香港城市大學
City University of Hong Kong

This book is targeted for maintenance professionals in manufacturing and other sectors. It introduces the RCM methodology, and associated tools, for achieving world class maintenance performance. This enables tactics for eliminating waste in equipment maintenance, an important operational issue in maintenance management, to be presented. and tools presented in the book is illustrated through practical examples taken from various industrial settings.

本書專為從事製造和其他產業的維護保養專業人士而寫，當中介紹了以可靠性為中心的維護保養(RCM)方法及相關輔助工具，冀藉著這些工具將維護保養工作臻至世界級水平。消除設備維護工作中的浪費，是維護保養管理的其中一項重要課題，書中對達成此項目標的策略進行了深入探討。箇中論及的各種理念與工具的使用方法，將以取材自不同工業界別的實例加以說明。

全面控制方法:
專注於製程、產品/服務之質量改善

TCM: Focusing on Quality Improvement of Processes, Products and Services

V. M. Rao Tummala, Katherine K. Y. Kwok

HKSAR Government Industrial Support Fund Project
"Developing Educational Materials to Encourage and Facilitate Hong Kong Manufacturers for Quality Transformation." (ISF Project no. AF/3/98)

香港特別行政區政府工業支援資助計劃
"開發優管教材以推動香港製造業的優質變革"(編號 AF/3/98)

ISBN 962-442-197-8

優質變革系列

Quality Transformation Series

Quality Transformation Series
優質變革系列

TCM: Focusing on Quality Improvement of Processes, Products and Services

V. M. Rao Tummala, Katherine K. Y. Kwok

全面控制方法(TCM): 專注於製程、產品服務之質量改善

V. M. Rao Tummala, 郭家燕

First published 2001
2001 年初版

ISBN 國際統一書號 962-442-197-8

TCM: Focusing on Quality Improvement of Processes, Products and Services
(全面控制方法(TCM): 專注於製程、產品服務之質量改善)

Authors (作者)
V. M. Rao Tummala, Katherine K. Y. Kwok (郭家燕)

Translator (翻譯)
Mr. Leslie Lee (李賢勝先生)

Book Editors (編輯)
Dr. K. S. Chin (錢桂生博士), Dr. K. F. Pun (潘傑輝博士)

Series Editor (系列主編)
Dr. K. S. Chin (錢桂生博士)

Published by
City University of Hong Kong
Department of Manufacturing Engineering and Engineering Management

Funded by
HKSAR Government, Industrial Support Fund Project no AF/3/98

Designed and printed by
Media Production Unit, City University of Hong Kong

Enquiry
Dr. K. S. Chin, Department of Manufacturing Engineering and Engineering Management
City University of Hong Kong, tel. 2788 8420, fax 2788 8423, email mekschin@cityu.edu.hk

Quality Transformation Series 優質變革系列

TCM: Focusing on Quality Improvement of Processes, Products and Services

V. M. Rao Tummala,
Katherine K. Y. Kwok 郭家燕

全面控制方法(TCM): 專注於製程、產品服務之質量改善

City University of Hong Kong
Department of Manufacturing Engineering and Engineering Management

Contents

Foreword

序言

我們很高興獲知已經有人最終重建了各種質量工具間的聯繫。 全面控制方法論(TCM)的技術改變了人們的思路：有了TCM他們考慮的是現有工具哪個是合適的和如何適應，而不是花時間去尋求新的工具，走回頭路。

作者開發了書中所述的TCM實施策略。它們從必備的條件，處理和補充方式出發詳細描述了質量工具間嵌套的相互關係。這將有助於我們理解各質量工具之間的相互關係。

作者採用實際案例且將TCM應用到世界知名企業摩托羅拉公司，取得了卓越的成效。通過TCM實施策略的執行，摩托羅拉公司已將全面優質指數(TQE)從38提高到49(最高為50)，福特汽車公司曾經是最高分得主之一。至於新產品線，達到6 sigma質量水準的時間周期已由原來的18個月縮減到6個月，這證明TCM對於質量已經領先的企業同樣有效。

目前，香港的產業正處於一個十字路口，全球性的競爭迫使他們認真地考慮向高附加值產品的製造轉產，消費者不再視高品質產品為奢侈，代之的是必然。TCM作為一種卓越的方法論，足以協助本地產業走出困境，使其在全球化的競爭中遊刃有餘。

唐偉國
香港品質學會主席(2001-2002)

We are pleased to know that someone has finally re-built the links between various quality tools. The technique of Total Control Methodology (TCM) serves to reform peoples mind: rather than spending time to search for new tools, they should step back and, with TCM, consider which existing tools are appropriate and how.

The authors have developed the 7-Step TCM Implementation Strategy in the book. They elaborate the nested interrelationships of quality tools in terms of their prerequisite, treatment, and supplement modes. This serves to help us understand the interrelationships between the quality tools.

The authors make use of real cases and apply the TCM in the world famous company, Motorola, with excellent results. Through the implementation of the 7-Step TCM Implementation Strategy, Motorola has increased the score of total Quality Excellence (TQE) from 38 to 49 (Maximum is 50), one of the highest scores ever given by the Ford Motor Company. As for new product line, the cycle time to reach 6 Sigma quality level has been reduced from 18 Months to 6 Months. This demonstrates that TCM is also valid for companies already running ahead in their Quality Journey.

Nowadays, the industries of Hong Kong are in the crossroads, global competitiveness forces them to consider the transformation into high value-added manufacturing seriously. Consumers no longer treat quality products a surplus, instead they have become a given. TCM is an excellent methodology to help local industries walk out of the dark and play well in this global game.

Ir. Aaron TONG
Chairman of HKSQ (2001-2002)

Foreword by the series editor

系列主編序言

優質變革系列

不斷增加的競爭壓力、動蕩不定的商業環境、持續變化的市場需求和日益提高的質量要求使得全球製造業的營運更為複雜。這些壓力迫使製造商集中精力制定可行的策略和戰術以獲得和保持競爭力。 香港正在經歷由低成本組裝轉到高附加值製造的重要轉型期。 為了成功轉型，香港製造商必須比它們的競爭者更快及更便宜地提供更高質量的產品。 實施有效的質量策略和管理是成功的一個關鍵因素。

“優質變革系列”是在香港特別行政區政府工業支援基金支持下所制作的質量推廣和教育材料，其中包括：與質量有關的小冊子、錄像和其他媒體。 它的目標是使公司主管明白推行質量提升的重要；介紹現代質量改進工具、模式和方法給香港製造商；和提供香港的最佳質量管理實踐的案例。

隨着這個系列的發行，我們希望能夠鼓勵和促進香港製造商進行優質變革。

錢桂生博士
系列主編

Quality Transformation Series

Global manufacturing competitiveness has been complicated with the accelerating pressures of industrial transformation, dynamic trading conditions, ever-changing market demands and uplifting quality requirements. These pressures have sharpened the industry's focus on developing viable strategies and tactics in gaining and retaining their competitiveness. Hong Kong is now undergoing a critical transformation from low-cost assembly to high-value-added manufacturing. For a successful transformation, Hong Kong manufacturers must provide better quality products faster and cheaper than those of their competitors. Adoption of effective quality strategies and practices is one of the crucial factors for success.

This "Quality Transformation Series" is supported by the HKSAR Government Industrial Support Fund to develop promotional and educational materials, such as booklets, video and other multi-media in quality topics. It aims to make the company executives more aware of their crucial role in leading successful quality transformation in their companies; to introduce modern quality improvement tools and methodologies to Hong Kong manufacturers, and to provide examples of best quality management practices in the Hong Kong environment.

With the launch of this series, we hope to encourage and facilitate Hong Kong manufacturers in making the quality transformation.

Dr. K S Chin
Series Editor

Introduction

簡介

自七十及八十年代以來，世界各地的企業日益察覺優質的產品/服務是提高本地及國際市場競爭力的重要元素。針對此市場需要，各界從事質量管理的業內人士及學者，先後開發出各種的質量控制工具、改善方法和解決問題技巧，並解說如何把它們運用於產品/服務。當製造業和服務界企業運用這些工具去改善其產品/服務質量時，皆能獲得良好的成效。這樣亦使部份工具的英文字母縮寫，如：3K、5S、舊7工具、新7工具、DFM、DOE、FMEA、GR&R、M/PCpS、PM、QFD、SPC、SQC、TPM、TQC和TQM等，漸漸為人所熟識。常用工具的英文縮寫和全名，可見[表一]。但若要牢記各項標籤，是頗為令人頭痛的事情；更令人困擾的是有時當企業嘗試在日常運作中應用這些質量工具，卻又不一定能達到預期效果。

追尋原因，人們往往發現並非那些質量工具無效，而是推行者使用未得其法，他們對於何時、何地、如何使用質量工具缺乏透徹的理解。故此，在一間企業中，某一項質量工具是否有成效，將取決於人們能否適當和有效地應用那工具。常見失敗的原因有很多，例如：許多企業會運用“控制圖”去控制製程或產品質量，要求操作員在日常工作中，收集數據和點線製圖；可是操作員對失控情況、成因分析及隨後應做的行動，往往瞭解不足。歸根究底，是當製程失控時，操作員和工程師均忙於儘快恢復生產，對失控的成因分析和相應的修正行動，未暇進行認真及深入研究。久而久之，操作員不明白為什麼在製程失控原因未

Since the 1970s and 1980s, many companies around the world have increasingly recognized that producing quality products or services is a major source of becoming competitive in domestic and global markets. Many practitioners in quality management and academicians have developed impressive quality control and improvement tools, as well as problem solving techniques, and explained how to use them in the workplace. Manufacturing and service organizations responded well in using these tools to improve the quality of their products and services. Some of them have become popularized by the acronyms (e.g., 3K, 5S, old seven, new seven, DFM, DOE, FMEA, GR&R, M/PCpS, PM, QFD, SPC, SQC, TPM, TQC, and TQM, etc) as shown in Table 1. Despite the headaches of memorizing their labels, some quality tools do not work exactly as they are intended when companies try to apply them.

The appropriateness and effectiveness of applying quality tools may determine the success of their adoption in a company. However, a lack of understanding of when, where and how to apply quality tools is attributable to their failures. For example, while applying SPC to monitor the process or product quality, many operators are busy with collecting data and plotting the control charts, as this is part of their routine work. They may be unaware of any out-of-control and special cause conditions, and subsequently perform inadequate analysis. Due to the prevailing pressure to resume production as soon as possible, the operators may not have sufficient time to conduct serious analysis of their work. In some circumstances, they may even not bother to understand why there is an out-of-control or special cause condition, what causes it to happen and what they should do. Although operators may know the benefits of using the tool, they do not know when and how to apply them effectively. As a result, control charts cannot perform their intended purposes and the effectiveness of many of their applications is affected.

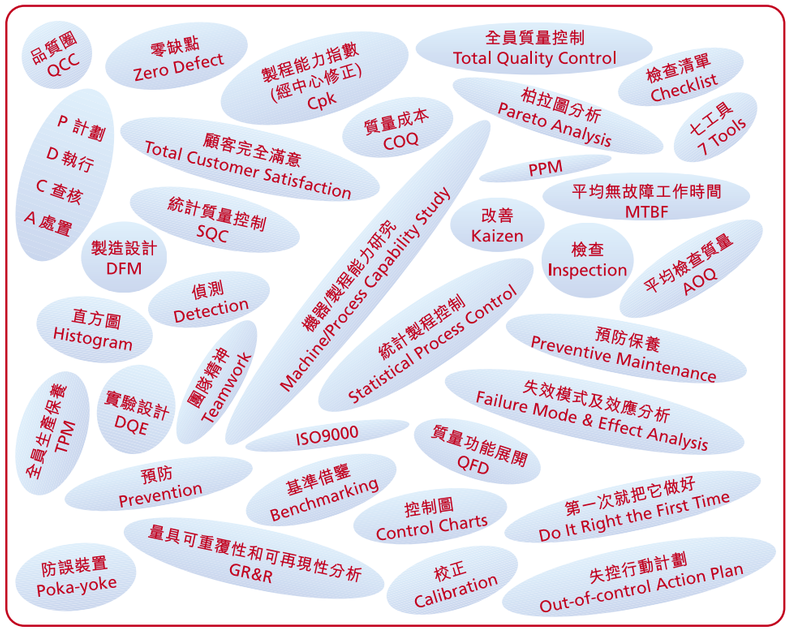
3K	思想、行動、改善 Kangae, Kodo, Kaizen
4M	人、機、物、法 Man, Machine, Material, Method
5S	整理、整頓、清掃、清潔、自律 Sort, Set, Shine, Standard, Strict; or Seiri, Seiton, Seiso, Seiketsu, Shitsuki
新7工具 New 7 QC Tools	KJ法、PDPC法、箭頭圖法、矩陣法、系統法、關連圖法、矩陣數據解析法 KJ method, PDPC method, Arrow diagram, Matrix Diagram, Systematic diagram, Relational diagram, Matrix data Analysis
舊7工具 Old 7 QC Tools	柏拉圖分析、直方圖、控制圖、石川(魚骨) 圖、散佈圖、分層法、檢查清單 Pareto analysis, Histogram, Control chart, Ishikawa (fishbone) diagram, Scatter Plot, Stratification, Checklist
ANOVA	方差分析 Analysis of Variance
AOQ	平均檢出質量 Average Outgoing Quality
AOQL	平均檢出質量水平 Average Outgoing Quality Limit
AQL	允收質量水平 Acceptable Quality Level
ARL	平均運作長度 Average Run Length
COQ	質量成本 Cost Of Quality
Cp	製程能力指數 Process Capability Index
Cpk	製程能力指數 (經中心修正) Process Capability Index (Centre-adjusted)
CQI	持續質量改善 Continuous Quality Improvement
CWQC	全員質量控制 Company-wide Quality Control
DFM	製造設計 Design For Manufacturability
DOE	實驗設計 Design Of Experiments
EVOP	漸近操作 Evolutionary Operations
FMEA	失效模式及效應分析 Failure Mode and Effect Analysis
FMECA	失效模式、效應及后果分析 Failure Mode, Effect and Criticality Analysis
FRACAS	失效報告及矯正行動系統 Failure Reporting And Corrective Action System
GR&R	量具可重覆性和可再現性分析 Gage Repeatability and Reproducibility Study
ISO	國際標準化組織 International Organization for Standardization
IQL	無區別質量水平 Indifference Quality Level
JIT	及時生產 Just In Time
LTPD	批容許(百份) 不合格品率 Lot Tolerance Percent Defective
M/PCpS	機器 / 製程能力研究 Machine / Process Capability Study
MRB	物料審核會 Material Review Board
MSA	測量系統能力分析 Measurement System Analysis
MTBA	平均無輔助工作時間 Mean Time Between Access
MTBF	平均無故障工作時間 Mean Time Between Failure
MTTR	平均無修理工作時間 Mean Time To Repair
OC	操作特性 Operating Characteristic
OCAP	失控行動計劃 Out-of-Control Action Plan
PDCA	計劃－執行－查核－處置 Plan-Do-Check-Act
PM	預防保養 Preventive Maintenance
QA	質量保證 Quality Assurance
QC	質量控制 Quality Control
QCC	品質圈 Quality Control Circle
QFD	質量功能展開 Quality Function Deployment
QIS	質量資訊系統 Quality Information System
QM	質量管理 Quality Management
R&QA	可靠及質量保證 Reliability & Quality Assurance
RQL	拒收質量水平 Rejectable Quality Level
S/N	信號與噪音比率 Signal-to-Noise
SDCA	標準－執行－查核－處置 Standardize-Do-Check-Act
SOP	標準操作程序 Standard Operating Procedure
SPC	統計製程控制 Statistical Process Control
SQC	統計質量控制 Statistical Quality Control
SS	樣本數量 Sampling Size
TPM	全員生產保養 Total Productive Maintenance
TQC	全員質量控制 Total Quality Control
TQM	全員質量管理 Total Quality Management
WIT	協進組 Work Improvement Team
ZD	零缺點 Zero Defect
ZIPS	零庫存生產系統 Zero Inventory Production System

表一　質量工具之英文字母縮寫
Table 1　Acronyms used for quality tools

明，及沒有作出適當的修正下，也可容許繼續生產！這樣令各人對應用“控制圖”產生懷疑及可能感到沮喪。在這樣環境下，“控制圖”是絕對不能發揮它們應有的功效。所以，操作員及工程師雖然知道理論上運用質量工具是可以解決/改善問題；可是，當他們面對未曾體驗過的個別情況，對應該何時和如何應用質量工具及技巧，就不一定能夠作出正確的判斷，所以令到許多質量工具的預期功效大為減弱。

此外，許多企業常犯的另一個錯誤，就是把各個質量工具作為單一個體，個別使用(如 [圖一] 所示)；各質量工具之間的使用，如互不相關聯繫，就沒法子改善整個製程，所以我們需要建立一個方法來監控及改進這些情況。例如：在製程還未用“檢查清單”確定前，便開始收集資料數據和繪製“控制圖”。或者，當安裝一個“自動防錯系統”去代替操作員的目測時，卻沒有設定相關的“維護保養”程序，結果可能會令使用效果比較原先的做法更差，因為在缺乏應做的“維護保養”下，這個“自動防錯系統”會日久失修，發生故障，而各操作員還懵然不知，亦沒有實行目測，這時候生產的產品質量就可能已經受到損害，但企業本身尚毫不知情；從這個例子，我們可以看到預防性的“維護保養”與“自動防錯系統”是互相緊扣，息息相關的。

同樣，許多企業也常常在沒有檢定製程的統計穩定性以前，就開始進行“製程能力和改善的研究”，他們所持的理由是不想停止生產；在這種環境下，當“控制圖”顯示失控時，企業



圖一　質量工具之孤獨荒島群
Fig.1　Isolated islands of quality tools

Another common mistake is that many companies treat individual quality tools as separate and isolated entities (see Figure 1). The application relationships among them and their sequence have seldom been taken into careful consideration. How to interweave one tool with another is often overlooked in the establishment of an effective quality system. For instance, the process output data for constructing control charts are collected before the process is set up. An automatic mistake-proofing system is installed to replace the human visual detection for a particular error. However, if having no appropriate maintenance procedure for this mistake-proofing system, then the control may perform even worse than the original human visual detection. When the automatic mistake-proofing system is out of order, the quality of the product may inevitably be compromised because no one has applied the human visual detection for the error. Therefore, preventive maintenance is often needed, contributing to the success of any automatic mistake-proofing systems.

Moreover, many companies conduct the process capability and improvement analyses even without checking for the statistical stability of the process. The main reason is that they do not want to stop their production. When the quality control charts indicate an out-of-control or special cause condition, the companies simply set aside the products produced. A task force from ASQC/AIAG has suggested that the process capability and improvement analysis can only be employed when the process is statistically stable and that the outcomes of the process approximately follow the normal distribution. Similarly, Pareto analysis can also be used to identify vital causes to implement quality improvement projects after identifying the major causes using the Ishikawa's cause-and-effect analysis.

Companies can benefit if they know the relationships among various quality tools and the sequence in which they can be applied to improve the quality of their products and services. A quality system should range from detection to prevention, from on-line control to off-line control, and from monitoring to improvement. A prior understanding of when, what and how to use various quality tools can help with their applications. For instance, the setup checklists should be used before any production starts. The control charts are employed as an on-line detection mechanism for monitoring cause occurrences. Similarly, the design of experiments is used to develop off-line strategies that help ensure proper processes and produce quality products and services.

In order to better understand their relationships, this necessitates a new methodology on determining how, when, and where to apply various quality tools. In the ensuing sections, a total control methodology (TCM) is introduced, considering the relationships among quality tools and the sequence in which they can be applied. The methodology focuses the development of a process in which all the available quality tools and techniques are integrated meaningfully. The process, once implemented, can help companies use various tools effectively in improving the quality of products and services and competing in the marketplace. Section 2 reviews the core principles of TCM and the process of applying these tools. Section 3 explains the purposes of individual tools involved in each level of the TCM framework. The interrelationships among these tools are discussed in Section 4, and the strategy of TCM implementation is elaborated in Section 5, respectively. Finally, Section 6 presents a case study of implementing and using TCM and explains the TCM benefits achieved by the company.

只好將產品擱置一旁，對質量和產量的影響卻更得不償失。故此，依據美國質量控制協會/汽車企業行動聯合組織的工作小組建議，工程人員只能在製程達到統計性穩定，和製程特性大致呈現正態分佈時，才可進行“製程能力和改善的研究”。另外，我們亦相信通過使用“石川因果圖”確認主因，再用“柏拉圖”分析鑑定關鍵原因，是有助實施質量改善項目。

經過理解質量工具之間的關係，安排推行的先後次序，使各工具相輔相承，發揮充份效益，改善質量；事實上，一個有效的質量系統必須包括偵測及預防、前線控制及後勤支援、監測及改善。舉例說，“作業前檢查清單”是一個前線預防工具，應在開始生產前使用；而“控制圖”則為一個前線偵測機制，用來監測偶然因素和異常因素的發生；同時，“實驗設計”通常是為訂定後勤策略的一個工具，藉以改善製程質量，提供高質素產品和服務。

為了讓人們能清楚瞭解各質量工具之間的關係，我們需要一個新的質量系統方法，令各工具可以各司其職，互相呼應支援。後面的章節將介紹如何建立一個“全面控制方法(TCM)”，藉這個方法把各質量工具，按照其作用、目的、關係和次序，有意義地聯繫在一個質量系統內，提高產品/服務之質量，繼而成為企業市場競爭力的利器。在第二章中，我們將介紹TCM的核心原則，和如何納入各質量工具的程序；在第三章中，我們會簡略解釋TCM架構中每個層次，和各層次內質量工具之作用安排及其要旨；然後在第四章及第五章，分別是談及各質量工具之關係和TCM的實施策略；最後，第六章將介紹一個實施“全面控制方法”的個案分析，及解釋該企業運用TCM後所獲得的益處。

The Total Control Methodology

全面控制方法 (TCM)

當製定“全面控制方法(TCM)”的架構時，首要目的是開發及建立一個系統，使它能廣泛地涵括所有需要的質量工具，並能互動互助，前後呼應，以達到有效的質量控制、改善製程質量、及提供高質素產品和服務。以下將會解釋如何利用特定的核心原則，和建立TCM架構的模式過程。

TCM的核心原則

“全面控制方法(TCM)”的架構是建基於三個核心原則。換句話說，這三個原則指導TCM的建立，從而改善製程，以生產高質素的產品/服務。

- **完整性**: 涵括所有各種質量工具，必須包括設計、工程、生產和檢測時所用的質量工具。
- **順序性**: 瞭解質量工具之間的關係，以及它們用於預防、偵測、至矯正的邏輯順序排列，以收最大效益。
- **效益性**: 按質量工具的作用、使用地點、應用時限、將會對產品/服務構成直接或間接的影響、和預期的成效，作出分類整理。以應用此系統的使用者角度出發，令它容易明白和方便應用，使到系統能在製造業和服務業中順利推行，產生預期的效益。

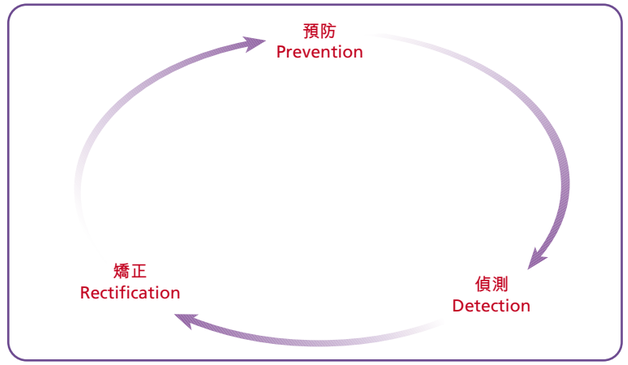
The purpose of the Total Control Methodology framework is to develop a comprehensive and integrated system of quality tools for effective monitoring of the processes, and improvement of products and services. This is accomplished by applying certain core principles and modeling the process for developing the TCM framework, as explained in the following sections.

Core Principles of TCM

There are three core principles of the TCM framework that govern the improvement of the processes and produce quality products and services.

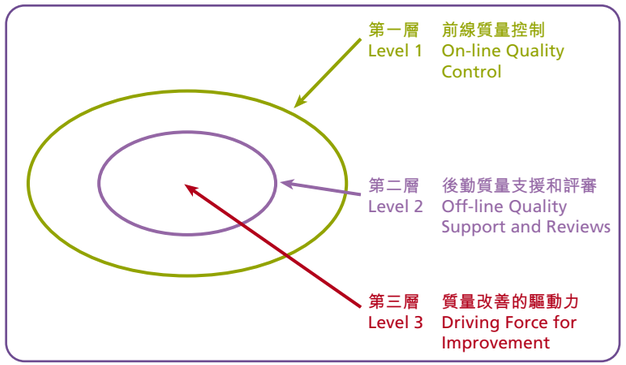
- **Completeness:** Include a comprehensive set of quality control and improvement tools for design, engineering, and production.
- **Sequencing:** Understand the relationships among the quality tools and the logical sequence of prevention, detection and rectification, in which they are used to achieve benefits.
- **Effectiveness:** Evaluate quality tools based on their purposes, location of use, duration of application, direct or indirect impact, and the results achieved. The TCM framework must be user-friendly and easy to understand and apply in manufacturing and service operations.

The completeness principle uses the life-cycle approach that involves the quality tools and techniques starting from building quality into products and services in the design and development stage. It then looks into production and providing service after sales in adding value to customers and increasing their satisfaction. The sequencing principle focuses on relationships that exist among various quality tools and the potential benefits of using them. The principle also stresses the logical sequence of prevention, detection and rectification as a basis to improve



圖二　在每個層次中質量工具之次序
Fig.2　Sequence of quality tools used in each level

the quality of the process output (see Figure 2). The effectiveness principle evaluates the use of quality tools in terms of their purposes, locations of use, duration of applications, direct or indirect impacts, and the results achieved. Three levels of TCM framework can be developed, as shown in Figure 3. The framework enables the operators and other related personnel to better understand the operations of TCM.



圖三　TCM 架構中的三個層次
Fig.3　Three levels of the TCM framework

The TCM framework classifies quality tools in a logical sequence of prevention, detection, and rectification. The first level (i.e., Level 1) addresses "On-line Quality Control" and consists of the tools that are always found and used on the shop floor or office floor. Operators and related personnel will use these quality tools directly on-line to timely prevent, detect and rectify any out-of-control and special cause conditions as much as possible. Besides, the operators need to ensure that no nonconformance product goes to the downstream processes. Generally, the tools developed range from pre-production preparation to on-line monitoring and then to post-production disposition. A stable environment is prerequisite for smooth and effective implementation, and successful operation of the tools in the first level of the framework.

完整性原則指引我們遵循整個企業運作流程，觀察和收集整個運作循環中，可以使用的所有質量工具和技巧，令質量能植根於各工作崗位中，包括從產品/服務設計、發展、生產、交付、直至售後服務，達到產品/服務增值，顧客完全滿意。順序性原則令我們透過瞭解各個質量工具的目的，特別是它們與其他工具的關係，從而獲取最大的潛在效益。此外，這原則亦強調改善質量時，須符合預防、偵測、及矯正的邏輯順序排列 (見[圖二])。效益性原則按照各質量工具的作用、使用地點、應用時限、將會對產品/服務構成的直接或間接影響、和預期的成效，評鑑各質量工具的使用，再從使用者角度出發，把它們安排到不同的層次，令各使用者能夠容易明白和實踐應用 (見[圖三])。

各質量工具的擺設位置要符合邏輯，按照預防、偵測、和矯正順序排列，在互相支援下，使整個TCM架構更加穩固健康，產品/服務的素質更有保障。第一層涉及“前線質量控制”，它把所有在生產車間或辦公室內容易找到之質量工具組織起來，授權各作業員及其他相關人士直接在前線運用這些質量工具。其主要目的是要使各作業人員能夠盡能及時預防、偵測、和矯正任何失控異常情況，並確保沒有不合格品流入下一項製作程序。基本上，這層次架構的質量工具是從

作業前準備、作業中監測、至作業後處理，逐步發展推行。

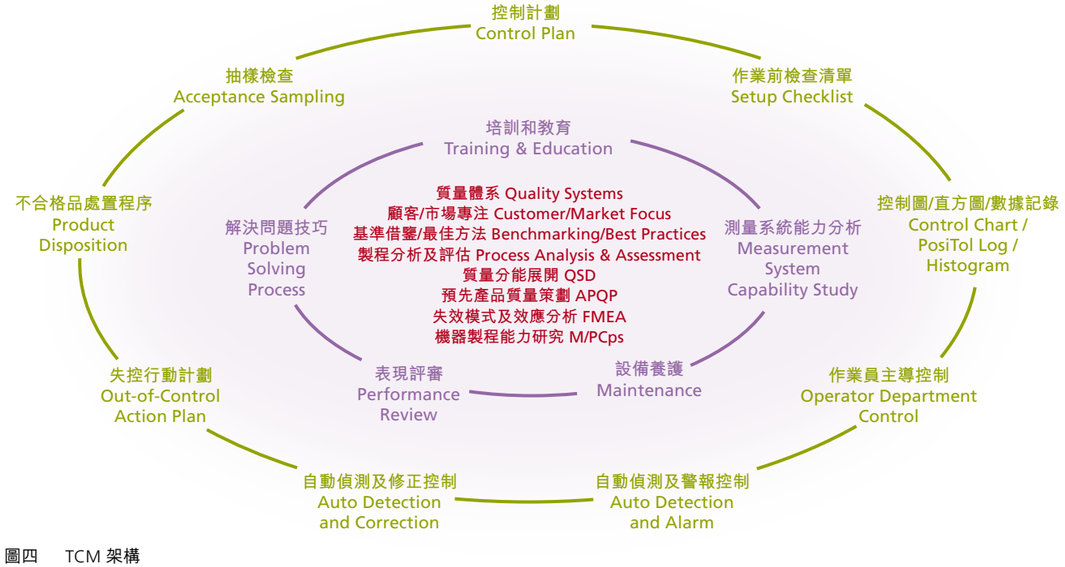
要確保第一層“前線質量控制”中所採用的質量工具可以順利和有效地推行，就必需有一個穩定的運作環境。第二層“後勤質量支援和評審”的質量工具所提供的效能，正是創造第一層所需的穩定環境，在這層次常用之質量工具計有“培訓和教育”、“測量系統能力分析”、“設備養護”、“表現評審”和“解決問題技巧”。各個“後勤質量工具”對改善產品/服務質量的影響，均是相對地屬於短期和中期的，其效果亦不一定能即時或直接地被察覺到。

在第一和第二層次工具是專注監測和控制每一個製程各方面的質量。若果這兩個層次均能有效地運作，那麼此企業的質量就可以保持在一個穩定的水平；另外，它們也具備能力進行一些簡單而個別的改善行動，改進產品/服務或製程的質量，作自我完善。可是，持續改善質量的真正突破，力量源於第三層的“質量改善的驅動力”。這個層次包括改善和策劃性的質量工具，及有系統的要

Level 2 is concerned with the "Off-line Quality Support and Review" that provides the stable environment for the preceding level. The common tools include training and education, measurement system analysis, equipment maintenance, performance review, and problem solving processes, etc. They address the medium-term to long-term effects that may not be realized directly and immediately.

Both Levels 1 and 2 tools regard the monitoring and control of a process and stress on the tactical and operational issues. Consistency and focus in these levels can help achieve continuous quality improvements of a process or a product. However, breakthroughs may come mainly from Level 3 – "Driving Force for Quality Improvement" that stresses for quality planning, improvement, root-cause identification and related analyses. This level addresses the strategic issues and the tools used form a closed-loop enhancement for tools in the preceding levels. Therefore, Level 3 tools can bring long-term impact of the results produced, whereas the Levels 1 and 2 tools would be of short-term and medium-term, respectively.

Figure 4 shows a generic TCM framework that encompasses the quality tools and techniques in three levels of grouping based on the their purposes. A quick reference of these tools and techniques is given in Table 2. This framework allows various tools to be added, dropped, or modified according to practical experiences in a given situation. The



圖四　TCM 架構
Fig.4　The TCM framework

第一層 Level 1	控制計劃 Control Plan	• 簡化的控制計劃 PosiTool Plan • 控制計劃 Control Plan • 團隊精神 Teamwork
	作業前檢查清單 Setup Checklists	• 檢查單 Checksheets
	控制圖、直方圖和數據記錄 Control Chart / Histogram / Data Logging	• 控制圖: 均值—極差控制圖、均值—標準差控制圖、單值—移動極差控制圖、不合格品數控制圖、不合格品率控制圖、單位缺陷數控制圖、缺陷數控制圖 Control Charts: X-bar & R Chart, X-bar & S Chart, X & Moving R Chart, nP Chart, P Chart, u Chart and c Chart • 直方圖 Histogram • 數據記錄 Data Logging
	作業員主導控制 Operator Department Control	• 授權 Empowerment
	自動偵測及警報控制 Auto Detection and Alarm	• 防誤裝置 Poka-Yoke
	自動偵測及修正控制 Auto Detection and Correction	• 防誤裝置 Poka-Yoke
	失控行動計劃 Out-of-Control Action Plan	• 失控行動計劃 Out-of-Control Action Plan
	不合格品處置程序 Product Disposition	• 流程圖 Flowchart
	抽樣檢查 Acceptance Sampling	• 抽樣檢查 Acceptance Sampling
第二層 Level 2	培訓和教育 Training and Education	• 培訓和教育 Training and Education • 學習型企業 Learning Organization
	測量系統能力分析 Measurement System Capability Study	• 校正 Calibration • 量具可重覆性和可再現性分析 Gage Repeatability & Reproducibility Study
	設備養護 Maintenance	• 五常法 5S • 預防保養 Preventive Maintenance • 故障維修 Breakdown Maintenance
	表現評審 Performance Review	• 柏拉圖分析 Pareto Analysis • 流程圖 Flowchart • 質量管理完成方格 Quality Management Maturity Grid • ISO9000 標準 ISO9000 Standards • 戴明獎 Deming Prize • 美國鮑烈治國家優質獎 Malcolm Baldrige National Quality Award • 歐洲質量獎項 European Quality Award • 六西格瑪質量 Six Sigma Quality • 改善 Kaizen
	解決問題技巧 Problem Solving Process	• 石川因果圖 Ishikawa Cause-and-Effect Diagram • 柏拉圖分析 Pareto Analysis • 散佈圖 Scatter Diagram • 腦力激盪 Brainstorming • 舊和新七工具 Old and New Seven QC Tools • 實驗設計 Design of Experiments • 計劃-執行-查核-處置 PDCA • 品質圈 QC Circles • 朱蘭三部曲 Juran Trilogy • 福特8D團隊式解決問題方法 Ford 8-Disciplines Team Oriented Problem Solving • 施樂質量改善及解決問題技巧 Xerox Quality Improvement Process & Problem Solving Process
第三層 Level 3	質量體系 Quality Systems	• 按ISO9000、QS9000建立的質量體系 ISO9000, QS9000 based Quality Systems • 施樂TQM模型 Xerox TQM model • 按美國鮑烈治國家優質獎建立的質量體系 Malcolm Baldrige National Quality Award based Quality Systems • 按戴明獎建立的質量體系 Deming Prize based Quality Systems
	顧客 / 市場專注 Customer / Market Focus	• 顧客完全滿意 Total Customer Satisfaction • 聆聽顧客的聲音 Listening to Voice of Customer
	基準借鑒 / 最佳方法 Benchmarking / Best Practice	• 基準借鑒 / 最佳方法 Benchmarking / Best Practice
	製程分析及評估 Process Analysis & Assessment	• 聆聽顧客的聲音 Business Process Re-engineering
	質量功能展開 Quality Function Deployment	• 質量功能展開 Quality Function Deployment • 聆聽顧客的聲音 Listening to Voice of Customer
	預先產品質量策劃和控制計劃 Advanced Product Quality Planning and Control Plan	• 預先產品質量策劃 Advanced Product Quality Planning • 控制計劃 Control Plan
	失效模式及效應分析 Failure Mode and Effects Analysis	• 失效模式及效應分析 Failure Mode and Effects Analysis • 失效模式、效應及后果分析 Failure Mode, Effect and Criticality Analysis • 故障樹分析 Fault Tree Analysis
	機器 / 製程能力研究 Machine / Process Capability Study	• 機器 / 製程能力研究 Machine / Process Capability Study • 實驗設計 Design of Experiments

表二　在TCM模型中的質量工具參考
Table 2　Quick reference of quality tools used in the TCM framework

因鑑定和相關分析，並把其積累的成果回饋給第一和第二層次的質量監控系統，增進整體效益。在TCM架構安排下，第一層次的質量工具專注於日常操作方面，第二層次的質量工具則著重改善手段，而第三層次的質量工具就負責改善策劃。第一和第二層次質量工具和技巧的影響是短期和中期的，第三層次的則能產生長期深遠而又巨大的改善效果。

我們根據各質量工具和技巧的作用和影響，把它們納入TCM架構的各個層次中（如[圖四]所示）。有關各質量工具和技巧的全文名稱見 [表二]。TCM架構是動態的，可參照企業的既定環境和實際體驗，作出增加、刪除、或更改。當採取修改後，可能會牽動同一層次內或不同層次間的其他質量工具，所以應及時作出相關的調整，以免產生重覆或不協調；平衡各種策劃、控制、和改善的不同工具，保障控制系統的有效性。

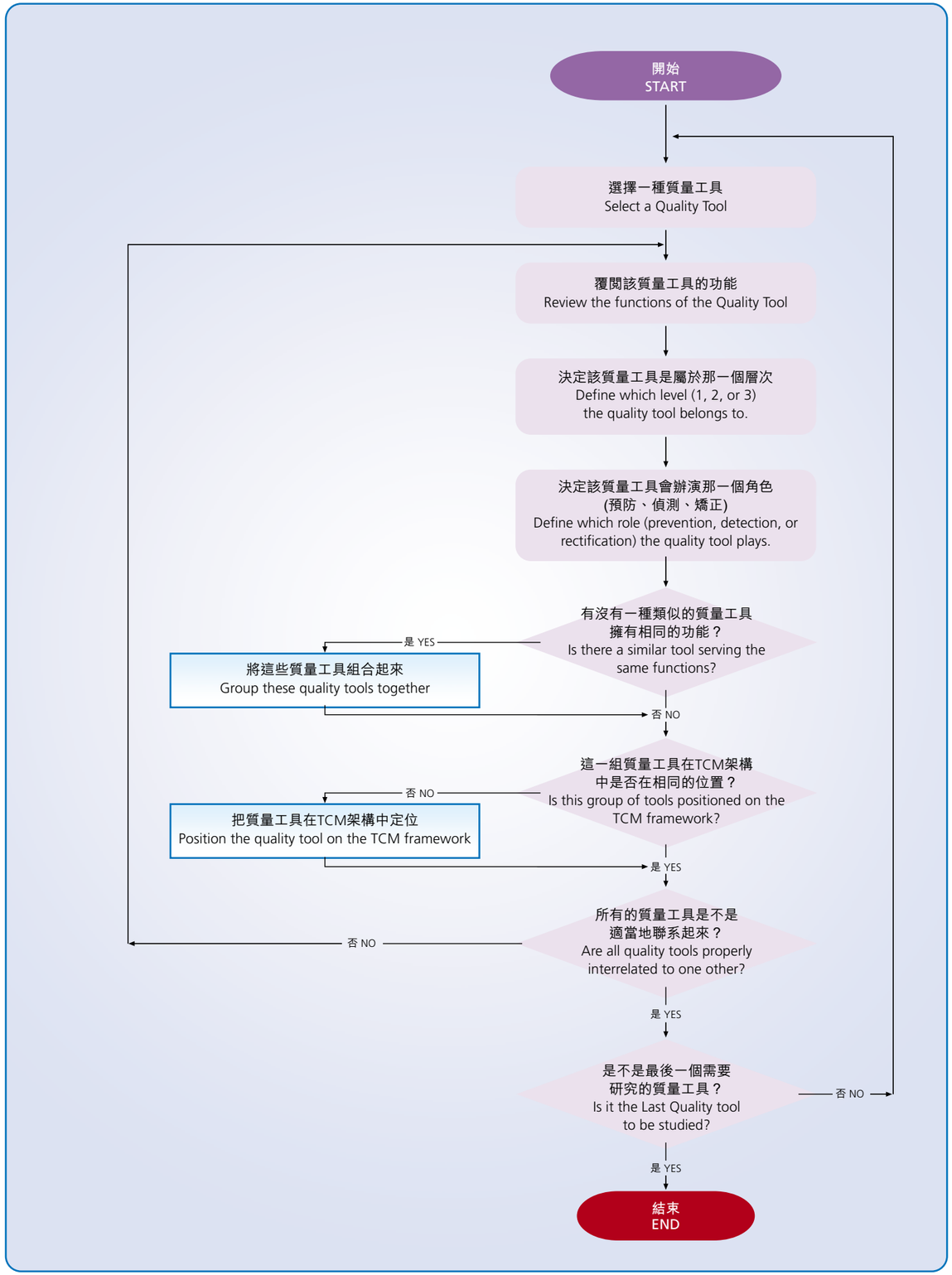
將各質量工具納入TCM架構內的重覆步驟

當建立TCM架構時，採用 [圖五] 所示的重覆步驟，把質量工具一一加以考慮。首先，每個質量工具按它的作用、使用地點、應用時限、對產品/服務構成直接或間接的影響、和預期的成效，作出分析甄別，放置在所屬的TCM架構層次中；接著，界定此工具的功能類別是屬於預防、偵測、還是矯正。再檢查在建造中的TCM架構內是否存在另一個質量工具提供雷同功能；如有重覆功能者，這些工具就合併為一組；若功能沒有任何重覆，這個工具就可以獲得一個新的定位。此外，還要一再思考各質量工具間的相互關係。若發現各質量工具間的定位有任何矛盾或不相配之處，便要重新將以上各步驟重做一遍，調整各質量工具的定位，直至它們全部都安排到最適合的位置為止。

adjustments or modifications of tools can avoid the occurrence of any redundancies or discrepancies. They also help safeguard the system for effective monitoring and attain a balance among different tools and techniques in planning, control and improvement.

Iterative Process of Selecting Quality Tools

An iterative process of selecting quality tools for the framework is presented in Figure 5. First, a quality tool is selected and its purposes are examined regarding the location of use, duration of application, direct or indirect impact, and the results achieved at an appropriate level. Eventually, different quality tools are identified according to the level of the framework that they belong to. Their roles in prevention, detection, or rectification are determined. Quality tools serving the same or similar function area will be grouped. Individual tools of unique features will have their own places in the framework. The interrelationship among their applications will be examined. If there is a mismatch or contradiction found in the relative positioning of quality tools, the iterating process will be reviewed and necessary adjustments will be made. This process is continued until all associated quality tools are placed in their appropriate positions within the TCM framework.



圖五　將各質量工具納入TCM架構內的重覆步驟
Fig.5　Iterative process of selecting quality tools for the TCM framework

Quality Tools of the TCM Framework

TCM架構內的質量工具

Level 1: On-line Quality Control

Quality tools in the first level are those used for on-line practices to detect and rectify any shop- or office-floor quality problems, thereby leading to find solutions and preventing further occurrence of same problems. These tools are generally simple and easy to use and many production personnel use them frequently. Besides, they are capable of providing fast responses to prevent non-conformances and out-of-control or special cause conditions. They can help detect and correct any out-of-control or special cause conditions to avoid any quality disasters. In order to prevent any non-conformances or out-of-control conditions brought into the downstream processes, the control elements are involved from pre-production preparation to on-line monitoring and further to post-production disposition.

Typical Level-1 quality tools include Control Plan, Setup Checklists, Control Charts, Histograms, Data Logging, Operator Dependent Control, Auto Detection and Alarm, Auto Detection and Correction, Out-of-Control Action Plans, Product Disposition, and Acceptance Sampling (see Figure 4).

1) Control Plan / PosiTrol Plan

It is difficult for people to come in front of a process to spell out and understand the complete picture of all elements in that process. Therefore, a simple but comprehensive list that includes all key control elements of a process is often useful. PosiTrol plan serves this purpose with high visibility. The plan helps remove barriers among departments, other than for simply presenting a set of documents for quick reference. During the development phase of a particular process, various departments (e.g., Maintenance, Engineering, Production, and Quality Assurance, etc.) should work together to eliminate the redundancies and deficient controls of the process. The unwanted situation of "everybody, somebody, anybody, and nobody" should be eliminated. All related parties should work as a team to understand the system and incorporate appropriate control elements into the PosiTrol plan. The relationships among these elements should be clearly defined.

第一層: 前線質量控制

第一層的質量工具是適用於前線（如：生產車間、辦公室或服務櫃前）實務作業，用作偵測和矯正所發現的質量問題，部份工具還能帶出預防同樣問題再次發生的方向。因為作業人員會經常在前線上運用這些工具，所以它們有一個共同特點，就是簡單、直接和容易使用。此外，它們必須能幫助作業人員，對預防不合格品的產生、製程的失控及異常情況的出現等，作出迅速和合理的反應及決定；還需具備偵測和矯正失控情況的能力，阻止質量問題擴大，和防止不合格品流進下一個製程。這些工具包括了作業前的準備、作業中的監測、和作業後處理等的控制元素。

在這個層次的質量工具包括“控制計劃”、“作業前檢查清單”、“控制圖”、“直方圖”、“數據記錄”、“作業員主導控制”、“自動偵測及警報控制”、“自動偵測及修正控制”、“失控行動計劃”、“不合格品處置程序”和“抽樣檢查”（見[圖四]）。

一) 控制計劃

“控制計劃”是一個簡單易明及包括全部關鍵控制元素之列表；若沒有“控制計劃”，當一個人站在某一製程崗位前，他將難以拼湊出一幅包含所有關鍵控制元素的完整藍圖。同時，“控制計劃”也有助提高此製程和相關部門之間的運作透明度，對各參與者提供一個簡單快捷的即時參考，協助消除部門之間的隔膜。在設計和建立一個可行的“控制計劃”過程中，各有關部門必須一起參與，如：生產部、工程部、維修保養部、和品質部等，經過不斷探討，揭露製程控制中的冗餘或缺失；從而避免“每個人、有些人、任何人、沒有人”的典型責任含糊不清情況。透過共同參與，各人會對

整體控制系統和各控制元素有較深刻的認識，控制元素間的關係亦可介定清楚，推行整個TCM架構更加容易。

二) 作業前檢查清單

開始作業前，應確保製程內各單元準備就緒，處於良好工作狀態。若某一作業涉及複雜的技術製程和機器操作，所需要的準備工作、事前檢查、核對項目等，非常繁多；只憑作業人員的個人記憶，難免會有錯漏。因此，必須設計一張完整的“作業前檢查清單”，使它成為一個常備的輔助檢查工具，協助作業人員於每次啟動作業前做準備。

“作業前檢查清單”是一張簡單易明的項目一覽表，列出啟動作業前必須進行及完成的控制元素和活動。一般是由四個主要部份組成，包括:

1. 機器：機器和工具準備
2. 方法：製程參數設定
3. 材料：來料檢查
4. 如需要，可利用廢料證實製程情況

再加上具備“認可”資格的作業員，4M元素(機器、方法、材料、作業員)就準備妥當。因此，“作業前檢查清單”是一個重要的前線防禦性工具，可幫助企業在正式開始運作時達到“第一次就做好”的基本質量原則。

三) 控制圖、直方圖和數據記錄

開始製程運作時，許多特性是控制質量的關鍵，這些特性可能與製程輸入、過程中途、或最終輸出之參數有關。只是量度這些特性，讀取數值，是很難判斷有關製程是否穩定。運用“控制圖”、“直方圖”或“數據記

2) Setup Checklists

Every production run should be started only when everything in the process is ready and in good condition for work. The more sophisticated the technology and machines are, the more items are to be checked. However, operators may inadvertently forget things, especially when they are required to memorize too much information. Therefore, a setup checklist is very useful and serves as a quick reference tool of a start-up of production run. The checklist is a list of control elements and activities that will be carried out and completed before a production run starts. Typically, it consists of four key areas including:

1. Machine and tooling setup,
2. Parameter setting,
3. Incoming materials check and
4. Verification by dummy, if necessary.

The checklist helps achieve the basic quality principle of "doing it right the first time", and therefore is often regarded as an important prevention tool in the “On-line Quality Control” level.

3) Control Charts / Histograms / Data Logging

When the production run starts, many critical characteristics of the process should be controlled. These characteristics can be related to input, process or output parameters. It is difficult to determine whether the process is in stable condition relied solely on measuring numerical values of these characteristics. Therefore, it is recommended to use control charts, histograms, and data logs on the production line. These tools are effective when detecting any changes in the distribution of the controlling process output characteristics.

Control charts are often referred directly to the practices of Statistical Process Control (SPC). The commonly used single-variable control charts in industries are "X-bar and R charts", "X-bar and s charts", "X-bar and moving R charts", "np charts", "p-charts", "u-charts", and "c-charts" etc. Besides, the use of “multivariate control charts” that can control more than one process variable is increasingly getting popular. All these charts are developed and implemented using statistical methods. Out-of-control or special cause decision rules are employed to determine if there are any shifts of distribution and changes in the process characteristic. Operators can easily detect any out-of-control or special cause conditions from the information displayed graphically in the charts. Traditionally, the making of these control charts involves a lot of work in data collection, data computation, plotting chart and checking, and therefore, their applications are often focused only on the most critical characteristics. With today’s emerging factory automation and on-line use of software, the applications of control charts are much expanded.

The histogram is another tool frequently used to examine the variation in the process output distribution graphically on the production line. It is one of the old seven quality control tools, and used to present the variation and shapes of the distribution of the process output or product characteristics. Although histograms are easy to understand and adopt, their ability to alert the operator against changes in distribution of the process output is relatively low when compared with control charts.

Nevertheless, both control charts and histograms can be costly in terms of time and labor if being used to monitor all the characteristics of a process. Data logging is an alternative that helps control parameters of less critical importance. With no particular requirements of computations or graphical plotting, data logging can record the data on a log sheet and check against pre-determined control limits. Some minimal controls can

錄”等質量工具，可以有效地偵測受控制的製程特性之分佈是否出現改變。

“控制圖”常常被人們直指為統計製程控制(SPC)。在工業界最常用的“單一變數控制圖”有“均值－極差控制圖”、“均值－標準差控制圖”、“單值－移動極差控制圖”、“不合格品數控制圖”、“不合格品率控制圖”、“單位缺陷數控制圖”、及“缺陷數控制圖”等；如需要在單一圖表上控制多個製程變數，可使用日漸普及的“多變數控制圖”。上述各“控制圖”均應用失控規則，判斷製程特性之分佈是否偏移或改變。由於“控制圖”是圖表形式，展示所得資料數據，令作業員能根據失控規則，容易地察覺任何失控或系統性因素的存在。但是在使用“控制圖”時，涉及非常大的工作量，包括數據收集、資料計算、點線畫圖、核查失控規則等，所以祇可在最關鍵的特性控制上使用。隨著生產自動化和前線軟件網絡化的潮流，應用“控制圖”的範圍已漸趨廣泛。

“直方圖”是另一種使用圖表型式展示資料的普及質量工具，亦是著名的基本品質控制七工具之一。它能顯現製程和產品特性分佈之形狀和變化。雖然“直方圖”是容易明白和採用，但與使用“控制圖”比較，在製程特性分佈變化方面，它只能對作業人員提供相對地較低的預警能力。

假若我們使用“控制圖”和“直方圖”來控制製程上的所有特性，這將消耗許多人力資源和工時，成本也十分昂貴；因此，簡單的“數據記錄”是另一個選擇，在指定的記錄日誌上，記錄其他關鍵性較低的控制參數，不必計算或繪劃圖表，直接與預設控制界限作比較，達到一定基本程度的控制。所以，“數據記錄”常常用於控制那些關鍵性較低的製程特性。

四) 作業員主導控制

當一個質量控制是非常依賴作業員去運作時，它就是“作業員主導控制”。例如：在推行“作業前檢查清單”、“控制圖”、“直方圖”、及“數據記錄”等，作業員是否能夠切實執行，都是成功的關鍵要素。因為由數據收集、資料計算、核查失控判定規則、失控時作出反應，均由作業人員負責處理。

此外，如果發生任何新失控情況，作業員能否及時發現，作出適當處理，更顯重要。他們的警覺和介入，往往能避免質量災難的產生。作業員根據失控判定規則，加上個人經驗，判斷停止作業，著手糾正行動，可以即時堵塞前線控制系統的漏洞。雖然作業員的表現水平並不可能長年保持如機器般穩定，但他們在質量控制中所發揮的功能和擔當的重要角色，是無可置疑的。

五) 自動偵測及警報控制

但對任何已知的潛在失控情況，就不可完全依賴“作業員主導控制”。作業員仍可能偶爾地忘記事情或犯錯，為防範未然，所以在部份關鍵組件或龐大產能的機器上，是需要安裝及使用“自動偵測及警報控制”。這就是在機器中，安裝感應器或其他自動偵測監控裝置，減輕作業員收集和分析資料的工作，及其核查失控情況的責任，而為了提醒作業員有失控情況發生，通常是會加裝一個警告信號系統，例如：蜂鳴器、指示燈等。當發生失控情況時，感應器

be achieved, and that helps monitor the characteristics of a process output that are less critical.

4) Operator Dependent Control

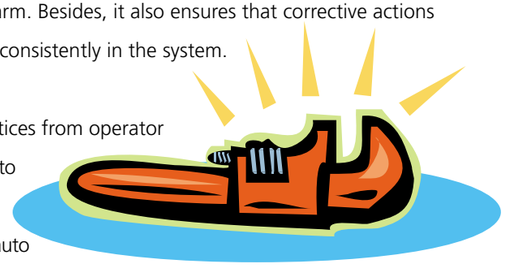
When the quality control work is dependent on an operator, it is labeled as “operator dependent control”. Operators are the key factors for success in the implementation (e.g., use of setup checklists, control charts, histograms, and data logging). This is because the sequence from data collection, to data computation, to checking against decision rules, and to responding to out-of-control conditions, are all dependent on operators. Moreover, this also accentuates the importance of operator dependent control if new out-of-control conditions arise. Experienced operators can make their judgements and initiate corrective actions. Their interventions are often essential to prevent many quality disasters, and help close the loopholes in on-line control system. Operators play an important role in quality control, even though they are not always as reliable as machines. Their contributions cannot be underestimated.

5) Auto Detection and Alarm

It will hardly be relied on operator dependent controls alone, particularly for the known potential out-of-control conditions. This is because people are not perfect; they will forget things or make mistakes. Therefore, auto detection and alarm are needed, and sensors or other monitoring devices are installed in machines to release the human worker from data collection and analysis, and responsibility for out-of-control detection. A warning signal system (e.g. a buzzer or a lamp) is usually added. Whenever the sensors or devices detect any out-of-control condition, they will activate the system to alert the operators. The auto detection and alarm devices are sometimes connected to the main control of machines for intervention. The operators can concentrate on initiating corrective actions to restore the production run to status quo. For instance, a sensor can be installed in the material loading or feeding areas of a machine. This can help detect any obstruction condition and ensure a smooth input of materials. Undetected malfunctions and inadequate material supply may lead to the defective products. The use of obstruction detectors can help relieve the operator’s workload to inspect certain areas regularly and improve product quality.

6) Auto Detection and Correction

Although the uses of auto detection and alarm control help achieve the objectives of quality control plans, the quality target can be advanced including auto detection and correction control. With such closed loop feedback control, the machine can measure the process characteristics, check against the pre-set standards, make a decision and adjust the input parameters of the characteristics, if necessary. This is a real-time automatic continuous monitoring that involves little on-line operator dependence. As compared with auto detection and alarm technique, the machine can replace operators to perform the corrective actions. This eliminates the danger of operators overriding the corrective action by resetting the alarm. Besides, it also ensures that corrective actions can be carried out consistently in the system.



The detection practices from operator dependent control, to auto detection and alarm, and then to auto detection and correction are developed based on the poka-yoke concepts. These practices are to release from human dependence via equipment modification and automation. However, as detection practices are often so obvious and obscured in a process, and in turn, are overlooked in the quality control system. It is therefore necessary to highlight the importance of detection in the mindset of technical and management personnel when solving those frequent out-of-control problems.

或其他偵測裝置便會觸動警報器，提示有關作業員應作出適當回應，或透過連接機器的主控制系統，自動停止機器運作；因此，作業員只需專注進行糾正行動，把機器回復至正常運作狀態。例如，在機器的供料位置，安裝感應器，偵測是否有阻塞狀況，並適當時對作業員警報提示，保証物料供應充足順暢；否則，供料位置發生故障時，作業員可能未能及時察覺，引起物料供應終斷，產生不合格品。所以，“自動偵測及警報控制”不僅能有效地減輕作業員的工作負擔，也可以間接地保障質量。

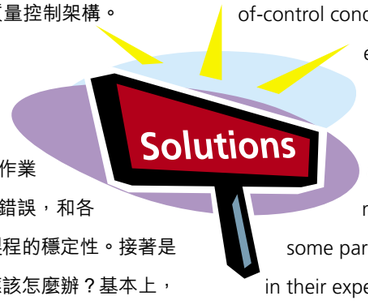
六) 自動偵測及修正控制

在追求改善、提升生產力的前題下，雖然“自動偵測及警報控制”已符合“控制計劃”的要求，但各企業均致力邁向“自動偵測及修正控制”，使整個機器的質量控制能夠閉路回饋，不經任何人手處理。首先，機器設備自動測量製程特性，再與預設的標準比較，自行運算並決定輸入參數的調整，修正製程特性。這種連續自動監測及控制系統只需極少作業員的參與。與“自動偵測及警報控制”比較，它是進一步以機器代替作業員，施行糾正行動。這樣能確保糾正行動是實時自動進行，避免個別作業員把警報當作誤鳴，祇是消除警報，而不採取任何糾正行動。除此以外，“自動偵測及修正控制”的糾正行動表現一般是比人手操作穩定。

這三個層次之監測：“作業員主導控制”、“自動偵測及警報控制”、及“自動偵測及修正控制”的改善歷程，是根據“防錯裝置”系統概念建立，與設備改良、作業自動化、和減輕作業員的負擔和依賴等，有密切關係。可惜，在現存的製程中，這些控制機制大都

是零碎地分散放置，並未串連成為系統，往往為人們視而不見，遭受忽略。我們這樣反覆地強調這三個監測層次，是祈望在解決常見失控情況的難題時，各技術和管理人員能常憶及此重要系統概念，以便在最初階段就建設一個完整的質量控制架構。

七) 失控行動計劃



前文已介紹如何使用“作業前檢查清單”預防發生錯誤，和各不同工具來偵測作業製程的穩定性。接著是當發現失控情況後，應該怎麼辦？基本上，作業員需獲授權，即時停止機器運作，實施相應的糾正行動。可是，不同的作業或工程人員，有各自不同的經驗、知識、工作責任、甚至個人專擅技能和喜好，對同一個特定的失控情況，可以產生不同的理解和意見，而作出不同的解決和處理方法，導至糾正行動的結果和效用發生很大差異。然而各人有關的經驗和教訓，亦未有進行適當的整理和歸納，難以互相學習模仿，解決類似的問題。引進“失控行動計劃”(OCAP)就可以幫助解決上述情況。

“失控行動計劃”(OCAP)是利用流程圖，指引各作業人員，按照先前籌劃的步驟，清楚地逐步檢查，糾正失控情況。流程圖順序列出各需要檢查的單元及要素，還有相對的特定糾正行動；故此，OCAP正如一位解決疑難的嚮導，它把證實有效的解決方案經驗文件化，向各作業或工程人員，即時提供解決問題的重要資料。隨著人工智能的進步和發展，部份企業已根據OCAP，開始建立資料庫，開發獨特的專家系統，進行實時連線的現場 (或遙距) 診斷及指導。

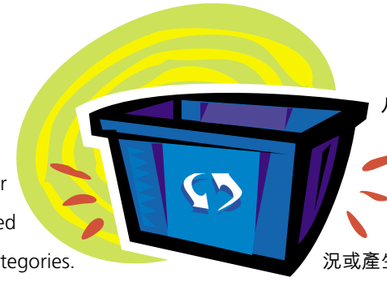
7) Out-of-Control Action Plans (OCAP)

The on-line quality control can help monitor a production process using setup checklists for prevention and various techniques for detection. It is also necessary to ascertain how to rectify the situation after an out-of-control condition is detected. The first issue is to detect a problem effectively, and then rectify the problem. Once an out-of-control condition is detected, operators should be empowered to stop the machine and take corrective actions. Different people (e.g., operators and engineers) may have their own opinions and methods to handle some particular out-of-control conditions due to the differences in their experience, knowledge and information, job responsibility and personal preference. Therefore, the rectification results may vary, and the lessons learnt at one time may not guarantee their usefulness in other occasions.

An out-of-control action plan (OCAP), that provides production personnel through a procedure in rectifying out-of-control conditions of a process, can help resolve this situation. OCAP is commonly expressed in a simple decision flow chart format where the necessary elements to be checked and the specific actions to be carried out are listed along the flow. This is a troubleshooting guide that provides a knowledge base for people (e.g., operators, technicians and engineers) to solve problems in the shortest possible time based on the documented experience. With the advancement in information technology, the knowledge base of OCAP can help develop an expert system for on-line diagnosis.

8) Product Disposition

On-line quality control is concerned with how to handle the products prior to an out-of-control condition or a defect being detected. Products manufactured during this period may be a mix of conforming and non-conforming products as the conditions are in between under control and out-of-control. Therefore, a procedure for product disposition must be defined, though it may vary greatly along with the pressures from production urgency, delivery or other strategic aspects.



Generally, product disposition can be classified into scrapped, degraded for alternative applications, accepted with or without repair by concession, or reworked to meet certain specified requirement categories. For instance, ISO 9001:2000 standard specifically includes "Control of nonconforming product" (i.e., Clause 8.3) in the development of a quality system. "Scrapped" means to throw all these suspicious products away. It is a simplest and safest way to handle the suspicious products, but is also the most expensive one. The method is seldom used except when the potential defect will result in a severe consequence in the end products. The screened defective units can be used for alternative applications, and they can be accepted with or without repair by concession, or reworked to meet certain specified requirements. Some companies have employed sophisticated product failure analysis (e.g., FMEA, or Fault Tree Analysis). When the defects cannot be detected by non-destructive tests, accelerated tests (e.g., burn-in) can be applied to remove potential failures. Therefore, the documented product dispositions procedures help provide fast decision-making on handling suspected defective units.

9) Acceptance Sampling

Last but not the least, acceptance sampling is another useful quality tool in on-line control level. Quality assurance and production personnel used it to screen any defective products. Based on statistical methods, a random sample of products is selected and determined whether the quality level is acceptable. Once the products pass the sampling test, they can be delivered to the next process or to the customers. The inclusion of acceptance sampling in the TCM framework is important, as the tool stresses that the supplier or the personnel carrying out this process should be responsible for the quality of products.

The on-line quality control starts from prevention using control plan and setup checklists, and then detection of out-of-control or special cause conditions using control charts, histograms, data logging and detection

八) 不合格品處置程序

在前線質量控制中，經常面對的另一個工作難題，是在發現失控情況或產生不合格品時，如何處理已製造的產品。這些成品/半成品可能是受控情況下製造的合格品，但亦可能包括失控情況下製造的不合格品；若處理失當，將導至部份有缺點的成品/半成品流轉到下一個製程，甚至顧客手上。所以，必須清楚釐定“不合格品處置程序”的流程及步驟，方便前線人員能迅速執行無誤；同時，亦要保留一定彈性，以應付實際情況需要，如：生產緩急、交貨期快慢、或其他策略性因素。

“不合格品處置程序”可分類為報廢、降級它用、作出讓步不返工接受、返工以滿足規格要求。事實上，在ISO9001標準 (2000年版) 內，把不合格品處置列為開發和建立質量系統的要求之一，它就是條款“8.3不合格品的控制”。報廢的定義是棄掉全部可疑的產品，這是最簡單、最徹底，卻又是最昂貴的方法；一般來說，除非其潛在的缺點對最終產品構成主要影響，或返工費用非常昂貴，否則很少選擇這種處置方法。另外，利用篩選，揀出有缺點的產品，把它們降級作其它用途，或作出讓步不返工接受，又或再返工以滿足規格要求後才接受。篩選時，有些企業運用詳細的產品失敗分析，例如：“失效模式及效應分析”或“故障樹分析”協助作業人員；假若缺點沒法經由非破壞性測試檢出，可考慮應用加速試驗，如：老化測試等，找出有潛在缺點的產品。因此，訂定和引用文件化的“不合格品處置程序”步驟，裁決處理那些懷疑不合格品，是對保持質量水平和效率的必備良方。

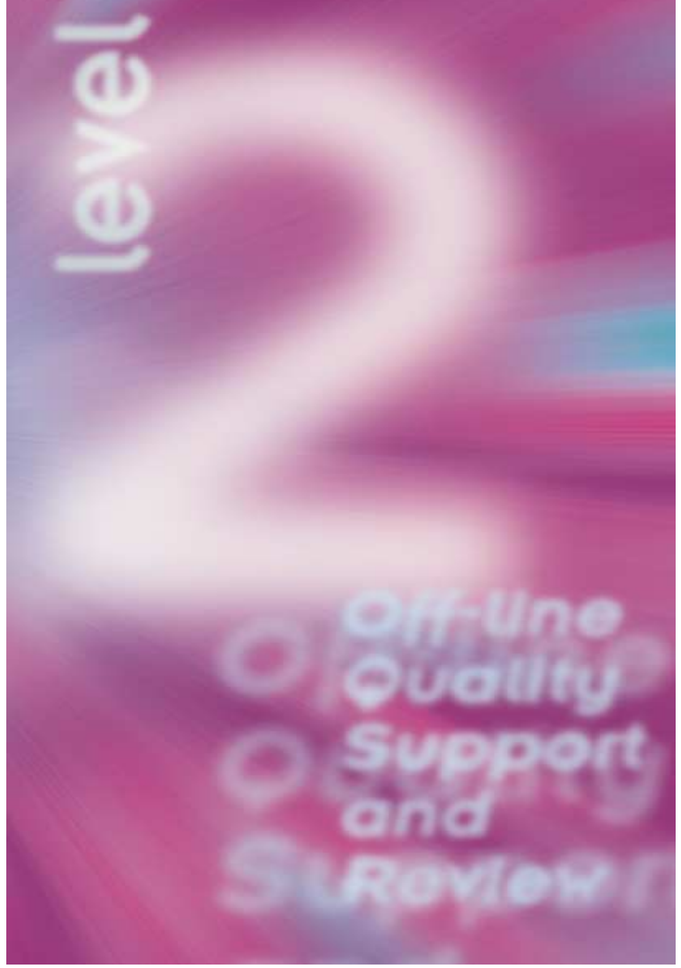
九) 抽樣檢查

“前線質量控制”中，最後一個把關之質量工具是“抽樣檢查”，保證產品達到一定可接受質量水平，才流入下一個製程作業。它利用統計方法，隨機抽取產品樣本，檢查確定產品是否達到預期的質量水平。除品控員外，生產人員亦應運用“抽樣檢查”測試產品，若產品合格，就可以交付到下一個生產製程或供應鏈環節的下一位顧客。在TCM架構中，加入“抽樣檢查”是非常重要的，因為它展示了供應者對質量水平的責任承擔。

在這“前線質量控制”層次，運用各質量工具，令前線作業製程獲得維護。首先，“控制計劃”描繪整體的控制，避色冗缺；接著，開始作業時，用“作業前檢查清單”準備妥當，預防失誤；再以“控制圖”、“直方圖”、“數據記錄”、“作業員主導控制”、“自動偵測及警報控制”、及“自動偵測及修正控制”等，偵測失控或異常情況；當發生異常情況時，利用“失控行動計劃”(OCAP)糾正失控情況；再按照“不合格品處置程序”處理那批可能含有潛在缺點的產品；最後，還有“抽樣檢查”做最後把關，產品必須通過質量水平檢查後，才可交付與下一個製程；在各個製程中重覆運用此層的質量工具控制，直至產品交付到最後一個供應鏈環節。

第二層: 後勤質量支援和評審

第一層的質量工具能否順暢地操作，令它們能發揮作用，是有賴第二層的全力支持。顧名思義，第二層質量工具“後勤質量支援和評審”是幕後的支援者，它建立一個穩定而可靠的環境，確保各前線質量工具能運作良好，維持有效水平。與第一層比較，第二層質量工具的應用次數是相對地較少，而其效果影響是短期或中期。



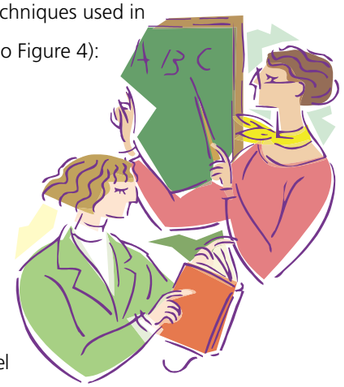
(i.e., operator dependent control, auto-detection and alarm, and auto-detection and correction). If an abnormal condition occurs, out-of-control action plans (OCAP) are used to rectify the conditions, and then product disposition to handle the potential defective batch of products. The products can only proceed to the next process if they pass the acceptance sampling tests.

Level 2: Off-line Quality Support and Review

The smooth operation of Level-1 quality tools depends significantly on a stable and reliable environment that is supported by the quality tools and techniques in Level 2. The Level-2 tools are used off-line and focused on the results in near- or medium-term. The frequency of their use is much less than those in Level 1.

When an on-line quality control tool is introduced, production personnel will normally request the information or instructions on what it comprises, how it works and is to be used. If the tool involves data acquisition, the off-line support needs to provide an objective measurement system to ensure the quality of data. Moreover, the tool can function properly only when a process can run smoothly. Quality tools cannot apply if a machine breaks down frequently. Therefore, equipment maintenance is an important aspect in the off-line support. When all these tools are in place, regular performance review can be carried out to ensure the proper function of on-line quality control tools. Problem-solving techniques are required to diagnose any problem found in the review. The Level 2 results will determine the success of on-line quality control. There are several common quality tools and techniques used in Level 2, as elaborated below (see also Figure 4):

1) Training and Education



Training and education are often overlooked before, during and after implementation of a process. With no understanding of using a particular quality tool, shop-floor/office personnel may simply think that the tool is being implemented for its own sake. Consequently, the real functions of the tool may be overlooked. Therefore, a good introduction to a quality tool is important and this is usually achieved via proper training. Provision of training and education courses should be designed from the trainees' points of view. Different levels of shop-floor/office personnel will need different emphases of training even for the same quality tool, and their learning objectives may also differ. Therefore, the training courses should meet their learning objectives and maintain their interests. The importance of the quality tool, the results that can be obtained, and the quality improvement objectives that can be accomplished, should be the part of the training course. In addition, the trainee should feedback any queries during the implementation period for further modification of the courses.

Training programs should be institutionalized and delivered regularly to cope up with personnel turnover and changing environment due to technology improvements. Refresher courses should also be provided. In general, the participants can retain learning better following a course

到前線上，推動任何質量控制工具前，必須配備資源，培訓有關人員，讓他們知道那工具由甚麼組成、如何運作、和怎樣到日常操作上使用。此外，前線工具可能涉及數據搜集，那麼後勤支援就要提供一套良好的測量系統，以確保數據的素質。另要妥善維修保養設備，穩定製程運作；否則，機器經常出毛病，質量工具也無法如常應用。還有，必須適時評審質量方面的表現，了解質量控制工具是否有效地在日常運作中執行。若需要，便有系統地進行研究，解決問題，改善情況。上述這些都是第二層“後勤質量支援和評審”質量工具的覆蓋範圍，所以它絕對影響第一層“前線質量控制”的成功與否。

一) 培訓和教育

“培訓和教育”是一個時常被忽略的環節。試想想，當作業人員尚未理解一個質量工具或一項工作，也不清楚它的必要性時，他們很可能只會不求甚解地為實施而實施；那麼，該工具或工作的真正功能便沒法子發揮，同時也延誤企業的進步。因此，培訓員工吸取充份的新知識是非常重要的。“培訓和教育”課程應以學員之觀點出發，同樣的學習主題，不同級別的學員需要不同程度的認識及理解，所持的學習目的也不一樣，故此，需要配合不同的課程；只有適度量裁的課程，才能滿足他們不同的要求，令他們保持興趣。在培訓課程中，導師應儘量解答各學員提出的疑難，透過互動溝通交流，使學員明白該學習主題之重要性、運用的竅門、預期的成果等，從而激勵學員積極運用。在實施階段時，各學員可以把遇到的問題回饋給導師，調整培訓課程，並且將這些寶貴資料送達有關人員跟進，調整實施行動的力度、深度及步伐，配合現場運作的實際情況，令成效培增。

此外，各課程必須制度化，定期開課和增設進修班，補償人員流失與配合因科技改進而引起的改變。根據過往的教學經驗，如果學員能在課堂中得到樂趣，他們會較容易掌握所學的資訊智識；反之，過多的理論往往令人感到沉悶，注意力分散；所以，在培訓材料及內容中，理論和實踐的比例必須適當分配。導師還要引導學員體驗缺乏該質量工具的情況，和對他們日常工作的影響。一個周詳的培訓課程，從評估培訓目的和要求開始，再開發綜合互動性的培訓材料，其中可以包括遊戲練習，鼓勵學員親身實習，將知識有組織地傳授給各學員，並給予模擬習作；課程完結後，還得進行評估跟進。此外，定時檢查或重覆考証各學員的能力，有助確保他們達到及保持培訓後要求的水平。

in which they are interested. Too many theories will result in boredom that deteriorates their attention. Moreover, they should understand the penalty for not practicing the trained skills and using learned quality tools. Therefore, a planned training program should include assessment of training needs, comprehensive and interactive training materials with games, organized knowledge delivery, and hands-on practical exercises. Furthermore, it should have follow-up assignments and on-line assessments. Presentation of certification and re-certification are often needed to recognize the learning results and the quality of training.

二) 測量系統能力分析

假若涉及數據收集，相關的測量系統就必須進行“測量系統能力分析”。因為，運用質量工具時，分析的數據必須是準確、可重覆和可再現的，這樣推斷出來的各種控制行動，才會有實際意義和效用；否則，該工具對前線的質量控制是不會產生預期的作用。

一個測量系統由測量儀器、測量步驟、操作者、基準和運作環境所組成，這些元素是相互關連，影響最終測量結果，以及整個系統的測量能力。所以，一個正規的“測量系統能力分析”必須全面研究整個測量系統運作，而非各元素各自獨立進行的。另外，那些精密複雜的自動測量儀器，使用者通常傾向對其較有信心，往往容易遺漏有關的“測量系統能力分析”。針對測量系統可以進行多種不同的研究，最普遍和基本的分析包括：校準、及可重覆性和可再現性的分析

2) Measurement System Capability Study

If the tool involves certain measurement for data collection, a capability study on the measurement system is necessary. Whatever action is developed from the data using an on-line quality control tool, it will only be meaningful if the data collected are accurate, repeatable and reproducible. The measurement system capability study can help safeguard the effectiveness of quality control practices in Level 2.

A measurement system consists of a gauge, a measurement procedure, an operator, standards and the environment to be observed. These elements are interrelated with each other and they affect the overall capability of measurement. Therefore, the capability study should be carried out on the whole measurement system. When the gauge becomes more sophisticated and automated, users will simply rely on the measurement system itself but neglect the purposes of the capability study. There are several capability studies on the measurement system. The calibration and the gauge repeatability and reproducibility (GR&R) tests are the two most common ones. The former is used to determine the accuracy of the system, whereas the latter is to assess the variation of a measurement system. GR&R should be carried out after calibration.

3) Maintenance

No quality tool can be used effectively if a machine breaks down frequently. Maintenance is thus another important element in the

off-line quality support and review. Production personnel are often busy in restoring production. Good machine maintenance system can help provide a stable production environment to implement quality programs. A machine maintenance system can be broadly divided into breakdown maintenance (BM) and preventive maintenance (PM). Breakdown maintenance means only carrying out repair or maintenance when the machine breaks down; whereas preventive maintenance is to perform maintenance on a regular basis to prevent the machine from breaking down. For monitoring and improving quality proactively, PM can help safeguard the machines in their optimum condition.

First of all, a checklist and procedure of PM are needed to specify what items need maintenance. Production personnel should then follow the PM schedule to carry out the maintenance tasks accordingly. The maintenance records should be kept so as to monitor the condition of the machine during PM. The last item in PM is the "buy-off procedure"; otherwise, the ironic situation of having frequent machine breakdowns may occur immediately after preventive maintenance.

PM plays an important role in the use of on-line quality control tools such as auto detection and alarm, and auto detection and correction. As the automated devices have taken up the role of detecting and/or correcting the out-of-control conditions, production personnel will rely on them to monitor the process. Therefore, PM can help ensure the operation condition of these devices so that they can perform effectively. Otherwise, quality failures are bound to occur.

4) Performance Review

Regular performance review ensures a process is functioning properly when an on-line control tool is implemented. The review can be carried out in different levels, ranging from quality system appraisals to management review and daily production briefing sessions. Quality audit is another method to evaluate the performance in the implementation of a quality system. The compliance requirements of the ISO 9000 series of standards, the guidelines of the Deming Prize, and the evaluation criteria of many quality awards (e.g. The Baldrige, European, and Australian) can help conduct quality audits/assessments. They provide

(GR&R)。校準是用來決定測量系統的準確度，GR&R則是用來測量偏差，一般的做法是先行校準，才開始進行GR&R分析。

三) 設備養護

“設備養護”是“後勤質量支援和評審”的另一個重要元素。如果機器不斷地發生故障，各作業人員都忙於修理，儘早恢復生產，怎可能有時間兼顧其他事情；況且在如此波動的情況下，大部份質量工具都不能夠有效地運作。故此，必需具有一個良好的“設備養護”系統，營造一個穩定的作業環境，提供給質量工具運作。一個“設備養護”可大致分為“故障維修”和“預防保養”兩種。“故障維修”是當機器發生故障時，被動地進行相關的修理；而“預防保養”是主動地定時執行機器養護工作，預防發生故障。從積極的質量控制和改善角度，系統重點應集中於“預防保養”，務求各機器長期維持最佳狀態。

準備“預防保養”時，需要確定工作步驟，製訂預防保養清單，並編訂定期養護計劃表；按照計劃表內的指定時段，作業人員執行清單上的養護工作，填寫及保存保養記錄，方便作為監察機器狀況之用；最後，清楚驗收設備，確保養護工作徹底執行妥當；否則，在“預防保養”後，機器發生更加頻密的故障，定必令人對“預防保養”信心全失。

另外，“預防保養”直接影響部份前線質量控制工具，如：“自動偵測及警報控制”、“自動偵測及修正控制”。由於這些自動裝置已擔當起偵測和/或糾正的角色，作業人員是完全倚賴它們監控製程，因此必須通過“預防保養”，保持它們正常運作和良好狀態，確切執行其設定的角色；否則，質量失誤必定遲早發生。

四) 表現評審

執行各前線質量控制工具的同時，運用不同程度的定期“表現評審”，由質量系統評估、營運管理檢討、到日常作業簡報等，衡量質量工具是否發揮預期的作用，企業運作是否達到水平要求。“質量審核”是一個評估質量系統運作和實施表現的工具，利用ISO9000標準、戴明獎準則、其他澳洲、歐洲著名的質量獎項、或美國鮑烈治國家優質獎準則，進行客觀的質量審核，鑑別質量系統的狀態，根據審核結果，計劃、執行和跟進各項質量改善行動。

為協助評估和方便溝通，是必需使用質量界共識的專用名詞及質量量度指標。最常使用的質量指標，包括：“平均檢出質量”(AOQ)、“成品率”、“製程能力指數Cp及Cpk”、“六西格瑪質量”、“平均無故障工作時間”(MTBF)、“機器與機器之間的差異變化”、“內部和外在顧客事故”等。不過，利用這些質量指標來衡量質量表現時，應了解設立指標的原旨，時常牢記在心；否則，整個評審可能變成毫無意義的指標分數追逐把戲，不但無助於質量的實質改善，還會引致不可逆轉的惡果，任由歪曲的數據縱橫，令評審表現完全不能反映實況，把整個質量系統淪為自欺欺人的文件製作“夢工場”。

五) 解決問題技巧

進行“表現評審”時，常常會找到問題及可以推行改善的機會。採用有系統性的“解決問題技巧”，處理那些已被確認的質量改善機會，將可加強改善效果、減省所需時間。可供選擇的“解決問題技巧”，包括：“福特8D團隊式解決問題方法”、“施樂質量改善製程和問題解決製程”、“PDCA”、“改善”、

an objective means to determine the status of the quality system and assess the implementation of action plans for quality improvement.

In order to facilitate the reviewing process, some quality indicators can be utilized. The commonly used indicators include average outgoing quality (AOQ), yield rates, process capability indices Cp and Cpk, six-sigma quality, mean time between failure (MTBF) of machines, machine-to-machine variation, and internal and external customer incidents, etc. However, great care is required when using these indicators; otherwise, the whole situation can become meaningless and the objectives of performance review may be lost.

5) Problem Solving Techniques

After identifying potential problems or opportunities for improvement from the performance review, a systematic problem solving approach can help address these identified areas. For instance, several systematic approaches (e.g. Ford 8D's team-oriented problem solving, Xerox quality improvement process and problem solving process, PDCA or Kaizen, QC circles, and so on) are developed to meet the objectives of individual companies. Moreover, many other tools like old and new QC seven tools, design of experiments, process re-engineering, or benchmarking can be applied. These problem-solving techniques are used to analyze, solve, and prevent the recurrence of quality problems.

The results may necessitate further changes in categories of quality tools, such as new items on setup checklists or data logging, modification of preventive maintenance frequency and procedures, and usage of a more precise gauge, etc. Therefore, it is important to have a close enhancement loop of different quality tools that help solve the problem effectively.

Level 3: Driving Force for Quality Improvement

Level 1 of the TQM framework shows how to prevent or react to out-of-control conditions, while Level 2 describes how to support and review the achievements in Level 1. These two levels help maintain the quality level of the process and attain some gradual improvement. However, it cannot bring significant breakthroughs in quality improvement. Therefore, an advanced level addressing the driving force for improvement is needed. In level 3, the quality tools are applied off-line and focus on the strategic issues involving the long-term impacts on quality.

Customer focus is the ultimate aim of quality improvement of products and services. This helps determine what customers really want and develop products and services to meet those identified needs. At the same time, benchmarking can be performed to address the best practices in the same or different fields in order to improve processes, customer service and the organization. Quality function deployment (QFD) can be used to review and transform customer requirements into product and internal process specifications in the design stage. Besides, failure mode and effect analysis (FMEA) can be applied to avoid the occurrence of potential defectives. After the setup of a production line, improvement can be made along with machine/process capability study, proper design of experiments and use of other tools. The common tools and techniques used in Level 3 are explained as follows (see also Figure 4):

1) Quality Systems

Several companies developed and implemented quality systems to improve their processes, products and services, according to the requirements of the ISO 9000/QS 9000 quality systems standards, the Baldrige, European, or Australian Quality/Excellence award criteria, and/or Deming Prize guidelines. The criteria of the Baldrige, European, or Australian quality awards and guidelines of the Deming Prize are often considered

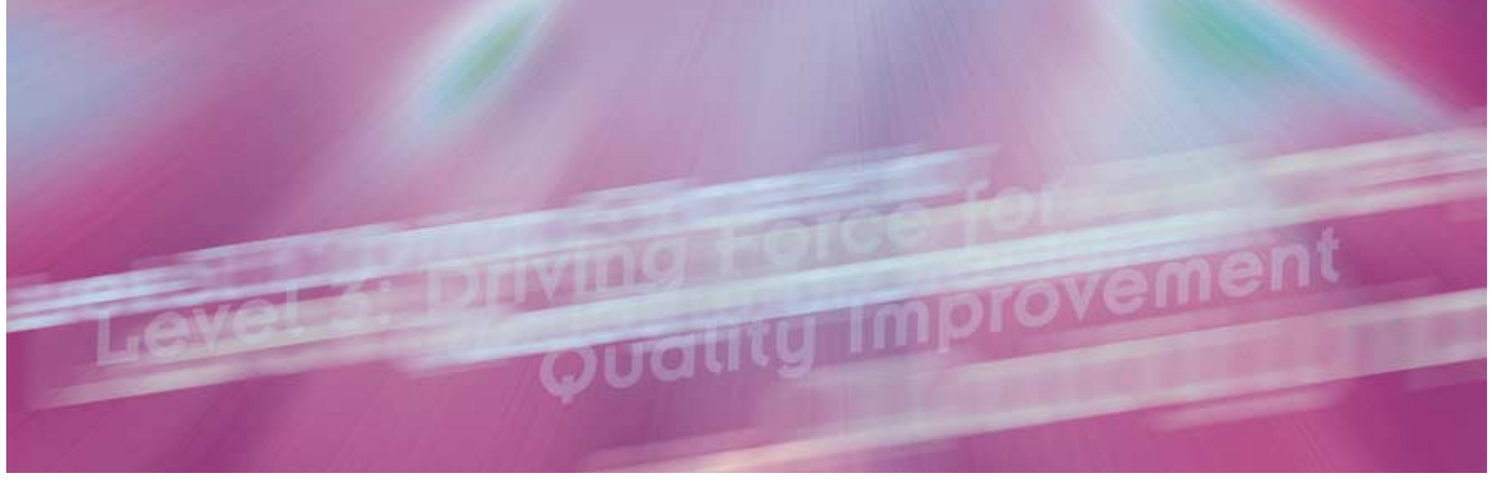
“品質圈”或其他任何具備有系統性的方法，達成改善目的。此外，亦可應用其他各種質量工具如“舊QC七工具”、“新QC七工具”、“實驗計劃”、“再造工程”、“基準借鑑”等等。它們都可用作分析、解決、和避免問題再發生。

根據使用“解決問題技巧”所獲得的成果，還需要仔細地考慮對其他質量工具的變化影響，例如：在“作業前檢查清單”或“數據記錄”加入新項目、更改“設備養護”的次數及步驟、使用更精密的量度儀器等等。因此，為有效地長期解決問題，更新與問題相關的質量工具是不可遺忘的。

第三層: 質量改善的驅動力

第一層次已經解說如何預防或應付失控情況，而第二層次則釋述如何支援和評審第一層次。正確運作這兩個層次，質量應該可以達到一定的穩定水平，甚至獲得局部漸進的改善；可惜，這兩個層次仍未能攝取足夠力量，並未可推動巨大的質量改善突破。因此，第三層“質量改善的驅動力”就成為不可或缺的能量供應者。它專注於後勤支援的應用，集中對質量策略方面的長遠影響。

要整體各方面有均衡發展，企業必須按照本身現狀，引進一個適合的“質量體系”，為基礎樹立支柱。接著，由專注顧客要求開始，了解他們真正想要甚麼東西，開發適合的產品/服務以滿足這些要求，因為質量之最終目標就是令顧客滿意。此外，一方面運用“基準借鑑”，在相同或不同的行業中，尋找最佳的方法或方案；另一方面使用“製程分析及評估”，理解及簡化自身製程，完善現行機制、改善顧客服務和企業運作。在產品/服務設計階段，可利用“質量功能展開”(QFD)



解讀評估顧客的要求，再轉化成為相應的產品規格和內部製程規範，並採用“預先產品質量策劃和控制計劃”對各方面作出妥善的計劃及安排。還需要引用“失效模式及效應分析”(FMEA)，研究失效成因，尋求方法，避免產生不合格品。假若作業生產線已經設定妥當，便進行“機器/製程能力研究”改善，其中包括“實驗設計”和其他相關質量工具。

一) 質量體系

不少企業以國際公認的“質量體系”標準，製訂和建立其質量系統，藉此發展各方面的質量基礎；獲得國際公認的“質量體系”，包括：ISO9000/QS9000質量體系標準、美國鮑烈治國家優質獎項準則、歐洲質量或澳洲卓越商業獎項準則、戴明獎準則等。很多企業引用上述獎項的標準/準則/指引，作為建立自身“質量體系”的藍本，推動質量系統改善，直至最終達到全面質量管理(TQM)概念。不論ISO9000/QS9000標準或其他獎項評定準則，都有相關的組織/機構定期進行專業檢討、修訂和更新，令它們適應不斷變更的市場趨勢和競爭要求。例如：ISO9000標準是按各企業實際情況和質量專業人士的回饋，定期每五年修訂一次；相同地，QS9000也將跟隨ISO9000標準修訂作出更新；美國鮑烈治國家優質獎項準則和其評分標準亦曾先後經歷多次修訂及更新。祇有不斷地自我完善及更新，才能及時地適應市場需要。

二) 顧客/市場專注

顧客完全滿意是改善產品/服務質量的最重要目的。為達到這個目的，我們必需能熟識顧客的需要，提供適當的產品/服務，迎合此市場需要。若是僅僅只專注心力和資源，持續改善現今的產品/服務，而忽略最新的顧客需要和市場狀況，企業便會自閉地滿足於現今那成功所規劃的框架，不知及時應變。事實上，美國鮑烈治、歐洲或澳洲質量獎項、和戴明獎都同時強調“顧客/市場專注”，增進顧客對產品/服務的滿意程度，是改善製程、提高產品/服務質量之首要宗旨。為了清楚顧客的真正需要，同時評估市場的最新實際情況，企業普遍使用的技巧是選擇性地拜訪其關鍵顧客，和進行專門而具針對性的市場調查。運用這些技巧，可以與顧客開闢定期的溝通渠道，彼此建立比較緊密的長期關係。

事實上，“拜訪顧客”和“市場調查”通常是市場研究活動之一，它們確認顧客和市場的最新需要，令企業可以制定導向市場需求的計劃。但相關的資訊是絕不可只局限於市場部門，而需要深入至質量改善的層面上。較為進取和合適的做法是組成跨部門小組，包括管理決策人員和相關工程師，一起進行顧客拜訪，確切了解顧客所需，及產品/服務在市場的最新前景狀況，仔細分析，回應市場調查和顧客投訴，提供高質素的產品/服務。

三) 基準借鑑 / 最佳方法

“基準借鑑”協助企業不斷地探索，直至尋獲“最佳的”方法、技巧或實施製程。所謂“基準”就是當某企業在個別特定製程或活動運作，已成為領先群倫的表表者時，我們就把此運作模式作為學習模做對象，重新釐定較高的目標參考值，作為基本準則。由於“基準借鑑”不祇是單單比較數值和結果，而是通過有系統地分析，選擇學習的對象，研究對方如何能夠出類拔萃，達成傑出成就的經驗歷程等。在挑選學習對象作為“基準借鑑”的過程中，可以從相同或不同的行

as the blueprints for promoting total quality management (TQM) philosophy. Many companies and quality professionals also believe that the setup of an ISO 9000/QS 9000 quality management system is a building block to ultimately the development and implementation of a TQM-based system. The ISO 9000/QS 9000 requirements and the awards criteria are structured in such a way that they can be modified to meet the changing requirements of the markets and competitiveness. For example, the ISO 9000 series of standards will be revised every five years based on feedback from industry and quality professionals. The QS 9000 is also revised whenever the ISO 9000 standards change. Besides, the several update of the Baldrige award criteria and the point system is another example that shows how the award is responsive to the changing company practices and market conditions.

2) Customer and Market Focus

Attaining customer satisfaction is an important goal of quality improvement of products and services. In order to achieve this, it is crucial to have clear identification of customer needs and market requirements. Focusing on continuous improvement without customer and market input may lead the firm to go astray. Various awards and prizes (e.g., the Baldrige, European, and Australian quality awards, and the Deming Prize) emphasize customer/market focus to increase the overall customer satisfaction, and regard it as the primary goal of improving the quality of processes, products and services. In general, customer visits and market surveys are the two commonly used techniques used to acquire what the market and customers really need and how to identify and assess them. Besides, long-term and closer customer-supplier relationships should be established.

Customer visits and surveys are marketing research activities that are used to identify customer and market requirements. They establish the importance of a market-oriented focus in addressing quality improvement efforts. These activities are necessary if managers and engineers attempt to understand customers needs. Involving them in customer visits and forming cross-functional teams are preferred approaches that can help understand the process by which they make the products and services. Besides, they should analyze customer surveys and customer complaints critically to improve product and service quality.

3) Benchmarking and Best Practices

Benchmarking is a process of continually searching for the best methods, practices, and processes. A "benchmark" can be regarded as the leader in a particular process or activity and serves as a reference point for setting targets and goals for improvement. However, benchmarking is not just a comparison of end results, but a systematic approach to study why and how to perform optimally. A cross-functional team can perform the benchmarking study based in the same field or in the other fields. By either adopting or adapting the best practice of the benchmark, the company can become the "best of the best". Benchmarking is also known as the best practices method.

4) Process Analysis and Assessment

Processes convert inputs into tangible outputs what customers want (e.g., a finished product or component, a newly designed product, a report or document). The processes should produce outputs that satisfy company's goals and objectives of competing in the marketplace.

業中尋找，並由企業組織一個跨部門小組進行，經過消化，融會貫通，直接地全盤採納或撮取部份精粹，改革企業現時的運作，祈能最終成為“最佳中的至佳”；故此，有些人亦稱“基準借鑑”為“最佳方法”。

四) 過程分析及評估

過程是將輸入資源，轉換達成顧客的需要，再以實質形態/訊息輸出，例如：一件製成產品或元件、一個最新設計的產品、一份報告、文件或資訊。通過此個創造價值的輸入/輸出過程，令企業能提供有價值的產品/服務，滿足顧客的需要，加強在市場中的地位，達成發展目標。所以，任何未能滿足以上要求的過程活動，都應予已刪除。

“過程分析及評估”是透過瞭解過程中的細節，檢討活動的成效，減少差異變動和浪廢，更快捷地創造合適的產品/服務，提供給予顧客。一個設計得宜的過程，應俱備三個基本元素，分別是：有效果、高效率、和適應力強。有效果是指輸出必須滿足一個或以上的企業目標，並達到或超越顧客的要求；高效率是利用最短的時間與最少的資源，完成輸入轉化為輸出的過程；適應力強則表示因應市場的變化和投資者的要求，企業可作出迅速的反應和適切的調整，刪除內部那些不合時宜和零增值的束縛，避免投入未能創造價值的資源。運用的方法包括：“改善”或“再造工程”進行“過程分析及評估”，設計或重新設計過程，以達到有效果、高效率、和適應力強的好處。

五) 質量功能展開

在完成聆聽顧客需求、學習“最佳方法”、和進行“過程分析及評估”後，跨部門的產品設

Therefore, any process activity that does not add value in satisfying customers and company goals and objectives must be eliminated. The purpose of process analysis and assessment is to understand every activity involved in a process and examine how to reduce variations and wastes and make a product or service faster. The three fundamental elements of a well-designed process are its effectiveness, efficiency and flexibility. To be effective, the output must satisfy one or more of the company's objectives while meeting or exceeding customer needs. Similarly, a process is efficient if the conversion of inputs is done with the shortest possible time and the best utilization of resources. The process is said to be flexible if it can be adjusted quickly and easily to meet the company's internal constraints, market needs and stakeholder requirements. Several approaches (e.g., Kaizen or Business Process Reengineering) can be used to design or redesign processes and to conduct process analysis and assessment.

5) Quality Function Deployment

After listening to customers, appreciating the best practices and reviewing the process, the manufacturing or product design team is required to transform the customer requirements into product or service features that meet the identified customer needs. Quality function deployment (QFD) is an effective tool to accomplish this purpose. It is a method for structured product planning and development that help identify customer requirements and evaluate each proposed product or service capability systematically to meet those needs. The QFD process involves constructing

a series of matrices. The first level of matrices called the House of Quality (HOQ) which displays the identified customer requirements and the design team's technical response in meeting the customer requirements. The HOQ consists of assembling several sections or sub-matrices together in various ways, each containing information related to the others. The QFD tool can translate customer requirements into the products that meet their wants.

6) Advanced Product Quality Planning (APQP)

Several US automobile companies (e.g., Chrysler, Ford, and General Motors) and other truck manufacturers have formed a task force to assure the quality requirements of their products. They have standardized the use of quality control tools and techniques, manuals, procedures, reporting formats, and technical nomenclature in the quality systems of their respective suppliers, including both internal and external suppliers. The task force produced initially five documents to be used by all their Tier 1 suppliers. These documents are the advanced product quality planning and control plan (APQP), the failure mode and effects analysis (FMEA), fundamentals of statistical process control (SPC), measurement system analysis (MSA), and the production part approval process (PPAP). Based on the contributions the task force, the three automobile companies further developed the quality systems requirements of the QS 9000 standard.

As one of the five documents, the purpose of APQP is to communicate the common product quality planning and control plan guidelines with

計/製造小組便開始籌備，如何把顧客要求轉化為產品/服務的訴求特徵，以滿足顧客的需要。“質量功能展開”(QFD)能有效地協成上述目的，它具備有產品構成、策劃和發展的方法，使有關人員能清晰地確認顧客要求，有系統地評估每個產品提案，核實是否有能力達到顧客所需要的產品/服務。

QFD的運作包括建立一連串的矩陣，第一個的矩陣稱為“質量之屋”(HOQ)，它一方面展示各個被確認的顧客要求，另一方面引導設計小組，訂立符合這些顧客要求的產品技術規格；HOQ再從不同的層次，衍生多個部份組合或子矩陣，而各個子矩陣都包含與其他部份相連的資訊，直至達成最終的相關製程規格；故此，企業運用QFD能有助創造出符合顧客要求的產品。

六) 預先產品質量策劃

“預先產品質量策劃”是QS9000質量系統要求的一部份。美國三大汽車公司：佳事拿、福特和通用，為達到改善產品質量，組成一個跨公司的特別任務小組，統一各公司對旗下內部及外在供應商的“質量體系”要求，並規範所使用的質量控制工具、操作手冊、步驟、報告格式、和技術專用名詞等。對第一層的供應者，使用五個共同質量工具規範其日常運作；此五個質量工具包括“預先產品質量策劃和控制計劃”(APQP)、“失效模式及效應分析”(FMEA)、“基本統計製程控制”(SPC)、“測量系統能力分析”(MSA)和“生產部件批准製程”(PAPP)。其後再加以發展，成為QS9000質量系統要求。

APQP的目標是透過與伙伴(例如：內部和外在供應者及分承包商)緊密溝通，運用產品質量策劃和控制計劃指引，支援產品/服務的

開發，滿足顧客的要求。APQP也詳述其他主要的質量工具和技巧，如並行共進工程、QFD、FMEA、DFMEA、流程圖、關鍵路徑分析、和設計評審等等，要求供應者在各設計、製造、和裝配製程時使用。在運用“預先產品質量策劃和控制計劃”的好處，包括可以：

- 及早確認必需的改變
- 避免產品或製程的後期改動
- 提供質優、價廉、準時的產品
- 在設計、製造、和裝配製程中，減少不必要的浪廢和改善產品之質量
- 集中資源在顧客認為重要的要素於製程和產品特性中
- 加強對產品和製程特性、控制方法、和特性計測量有關改變之溝通

partners (e.g., the internal and external suppliers and subcontractors) to support the development of a product or service that will satisfy the customer. The APQP also specifies certain quality planning tools and techniques (e.g., concurrent engineering, QFD, FMEA, DFMEA, flow charts, critical path method, and design reviews, etc.) used by suppliers in design, manufacturing and assembly. Some benefits of using APQP are:

- To promote early identification of required changes,
- To avoid late changes,
- To provide a quality product on time at the lowest cost,
- To reduce waste and improve the quality of products during design, manufacturing and assembly,
- To focus resources on processes and products related to characteristics that are important to the customer, and
- To communicate changes in the product/process characteristics, control method, and characteristic measurements.

七) 失效模式及效應分析

“失效模式及效應分析”是應用於產品/製程設計階段，預防可能發生的潛在失效模式。它先從確認所有潛在失效模式開始，找出可能引發失效的原因，預計相關的效應，根據其潛在失效的發生頻密程度、可檢測性、和嚴重性，排列出緩急先後，設定相應處理措施和控制方法。成功的FMEA，應該活像一個不斷更新資料的圖書館，也能夠作為解決產品失效問題的手冊。在產品/製程設計階段，工程人員運用它作為預防工具；於正式投產後，其資料應不斷更新，符合實際運作，並可利用它來做新聘員工的培訓材料。

7) Failure Mode and Effects Analysis (FMEA)

Failure mode and effects analysis (FMEA) is used to prevent potential failure modes beginning in the design stage. It is a structured analysis starting from identification of all potential failure modes, and followed by a determination of possible causes and their effects. The priority of counter measures and controls is set according to the frequency, detectability and severity of the potential failures. FMEA serves as a live library guide for shooting troubles and product failures. Besides, production personnel can use it as a prevention tool at the design stage. The guide needs to be updated after product release, and that can also be used as training material for new recruited personnel.

八) 機器/製程能力研究和實驗設計

經過搜集及整理各外部有關改善質量的資料後，我們便可著手進行“機器/製程能力研究”，分析和優化各機器和製程能力；整個工具涉及五個步驟，包括“特性記述”、“測

8) Machine/Process Capability Study and Design of Experiments

After getting the external information for quality improvement, a capability study can be performed to analyze and optimize the capability of a machine or a process. It involves a five-step process including characterization, measurement system study, capability determination, optimization, and control. The study aims to evaluate the capability of a machine or a process according to the pre-determined criteria. The optimization obtained during the study also helps improve the quality level of the faulty process. Besides, design of experiments is often carried out in the optimization step. Therefore, the machine/process capability study can help safeguard the improvement of product or service quality.

The TCM framework consists of three levels and each level has a set of respective quality tools. In order to help the users understand the use of quality tools from the practitioner's point of view, the framework integrates the isolated islands of quality tools into an organized structure, and helps focus the direction when implementing the quality tools and techniques. Besides, the applications of quality tools become easier when the users can better understand their interrelationships. It is anticipated that individual quality tools can be used more effectively and improper or failure use can be minimized. The TCM framework is dynamic in nature. In other words, it can be further enhanced and modified where there is a new quality tool developed fitting into its different levels.

量系統能力分析”、“能力判定”、“優化製程”、和“日常控制”。

“機器/製程能力研究”是針對某一個製程中的某一部機器進行研究，以確認它是否有能力滿足預定的標準。當進行“優化製程”後，將明顯地提升有問題製程的質量水平；人們時常在“優化製程”中使用“實驗設計”。故此，“機器/製程能力研究”亦有助推行質量改善。

TCM架構是由三個層次所組織而成。從實施者的角度出發，TCM架構協助使用者瞭解和應用各個工具，並且連接起那些像荒島般單獨地運作的質量工具，有組織地整合於TCM架構的三個層次內，令推行這些質量工具和技巧時，能統一地邁向改善整體質量的大方向。另外，如果各使用者能瞭解各個質量工具間的相互關係，使用各質量工具將更得心應手，事半功培，效力大增。這個TCM架構是動態和需要不斷更新的。假若開發了任何新的質量工具，便可參考它的功能，加入其所屬層次中，使整個TCM架構得到及時的修訂。

Interrelationships among Quality Tools

質量工具的相互關係

雖然建立TCM架構，是從實施者之角度出發，由前線到後勤支援、由預防到偵測及矯正，但於相同和不同層次的質量工具中，仍存有其他的相互關係。下面將以矩陣形式，詳列各質量工具之間的關係，並把它們大致歸納為三種不同的相互關係模式，以舉例說明，

各質量工具間的關係矩陣

充份理解質量工具間的相互關係，固然是十分重要的，但若要在本文中逐一描述每個質量工具間的關係，將衍生冗長沉悶的篇幅頁數；所以我們就利用矩陣，表達它們的關係模式，展示於 [表三]。解讀 [表三] 的方法，應從最左面直欄的質量工具開始，它怎樣協助首行橫列的某一個質量工具發揮功用，那個相互關係就處於相交點，用英文字母代表：先決條件(P)、處理方法(T)、及輔助補充(S)作解釋。

相互關係模式

一) 先決條件

當一個質量工具能影響另一個質量工具能否應用或有效地執行，它便成為另一個質量工具不可或缺的先決條件，彼此就發生了關連。典型的先決條件，包括：提供穩定的環境、確定數據的準確性、解釋質量工具的運用、啟動各種工具的應用、和輸入必需的資料。

Although the TCM framework is developed based on the practitioner's point of view, from on-line to off-line, and from prevention to detection to rectification, many interrelationships would exist among the quality tools used in terms of their applications. These interrelationships may be nested in the same level and between different levels. Below will explain these interrelationships in the form of matrix as well as the three consolidated modes of relationships.

Quality Tool Relationship Matrix

With respect to their functions, the interrelationships among quality tools can be summarized in a matrix as shown in Table 3. The matrix indicates how the quality tools on the left-hand column will contribute to the success of the quality tools that are shown on the top row. It elaborates the nested interrelationships of tools in terms of prerequisite (P), treatment (T), and supplement (S) modes. These modes help understand the interrelationships and applications of quality tools in the TCM framework.

Three Modes of Relationships

1) The Prerequisite Mode

It refers that a quality tool is complement with the application of other quality tools as a pre-condition. In other words, the application of the quality tool becomes a prerequisite to that of the other tools. Typically, the prerequisite conditions can accompany a stable environment, data accuracy, understanding of quality tools, triggering application of other tools, and the information inputs.

The interrelationship of providing stable environment as a prerequisite is indicated by P1 as shown in Table 3. For example, the setup checklists

註Remarks:

P1 代表此質量工具提供穩定環境的先決條件
denotes a quality tool being a prerequisite by establishing stable environment

P2 代表此質量工具提供準確數據的先決條件
denotes a quality tool being a prerequisite by ensuring data accuracy

P3 代表此質量工具提供正確認識的先決條件
denotes a quality tool being a prerequisite by providing correct understanding

P4 代表此質量工具提供引發啟動其他工具的先決條件
denotes a quality tool being a prerequisite by triggering other tool

P5 代表此質量工具提供設定其他工具參數的先決條件
denotes a quality tool being a prerequisite by define characteristics in other tool

T1 代表此質量工具提供製程的處理方法
denotes a quality tool being a treatment on process

T2 代表此質量工具提供產品的處理方法
denotes a quality tool being a treatment on product

S1 代表此質量工具提供証實和檢定的輔助補充
denotes a quality tool being a supplement for verification and counter-checking

THIS QUALITY TOOL ↓ / WILL CONTRIBUTE TO THE SUCCESS OF →	控制計劃 Control Plan	作業前檢查清單 Setup Checklists	控制圖、直方圖和數據記錄 Control Chart / Histogram / Data Logging	作業員主導控制 Operator Dependent Control	自動偵測及警報控制 Auto Detection and Alarm	自動偵測及修正控制 Auto Detection and Correction	失控行動計劃 Out-of-Control Action Plan	不合格品處置程序 Product Disposition	抽樣檢查 Acceptance Sampling	培訓和教育 Training and Education	測量系統能力分析 Measurement System Capability Study	設備養護 Maintenance	表現評審 Performance Review	解決問題技巧 Problem Solving Process	質量體系 Quality Systems	顧客/市場專注 Customer / Market Focus	基準借鑒/最佳方法 Benchmarking / Best Practice	製程分析及評估 Process Analysis & Assessment	質量功能展開 Quality Function Deployment	預先產品質量策劃 Advanced Product Quality Planning	失效模式及效應分析 Failure Mode and Effects Analysis	機器/製程能力研究 Machine/Process Capability Study
控制計劃 Control Plan		S1	S1	S1	S1	S1			S1			S1										
作業前檢查清單 Setup Checklists			P1	P1	P1	P1	P4					P4										
控制圖、直方圖和數據記錄 Control Chart / Histogram / Data Logging						P4	P4					P4										
作業員主導控制 Operator Dependent Control		S1	S1		S1	S1	P4	P4	S1			P4										
自動偵測及警報控制 Auto Detection and Alarm							P4	P4				P4										
自動偵測及修正控制 Auto Detection and Correction																						
失控行動計劃 Out-of-Control Action Plan		T1	T1	T1	T1			T1				T1										
不合格品處置程序 Product Disposition			T2	T2	T2			T2				T2										
抽樣檢查 Acceptance Sampling		S1	S1	S1	S1	S1	P4	P4				S1										
培訓和教育 Training and Education	P3	P3	P3	P3	P3	P3	P3	P3	P3		P3	P3	P3	P3	P3	P3	P3	P3	P3	P3	P3	P3
測量系統能力分析 Measurement System Capability Study		P2	P2	P2	P2	P2	P2	P2	P2			P2	P2	P2			P2		P2		P2	P2
設備養護 Maintenance		P1	P1	P1	P1	P1				P1												P1
表現評審 Performance Review		P5	P5	P5	P5	P5	P5	P5	P5	P4/P5	P4/P5	P4/P5		P4	P4	P4	P4	P4	P4	P4	P4	P4
解決問題技巧 Problem Solving Process		P5	P5	P5	P5	P5	P5	P5	P5	P4/P5		P5	T1				T1					
質量體系 Quality Systems	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1	P1		P1	P1	P1	P1	P1	P1	P1
顧客/市場專注 Customer / Market Focus												P4		P5			P4	P4	P5	P4	P5	
基準借鑒/最佳方法 Benchmarking / Best Practice																S1			P5			
製程分析及評估 Process Analysis & Assessment	P5																P4		P1	P1		
質量功能展開 Quality Function Deployment																					P4	P4
預先產品質量策劃 Advanced Product Quality Planning										P4						P4	P4	P4	P4		P4	P4
失效模式及效應分析 Failure Mode and Effects Analysis		P5	P5	P5	P5	P5			P5	P5		P5										P4
機器/製程能力研究 Machine/Process Capability Study		P5	P5	P5	P5	P5			P5	P5		P5										

表三　質量工具間的關係矩陣
Table 3 Interrelationships among quality tools

提供穩定環境，這類相互關係在 [表三] 以P1顯示。例如：使用“作業前檢查清單”，預防準備時不必要的失誤，對應用“控制圖”、“直方圖”和“數據記錄”等，提供了其必需的先決穩定環境；又例如：“設備養護”能否提供可信賴的設備，就會直接影響其他質量工具的運作，如：“作業前檢查清單”及“控制圖”等等。此外，“設備養護”對“自動偵測及警報控制”與“自動偵測及修正控制”的關連，尤其重要；因為偵測失誤是依賴自動警報裝置來監控，假若日久失修，警報失效，可引發產品/服務質量災難。因此，二者之間的關連是密切、直接和巨大的。

另外，要確保質量工具所推斷的結論，是可靠和有意義的，所搜集和使用的數據，必須備有一定的準確性；因此，“測量系統能力分析”成為各種需要數據收集之質量工具的先決條件。還有，在應用各有關質量工具前，應該先進行“培訓和教育”，令各使用者有清晰和正確的認識。上述兩種類別的相互關係，分別以P2及P3在 [表三] 內顯示。

一方面，有些質量工具會誘動其他工具的運作實行，例如：當發現異常情況時，“控制圖”會觸發“失控行動計劃”和“不合格品處置程序”的運作；或“表現評審”後，一般會啟動“解決問題技巧”。另一方面，有些質量工具就為其他工具提供必需的資料，例如：FMEA和M/PCpS就為“作業前檢查清單”和“控制圖”提供需要設定的特性項目。這兩種關係模式就分別以P4及P5在 [表三] 內顯示。

二) 處理方法

這種關係模式通常是當其他質量工具發現異常情況時，需要此質量工具提供必要的步

often contribute to the use of control charts, histograms, and data logging effectively. This is because the checklists can offer the prerequisite conditions necessary for a process before applying control charts, histograms, and/or data logging. Similarly, maintenance can safeguard proper equipment operations that are also the preconditions for adopting other quality tools (e.g., setup checklists, control charts, histograms, and/or data logging). Moreover, maintenance is a prerequisite to employ auto-detection and alarm and auto-detection and correction. Automatic alarm devices can help monitor the error detection. However, if the devices are not maintained properly, this may cause serious quality disasters with no warning of out-of-control conditions. Preventive maintenance should therefore be needed to ensure the functionality of the devices.

Provided the data used for analysis is accurate and reliable, the conclusions drawn from the use of other quality tools will then be useful and meaningful. Thus measurement system capability study is a prerequisite to whichever quality tool that needs data collection. Moreover, proper training and education is essential to acquire clear understanding and right applications of quality tools. Such two kinds of interrelationships are represented as P2 and P3 in Table 3, respectively.

When an abnormal condition is found, control charts and performance reviews provide inputs that trigger the use of rectification tools (e.g., OCAP, product disposition and problem-solving techniques). Similarly, FMEA and M/PCpS also provide information that defines the controlled parameters in the corresponding quality tools (e.g., setup checklists and control charts). These prerequisite modes of interrelationships are shown as P4 and P5 in Table 3, respectively.

2) The Treatment Mode

This mode describes that a quality tool is used to correct the abnormalities caused by the use of other quality tools. It provides the necessary rectifying procedure to bring the process and/or the product under control.

For example, an action plan is needed to rectify any out-of-control conditions found through utilizing the setup checklists and control charts. The plan can advise production operators on what action to take. Otherwise, the operators may not know how to respond and simply disregard the out-of-control conditions. As a result, the setup checklists and the control charts will inevitably become ineffective. The core functions of quality tools are to take corrective actions to prevent and rectify any out-of-control conditions. In this regard, the out-of-control action plan is the treatment for the abnormalities found in the process using various quality tools (e.g., operator dependent control, auto detection and alarm, acceptance sampling, and maintenance). This mode of treatment is indicated by T1 in Table 3.

Likewise, product disposition is the treatment on the product when the out-of-control condition is found (e.g., in setup checklists, control charts, data logging, histograms, operator dependent control, auto detection and alarm, acceptance sampling, and maintenance). This mode focuses on the product. Such interrelationship is represented by T2 in Table 3.

3) The Supplement Mode

This is concerned with the functions of verification and counter-checking of a quality tool so as to improve the effective use of the other quality tools. In other words, the tool is taken as a supplement of the other quality tools. For example, a PosiTrol plan is used to verify the presence and the continued use of some preventive and detective quality tools (e.g., setup checklists and control charts). Similarly, acceptance sampling is used as a supplement gate to counter-check the proper functions of the tools. It ensures that no defective is escaped to the downstream processes. This mode of interrelationship is indicated by S1 in Table 3.

驟和行動，以矯正情況，令製程和產品回覆正常受控情況。

在製程層面上，“失控行動計劃”提供了當“控制圖”發現異常情況的矯正行動，這就是一個典形的例子。它建議作業員應作的行動，避免作業員在不知所措的情況下，心慌疏忽，無視失控情況，繼續生產而不顧，引起災難性的後果。所以，這些處理方法的核心，是以矯正行動來預防和修正失控情況，而非單純地作出善後行動，一般適用於那些偵測質量工具所發現的不正常情況；這種關係模式以T1於 [表三] 內展示。

相同地，“不合格品處置程序”則涉及產品處理的層面。當“作業前檢查清單”、“控制圖”、“數據記錄”、“直方圖”、“作業員主導控制”、“自動偵測及警報控制”、“抽樣檢查”、及“設備養護”等，發現失控情況後，它指引處理產品的方法；這種關係模式以T2在 [表三] 內展示。

三) 輔助補充

輔助補充的關係模式，是指一個質量工具輔助其他工具，提供證實和補足檢定之功能，令其他工具能更有效地發揮；舉例說，“控制計劃”檢證一些預防及偵測的細節項目，在“作業前檢查清單”、“控制圖”等質量工具中是否存在，會否重覆或遺漏。同樣地，“抽樣檢查”亦作為一個流程放行的關閘，以輔助檢定補充其他工具的功效，確保沒有不合格品流出某一個過程；上述關係模式以S1於 [表三] 內展示。

TCM Implementation Strategy

TCM實施策略

Areas of Concerns in Implementing TCM

Implementation of the TCM framework is a complex process starting from its formulation and development to incorporating all quality tools and techniques properly. Basically, the framework aims at integrating isolated individual quality tools together and enhancing the quality system to improve the quality of processes, products and services. Therefore, the implementation process depends significantly on the responsiveness of individual quality tools. Some tools may be implemented inappropriately, and others may not be linked up. These situations may create barriers for TCM implementation, and extra efforts are needed to resolve the problems and restore the normality. The following sections discuss some areas that can make the implementation easier and smoother.

1) Implementation Sequence - Simultaneous or Sequential

The TCM is structured by including all available quality tools as described in the iterative process flow chart of Figure 5. It shows the applications of quality tools with attention to their synergistic interrelationships. Theoretically speaking, all quality tools can be applied simultaneously with the implementation of entire TCM framework. Such simultaneous implementation approach can better observe the interrelationships among quality tools. Besides, it can also help fulfill the management expectations and get things done in a shorter period of time.

However, the simultaneous approach will require many resources that may not be available. Moreover, the abrupt change may cause a lot of confusion, and hence frustration and resistance especially on the production floor. Management of change is required to be handled with great care. The TCM implementation involves the fundamental change in the quality mindset that is cultural and takes time.

The TCM framework should be implemented gradually with care over time (usually one to three years) depending on the current use of quality tools and techniques in a given company. The time required for implementation may vary due to learning capability of the organization,

注意事項

在一個架構系統內，TCM把個別獨立運作的質量工具連結起來，在互動、增強、補充的作用下，提昇整體質量水平，達到不斷改善產品/服務之質素的效果。其實，由籌劃到展開，直至全部質量工具能恰當地執行，有效地就位運作，實施TCM是一個頗繁複的過程。在推行TCM的過程中，需要不斷留意作業員對個別質量工具的回饋，及整體表現；有些質量工具可能已被全面採用，但卻祇是形似實非，失卻神髓；另一些質量工具可能未跟其他技巧完全銜接，令整個TCM體系未能順暢運作。故此，需要在適當的關節眼處著力，解決此等問題，方能令TCM正常及有效地運作。

一) 實施的關聯 – 同時併行或循序漸進

如 [圖五] 所述，TCM已經包括全部可用的質量工具，實施時應該先清楚認識它們的正確應用方法，和彼此之間的相互關係。理論上，在TCM系統架構下的所有質量工具，是可以同一時間推行運作，以體驗TCM各層次的協同效應。期間也可以觀察作業員的使用情況，知道他們是否理解質量工具的相互關係；亦可在較短的時間內，實現管理階層完成對建立TCM系統的期望。

但是，使用“同時併行”的方法，實施TCM，需要較多資源，並不是任何企業都可以承擔的；而且，在前線生產現場，同時改變多項對質量控制的日常運作，會有較大機會產生不同程度的混亂、不習慣、或運作不順暢。若能按步就班，小心處理，管理改變，從根本的質量概念等基礎著手，植根於企業的文化內，對TCM的實施和長期應用更有保障。

按照“循序漸進”的方法，要視乎企業情況、運作複雜程度、企業的學習能力、和現行質量

工具之應用狀態等，可能需要經歷由一年到三年時間不等。不論使用“同時併行”或“循序漸進”的方法，均應揣摩TCM的三個核心原則，將質量工具逐一推敲選用。有更新的質量工具考慮引入時，應該考核工具功能，及它與其他質量工具的相互關係；利用如 [圖五] 的重覆步驟，確定它在TCM中的位置。當大部份的質量工具已經實施妥當，整個TCM架構就能明顯地展現出來，令各使用者對TCM有更透徹的認識，更容易有效地改善質量工具的運用。

二) 實施的次序

實施TCM架構時，可根據各種先前所述的關係法則，按企業實際情況，先把相關的質量工具串連集合在一起，加以執行使用；利用這種安排，使各工具之間能互相支援。例如：策劃在前線現場實施“控制圖”時，工程師應該首先安排相關的“機器/製程能力研究”，瞭解製程，設定“控制圖”所偵測的關鍵特性；接著，開始使用“控制圖”時，可能發生失控情況，但部份作業員尚未完全明白及知道應如何處理，他們只好慣性地以“通知工程師，等待建議”作為處理行動；為減省此種倚賴行動，納回正軌，工程師當儘快開發合適的“失控行動計劃”，輔助有關作業員，作出正確反應和行動，矯正失控情況；同時，建立“不合格品處置程序”，指引作業員如何處理產品。這樣，“機器/製程能力研究”、“控制圖”、“失控行動計劃”、及“不合格品處置程序”等就能一條龍地順序實施，建立TCM架構的雛型。

三) 作業人員的參與

在實施和運用TCM時，各相關作業人員的密切參與，是十分重要的。例如：實施使用“控制圖”各階段時，需要對各工程師和作業員，

as well as application status of different quality tools. It is recommended to implement the TCM framework by observing the three core principles of TCM and applying various quality tools one by one. For instance, once a quality tool is introduced, its basic functions and interrelationship with other quality tools should be examined. The iterative process (see Figure 5) also helps position a new tool in the framework properly. When many quality tools are ready, the TCM framework can integrate them together. It is anticipated that the opportunities to enhance the applications and contributions of quality tools will easily be identified with the thorough understanding of TCM.

2) An Order of Implementation

During the sequential implementation of the TCM framework, those interrelated tools can be grouped together, and some tools can support one another. For instance, engineers use the machine/process capability study to understand the process, and define the critical characteristics to be observed on control charts. Then the control charts are adopted on-line. However, many operators may still not know how to rectify the out-of-control conditions. What they may do is to ask for help and “inform engineers and wait for advice”. In order to relieve their workload and rectify the out-of-control conditions, engineers can develop out-of-control action plans and assist operators to respond appropriately. Besides, engineers can also design the product disposition process to help operators with the handling procedures. Therefore, several tools like machine/process capability study, control charts, out-of-control action plans, and product disposition can be implemented in sequence. They can support each other within a relatively short time frame.

3) Participation of Operations Personnel

People participation is important in implementing TCM in manufacturing and service operations at all levels. For the implementation of control charts, proper training can help operators and engineers understand the basic SPC concepts and the application procedures. Production operators are involved in the daily operations like data collection, plotting the points, and detection and rectification of any out-of-control conditions.

Other functions (such as equipment maintenance) also involve in reacting to any out-of-control conditions. Engineers need to review the out-of-control conditions and the corrective actions on the control charts, identify improvement opportunities and develop continuous improvement projects. It is also necessary to initiate changes in training, use of setup checklists and preventive maintenance and encourage participation of the respective parties. This example of control charts implementation clearly shows the need for people involvement (e.g., training, production, equipment maintenance, engineering, and quality personnel). Despite the participation at the grass-root level, top and middle management should understand and support the implementation process. Their recognition and appreciation of the efforts and the results achieved can encourage the front-line personnel to maintain the momentum of the TCM implementation. Therefore, total participation across the entire organization, especially the manufacturing and service operations people, is a key to the success of TCM implementation.

4) Appointment of a TCM Coordinator

With an encouragement of people participation, a TCM coordinator (or leader) is needed to drive the implementation activities. The person is delegated with the focal point for the entire TCM implementation. Good leadership and behavioral skills (e.g., managing change) are the pre-requisites for the coordinator. In addition, he/she needs to have a quality mindset and good understanding of statistical techniques. This knowledge is vital to gain credibility and influence to motivate others during the TCM implementation. A lot of stress may be induced including inadequate support from peers or middle management, resistance to change, communication problems, unsatisfactory progress, conflicts in resource allocation, and perhaps other unexpected obstacles. Therefore, the coordinator also needs a strong character to withstand any pressures from the TCM implementation. Above all, management must support the coordinator, assist him/her and share his/her workload. Otherwise, the coordinator may easily be overloaded and fall into a “burn out” syndrome.

提供切合進度的培訓課程，令他們瞭解基本的統計製程控制概念及應用竅門；其後，在實施過程中，作業員必須將“控制圖”所需的相關規律性工作，如：數據收集、點線畫圖、偵測和矯正任何失控情況等，編配在日常工作中；其他功能小組，如：設備維修，就提供相關功能支援，協助應付失控情況；工程師則定時查閱“控制圖”，審定應用有否偏差，失控時所作的矯正行動是否正確有效，通過不斷檢討而開展持續改善行動方案；若有需要，亦應更新有關培訓課程內容配合，或改動修正其他質量工具，包括“作業前檢查清單”和“預防性養護”等。從以上例子，可以看到當實施TCM時，涉及許多不同部門的人員，包括培訓部、生產部、設備維修部、工程部、和質量部等，令他們熱烈參與，全力投入，對長久發展有十分大的幫助。除此之外，有關中層和高層管理人員對TCM的瞭解和支持、對實施成果的鼓勵和讚賞等，均可令各參與成員對TCM保持熱誠，成為推動TCM更上層樓的巨大力量。所以，促成此種全員參與，維持這股持久力量，也是實施TCM的成功關鍵竅門之一。

四) 任命一位TCM統籌專員

為推動各相關人員的全力參與，必須特別指派一位統籌人員，策劃、編排、督促、跟進及調節整個系統實施的進程。這位實施TCM的重點核心人員，是推動TCM的鑰匙人物，可以稱為TCM統籌專員。他/她必須具備領導才能、聆聽技巧、感染他人的能力、可以促成文化改變等管理知識；此外，他/她亦需要清晰的質量思想概念，充份的瞭解統計技巧，以這些專業知識贏取同儕信任，增強他人信心，激勵大家同心共進。在實施TCM的各階段中，推行期間也許會遭遇到個別朋輩同袍的阻力、出現溝通問題、進度未達預期、資源調配發生

衝突、或發生其他未能預知的障礙及事故等等，而產生許多預期和未能預期的困難；面對困境時，這位TCM統籌專員要秉承對真理的堅持和執著，負責又不妥協地達成肩負的任務。在這些重要時刻，高層管理人員的精神支持，加強授權或資源調配等，可以幫助這位TCM統籌專員克服各種困難。雙方有默契地建立及實施整個TCM系統，成功是可以預期和能達到的。

另外，我們建議這位TCM統籌專員應該隸屬於使用者的部門，如：生產/營運部門，而非質量部。因為假若這位TCM統籌專員和前線人員隸屬於同一個部門，他們接受同一個高層管理人員領導工作，就不需要克服跨部門間無形的障礙，而且實施期間，若有任何意見、不滿或誤解，該高層主管也會相對地容易幫助化解，減低內部對改變的阻力，獲得較佳的資源支援和整體支持，令實施TCM架構變得較為順利。

實施步驟

確立一個有系統和有效的TCM實施策略是達至成功的第一步。但是，不同企業有不同的自身使命、文化、架構、管理模式等，所以在確立實施策略前，應對企業作出適時合理的評估，獲得充份的了解。

下列是TCM實施策略的七個基本步驟：

步驟一: 獲取高層管理的承諾與承擔
步驟二: 任命一位TCM統籌專員
步驟三: 建立一個跨部門的TCM核心小組
步驟四: 安排TCM培訓
步驟五: 組織一個實施TCM隊伍
步驟六: 制定衡量TCM表現的準則
步驟七: 集中於持續不斷的改善

It is recommended that the TCM coordinator better come from the user departments (e.g., Production/Operations Department) rather than the QA Department. If the coordinator is working with other manufacturing or service operations personnel under the same roof, then there will be no inter-departmental barrier to overcome. Even if conflicts occur during the implementation stage, the supervisor can resolve them more easily. Resistance to change can be minimized and better support can be achieved. Hence, it is expected that the implementation of the TCM framework can become smoother and easier.

Seven-Step TCM Implementation Strategy

There is a need to establish a systematic and effective strategy for TCM implementation. However, a host of factors may affect the success of TCM implementation, including the company mission, culture, organizational structure, and management style, etc. Therefore, it is recommended to gain a thorough understanding and analyze the current developments within the organization. A generic seven-step TCM implementation strategy is proposed as follows:

Step 1: Obtain top management commitment
Step 2: Appoint a TCM coordinator
Step 3: Form a cross-functional TCM team
Step 4: Provide TCM training and education
Step 5: Form a TCM implementation team
Step 6: Develop TCM performance measures
Step 7: Focus on continuous improvement

Step 1: Obtain Top Management Commitment

Like in many other quality improvement programs, top management commitment is the first and one of most important pre-requisites in the TCM implementation. Without this, the TCM adoption may die before it is fully implemented. Top management commitment also determines the allocation of resources, encouragement and recognition. The commitment messages must be strong and consistent, as many of their impacts may lose when transmitted through so many people and phases. The further a message travels through the chain of command, the less effective it becomes. When the middle management and line supervisors are facing a lot of pressures and requirements (e.g., yield, cycle time, productivity, use of technology, and cost reduction), they will typically ask for increased allocation of resources. These predominant concerns may affect and cause postponement of TCM implementation. Therefore, the commitment and support from top and middle management are crucial to the entire implementation of TCM.

Step 2: Appoint a TCM Coordinator

After obtaining top management commitment, a delegated person should be appointed to coordinate all activities related to the TCM implementation. The coordinator should be selected based on the criteria mentioned earlier. He/she has to liaison with middle management and line supervisors to gain their support and acceptance. The pace of the TCM implementation must be transparent in order to retain the awareness and interests of top management. The formal reporting structure to top management needs to be formed. Moreover, the TCM coordinator cannot work alone, and he/she can take a lead to form a cross-functional team for facilitating the TCM implementation throughout the organization.

Step 3: Form a Cross-functional TCM Team

The structure, culture and situation of an organization would affect the formation of teams. The cross-functional team should consist of the TCM coordinator and members from different departments such as Production, Engineering, and Quality Assurance, etc. The departmental involvement is crucial because it can collate different points of views and expert opinions that can better represent the interests of different parties and reduce the resistance to change. The main purpose of the team is to define the overall strategies and to provide resources and assistance to those who are involved in the TCM implementation. It also monitors and reports the progress to top management and other personnel involved in the implementation project. Moreover, the team should maintain close working relationships with other teams (e.g., the training and education and implementation teams) to ensure effective TCM implementation.

步驟一: 獲取高層管理的承諾與承擔

正如推行各種專案計劃一樣，高層領導的堅定承諾和堅決承擔，將會是推行和實施TCM最優先和最重要的基礎；否則，TCM在還未完全實施前，可能已被延誤或取消。高層領導的承擔是包括適當的參與、提供充沛資源、鼓勵打氣、對好表現的讚賞等；而承諾則是對建立TCM具有貫徹如一的堅定信心，言行合一，保持一致的方向，使全企業員工對實施TCM不會掉以輕心。

中層管理經常面對各種來自四方八面的要求和壓力，如：產品合格率、生產週期、生產力、技術應用、及顧客要求等，對有限資源的分配和使用，難免十分小心緊慎；假若高層領導沒有對建立TCM持久不變的信心、對改善抱有堅定不移的執著，中層管理往往會因不同的情況理由，削減先前所承諾提供的資源，把TCM的推行計劃延期；故此，高層領導的決定和支持是成就TCM建立的關鍵所在。

步驟二: 任命一個TCM統籌專員

獲取高層管理的承諾和承擔後，挑選及任命一個指定人員，負責統籌和推行所有有關實施TCM的活動。挑選合適的TCM統籌專員，可參考先前所述的準則。他/她需能直接與中層管理人員及前線人員聯絡溝通，互相了解，建立伙伴關係，令他們能衷心接納和全力支持TCM的實施。他/她亦必須定期檢討TCM的進度，準備具透明度的報告，使各有關參與人員(包括高層領導)，獲得足夠的資訊，作出關注、改進及獎賞等。透過正式的定期回顧及報告，驅使企業內各人員更投入參與，有效地實施TCM。

步驟三: 建立一個跨部門的TCM核心小組

企業組織架構、文化和狀況，均會影響TCM核心小組的成立。除TCM統籌專員外，這TCM核心小組亦應該由跨部門委派代表人員組成，包括生產部，工程部，和質量部等。因為擁有不同部門代表的參與和討論，提出部門間的不同意見看法，指出其隸屬部門的局限和顧慮，TCM統籌專員才能引領大家，策劃一個令各部門均滿意接納的方案，減少實施時面對的阻力。這個TCM核心小組的主要功能，是釐定整體策略，提供資源和支援，監督實施，定期向高層領導匯報進度。它還需要與其他TCM工作小組保持密切的伙伴關係，確保溝通無間。

同時，這個跨部門TCM核心小組也要定期審核TCM實施進度是否達到預期。此外，它亦要制定評估TCM進度的審核清單，釐定評分標準。要通過審核，不能僅靠執行TCM的措施，必須證明執行已達致成效，例如：在審核培訓時，除檢查培訓出席紀錄外，還應到現場實地觀察，向各已合格人員發出提問，了解他們對培訓課題的認識，確定培訓是否有效。TCM核心小組準備TCM審核清單後，還需要培訓各審核人員，才可進行定期審核，確保審核水平保持一定程度。透過檢討審核結果，找出可改善的地方，調整步伐，加以配合。此外，審核過程中，使用表現指標，檢定改善進度，亦可利用“比較分析”或“基準借鑑”，幫助TCM核心小組進一步策劃改善工作。

步驟四: 安排TCM培訓

為了對各員工重新灌輸及建立質量的概念、個別質量工具的使用、工具間的關係、以及整個TCM的架構模式等，使他們有清楚正確的認識，適當的培訓及教育是非常重要的。TCM

The cross-functional team needs to review the TCM implementation periodically. It is also the responsibility of the team to develop a TCM audit checklist and the detailed scoring criteria. The audit should look into the effectiveness rather than the conformance areas. For example, in assessing the training status and effectiveness, operators' attendance will be checked and a verbal questioning will also be used to test their understanding. With the completion of the TCM audit checklists, the team may need to offer auditor training before the regular audits are conducted. Through the review of the audit results, opportunities and trends of improvement can be identified. Moreover, some performance measures can be provided in the audit, so that the team can keep track of the progress and project the improvement trend. Comparative analysis and benchmarking can also be carried out.

Step 4: Provide TCM Training and Education

Proper training and education can allow related personnel understand the entire TCM framework and its quality tools and interrelationships. Its main purpose is to help them build up quality mindset and provide the foundation for TCM implementation. The TCM training and education team must plan, design and deliver the training programs related to TCM. In general, there are two basic kinds of training programs. The first focuses on the awareness, and main features and benefits of adopting TCM, while the other involves what the quality tools and techniques being used, and how and when to use them. Different programs need to suit varied levels of target audiences. For example, engineers should clearly know how to develop an out-of-control action plan by taking an in-depth training course; whereas for operators, it will be sufficient if they can understand and apply the OCAP by attending a basic course that covers the execution activities. Since there will have varied emphases in different training courses, it is advisable to build a cross-functional team for TCM training and education. The team should consist of the TCM coordinator or his/her representative who is the expert on the subject matter, a training officer who understands the training instructional design, and other manufacturing/operations personnel. If the team can have more experienced and knowledgeable members, it can help enormously in assessing training needs, course design and delivery, evaluation of course effectiveness, and many other related training logistics.

Step 5: Form a TCM Implementation Team

Besides the TCM training and education team, another TCM implementation team should be setup to assess specific needs and implement TCM throughout the organization. The team needs to plan with great care the entire implementation strategy and schedule, as it will affect all the future work. If the plan is too aggressive, it may bring great resistance during the implementation. On the other hand, if the plan is too conservative, it may also be difficult to meet management expectations. Therefore, a balance plan is preferred. During the actual implementation, the TCM implementation team will develop quality tools, provide expertise and trials, evaluate effectiveness, and then establish the applications. As the team is directly engaged in implementation, it plays a leading role in working with other teams (e.g., the TCM training and education team). It deals directly with necessary requirements so as to match the progress. Moreover, this team also needs to continuously upgrade and enhance the TCM framework whenever a new quality tool is developed and introduced.

Step 6: Develop TCM Performance Measures

Two basic ways are developed to evaluate the performance of TCM implementation. The first is to review some quality measures (e.g., the number of customer complaints, external and internal audit results, and the time to achieve six-sigma quality in a new product) that help understand the TCM impacts. Another is to assess the progress of TCM implementation and its effectiveness against the expected and the actual results. The cross-functional TCM team should develop appropriate measures to evaluate the progress of TCM implementation and the effectiveness of the framework.

Step 7: Focus on Continuous Improvement

The prime objective of TCM implementation is to improve the quality of the process continuously and hence the quality of products and services. This is a never-ending process. By observing the three basic TCM principles (i.e., completeness, sequencing and effectiveness),

培訓課程的內容核心可歸納為兩種；第一種是令學員了解TCM概念，它的重要性，其主要特點，及使用後的益處等；另一種是教導學員認識在TCM環境中，運用各質量工具的技巧，包括應何時、何地、及如何使用等。由被挑選的TCM培訓人員隊伍負責，盡力發展不同程度的培訓課程，配合不同階層人員的需要。舉例說，工程師需要參加高階研討課程，清楚了解如何開發一個可供使用的OCAP，而操作員則只需要參加基礎應用課程，明白如何運用OCAP。正因不同程度的培訓課程要有不同的重點，TCM培訓人員隊伍應由不同方面的代表組成，包括熟悉課程內容的TCM核心小組成員、明白課程設計的訓練員，及其他具有培訓技巧才能的生產成員。他們透過所擁有的豐富經驗和專業知識，評估培訓需要，設計課程，教育傳授，評估課程的成效，對整個TCM培訓工作和過程，作出極大貢獻。

步驟五: 組織一個實施TCM隊伍

為妥善按排實施TCM的細節，跨部門TCM核心小組應組織一支實施TCM隊伍，評估特定需要，施行項目活動。首先，該隊伍要開展整個實施策略，編排活動詳程及時間進程表；其間，必須留意會否影響未來的工作。如果計劃過於進取，實施時將面對龐大的阻力；如果計劃過於保守，便未能達到各方期望。故此，怎樣在兩者之間取得平衡點是關鍵所在。在正式實施時，該隊伍會進行一系列的活動，例如：發展合適的質量工具，提供有關知識，測試及評估其有效性，並建立實際應用作業。因為它是直接與實施有關連，所以要擔當主導角色，主動地向其他小組要求配合，例如：TCM課程培訓等，以符合計劃進度。同時，TCM實施隊伍亦必須持續地提昇其才能和水平，開發及介紹新的質量工具，不斷加強及更新TCM的架構。

步驟六: 制定衡量TCM表現的準則

基本上，有兩個方法可評估整個實施TCM的表現。第一個方法是檢查一些質量量度指標，如：顧客投訴的次數，外在和內部的審核結果，及新產品達到六西格瑪的時間等，幫助各人了解TCM的成果。另一個是審核TCM的實施，觀察真實的結果，與預定的期望比較，決定實施是否符合進度和有效。此外，跨部門TCM隊伍亦可制定適當的指標及審核準則，考證TCM的實施進度及成效。

步驟七: 集中於持續改善

實施TCM的基本目的是持續改善過程，提供高質素的產品/服務。故此，這個持續不斷改善步驟是非常重要。根據實施TCM的三個基本原則(即：完整性、順序性、效益性)，企業應提供資源和動力，持續加強及改善過程、產品和服務的質素。

上述的TCM實施策略，可因應各企業不同的要求，其員工的程度差異，作出一定程度的修訂，加以使用。

成功要素

基於上述TCM實施的考慮因素和七個策略步驟，以下簡略地介紹一間企業成功和有效地推行TCM的重要原素。

- 管理層的承諾
- 對顧客的專注
- 團隊精神
- 培訓
- 持續改善
- 文化的轉變

companies can focus on continuous improvement of the TCM framework and hence enhancing the quality of processes, products and services.

The above TCM implementation strategy can be applied to different types of companies. The differences in the employee awareness to quality and their knowledge about quality tools, the management commitment and support to TCM implementation, organizational structure and company practices, etc. may necessitate a different way of implementation strategy. In other words, this seven-step strategy could be modified with respect to varied requirements of a company.

Success Factors to Implement TCM

In addressing the concerns of TCM implementation and the seven-step strategy, several success factors can be identified to help transplant TCM in companies effectively. They are described below:

- Management commitment
- Customer focus
- Teamwork
- Training
- Continuous improvement
- Culture shift

It is needless to emphasize the impacts of senior management commitment and support not only on committing resources, resolving conflicts and resistance, but also keeping the TCM implementation and application highly visible and providing support for change management. Customer focus should govern the operations of various TCM teams (including the cross-functional team, the training and education team and the implementation team). They should stress the need of internal customers and use of different quality tools. Similarly, they should also focus in producing the products and services to meet the needs and expectations of external customers.

Teamwork and training are another two success factors that stress the people's expertise and experience from different functional areas and build committed teams in the company. It is crucial to understand various quality tools and techniques and integrate them into TCM. The TCM teams, the workforce and the managers should strive for continuous improvement and enhance TCM to meet the changing conditions (e.g., the market requirements and emergence of new tools and techniques). In addition, the management should establish quality mindset that improves the processes and produces quality products and services. They should also provide the supporting infrastructure and encourage employee involvement to use their expertise and experience in decision making. In other words, the necessary culture shift should occur across the entire organization for an effective TCM implementation.

TCM Performance Measures

It is important to identify performance measures in implementing TCM and in achieving the desired benefits. In other words, it will be very difficult to monitor the implementation plans and to assess the TCM benefits without the performance measures. The performance measures to implement TCM must relate to resources allocated and management commitment (e.g., number of people assigned in teams, hours of training given to understand and apply the concepts and quality tools, number of quality audits conducted, number of corrective actions planned, number of management reviews, etc.). On the other hand, the performance measures to assess the benefits of TCM must be related to customer satisfaction and reduction of process variation. They encompass a lot of evaluation measures including customer complaints, customer audit results, time to achieve six-sigma quality, warrantee costs, things gone wrong, first time capability and other capability indices, supplier quality indicators, etc.

Depending on the business nature and the company practices, appropriate measures must be defined in assessing the effectiveness of TCM. Despite the evaluation measures of TCM performance, other success factors can be considered. Appendix 1 presents a sample checklist that can help assess the TCM implementation and the benefits achieved in a typical organization.

高層領導的承諾和支持，包括資源的承諾、解決糾紛和消除阻力的決心、保持實施TCM的高透明度、和支持改變的行動。另外，跨部門TCM核心小組、TCM培訓人員隊伍和實施TCM隊伍等，必須關注顧客的需要；一方面，他們要留意內部顧客在實施TCM後是否獲益；另一方面，也要關注外部顧客對改善的產品/服務是否滿意。而團隊精神能促成不同部門的人員，運用其相關功能的專業知識，建立一隊齊心和志氣高昂的團隊，推動TCM施行。還有，企業內各階層人員未必能夠完全明白各質量工具、認識如何實施TCM系統，通過切合其需要的培訓課程，加強各人員對TCM中各質量工具的認識和使用。最後，持續TCM的蛻變進化，改善整個企業內部質量文化，迎合市場最新的變化情況和顧客不斷改變的要求。

表現指標

我們必須對TCM進度和其實際得益釐定指標，這樣才能把TCM的整體效益展現出來，方便監察它的進度和成效。TCM進度指標，除量度基本內部運作外，亦是與資源分配及高層領導承諾掛勾的，例如：參與TCM的人數、培訓質量工具的時間、審核的次數、糾正措施的多寡、管理評審的次數等。另一方面，也應延伸至顧客滿意和製程穩定的實際得益層面，舉例說，這些指標可以包括：顧客滿意程度的增減、過程變化的幅度和次數、顧客投訴的多寡、顧客審核的結果、達到六西格瑪質量的時間進程、產品質量保證承諾的費用、補償過失的花費、"第一次就成功"的達成次數、及主要供應商質量指數等等。

另外，根據不同的行業及企業條件，可以挑選其他適合的指標，評估其實施TCM的實質進度和效益。[附件一] 是一份檢查TCM有效性清單的實例。

A Case Study of Using TCM

一個應用TCM的實例

這部份介紹摩托羅拉半導體香港有限公司，實施TCM的經驗和效益，以作參巧。

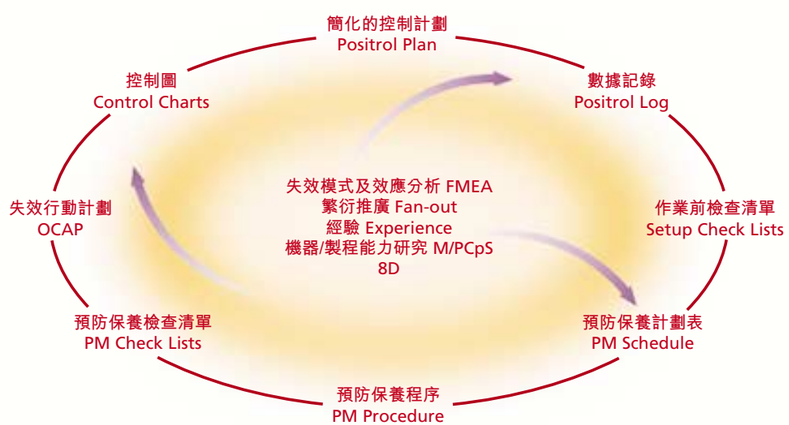
摩托羅拉半導體香港有限公司

早於1992年，摩托羅拉半導體美國總部對TCM的概念已有初步構思，並進一步於1993年，把該構思概念開發成TCM架構，在公司內部發表。當時所指的TCM架構，只包含十三種不同的質量工具，放置於兩個層次中，如 [圖六] 所述。該TCM架構是基於一個概要順序，一條生產線由數個工序組成，每一個工序均擁有一份獨立計劃監控各個關鍵特性，例如：機器、工序和產品等，而且需要包括各工序控制的週期性監察要求。它也必須簡單易明，使有關操作員樂於跟從，可以輕易地在工作崗位上使用。並且，當時已建

In this section, one success case of using TCM is presented based on the experiences and benefits achieved in the Automated Assembly Division of Motorola Semiconductors Limited in Hong Kong.

Motorola Semiconductors Hong Kong Limited

It is noted that the Worldwide Semiconductor Products Sector of Motorola Inc., first conceived the basic idea governing the Total Control Methodology, in 1992. The TCM framework was then developed and formally released by the same company in 1993. Its structure, as shown in Figure 6, is based on the scenario that several separate processes usually exist within each product line to manufacture a product. It has 13 quality tools and techniques with two levels. Every process should have an individual plan to control significant machine, process, and product characteristics. The plan must be sufficiently complete to cover all periodic process control requirements. At the same time, the plan must also be simple with easy-to-follow instructions and made available



圖六　1992版的TCM架構
Fig.6　The TCM framework – 1992 Version

to operators for controlling each process. In addition, the TCM framework must be implemented at each step of the process within a product line. A cross-functional team approach was adopted and the design of the TCM framework was flexible to adapt to different environments.

One of the authors has involved in the development of the basic TCM framework, and participated in the trial implementation commenced in 1992 in Hong Kong. The entire process took approximately 27 months in a manufacturing operation of the company. With the success achieved in the trial implementation, the model has been fanned out to the company in the subsequent years. The results achieved were impressive. Two performance measures were used to assess the TCM effectiveness. The first was to listening to external feedback from the customers because total customer satisfaction is one of the company's ultimate goals in achieving quality. Another measure was the time for a new product-line that achieves a six-sigma quality level. This is an internal measure on quality and cycle time improvement obtained by implementing the TCM framework.

1) Audit Results and Customers Comments

Several visits and audits were conducted by key customers (e.g., Ford Motor Company, Chrysler Motors, Hewlett-Packard, Seagate, and Delco Electronics, etc.). Positive results of improvement have been obtained when contrasted before and after the TCM implementation in the company. For example, the Total Quality Excellence (TQE) audit conducted by the Ford Motor Company was one difficult audit that the company has come across. The minimum requirement of the audit was to have a score greater than or equal to 45 out of the total 50.

議運用跨部門小組發展此架構模式，在生產線的每個步驟運用此計劃執行，也要預留足夠的靈活空間，使此架構能容納於不同的情況和環境。

本文其中一位作者就是當時有份參與開發TCM架構的推行者。在1992年，她引進開發中的TCM架構到萬力半導體香港有限公司(即摩托羅拉半導體之香港分廠，後簡稱為香港摩托羅拉)的自動裝配部門，進行現場實施、試驗應用及修訂改進，歷時二十七個月才正式實驗成功，繼後再將本書的更新版本推廣到全公司應用。令人振奮的是TCM的成效已被進一步肯定，通過細心聆聽外間顧客的意見及回饋，公司的質量已提昇至“顧客完全滿意”的水平；另外，新產品的生產線達到六西格瑪質量要求的時間，也大為縮短。這二個成果亦堅定了公司對實施TCM的信心。

一) 審核結果或客戶的意見

當摩托羅拉半導體的重要客戶，如：福特汽車(Ford Motor)、佳士拿汽車(Chrysler Motor)、惠普(Hewlett-Packard)、思捷(Seagate)、和Delco Electronics等，均曾親臨香港摩托羅拉探訪和審核，他們對實施TCM所獲得的成績，都給予高度的評價。舉例說，當時福特汽車公司的TQE審核，可算是香港摩托羅拉所經歷過最嚴峻的審核之一，在TQE中有關“統計製程控制”的環節，若能在總分50分中達到45分才算合格。

當時，雖然香港摩托羅拉已推行“統計製程控制”數年，但在首次審核僅取得38分，未能符合要求。主要原因是由於使用中的“統計製程控制”，以一個獨立質量工具形式運作，與其他質量工具如：“機器/製程能力研究”和“失控行動計劃”等，沒有密切的連繫及相互支援。

其後，香港摩托羅拉決定任命一位工程師統籌，利用初版的TCM架構概念，把“機器/製程能力研究”和“統計製程控制”連結一起運用，重新展開更新的培訓課程。繼後進一步將各種控制圖的格式標準化，統一其使用方式。另外，又開發“失控行動計劃”和“統計製程控制定期審核”配合運作。此時，“統計製程控制”的效力已經大增；另一次TQE審核中，“統計製程控制”的環節已能取得46分佳績(合格分數為45分)。最後歷時整整27個月的實驗後，控制計劃已正式廣泛地在生產現場使用。福特汽車公司再進行審核時，TQE的“統計製程控制”環節更跳昇至49分(滿分是50分，而49分是當時福特汽車公司評核中，前所未有給予的分數)。事實上，大部份香港摩托羅拉的其他客戶對此質量控制系統的成績，均非常滿意及作出高度的評價。

At the very beginning, the company obtained a score of 38 despite it has implemented a SPC program for several years. This was because the SPC program was applied as an isolated tool, and thus could not be supported by other quality tools such as M/PCpS and OCAP. Subsequently, the TCM framework has been rolled out to improve the SPC system. The TCM implementation was started with assigning a full-time TCM coordinator, conducting machine/process capability studies, and identifying and delivering SPC training. The aim of this implementation was to standardize the format and practices of control charts, development of OCAP, and SPC audits. As a result, the score of TQE audit gradually increased from 38 to 46. At the end of the period of 27 months, a control plan was developed. The score in the SPC section of the TQE audit was increased to 49 from 46, which was one of the highest scores that has ever been given by the Ford Motor Company. As a matter of fact, most (if not all) of the customers admired and were well satisfied with the results of the quality control system after the TCM implementation in the company.

2) Cycle Time to Reach Six-Sigma Quality Level

Apart from customer satisfaction on the quality aspects, the company also enjoyed the benefits of quality improvement and cycle time reduction. In the past, a new product line typically required 18 months to achieve the level of six-sigma quality. During the implementation period, some missing quality tools were re-installed, and other interrelated tools were fine-tuned to support one another. The entire learning was made by trial and error. After the TCM implementation, a new product line reaching six-sigma in 6 months has been achieved. This was because the TCM framework provided a readily available well-structured quality model for new product lines from the very beginning. With the framework, engineers could review the quality system and make the required quality tools readily available for full use within a short period of time. If there was any imperfection in the system, an adjustment could be easily made. Furthermore, there was an index to reflect the effectiveness of TCM performance with respect to quality and cycle time.

二) 到達六西格瑪質量程度所需的時間

此外，香港摩托羅拉實施TCM後，在改善產品質量和縮短全面投產期方面，亦能獲得裨益。以往，一條新產品的生產線約需時18個月，才能達到六西格瑪的質量水平；在這18個月中，時間都耗花在不斷加入不同的質量工具，微調各質量工具，逐步修正製程的控制參數，整個質量改進過程可說是一個不斷從錯誤中學習的漫長旅程。但在實施TCM後，香港摩托羅拉的其中一條新產品生產線。以破記錄的6個月時間就達到六西格瑪的質量水平，與過往的18個月比較，只用了三份之一的時間。這個成果再次證明TCM已達穩定成熟階段。在新產品的生產，工程師可通過TCM檢討整個質量系統，簡易地使用所需要的質量工具，令過去漫長的摸索期縮短，甚至消失；而且，由於TCM是可以不斷更新，故此改進調整亦是非常容易。這方面的成果，亦可用於反映TCM對質量和縮短產品成熟期的成效指標。

Appendix:
TCM Effectiveness Assessment Checklist

附件: TCM有效性的檢查清單

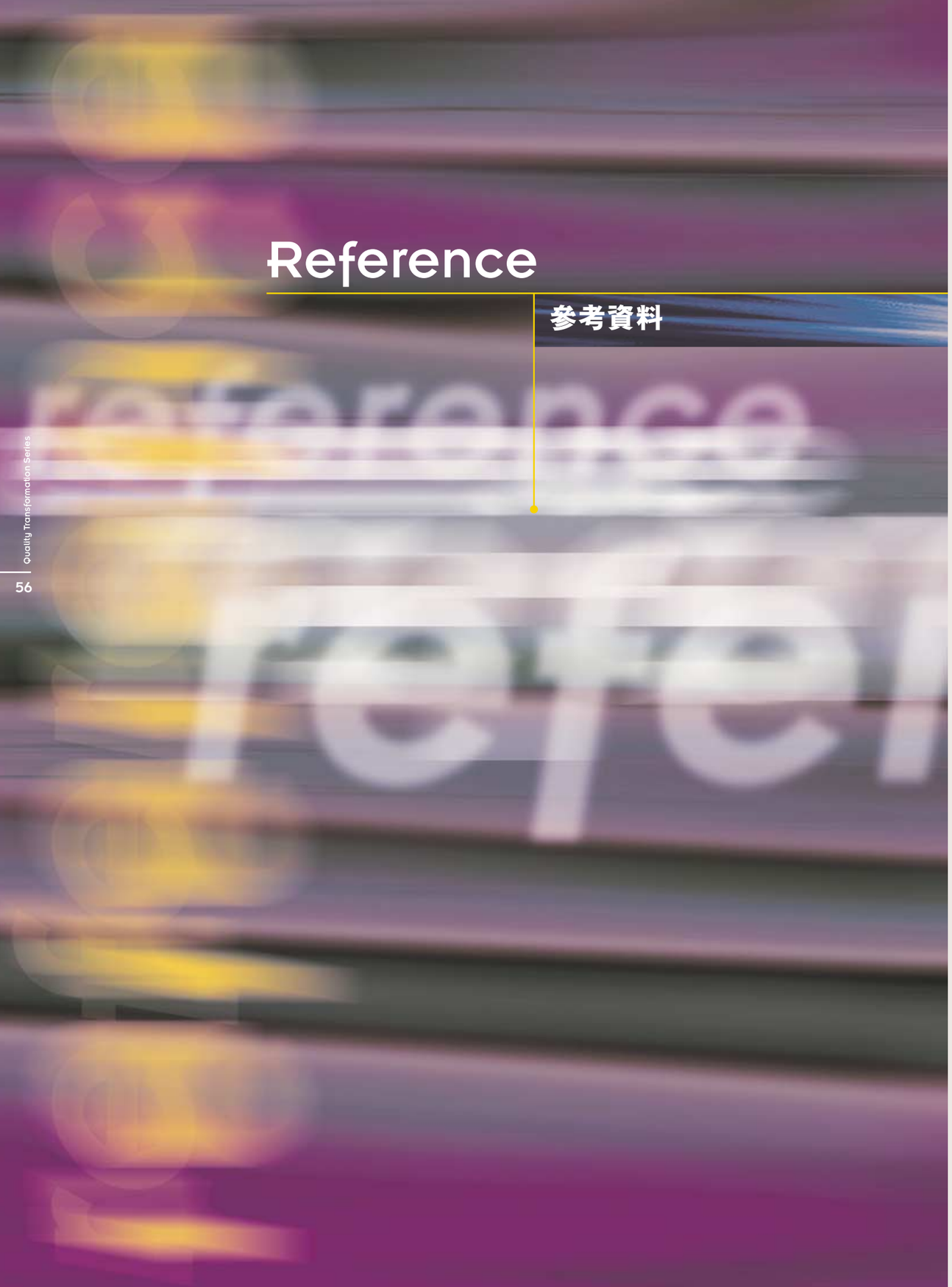
使用TCM高效評估檢測表進行等級評估
Evaluation of the rating assessment using TCM Effective Assessment Checklist

根據下列等級分數結果找出你所得到的總分和其註解：
Find the total score you received and interpret as in the following the resulting rating score.

80 – 100	很好，基於TCM系統，TCM構架使公司績效得以改善，公司的產品/加工質量達到上乘。 Very good TCM based system in place. The TCM framework improves the company's performance in quality products/processes as the best in class category.
60 – 80	良好，基於TCM系統，在一些地方還需要改進，公司在產品/加工質量方面的績效還可以進一步改善。 Good TCM based system in place. Needs improvement in some areas. Company's performance in quality products/processes can be improved further.
30 – 60	需要重大的改進，個別地方基於TCM系統，TCM小組應該評估並作出適當決定以實施一個基於TCM的高效系統。 Needs significant improvement in TCM based system in several areas. The TCM Team should assess and make appropriate decisions to implement an effective TCM Based system.
低於 Below 30	需要大量的工作以實施一個適當的基於TCM的系統，高層管理者和TCM小組應該對現有的系統進行缺陷分析並採取適當的行動來改進系統。 Needs a great deal of work to implement an appropriate TCM based system. Senior management and TCM Team should conduct the gap analysis on the existing system and take appropriate actions to improve the system.

請圈出每個問題的適當等級數值，並將所有已評定的等級數值加起來。
Circle the appropriate rating value for each questions and add all the assigned rating values.

管理階層的承諾 Management Commitment						
1.1	管理階層是否支持成立TCM隊伍？ Search for management support for forming TCM team?	1	2	3	4	5
1.2	管理階層是否支持跨功能隊伍？ Search for management support for cross functional teams?	1	2	3	4	5
1.3	管理階層有否為TCM活動提供資源(例如：培訓、實施、審核)？ Does the management allocate the resources for TCM activities (such as training, implementation and audit)?	1	2	3	4	5
1.4	管理階層有否推廣及宣傳運用TCM模型的重要性和好處？ Does the management promote and communicate the importance and the benefits of using the TCM model?	1	2	3	4	5
1.5	TCM隊伍有否安排適當的審核員進行審核？ Does the TCM team audit the implementation with appropriate auditors?	1	2	3	4	5
1.6	管理階層有否查閱審核結果，並作出反應？ Does the management review and respond to the audit results?	1	2	3	4	5
1.7	相關的矯正 / 預防行動有否跟進，並確定其有效性？ Are the corrective / preventive actions followed up to ensure their effectiveness?	1	2	3	4	5
培訓 Training						
2.1	有否提供任何TCM模型中質量工具的培訓？ Is there any training offered for quality tools used in the TCM model?	1	2	3	4	5
2.2	有沒有系統評估對質量工具運用和它們相互關係的培訓需求？ Is there system to assess the training needs to understand the application of quality tools and the relationships among quality tools?	1	2	3	4	5
2.3	有沒有系統量度培訓(課程)的質量和有效性？ Is there a system to measure the quality and effectiveness of the training (programs)?	1	2	3	4	5
2.4	TCM隊伍有否確認新的質量工具和相關的培訓？ Does the TCM team identify the new quality tools and the related training?	1	2	3	4	5
持續改善 Continuous Improvement						
3.1	TCM隊伍有否確認改善的機會？ Does the TCM team identify the opportunities for improvement?	1	2	3	4	5
3.2	有否按照控制原則，由矯正、到偵測、到預防？ Is the principle of control from rectification, to detection, to prevention followed?	1	2	3	4	5
3.3	公司有沒有根據科技發展更新質量工具的應用？ Does the company upgrade the application of quality tools with respect to the technology advancement?	1	2	3	4	5
3.4	TCM隊伍有否融合新的質量工具於TCM模型內？ Does the TCM team integrate the new quality tools to the TCM model?	1	2	3	4	5
3.5	TCM隊伍有否應用新的質量工具改善製程？ Does the TCM team apply new quality tool to improve the process?	1	2	3	4	5
TCM表現 TCM Performance						
4.1	顧客滿意度和 / 或投訴有否改善？ Is there any improvement in the customer satisfaction and/or complaints?	1	2	3	4	5
4.2	公司營運在以下方面有否改善？ Is there any improvement in the company's operations such as					
	生產力 Output productivity?,	1	2	3	4	5
	成本 Cost?,	1	2	3	4	5
	運轉期 Cycle time?	1	2	3	4	5
	製程能力指標 (滿足顧客規格) process capability index achieved to satisfy customer specifications?	1	2	3	4	5
4.3	新產品開發在以下方面有否改善？ Is there any improvement with respect to new product development in terms of					
	成本 Cost?	1	2	3	4	5
	運轉期 Cycle time?	1	2	3	4	5
	質量水平 Output quality?	1	2	3	4	5
4.4	質量成本有否改善？ Is there any improvement on the cost of poor quality?	1	2	3	4	5



Reference

参考資料

AIAG (1995a), *Advanced Product Quality Planning and Control Plan*, APQP, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA.

AIAG (1995b), *Failure Mode and Effects Analysis*, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA

AIAG (1995c), *Fundamental Statistical Process Control*, SPC, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA.

AIAG (1995d), *Measurement System Analysis*, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA.

AIAG (1995e), *The Production Part Approval Process*, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA.

AIAG (1995f), *QS-9000 Quality System Requirements*, 26200 Lahser Road, Suite 200, Southfield, MI 48034, USA.

Australian Business Excellence Awards (2000), Australian Quality Council, PO Box 298, St Leonards NSW 2065

The Deming Prize Guide for Overseas Companies (1996), International Cooperation Group, Union of Japanese Scientists and Engineers (JUSE) 5-10-11 Sendagaya, Shibuya-ku, Tokyo 151 Japan.

European Quality Awards (2000), The European Foundation for Quality Management, Avenue des Pleiades 15, 1200 Brussels, Belgium

ISO (2000), *ISO 9001: 2000 Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation and Serving*, Geneva, Switzerland, December.

Malcolm Baldrige National Quality Award (2000), National Institute of Standards and Technology (NIST), Department of Commerce, Washington D.C., USA

BIOGRAPHIES

作者簡介

V. M. Rao Tummala博士

V. M.Rao Tummala，美國密芝根州立大學博士。曾任美國東密芝根大學營運研究及資訊系系主任，現職該大學商學院生產/營運管理系教授。

他對質量管理的學術貢獻獲得廣泛認同，除積極地協助及提供建議予大學開發質量管理課程外，還籌劃會議和研討會、指導質量管理中最佳方法的研究。另外，他對項目風險管理、巴氏決策原理、架構分析方法、產品開發方法，所作出的貢獻，均獲得認同。著有五本書、發表超過五十篇期刊文章和超過六十份國際會議文章。其中包括： *Quality Management Journal*、 *International Journal of Quality & Reliability Management*、*OMEGA*、*The International Journal of Management Science*、*Journal of Operational Research Society*、*International Journal of Project Management*、*Production Planning and Control*、*International Journal of Quality & Reliability Management*、*The Journal of Supply Chain Management*、*Concurrent Engineering Research and Applications*、*and Construction Management and Economics*。

他是Alpha Kappa Psi and Beta Gamma Sigma的榮譽會員，亦躋身於Who is Who in the Frontier of Science and Technology、American Men and Women of Social and Behavioral Science及Who is Who in Electronics & Computer Science。

V. M. Rao Tummala

Dr. V.M. Rao Tummala is Professor of Production/Operations Management in the College of Business, Eastern Michigan University, Ypsilanti, Mi, USA. He has a Ph.D. degree from Michigan State University and a former Head of Department of Operations Research and Information Systems, Eastern Michigan University, Ypsilanti, Michigan, USA.

Professor Tummala widely recognized for his scholarly contributions in Quality Management. He is very active in assisting and advising universities in developing quality management programs, organizing conferences/symposiums, and conducting research in best practices in quality management. In addition, he is recognized for his contributions in Project Risk Management, Bayesian Decision Theory, and Analytic Hierarchy Process, and Product Development Practices. He has published five books and over 50 journal papers and over 60 international, and national conference proceedings papers in these areas. Some of the journals in which he has published papers include *Quality Management Journal, International Journal of Quality & Reliability Management, OMEGA, The International Journal of Management Science, Journal of Operational Research Society, International Journal of Project Management, Production Planning and Control, International Journal of Quality & Reliability Management, The Journal of Supply Chain Management, Concurrent Engineering Research and Applications, and Construction Management and Economics.*

He is an honorary member of Alpha Kappa Psi and Beta Gamma Sigma. He is also listed in Who is Who in the Frontier of Science and Technology, American Men and Women of Social and Behavioral Science, and Who is Who in Electronics & Computer Science.

Katherine K.Y. Kwok

Ms Katherine Kwok is a freelance quality management consultant in Hong Kong. She has a first class honors degree in BEng (Hons) in Manufacturing Engineering from the Hong Kong Polytechnic, a MSc in Engineering Management with Distinction from the City University of Hong Kong and a Diploma in Training Management from the Chinese University of Hong Kong. She was also qualified as IRCA Lead Auditor.

Ms Kwok has strong industry and consultancy background. She has worked at engineer and manager levels in Motorola Semiconductors Hong Kong Limited for 6 years. Afterwards, she joined several companies in capacities as Quality Manager (Continuous Improvement), Customer Operations Manager, Lead Auditor, and Consultant. Up till now, she has assessed more than 100 companies with respect to their quality management systems. These companies covered many fields including: electronics / electrical components and assemblies, light electronics equipment manufacturing, fabricated and finished metal products, machinery manufacturing, automobile parts, food processing, construction, banking, insurance, jewellery, management consultancy services, property management, etc.

Ms Kwok has published various papers in journals and conferences such as *International Conference on Quality in Japan 1996, the Sixth World Congress on Total Quality in New Delhi 1996, and International Journal of Quality and Reliability Management 1998.*

郭家燕

郭家燕，現為自顧質量管理顧問。香港理工學院製造工程一級榮譽學士畢業。隨後任職於萬力半導體香港有限公司(即香港摩托羅拉)，期間進修，取得香港城市大學工程管理碩士學位、香港中文大學培訓管理文憑。擁有國際註冊主任審核員資格。

她曾在多間跨國企業任職，負責持續質量改善、客戶營運、品質審核、管理顧問等。至今，已經評估超過一百間企業的質量體系，涉及行業包括：電子/電機零件和裝配、輕型電子設備製造、五金製件、機械製造、汽車零件、食品加工、建築、銀行、保險、珠寶、物業管理等等。對多種不同行業運作均有認識。

她亦於不同的國際會議和期刊發表數篇文章，包括：1996年日本舉行的*International Conference on Quality*、1996年新德里舉行的*the Sixth World Congress on Total Quality*、*International Journal of Quality and Reliability Management 1998*。

HKSAR Government Industrial Support Fund Project

"Developing Educational Materials to Encourage and Facilitate Hong Kong Manufacturers for Quality Transformation" (AF/3/98)

香港政府工業支援資助計劃 "開發優管教材以推動香港製造業的優質變革" (AF/3/98)