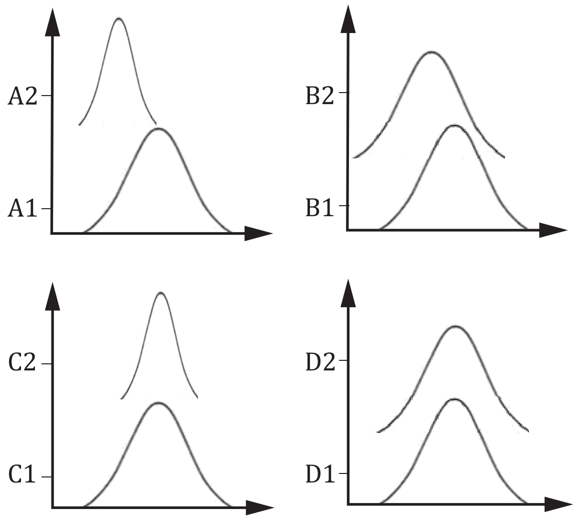


Figure 2 — Types of factors

5.2 When to use quality engineering

Quality engineering can be used throughout the new product development process[9].

a) In the planning and development phase, it can assist technological research and feasibility studies of project concepts as described in ISO 16355-2:2017, 9.1.2.8.2.

b) In the design phase, it can help structure simulation studies, failure mode and effects analysis (FMEA), as described in ISO 16355-5:2017, 10.4.5.8, in testing specifications as described in ISO/TR 16355-8:2017, 11.2, and in making design decisions.

c) In the product planning phase, it can influence process design as described in ISO/TR 16355-8:2017, Clause 10, prototype development as described in ISO/TR 16355-8:2017, 11.5, standardization as described in ISO/TR 16355-8:2017, 13.5, and supply chain decisions as described in ISO/TR 16355-8:2017, 12.4.

d) In the production phase, it can improve process controls as described in ISO/TR 16355-8:2017, 13.2, tolerancing as described ISO/TR 16355-8:2017, 9.2, and inspection as described in ISO/TR 16355-8:2017, 13.5.1.

e) In the sales and service phase, it can improve service procedures and technical bulletins as described in ISO/TR 16355-8:2017, 15.5 and Clause 16, and with customer satisfaction with product functions and performance as described in ISO 16355-3:2019 and ISO/TR 16355-8:2017, Clause 17.

5.3 Robust parameter design, QFD, and TRIZ

QFD is a framework for new product development quality assurance. This framework facilitates integration with multiple quantitative and qualitative analytic tools, as described in the QFD tools matrix in ISO 16355-1:2015, A.1. ISO 16355-5:2017, 10.4.3.4, describes the basic process for the theory of inventive problem solving, abbreviated in Russian as TRIZ. Like robust parameter design, TRIZ examines functions and their ability to satisfy customer needs. When TRIZ is conducted first and identifies multiple solutions to a problem, robust parameter design can be used to select and further improve the most robust[1],[6].

The following steps integrate QFD, TRIZ, and Taguchi's robust parameter design[14]. Their relationships are shown in Annex A.

1) Project level

   i) Identify and prioritize customer segments as described in ISO 16355-2:2017, 9.2.

