# Function Dependent Quality Assurance in Modern Production Engineering

## Funkčne závislé zabezpečenie kvality v modernom výrobnom inžinierstve

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## Abstract

There is a considerable drive in both engineering and technology to develop and improve the systems of Quality Assurance and Quality Management during the manufacturing process. This drive has led to the development of international (CEN, ISO) and European national standards (BS, ON, DIN, AFNOR) to assist engineers, metrologists and designers in the specification of products to achieve this objective. The main problem with the developments so far is that although they clearly contribute to the quality of products and their components, the quality assured may have little relevance to the function performance of the product. This paper examines as a model the functional quality assurance system that inherently exists within a human being to see if an analogy can be drawn to the differences between the human quality assurance system and what is really required in a manufacturing environment. As a result of this assessment and comparison with the human quality assurance system, proposals are made for a way forward in developing Quality Assurance protocols for engineering manufacture, an alternative philosophy that may lead to an approach that stems from developing a comprehensive functional specification for both manufactured parts and products. Such a new basis would meet the aims of the Quality Assurance Community and could lead to the provision of more reliable functional product design.

**Keywords**: Quality Assurance, data evaluation, production metrology, surface structure, surface evaluation, design for function, functional quality assurance, design for manufacture, the human quality assurance system, function dependence

## Abstrakt

V inžinierstve rovnako ako aj v technológii existuje značná snaha rozvinúť a zlepšiť systém zabezpečenia a riadenia kvality počas výrobného procesu. Táto snaha viedla k rozvoju medzinárodných (CEN, ISO) a európskych národných noriem (BS, ON, DIN, AFNOR), ktoré mali pomôcť inžinierom, metrológom a konštruktérom pri špecifikácii produktov dosiahnuť tento cieľ. Hlavný problém s týmto rozvojom zatiaľ spočíva v tom, že aj keď jasne prispieva ku kvalite produktov a ich súčastí, zabezpečenie kvality môže mať len malú súvislosť s funkčným výkonom výrobku. Tento príspevok vyšetruje ako model taký systém funkčného zabezpečenia kvality, ktorý prirodzene existuje v každej ľudskej bytosti, aby sa dalo posúdiť, či je možné načrtnúť analógiu rozdielov medzi ľudským systémom zabezpečenia kvality a tým, čo je skutočne požadované v prostredí výroby. Ako výsledok takého hodnotenia a porovnania s ľudským systémom zabezpečenia kvality sú utvorené návrhy pre spôsob vývoja protokolov zabezpečenia kvality pre výrobné inžinierstvo – alternatívna filozofia, ktorá môže viest k prístupu, ktorý vyplýva z rozvoja súhrnnej funkčnej špecifikácie pre vyrábané súčasti ako aj výrobky. Takáto nová základňa by mohla naplniť ciele Spoločenstva zabezpečenia kvality a mohla by viesť k poskytnutiu spoľahlivejšej funkčnej konštrukcie produktu.

**Kľúčové slová**: zabezpečenie kvality, hodnotenie dát, výrobná metrológia, povrchová štruktúra, hodnotenie povrchu, funkčná konštrukcia, zabezpečenie funkčnej kvality, výrobná konštrukcia, ľudský systém zabezpečenia kvality, funkčná závislosť

## 1 Introduction

During the last few decades there have been many attempts to improve the quality of components and products by industry and as a consequence to reduce the manufacturing defects that disrupt the manufacturing process and become a severe cost burden to industry in general. This cost burden is inevitably passed on the consumers. Currently in the European Union there is a rapid expansion of legislation that is designed to protect the consumer and is placing more stringent requirements on the manufacturer and the seller of products to be financially liable for the conformance of the product to its specification. In simple terms this conformance is related initially to the product specification but in reality it should be related solely to the expectation of the functional performance of the product. In other words the "proper functional performance" of the components and products and not necessarily the actual performance that may be deficient or alternatively over specified.

## 2 The Functional requirement of an automobile windscreen wiper blade

To explain this concept more fully it is appropriate to consider a simple domestic device that is in common-every-day-usage and to illustrate the requirements of such a product a windscreen wiper blade of a private passenger car is selected. The general expectation of a windscreen wiper blade is that it lasts (functionally performs its intended purpose) an appropriate length of time. During the period that it operates successfully it should, in cooperation with the windscreen water spray, remove dirt and debris that builds up on the car windscreen in a few traverses (cycles) across the screen, and in doing so leaves the windscreen as bright and as clear as possible.

In reality there are several contributory technologies that are necessary to make the functional objectives of the product to work properly. These individual factors are listed in the following:

1. The efficiency of the windscreen wiper-arm as it moves across the windscreen, in terms of its rigidity and confor-

mance to the windscreen shape and contours, is an important issue.
2. The force that the windscreen wiper-arm exerts on the windscreen itself to ensure that the wiper blade maintains in close contact with the window surface.
3. The tribological interaction between the "three-body" mechanism that relates to two individual components in relative motion and at times a third body water as lubricant.

It is important to note that in the case of a window wiper blade, this is not a simple tribological interaction. In the following paragraphs it is tried to state the details of the real functional requirements of a windscreen wiper blade:
a. The surface sliding velocity is non-constant along the length of the surface. This is because the windscreen wiper moves through a radial arc and the length of sliding is much smaller on the inside of the arc than it is on the outside of the arc. In reality the ratio of sliding distance is probably in the order of 3:1 and so the windscreen wiper blade must be manufactured to a condition that will meet the longer distance travelled by the outside of the radial arc.
b. The surface of the blade, which is the softer of the two surfaces must conform to the contours of the windscreen and those contours are continually changing as the windscreen wiper blade moves across the surface. This implies that the surface of the blade, a rubber compound, must constantly change its shape and conform to the surface that it is sliding over.
c. The surface of the windscreen wiper must be robust in that it 'resists wear' caused by adhered debris lying on or attached to the windscreen.
d. The windscreen wiper blade must have an acceptable functional life during which it performs satisfactorily and cleans to the required standard the windscreen to provide the vehicle driver with an unimpaired view.
e. The windscreen wiper blade must stand up to some unreasonable abuse caused by the vehicle owner who at times may use the windscreen wiper blade to clear snow and ice from the window.
f. The wiper blade must perform its intended function in a number of diverse climatic conditions that may include the abrasiveness of ice and snow in the extremes of the northern and southern hemispheres or the presence of sand and grit in the desert regions. They must also withstand the extremes of temperature that affect the subtropical and tropical regions of the planet.
g. The windscreen wiper blade must remain functional for a period of time that is judged by the manufacturer to be appropriate for its purpose. This 'life-time' functional performance must be in line with customer expectation and be comparable to similar artefacts manufactured by the motor industry competition.

# 3 The legislative position

The legislative position is fraught with difficulty since it may or may not be truly objective. The legislator tries independently to meet the needs of the consumer by specifying specification performance in a completely non-technical way, but instead choosing a standard for conformance that it believes is in the consumer interest. There are no real rules to help define such a position. Instead the legislator will define and a professional will judge whether the object's functional life is appropriate for the owner of the product, in as far as he has received good value for its purchase and its life expectancy, its real functional life was, in the eyes of "right thinking men" was reasonable.

In practice appropriate functional performance is an arbitrary concept that is based on a vague criteria of what is regarded as value for money. This arbitrary concept is also a changing one as is clearly seen by the development of the automotive vehicle power unit. If we consider the development of car engines fifty years ago the customer had on many low cost vehicles the perception that they would last approximately 70.00 to 80.000 kilometres before the vehicle would require a comprehensive overhaul. As the technology behind the development of motor vehicles has developed over the last fifty years and through the introduction of sophisticated engine management systems the life expectancy of an engine has dramatically increased.

As a consequence of the increased public expectation this product functional life is steadily being required to extend. A secondary factor is that on average the distance per year travelled by a typical motor vehicle has increased from 12.000 to 16.000 km per annum from a base fifty years ago that was previously regarded as being in the region of 9.000 to 12.000 km per year. The legislators, severely worried about the damage to the environment and the rate of use of limited material resources is deliberately driving up the life cycle expectation. The net result of these complimentary pressures is that it is now typical that a simple domestic vehicle is expected to have a largely trouble free functional life that exceeds 160.000 km. At the luxury end of the range the functional life cycle may well be expected to exceed a 400.000 km.

# 4 Design for function

There is a need for manufacturing companies to fundamentally change or develop their approach to design to ensure that the final product meets the functional needs of its application. This can be a difficult concept to realise and to do so may mean that there is considerable expense in functional testing to realise the parameters necessary to ensure that the design and its manifestation through manufacture, taking into account the materials selected and its fabrication yields the desired conditions. Function related data collections [1, 2], handbooks [3] and standards [4] support design engineers and constructors when they carry out their tasks.

Many products are not designed and tested to such stringency but there are numerous examples where such detailed functional testing has been carried out and the manufacture of hip joint implants, artificial heart valves and artificial arteries are examples where such testing is routinely conducted. Similar examples are found in the manufacture of aerospace components and automobile engines as well as the rigorous testing of lubrication oils.

# 5 The negative feedback systems-human concept

The human body can be seen basically as a quality assurance system that has evolved as a part of natural human evolution. The human body is an interesting product. It has a very advanced brain that is only partly used but the single largest activity that the brain undertakes is self-maintenance and quality assurance.

The brain having dealt with the self-maintenance first order priority, then uses a modest part of its excess capacity

initially for the second order activities that include physical maintenance through nourishment, coping with the conditions of excitement, gratification, pleasure, stress, anger and fear. Finally the third order activities are indulged and include social and technical advancement, evolutionary, scientific and artistic advancement. But all of these are secondary to the basic need for self-protection. In short it is an optimum system for self-protection and self-development along the evolutionary path.

Since the brain has evolved as a quality assurance system primarily, it is appropriate to identify how it has achieved it. The process of quality assurance is its negative feedback system. The brain constantly servos the human system looking for exceptions and immediately moves to correct it. Normally it makes the correction efficiently and quickly and the human servo control system maintains a balanced integrity. It is only when the human servo system breaks down, that the route to recovery and the restoration of health is assisted by the medical profession. The medical profession tries to correct the mal-function that has occurred either chemically or by engineering physical changes. If successful, full or hopefully, satisfactory health is restored to the human.

Such a self-protection system is defined in the subjects of Anatomy and Physiology as a "Negative Feedback System" [5]. This is where a physiological negative feedback mechanism is used to control the body function and returns it from imbalance to normal balance (see Fig 1).

# 6 The negative feedback systems-industrial concept

In a Negative Feedback system the essence of the control is customer acceptance of the product whilst product design must be undertaken to ensure that the expectation of the customer is of paramount importance. In principle it is just a way of creating and monitoring the manufacturing system that considers the end result and tailors everything top it. It prevents one of the largest problems facing industry today, design by experience without recourse to functional need. To move to a more comprehensive and functionally useful scenario requires a complete change in emphasis and one that will lead to the dominance of functional performance. Such a scenario leads towards economic manufacture because of the minimisation or elimination of defect products. It also leads towards design for function and routes to economic manufacture. In an era of increasingly competitive manufacture and a reduction of resources it is an important strategy for ensuring financial success. Many companies who were once a significant part of the manufacturing scene no longer exist today because they did not change there ways of operating to meet the challenges of the modern industrial and financial environment.

# 7 The way forward in implementing this concept

It is suggested that the way forward in implementing this concept is to consider the human control system and to mirror the manufacturing one on it. The manufacturing organisation has to identify two areas and accept that they are each comprehensively inter-related. The design process is one that must be directed to economic manufacture for function. The quality assurance function is one that puts in place all the necessary checks and measurements to ensure that the function is satisfactorily achieved. The function and its manifestation must be carefully defined in relation to marketing and product development. As these separate effects must be integrated by a project team that by necessity is composed of people from interdisciplinary backgrounds.

# 7 Discussion and conclusions

The concept of "Negative Feedback" is functionally related. It implies that the component and product are fit for their purpose and in the event of in-service failure these will be reported and will lead to the initiation of protocols that will influence modifications in the design process.

If industry addresses the concept of "Negative Feedback" in their quality assurance systems in a formal manner then they provide two complimentary approaches to product quality assurance.

At the start of the product design there will have to be a stronger emphasis on design for function. This will replace the current practices that are largely design from experience that will produce solutions that still are either overdesigned and costly or alternatively underdesigned and problematic. This philosophy requires that mechanical designers work much more closely with materials engineers the manufacturing process engineers, marketing, sales and quality assurance. In essence the design process is a complete and comprehensive team process. It is a process where each significant stage in the whole development from the design concept to finished and in-service artefact is part of the quality assurance feed back cycle. The customer satisfaction with the product is of paramount importance and the customer perception of it will influence its long-term success in the marketplace. Companies that develop such strategies will have a significant advantage over those companies that fail to embrace it fully. What is particularly interesting about this concept for quality assurance is that it has been initially evolved and been recognised as a part of natural human evolution. It is interesting to recognise that the same principles can be employed with benefit in the manufacturing environment and by doing so it is possible to clearly define all the relevant stages in the process and to develop a comprehensive suite of quality procedures to monitor the entire process from design to large scale manufacture where the object is to manufacture economic, functionally effecttive products that will perform with satisfaction throughout their entire product life. In reality this is a mirror of the human servo control system.

The authors of this paper are strongly of the opinion that applying the concept of "Negative Feedback" to Quality Assurance Systems, provides the opportunity for both engineers and designers to design and evaluate the functional requirements of components and products and to create a basis whereby Functional Quality Assurance Systems are defined.

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