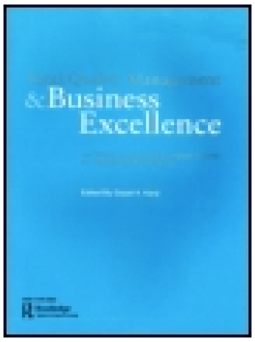

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Embedding sustainability concerns into quality assurance

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Embedding sustainability concerns into quality assurance

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TQM can be described as a way of managing an organisation with quality at its centre. Quality Assurance (QA) is concerned with managing the quality of products and services, from concept stage onwards to the very end. K. Ishikawa considered QA to be 'the heart and soul' of TQM. QA is defined in terms of 'guaranteeing' or 'providing confidence' to customers. Some authors have compiled generic lists of quality dimensions. Generally, the way products create or fail to resolve societal concerns do not figure in these lists. It is time to consider such common requirements as an integral part of quality. Societal quality has a large overlap with sustainability. This paper provides a model to embed sustainability outcomes in the dimensions of quality. It outlines the inevitable addition to the QA system that will follow such a step, with an example.

Keywords: quality assurance (QA); dimensions of quality; sustainability; harmlessness

Introduction

The quality guru Kaoru Ishikawa (1990) placed quality assurance (QA) as 'the heart and soul' of TQM. 'Quality assurance,' he explained, 'consists of *guaranteeing* that a consumer can purchase a product or service with *confidence* and enjoy its satisfactory use over a long period.' ISO 9000:2015 defines QA in similar fashion as 'focused on providing *confidence* that quality requirements will be fulfilled.' (Italics are by the author.) In a thesaurus, assurance is a synonym of the word confidence, while the word guarantee is a synonym of assurance.

Shigeru Mizuno (1988), in the English translation from Japanese of his 1984 book on quality control, developed eleven elements of quality, seven of which, such as durability, safety or ease of use he regarded as 'negative' quality factors and four, such as good design or physical appeal as 'positive'. He elaborated 'negative' elements to mean that their 'absence can doom a product, but their presence alone does not ensure that a product will survive competition', a concept that came to be labelled as 'must-be' quality. The widely cited David Garvin (1987,november–december, 1988) came up with a model comprising eight dimensions of quality – such as performance, reliability, aesthetics and even perceived quality. Deming followers Ronald Moen et al. (1991) expanded the Garvin list to 11 elements, and were ahead of their times by including harmlessness, which they defined as characteristics related to safety, health or environment.

The idea of incorporating societal or environmental issues of products into quality management is not really new. Genichi Taguchi (1986) defined quality as the loss to society from the time a product is shipped. Kackar (1986) extended the loss function to include the period when a product is manufactured. This paper emphasises loss during use and disposal of products, as loss during manufacture will require a separate treatment. Shiba and Walden (2001) placed fitness to societal and global environment atop fitness to

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standard, to use, to cost, and to latent requirements. In 2009, Hitoshi Kume, building on his earlier descriptions of social quality, included in it 'factors such as noise, vibration, emission, pollution, etc. generated at the time of production and use of product or service on a third person.'

Despite such mentions of societal and environmental elements as part of quality, in practice it is hard to find these elements as integral to quality assurance systems in companies. Commonly, environment is treated as a separate category of control items. This approach is problematic as it assumes that the quality of a product or service is independent of any harm it might do to third persons during its production, use or disposal. This paper aims to integrate quality assurance activities with sustainability in the sense of prevention of harm to the health of the planet, as such harm may hurt the well-being of society today and in the future.

The management system chart

The practice of Deming Prize winning companies is to prepare a 'Management System Chart' (MSC) – a cross-functional flow chart – that clarifies every function's responsibility towards quality, mapping it from the planning and concept stages through design, installation, operations, sales and service. Such charts have their origin in the mechanism of Cross-functional Management pioneered at Toyota in the sixties but definitely 'devised and administered' by them in the seventies (Kurogane, 1993). These systems are also hinted at from early on by Feigenbaum (1991), and by Juran (1989) who labelled them 'macro-processes'. Explanations and real-life examples of MSC are available in literature, for instance, in Kurogane (1993), or Hino (2006). The latter presents a short version of a Toyota QA chart involving Sales, Engineering, Production engineering, Manufacturing, Purchasing and QA departments, but cautions that a full version runs into ten sheets.

To apply for diagnosis or examination leading to the Deming Prize, an applicant company is required to attach its 'QA diagram' – which is an MSC depicting in nutshell how QA is managed company-wide and clarifying every department's role and interface. (See The Application Guide for Deming Prize, 2020). In effect, the QA diagram defines the business of the applicant organization. Each diagram typically carries some 50–100 rectangular boxes, together with KPI and references to standards, and covers the entire product lifecycle.

A QA diagram is sometimes constructed by first identifying the stages in the product life cycle and numbering them from Q_0 to Q_n. The Industrial Synthetics Business of SRF, in its run-up to challenging the Deming Prize in 2004, devised a fourteen-step QA system, from Q_0 to Q_{13}, starting with product planning and ending with quality of customer relationships. Tata Steel, a company with a long and illustrious history, and a deep value chain that includes coal and iron ore mines, created a twenty-part corporate level QA system from Q_0 to Q_{19} while preparing for its Deming Grand Prize examination in 2008.

A cautionary note here is that a QA diagram is constructed for a business or product line as a whole and not necessarily for each product type or application segment.

Contours of a QA system

In organisations practicing TQM, it is understood that QA begins at the strategic planning or at least the product planning stage. Indeed, some 80 per cent of QA's attention ought to be with upstream stages, which capture the needs of customers and translate them into designs, for subsequent deployment into production, sales and service.

The product planning stage is about deciding what to make, while succeeding stages are about how they should be made, sold, used, and disposed at end-life, to the satisfaction of those concerned. When developing the concept of a product or service, the discovery of customer requirements is clearly a first step. ISO 16355–1 (2015) uses terms like 'voice of customer' and 'voice of stakeholder' and calls for clarifying relationships among various customers and prioritising them through cluster analysis, factor analysis and analytical hierarchy process (AHP) – the latter formulated by Thomas Saaty (1980). In their three-part paper, Kanda et al. (1996) delineate seven product planning tools starting with group interviews, through conjoint analysis to the quality table that links needs to design. Thus, QA is expected to be involved in customer need identification even before a product is conceived.

Yoji Akao (1990) developed, from 1966 on, the concept of deploying customer needs all the way into quality assurance and coined the term 'quality deployment' in 1972. Leading a research committee set up by Japanese Society for Quality Control (JSQC) he, with Shigeru Mizuno, produced a book called Quality Function Deployment (QFD). The planning stage transitions to the concept stage through the quality table, historically a giant A_0 sized matrix, and the first in a series of tables. Bob King (1987) wrote what he himself called a 'cookbook' or toolkit comprising 30 charts including a 'QA Table' and the QC Process chart, thereby asserting the linkage to QA.

Over time, a system portrayed as Modern QFD has evolved. Through sharp prioritisation, it eliminates the oversized matrix, bringing greater focus on important elements. This is also the stage when the Kano model (and Kano surveys, if need be) might be used to identify potential attractive qualities, besides the one-dimensional and must-be qualities. The first matrix that links customer needs to quality characteristics – features and specifications – is partially illustrated in Figure 1. For complex products, more matrices that capture linkages to requirements from subsystems and parts are usually constructed.

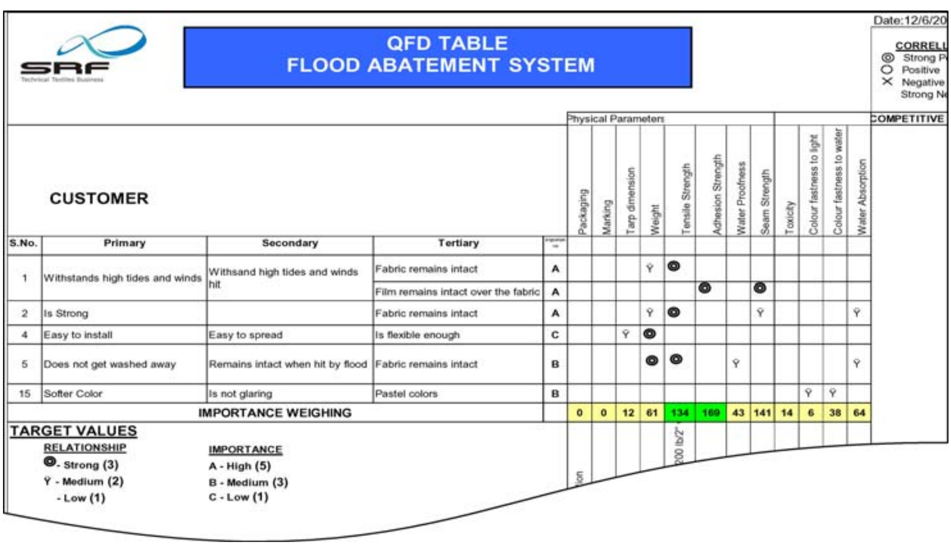

Figure 1. Cut-out of partial Quality Table for a flood abatement fabric (Courtesy: SRF Limited).

In the design stage, QFD is sought to be combined with well-known techniques such as the Taguchi loss function, Pugh matrix, AHP, TRIZ (Abbreviation of a Russian phrase meaning theory of inventive problem solving), and robust design, as for example by John Terninko (1997), and forecasts of the future voices-of-the-customer or variability analysis (Xie et al., 2003). ISO 16355 standards add robust parameter design and tolerance designs. Potential failure modes are customarily anticipated and averted through techniques such as Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA).

The design and prototype phase moves to process development, concurrently in many cases. If the process consists of assembling of parts or sub-assemblies, error modes are tabulated, and prevention measures built in. In continuous processes, the process steps and the key process variables should be linked to product quality characteristics and potential defects at each stage through a matrix as in Figure 2. Process FMEAs are also developed, and potential failure modes are either forestalled or controlled. The linkage of process and product characteristics to input materials should also be made in case of process industries and to parts and materials for engineering or assembly plants.

Tata Steel built resilience in the face of recession (Kano, 2009) by taking up the theme 'Develop and improve upon Quality Assurance System.' The company summarised the important characteristics for every step in the value chain that may need statistical process control or other means of control into 'QA Maps'.

Tata Steel has now further refined the model by developing an 'Integrated QA chain', a partial specimen of which is illustrated in Figure 3.

A simpler QA Map in a process industry is exemplified by the SRF system for a plant, at each stage of the process, in Figure 4. At a glance it provides all the key characteristics that need statistical process control.

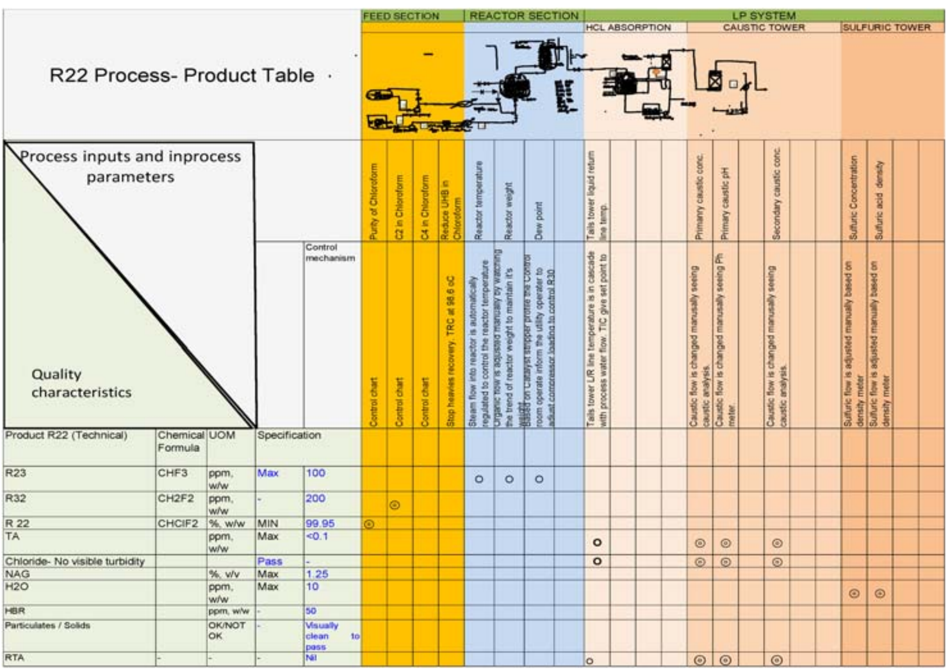

Figure 2. Cut-out image of Matrix of Product-process characteristics for a refrigerant (Courtesy: SRF Limited).

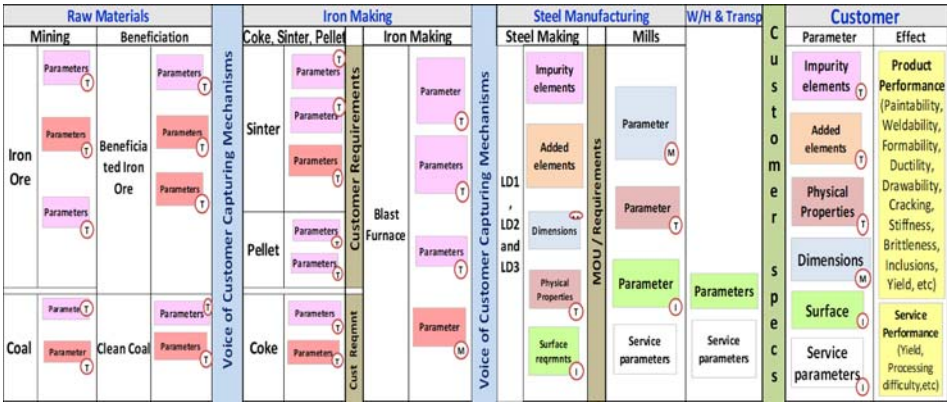

Figure 3. Cut-out of Integrated QA Chain (Courtesy: Tata Steel Limited).

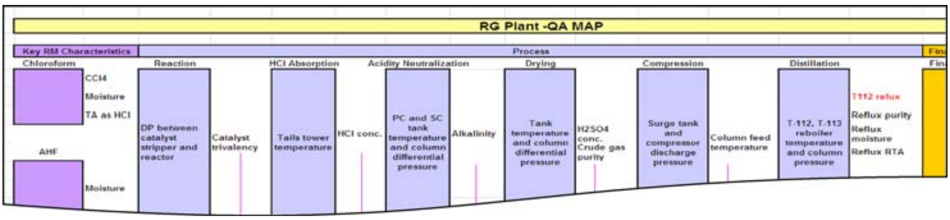

Figure 4. Cut-out of QA Map for a plant (Courtesy: SRF Limited).

The next stage would be to develop what is known in Japan as Quality Control Process Chart (QCPC) and in the west as Control Plan. (Figure 5) This document exhaustively lays out characteristics at each step of the process and the methods of controlling each of them.

Despite best efforts at these stages upstream, when it comes to actual manufacture, even assuming that operators are well trained and conscientious, and many steps to prevent human or machine errors are in place, defects do arise. Toyota came up with Ji Kotei Kanketsu -literally 'by oneself, process completion' and more meaningfully, 'built-in quality with ownership' – as explained by the creator of JKK, Shinichi Sasaki (2017) and uses what is called QA Network (Kojima & Amasaka, 2011), to identify the current rating of each step of the process in terms of its reliability. An example of a QA

S. No	Sub. Process	Characteristics		Criticality	Spec	Unit	Method	Freq.	Resp.	Record	Effect Of Abnormality	Reaction Pla
		Material	Process									
2e	Chill roll temperature		°C		20-35	mm	scale	Continuous	Shift Op	Online	**1-High Temp. increase:** Pinning marking, Inlet dancer variation and increased gauge variation **2-Low temp. gives chill roll impression**	1- If PV>SV, check c water inlet temp.and inform Utility sup.
2f	Pinning voltage		KV		7.0-10	A	PLC	Continuous	Shift Op	Online	**low voltage creates:** Pinning Marking, breaks and increased guage variation **high Voltages Increase:** may lead to breaks	1- Maintain Voltage i specified range .
2g	Die & Chill roll gap		mm		7-20	mm	Physical scale	Once/day	Shift Op	Online +	High ...	

Figure 5. Cut-out of QC Process Chart for film extrusion (Courtesy: SRF Limited).

Network table from the company Ceat is shown in Figure 6. It does require detailing! The table of rankings of each subprocess from A to F, the most reliable to the least, is contained within Figure 6. The rating is a combined evaluation of expectations of defect outflow and occurrence. Each process step, thus ranked, illuminates the improvements needed to improve process reliability.

Besides these, QA activities downstream include testing and inspection at all stages, establishment of process control systems, assuring vendor quality from selection onwards, and of course establishing systems to handle claims and complaints. QA begins with identification of customer needs and expectations and closes with managing claims and complaints effectively and connecting these to customer satisfaction. The steps in such a system are all covered in QA diagrams.

Why quality dimensions

The foregoing description of a QA system appears to be complete in itself. Why then do we need to introduce another concept called Quality Dimensions – a generic list of elements that can classify customer requirements?

One, dimensions constitute a useful checklist, so that no important customer requirement is left out.

Two, if the dimensions are laid out comprehensively, assurance could be built for addressing all relevant customer and societal constituencies.

Three, we have the admonition from Ishikawa (1990): For each type of product, standardise the QA steps, prepare checklists, devise control methods, and improve them repeatedly through PDCA. Quality Dimensions could help establish a QA system tailor-made and end-to-end for every product-market segment, even when variants or enhancements are being developed.

Four, especially in the crucial upstream stages of planning and design, NPD teams can have quality templates handy; QA departments can ensure that nothing is missed out; and design reviews can shoot sharp on real issues.

Five, the way a product is promoted and sold is too often at variance with design intent and actual realisation. Quality dimensions can aid synchronisation of promotional and

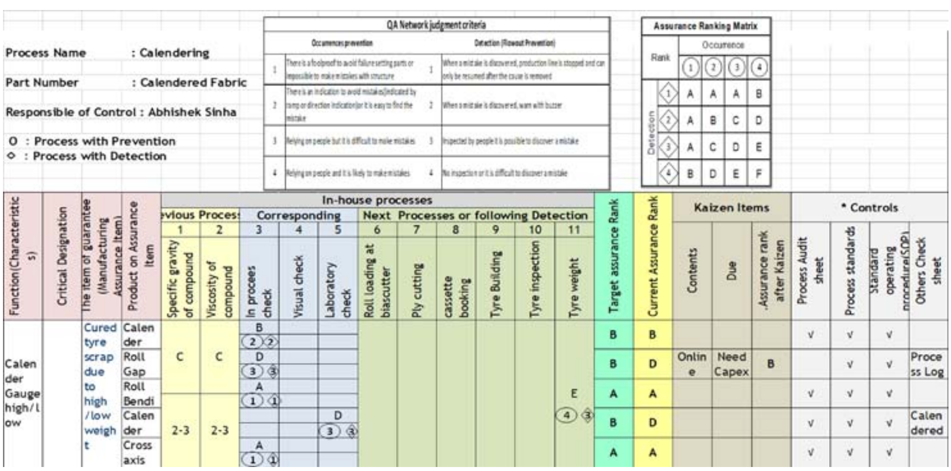

Figure 6. Cut-out of QA network for calendering process (Courtesy: Ceat Limited).

selling messages of company personnel as well as of channel partners with the true benefits of a product.

Six, a compilation of quality dimensions, populated with specifics for each segment, alongside proactively evaluated competitive comparisons could be the starting point for both company strategies and the generation of issues in annual policy management cycles.

Though QFD is meant to go down the line into manufacturing and sales, it is uncommon to find a complete, visible QA system in one place for each product-market segment. For a company with a primary product category that incorporates many product lines, products and variants, the number of such systems can be large, but necessary. The overarching QA diagram is not a substitute for this.

Thus, a company making consumer durables might have product lines like washing machines, refrigerators, cooking ranges and so on. In each line there might be products – the refrigerator line may offer different capacities (in litres) meant for households or restaurants and hotels or supermarkets and each of these might have variants in colour, features, energy rating and so on. Even if the company builds a separate QA system for refrigerators as a whole, it would still need to understand separately the dimensions of quality that matter most to each market segment.

Types of customers

Management and quality literature emphasise the need to determine who the customers for a product type are – and to distinguish the purchaser, the processor, and the user. Users may not always be purchasers – as with gift items, children as users, life-insurance claimants, and so on. Another case is where a supplier makes products that are processed into another product by the purchaser. The end-user may have little knowledge of the product of the first stage supplier, and yet is important to this supplier. For example, a car-user may like the paint colour and sheen but may give no thought to its durability or abrasion resistance. But a paint-maker has to necessarily devise products that maintain their characteristics durably in actual car-use.

One requirement to be emphasised is harmlessness. Unfortunately, users as well as those who handle a product for maintenance and service may be subject to hazards that they are sometimes unaware of. The fire hazard of a cell phone, skin irritants in cosmetics, harm from pesticides and a multitude of chemicals in food products, or off-gassing from wall paints are but examples.

Processors and assemblers have some specific needs – processability in the main. Some examples are additives for makers of processed foods, plastic granules for injection moulders, or steel or textile cords for tyre makers, or transmissions for a chassis line.

Up to this point, quality professionals and companies practising TQM do understand these points, and many successfully build products that account for the needs of purchasers, processors and users.

However, there are other stakeholders to consider.

Firstly, there are those in the vicinity of a user or a disposal site, affected by a product but who do not count as customers. Non-users may suffer accidents from automobiles, they might have to handle toxic wastes or to transport used but hazardous items, or they may live near waste dumps, or they may suffer a noisy generator or concrete mixer close-by.

Two, at intermediate distances, there are those in the community who might be inhaling fumes or particulate matter in the air which are generated by products in use, or find water sources contaminated by pesticides and a variety of toxins from products used by others.

Three, consider society at large. Products that consume electricity from fossil- or biofuels add to greenhouse gasses (GHG). Most products and packages, when disposed off, pose hazards, and also scar the landscape, especially when the scrap is not degradable in the normal course. More invisible is the loss of non-renewable resources – minerals or fuels, or rapid loss of renewable resources, as with many forests or marine fisheries. Loss of habitats together with hazards also deplete biodiversity, a phenomenon correlated with bio extinction.

In many cases, governments and international protocols set maxima on the harm or collateral damage to users and society. Such regulations usually get included in specifications. In contrast, Quality Assurance has rarely incorporated the requirements of affected parties or even of users, beyond the legal minima.

Therefore, it is time that the scope of quality assurance is broadened to include harmlessness as a principle. Concerns regarding society and planet can no longer be banished as externalities. The very definition of quality should be expanded to add societal quality neatly to the customary list of qualities. Figure 7 provides such a definition and concept. (Ramanathan, 2019)

Quality dimensions

The dimensions of quality listed by Garvin and others as cited in the introductory section of this paper, and that of others, together with various 'Q_0 to Q_n' conceptions, when consolidated, come to a tally of fifteen. Excluded are the dimensions of 'price' which is best treated separately, 'uniformity and consistency' which can apply to a number of dimensions such as performance, features, reliability etc., and overarching requirements like 'good design', 'superiority over competition', 'originality' etc. which are generic and can apply to a number of dimensions. These dimensions represent the point of view of customer needs, and do not include manufacturing dimensions such as ease of assembly or detectability of defects. The fifteen dimensions here seem to be comprehensive, though further additions cannot be ruled out.

We now need to add in dimensions relating to not causing harm to the community, members of which may or may not be identifiable as customers. In selecting these, elements that may be important to management – such as social sustainability for which stakeholders include employees and concerns include equitability, fair labour practices etc. The elements chosen are strongly attached to products or services from a quality assurance point of view. Five elements relating to not causing harm emerge from the White Paper issued by the International Academy for Quality (2019) and Ramanathan (2019)

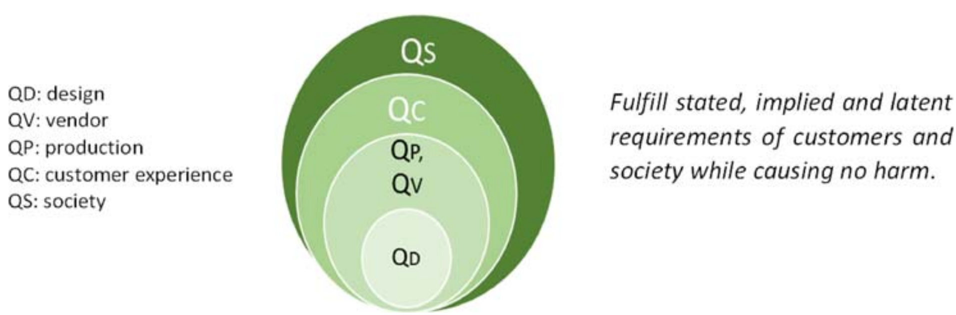

Figure 7. Enlarging the domain of quality assurance (Ramanathan, 2019).

cited earlier, which identify five environmental phenomena and seven sources of their occurrence. Quality cannot be claimed if the community may be exposed to toxins, or the effects of GHG, the earth's resources are depleted too fast for recovery, and disposal creates permanent troubles. Mizuno (1988) did mention ease of disposal, but it is doubtful if he meant it in an environmental sense.

The five dimensions are all environmental, and are capable of being incorporated into a quality assurance system. There is no attempt to connect QA with, for instance, all the 17 elements of the UN Sustainability Goals. It would be far-fetched to link QA with, say, the SDG goal of eliminating poverty. Nevertheless, as will be shown, some of the first fifteen quality dimensions and the next five so connect to at least seven of the SDG goals.

We thus get a total of twenty dimensions of quality to work with, and incorporate into QA systems, as shown in Figure 8. The round number of twenty is accidental and need not be frozen for all times to come.

Each of these elements bears an explanation, however brief.

(1) Perceived Quality: This is a dimension from Garvin's list. Customers have expectations from a product, which is based on their perception of a brand and/or company it represents. Reputed brands start with an advantage and a 'reserve' of goodwill that buffers them from ill effects of the odd failure.
(2) Product Selection: It is incumbent on a company to sell the right product from its line after understanding the customer's needs. The 'right' product would be one that is designed to provide the performance and features that a customer needs.

1. Perceived quality
2. Product selection
3. Performance
4. Features
5. Safety in use
6. Ease of use
7. Sensory attributes
8. Emotional attributes
9. Economy in running
10. Durability
11. Reliability
12. Service attributes
13. Technical assistance
14. Relationship
15. Ease of doing business with
16. Freedom from toxins and waste
17. Contribution to greenhouse gases
18. Amount of non-renewable resources
19. Amount of renewable resources
20. Recyclability

Figure 8. Twenty Dimensions of Quality.

Take shoes for a jogger, PC memory, shirt size, table height, the flux type for a foundry, and so on.

(3) Performance: This refers to the delivery of the functions promised by the product to meet customer requirements and is a prime dimension. Acceleration or noise in a car, detergent efficiency, PC speed, cooling efficiency of an air conditioner, TDS of water from a purifier, tripping frequency in electric supply, speed of a train are examples.

(4) Features: This is about the quality and range of features available to meet the requirements. Features also contribute to comfort, ease, or pride for customers. Some examples of features could be car-reversing aid, face recognition in a PC, range of apps available for a phone, dust repellence in a shirt, air-purifier in an air-conditioner etc.

(5) Safety in use: This means protection from accident to the person or property of the user or to others. Examples of prevention of accidents include automatic stops by photo-electrics in a welding machine, closed access to a running paper shredder, stops in elevators and escalators, crash-proof side members in a car, safety valve in a pressure cooker, curved edges in toys, and the like. Product liability issues stem largely from safety concerns.

(6) Ease of use: Erstwhile video-cassette recorders were a joke among users for being difficult to operate. The harder it is to use a product or service the lesser its quality. Examples include navigating a website, using a statistical software, installing a TV, opening some types of packages, settings of washing machines, etc.

(7) Sensory attributes: These are about appearance, colour, shapes, patterns, texture, odour, sounds, and taste. Especially in market products, appearance is what strikes a customer first. Some examples: The shiny redness of a cricket ball, the sharp taste of a mouthwash, the colours, shapes and patterns of a car interior.

(8) Emotional attributes: Often there are emotional reactions to sensory inputs. Feeling proud about one’s classy new car, or even a scooter, the evocativeness of a perfume, a comfort food, the anticipation induced by a wedding dress, wondrous feelings from a great package design – are some examples. Advertising helps in positioning emotional motivations.

(9) Economy in running: This might appear to be a cost function at first glance but is very much a quality dimension. Fuel or energy efficiencies; consumption of water, lubricants; parts needing periodic replacements; and servicing frequencies and costs over the entire life cycle represent the economy-in-use angle. This is not to be confused with life cycle costs which include capital and maintenance costs and product life.

(10) Durability: This is about the functional life of the product. Durability also affects life cycle cost and the use of the earth’s resources. Durability in consumables relates to shelf life of the product, hopefully without adding harmful preservatives. Market economy makes a virtue of retiring products early, and fashions run out rapidly, but durability will remain not only a requirement of customers but of society as well.

(11) Reliability: This is about remaining functional for the promised time, given an environment. It includes maintainability. It is fitness-for-use over an extended time. Reliability is a requirement with durable products. Examples: Servicing frequency, abrupt breakdowns or intermittent malfunctions, gradual deterioration of, say, a truck, leakage of water-pipes in a house, or persistent cartridge misalignment in a printer.

(12) Service attributes: As early as 1985, Parasuraman et al. 1985 delineated ten components of service quality to include consistency, responsiveness, courtesy and communication. Zeithaml et al. (1990), applying a 22-point questionnaire, identify five service quality dimensions – tangibles, reliability, responsiveness, assurance and empathy. Though not showing up on the invoice, service attributes are an intrinsic part of product sales. Channel partners and retailers are important in delivering service. For industrial products too service elements could make or break sales.

(13) Technical assistance: Most durables are complex enough for the customer to need technical assistance – whether a PC, printer, software, dishwasher, or central air-conditioning. Industrial sales of complex products always require a high degree of technical service. Assistance is required to help users manoeuvre the steps to correctly install and operate the device, as well as to get competent maintenance.

(14) Relationship: As long as a product is in use, there is a customer. Especially for industrial products, the quality of the relationship can make a vital difference, and should be measured and tracked, through surveys and other means. This element also has a link to perceived quality.

(15) Ease of doing business with: Some organisations are notoriously difficult to do business with. This factor can either aid sales or cancel the benefits of having good products to offer. Communication of delivery status or delays, being responsive in settling claims, prompt and clear replies to queries and requests enhance this quality attribute.

The next five quality dimensions relate to sustainability, in the sense of rendering the planet conducive to long human existence.

(16) Freedom from toxins and waste: There are products that expose users or the community to toxins by contact or ingestion. Radiation hazards may be included here. Rampant chemicaliszation of the world poses risks for everyone through air pollution, water contamination, pesticide saturation etc. during use or disposal of products. Solutions include reduction in average chemical use for products. Further, there is the question of disposal of scrap – of packaging (including plastics), oil, membranes, junked products, medical and electronic wastes, lead acid batteries, and so on. These constitute harm to society, and the product maker must take the responsibility.

(17) Contribution to GHG: Apart from greenhouse gases such as carbon-di-oxide, methane or certain refrigerant gases released in generation of energy or by factories, products that utilise energy contribute significantly to raising GHG in the atmosphere. The correlation between GHG and climate warming is well established. Improving energy efficiency of products and increasing the proportion of renewable energy used are two of the obvious directions.

(18) Amount of non-renewable resources: Most products today involve some depletion of the earth's finite resources of non-renewable metals, minerals and fuels, rocks which therefore diminish options for future generations. Freshwater is a fixed quantity too, and is getting diverted to more inaccessible places. Is it possible to cut resource use, though? Can resource efficiency be raised ten times? Hawken et al. (2010) decry current car designs – the vehicle weighs 20 times the driver. Can a safe and functional car made to weigh just 300 kilograms? Donella Meadows et al. (2004) put sustainable use of non-renewables as that

which is 'no greater than the rate at which a renewable resource, used sustainably, can be substituted for it.'

(19) Amount of renewable resources: Companies or individuals with products that use up forests, topsoil, marine life etc. need to compensate by ensuring their regeneration too, or else there is a clear quality loss. Meadows again on what is sustainable: the usage rate must be 'no greater than the rate of regeneration of its source'.

(20) Recyclability: If products can be reused, recycled, re-manufactured or reassembled, or better, upgraded close to the end of their lives, mitigation would occur in toxin release, GHG, and the exhaustion of resources. Some work has been reported in terms of drastically reducing the weights of products, moving to a service economy, and using cradle-to-cradle design concepts. (Walter Stahel, 2010)

Connection to SDGs

In 2015, the United Nations adopted the 2030 Agenda for sustainable development with 17 Sustainable Development Goals, abbreviated as SDGs. It would be useful to check the relationship between some of the quality dimensions and the SDGs. Not every quality element relates to SDGs. It is beyond the scope of QA to directly address SDG goals such as zero hunger or peace and justice. On the other hand, the SDGs do not – not even SDG No. 12, Responsible Consumption and Production – directly address depletion of non-renewable resources or the overexploitation of renewables, which the 20 quality dimensions cover. Figure 9 is a matrix of some linkages between quality dimensions and SDGs.

Some radical expectations from products

QA is expected to be involved in the product planning and concept stages of product development, followed by the product and process design stages. QA must understand the expectations of customers and society at the concept and development stages of the product life cycle. Taking a consumer product like household detergent powder as an example, freedom from skin irritation might be one of the requirements of users, but societal requirements would include freedom from chemical damage to water resources, and degradable disposal of packaging.

In this context a speculative example of what the world might demand in the future from passenger cars – radical though it seems now – is shown in Figure 10, which links such requirements with quality dimensions.

Quality Dimensions			SDG Goals						
No.	Dimension	Examples	3. Good health & well-being	6. Clean water and sanitation	7. Affordable and clean energy	12. Responsible consumprion and production	13. Climate action	14. Life below water	15. Life on land
3	Performance	noise, vibrations	■						
5	Safety in use	accidents to non-users	■						■
9	Economy in running	fuel efficiency, water, energy consumption		■	■		■		
10	Durability	years of service, shelf life				■			
11	Reliability	energy, materials in maintenance		■	■	■	■		
16	Freedom from toxins	pollutants in products, land, water, air	■	■				■	■
17	Contribution to GHG	CO2, methane, refrigerant release			■		■	■	
18	Amount of non-renewables	amount of minerals, soils, fossil fuels used				■	■		
19	Amount of renewables	overuse of forests, fisheries		■	■	■	■	■	■
20	Recyclability	enabling reuse, recycling, remanufacturing				■	■	■	■

Figure 9. Matrix of Quality Dimensions with SDGs.

Figure 10. Matrix of expectations from futuristic car with quality dimensions.

It is obvious that the direction in which cars will evolve would be radically different from current designs. A car that weighs say 300 or 400 Kg in place of 1500 Kg, would require far less energy to move it. If it is safe at the same time, is upgradable, there are no parts that need replacement during servicing, is capable of being dismantled and remanufactured and is accident proof, it would be economical, and go easy on toxins and GHG, and on the earth's resources. One way to measure this progress on the benefit to the earth would be the value to weight ratio (Stahel), which would rise steeply. Considering the car's re-manufacturability, this ratio will improve further in the next round of use.

Brief case example of applying quality dimensions to a product type

Ceat Ltd. is a tyre maker headquartered in Mumbai. It won the Deming Prize in the year 2017. Ceat has been practicing a high level of quality assurance along the lines indicated in this paper and is strong in defects control and management of complaints. However, the product development department has sometimes found that a new product did not succeed at one go, and needed two or more cycles before settling in. These issues came up during policy management sessions in the annual planning cycle.

Ceat has a leading market share in two-wheeler tyres in India. The QA department launched a pilot project based on the 20 quality dimensions and chose motorcycle tyres for Original Equipment Manufacturers (OEM). Eleven dimensions emerged as relevant. Customer needs in this segment have previously been identified through QFD and now get updated through a 'Customer Specific Requirements' document. Still, two sustainability-related dimensions, which had been recognised previously but without getting into the QA system, emerged as additional elements. Figure 11 shows a partial list.

Quality Dimension	Quality Characteristics
Performance	Dry braking distance Wet/loose-soil braking distance Ride & handling evaluation
Safety in use	Load carrying capacity – load safety Speed rating Bead safety
Ease of use	Easy tyre mounting in OEM automatic line
Sensory attributes	Black tread pattern
Economy in use	Rolling resistance (Fuel efficiency)
Durability	Useful life in kilometers run No centre wear-out No uneven wear
Reliability	Weather resistance – no cracking No groove crack Puncture resistance
Freedom from toxins and waste	Greater use of 'green' materials in recipe
Resource use	Lowering use of straps and spacers

Figure 11. Practical application of Quality Dimensions (Partial). Courtesy: Ceat Limited.

This table becomes the basic template for decisions on target qualities at the start of product development. For each variant within this segment, there could be some changes, and target values are specific. Targets are also based on the latest comparative studies of top-rated tyres in the segment. In developing recipes and processes, these requirements constitute inputs. At each product development gate, Design Review checklists incorporate these requirements. Ceat carries out system improvements continually by analysing the causes of gaps between plans and actual outcomes and puts countermeasures in place.

In a simple yet powerful way, sustainability considerations have seamlessly gotten into the QA system.

Work remaining

The object of this paper is to help embed societal and planetary concerns arising from the use and disposal of products into standard quality assurance practice. Implanting something relatively new – sustainability – into an entrenched discipline like quality assurance requires persistence from many professionals. The integrated checklist of 20 quality dimensions rests on the solid foundations of well-recognised QA systems, in no way disturbing it. Therein lies the hope of widespread acceptance of routinely seeking harmlessness from the products of tomorrow.

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