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Improvement of Quality Evolution System for Inground Storage Tanks

Amélioration du système de développement de la qualité pour des réservoirs sous terre

Verbesserung eines Qualitäts-Entwicklungs-Systems für Erdbehälter

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SUMMARY

In 1979 Total Quality Control was adopted in our company and it was our great honor to receive the Demming Prize in 1983. Through quality control activities, the role of the authors' department has always been examined from the viewpoint of quality assurance. It was then that the quality evolution system was adopted and has been improved since that time as a measure for quality assurance. The improvement process of the «Quality Evolution System» and various other activities using it are described in this paper.

RÉSUMÉ

En 1979 un système de contrôle de la qualité très développé a été introduit dans notre société et nous sommes fiers d'avoir obtenu le prix Demming en 1983. Notre attention a toujours été dirigée vers une assurance de la qualité globale, laquelle peut être mesurée à l'aide d'un système de développement de la qualité. Ce système a été introduit ces dernières années et est en permanente amélioration. L'article présente ce processus.

ZUSAMMENFASSUNG

1979 wurde ein umfassendes Qualitäts-Kontroll-System in unserer Firma eingeführt, und wir sind stolz darauf, dafür 1983 den Demming Preis erhalten zu haben. Unsere Aufmerksamkeit war dabei jedoch immer auf eine umfassende Qualitätssicherung gerichtet, in der als Massnahme ein Qualitäts-Entwicklungs-System figuriert, das in den letzten Jahren eingeführt und laufend verbessert wurde. Dieser Prozess wird dargestellt.

1. PREFACE

Inground storage tanks are facilities for storing energy resources i.e. LNG, LPG and crude oil etc., safely inground, in volumes ranging from 60,000 KL to 130,000 KL. Up to now approximately 50 inground tanks are either already in operation or are under construction in Japan.
The inground storage tank is mainly composed of an outer concrete structure, an insulation layer, a stainless steel membrane and a steel roof. The insulation layer and the membrane are attached to the outer concrete structure.
In the actual construction of the tanks, high tecnology is utilized in the design and construction techniques which take into account the necessity of maintaining stafety standards. The construction period itself is usually up to 3-4 years.

2. QUALILTY EVOLUTION SYSTEM (QES)

In our company TQC was first introduced in 1979. In the beginning, however, only classification regarding the design documents, which are the main work of our dept., was carried out, because it was believed the QA of our dept. should assure the design documents, but this was unclear.
Incidently, that the the most important stage of our QC activities was to assure the functions of the tank that is a result of our design and construction technologies was appreciated. So the design action itself comes under QA.
Therefore the consistency of customer requirements as to parts of the tanks was considered very important and in the process of this consistency, QA of the tank, QA of the design and in addition the QA of the construction had to be taken into account. The inter-relationship of these three was also taken into account.
So, customer requirements (Q), the substitutive characteristics of the tanks (HA), QA items at the design stage (SA), QA items at the construction stage (PA) and parts evolution (L) were separated clearly into respective divisions and organized in the manner of a matrix in order to correspond and relate to each other. This organized form is hereafter referred to as the quality evolution system (QES).
After the QEC was formed and started to function, the constitution of tank parts was made clearer by rearranging the parts sequence and by a comparison of construction methods and a more cost efficient method was discovered. Furthermore, an approach for a greater reliability was also uncovered.
Once it came to this stage the quality of various items being classified clearly became themselves vast in number. Furthermore, the volume of corresponding data got to be enormous and it also bacame apparent that the large amount of paperwork used in QEC was necessary.
So as a countermeasure computerization was introduced and a paper conservation compaign was adopted and promoted. The computer was used and a speed up regarding the searching, correcting and delating of items was accomplished.

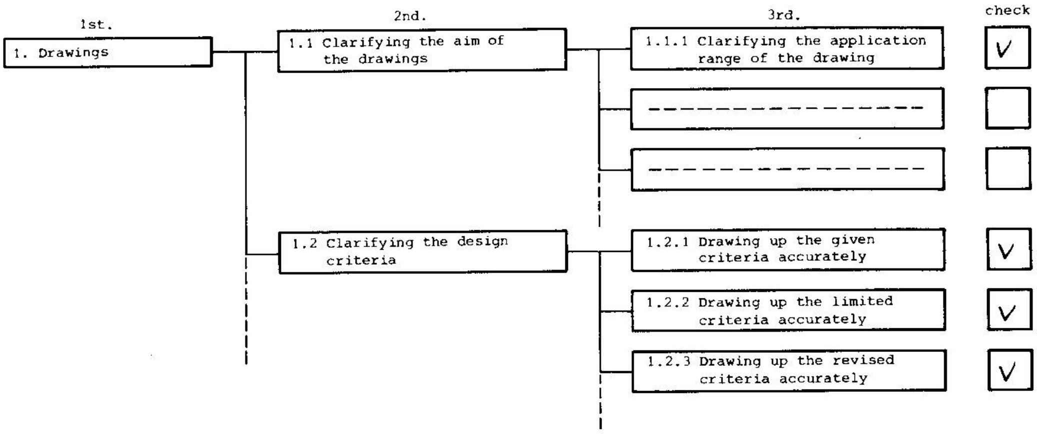
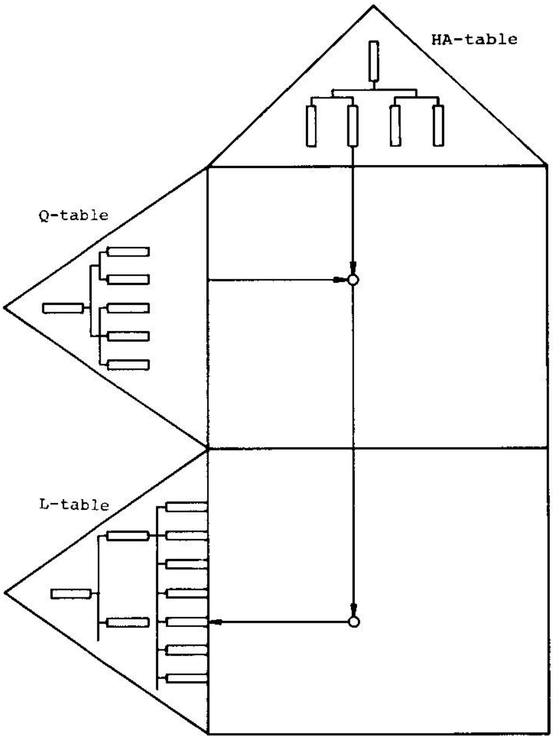


Fig. 1 One Dimensional Table

Design Calculations

Substitutive characteristics / Customer requirements		1st.	Drawn up so as to be easily understood					
		2nd.	The description written so as to be easily understood					
1st.	2nd.	3rd.	Plain and general description	Not use of polite language form	Ordered concise description	Use of detailed information i.e. figures, tables etc.	------	
Easily understood	Not to intricate		○	○	○			
	Visual					○		
	Aesthetic					○		

Fig. 2 Two Dimensional Table



Q -table : Customer requirements table

HA-table : Substitutive characteristics table of tanks

L -table : Parts table

Fig. 3 Three Dimensional Table

3. DETAILS OF ACTIVITIES (The road to improvement)

3.1 The One Dimensional Table Period ('80 Oct.-'81 Feb.)

First the process of our dept. action was broken down into 21 minute processes and a one dimensional table of each process was drawn up, taking into account that QA would be clarified by means of the evolution of the quality characteristics produced in each process. (Ref. Fig. 1)
This one dimensional table was drawn up for every major design document (i.e. Calculations and Drawings) and it was used as a checksheet in order to ascertain whether these documents possessed the required characteristics.
But in the table, the customer requirements, substitutive characteristics and the characteristics of products were evolved in some confusion and each of the items was ambiguous.
That is, there was some confusion as to what should be done in order to satisfy the customer requirements.

3.2 The Two Dimensional Table Period ('81 Dec.-'82 Apr.)

On the basis of a review of activities in using a one dimensional table, a separation, reclassification and a reassesment of the inter-relationship of the customer requirements, the action of our dept. and the characteristics of our products was considered necessary.
Thus a two dimensional table composed of the customer requirements and substitutive characteristics was drawn up. (Ref. Fig. 2) This then allowed the customer requirements and substitutive characteristics to correspond with each other.
But this table was mainly drawn up for design documents, so it didn't have a positive role in QA of the completed tanks. Furthermore it was then thought that in substitutive characteristics a certain value should be specified and this value would be transferred and correspond to the actual part of the tank. If water pressure resistance is set, as a substitutive characteristic, at a value of 2 kg/cm , the substitutive characteristic would be transferred the actual part of the tank in the form of a cutoff wall of 1 m in thickness.

3.3 The Three Dimensional Table Period ('82 May-'82 Jul.)

Here a three dimensional table composed of a two dimensional table and a parts evolution table was completed. (Ref. Fig. 3)
However, even when the table was completed, the items regarding design documents and actual tanks were still not clearly visible in both the customer requirements part of the table and the substitutive characteristics evolution part. The opinion at the time of the review in this period was that the important thing about our dept. QC activities was to assure the quality of the functions of the tanks as a storage tank and not to assure the quality of the design documents.
Therefore it seemed juistified to order the customer requirements from the structural construction viewpoint and then transfer them to structural characteristics which correspond to parts of the tank. Thus the QA of documents was thought to be positioned in the total process of the QA for tanks.

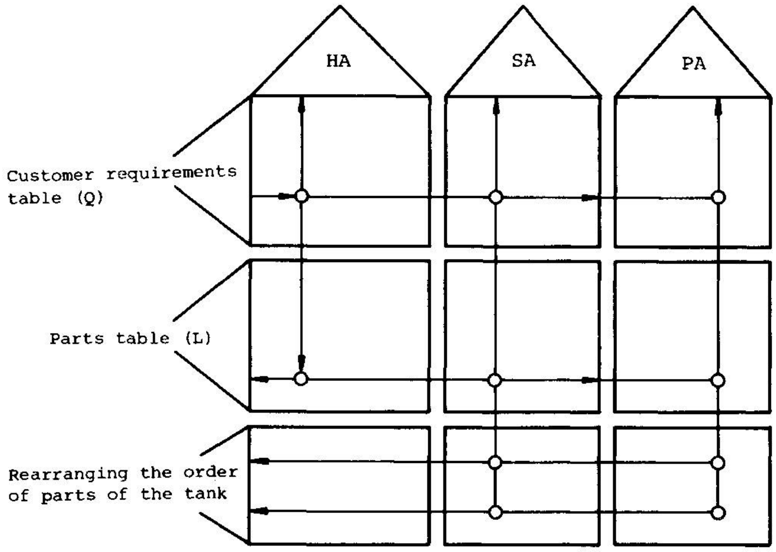


Fig. 4 The Concept of the Quality Evolution System

Project Name ______________________ Type of Tank ______________________

Design Dept. → Construction Dept.

Design Quality Information Sheet

GM	DM	SM	P	GM	DM	SM	P
Design Dept.				Construction Dept.			

Design Quality (Written by Design Dept.)								(Written by Construction Dept.)					
No	Customer Requirements (Q)	Substitutive Characteristics of Tanks (HA)	Standard Value or Specifications			Date	Remarks	Construction Process Capability Index	Construction Process Capability			Date	Remarks
			Components	Parts	Standard Value, Specifications				Controled Point	$\bar{x}$	s		

GM : General Manager DM : Deputy Manager
SM : Section Manager P : Personnel

Fig. 5 Design Quality Information Sheet

3.4 Quality Evolution System ('82 Aug.-The present)
After QC activities for 2 years, it gradually became clear that the aim of QC activities of our dept. was to transfer the customer requirements to substitutive characteristics in the design stage and to transmit those characteristics to the ones of the tanks precisely by promoting consistency in quality.
Thus the present QES now in operation at our company was arrived at.
The details of the present QES are as follows. (Ref. Fig. 4)

1) A three dimensional table is the main framework, in which the customer requirements (Q) are transferred to the substitutive characteristics (HA) and to the parts of the tank (L).
2) The elements of design technology are corresponded to the quality characteristics which should be guaranteed at the design stage and are called SA. These are added to the three dimensional table.
3) The manufacturing technologies at the construction stage are defined in relation to the construction substitutive characteristics and are called PA. This PA is also added to the three dimensional table.
4) As a result of their corresponding to each other, a mutual relation between HA, SA and PA is made clear and when the level of HA is once determined, it is to be related to SA and PA.
5) Another table of parts of the tank is added in order to compare the tank types by rearranging the order of the parts of the tank.

4. EXAMPLES OF QES ACTIVITIES

4.1 Examples of QES Activities
The actual activities described below were carried out in the process of setting up the quality evolution system and its improvement.

* The Review of the Customer Requirements (Q-table)
At this time the customer requirements table (Q-table) was drawn up by us on behalf of the users. A review activity was then carried out to make sure that customer requirements were reflected in the Q-table which was then drawn up. A number of people from relivant departments, from major client companies, were interviewed to obtain authentic customer requirements. And new Q-table was compiled by grouping the data thus obtained from these interviews.

* Cost-Planning Activities
The users' planned tank cost is set and the activity of keeping our price close to the users' planned cost is carried out by rearranging the order of parts of the tank. In this activity QES is used in order to get an idea of the influence on the customer requirements and the substitutive characteristics when the order of parts is changed. Actually 'The revised price sheet', in which the change of price after the rearrangement and the influence on the Q-table and HA-table are recorded accurately, is used.

* Approach for Reliability
This QES being completed, the order of the parts and components became clearer. The reliability of the tank as a total system is enhanced as the reliability of individual parts and components is increased.
In our present QC activities the FMEA and FTA methods are utilized and reliability tests are carried out if necessary for the parts and components.

4.2 Transferring the Design Quality to the Construction Side
The design quality was transferred to the construction side one-sidedly in the form of drawings, that didn't take into account the construction process capability. As a result unfortunately there were quite a few cases where the difficulty of the construction and the cost were unnecessarily increased due to the design.
Then the Design Quality Information Sheet (Ref. Fig. 5) was drawn up and information transfer between our dept. and the construction dept. was set up to overcome communication difficulties. The details of this information transfer are as follows.
First our dept. completed the design quality sheet in the form of standard values or specifications and sent this sheet to the construction dept. The latter fills in the construction capability range on this sheet and the projected construction process capability. If the capability is less than expected, the sheet is returned to our dept. and a review of the design quality is carried out. After the review, if the construction process capability index increases, the difficulty of construction is lessened and the construction period shortened and cost efficiency is achieved without overlooking the substitutive characteristics.
This sheet is used actively in order to transfer quality from our dept. to the construction dept. and to improve the construction process. So far having an idea of the construction process capability is the main activity when parts are assembled, but the results of this activity are considered a prototype for the next scheduled inground tank.

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