Original Paper

Quality assurance in the glass industry[1])

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The following three chief functions characterize the way in which the quality-assuring measures have an effect on the company events: quality planning, quality control, quality evaluation. The functions of quality assurance extend to all classical product generation phases, the duties in respect of the following being of a varying character: phase of development, design, prototype, phase of preparation (provision), phase of production (manufacture) and service phase (practical proof).

The quality circuit, a closed series including all measures relevant to quality, guarantees prompt feed-back of the results to a short-dated adjustment of variations, thus contributing substantially to the prevention of defects.

The quality assurance system is presented here in sections of a production line serving as an example.

Qualitätssicherung in der Glasindustrie

Die Wirkung der qualitätssichernden Maßnahmen auf das Unternehmensgeschehen wird durch drei Hauptfunktionen gekennzeichnet: Qualitätsplanung, Qualitätslenkung, Qualitätsbeurteilung. Die Funktionen der Qualitätssicherung erstrecken sich über alle klassischen Phasen der Produktentstehung mit differenzierten Aufgaben für die Entwicklungsphase (Konzept, Prototyp), die Vorbereitungsphase (Beschaffung), die Produktionsphase (Herstellung) und schließlich für die Kundendienstphase (praktische Bewährung).

Der Qualitätskreis, eine geschlossene Folge aller qualitätsrelevanten Maßnahmen, gewährleistet dabei eine unverzügliche Rückkopplung der Ergebnisse zur kurzfristigen Korrektur von Abweichungen und leistet somit einen wesentlichen Beitrag zur Fehlerverhütung.

Am Beispiel einer Fertigungslinie wird in Ausschnitten das praktizierte Qualitätssicherungssystem vorgestellt.

1. Introduction

The term quality has become a catchword in our time, it has become a fashionable publicity term, which is often used improperly without hitting the real meaning. It underwent various usages and differing interpretations. Thus, for industrial products the term "guarantee of quality", for natural produce the term "seal of quality", while with respect to environment and society the term "quality of life" is applied. Gradual steps of quality, such as optimum, maximum, top, purest quality, and similar quantifications are employed additionally.

Hence, the term quality needed to be defined, and the wording of the respective definition laid down in DIN 55 350 [1] runs as follows: "Quality constitutes the aggregate of a product's or an activity's properties and characteristics relating to the ability of these to meet any given requirements" or in other words: Quality, as a matter of fact, is only the fulfillment of the requirements.

Conformity of condition and requirement is to be understood by quality, not some form of aesthetic derivation from excellence or perfection. So, quality merely means to manufacture and control precisely according to the agreed specification. Given this causality, to meet the needs of application there exists really no economic quality.

Optimum-cost quality certainly cannot be considered a financial factor. What is correct is that it is an economic factor in the sense of the prevention of defects and, consequently, of higher return of capital. Experts on economics say: "Quality is the largest production reserve which we have and, therefore, is an economic factor".

The quality of German products – the expression "Made in Germany" is part of it – still enjoys its good reputation all over the world. However, it would be naive, even risky, to rely on this in the future. For this, there are convincing arguments:

a) The speed of development in technology rises increasingly.

b) Contingency reserves, common in design and construction in the past, are subject to cost pressure.

c) The rate of specialization is growing, while the number of managing staff with a "grasp of overall control" is receding.

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[1]) Presented in German on 6 November 1986 at the HVG-Kolloquium „Qualitätssicherung in der Hohlglas- und Flachglasproduktion“ in Frankfurt am Main (FRG).

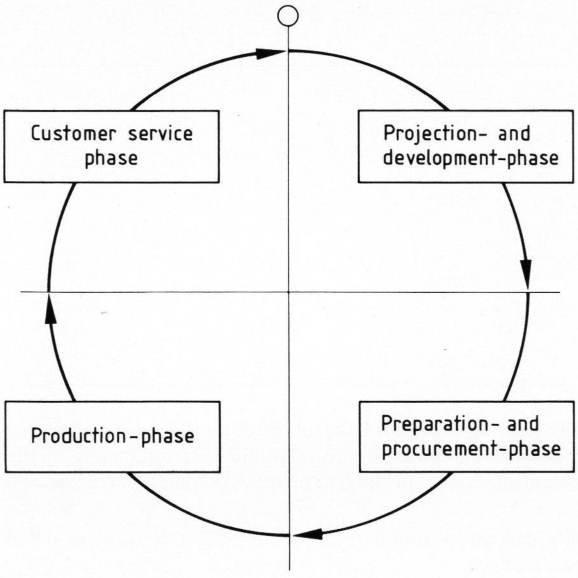

Figure 1. Quality control circle.

d) 25 % of migrant workers, roughly speaking, fit in with the work process, but do not always fully satisfy the qualifications.

e) The approach to work as such is changing. The "job" is frequently substituted for the lifelong dedication to work.

f) Buyers expect to be offered products of higher complexity, with a continually rising quality level and a higher reliability.

g) In a case of loss, the manufacturer is obliged to furnish proof that he has, in accordance with the state of the art, done everything to avoid any damage. The latest practice in law demands the onus of the proof to be reversed.

Quality, accordingly, is no longer a result of conscientious and skilled workmanship. Quality is part of the corporate planning, while quality assurance is one of the most eminent tasks within the organization of a company.

2. Quality assurance

Now the position of quality assurance within a company and the way it is fitted into the organizational structure are considered. Quality efforts are not necessarily bound to fail as long as the quality assurance manager is not under the direct control of the board of management. But the question of quality will not be well served if the quality manager is not vested with the authority and the competence required in order to enforce quality demands. A modern organizational form of quality assurance, the systematic flow of (quality data) information, and the clearly arranged registration of quality costs are prior conditions for economical production and distribution to become a reality. This makes "quality assurance" also a management function of outstanding character.

Quality has become an integrated constituent of corporate planning. Quality is the "manager's concern", and it is not a matter solely confined to staff members entrusted with selection, or employees within the quality assurance department. Strict coordination and close cooperation between many of the company's departments are required to plan, produce and assure the agreed quality. The function of quality assurance in connection with the above is chiefly limited to the following basic activities:

- quality planning
- quality control and
- quality compliance.

These functions serve the objective evaluation of the quality level and prophylactic defect prevention during all the product phases.

Quality planning involves the planning of quality targets, their establishment and corrective measures, if necessary.

Quality control is to understand in the sense of steering, i.e.: determination of results, comparison of these, and carrying through corrective measures in cases where the quality varies.

Quality compliance is characterized by the supervision and weighting of all quality results, in order that realistic recommendations may be passed on to the top management.

Using as an example one of the production lines at Schott Glaswerke, Mainz, it will be demonstrated what the practice looks like, i.e., extracts describing the quality assurance system.

The quality assurance system constitutes the established organization responsible for the setting-up, performance and carrying out of quality assurance, as defined for the mentioned company in the quality assurance manual. In figure 1 a product's process history is represented in the simplified quality control circle. Work on the product commences with the "design" (development concept) and proceeds via customer negotiations onto the obligatory specification and drawing. This part of the cycle already consumes an immense amount of time as it includes development and design. From here on, at the latest, sufficient information ought to be available to precisely describe each part of the end product physically and mechanically. This laying-down of details has to be comprehensive and must include dimension, function, material properties and even colour. This is the first target. In brief, here are the activities taking place during the phase of development:

a) quality planning by release of the concept (booklet of requirements exists);

b) quality control by supervision of concept, booklet of requirements and concept status are compared (specified and actual values are compared) and also

c) quality compliance during the development phase by a qualification test on the prototype. This means evaluation and analysis of test results, in order to already initiate any corrective action if required.

When development is completed, the completion report is on hand with all the results, while production release has been given. The phase of preparation and procurement is then entered, and it is there that many problems arise. Because, if an order with another company is placed, a most accurate specification of the items has to be made, in order to get what is really needed. This applies in like manner to the preparatory phase for products made by the company itself. The prevention of defects has to start as early as possible.

Quality planning in the preparatory phase already plans the positions for testing in the production flow. The testing instructions are formulated and describe who is to test what, where, how often, and the means with which it is to be tested. Quality planning is also concerned with establishing which tests have to be performed. This must not be left to the discretion of the tester; otherwise, features may be tested several times with higher expenditure, while others may not be tested at all. In order to perform the test, means for testing and gauging are required, that likewise have to be designed, constructed and completed in time. Time and again, production is already started, while at the end of the line, improvisation takes place in connection with the final acceptance test, because gauges are not available since they have not been completed in time.

The sector of quality control during the preparatory phase covers all the releases following a positive test report for the additionally purchased components, test instructions, gauging means and even production methods, respectively, which means software is critically judged and compared with earlier experiences in order to eliminate in advance as many sources of errors as possible.

During this phase of procurement, quality compliance has to deal with the evaluation of suppliers and their rating (incoming inspection report), in order to assist the purchasing division in its purchasing decision prior to the start of the production phase. According to an article in the technical journal Quality Control, the organ of the "American Society of Quality Control", the purchasing agents' purchasing decision is influenced with 50 points by the quality standard of the suppliers, while the price influences this decision with 35 points, and service with the remaining 15 points.

The most significant phase in quality assurance is the generation of the product. Software is converted into hardware. Quality planning during the production phase has classified the test characteristics, selected the test methods and specified the work standard. All of course, is specifically related to the product and is analogous to the customer requirement, in order that quality control may apply a systematic production control for the intermediate and final inspection and testing.

For the finished-product test, a prior incoming-product test for the customers, mutually agreed-quality certificates are available which are part of the contractual conditions with most of the business partners.

Quality compliance during the phase of production is carried out by

– a qualification test,
– type sample tests and
– a quota test (random sampling), using lots already selected.

All results are incorporated into the quality reports periodically published, which allow trends to be recognized and rejects to be analyzed. The corrective actions resulting are a significant contribution to fault prevention.

Quality planning belongs to the customer service and is responsible for working out transportation instructions concerning the prevention of damage. Storage conditions, such as humidity and heat – in short: climatic conditions – have to be laid down. For, whatever the degree of care and perfection with which some product has been manufactured, the product will be damaged in the case of inadequate transportation or deficient packaging, and if stored improperly. During this phase, the products are proving their value within the customer process producing a quality control effect with orientation towards results. In addition, shipping controls are carried through, which allow conclusions to be drawn about the packaging materials ability to be used for transportation and for packaging units.

For quality compliance, detailed complaint analyses are on hand, grouped either in relation to customers or to characteristics. The analysis of "line rejects", the losses at the purchaser's end, is carried out with the same purpose as during all the product phases, in order that activities may be made in time to prevent faults. Conscious fault prevention during all of the product phases enables the work invested and the planning to pay dividends in the form of greater efficiency and quality. Capital returns will automatically rise if costs produced by faults are lowered.

3. Quality costs

The fault costs, still, constitute the major part of quality costs. By costs for quality is understood the sum of all expenditures required for reconditioning, rejects, complaints, quality tests and quality assurance. It seems to have become a favourite pastime in

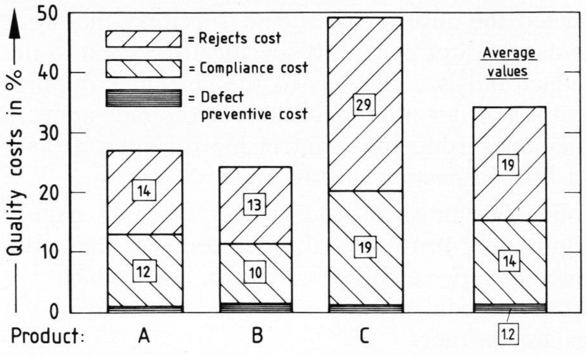

Figure 2. Quality costs.

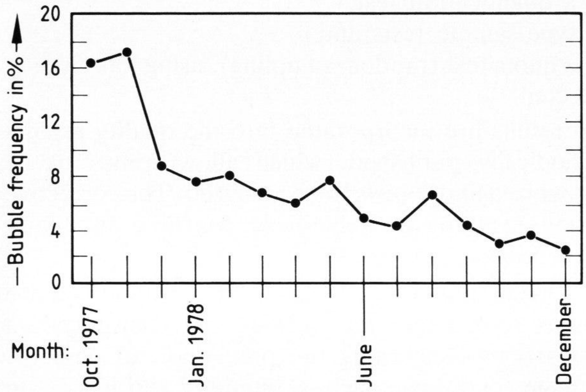

Figure 3. Decrease of bubble frequency in a melting tank during a quality improvement program.

industrial circles complaining about what quality costs. Everybody is agreed that the quality costs are too high. However, there is no agreement about what these costs are actually composed of and why they are so high. As a matter of fact, the expenditure for quality assurance is actually quite acceptable. The largest portion of quality costs by far (at least two thirds) is caused by non-quality, i.e., by rejects, reconditioning, warranty replacements and the administrative work associated with these. The 34 % balance of overall quality costs fall to the share of regular fault prevention and test functions.

From investigations which the author carried out himself emerged that a typical company spends more than 20 % of the sales volume for quality. To understand this better a practical example is given in figure 2. Effective fault prevention costs are between 1.0 and 1.5 % of the manufacturing costs, while test costs vary between 10 and 19 %. Fault costs, on the other hand, cover nearly 20 % of the manufacturing costs which is a considerable portion.

By manufacturing costs the sum of expenditures is understood, starting from the use of raw materials until the delivery at the finished-product ware-house. What needs to be done, then, is to bring tougher fault prevention measures to bear, in order to reduce testing and fault costs, which together represent 35 %, roughly one third, of the manufacturing costs.

4. Means of fault prevention

Measures for remedying the causes of faults have to be taken, if the testing and fault costs are to be reduced. Effective fault prevention requires proven deviations to be corrected once and for all, as otherwise the same situation will occur some time later and has to be tackled again the same problem. Any quality deviation needs precise investigation so that the genuine cause is found and no time must be sacrificed for mere symptoms.

To avoid any misunderstanding, again an example is taken and studied. Supposing the quality report states that the production is experiencing difficulties with sealing-in problems in conjunction with the anode buttons. The faults detected are bubbly seal, tilted anode button, convex wetting angle and too low an insertion height. The quality engineer in charge investigates the matters to find that, as a consequence of the change of personnel, new staff was assigned to production. Apparently, the new members of the staff have not received sufficient training, and the quality engineer discusses the result with the production manager. The staff members are subjected to improved training, with most of the symptoms detected disappearing. If the two, with the self-contentedness typical of people who have resolved a difficult task, now proceed to their routine functions, they are bound to face the same problem again soon.

This must be avoided as a matter of fact by:

a) a training scheme for new staff members, with a certificate of qualification being required;

b) only qualified personnel is assigned in future;

c) in addition any new man is trained at his place of work for a period of time long enough for him to fulfill the department's quality standard.

It has to be investigated, whether or not the sealing-in problems have been caused solely as a consequence of insufficient training, because the obvious solution, which is not always the correct one, often yields relief for a short time only.

The cooperation of experienced staff is required for all these investigations. If, however, a little more time is spent in this attempt, spared lots of trouble would be spared in the future. Unfortunately, it is in rare cases only that sufficient time is taken for proper planning, but rather much time to remedy muddled situations.

With the aid of the bubble frequency produced by a melting tank it shall be demonstrated how such a quality improvement program works (figure 3). Over a number of months, various corrective measures were taken more or less successfully. The improvement attained was significant, which may likewise be expressed in terms of hard DM currency. There were expenditures of the order of approximately DM 10 000 for corrective measures compared with net cost savings of DM 2.9 mio per year.

5. Conclusions

This brief account of quality assurance activities has covered all main functions. Certainly, a lot of aspects have been left unmentioned. Quality assurance has been characterized as a function making exacting demands on planning, integrity and care in details. It begins with the contract and ends with the customer process. Quality assurance is a circuit of planning, testing, analysis, corrective actions, returning again to planning, because even corrected discrepancies will definitely reappear at the first opportunity, as long as experience is not incorporated as an element into the quality feedback control system.

Labour costs in the Federal Republic of Germany are the third largest in the world with the third lowest amount of annual working time. Semi-industrialized countries, which means low-cost manufacturers, push their way into stagnant markets side by side with industrialized countries.

The lesson is simple: Facts like these demand to raise productivity, improve flexibility in connection with customer requirements and offer a high quality standard. Quality becomes the central-core in safeguarding the company. In the long run, it will play, if not the most important certainly a highly important role.

6. References

[1] German standard DIN 55 350, pt. 11 (draft) (March 1986): Begriffe der Qualitätssicherung und Statistik; Grundbegriffe der Qualitätssicherung. Berlin: DIN 1986.

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