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By
AHMED SAID DESOUKY

DEVELOPMENT OF SOFTWARE TO FACILITATE THE IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE IN AN ISO 9000 - TOTAL QUALITY MANAGEMENT FRAME WORK

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PAR
AHMED SAID DESOUKY

DÉVELOPPEMENT D'UN LOGICIEL POUR FACILITER L'IMPLANTATION DE LA MAINTENANCE PRÉDICTIVE TOTALE DANS LE CADRE DE ISO 9000- GESTION DE LA QUALITÉ TOTALE

MONTRÉAL LE 15 FÉVRIER 2000

CE MÉMOIRE A ÉTÉ ÉVALUÉ
PAR UN JURY COMPOSÉ DE :

- M. Yves Beauchamp, professeur-tuteur et directeur de l'enseignement et de la recherche à l'École de technologie supérieure
- M. Youssef A. Youssef, professeur-cotuteur et professeur au Département de génie mécanique à l'École de technologie supérieure
- M. Kamal Al-Haddad, professeur au Département de génie électrique à l'École de technologie supérieure
- M. Maarouf Saad, professeur au Département de génie électrique à l'École de technologie supérieure

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DÉVELOPPEMENT D'UN LOGICIEL POUR FACILITER L'IMPLANTATION DE LA MAINTENANCE PRÉDICTIVE TOTALE DANS LE CADRE DE ISO 9000- GESTION DE LA QUALITÉ TOTALE

(Sommaire)

Ce mémoire a comme objectifs le développement d'une méthodologie d'implantation de la gestion de la qualité totale (TQM) et la maintenance productive totale (TPM) dans un environnement ISO 9000 et ISO 14000. Pour faciliter une telle implantation, un logiciel intégré est développé en vue de gérer les diverses activités électromécaniques d'un département d'entretien en entreprise.

Dans la première partie du mémoire, tous les éléments qui permettent de comprendre les fondements de la qualité totale et de la maintenance productive totale sont présentés et clarifiés, avec la satisfaction du client comme un objectif majeur à atteindre. Une approche systématique sera suivie afin que tous les éléments de la TQM et TPM soient examinés attentivement et intégrés harmonieusement avec les autres éléments de ces deux philosophies de gestion. Ceci est fait dans le but d'assurer le succès de l'implantation de la TQM et la TPM dans l'environnement difficile, et souvent exigeant d'un département de maintenance.

Dans ce mémoire, les normes internationales en gestion de qualité (ISO 9000) et de l'environnement (ISO 14000) acceptées à travers le monde vont jouer un rôle de premier plan afin de comprendre, clarifier et satisfaire les besoins des clients. Que ces standards soient développés par l'organisation internationale de normalisation (ISO), ou par d'autres organismes, ils sont utilisés durant toutes les phases de cette recherche comme un instrument technique et manageriel pour nous guider dans le développement de la méthodologie. Il est à noter que ces normes visent la mise en place et l'application des principes du travail en équipe, de consensus lors des prises de décision, de communication efficace et de la transparence. De cette façon ISO et les autres standards font la promotion du rationalisme, de la sécurité, de l'efficacité, de réduction du gaspillage, de la protection de l'environnement, de la santé et sécurité au travail et utilement, de la satisfaction du client.

La deuxième partie du mémoire est consacrée au développement d'un logiciel sous plate-forme ACCESS. Le logiciel est conçu pour gérer les activités de la maintenance dans une entreprise certifiée ISO 9000 ou 14000. Il permet à l'organisation de s'adapter et répondre rapidement aux besoins de ses clients. Afin d'atteindre les objectifs d'un service rapide et efficace, une planification chronologique des travaux d'entretien doit être établie et suivie. Pour accomplir leurs tâches, chaque membre de l'équipe de maintenance doit suivre les procédures écrites préétablies. De plus, le personnel impliqué doit être informé lorsque des déviations du plan surgissent pour demander de l'aide ou entreprendre des actions correctives appropriées. Le logiciel permet qu'une évaluation en temps réel des besoins des travaux d'entretien en cours soit disponible à tous les décideurs concernés. De plus, plusieurs rapports techniques sont disponibles pour permettre aux responsables d'allouer, ou replanifier l'allocation des travaux aux diverses équipes d'entretien.

Cet outil informatique sera de grande utilité lorsque les gestionnaires désirent obtenir la mise à jour des données sur un système de production, un équipement en particulier ou même une composante. Nous croyons qu'un tel accès instantané et en temps réel à des rapports ou données adéquatement classés facilitera l'implantation de la TQM et la TPM afin d'optimiser et d'améliorer la gestion des activités de maintenance en entreprise.

DÉVELOPPEMENT D'UN LOGICIEL POUR FACILITER L'IMPLANTATION DE LA MAINTENANCE PRÉDICTIVE TOTALE DANS LE CADRE DE ISO 9000- GESTION DE LA QUALITÉ TOTALE

(Résumé)

Ce mémoire a comme objectifs le développement d'une méthodologie d'implantation de la gestion de la qualité totale (TQM) et la maintenance productive totale (TPM) dans un environnement ISO 9000 et ISO 14000. Pour faciliter une telle implantation, un logiciel intégré est développé en vue de gérer les diverses activités électromécaniques d'un département d'entretien en entreprise.

Dans la première partie du mémoire, tous les éléments qui permettent de comprendre les fondements de la qualité totale et de la maintenance productive totale sont présentés et clarifiés, avec la satisfaction du client comme un objectif majeur à atteindre. Une approche systématique sera suivie afin que tous les éléments de la TQM et TPM soient examinés attentivement et intégrés harmonieusement avec les autres éléments de ces deux philosophies de gestion. Ceci est fait dans le but d'assurer le succès de l'implantation de la TQM et la TPM dans l'environnement difficile, et souvent exigeant d'un département de maintenance.

Dans ce mémoire, les normes internationales en gestion de qualité (ISO 9000) et de l'environnement (ISO 14000) acceptées à travers le monde vont jouer un rôle de premier plan afin de comprendre, clarifier et satisfaire les besoins des clients. Que ces standards soient développés par l'organisation internationale de normalisation (ISO), ou par d'autres organismes, ils sont utilisés durant toutes les phases de cette recherche comme un instrument technique et manageriel pour nous guider dans le développement de la méthodologie. Il est à noter que ces normes visent la mise en place et l'application des principes du travail en équipe, de consensus lors des prises de décision, de communication efficace et de la transparence. De cette façon ISO et les autres standards font la promotion du rationalisme, de la sécurité, de l'efficacité, de réduction du gaspillage, de la protection de l'environnement, de la santé et sécurité au travail et utilement, de la satisfaction du client.

Il y a aussi la demande continue afin que les gestionnaires offre un meilleur service à la clientèle, améliore l'aménagement, offre des rendements d'énergie électrique et mécanique fiables et ce, au même coût qu' à celui du budget d'opération de l'année dernière. En général, cette nouvelle façon de regarder comment la maintenance et les opérations reliés aux bâtiments constitue une excellente idée. Dans cette thèse, nous discuterons des concepts et des éléments principaux qui améliorent les fonctions reliées à la maintenance de bâtiments ainsi qu'à préparer ces endroits à un environnement informatisé.

La conjoncture économique et compétitive dans laquelle nous vivons exige que l'industrie maintienne des capacités de production maximale et l'investissement en capital au minimum. Du point de vue de la maintenance, cela signifie qu'il faut trouver des moyens pour maximiser la fiabilité des équipements et les temps de marche ainsi que d'étirer la durée de vie des équipements et de l'usine par le biais d'une maintenance efficace. Pour atteindre ces objectifs, l'industrie doit s'éloigner des méthodes de maintenance réactives traditionnelles et se tourner vers des philosophies de maintenance et de gestion proactives. Les processus de maintenance qui répondent au programme et aux préoccupations techniques de la maintenance doivent être adoptés et le processus devra tenir coTPMe de l'importance de l'intégration, de l'ingénierie, de la planification et de la qualité. De tels changements requièrent un virage complet en ce qui a trait à l'approche de la maintenance. La maintenance préventive totale constitue une telle approche.

La maintenance préventive totale est basée sur le principe qu'une maintenance efficace nécessite que les éléments de la maintenance soient définis, opérationnels et interactifs. Ceux-ci seront présentés dans cette thèse, en plus des concepts d'implantation de la maintenance préventive totale dans des installations de maintenance dépendante ou indépendante.

Lorsque nous développons un programme de maintenance planifiée pour une compagnie, il est important de considérer chacun des éléments de fonction (logique) de la maintenance et ainsi, développer la fonction globale afin que chaque élément rencontre les besoins de l'entreprise et les besoins techniques qui s'y rattachent.

L'aspect le plus important d'un programme de maintenance est le développement et l'utilisation d'activités de maintenance efficaces. Une des méthodes utilisée pour déterminer quelles sont ces activités est la maintenance axée sur la fiabilité. La maintenance a un grand impact sur la durée de vie des équipements car le département de la maintenance doit participer à toutes les étapes de la sélection des nouveaux systèmes et équipements. Ces étapes qui sont identifiées dans la présente thèse sont : l'identification des besoins, la planification et le développement anticipés, le développement anticipé ainsi que le design d'un système préliminaire, le design des détails et le développement, la conception et le montage, l'entretien des systèmes par le biais d'un soutien pour sa durée de vie et la mise hors service du système. De plus, il faut considérer d'autres facteurs qui ont un impact direct sur les activités de maintenance telles que les exigences de manutention des appareils, l'entraînement du personnel affecté aux opérations et à la maintenance, l'installation auxiliaire, la cueillette des données, le traitement de la gestion et d'autres facteurs reliés.

La deuxième partie du mémoire est consacrée au développement d'un logiciel sous plate-forme ACCESS. Le logiciel est conçu pour gérer les activités de la maintenance dans une entreprise certifiée ISO 9000 ou 14000. Il permet à l'organisation de s'adapter et répondre rapidement aux besoins de ses clients. Afin d'atteindre les objectifs d'un service rapide et efficace, une planification chronologique des travaux d'entretien doit être établie et suivie. Pour accomplir leurs tâches, chaque membre de l'équipe de maintenance doit suivre les procédures écrites préétablies. De plus, le personnel impliqué doit être informé lorsque des déviations du plan surgissent pour demander de l'aide ou entreprendre des actions correctives appropriées. Le logiciel permet qu'une évaluation en temps réel des besoins des travaux d'entretien en cours soit disponible à tous les décideurs concernés. De plus, plusieurs rapports techniques sont disponibles pour permettre aux responsables d'allouer, ou replanifier l'allocation des travaux aux diverses équipes d'entretien.

Afin de développer de tels outils, il faut identifier les principaux éléments de fonction (logiques) de la maintenance. Les éléments et leurs buts sont identifié comme suit :

a. Organisation et administration de la maintenance - Fournir des principes régissant et des concepts sur lesquels la fonction de la maintenance est basée.
b. Mesure d'efficacité - Fournir des indicateurs de performance qui seront utilisés pour mesurer l'efficacité de chacun des éléments ainsi que le processus de maintenance en général.
c. Contrôle du travail - Fournir des façons de planifier, d'ordonnancer, d'exécuter la maintenance et d'enregistrer les données nécessaires afin d'évaluer les performances vs les buts et objectifs.
d. Système d'information de gestion de la maintenance - Outil par lequel les ressources de maintenance sont gérées. La technologie qui procure un avantage concurrentiel quant à la fonction de la maintenance.
e. Personnel – les politiques, programmes et les systèmes utilisés afin de s'assurer que le personnel soit en mesure d'accomplir certaines activités nécessaires à l'exécution efficace de la fonction de maintenance.
f. Documentation technique – Maintenir une cohérence entre le matériel des installations et la documentation qui définit le matériel(hardware).
g. Gestion de la configuration – Maintenir le matériel (hardware) dans une configuration connue.
h. Support logistique – S'assurer que les bonnes ressources sont en place pour les activités de maintenance, lorsque nécessaire.

i. Activités de maintenance – S'occuper de bien entretenir les actifs de l'usine afin que l'on puisse maximiser la durée de vie des équipements.

j. Ingénierie de la maintenance –Surveiller les fonctions de maintenance afin de s'assurer que les bonnes choses sont faites correctement.

Ce programme logiciel de maintenance (Master) est en fait une méthode de maintenance et de gestion informatisée qui préconise la planification de la maintenance sous tous ses aspects (i.e, préventive, prédictive et corrective) ainsi que le contrôle de la qualité en ce qui a trait à la maintenance. Il s'agit d'un concept qui examine à la fois la programmation mais aussi les préoccupations techniques de la maintenance, et considère la maintenance en tant que fonction intégrée. Le programme de logiciel de maintenance est basé sur le principe qu'une maintenance nécessite que les éléments de celle-ci soient définis, opérationnels et interactifs.

L'aspect le plus important de ce programme logiciel de maintenance est le développement et l'utilisation efficace des activités de maintenance. Notre outil sera aussi utile afin de fournir des informations réelles et en-ligne concernant le statut des équipements et des composantes. L'on s'attend que de telles données instantanées, précises, classifiées de façon appropriée et facilement accessibles puissent favoriser l'implantation de la TQM et TPM de façon à gérer et optimiser les installations de maintenance.

En mettant l'emphase sur la satisfaction aux exigences d'ISO, la date d'achèvement planifiée et l'horaire des activités doivent être établis pour chaque étape du travail. Le membre de l'équipe désigné doit être informé de tout délai qui survient ou qui pourrait survenir afin que des interventions ou des mesures correctives puissent être examinées. Ainsi, le travail approuvé peut se dérouler activement et avec succès jusqu'à ce qu'il soit complété.

Le logiciel élaborera des moyens afin de réévaluer périodiquement la situation d'un point de vue technique et administratif. Des mécanismes existants qui seront fournis par le biais des rapports de gestion technique seront utilisés afin d'établir diligemment le plan de contingence et réaffecter le travail aux équipes disponibles ou alternatives.

Cette thèse explique de quelle façon les approches traditionnelles et planifiées ainsi que les procédures et techniques utilisées peuvent simplifier l'implantation de la gestion de la qualité totale et la maintenance préventive totale dans des installations industrielles. Un outil informatisé intelligent (MASTER) a été développé afin de gérer les différentes activités dans toute installation de maintenance, basée sur les normes des exigences d'ISO 9000 et 14 000.

Puisque les données d'entrées et de sorties peuvent être classifiées dans des catégories distinctes, de tels outils s'avéreront utiles quant à l'évaluation de la fiabilité et en-ligne des systèmes et du statut des composantes. De plus, cela fournira les données mises à jour pour tous les niveaux d'usagers.

Nous croyons fermement que ce logiciel aidera grandement le personnel affecté à la maintenance dans les installations afin de correctement identifier et de régler les problèmes reliés aux équipements. Ce logiciel aidera aussi à prédire la durée de vie à venir ainsi que la valeur de tout le matériel à l'intérieur des installations, à l'aide de statistiques. Donc, les machines peuvent être fiables et opérées sans danger. Par exemple, le logiciel peut fournir des données importantes à l'ingénieur de maintenance sur une base régulière via son terminal afin de l'aider à prendre les actions appropriées et ce, en tout temps. Une fois entièrement implantée, une cette approche et cet outil logiciel permettront la détection de problème et réduira la défectuosité de l'équipement et les temps de mise hors fonction.

En travaillant sous l'infrastructure des normes de la famille ISO 9000, cela apporte des lignes directrices en vue d'une amélioration continue de la qualité. De plus, il ne faut pas oublier que la famille ISO 14000 permettra à l'installation de contrôler l'impact de ses activités ou de ses services dans son environnement.

L'implantation de la gestion de la qualité totale dans l'installation de maintenance, utilisant cet outil logiciel, apportera un concept d'ensemble qui favorise l'amélioration continue dans une organisation. Cela permettra de se concentrer sur la satisfaction totale des besoins des clients internes et externes. Cela peut être accompli au sein d'un environnement qui recherche une amélioration continue de toutes les fonctions et les processus. L'on mettra l'emphase sur les coûts du cycle de vie optimal et des mesures appropriées à l'intérieur d'une méthodologie dirigée en vue d'atteindre de telles améliorations.

L'utilisation de ce logiciel aidera le personnel de maintenance des installations d'identifier les problèmes reliés aux équipements avec précision. Le système aidera à prédire la durée de vie à venir ainsi que de la valeur du matériel à l'intérieur des installations, à l'aide de statistiques. Par conséquent, les machines peuvent être fiables et opérées sans danger. Le rendement d'une machine du système deviendrait disponible pour l'ingénieur de maintenance via son terminal et pourrait l'aider à prendre des actions lorsque nécessaire. Une fois que le tout a été entièrement implanté, cette approche et ce système permettraient la détection de problèmes et réduiraient de telles occurrences.

L'objectif de cette thèse a été réalisé par le développement d'un moyen qui puisse déterminer l'état du système et de la machine tout en fonctionnant (rapports en-ligne). Les données d'entrées et sorties du système peuvent être classifiées dans des catégories distinctes et qui peuvent indiquer l'état des équipements, de façon fiable. Basé sur cette approche, un système implanté aidera le personnel de maintenance dans les installations afin d'identifier les problèmes reliés aux équipements avec précision. L'implantation de la gestion de la qualité totale en ce qui a trait à la maintenance dans les installations apportera un concept global qui favorisera l'amélioration continue dans l'organisation. Le focus sera mis principalement sur la satisfaction à la fois des clients internes et externes, dans un environnement de gestion qui recherche à continuellement améliorer tous les systèmes et processus. L'emphase sera mis sur les coûts du cycle optimal de vie et l'utilisation de mesures au sein d'un méthodologie dirigée, visant à atteindre l'amélioration continue.

Le succès d'une installation de maintenance nécessite l'identification systématique et l'établissement des priorités pour chacune des différentes activités de telles installations. Cela doit être fait en relation en temps opportun ainsi qu'en tenant compte des besoins des clients de chacun des secteurs spécifiques dans la compagnie.

Des procédures et règles claires sont obligatoires afin d'atteindre l'établissement des priorités et du suivi des activités complétées. La direction doit mettre l'emphase sur l'achèvement des activités à priorité supérieure; elle doit aussi utiliser les données disponibles et les rapports générés par le logiciel. Afin de s'assurer de la disponibilité de ressources adéquates et de la réalisation des résultats planifiés, une application proactive des concepts de techniques de gestion de projet doivent être utilisée.

La maintenance prédictive, préventive et proactive ne sont pas des programmes mais plutôt un style de maintenance qui mène les composantes vers la fiabilité. Un changement vers ce style de maintenance n'est guère facile. Cela nécessite un virage majeur non seulement dans la façon d'effectuer la maintenance mais aussi dans la façon dont l'équipement est opéré. La route vers la fiabilité doit être composée de systèmes entrecroisés dynamiques, visant toujours l'amélioration continue. Des indicateurs de surveillance doivent être établis car ils indiqueront les effets du changement au niveau des systèmes. Des indicateurs de surveillance doivent aussi être utilisés pour démontrer l'impact des efforts sur les processus.

Avant que l'on puisse utiliser le contrôle du processus statistique sur le processus, avant que les goulots d'étranglement puissent être identifiés au sein des processus intégrés, avant qu'un plan de contrôle puisse être implanté, la maintenance reliée aux défaillances doit être réduite au minimum, et si possible, éliminée. Les processus qui opèrent avec une méthode de défaillance ne sont pas stables, rendant les données reliées au processus presque inutiles. Les processus qui opèrent dans un mode de défaillance sont insatisfaisantes, faisant en sorte qu'il devient impossible de déterminer la zone où pourrait se trouver le goulot d'étranglement.

L'implantation d'un système de code à barres améliore la productivité du travail mais l'avantage principal demeure les données de maintenance qui sont précises, fiables et auxquelles on peut accéder lorsqu'opportun. De nos jours, le codage par code à barres est devenu nécessaire aux opérations de gestion des matériaux et de la maintenance car les équipements d'analyse de vibrations servent à prédire la maintenance (prédictive) ainsi que l'amélioration continue de la fiabilité. Les temps où l'on écoutait un coussinet qui faisait du bruit par le bout d'un tournevis est presque révolu. La technologie d'identification automatique maintenant disponible offre aux leaders de la maintenance un autre outil important – un outil qui recueille des informations reliées à la maintenance de façon précise et au moment opportun, afin de gérer et de diriger des opérations de maintenance essentielles à la mission.

Cet outil informatique sera de grande utilité lorsque les gestionnaires désirent obtenir la mise à jour des données sur un système de production, un équipement en particulier ou même une composante. Nous croyons qu'un tel accès instantané et en temps réel à des rapports ou données adéquatement classés facilitera l'implantation de la TQM et la TPM afin d'optimiser et d'améliorer la gestion des activités de maintenance en entreprise.

DEVELOPMENT OF A SOFTWARE TO FACILITATE THE IMPLEMENTATION OF TOTAL PRODUCTIVE MAINTENANCE IN AN ISO 9000 - TOTAL QUALITY MANAGEMENT FRAME WORK

(Abstract)

The objective of this thesis is to develop a methodology to implement the total quality management (TQM) and total productive maintenance (TPM) under an ISO 9000 and ISO 14000 fram work. To facilitate such implementation, an integrated computer software is developed to manage the different activities in the electromechanical maintenance facilities in any type of industry.

In the first part of this thesis we start by introducing and clarifying every element that form the base to the understanding of the total Quality Management and total Productive Maintenance philosophies with the customer satisfaction as a major target. A systematic approach will be followed so that each element of the TQM and TPM can be brought under attention and bonded smoothly with the other elements of these two philosophies. This is done to ensure the success of the implantation of TQM and TPM in the difficult and sometimes demanding environment of the maintenance facilities.

To help clarify, understand and support the customer needs, globally applicable standards will play a key role. Such standards, whether developed by the International Standardization Organisation (ISO 9000 for Quality Management and ISO 14000 for Environment Management) or other organisations will become the primary instrument to guide us in the process.

These standards strive to perfect, at all times, the application of teamwork consensus, direct communication, and transparency principles in management. In this way ISO and other standards promote the values of rationality, utility, safety, waste reduction, environmental protection and ultimately, the customer satisfaction.

In the second part of the thesis, a computer software is developed to manage the activities of the maintenance facility within ISO 9000 and 14000 framework. The software will give the organisation the capability to adapt and to respond rapidly to the ever-changing needs of the customers it serves. Such fast and cost efficient service

requires a planned completion date and a supporting timetable for actions that must be established for each job. To achieve these objectives, each team member should follow written procedures and must be informed when deviations from the planned schedule occur or is expected so that possible assistance or remedial actions may be considered. The software is developed such that real-time evaluation and current needs for standing activities are available to all levels of management. Many Technical Management Reports are also introduced to rapidly assign or re-assign jobs to the working teams.

The tool will also be useful in providing on line and real time information on the equipment and components' status. Such instantaneous, precise, properly classified and readily available data are expected to help the implantation of the TQM and TPM in order to manage and optimize the maintenance facilities.

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UNITS OF MEASURMENTS USED

Throughout this thesis, S.I. metric units are used. It was decided to maintain S.I. metric units for all subsequent data.

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ABBREVIATION LIST

CAA	: Calibration Level A
CAB	: Calibration Level B
CAC	: Calibration Level C
CE	: Cost Effectiveness
CEO	: Chief Executive Officer
COR	: Corrective Maintenance
DB	: Data Base
DEM	: Demanded
DES	: Description
ELE	: Electrical
ENV	: Environmental Corrective Maintenance
EOS	: Electro Optical System
EST	: Estimated
FE	: Facilities Engineering
HP	: Horse Power
ID	: Identification Code
ISO	: International Organization for Standardisation
LCC	: Life-Cycle Cost
LCM	: Life-Cycle Maintenance
LS	: Logistics Support
MEC	: Mechanical
MTBF	: Mean Time Between Failure
MTBM	: Mean Time Between Maintenance

O&M : Operation & Maintenance
OMM : Operations and Maintenance Manuals
ORD : Ordered
PDCA : Plan-Do-Check-Act
PDSA : Plan-Do-Check-Study
PR1 : Preventive Maintenance Level (1)
PR2 : Preventive Maintenance Level (2)
PR3 : Preventive Maintenance Level (3)
PR4 : Preventive Maintenance Level (4)
QC : Quality Control
QCC : Quality Control Circle
R&D : Research & Development
RAD : Radar
SE : System Effectiveness
TPM : Total Productive Maintenance
TQM : Total Quality Management
WM : Wait Machine Or Tool
WP : Wait Parts
WR : Wait Repair
WS : Wait Shop
WT : Wait Technician

INTRODUCTION

Historic

Quality can be interpret as "Customer's expressed and implied requirements are met fully". This is a core statement from which some eminent definitions of quality have been derived. They include "the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need" [ISO, 1994] [27], "fitness for use" [Juran, 1988] [15], and "conformance to requirement" [Crosby, 1979] [22].

It is important to note that satisfying the customer's needs and expectations are the main factor in all these definitions. Therefore it is an imperative for a company to identify such needs early in the product/service development cycle. The ability to define accurately the needs related to design, performance, price, safety, delivery, and other business activities and processes will place a firm ahead of its competitors in the market.

In 1992 Crosby [22] broadened his definition for quality adding an integrated notion to it: "Quality meaning getting everyone to do what they have agreed to do and to do it right the first time is the skeletal structure of an organization, finance is the nourishment, and relationships are the soul." Some Japanese companies find that "conformance to a standard" too narrowly reflects the actual meaning of quality and consequently have started to use a newer definition of quality as "providing extraordinary customer satisfaction". There is a trend in modern day competition among Japanese companies to give you rather more in order to 'delight' you.

Objectives

This thesis consists of two objectives. The first one is to select a methodology to implement the total quality management and the total productive maintenance in the maintenance facilities. The second one is to develop a software tool to implement and control the total productive maintenance under ISO 9000 and ISO 14000 frame work.

CHAPTER 1

TOTAL QUALITY MANAGEMENT & TOTAL PRODUCTIVE MAINTENANCE REVIEW

Introduction

The term Total Quality Management still poses problems of definition for writers on quality, and consequently often remains a rather abstract term. There are a number of well-known quality definitions. ISO 8402 [ISO, 1986] [10] defines quality as "the totality of features and characteristics of a product or service that bears on its ability to meet a stated or implied need". [Crosby, 1979] [10] Defines quality as "conformance to requirement". [Juran, 1988] [10] Defines quality as "fitness for use". Japanese companies found the old definition of quality "the degree of conformance to a standard" too narrow and consequently have started to use a new definition of quality as "user satisfaction" [Wayne, 1983] [27].

1.1 Quality Definition

The quality has three types of definition (figure 1):

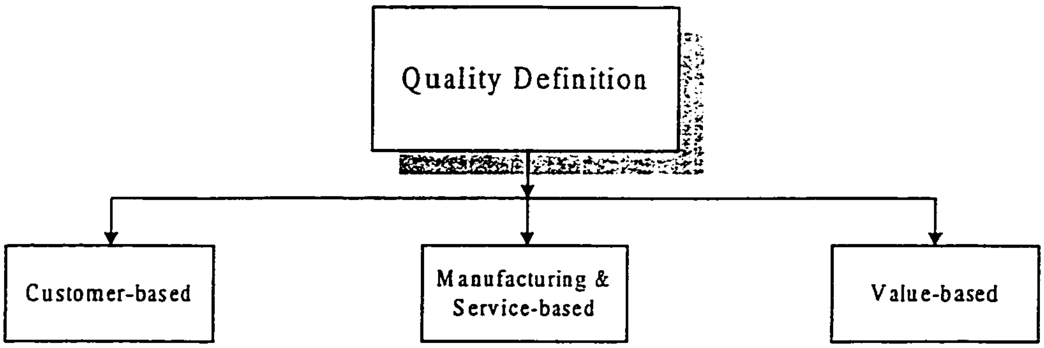

Figure 1 : Quality Definition

1.1.1 Customer-based Definitions

Quality is the degree to which a specific product satisfies the wants of a specific consumer. Kuehn & Day [1962] [27] defines it as " In the final analysis of the marketplace, the quality of a product depends on how well it fits patterns of consumer preferences". And had been defined as Quality consists of the capacity to satisfy wants. We can say that Quality consists of the capacity to satisfy wants and it is "fitness for use " Juran [1988] [15]. The core of a total quality approach is to identify and meet the requirements of both internal and external customers.

1.1.2 Manufacturing & Service-based definitions

From the manufacturing & service point of view, Crosby [1979] [21] define it as the conformance to requirements price [1985] "Do it right first time".

1.1.3 Value-based definitions

Quality is to satisfy customer's requirements continually, Total Quality Management is to achieve quality at low cost by involving everyone's daily commitment. Quality must be achieved in five basic areas: people, equipment, methods, materials and the environment to ensure customer's need are met. Quality is the degree of excellence at an acceptable price and the control of variability at an acceptable cost.

1.2 Total Quality Management

Total Quality Management provides the overall concept that fosters continuous improvement in an organization. The Total Quality Management philosophy stresses a systematic, integrated, consistent, organization-wide perspective involving everyone and everything. It focuses primarily on total satisfaction for both the internal and external customers, within a management environment that seeks continuous improvement of all systems and processes. Total Quality Management emphasizes use of all people, usually in multifunctional teams, to bring about improvement from within the organization. It stresses optimal life cycle costs and uses measurement within a disciplined methodology in achieving improvements. The key aspects of Total Quality Management are the prevention of defects and emphasis on quality in design. Total Quality Management is a necessity. It is a journey that will never end. It makes Japanese industry a miracle. It is the way to survive and succeed. What does it entail, then? Total Quality Management is the totally integrated effort for gaining competitive advantage by continuously improving every facet of an organization's activities. If we look at the meaning of each word, Total Quality Management can be defined as:

Total - Everyone associated with the company is involved in continuous improvement (including its customers and suppliers if feasible),

Quality - Customers' expressed and implied requirements are met fully,

Management - Executives are fully committed.

It is apparent that all companies that have implemented Total Quality Management want to provide good quality goods and services to their customers. The end result is that they will enjoy prosperity and long-term growth. Once an organization have gone through all the five stages of the Total Quality Management model, it is likely to have built a very strong basis and a proactive environment for the final stage, Total Quality Management. There are clear business objectives and effective processes installed, with empowered employees committed to quality; ISO 9000 quality management system is in place to demonstrate the disciplined approach to quality improvement and all equipments and facilities are in good condition and utilization consistently.

1.3 Total Quality Management Gurus' Ideas

We need to introduce the total quality management guru's ideas as a guide to help us in building quality model, for implementing the TQM.

- Dr. Edward W. Deming (management philosophy and systems)
- Dr. Joseph M. Juran (quality trilogy)
- Dr. Philip Crosby (zero defects and cost of quality)
- Dr. Kaoru Ishikawa (simple tools, company-wide quality)
- Dr. Shigeo Shingo (Fool-proofing)
- Dr. Yoshio Kondo (four steps for making creative and quality work)

1.3.1 Deming's Message

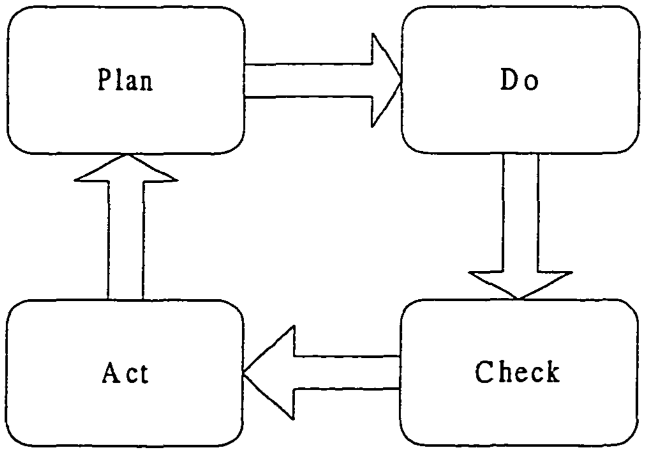

Figure 2 : Plan-Do-Check-Act

Deming [34] encouraged the Japanese to adopt a systematic approach to problem solving, which later became known as the Deming or Plan-Do-Check-Act Cycle (figure 2). He subsequently replaced "Check" by "Study", as that word reflects the actual meaning more accurately. Therefore an alternative abbreviation for the Deming Cycle is PDSA Cycle. Deming also pushed senior managers to become actively involved in their company's quality improvement programs. His greatest contribution to the Japanese is the message regarding a typical business system. It explains that the consumers are the most important part of a production line. Meeting and exceeding the customers' requirements is the activity that everyone within an organization needs to accomplish. Furthermore, the management system has to enable everyone to be responsible for the quality of his output to his internal customers.

1.3.2 Juran's Message

Juran [17] developed the idea of quality trilogy: quality planning, quality improvement and quality control. These three aspects of company-wide strategic quality planning are further broken down in Juran's 'Quality Planning Road Map', (figure 3) into following key elements:

Figure 3: Quality Planning Road Map

Quality Planning

Identify who are the customers.

Determine the needs of those customers.

Translate those needs into our language.

Develop a product that can respond to those needs.

Optimize the product features so as to meet our needs & customer needs.

Quality Improvement

Develop a process, which is able to produce the product.

Optimize the process.

Quality Control

Prove that the process can produce the product under operating onditions.

Transfer the process to Operations.

1.3.3 Crosby's Message

Crosby's [22] name is best known in relations to the concepts of “Do It Right First the time” and “Zero Defects”. He considers traditional quality control, acceptable quality limits and waivers of sub-standard products to represent failure rather than assurance of success. Crosby therefore defines quality as conformance to the requirements, which the company itself has established for its products, based directly on its customers' needs. He believes that since most companies have organizations and systems that allow deviation from what is really required, manufacturing companies spend around 20% of their revenues doing things wrong and doing them over again. According to Crosby this can be 35% of operating expenses for service companies.

He does not believe that workers should take prime responsibility for poor quality; the reality, he says, is that you have to get management straight. In the Crosby scheme of things, management sets the tone on quality and workers follow their example; whilst employees are involved in operational difficulties and draw them to management's attention, the initiative comes from the top. Zero defects means that the company's objective is 'doing things right first time'. This will not prevent people from making mistakes, but will encourage everyone to improve continuously.

In the Crosby approach creating a core of quality specialists within the company spreads the Quality Improvement message. There is strong emphasis on the top-down approach, since he believes that senior management is entirely responsible for quality.

The ultimate goal is to train all the staff and give them the tools for quality improvement, to apply the basic precept of Prevention Management in every area. This is aided by viewing all work as a process or series of actions conducted to produce a desired result. A process model can be used to ensure that clear requirements have been defined and understood by both the supplier and the customer. He also views quality improvement as an ongoing process since the work 'program' implies a temporary situation. Crosby's Quality Improvement Process is based upon the Four Absolutes of Quality Management

a. Quality is defined as conformance to requirements, not as 'elegance'.
b. The system for causing quality is prevention, not appraisal.
c. The performance standard must be Zero Defects, not "that's close enough".
d. The measurement of quality is the Price of Nonconformance, not indices.

1.3.4 Ishikawa's Message

Ishikawa's [33] biggest contribution is in simplifying statistical techniques for quality control in industry. At the simplest technical level, his work has emphasized good data collection and presentation, the use of Pareto Diagrams to prioritize quality improvements and Ishikawa Diagrams. Ishikawa sees the Cause-and-Effect Diagram or Ishikawa Diagram, figure (4), like other tools, as a device to assist groups or quality circles in quality improvement. As such, he emphasizes open group communication as critical to the construction of the diagrams. Ishikawa diagrams are useful as systematic tools for finding, sorting out and documenting the causes of variation of quality in production and organizing mutual relationships between them. Other techniques Ishikawa has emphasized include the seven Quality Control tools.

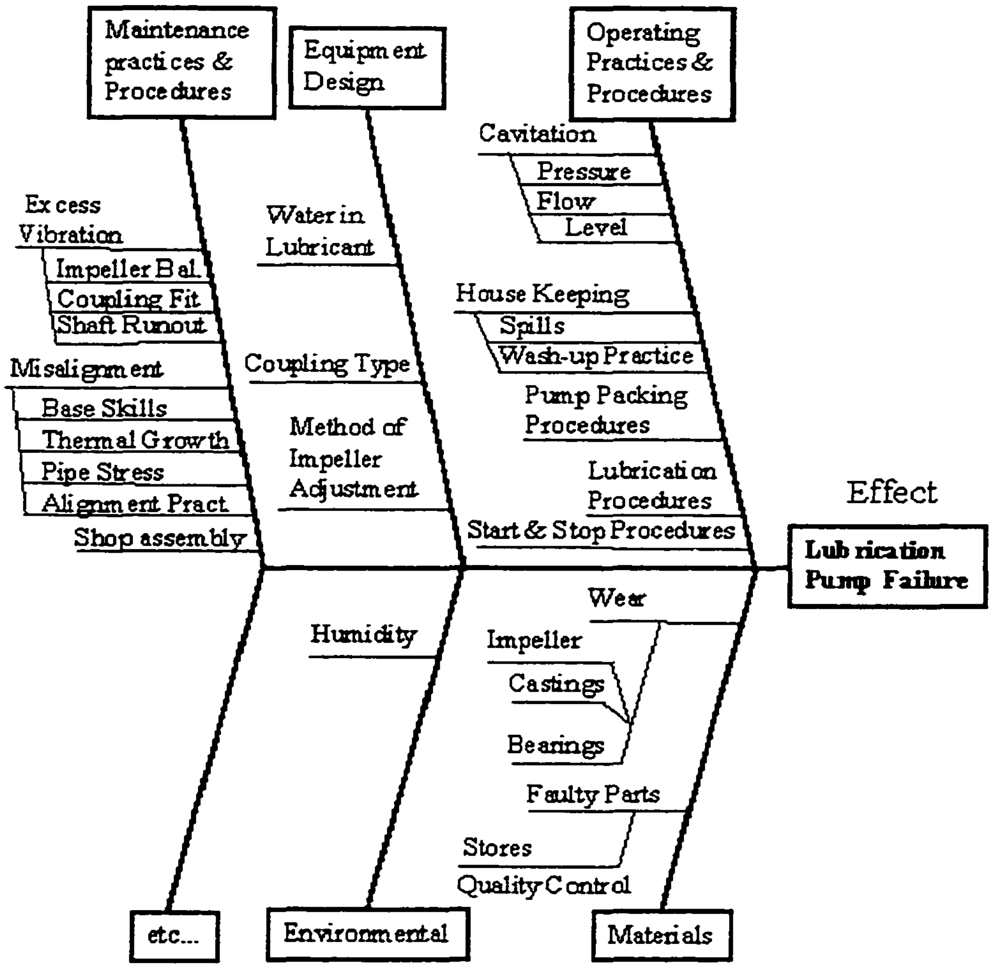

Figure 4: Cause-and-Effect Diagram

Other than technical contributions to quality, Ishikawa is associated with the Company-wide Quality Control. Movement that started in Japan during the period 1955-60 follows the visits of Deming and Juran. Ishikawa sees the Company-wide Quality Control as implying that quality does not only mean the quality of product, but also of after sales service, quality of management, the company itself and the human life. The outcomes of such an approach are:

a. Product quality is improved and becomes uniform. Defects are reduced.

b. Reliability of goods is improved.
c. Cost is reduced.
d. Quantity of production is increased, and it becomes possible to make rational production schedules.
e. Wasteful work and rework are reduced.
f. Technique is established and improved.
g. Expenses for inspection and testing are reduced.
h. Contracts between vendor and vendee are rationalized.
i. The sales market is enlarged.
j. Better relationships are established between departments.
k. False data and reports are reduced.
l. Discussions are carried out more freely and democratically.
m. Meetings are operated more smoothly.
n. Repairs and installation of equipment and facilities are done more rationally.
o. Human relations are improved.

1.3.5 Shingo's Message

In terms of quality, Shingo's [32] paramount contribution was his development in the 1960s of Poka -Yoke and source inspection systems. These developed gradually as he realized that statistical quality control methods would not automatically reduce defects to zero.

The basic idea is to stop the process whenever a defect occurs, define the cause and prevent the recurring source of the defect. No statistical sampling is therefore necessary. A key part of this procedure is that source inspection is employed as an active part of production to identify errors before they become defects. Error detection either stops production until the error is corrected, or it carries adjustment to prevent the error from becoming a defect. This occurs at every stage of the process by monitoring potential error sources. Thus defects are detected and corrected at source, rather than at a later stage.

Following a visit to Yamada Electric in 1961, Shingo [27] started to introduce simple, mechanical devices into assembly operations, which prevented parts from being assembled incorrectly and immediately signaled when a worker had forgotten one of the parts. These mistake-proofing or 'Poka-Yoke' devices had the effect of reducing defects to zero. In 1967 Shingo [27] further refined his work by introducing source inspections and improved Poka-Yoke [32] systems, which actually prevented the worker from making errors so that defects could not occur. Associated advantages were that statistical sampling was no longer necessary, and that workers were more free to concentrate on more valuable activities such as identifying potential error sources. Having learned about and made considerable use of statistical QC in his 40s. It was some 20 years later, in 1977, that Shingo observed that the Shizuoko plant of Matsushita's Washing Machine Division had succeeded continuously for one month with zero defects on a drain pipe assembly line with involvement of 23 workers. He realized that statistical QC is not needed for zero-defect operations. This was achieved principally through the installation of Poka-Yoke devices to correct defects and source inspection to prevent defects occurring. Together these techniques constitute Zero Quality Control, which, Shingo argues, can achieve what may have been impossible using statistical quality control methods.

Shingo advocated the practical application of zero defects by good engineering and process investigation, rather than slogans and exhortations that have been associated with the quality campaigns of many American and Western companies. Shingo, like

1.3.6 Kondo's Message

Kondo [27] emphasizes the interrelationship between quality and people. He sees humanity as the essence of motivation. He endorses that human work should always include the following three components:

- Creativity - the joy of thinking
- Physical activity - the joy of working with sweat on the forehead
- Sociality - the joy of sharing pleasure and pain with colleagues

He further points out that the elements of creativity and sociality are involved in company-wide quality control as well as physical activity. Since the aim is to ensure the superior quality of manufactured products and service through the stages of marketing, designing and manufacturing and, in doing so, promote customer satisfaction.

The major problems lie in the stages of designing the manufacturing process and evaluating the results of the work. When manufacturing is conducted only by standardizing and simplifying the work and by separating planning from actual execution and when the results of the work are judged only in terms of money, how can we motivate workers by offering them meaningful jobs? In his book Human Motivation - A Key Factor for Management published in 1989 [27]; Kondo advocates that making work more creative is important for motivation. He suggests four points of action:

a. When giving work instruction, clarify the true aims of the work. Instead of explaining clearly what the aim of a job is, people tend to concentrate on the methods and means to be used for achieving that aim. However, every job has an aim, and it goes without saying that achieving this aim is the most important thing. Aside from mandatory restrictions related to safety and quality assurance, information concerning means and methods should be given for reference only, and we should encourage people to devise their own best ways of achieving the objectives.

b. See that people have a strong sense of responsibility towards their work. This is related to the previous point. As we know well, human beings are often weak and irrational and tend to try to shift responsibility onto someone else when their work goes wrong, complaining or being evasive. It is, therefore, necessary to devise ways of nipping such excuses in the bud whenever they seem likely to appear. The 'mandatory objectives, optional means' approach described in Point (1) above serves this purpose, and techniques. Such as the stratification of data, the correction of data by mean value or by regression, and the application of the orthogonal principle in the design of experiments [Taguchi, 1986] [27] are all effective devices for putting a stop to excuses.

c. Give time for the creation of ideas. Once people start feeling such a strong sense of responsibility, they will go back to the essence of the problem and think about it deeply. This will result in flashes of inspiration and the creation of new ideas. Excellent ideas are most easily generated during those times when we have pondered the problem deeply and have arrived at a detached, meditative state of mind. An ancient Chinese proverb tells us that this kind of time occurs when we are horseback riding, lying down and relaxing. The times at which ideas come most readily are different for every individual. The important thing is to give people the time to be creative.

d. Nurture ideas and bring them to fruition. Newborn ideas created in this way are extremely fragile. If they are examined critically with the intention of picking them to pieces or squashing them down, it is very easy to obliterate them completely. However, to find out whether such ideas are really good or

> not, or to develop them in superior ways, they must be allowed to grow. There is no objection during this stage of growth to allowing an idea to change gradually from its original form into a better one. It is often said that the main enemies of new product development are found within the company itself. This means that people are more concerned about going around stepping on new ideas than about encouraging their development. A newborn idea is like a newborn baby, and raising it to maturity always requires someone to look after its interest and act as a loving parent. In most cases, those in positions of authority are the only ones who can play this role. In other words, managers should not go around throwing cold water on new ideas but should become their patrons and encourage their growth.

Kondo concludes that only by addressing all four points will it be possible for work to be reborn as a creative activity. If ideas are created and fostered, those concerned will come to feel a real sense of self-confidence. This is an extremely valuable experience from the standpoint of motivation.

1.4 ISO Standards

Standards are documented agreements containing technical specifications or other precise criteria to be used consistently as rules, guidelines, or definitions of characteristics, to ensure those materials; products, processes and services are fit for their purpose.

For example, the format of the credit cards, phone cards, and "smart" cards that have become commonplace is derived from an ISO International Standard. Adhering to the standard, which defines such features as an optimal thickness (0,76 mm), means that the cards can be used worldwide.

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies from some 100 countries, one from each country. ISO's work results in international agreements, which are published as International Standards.

Industry-wide standardization is a condition existing within a particular industrial sector when the large majority of products or services conform to the same standards. It results from consensus agreements reached between all economic players in that industrial sectors - suppliers, users, and often governments. They agree on specifications and criteria to be applied consistently in the choice and classification of materials, the manufacture of products, and the provision of services. The aim is to facilitate trade, exchange and technology transfer. Enhanced product quality and reliability at a reasonable price, improved health, safety and environmental protection, and reduction of waste, greater compatibility and interoperability of goods and services, simplification for improved usability, reduction in the number of models, and thus reduction in costs, increased distribution efficiency, and ease of maintenance.

Users have more confidence in products and services that conform to International Standards. Assurance of conformity can be provided by manufacturers' declarations, or by audits carried out by independent bodies.

1.4.1 ISO 9000 and ISO 14000 Norms

The ISO 9000 series [17] of International Standards for quality management and quality assurance has been adopted in more than 90 countries and is being implemented by thousands of manufacturing or service organizations in both public and private sectors.

One of the most successful series of standards in the history of ISO (International Organization for Standardization), ISO 9000 has generated much publicity and made the name of ISO known to a wider business community than the specialists directly concerned with technical standards. The publication in September 1996 of the first standards in the ISO 14000 series on environmental management, and the speed, with which the business community is taking them up, promises more publicity for the name "ISO".

ISO 9000 and ISO 14000 certificates are issued by certification bodies (in some countries, they are called "registration" bodies) independently of ISO, even when a particular body may be part of a national standards organization that is an ISO member. ISO has no authority to oversee the work of quality management system or environmental management system certification bodies. However, the relevant ISO Guide forms a basis for acceptable practice by such bodies. A certification body's adherence, or the lack of it, to these guidelines may be used by a company as one of its criteria for choosing a certification body to audit its quality or environmental management system and issue an ISO 9000 or ISO 14000 certificate.

ISO 9000 is not a product quality labels or guarantee. ISO 14000 is not a "green" or "environmentally friendly" label for products. When an organization has a management system certified to an ISO 9000 or ISO 14000 standard, this means that an independent auditor has checked that the processes influencing quality (ISO 9000), or the processes influencing the impact of the organization's activities on the environment (ISO 14000) conform to the relevant standard's requirements. In plain language, ISO 9000 and ISO 14000 relate to the making of products. They are not product labels.

1.4.2 ISO 9000 family

The ISO 9000 family of standards represents an international consensus on good management practice. Its primary aim is to give organizations guidelines on what constitutes an effective quality management system, which in turn can serve as a framework for continuous improvement. The standard ISO 9004-1 (and the other parts of ISO 9004) gives guidelines on the elements of quality management and a quality system.

The family also includes three quality assurance models ISO 9001, ISO 9002 and ISO 9003 against which the quality system can be audited to see that it complies with ISO 9000 requirements. The organization should carry out this auditing itself to verify that it is managing its processes effectively. In addition, it may invite its clients to audit the quality system in order to give them confidence that the organization is capable of delivering products or services that will meet their needs.

Lastly, the organization may engage the services of an independent quality system certification body to obtain an ISO 9000 certificate of conformity. This last option has proved extremely popular because of the perceived credibility of an independent verification. It may thus avoid multiple audits by the organization's clients, or reduce the frequency or duration of client audits. The certificate can also help establish the organization's credentials as a reliable business partner to potential clients, especially when supplier and customer are new to each other, or far removed geographically, as in an export context.

In some countries, government departments and public authorities are requiring companies bidding for procurement contracts to be ISO 9000 certificate holders.

In some industrial sectors, major companies are requiring their suppliers to comply with ISO 9000. The Client Company may verify compliance itself, or may require the supplier to have an ISO 9000 certificate issued by an independent certification body.

1.4.3 What Standards make up the ISO 9000 family?

The following standards currently make up the ISO 9000 family [17], [25]. Note that standards are constantly being added and revised, so this list can quickly become out of date.

- ISO 9000-1: 1994 Quality management and quality assurance standards-Part 1: Guidelines for selection and use.

- ISO 9000-2:1993 Quality management and quality assurance standards-Part 2: Generic guidelines for the application of ISO 9001, ISO 9002 and ISO 9003.

- ISO 9000-3:1991 Quality management and quality assurance standards-Part 3: Guidelines for the application of ISO 9001 to the development, supply and maintenance of software.

- ISO 9000-4:1993 Quality management and quality assurance standards - Part 4: Guide to dependability program management.

- ISO 9001:1994 Quality system-model for quality assurance in design, development, production, installation and servicing.

- ISO 9002:1994 Quality system-model for quality assurance in production, installation and servicing.

- ISO 9003:1993 Quality Systems-Model for quality assurance in final inspection and test.

- ISO 10011-1: 1990 Guidelines for auditing quality systems. Part 1: Auditing.

- ISO 10011-2: 1991 Guidelines for auditing quality systems. Part 2: Qualification criteria for quality systems auditors.

- ISO 10011-3: 1991 Guidelines of auditing quality systems. Part 3: Management of audit programs.

- ISO 10012-1: 1992 Quality assurance requirements for measuring equipment-Part 1: Meteorological confirmation system for measuring equipment.

- ISO 10013 Guidelines for developing quality manuals.

- ISO/TR 13425 Guidelines for the selection of statistical methods in standardization and specification.

1.4.4 Design and implement the quality system

Writing a quality manual, describing your quality system at a high level. Writing procedure documents to describe how most work in the organization gets carried out. Creating a system to control distribution and re-issue of documents, designing and implementing a corrective and preventive action system to prevent problems from recurring. Identifying training needs for most positions in the organization, calibrating measurement and test equipment. Training the people in the organization on the operation of the quality system. Planning and conducting internal quality audits. Attending to the other requirements of the Standard that the organization does not now comply with. ISO 9000 relies on a system of audits to provide assurance that the organization is meeting the requirements of the standard.

An audit is an inspection of the documents and records that make up your quality system. Most importantly it is an inspection of the way the people in the organization work and the knowledge they have about the operation of the quality system. It is required that the organization carry out scheduled and planned internal audits of the quality system. This in itself is not sufficient, however, to obtain registration.

Only a "third party registration agency" is accredited to issue a certificate attesting that your organization meets the requirements of the selected ISO 9000 standard. Select this registration agency carefully. Choose the registration agency early in the project so that you can learn in detail what they require before granting a registration.

Although registration requirements vary, it is typical to have a "pre-assessment" followed by a "registration audit". At both the pre-assessment and the registration audit; a comprehensive audit of the organization is performed. When the auditor identifies a discrepancy between the work that is being performed and the requirements of ISO 9001, the "noncompliance" will be written up. If only a few minor nonconformances are found during the registration audit, the agency will issue a certificate stating that your organization complies with the requirements of the selected ISO 9000 standard. This certificate typically expires after three years. Also, the registration agency typically requires surveillance audits at six months intervals to maintain the currency of the certificate. The action-planning checklist provides a more detailed list of steps to follow, once the decision to seek registration has been made.

The major requirements of the ISO 9001 standard, often called the "20 elements of the standard" are described in sections 3.1 through 3.20 of the actual Standard. Choosing ISO 9001. The only difference in the standards' requirements is in section 3.4 "Design Control" this section is required in ISO 9001 and is "not applicable" in ISO 9001.

1.4.5 ISO 9000 Scope

ISO 9001 applies in situations when:

- Design is required and the product requirements are stated principally in performance terms, or they need to be established and,
- Confidence in product conformance can be attained by adequate demonstration of a supplier's capabilities in design, development, production, installation and servicing.

ISO 9002 applies in situations when:

- The specified requirements for product are stated in terms of an established design or specification and,
- Confidence in product conformance can be attained by adequate demonstration of a supplier's capabilities in production, installation and servicing.

ISO 9003 applies in situations when:

- The specified requirements for service are stated in terms of an established inspection and testing not included design or production and,

1.4.6 ISO 9000 and the services industries

ISO 9000 applies as much to services industries as it does to manufacturing industries. Although the language of the standard uses the word "product" it include service, hardware, processed materials, software or a combination thereof." The standard also states (in the introduction) that the requirements "are generic and independent of any specific industries or economic sector."

In practice, the manufacturing industries have gotten an earlier start on registration than the services industries. Regardless of what industry segment they are in, deciding whether or not to seek compliance depends on what their customers expect of your organization.

1.4.7 ISO 14000 family

The ISO 14000 family, of which the first standards were published in September and October 1996, addresses various aspects of environmental management. The very first two standards, ISO 14004 and ISO 14001, deal with environmental management systems. These are management tools to enable an organization of any size or type to control the impact of its activities, products or services on the environment. An environmental management system represents a structured approach to setting environmental objectives and targets, to achieving these and demonstrating that they have been achieved.

The standards do not specify levels of environmental performance – a fact which allows them to be implemented by a wide variety of organizations, whatever their current level of environmental maturity. However, a commitment to compliance with applicable environmental legislation and regulations is required, along with commitment to continual improvement for which the environmental management system provides the framework.

ISO 14004 provides guidelines on the elements of an environmental management system and its implementation, and discusses the principal issues involved.

ISO 14001 specifies the requirements for such an environmental management system. Fulfilling these requirements demands objective evidence, which can be audited to demonstrate that the environmental management system is operating effectively in conformance with the standard. ISO 14001 can thus be used for internal purposes to provide assurance to the organization's management and for external purposes to provide assurance to interested parties. In the external context, conformance to ISO 14001 can be used to support what an organization claims about its own environmental policies and actions. It is suitable for both suppliers' declarations of conformity, assessment of conformity by an external stakeholder such as a business client and for certification of conformity by an independent certification body.

The ISO 14000 series of standards is being developed by ISO (International Organization for Standardization), the series bring a comprehensive systems-based approach which can be used by businesses and other organizations to manage the impact of their activities on the environment.

The first two standards of the new series are ISO 14001, Environmental management systems - Specification with guidance for use, and ISO 14004, Environmental management systems - General guidelines on principles, systems and supporting techniques. These two documents are the pillars of the ISO 14000 series, and will allow it to fulfill business needs all the way from general guidance to self-assessment and registration/certification.

The ISO 14000 series will provide guidelines on the elements that an environmental management system should have, as well as on supporting technologies - such as environmental auditing - and on issues such as environmental labeling, life cycle analysis, and on environmental aspects for product standards.

The ISO 14000 standards do not in themselves set levels of environmental performance but rather specifies the requirements of an environmental management system. ISO 14001 state: "This International Standard does not establish absolute requirements for environmental performance beyond commitment, in the policy, to compliance with applicable legislation and regulations and to continual improvement."

Among the expected benefits of ISO 14000 International Standards will be the creation of a reference framework in all the various areas concerned. By providing an international benchmark or method of evaluating protection of the environment, controlling information for the purposes of insurance, correct and clear labeling for the consumer, information on product recycling and on the origin of the products, and information to prevent trade barriers arising.

The eagerness with which business and industry have been awaiting the ISO 14000 series indicates that ISO is providing a strategic solution for handling the question of environmental management. Indeed, businesses in a number of countries have been implementing environmental management systems based on draft ISO 14000 standards.

1.5 Total Productive Maintenance

In modern day manufacturing and service industries, improved quality of products and services increasingly depend on the features and conditions of organizations' equipment and facilities. In the late 70's, there was heavy snow in Sapporo, the northern-most island of Japan. Because the workers could not get to work, Matsushita's vacuum cleaner factory stood still. Mr. Matsushita thought, “Can we not rely on our workers for production?” A year later, the first unmanned-factory in the world was born. As the production relied 100% on equipment, Total Productive Maintenance became mandatory. Today, there are many similar examples such as Fujitsu-Fanuc, the world's most advanced unmanned-factory, which uses reliable computer controllers for manufacturing automation. Likewise super-computers run 24 hours a day all over the world to provide uninterrupted services to the banking, finance, air-flight, hotel, tourist, telecommunication and other service industries. However, this would not be possible without Total Productive Maintenance.

Total Productive Maintenance is a program for fundamental improvement that involves the entire human resources. When implemented fully, Total Productive Maintenance dramatically improves productivity and quality and reduces costs. As automation and laborsaving equipments take production activities away from humans, the condition of production and office equipments increasingly affects output, quality, cost, delivery, health and safety, and employee morale. In a typical factory, however, many pieces of equipment are poorly maintained. Neglected equipment results in chronic losses and time wasted on finding and treating the causes.

"Equipment Effectiveness is Everyone's Responsibility"

Both operations and maintenance departments should accept responsibility of keeping equipments in good conditions. To eliminate the waste and losses hidden in a typical factory environment, we must acknowledge the central role of workers in managing the production process. No matter how thoroughly plants are automated or how many robots are installed, people are ultimately responsible for equipment operation and maintenance. Every aspect of a machine's performance, whether good or bad, can be traced back to a human act or omission. Therefore no matter how advanced the technology is, people play a key role in maintaining the optimum performance of the equipment.

When company employees accept this point of view, they will see the advantage of building quality into equipment and building an environment that prevents equipment and tools from generating production or quality problems. This company-wide team-based effort is the heart of Total Productive Maintenance. It represents a dramatic change from the traditional "I make - you fix" attitude that so often divides workers. Through Total Productive Maintenance, everyone co-operates to maintain equipment the company depends on for survival and ultimately for profitability. The goal of Total Productive Maintenance is to increase the productivity of plant and equipments. Consequently, maximized output will be achieved through the effort of minimizing input - improving and maintaining equipments at optimal levels to reduce its life cycle cost.

In conclusion, Total Quality Management is a process, not a destination. As Deming said, "We have to do it forever." It will guarantee continuous improvement and customer satisfaction, no matter how demanding that could be. Firms can acquire the Total Quality Management Model through a series of training and implementation programs.

Total Productive Maintenance is a program for fundamental improvement that involves the entire human resources. When implemented fully, Total Productive Maintenance improves productivity and quality and reduces costs.

CHAPTER 2

TOTAL QUALITY MANAGEMENT IMPLEMENTATION

Introduction

In order to have a systematic approach to Total Quality Management, it is necessary to develop a conceptual model. Generally, a model is a sequence of steps arranged logically to serve as a guideline for implementation of a process in order to achieve an ultimate goal. The model should be simple, logical and yet comprehensive enough for Total Quality Management implementation. It also has to sustain the changes in business environment of the new era.

2.1 Model Selection

The Total Quality Management selected Model must reflect teachings of the contemporary quality gurus. The next five steps (figure 5) are a logical systematic model for total quality implementation method:

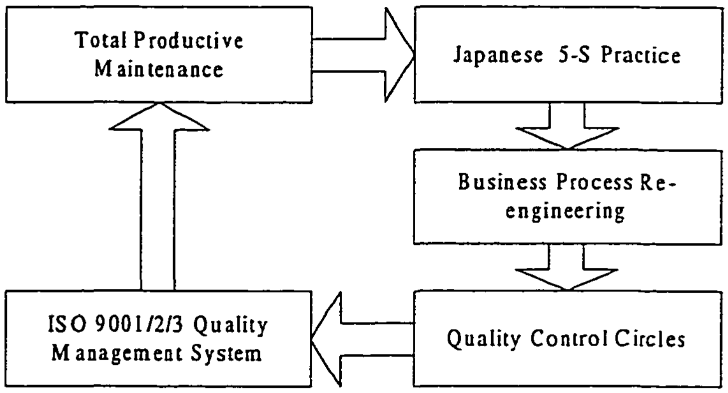

Figure 5: Total Quality Implementation Method

Step 1: Japanese 5-S Practice.

Step 2: Business Process Re-engineering.

Step 3: Quality Control Circles.

Step 4: ISO 9001/2/3 Quality Management System.

Step 5: Total Productive Maintenance.

Japanese 5-S Practice is the key to total quality environment. Therefore, it should be the first step. Business Process Re-engineering is concerned with re-defining and designing your business process in order to meet the needs of your customers effectively. It is more concerned with the business objectives and systems, and should follow as Step

1. Quality Control Circles are concerned with encouraging the employees to participate in continuous improvement and guide them through. They improve human resources capability to achieve the business objectives. Therefore, this should be Step 2. ISO 9000 is to develop a quality management system based on the good practices in the previous three steps. Total Productive Maintenance is a result of applying Japanese 5-S Practice to equipment based on a sound quality management system. In fact, ISO 9001 requires procedures for process control and inspection and testing equipments, which are part of Total Productive Maintenance. Therefore Total Productive Maintenance should be implemented in Step 4.

If the above five steps have been implemented successfully, the organization is already very close towards achieving Total Quality Management. Total Quality Management is a sequential model, which is easy to remember, and simple to implement. This is in lining with the quality principle of "Keep It Short and Simple", although it is not simple to make a model simple! Companies starting to implement Total Quality Management should follow Total Quality Management step-by-step. Companies which have already gone through some degree of improvement using some of the steps should review what have not been done and do it as their next step of improvement.

2.2 Japanese 5-S Practice

The Japanese 5-S Practice is a technique used to establish and maintain quality environment in an organization. The name stands for five Japanese words: Seiri, Seiton, Seiso, Seiketsu and Shitsuke [Osada, 1991] [25]. The English equivalent, their meanings and typical examples are shown as follows:

JAPANESE	ENGLISH	MEANING	TYPICAL EXAMPLE
Seiri	Structurise	Organization	Throw away rubbish
Seiton	Systemize	Neatness	30-second retrieval of a document
Seiso	Sanitize	Cleaning	Individual cleaning responsibility
Seiketsu	Standardize	Standardisation	Transparency of storage
Shitsuke	Self-discipline	Discipline	Do Japanese 5-S Practice daily

The Japanese 5-S Practice technique has been widely practiced in Japan. Most Japanese Japanese 5-S Practice practitioners consider Japanese 5-S Practice useful not just for improving their physical environment, but also for improving their thinking processes too. Apparently the Japanese 5-S Practice can help in all strata's of life. Many of the everyday problems could be solved through adoption of this practice. Unfortunately, unlike other quality tools and techniques, this basic but powerful technique for quality improvement has not been known to the western world.

The following sections will explain each of the constituents of the Japanese 5-S Practice practice in appropriate depth to enable practitioners to get the maximum benefit from its implementation, yet not making it too complicated to understand.

What is Organization (Seiri)?

What is Neatness (Seiton)?

What is Cleaning (Seiso)?

What is Standardization (Seiketsu)?

What is Discipline (Shitshke)?

2.2.1 How to implement the Japanese 5-S Practice?

Japanese 5-S Practice implementation requires commitment from both the top management and everyone in the organization. It is also important to have a Japanese 5-S Practice Champion to lead the whole organization towards Japanese 5-S Practice implementation step-by-step. If you decide to be the Japanese 5-S Practice Champion of your organization, the following steps will help you to achieve success.

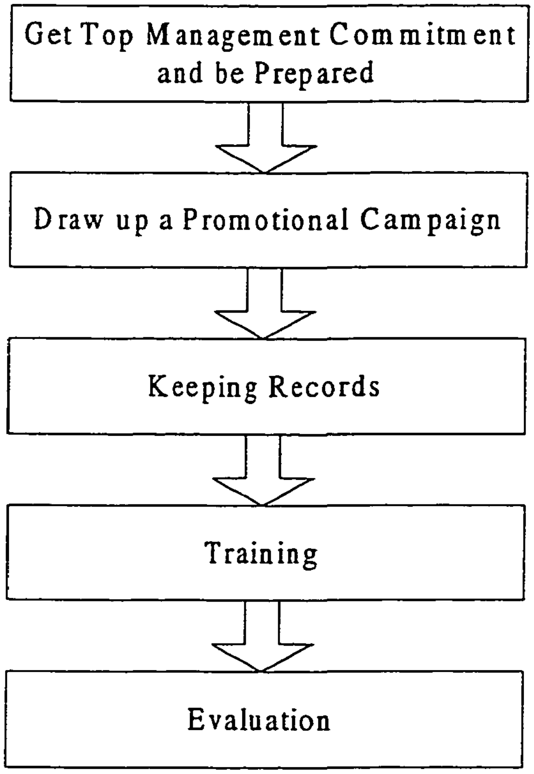

Figure 6: Japanese 5-S Practice Implementation

Step 1: Get Top Management Commitment and be Prepared

You have to sell the idea of the Japanese 5-S Practice to the most senior executive of your organization. Moreover, and like any other quality program, it is no good to get just his lip service. He needs to be 100% committed; not just in announcing the start of the Japanese 5-S Practice in the promoting campaign, but committed to give resources for training and improvements. Then you need to get prepared yourself. In promoting the Japanese 5-S Practice activities, the important thing is to do them one at a time and to do each thoroughly. Even the little things have to be taken seriously if they are to make any meaningful impact. This process can be stratified as follows:

a. Make a decision and implement it.
b. Make tools and use them.
c. Do things that demand improvements as prerequisites.
d. Do things that require help from other departments (e.g., fixing defective machinery, changing the layout, and preventing oil leakage).

Step 2: Draw up a Promotional Campaign

The first thing to do for a promotion campaign is to set up a timetable. In general, the plan can be broken down into key activities.

Step 3: Keeping Records

It is important to keep records not only of decisions made but also of the problems encountered, actions taken and results achieved. Only if past practice has been recorded people will have a sense of progress and improvement over time. There are a number of tools for keeping records, these are computer, photographs, videos, others.

Step 4: Japanese 5-S Practice Training

The Japanese 5-S Practice activities are all directed at eliminating waste and effecting continuous improvement in the workplace. Right from the beginning there will seem to be lots of Japanese 5-S Practice activities to be done. As you go on, you will notice that there is always additional Japanese 5-S Practice problems to solve. They are not insurmountable, though, if considered and solved one at a time.

It is essential in the Japanese 5-S Practice activities that you train people to be able to devise and implement their own solutions. Progress that is not self-sustaining, progress that always has to rely upon outside help is not real progress. It is important that your people know, for example, how to use the computer to do charts and graphs, even if it is not part of their job description. They need to study maintenance techniques. And oddly enough, the more problems they are capable of solving, the more problems they will spot.

Training should also include section-wide or company-wide meetings where people can announce their results. Not only does this provide incentive, but also the exchange of ideas and information is often just what you need to keep everybody fresh.

Step 5: Evaluation

As with so many other things, it is very easy to get into a routine with Japanese 5-S Practice activities - particularly because they demand constant everyday attention to routine details. At the same time, because the individual activities appear minor even though they have great cumulative impact, it is easy to think that you can put them off. Everybody is busy, and it is difficult to make alert Japanese 5-S Practice activities a part of the daily routine. Workplace evaluations and other means are needed to keep everyone abreast of what is happening and to spot problems before they develop into major complications. In essence, you need to devise ways that will get everybody competing in a friendly but no less intense manner. Your evaluation tools are the keys and it is as simple as using the Japanese 5-S Practice Audit Worksheet as your evaluation criteria. "Patrols and Cross-evaluations" Two other techniques that you can adopt to promote the Japanese 5-S Practice activities are patrols and cross-evaluations. Patrols can go around to the various workshops and offices and point out problems. This is similar to 'managing by walking around', but the patrol members do not even need to be management personnel. They simply need to know what to look for and have the authority to point out problems that need to be worked on. They simply need to know what questions to ask. Cross-evaluations are a variation on this theme in that they involve having teams working on similar problems offering advice to other teams. One advantage of doing this is the exchange of ideas and mutual learning.

The objectives of the evaluation are to ensure that the Japanese 5-S Practice implementation will lead to a conducive total quality environment.

2.3 Business Process Re-engineering

Business Process Re-engineering is a management process used to re-define the mission statement, analyze the critical success factors, re-design the organizational structure and re-engineer the critical processes in order to improve customer satisfaction. Business Process Re-engineering challenge managers to rethink their traditional methods of doing work and commit them to a customer-focused process. Many outstanding organizations have achieved and maintained their leadership through Business Process Re-engineering [Oakland, 1995] [27]. Companies using these techniques have reported significant bottom-line results, including better customer relations, reductions in cycle time to market, increased productivity, fewer defects/errors and increased profitability.

Business Process Re-engineering uses recognized techniques for improving business results and questions the effectiveness of the traditional organizational structure. Defining, measuring, analyzing and re-engineering work processes to improve customer satisfaction pays off in many different ways. Re-engineer your business to the needs of your customers.

Improvements in business performance of, say, 10-15 per cent can be achieved in most companies using conventional consultancy techniques. Where quantum leaps are required - for example, where the old needs to be completely replaced with the new - then re-engineering is a good way forward. The key to grasping the way Business Process Re-engineering differs from other improvement studies lies in understanding the focus, breadth and duration of the re-engineering process.

The primary focus is on the customers - those people who pay the money, which keeps the business going. So if a process does not help to serve a customer then why have the process in the first instance? Although Business Process Re-engineering requires a detailed knowledge of what the customers want it does not demand a highly detailed understanding of the activities involved in every activity of the business. This makes Business Process Re-engineering economical in terms of investigation time when compared with conventional methods, in which highly detailed studies are usually undertaken before any change is made. Business Process Re-engineering requires that those conducting the study are highly experienced in business practices and systems, and is able to identify the features of the business, which are crucial to its success. A high-level in-house team, working with experienced consultants, would be able to provide the necessary expertise.

A further facet of the Business Process Re-engineering approach concerns the speed with which changes are introduced. Conventional wisdom states that change is best brought about through an evolutionary approach. If it is required to introduce a radically changed organization, it can be argued that it makes good sense to carry out the necessary changes quickly. Many major Business Process Re-engineering projects have been implemented within one year.

2.3.1 How to Implement the Business Process Re-engineering ?

Business Process Re-engineering creates change. Change must create something that did not exist before, namely a 'learning organization' capable of adapting to a changing competitive environment. A learning organization aims to create a self-perpetuating momentum, which changes the culture of the organization. That is to say, the aim is that the norms, values and attitudes underpinning behaviors be changed towards continual questioning and continual improvement. It embraces human resources development on the one hand and systems development (including Business Process Re-engineering) on the other. For without addressing the systems of an organization, from communication and information systems to reward and recognition systems, you are building your houses on sand, foundationless. Implementing the Business Process Re-engineering steps:

a. Focus in customer requirements.
b. Analyzing Requirements.
c. Detailed data about customer demands.
d. Develop the mission into its Critical Success Factors to coerce and move it forward.
e. Break down the Critical Success Factors into the key or critical business processes and gain process ownership.
f. Break down the critical processes into sub-processes, activities and activity and form the teams around these.
g. Re-design, monitor and adjust the process-alignment in response to difficulties in the change process.

The organization must also learn how to continually monitor and modify its behavior to maintain the change-sensitive environment. Some people will, of course, find it difficult to accept the changes and perhaps will be incapable of making the change, in spite of all the direction, support and peer pressure brought about by the process alignment. There will come a time to replace those managers and peoples who cannot function in the new organization, after they have been given the opportunity to make the change.

With the growth of people's understanding of what kind of managers and employees the new organization needs, and from experience of seeing individuals succeed and fail, top management will begin to accept the need to replace or move people to other parts of the organization.

2.4 Quality Control Circle

A Quality Control Circle is a small group of staff working together to contribute to the improvement of the enterprise, to respect humanity and to build a cheerful workgroup through the development of the staff's infinite potential. A quality control circle Quality Control Circle team of people usually coming from the same work area who voluntarily meet on a regular basis to identify, investigate, analyze and solve their work-related problems.

It has been the Japanese experience that 95% of the problems in the workshop can be solved with simple quality control methods such as the 7 quality control tools [Ishikawa, 1986] [17]. They are: Pareto diagrams, cause-and-effect diagrams, stratification, check sheets, histograms, scatter diagrams, and graphs & control charts. These tools will help Quality Control Circles to do brainstorming systematically and to analyse the problems critically. Then, through logical thinking and experience, most problems can be solved.

Programs which are based on Quality Control Circle practices have been introduced for a variety of reasons, but firms invariable find that the quality of product and service is improved as a result of Quality Control Circle activities.

Another benefit is an improved two-way communication. The management becomes more concemed with the staff problems and, in turn, the staff becomes aware of the day-to-day problems of running an organisation. Communication between departments also improves. While Quality Control Circles work on their own area's problems, their systematic approach often reveals previously unsuspected causes of difficulties in related processes of the production flow. A Quality Control Circle program in general requires the same framework as ISO 9000 quality standards regarding the management structure and in-company training. Therefore, Quality Control Circles should bc part of any company's Total Quality Program.

Everyone's commitment to improvement imposed by a Quality Control Circle program also helps to establish customer confidence. Although some companies do not set out to achieve a pure financial return, most find that the financial benefits considerably overrun the costs.

2.4.1 How to Implement the Quality Control Circle?

Companies with the most successful Quality Control Circle programs have spent time in the early stages making sure that everyone in the company is properly informed and consulted before any Quality Control Circle activity begins. Often an outside specialist will have assisted with the first awareness presentations. Once established, a typical program will have Quality Control Circles operating in all parts of the company - in offices, service operations and manufacturing. Experience shows that the size of a company is not important to a program's success but it significantly affects the support structure and organization. The steps of implementation are:

- Management is made aware of the Quality Control Circle process through a management briefing.
- The feasibility of the Quality Control Circles is analyzed.
- A steering committee is formed.
- Coordinators and in-house instructor is selected.
- Potential area for initial circles is selected.
- Quality Control Circle presentations are made to first-line supervisors in identified areas, divisions or departments.
- Coordinators and middle management receive extensive training on the process and their roles.
- Supervisors who are interested volunteer and receive training.
- Following training, Quality Control Circle presentations are made to the employees who report to the newly trained supervisors.
- Employees volunteer to be members of a circle and receive training.
- A circle is formed and begins work.
- Additional circles are formed as interest broadens.
- Circles work in a systematic way in solving problems, not just discussing them.
- Management must ensure that solutions achieve a quick implementation once they have been accepted.
- Circles are not paid directly for their solutions, but management must ensure appropriate and proper recognition.

In order to implement Quality Control Circle successfully, the following guidelines have to be considered:

a. Participation is voluntary.
b. Management is supportive.
c. Employee empowerment is required.
d. Training is integral part of program.
e. Members work as a team.
f. Members solve problems not just identify them

Quality Control Circle Nominal Group Technique, this is a technique for increasing contributions from individuals in a group setting. It is designed to overcome social and interpersonal barriers between people from different levels, social status, or competencies involved in solving a common problem. It is structured so that people generate a list of solutions to a problem individually. For example, a question might be "What are the limiting factors to this company delivering a product on time?" Each participant would write his own list of limitations. All the lists of limitations are collected and made public without comment and criticism. This exercise is completed before anyone talks, thus eliminating any inhibiting factors to influence the problem solving process. The process shares this characteristic with brainstorming. After a period of discussion to clarify limitations and to omit duplications, a vote is taken to prioritize the limitations left on the list. The priority list becomes the basis for further problem solving. During the brainstorming session the leader should consider the following questions:

a. Is everyone thinking about the same problem?
b. Are all ideas (good and bad) encouraged?

c. Are all ideas recorded?
d. Do all members have equal chance to participate?

Quality Control Circle Code of Conduct, in general, the following code of conduct for Quality Control Circle discussion applies:

a. Criticize ideas, not persons.
b. The only stupid question is the one that is not asked.
c. Everyone in the team is responsible for team progress.
d. Be open to the ideas of others.
e. Pay, terms of employment and other negotiable items are excluded.

2.5 ISO 9000

The ISO 9000 series is a family of quality management and quality assurance standards. ISO 9001 is the Quality systems - Model for quality assurance in design, development, production, installation and servicing. It is the most comprehensive model of quality systems offered by ISO.

As quoted from the Scope of the ISO 9001:1994, this International Standard specifies quality system requirements for use where a supplier's capability to design and supply conforming product needs to be demonstrated. The requirements specified are aimed primarily at achieving customer satisfaction by preventing nonconformity at all stages from design through to servicing. In our case we will consider ISO 9001 because in some cases it happens to do some modifications during the maintenance phase. This International Standard is applicable in situations when:

a. Design is required and the product requirements are stated principally in performance terms, or they need to be established; and
b. Confidence in product conformance can be attained by adequate demonstration of a supplier's capabilities in design, development, production, installation and servicing.

ISO 9004-4:1993 The Quality management and quality system elements Part 4: Guidelines for quality improvement. It gives suggestions for effective quality management, helps organizations in building their quality systems, so that they can develop quality improvement practices for Total Quality Management.

In this study to assess the interest for organizations in implementing ISO 9000 and the difficulties they faced, there are four different reasons for implementing the standard.

a. Due to pressure from large customers,
b. To maintain contracts with existing customers,
c. To use the constraints of the standard to prevent scrap,
d. To reduce auditing of the quality system by customers.

Failure to implement the standard for the right reason may prevent companies from gaining the potential benefits from the system. Besides the right reasons, the degree of commitment by top management will determine the success of the system. Top management needs to generate a conducive environment to enhance the development of the system. This can be achieved by developing a company quality policy and objectives. This will enable all the employees to work towards the same quality goal.

2.5.1 How to Implement the ISO?

Implementation of ISO 9000 affects the entire organization right from the start. If pursued with total dedication, it results in 'cultural transition' to an atmosphere of continuous improvement. How difficult is the process of implementing ISO 9000?
The answer depends on:

a. The sophistication of your existing quality program.
b. The size of your organization.
c. The complexity of your process.

There are 9 essential steps (figure 7) to be followed through in order to implement ISO 9000 successfully.

Step 1: Top Management Commitment
Step 2: Establish Implementation Team
Step 3: Assess Current Quality System Status

Step 4: Create a Documented Implementation Plan

Step 5: Provide Training

Step 6: Create Documentation

Step 7: Document Control

Step 8: Monitor Progress

Step 9: Review -Pitfalls to Effective Implementation

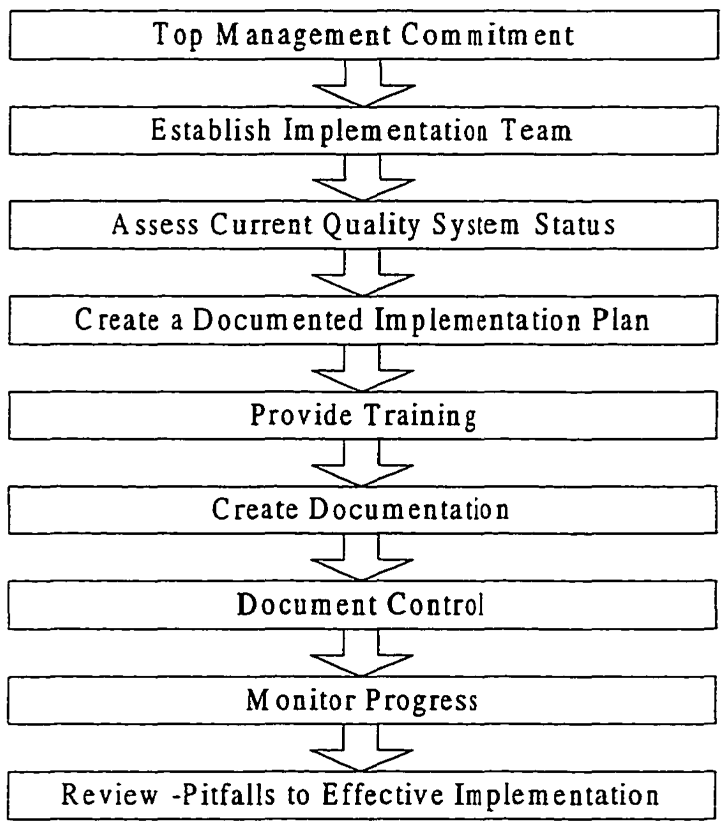

Figure 7: How To Implement ISO

STEP 1: Top Management Commitment

Without Chief Executive Officer's commitment, no quality initiative can succeed. Where does this type of top management commitment come from? Many ISO 9000 registered company's find that the commitment comes from some, if not all of the following points:

a. Direct marketplace pressure: requirements of crucial customers or parent conglomerates.
b. Indirect marketplace pressure: increased quality levels and visibility among competitors.
c. Growth ambitions: desire to exploit EC market opportunities.
d. Personal belief in the value of quality as a goal and quality systems as a means of reaching that goal.
e. Personal belief in the value of quality as a goal and quality systems as a means of reaching that goal.

STEP 2: Establish Implementation Teams

People implement ISO 9000. The first phase of implementation calls for the commitment of top management - the Chief Executive Officer and perhaps a handful of other key people. The next step is to create a personnel structure to plan and oversee implementation. The first component of this personnel structure is the Management Representative. In the context of the standard, the Management Representative is the person within the organization who acts as interface between organization management and the ISO 9000 registrar. His role is, in fact, much broader than that. The Management Representative should also act as the organization's "quality system champion," and must be a person with:

a. Total backing from the Chief Executive Officer,
b. Genuine and passionate commitment to quality in general and the ISO 9000 quality system in particular,
c. The dignity - resulting from rank, seniority, or both - to influence managers and others of all levels and functions,
d. Detailed knowledge of quality methods in general and ISO 9000 in particular.

STEP 3: Assess Current Quality System Status

ISO 9000 does not require duplication of effort, redundant systems, or make-work. The goal of ISO 9000 is to create a quality system that conforms to the standard. This does not preclude incorporating, adapting, and adding onto quality programs already in place.

So the next step in the implementation process is to compare the organization's existing quality programs - and quality system, if there is one - with the requirements of the standard. Program assessment can be done internally, if the knowledge level is there, or a formal pre-assessment can be obtained from any one of a large number of ISO 9000 consulting, implementing, and registration firms.

STEP 4: Create a Documented Implementation Plan

Once the organization has obtained a clear picture of how its quality system compares with the ISO 9000 standard, all nonconformances must be addressed with a documented implementation plan. Usually, the plan calls for setting up procedures to make the organization's quality system fully in compliance with the standard. Procedures, which affect high-level policy elements of the quality system, may be handled by the council itself, or by designated members. Others may be handed down to various oats for development.

The implementation plan should be thorough and specific, detailing:

a. Procedures to be developed.
b. Objective of the system.
c. Pertinent ISO 9000 sections.
d. Person or team responsible.
e. Approval required.
f. Training required.
g. Resources required.
h. Estimated completion date

These elements should be organized into a detailed Gantt chart, to be reviewed and approved. Once approved, the Management Representative should control the plan and its Gantt chart. The chart should be reviewed and updated at each meeting as the implementation process proceeds.

STEP 5: Provide Training & Documenting

The ISO 9000 implementation plan will make provision for training in various functional areas of the quality system. Certain training needs will depend on the nonconformance addressed. The oats should take responsibility for providing specific training in their respective functional areas.

Since the ISO 9000 quality system affects all areas and all personnel in the organization, it is wise to provide basic orientation in the quality system standard to all employees. This can be a one-day program which informs personnel about quality system in general and the ISO 9000 quality system in particular. Documentation is mandatory. It is essential to the ISO 9000 registration process because it provides objective evidence of the status of the quality system. The two basic rules of ISO documentation are: "Document what you do" & "Do what you document".

Many organizations find that their existing documentation is adequate in most respects. To bring it into full ISO conformance, they implement control procedures to ensure that documentation is available as needed and is reviewed, updated, stored, and disposed of in a planned, orderly manner.

STEP 7: Document Control

Once the necessary quality system documentation has been generated, a documented system must be created to control it. As noted in the Technical Requirements and Guidelines sections, control is simply a means of managing the creation, approval, distribution, revision, storage, and disposal of the various types of documentation. Document control systems should be as simple and as easy to operate as possible - sufficient to meet ISO requirements and that is all.

The principle of ISO 9000 document control is that employees should have access to the documentation and records needed to fulfill their responsibilities. Ironically, direct access can often result in certain employees having less record keeping and documentation to deal with - and can be a cause of resistance. The organization's quality manual is a primary example. "We got minor resistance from some major players who were used to having the quality manual, but who didn't really need to have their own copy of it," says Jim Ecklein of Augustine Medical [Johnson, 1993] [27]. "We solved that by having a master quality manual, with references to sub-manuals for each organization area. That way, people had what they needed, but we weren't passing quality manuals out to people who didn't really need it and wouldn't use it."

STEP 8: Monitor Progress

When the procedures have been completed and the quality system fleshed out, it is time to put the quality system into effect. In this extremely important phase, management must pay close attention to results to make sure that the elements of the quality system are logical and effective.

Effective monitoring is what makes or breaks ISO 9000 implementation. It is also the ultimate measure of how well – or poorly - organization management lives up to its responsibilities, as described in the Management Responsibility section of the standard. In particular, management at all levels should watch out for gaps and assuTPMions in procedures and steps, which are difficult, ineffective, or impractical.

The oats can deal with many such problems. Resulting changes should, of course, be documented and approved in accordance with procedures provided for in the quality system. Management, up to the level of the Quality Action Council, should simultaneously carry out its review function as prescribed by the standard and its own documented procedures. These activities include:

a. Internal quality audits,
b. Formal corrective actions,
c. Management reviews.

STEP 9: Review - Pitfalls to Effective Implementation

Here is a brief checklist of the most significant barriers to effective ISO 9000-quality system implementation.

a. Lack of Chief Executive Officer commitment. As Lorcan Mooney [27] says, "If senior management consists of four or five people, and two of them are not committed, over time they can be won over. But if the Chief Executive Officer is not committed, then in no way are you going to win in the long run".

b. Failure to involve everyone in the process. Ownership and empowerment are the keys to effective implementation. To help employees feel like owners of their activity, make them responsible for developing and documenting their procedures.

c. Failure to monitor progresses and enforces deadlines. People in organizations have their routine work to do. If progress is not monitored, ISO 9000 can never be implemented effectively because programs just drag on.

All three pitfalls are directly traceable to management.

2.6 Total Productive Maintenance

Total Productive Maintenance is a system of maintenance covering the entire life of the equipment in every division including planning, manufacturing, and maintenance. Because of its targeted achievement to increase productivity out of the equipment, the term Total Productive Maintenance is sometimes known as Total Productivity Management.

The Japan Institute of Plant Maintenance runs the annual Productive Maintenance Excellence Award and they provide a checklist for companies applying for the award. There are 10 main items in the checklist:

a. Policy and objectives of Total Productive Maintenance.

b. Organization and operation.
c. Small-group activities and autonomous maintenance.
d. Training.
e. Equipment maintenance.
f. Planning and management.
g. Equipment investment plans and maintenance prevention.
h. Production volumes, scheduling, quality, and cost.
i. Safety, sanitation, and environmental conservation.
j. Results and assessments.

2.6.1. How to Implement the Total Productive Maintenance

a. Element losses based on project teams organized by the production, maintenance, and plant engineering departments.
b. Planned maintenance carried out by the maintenance department.
c. Autonomous maintenance carried out by the production department in seven steps.

    Step 1: Initial cleaning
    Step 2: Actions to address the causes and effects of dust and dirt
    Step 3: Cleaning and lubrication standards
    Step 4: General inspection training
    Step 5: Autonomous inspection
    Step 6: Workplace organization standards
    Step 7: Full implementation of autonomous maintenance

d. Preventive engineering carried out mainly by the plant-engineering department.

e. Easy-to-manufacture product design carried out mainly by the product design department.

f. Education and training to support the above activities.

Total Productive Maintenance can be successful in achieving significant results only with universal co-operation among all constituents involved with the six activities listed above. Once a decision has been made to initiate Total Productive Maintenance, company and factory leadership should promote all six of these activities despite excuses that may come from various quarters.

Through these activities, the company can gradually eliminate the losses, establish a more effective relationship between operators and machines, and maintain equipment in the best possible condition. In the next chapter we will discuss the main concepts for implementing the Total Productive maintenance in more detail.

In conclusion, implementing the Total Quality Management is a necessity. It is a journey. It will never end. It makes Japanese industry a miracle. It is the way to survive and succeed. Total Quality Management emphasizes use of all people and resources It stresses optimal life cycle costs and uses measurement within a disciplined methodology in achieving improvements. The key aspects of Total Quality Management are the prevention of defects.

CHAPTER 3

TOTAL PRODUCTIVE MAINTENANCE IMPLEMENTATION

Introduction

The continuous request that managers provide better customer service, improve space comfort, supply reliable mechanical and electrical energy performance, and to do so at no more cost than last year's operating budget. Overall, this fresh look at how building operation and maintenance is done is a very good idea. In this chapter we will discuss the concepts and the main elements to improve the maintenance facility functions and to prepare the facility to work in computerized environment.

Today's economic and competitive environment requires that industry sustain full production capabilities and minimize capital investment. From the maintenance perspective, this means finding ways to maximize equipment reliability and up time, and extend plant and equipment life through cost effective maintenance. To achieve these objectives, industry must move away from the traditional reactive maintenance mode and move to proactive maintenance and management philosophies. Maintenance processes that fully address the program and technical concerns of maintenance must be adopted and the process must realize the value of integration, engineering, planning and quality. Such change requires a complete shift in the maintenance approach. Total Productive Maintenance is such an approach.

3.1 Total Productive Maintenance Implementation Phases

Total Productive Maintenance is based on the premise that effective maintenance requires that the elements of maintenance be defined, operational, and interactive. Next we will present the phases (figure 8) and concepts to implement the Total Productive Maintenance in a dependent or independent maintenance facility.

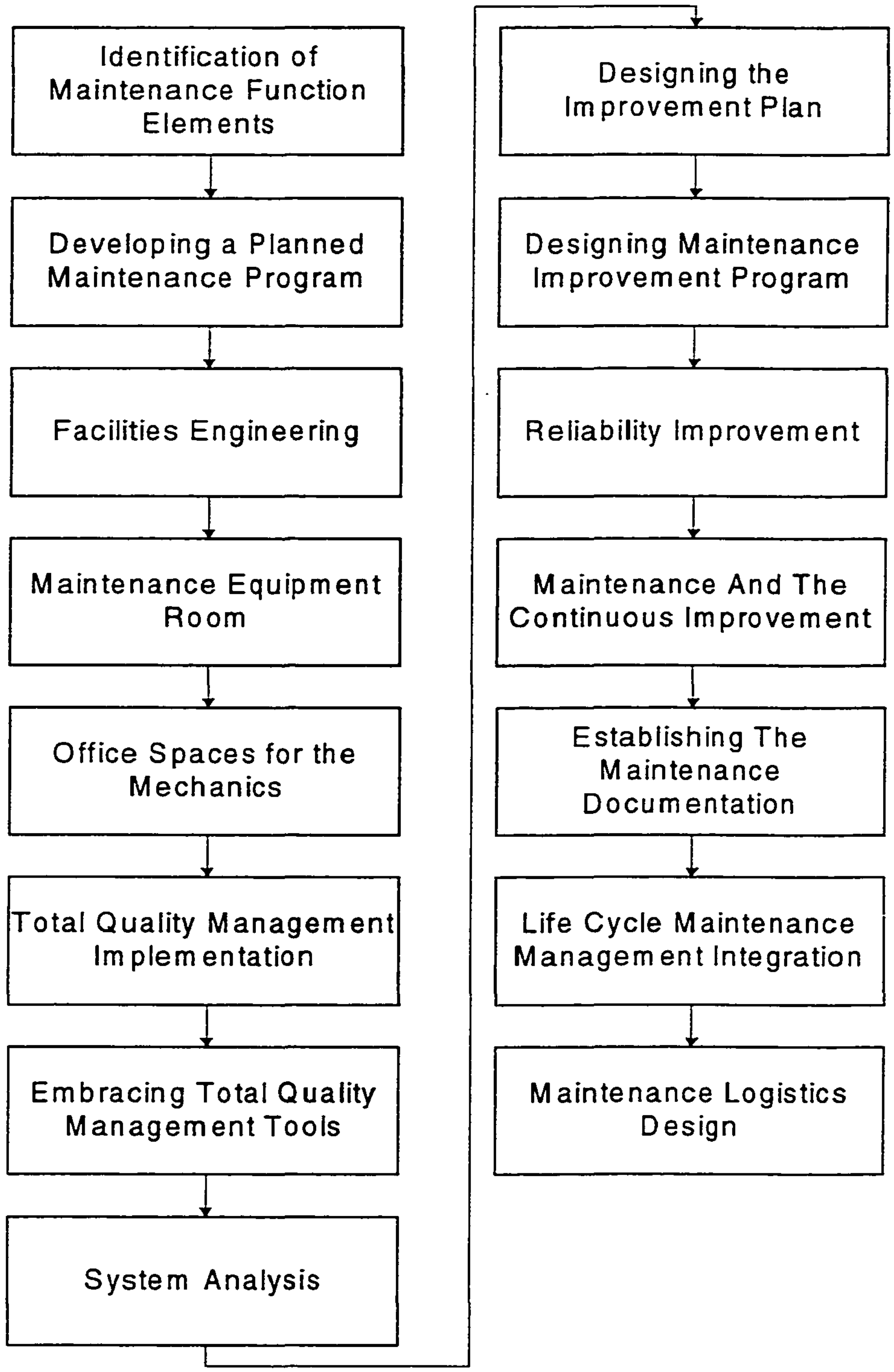

Figure 8: Total Productive Maintenance Implementation Phases

3.2 Identification of Maintenance Function Elements

The Elements and their purpose (figure 9) are identified as follows:

a. Maintenance Organization and Administration: Provide governing principles and concepts upon which the maintenance function is built.

b. Measures of Effectiveness - Provide performance indicators used in measuring the effectiveness of each of the elements and the overall maintenance process.

c. Work Control - Provide the means to plan, schedule, execute maintenance and to record data necessary for evaluating performance against goals and objectives.

d. Maintenance Management Information System - The tool by which maintenance resources are managed. The enabling technology for the maintenance function.

e. Personnel - The policies, programs, and systems used to ensure the work force is capable of performing activities required to effectively executing the maintenance function.

f. Technical Documentation - Maintain consistency between facilities assets and the Documentation that defines the hardware.

g. Configuration Management - Maintain hardware in a known configuration.

h. Logistics Support - Ensure the right resources are in place, when needed, for maintenance activities.

i. Maintenance Activities - Do the right things to plant assets to effectively maintain the assents for their life cycle.

j. Maintenance Engineering - Maintenance function oversight to ensure the right things are being done correctly.

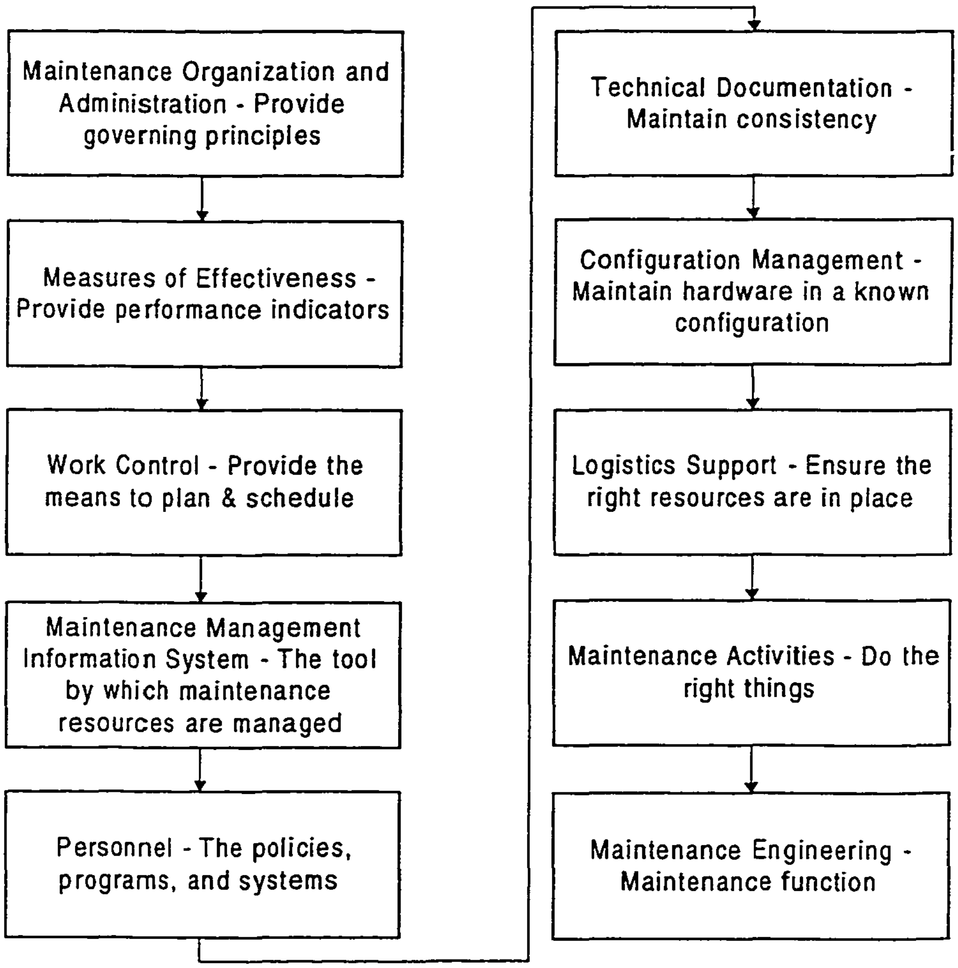

Figure 9: Identification of Maintenance Function Elements

3.3 Developing a Planned Maintenance Program

In developing a planned maintenance program for a company, it is important to consider each of the maintenance function elements and to design the overall function and each element to meet the business and technical needs:

a. Reliability Centered Maintenance

The most important aspect of a maintenance program is the development and use of effective maintenance activities. A method used to determine these activities is Reliability Centered Maintenance. Reliability Centered Maintenance (figure 10) services include:

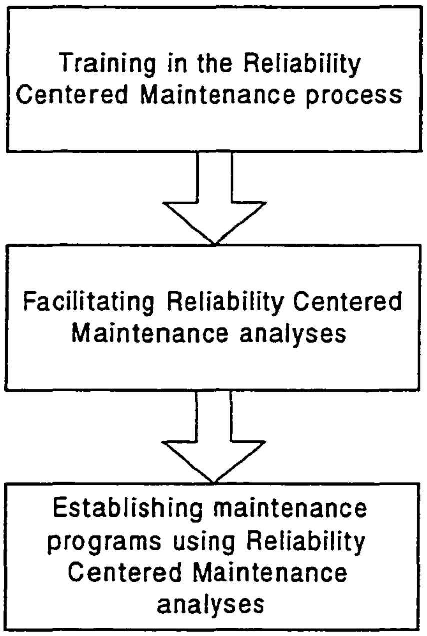

Figure 10: Reliability Centered Maintenance

a. Training in the Reliability Centered Maintenance process
b. Facilitating Reliability Centered Maintenance analyses
c. Establishing maintenance programs using Reliability Centered Maintenance analyses.

b. Life-Cycle Maintenance Cost Analysis

Maintenance departments often see and begin to have input into equipment life-cycle care only after it has been selected, installed and turned over to the facility for commissioning and subsequent operations. Starting at this point, 95% of the total maintenance burden of the equipment or system has been fixed, leaving only a small opportunity for the maintenance department to influence the effectiveness of equipment care. Many equipment selections are based entirely upon costs by persons following a list of specifications that usually do not include maintenance considerations. Therefore, the less expensive selection may, in the long run, be considerably more costly for the facility and a large headache for the maintenance department. Life-Cycle Maintenance Cost Analysis includes the maintenance department in the process when planning for new equipment and systems. The maintenance department participates (figure 11) in all phases of:

a. Identification of need
b. Advance planning and design
c. Advance development and preliminary system design
d. Detail design and development
e. Construction and assembly
f. System care through life cycle support
g. System retirement.

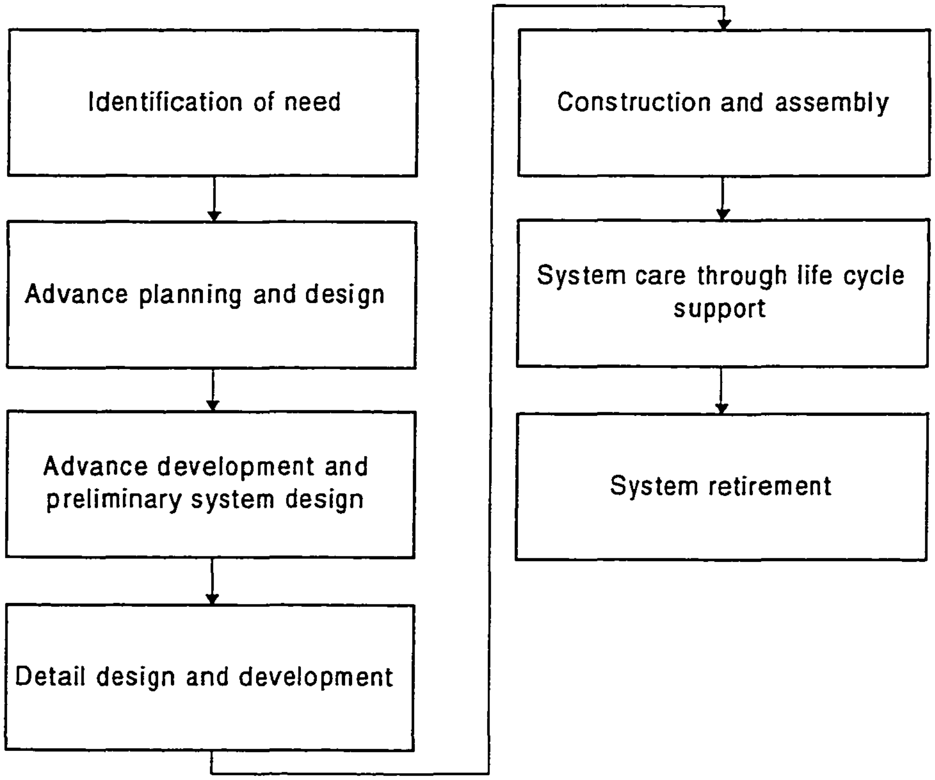

Figure 11: The Maintenance Department Participates Phases

Life-Cycle cost (figure 12) considerations include:

a. Maintenance planning
b. Repair parts, consumables, special supplies
c. Special test and support equipment
d. Materials handling requirements
e. Operations and maintenance personnel training
f. Support facilities
g. Data collection and processing management.

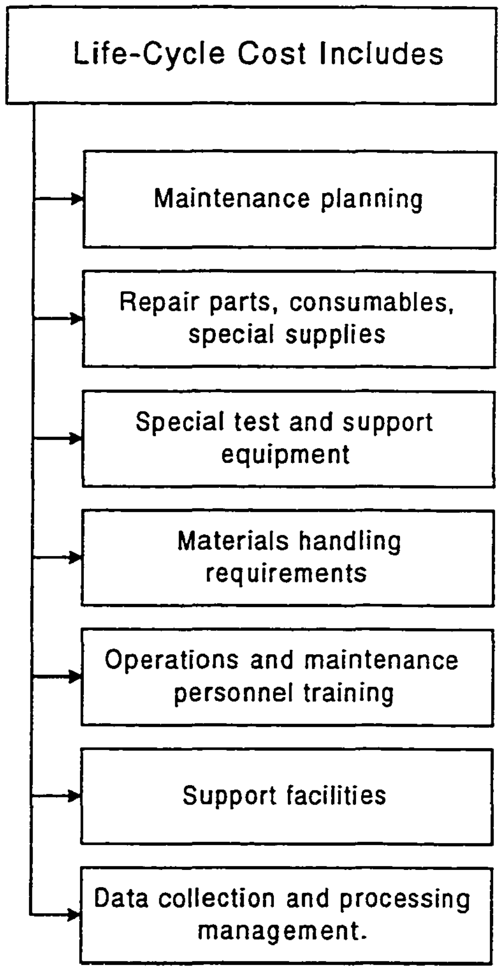

Figure 12: Life-Cycle Cost

3.4 Facilities Engineering

As growth occurs and product lines change, the original well structured plans for facility, equipment, and personnel utilization may lose some of their definitions. Engineers can help to assess, document, and structure for current production plus corporate expectations of future growth. We will again establish control over the manufacturing future through the accomplishment of the following activities (figure 13):

a. Identifying and documenting the objective of the facility.

b. Ensuring the facilities current and planned resources are compatible with corporate objectives.

c. Identifying and specifying the primary and secondary processes that must be accomplished to fulfill the corporate objectives.

d. Identifying the functional interrelationships of all process activities.

e. Developing plans to support facility processes.

f. Assisting with implementing selected facility plans.

g. Identifying facility design attributes for ease of maintenance.

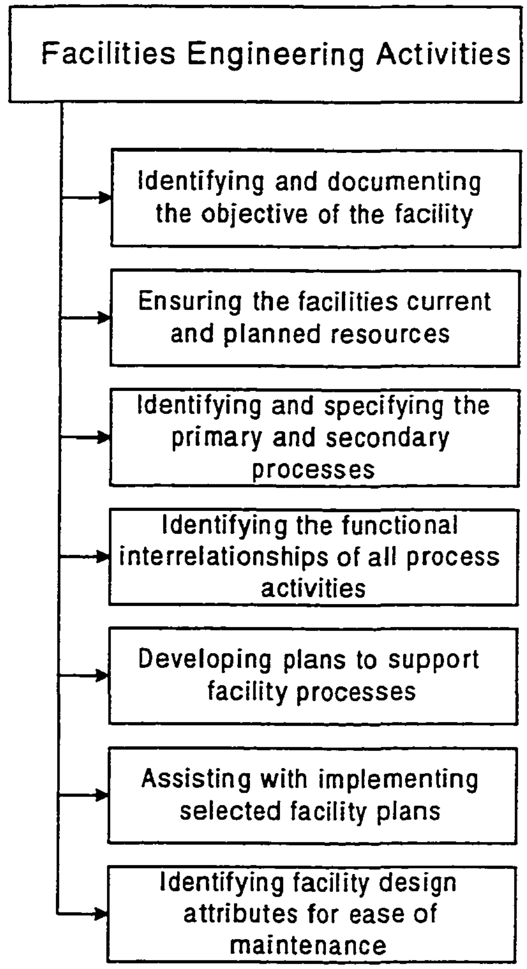

Figure 13: Facilities Engineering Activities

3.5 Maintenance Equipment Room

The commitment to cleaning and organizing machinery spaces involves the participation of all the staff, from the highest level of the facilities department to the apprentice level. Equipment rooms; those cryptic, locked away spaces that contain our mechanical and electrical equipment - are rarely visited, unless there is an electrical or mechanical problem that disrupts an office or work area within the facility. These equipment rooms are "out of sight, out of mind." Many facility managers, especially if the facility is older, would not want an unannounced tour of the equipment rooms.

Yet at one time, as many facility managers still remember, these rooms were clean, adequately illuminated, and well maintained. But times have changed, and lower operating budgets and manpower cutbacks have caused the equipment rooms to fall into states of neglect and disrepair. Today these spaces are all but forgotten, especially with the myriad of other issues facing the modern facility manager. These spaces are more constrained than ever by limited resources and personnel. Overlooked were the reasons for maintaining these spaces and their equipment. Forgotten too, quite often, is the pride that well-maintained equipment rooms instill in the professional mechanic, and how cost-effective and necessary it is to a vibrant facility management program to have well-maintained equipment rooms.

Today, more than ever, these spaces need to be clean, well organized and safe. The addition of more electronic equipment, specifically variable frequency drives and direct digital control cabinets, warrants a cleaner environment to perform as designed. More importantly, indoor air quality issues have made equipment rooms and the various systems they contain the subject of intense scrutiny.

3.6 Office Spaces for the Mechanics

The attitude today toward the expenditure of time and money necessary to organize and clean equipment rooms is usually one of "if we have the time. or if any money is left over, maybe then..." All too often, these important, primary infrastructures are the first areas to be neglected and often are regulated to secondhand storage spaces. Instead of being a low priority, the prudent facility manager will foster and try to instill the attitude that the equipment rooms are the "office spaces for the mechanics." A typical, impressive facilities office space is one that has plenty of light, is well ventilated and all documents are accessible at a moment's notice. No time should be wasted looking for documents or other pertinent information.

Why shouldn't this approach be carried over to equipment spaces? A mechanic spends a lot of time in the equipment rooms so the areas should reflect the standard of the entire department. The theme that the proactive facilities manager should promote is that equipment rooms are our work areas and should reflect our professionalism and pride in our facilities and trade skills.

These rooms should mirror the professional image of the entire maintenance department. These rooms are the "heart and soul" of the facility infrastructure and reflect the general "health" and condition of the facility. Recent surveys of facilities in pursuit of "world class equipment rooms," show concern with the condition "behind the walls" of buildings and concern the perceived neglect behind these walls. Those surveyed fully endorsed a strategic plan, and the reasons for this plan, that were presented on the advantages of world class equipment rooms.

3.7 Total Quality Management Implementation

A Total Quality Management team to be made up of facility managers, supervisors and workers to ensure that all levels are represented in the process.

Utilizing the Total Quality Management process, the team set up its first challenge of developing a data collection tool. A five-step process to be used to guide the Total Quality Management team (figure 14) through the project:

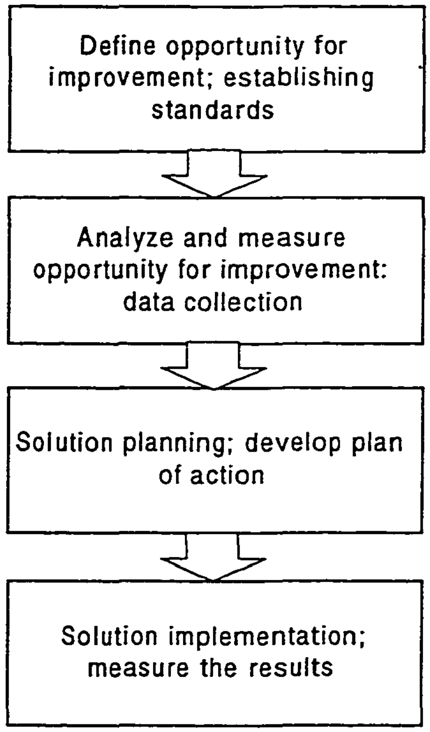

Figure 14: Total Quality Management team Guide

a. Define opportunity for improvement; establishing standards
b. Analyze and measure opportunity for improvement: data collection
c. Solution planning; develop plan of action
d. Solution implementation; measure the results

3.7.1 Define Opportunity for Improvement

To move forward a standard survey sheet needed to be developed that identified a menu of potential deficiencies and/or areas of concern. Standardization is the cornerstone to Total Quality Management and a simplistic check sheet would serve the immediate need and be a means to measure success further into the process. With this in mind, the team developed the first draft of the survey form. Using this form, a preliminary inspection of selected equipment rooms was conducted utilizing the following themes:

a. The equipment rooms are clean, insulated where needed, and free of leaks.
b. The equipment rooms are a safe place to work.
c. The equipment rooms address all environmental concerns.
d. Equipment and associated distribution systems are identified for ease of maintenance, repair and troubleshooting.

Utilizing the preliminary data that was gathered from this survey sheet the Total Quality Management team completed the first milestone it is imperative that benchmarks to be established so that improvements are consistent throughout the campus complex, therefore closing the Total Quality Management loop.

3.7.2 Data Collection

Utilizing the equipment room survey format, an action agenda became a BI-product of this check sheet. The resulting action needed would become the team's "means-to-measure" corrective work progress in the future. This original information to be reviewed and categorized according to urgency:

a. Life safety and employee safety. Included in this category is personal protective equipment (i.e., goggles, gloves, eye wash stations), lighting and fire proofing, Hazardous materials and spill containment.

b. Insulation. Included in this category is any uncovered steam lines, valves or reducing stations, chilled water lines and valves, and any equipment or piping that needed insulation to prevent condensation.

c. Organization and clean up of the equipment areas

d. Painting requirements (walls, equipment pads and floors)

e. Labeling of equipment and piping (system identification and directional arrows, valve tags and charts, one-line drawings and operating sequences)

Once deficiencies are identified and prioritized, it is easier to assess the problems and develop a plan of actions. An analysis of what work can be performed in-house versus contracted out needed to be discussed and agreed upon relative to the course of action. It is also agreed that one equipment room would be completely finished to establish the standard (the model) and demonstrate the desired end results. Thereafter, the corrective action would be completed in phases to efficiently expedite the process. For those Total Quality Management teams that choose to use the equipment room survey sheet, a solution plan implementation follows the data collection, data analysis and solution plan in the Total Quality Management process. The team used the equipment room action agenda. This audit form assists the team with the ability to track the scheduling, progress and completion of activities assigned. Using this form, a clean up team to be assigned the activity of correcting the deficiencies previously noted by the Total Quality Management team. The corrective work to be broken out into phases:

a. Price the cost to complete the work per equipment room.
b. Implement life safety and employee safety needs within these rooms.
c. Remove or properly store hazardous materials and create spill containment space in assigned rooms.
d. Begin insulation as needed.
e. Organization and clean up of the equipment areas, including painting of walls, equipment pads and floors (In addition, complete the labeling of equipment, duct and piping distribution).

3.7.3 Develop a plan of actions

It should be noted that this project was developed in response to building owners who were not satisfied with the existing conditions of their facility equipment rooms. At the same time, it is important to point out that once the deficiencies were identified, it became apparent to the team that corrective measures needed to be implemented due to unsafe working conditions. What began as a desire to have clean, well-lighted workspace became an action agenda to improve these rooms so that the workers were not exposed to an unsafe environment. Unfortunately, our surveys have shown that most equipment rooms present an unsafe work environment and that the original owner requests had now taken on a sense of urgency to avoid an unnecessary accident to an employee or a contractor. Perhaps more important than being able to quickly troubleshoot and correct equipment problems are the elimination of hazards and the subsequent injuries caused by unsafe equipment and associated mechanical rooms. Four of the top violations could be attributed to neglected mechanical rooms:

a. General Requirements for Machines.

b. Protective devises on machinery need to be in place to prevent the operator from injury by keeping any body parts from contact with moving/rotating equipment.

c. Personal Protective Equipment such as eye protection, gloves and hearing protection are a few of the needed equipment that should be made readily available in equipment areas. A survey of each work area should be completed to determine what Personal Protective Equipment is needed. Hearing protection is required in areas that exceed decibels. Eye protection, gloves and face shields should be located in areas where chemicals or corrosive materials will be handled. The more accessible personal protective equipment is the more likely it will be used in the situations it was intended. It is the responsibility of the employer to determine and supply the necessary equipment. Eyewash and Shower Equipment Mechanical rooms with chemical treatment systems should be equipped with eyewash station or showers. The location of the stations are critical and should be researched before installing Electrical Hazards No exposed wiring should exist or temporary wiring left in place. It is critical that junction box covers are in place and blanks installed in breaker panels where applicable. The team understood that other hazardous situations, within these rooms, could be eliminated when good proactive maintenance practices and upkeep were used in equipment rooms.

d. Lighting conditions are important to enable mechanics in which to work and affect repairs. It is also important that emergency lighting sources are available and that these lights are not left on when not needed.

3.7.4 Solution Implementation

The clean-up team consisted of a combination of in-house labor and contract labor. If in-house labor can be made available and is found to be cost-effective, organizing and cleaning the machinery spaces with the resident crew has the most advantages because this crew inherits a sense of ownership and pride of accomplishment. Installing the Total Quality Management process of employee empowerment to the employee is a key factor to the success and measurement of this project. It also sends a signal to this facility staff that there is a renewed commitment to quality workmanship and employee empowerment. Although there will become an apparent sense of urgency once the survey has been completed, slow progress is better than no progress. Tactically, the Total Quality Management team chose to complete a minimum of one equipment room per month to the new building standard and, when possible, more work would be assigned to accelerate the process. This way those involved were always moving in the correct direction in a timely manner to accomplish the ultimate goal. With the new focus on the equipment room project, a means to track the corrective work needed to be developed. An integral part of this improvement plan was to measure the deficiencies by specific categories and monitor the work in progress. This data was plotted out monthly in an equipment room Total Quality Management measurement graph that illustrates the trending of corrections. This "visual aid" provides a means to measure the clean up team's progress and serves as an excellent motivator for the maintenance crew. Another visual aid to show progress has been to take photographs of existing spaces at the time of the original survey.

When an equipment room had been completely restored, a second photo was taken showing the exact area in the initial picture; but now it clearly showed a clean, well-lighted and painted workspace. As each equipment room has been elevated to the new "model," ongoing upkeep of these rooms through tours and scheduled maintenance needs to be developed. It is important that once the areas have been cleaned, impress upon the various contractors and maintenance personnel who work on site, that they will be responsible for leaving the areas in the same condition as when they entered the space. Part of the planned maintenance program has now been expanded to included necessary “Job orders & Sub Job orders” to continually maintain the level of quality work space that the facility had elevated itself to. The advantages of a clean and well-organized equipment room also must be measurable. For example, the importance of emergency response personnel being able to enter into any equipment room and immediately be able to determine what each piece of equipment serves, where emergency shutoffs are located and the correct operating ranges, will minimize the response time to address a critical situation. Another benefit of having a clean, well-organized, standardized room will be when a new employee has been assigned to the workspace. Being able to respond to and quickly troubleshoot an urgent situation will minimize training time for this person.

The knowledge that the locations of key isolation valves and contents are clearly identified and that there are line system drawings conveniently mounted on or adjacent to equipment will simplify the operation and maintenance within these rooms.

a. Justifying the Costs: In completing the Total Quality Management process, the team summarized their exercise by identifying how cans the cost to upgrade equipment rooms to this building standard. In addition to it being a great morale booster for the operation and maintenance department, there are several other considerations that should be added to the equation when providing cost justification for upgrading of these equipment rooms.

b. Safety Considerations: It is every company's responsibility to provide a safe working environment for its employees.

c. Improved Productivity: It is easier and therefore more cost-effective to maintain the electrical and mechanical repairs in a well-organized equipment room. Minor deficiencies can be easily detected in a clean, painted and well-lit equipment room. Trouble shooting the equipment systems in these rooms are easier, if every gauge is marked as to its control and operating ranges, pipes have contents marked with flow indicators, areas served are indicated, valve charts are current and single line diagrams are available. These deficiencies can be corrected before they escalate into a major repair that can adversely impact a facility's operation and bottom line. If the mechanic is still not able to quickly correct the problem, then there is a list of contacts to notify for further assistance.

d. An Ongoing Commitment: The commitment to cleaning and organizing machinery spaces involves the participation of all the staff, from the highest level of the facilities department to the apprentice level. A Total Quality Management process and a Total Quality Management team are needed to begin the work while a department commitment is needed to finish the project and maintain the areas there after. Once completed, the standard is set and a message is sent that this is a world-class equipment room. Employee ownership has embraced the goal and pride has been restored to the workplace. Assigning specific maintenance personnel to have responsibility for individual rooms will foster and reinforce a sense of ownership and pride. Peer pressure and competition also will help keep everyone working together to help maintain these rooms. Maintenance Job orders & Sub Job orders can be set up on a computerized preventive maintenance program to help initiate equipment room inspections and cleaning. In the end, cost-effective equipment room maintenance will be a day-to-day Total Quality Management process.

3.8 Embracing Total Quality Management Tools

An advocate for applying the quality process to problem solving, it has been proven that a standardized facility survey will provide a continuously improving audit process where the building owner reaps the benefits. To receive this assistance, the facility owner will need to sincerely believe in the Total Quality Management tools, which are (figure 15):

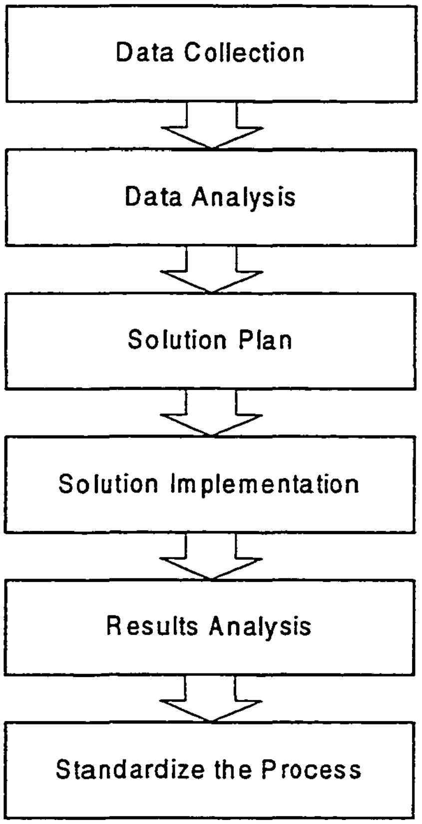

Figure 15: Embracing Total Quality Management Tools

3.8.1 Data Collection

Getting the facts. Before a doctor offers medicine to a patient, he will interview the patient, take tests and perform necessary examinations. The same applies to a facility audit. The maintenance doctor needs to interview his patient, and gather the details and facts.

3.8.2 Data Analysis

Another term for statistical analysis, data analysis puts to paper the evidence collected. Total Quality Management tools, such as Pareto diagrams, histograms, etc., all offer the maintenance doctor the equivalent to reading an x-ray chart. When done correctly this study will clearly identify the problems in a chronological order of importance.

3.8.3 Solution Plan

The process of targeting the number one problem shown on the maintenance doctor's x-ray chart and creating a practical solution to the dilemma. Based on the data previously collected, the facility manager will need to focus on one issue at a time. Often, departments are anxious to rush to the solution and in the end, the plan fails. It is imperative that a solution is clearly thought out and tactically carried out. Major operation and maintenance issues do not occur overnight and the solution is not going to cure the problem overnight.

3.8.4 Solution Implementation

Buy-in by the staff is essential to the success of any solution plan. No one person can correct the problem and prevent it from reoccurring. Implementation may prove to be a culture change for the participants and change is not always easily welcomed by all.

3.8.5 Results Analysis

No solution can be successful if it cannot be measured. Many will disagree with this statement but it is true. If remedial steps are not documented on a Total Quality Management measurement chart, then people's interpretation of progress becomes abstract. The results come down to one person's opinion versus another person's opinion.

3.8.6 Standardize the Process

Once a solution has clearly come to a successful conclusion, a facility manager needs to establish it as a standard operating procedure. In addition, based on the implementation experience, improvements to the solution plan can be incorporated into this standard. Total Quality Management is a continuous process where standards are used and improved upon based on feedback results. Believing in the standardized facility survey process, reporting format and the skills of the individuals doing the work is essential when designing an improvement plan of action.

A manager has to understand and/or accept that historically Total Quality Management works and that, when completed by professionals; standardized investigative functions are a very good investment. Problem solving via data collection, analysis, solution plan and implementation, and measuring the results are milestones along the way to improved maintenance management. Standardizing this roadmap to success is a building block within the action plan. It removes the opinions of many with statistical facts based on data routinely collected by Total Quality Management trained facilitators. Equally important to Total Quality Management will be the experience of the surveying team. Total Quality Management tools in the hands of inexperienced personnel will only result in less than complete results. Expert surveyors will inherently be more proficient in expediting the work-at-hand with minimal disruption to the ongoing daily facilities management activities.

The building owner will also need to recognize that no one person is an expert in all areas of the facility audit. In turn, the Total Quality Management team will need to be structured by providing a diverse group of people who can be called upon to assess their area of expertise. For example, a building automation analysis person will most likely not be the same individual who will be assigned to review and comment on the computerized maintenance management system or the job descriptions of those workers assigned to the operation and maintenance group. Diversity of experience will be an integral part of the survey team and the owner will need to recognize and agree with this format.

3.9 System Analysis

Total Quality Management process established; a team in place, the building owner could now authorize an audit to assess the entire facilities management operation. If the ultimate goal is to be cost effective while providing a better facility environment, studying all aspects of the operation and maintenance program will be needed. Here is where many of those cost analyses, management consultants and displaced former facility managers fall short of the target; designing and implementing a maintenance improvement plan. Facilities management is a 10-section structure (figure 16) consisting of:

a. Operating cost-energy: completed by the design engineer.
b. Operating cost-in house labor: completed by the director of engineering.
c. Operating cost-vender contracts: completed by the director of engineering.
d. Building automation system: completed by the application engineer.
e. Work-order system: completed by the operations manager.
f. Equipment room: completed by the design engineer.

g. Department safety: completed by the safety officer.

h. Administrative support: completed by the office manager.

i. Documents room: completed by the design engineer.

j. Training: completed by the director of engineering.

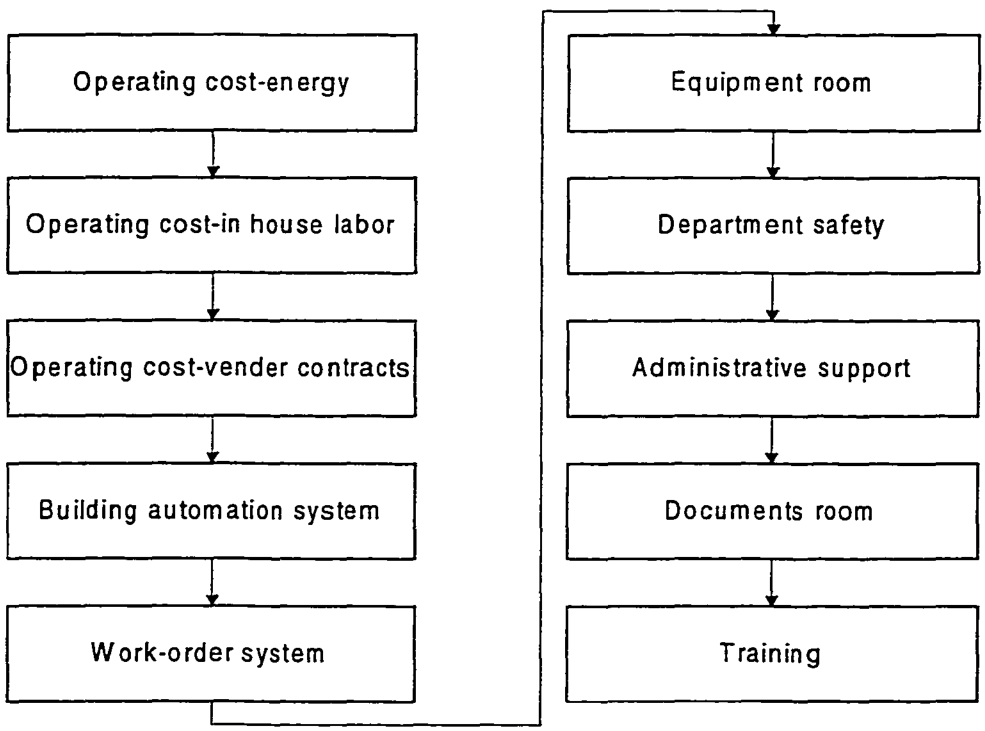

Figure 16: System Analysis

Collectively, these 10 sections and the staff assigned to these categories comprise the entire facilities management system. With a skilled workforce surveying these 10 areas, a building owner can enter phase one of the improvement plan, the facility assessment. Authorized to proceed, the team will perform the survey using a Total Quality Management process of standardized check sheets, survey sheets, inventory sheets, etc.

3.10 Designing the Improvement Plan

Providing a cost-effective solution to a department that has traditionally been perceived as a necessary evil requires a very special person(s) to transform the audit findings into a business plan (figure 17). Today, building occupants want better customer service, improved space comfort, and reliable mechanical and electrical systems. Building owners want a reduction and/or elimination of tenant complaints, as well as, improved energy consuTPMion. In addition, the facility manager will need to meet these requests while spending no more money this year than was spent last year in the operating budget.

Experience has shown us that most building owners committed to facilities management improvements will agree that budgets can't be cut right away, but in time they do expect these costs to drop. Before improvements can begin to be measured, employees need to embrace the plan because they are the ones who will be responsible for its success. Experience has also shown us that initiating improvements mean agreeing to a reasonable timeline.

It will realistically take a minimum of six months but may take up to the forecasted full year for the plan to take affect. This re-engineering process will be a "culture change" for the Operation & Maintenance department and seldom do groups rush to embrace change. Adjustments take time for the workforce to accept and before employee empowerment truly takes hold within the department.

Once people realize that this improvement plan has been established for there benefit and the building owner and occupants benefit, then progress can begin. The second year will be the period when change begins to show results. Every recommendation should be in place by the second year and measurement continually monitoring the results. The third year is simply to repeat the benefits received to date. The third year is a statement of success because the group has shown that they can repeat the results, as well as, build on these results.

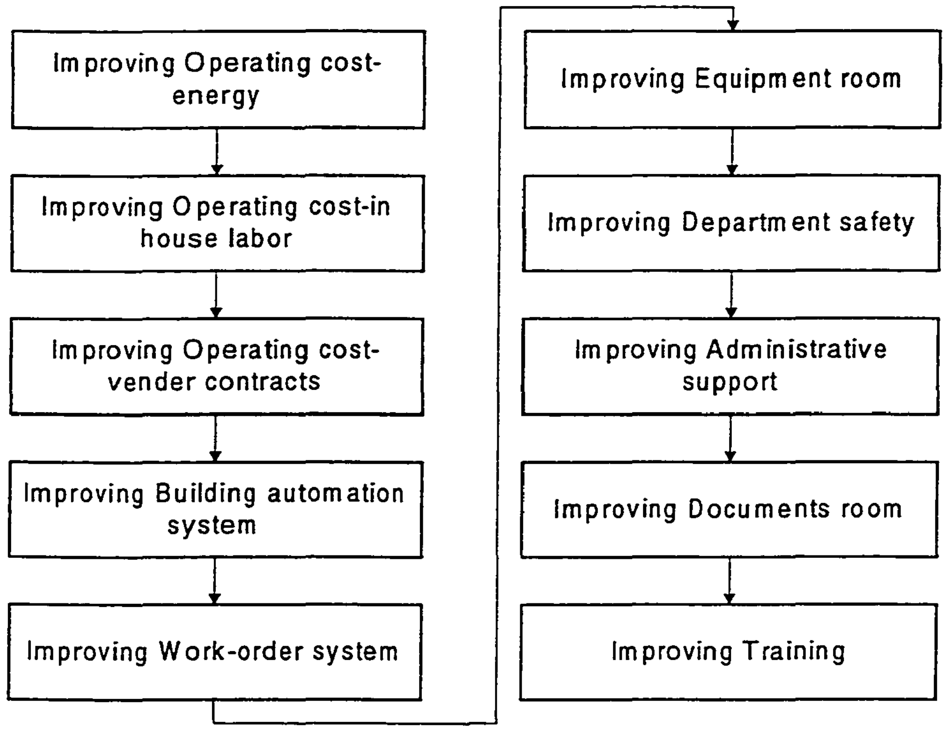

Figure 17: Designing the Improvement Plan

3.10.1 Improving Operating Cost-Energy

The facility energy consuTPMion will need to be continually measured in BTUH per square foot per year and compared monthly with this guideline. The audit has to identified the existing energy consuTPMion and then suggest an "energy profile" goal to strive to achieve. If the facility is currently at 350,000 BTUH/Sq.Ft./Yr, for example, the goal will be to reduce it toward the 250,000 BTUH by setting a goal of maybe 300,000 BTUH within a fixed time of the implementation plan.

3.10.2 Improving Operating Cost-In House Labor

The audit will first address the optimum labor coverage depending on the application (i.e., health care is recommended at 24-hour shift coverage, 7 days a week). Shift coverage is essential when assessing labor costs.

3.10.3 Improving Operating Cost-Vendor Contracts

It has been found that frequently the annual contract renewals are not competitively bid and/or the resulting contracts do not provide the necessary service results needed by the facilities management group. As a result, the building owner does not receive the "best buy for the buck." The audit will address this deficiency with recommended bidding guidelines. An important requirement will be that the venders have their own Total Quality Management process already in place and that they can show how their Total Quality Management process will help this facilities management group.

3.10.4 Improving Building Automation System

The most misunderstood piece of facilities management, the Building Automation System is the driving force in today's computer age facilities management. Like so many computer software, the Building Automation System application is a problem in itself. There are no recommended standards for this operation nemesis and the technology is continuing to rapidly change with each passing year. The audit solution lies in seeking out an experienced application engineer to take control of this diverse menu of issues (i.e., up-to-date software, automated reporting, prioritizing of alarms, etc.).

3.10.5 Improving Work Order System

The cornerstone of planned maintenance, industry standards have implied that 85 percent of all "Job orders & Sub Job orders" are unscheduled, leaving 15 percent of the "Job orders & Sub Job orders" as preventive maintenance. A comprehensive audit will surface whether a facility is proactive or reactive with their "Job order & Sub Job orders" process. Through Total Quality Management measurements, more emphasis can be tactically placed on planned, preventive maintenance once an audit has been completed.

3.10.6. Improving Equipment Room

The corporate offices of operation and maintenance, these spaces often serve as storage rooms and reflect the attitude of the facility workforce. Experience has shown us that these workspaces are frequently the places where problems occur. Audits of these rooms will catalog the many deficiencies that affect efficient system operation, as well as create an unsafe work environment for the employees.

3.10.7 Improving Department Safety

Rules and regulations exist for all building categories and an audit will simply document the applicable federal, province and local requirements.

3.10.8 Improving Administrative Support

There are no industry standards for this invaluable function, but as operation and maintenance becomes more automated and networked, this activity will be inherently mandate via computer-driven technology.

3.10.9 Improving Documents Room

This space can have its benchmark if an audit team has created a standardized reporting check sheet. This space will inherently be a computer-driven mandate for documents to be on computer software, user-friendly, etc.

3.10.10 Improving Training

The training agenda and plan should focus on three categories of training subjects to be consider:

a. Job-related training applicable to all;
b. Management training for supervisors and those individuals above the supervisor level;
c. Trade specific training presented by the appropriate supervisor to their staff.

3.11 Designing Maintenance Improvement Program

The design of a maintenance improvement program (figure 18) is basically the same for any type of facility. It consists of a study of the facility, listing the equipment and building components that require maintenance, prioritizing the items both from a standpoint of use and cost of replacement, determination of how each item is best maintained, preparation of a program of maintenance for each item and the preparation of a master schedule for the carrying out of improvement program.

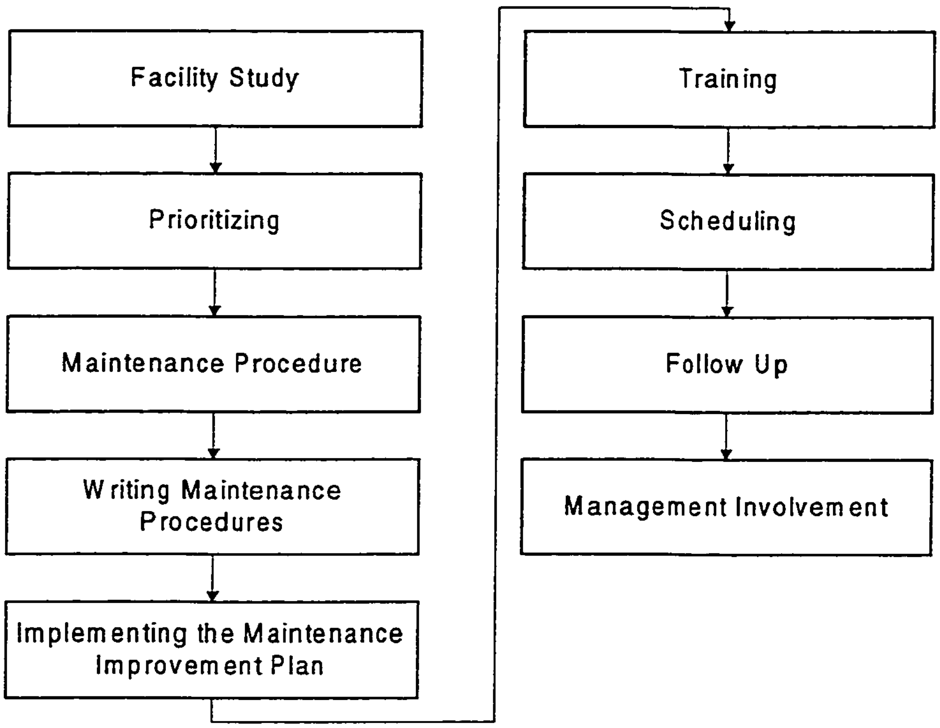

Figure 18: Maintenance Improvement Program

3.11.1 Facility Study

In conducting a facility study there are two basic things to consider: what is the function of the facility, and what has to be maintained in order for the functions to be achieved. The functions will vary greatly depending on the type of facility being studied. With the knowledge of the function solved, the next step in the procedure is to list all equipment in the facility and all building items such as roof, windows and access ways that will have a predictable life expectancy, which is dependent upon maintenance. The facility study then can be seen to be the foundation on which the maintenance improvement program is going to be built.

3.11.2 Prioritizing

A committee responsible for the operation, management and maintenance of the facility will most appropriately handle setting priorities for a maintenance improvement program. They will look at each item and determine how important it is to satisfying the fulfillment of the facility functions.

3.11.3 Maintenance Procedure

For each item on the list, there will be a most effective procedure. In some cases the cost of maintenance will exceed the cost of replacement. Building components such as a roof can have the expected life extended significantly by means of a well-designed maintenance program. This portion of the maintenance improvement program is best conducted by the facilities engineering people with some input from the financial group.

3.11.4 Writing Maintenance Procedures

In the design of a maintenance improvement program, the most time consuming function is the preparation of the written maintenance procedures, activities, etc. It is this step that often becomes the stumbling block to the whole process. Recognizing this in advance should help to keep the program moving. By involving more people at this stage there will be a better chance of success. Ideally, facility management will generate a generic format. The people conducting the maintenance, though it can be time consuming, should do the completion of forms. This will give them a sense of ownership and will be helpful when it comes to the actual implementation of the maintenance improvement program. Make sure the document format is consistent and all information is provided for review.

They can then be finalized in a neatly processed manner. Initially, it will be necessary to estimate the frequency that the procedure is to be performed and the approximate time required performing it. This will be necessary for scheduling the work. Having completed this work the design of the maintenance improvement program is essentially completed.

3.11.5 Implementing the Maintenance Improvement Plan

When business people first look at the idea of implementing a maintenance improvement program they are often overwhelmed and fearful that the cost will be prohibitive. There is a wealth of success stories to prove that, when properly administered, a good planned maintenance program will show significant, positive results on the bottom line.

One of the keys to success is the phasing in of the work rather than trying to accomplish everything at once. In the designing of the maintenance improvement program, talk about prioritizing and preparation of the maintenance procedures. Each item in the facility will be considered a separate maintenance item. Once a procedure has been prepared and approved and the people trained there is no reason to wait to complete the implementation. If routine preventive maintenance work at a facility has not been a normal practice, the phasing in of the new procedures will start to reduce the emergency type work that probably is occurring.

3.11.6 Training

To be successful, a maintenance improvement program must be consistently administered. In most facilities, more than one person will be performing the work required in a given procedure. Also, if a procedure is only required to be performed once a year, even the same person doing the work may not remember exactly how the job is to be performed. For this reason it is important that each person who is to perform the work is trained on how to do the work as it is intended. The training should follow the written procedure. During the training it will be a good chance to test the procedure to see that it was prepared properly. The person doing the training should be very knowledgeable about the equipment. Often, companies use the person who prepared the procedure to do the training. This will instill a sense of ownership and pride in the person and serve as a morale builder.

3.11.7 Scheduling

One of the keys to successful maintenance program is the preparation of reasonable maintenance schedules. In facilities where a good preventive program is not in place it is not unusual for the day's work schedule to be disrupted by emergency work. In a well-organized program, the emergency disruptions should be less than 10 percent of the scheduled work. One thing that is done in the preparation of maintenance jobs is the estimating of the time required to perform the work. If each job is known to require a certain amount of time to perform and the number of man hours available to perform work is known, it should be a simple matter to prepare a work schedule.

At the early stages of implementing a maintenance improvement program it will be necessary to allow for significant amount of emergency work. As the program progresses it will be seen that less and less emergency work is occurring and less time will be set aside for it. To assure that the maintenance improvement program is successful; it will be necessary for the person preparing the weekly work schedule to assign top priority to the preventive work. In a well-designed and implemented maintenance program there will be sufficient time for preventive work, people requested work and the emergencies that can always occur.

3.11.8 Follow Up

Simply designing and implementing a maintenance program is not the end of the process. With use of modern computer techniques it is possible to track the program's success by developing an ongoing equipment history. If a particular item is failing or not failing it may mean that we are either performing the preventive maintenance too few or too often. Some jobs may be consistently requiring too little or too much time to perform. This data can be used to fine tune the program and adjust as necessary.

3.11.9 Management Involvement

No maintenance improvement program will be successful without the complete support of top management. Most manufacturing facilities have recognized the importance of sound maintenance programs for many years. However, with the shift to a more business oriented society we now have many facilities that have no relation to manufacturing and many managers who do not recognize the importance of the maintenance function to the successful operation of their facilities. The best way to obtain management support for a sound maintenance improvement program is to show them the cost of the program and relate it to the dollar savings to be realized over the long haul.

3.12 Reliability Improvement

All types of maintenance are components that drive continuous improvement for equipment reliability. The road to reliability can be a long and winding one, with many steep hills, abrupt down grades and an occasional washout. Although some of this is part of learning and growing, a great deal of it can be avoided. How the various aspects of the journey to reliability are approached and supported will impact the number and size of the obstacles that will be encountered. It will also dictate your ability to overcome the barriers and may ultimately determine how long the journey to reliability will be, or if the trip will be canceled.

One can frequently read about rapid changes from breakdown maintenance to preventive maintenance and the enormous gains that are made. This is a cultural change, which requires us to change not only how we maintain the equipment, but also how we operate it. Unless born of necessity, cultural change is not likely to happen that rapidly. Where are these programs in their later years? What about programs that move to reliability at a much slower pace?

Equipment reliability can generally be approached in three areas, preventive maintenance, predictive maintenance and proactive maintenance. The first obstacle is determining which area should be the starting point.

3.12.1 Predictive Maintenance

Assuming that the plant is being operated in a run-to-failure mode and those basic preventive activities (greasing and oiling) are being accomplished, the logical starting point is predictive maintenance. The first place to start a predictive effort is vibration monitoring and analysis. This requires the personnel, equipment and training necessary to set up the system and do the monitoring. If maintenance personnel are used for this purpose, the maintenance work force will be reduced. At the same time, the maintenance workload will increase as a result of the findings of the predictive effort. This presents a difficult situation: you don't have enough people to do the work, so you have to assign some of those people to find more work. This is a very difficult barrier to overcome, getting that initial commitment for people, equipment and training. But, it is even more difficult to maintain a high level of commitment over time.

Long-term commitment will often be cyclic, driven by equipment failures. Equipment failures will even affect the response to problems that are identified. If there has been a serious failure recently, operations will want to shutdown at the mention of a minor equipment problem. While if there haven't been any failures for some time or if identified problems have made it to the next scheduled down, operations may not be willing to shut down, no matter how serious the equipment problem. One way to approach the problem of initial commitment is to wait until a predictable catastrophic failure occurs, then strike. Be prepared with the cost of equipment and personnel requirements to initiate a predictive effort that would eliminate that catastrophic failure and the associated costs. Often one failure can be found that will more than pay for the cost of the initial predictive effort.

If this is not the case, accumulate failure costs and use the same approach. Care must be used to look at unscheduled downtime caused by rotating equipment failures that are predictable in nature. Unscheduled Downtime another approach might be to look at the percentage of unscheduled downtime to the total equipment availability. What would a small percentage increase in equipment availability mean in dollars of production?

An individual should be chosen to spearhead the predictive effort. This person should be someone who is extremely interested in doing this kind of work, has a strong desire to learn, is highly self motivated and is likely to be around for a while. Many successful predictive efforts have later failed due to the loss of this individual. This is a full time position, not one of many duties. If it is set up as one of many duties then the predictive effort, depending on plant size, is probably doomed from the start. The first effort should be to reduce downtime by increasing reliability and equipment availability. One of the first stops is reduced unscheduled downtime. This is accomplished through the identification of equipment problems and scheduled repairs.

Cost savings associated with problems that are identified and corrected and the increase in equipment availability or reduction in unscheduled downtime are two good parameters to track and communicate. They will help maintain commitment and show the progress of the predictive effort. Use this data to climb hills and knock down barriers. The catastrophic failure that got us the ticket can now be used to expand the predictive effort. The more you use reliability, the lower the avoided unscheduled downtime savings will be. This makes it important to try to envision what equipment is needed and obtained prior to downtime. For example you may feel that your company won't be ready to do in-depth vibration analysis for a year, so the company does not need a vibration analyzer now. In a year it may be difficult, and sometimes not possible to get that analyzer. There are fewer equipment failures, there is no money, and there are more reasons than one can possibly imagine. Additionally, if you have the equipment on site you will begin using it much sooner than if you wait until you think you need it, to try to procure it.

This is not to say that there will not be barriers. There will be a time when the breakdown work is still happening, equipment is repaired for no apparent reason, and the predictive effort is piling it on. The amount of work generated by the predictive effort will increase with time, level out and then begin to decline. There can be an evolutionary process when it comes to predictive maintenance generated "Job orders & Sub Job orders". More people become involved in the predictive effort and applying the effort to more equipment. Increased knowledge in performing predictive maintenance also facilitates the identification of more problems.

Scheduled shutdowns or predictive maintenance days are an essential part of the move to reliability. Scheduled predictive maintenance days require a commitment from operations to take their equipment down on a regular basis, another roadblock. The regularly scheduled shutdowns need to be frequent enough to allow for repairs of identified problems and the performance of required predictive maintenance. Initially this may mean a shutdown every other week. This will increase over time, which may also increase grievances as a result of working with the wrong person. Product quality may be negatively impacted as a result of starting up and shutting down. Scheduled predictive maintenance days must be taken to get out of the breakdown mode of operation and is further justified through a reduction in unscheduled downs.

Breakdowns are significantly less beneficial and more costly. It takes three to five times as long to repair a breakdown, as it does to make a scheduled repair. Additionally, the breakdown is the only repair that is made, while on a scheduled down many problems can be addressed. Breakdown repairs are also likely to be "Band-Aids" that require further correction on a scheduled down, if they make it. There is likely to be a decline in the quality of the repair and an increase in the potential for accidents. due to the pressures of the equipment being off line and the need to get it back on line. Increased scheduled downtime and reduced unscheduled downtime will soon equate to increased availability, increased production and big bucks. Another barrier to regularly scheduled shutdowns is the inability to bring the equipment down and back up in the desired time frame. This barrier will not come into play until after the initial commitment to take the scheduled predictive maintenance days.

3.12.2 Planning and Scheduling Predictive Maintenance

To maximize the use of scheduled downtime, all work must be planned and scheduled. This planning and scheduling should include everything that will happen from product to product for both operations and maintenance. Equipment downtime is very valuable and must be utilized to the greatest extent possible.

Establish a timeline for activating that will occur during the scheduled shutdown. There needs to be a critical path for the controlling jobs. There should be a set time for shutdown and clean up, lockout, maintenance, felt changes, rolls changes, start-up, etc. Monitor these events with respect to the time that was planned and note any deviation. Track the causes for deviation to plan and Pareto them. This will tell you where to focus your efforts to have the greatest impact on reducing scheduled downtime. Minimizing scheduled downtime will become very important once unscheduled downtime is no longer a major issue. The ultimate goal is to run the equipment at its maximum sustainable rate, at the desired level of quality and with maximum availability.

In order for reliability, planning and scheduling to be successful, operation and maintenance must dissolve the supplier/customer relationship and become partners. Operations and maintenance must work as a team to best utilizes downtime. They must get out of the finger pointing mode when problems occur and work together to resolve problems to root cause. They must strive to put systems in place that ensure that problems are resolved and will not re-occur. If you are working on the same problem that you were working on six months ago or a year ago, you are not making progress. You will never get to work on the next problem that needs to be addressed, because the last problem will always be there to be fixed again.

Scheduled downtime or any downtime is very important, so it is necessary to recognize that the barrier will be there and that some method of dealing with it will be necessary. This process and procedure should include:

a. A method to categorize the importance of equipment and how the equipment in each category will be monitored
b. How databases will be built, including point identification, analysis parameter set, alarm limits, etc?
c. How often the data will be collected and how many points for each unit?
d. When and how walk-through inspections will be done?
e. How data will be reviewed and problems prioritized?
f. What data will be tracked to show the progress made relative to vibration monitoring?
g. What method will be used to communicate the equipment's condition?
h. A method of identifying repetitive problems and how to deal with them.
i. A repair follow-up procedure.

The development of the process and procedures will only be a starting point and will undoubtedly require modifications as the process is implemented. This is inevitable, as you learn more about the equipment and the monitoring software.

The process and procedure is important for consistent vibration monitoring of the equipment. If there is a problem with the monitoring that requires a change to the process;

the effects of the change can be seen in the data used to track progress. Or if a change is made to improve the vibration monitoring process it will be consistent for all monitoring, again the data will indicate if the change had the desired effect.

3.12.3 Preventive Maintenance Approaches

Preventive maintenance can be approached in two areas. One is the care and feeding of the equipment, which includes lubrication, cleaning, calibration, etc. The other is the preventive maintenance activity that is required by the equipment or to meet safety, environmental, insurance or other regulatory requirements.

A computerized preventive maintenance system is almost a must in a plant of any size. The preventive maintenance requirements of the equipment need to be identified. The level of preventive maintenance activity needs to be driven by the importance of the equipment to the process and the desired level of reliability. This ultimately means, does it cost more to do preventive maintenance than it does to run the equipment to failure. The higher the failure consequences, the greater the level of preventive maintenance that is justified. Of course, failure consequences do not drive preventive maintenance activities that are dictated by safety, environmental, insurance or other regulatory compliance.

As it is relatively easy to see, a preventive maintenance effort is a very large undertaking that will require significant time and resources, not only to set-up, but to perform the required activities once completed. As with the other areas, a process and procedure and tracking indicator need to be developed.

A preventive maintenance system also needs to be dynamic, as do any of the pieces of the reliability effort. There also needs to be some interlock between the various systems. For example, preventive activities should have some mechanism for review to ensure that the activating is still valid and to see if it can be replaced with a predictive activity.

Some of the required resources that will be utilized to perform predictive maintenance will result from the reduction in breakdown maintenance and the increased utilization that results from planning and scheduling. The resources utilized on preventive maintenance are much more effectively utilized than on either breakdown or corrective maintenance. It takes considerably less time to ensure that a pump is properly lubed, than it does to replace the pump. Proactive maintenance techniques can be put in place from the beginning of the journey. Improved alignment and balancing can be implemented at nearly any point, the earlier the better. Root cause failure analysis must also be done as required along the way. It may be necessary to establish some criteria to identify and prioritize when to perform failure analysis, as there may be too many failures to keep up with initially.

It is necessary to address repetitive problems along the way. If not, all the predictive effort will be spent identifying the same problems. Good record keeping is very important to identify repetitive problems, and which ones are having the greatest impact. One suggestion to identifying what piece of equipment is a problem is to open the file drawer and start with the thickest file, no capital investment required. Remember that if you are working on the same problem again and again, you are not making progress. Elimination of repetitive problems can often be done in bulk form. Improved alignment and balance can eliminate many repetitive problems. If numerous failures are the result of contaminated lubricants, improved sealing and greater care in the application of lubricants can also eliminate many repetitive problems.

Through the evolution to reliability, the predictive efforts focus should swing from identifying problems before they fail, to driving problems to root cause so that the problem doesn't occur again. Still beyond that is improving the operating condition of the equipment to extend the mean time between repair. This improves reliability and further reduces corrective maintenance requirements.

Career patching of leaders can play a critical role in the success of an organization that is dependent on equipment throughput. All managers should have some maintenance background or should have people with maintenance experience. The normal career path to operations should be through maintenance.

3.13 Maintenance and the Continuous Improvement

Predictive maintenance, preventive maintenance and proactive maintenance are not programs, but a style of maintenance that comprise the components of the move to reliability. The move to this style of maintenance does not come easily. It requires a major shift in not only the way we perform maintenance, but also in the way we operate equipment. The road to reliability must consist of interwoven dynamic systems, which drive continuous improvement. Tracking indicators must be established, which indicate the effect of changes to the systems. There also must be tracking indicators that show the impact of the efforts on the processes.

Before statistical process control can be utilized on the processes, before bottlenecks can be identified in integrated processes, before plan of control can be implemented, breakdown maintenance must be reduced to a minimum, if not eliminated. Processes operating in a breakdown mode are not stable, making data on the process virtually useless. Processes operating in a breakdown mode are not capable, making it impossible to determine what area might be the bottleneck.

Implementing a bar coding system improves labor productivity, but the key benefit is having accurate, reliable and timely maintenance data. Today, bar coding is becoming as necessary to maintenance and materials management operations as vibration analysis equipment is to predictive maintenance and continuous reliability improvement. The days of listening to a noisy bearing through the end of a screwdriver are almost over. Today's automatic identification technology offers progressive maintenance leaders another important tool - a tool that collects accurate and timely maintenance-related information to manage and lead mission-essential maintenance operations.

3.14 Establishing the Maintenance Documentation

3.14.1 Operations and Maintenance Manuals

Operations and Maintenance Manuals are developed to establish the operational procedures and maintenance requirements of equipment that make-up process lines and facility support equipment. Industry's utilization of Operations and Maintenance Manuals documentation is still in its infancy. With the complex equipment being used in modern manufacturing production lines, coupled with sophisticated drive and control systems, the need for standard operating procedures and proper maintenance is a must.

Operation Manuals are developed at the system level and define the physical and functional description of each component within the system. The functional description is expanded to encompass the overall operation of the system. Standard Operating Procedures are developed to cover all operational concepts of the manufacturing process. Standard Operating Procedures cover pre-Start-Up, Start-UP, In Process Actions and Monitoring, Shut-Down (Normal and Emergency), and Post Shut-Down phases of the manufacturing process. Quality control issues and ISO-9000 requirements are researched and incorporated into the Standard Operating Procedures.

Maintenance Manuals are developed to define the maintenance requirements for all equipment, which make up the process line. Equipment Maintenance Plans define the Maintenance Requirement frequency, and craft responsible for conducting the

Maintenance Requirements. Maintenance Requirements are step-by-step formal procedures, which include all safety requirements, special tools/test equipments and required parts.

3.15 Life Cycle Maintenance Management Integration

Life Cycle Maintenance Management integrates systems, and management expertise into the maintenance team to achieve a proactive maintenance program that provides you the following benefits (figure 19):

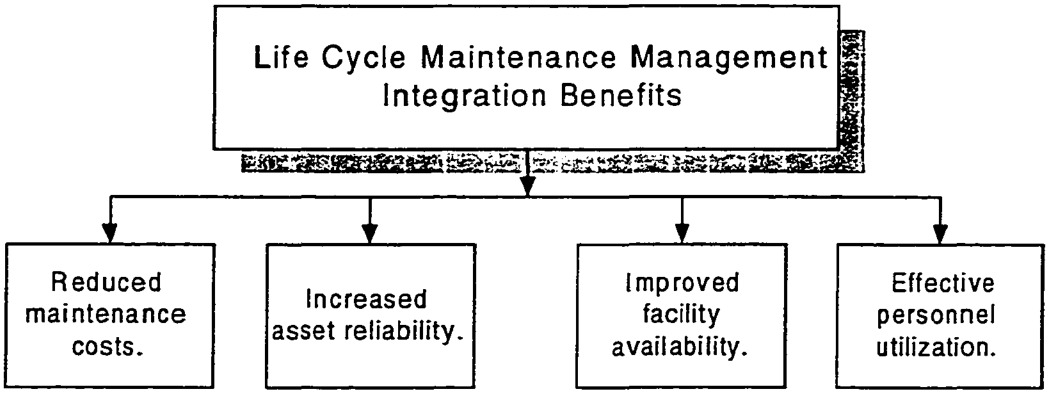

Figure 19: Life Cycle Maintenance Management Integration Benefits

a. Reduced maintenance costs.
b. Increased asset reliability.
c. Improved facility availability.
d. Effective personnel utilization.

A maintenance management that provides (figure 20):

a. A current Equipment Inventory.
b. Preventive Maintenance activity identification.

c. Preventive Maintenance Procedures.

d. Corrective Maintenance Procedures.

e. Pre-planned work packages.

f. Objective data analysis.

g. Performance reporting.

h. Machinery history.

i. Problem analysis.

j. Periodic maintenance program reviews.

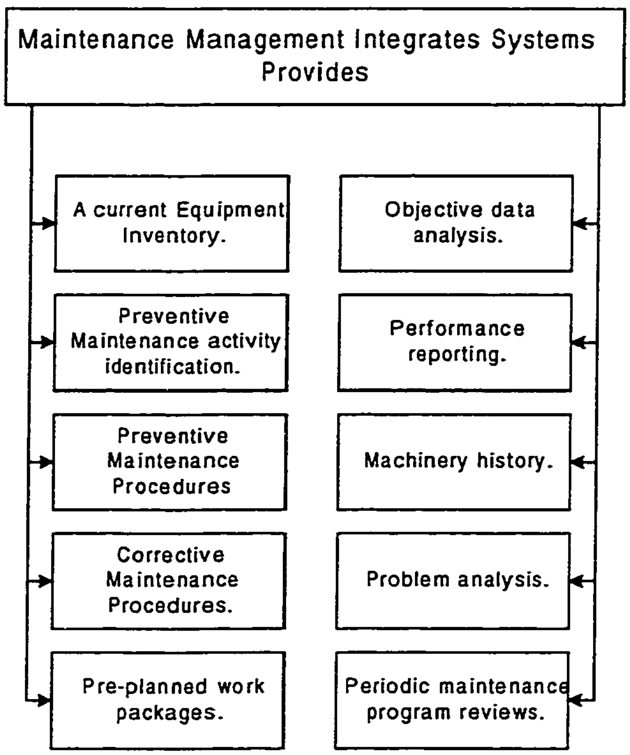

Figure 20: Life Cycle Maintenance Management Integration Elements

3.16 Maintenance Logistics Design

3.16.1 Scope of Logistics

The art and science of management, engineering, and technical activities concerned with requirements, design, and supplying and maintaining resources to support objectives, plans, and operations.

3.16.2 System Design and its Logistic in the System Life Cycle

Logistics in the system life cycle will involves planning, analysis and design, testing, distribution and sustaining support of the system though out the consumer use period.

3.16.3 The Language of Logistics

A few terms and definitions are discussed to provide the reader with the fundamentals necessary to better understand the material presented in this text. Additional terms are introduced throughout subsequent chapters. The major elements are as follows:

Maintainability

Maintainability can be defined as a characteristic in the design that can be expressed in terms of maintenance frequency factors.

Human Factors

Human factors are the interface between the human and the system. That to assure complete compatibility between the system physical & functional design features & the human element in the operation, maintenance & support of the system.

Maintenance

Maintenance includes all actions necessary for retain a system or product in a serviceable condition.

Maintenance Level

Maintenance Level is related to actions and activities to be performed in on the system/product in specific maintenance area or level. That depends on:

a. Activity complexity.
b. Personal skill level requirements.
c. Special facility needs.
d. Others.

Maintenance may be classified as

a. Organization. (E1 = Echelon 1)
b. Intermediate. (E2 = Echelon 2)
c. Depot. (E3 & E4 = Echelons 3 & 4)

Maintenance Concept

The Maintenance Concept constitutes a series of statements defining criteria covering maintenance levels, major functions at each level, basic support policies, effectiveness factors (e.g., MTBM, MTBF, etc.), & primary logistic support requirements.

Maintenance Plan

The Maintenance Plan is a detailed plan specifying the methods & procedures to be followed for system support throughout the life cycle during the consumer use period.

System Effectiveness (SE)

System Effectiveness represents the extent to which the system is able to perform the intended function.

Life Cycle Cost (LCC)

Life Cycle Cost is all costs within the system life cycle and it includes:

1. Research & Development Cost (R&D).
2. Production Cost.
3. Operation & Maintenance Cost.
4. System Retirement & Phase out Cost.

Cost Effectiveness (CE)

Cost Effectiveness relates to the measure of a system in term of mission fulfillment (system effectiveness) and total life cycle.

3.16.4 Measure of Logistics

Logistics is the composition of all considerations necessary to assure the effective and economical support of a system throughout its programmed life cycle. It is an integral part of all aspects of

a. Planning.
b. Design.
c. Development.
d. Testing.
e. Evaluation.
f. Production and / or Construction.
g. Consumer use. (Operation & Maintenance)
h. Retirement.

In conclusion, Total Productive Maintenance is a maintenance and management philosophy that advocates planning all maintenance (i.e., preventive, predictive, corrective, and inactive), and the control of quality in maintenance. It is a concept that addresses both programmatic and technical concerns of maintenance and considers maintenance an integrated function rather than a specific activity.

CHAPTER 4

MAINTENANCE SOFTWARE PROGRAM DEVELOPMENT

Introduction

The maintenance Software Program is maintenance and management computerized method that advocates planning all maintenance (i.e., preventive, predictive and corrective,), and the control of quality in maintenance. It is a concept that addresses both programmation and technical concerns of maintenance and considers maintenance as an integrated function. Maintenance Software Program is based on the premise that effective maintenance requires that the elements of maintenance be defined, operational, and interactive.

4.1 Maintenance Software Program Concepts

The Concepts of the Maintenance Software Program (figure 21) are identified as follows:

a. Maintenance Organization and Administration - Provide governing principles and concepts upon which the maintenance function is built.

b. Measures of Effectiveness - Provide performance indicators used in measuring the effectiveness of each of the elements and the overall maintenance process.

c. Work Control - Provide the means to plan, schedule, and execute maintenance and to record data necessary for evaluating performance against goals and objectives.

d. This Maintenance Management Information System is the tool by which maintenance resources are managed; the enabling technology for the maintenance function.

e. Personnel - The policies, programs, and systems used to ensure the work force is capable of performing activities required to effectively execute the maintenance function.

f. Technical Documentation - Maintain consistency between facilities assets and the documentation that defines the hardware and the software, and maintain hardware in a known configuration.

g. Logistics Support - Ensure the right resources are in place, when needed, for maintenance activities.

h. Maintenance Activities - Do the right things to plant assets to effectively maintain the assents for their life cycle.

i. Maintenance Engineering - Maintenance function oversight to ensure the right things are being done correctly.

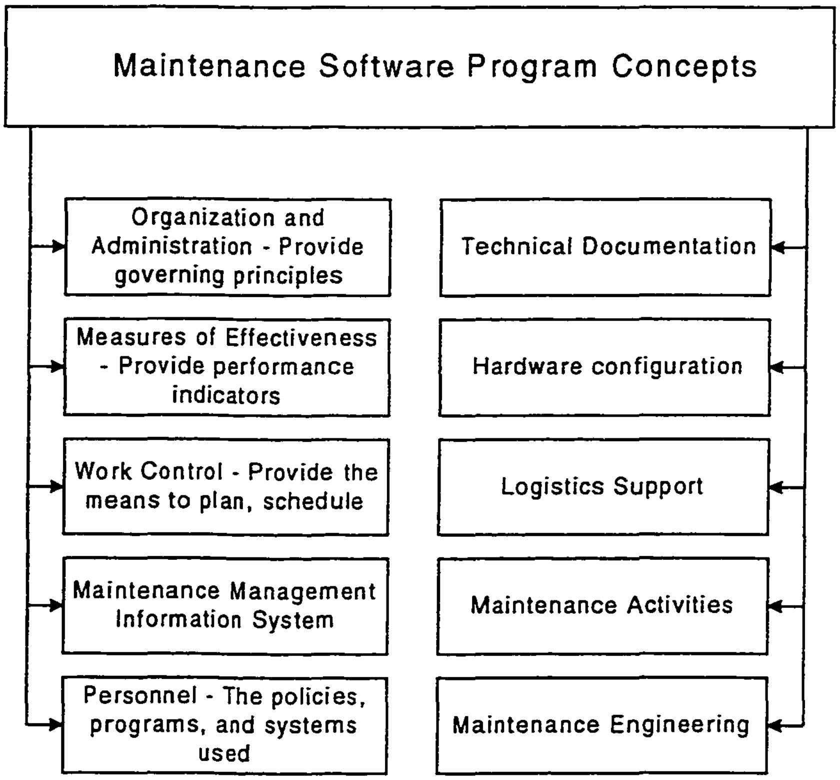

Figure 21: Maintenance Software Program Concepts

In developing a Maintenance Software Program, it is important to consider each of the maintenance function elements and to design the overall function and each element to meet the business and technical needs.

The most important aspect of a Maintenance Software Program is the development and use of effective maintenance activities.

4.2 Application Main Menus Design

The application main menu and sub menus (figure 22):.

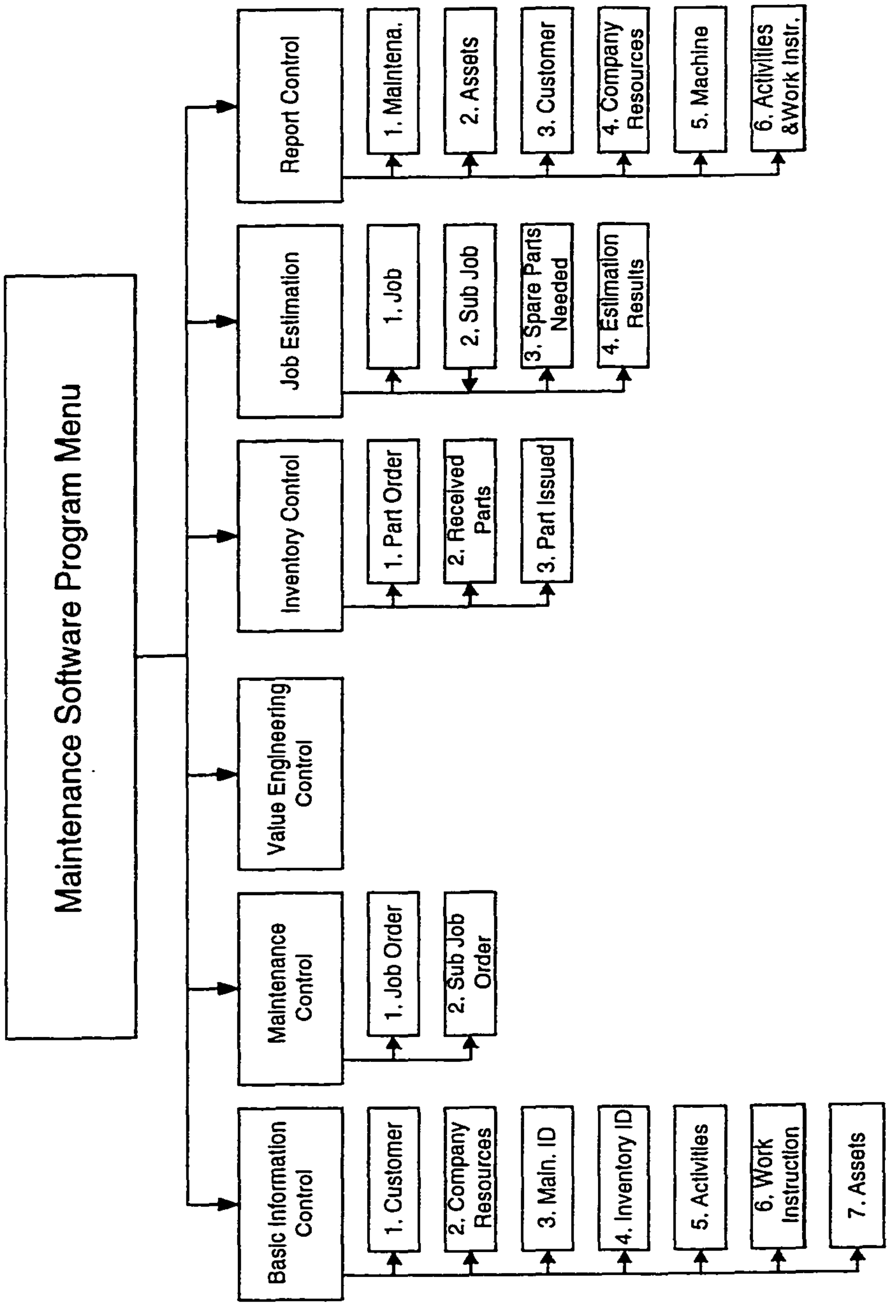

Figure 22: Application Main Menus

I. Basic Information Control.

1. Customer Information.

All customer information name, address, telephone, fax. ...etc.

2. Company Resources Information.

Resources include (figure 23) the facility, employees, all types of internal and external shops, all types of equipment, tools, stands, test benches, etc.

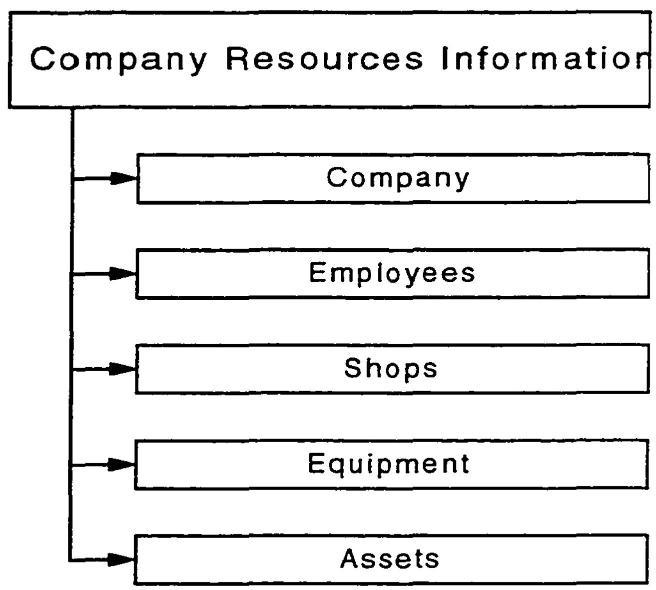

Figure 23: Company Resources Information

Company Information.

Company Information includes, company name, address, phone number, and fax number. Figure (48) shows the company information screen.

Employees.

For each employee there is a record which contains, employee identification code, name, title, office location, phone number and extension. Figure 49 shows the window to enter this data.

Shops.

Figure 43 had been designed to keep the data needed for the deferent workshops either owned by the facility or external one. Data to be kept in this record are shop ID, shop name, shop type, location, address, and the manager of this shop.

Equipment.

This is one of the most important records. It includes all the necessary information about the equipment. Figure (51) shows the screen used to enter the equipment information starting from the owner of this equipment to the last maintenance that has been performed.

Assets Categories.

In the Assets category identification window, figure (39), the user identifies his assets (main building, machine, tool, etc).

3. Maintenance Code Information.

This menu (figure 24) gives the user the facility to identify all types of activities, status and resources.

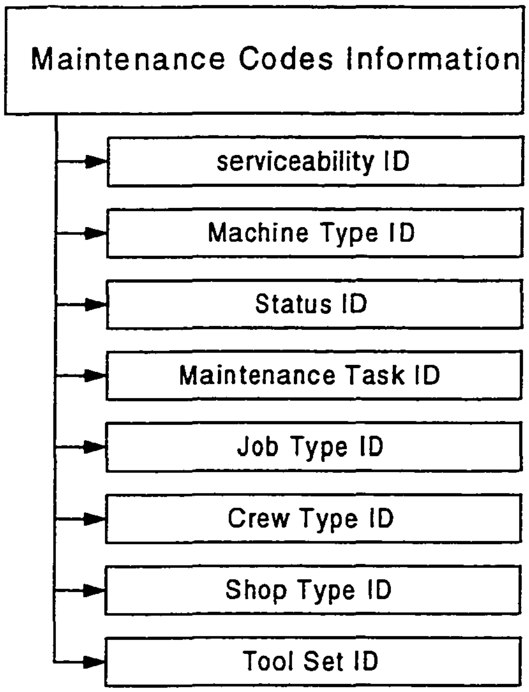

Figure 24: Maintenance ID Codes

Serviceability Code.

This code is designed to help the facility manager to identify the serviceability condition of each equipment (serviceable, not serviceable, serviceable but needs maintenance, ...etc). This record is flexible enough to accommodate any number or type of code.

Machine Type Code.

Users can categorize all types of equipment and assets in deferent categories and identify each type by identification code. Figure 40 shows the window used for this purpose.

Status Code.

The Status code is designed to identify the status of each equipment owned by the facility or owned by an external customer. Figure 46 shows the screen designed for this purpose (new, used, in repair, waiting spare parts, waiting shop, etc).

Maintenance Task Code.

There are several maintenance tasks that can be performed: preventive level 1, preventive level 2, preventive level 3, corrective, calibration level A, calibration level B, calibration level C, environmental corrective maintenance, quality improvement maintenance and any other maintenance. Figure 42 shows the window designed for this purpose.

Job Type Code.

There are deferent types of jobs that can be performed in the maintenance facility: job estimation (to estimate the maintenance costs and the needed man hours to perform this job), job demand (customer asks for job to be performed on his equipment), job ordered (facility manager ordered to accept equipment for maintenance activity) (see figure 44).

Crew Type Code.

This code is designed to accommodate the deferent types of crews in the facility (mechanical, electrical, hydraulic, ...etc).

Shop Type Code.

This code is designed to accommodate the deferent types of shops in the facility (mechanical, electrical, hydraulic, ...etc).

Tool Set Code.

For each job performed, the work instructions,will list a set of tools needed to be delivered from the tool store. For that purpose, a tool set identification code will help the store keeper to prepare this set. (figure 47).

4. Inventory Code Information.

Give the user the facility to identify spare parts, product category, and the shipping methods.

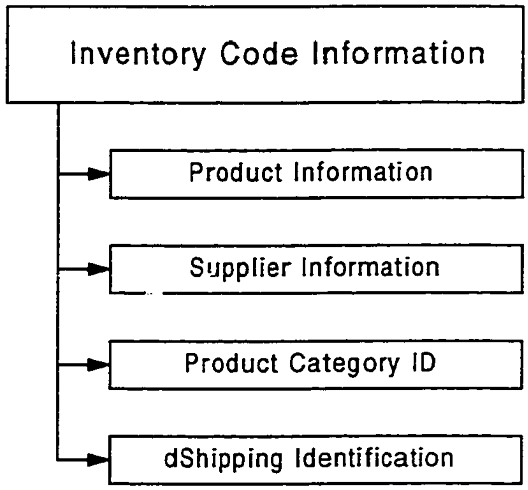

Figure 25: Inventory Code Information

Product Information.

Figure 52 shows the interactive window used to enter all Product information. This window is divided into 4 parts;.the first part includes product identification, part number, product name, lead time, reorder level, units on hand and units in order;the second part shows all inventory transactions for that product;the third part shows received product ,and the last part shows product issued.

Supplier Information.

The supplier information window (figure 54) holds all the necessary information about the facility suppliers, supplier name, contact name and title, address and phone number.

Product Category Code.

The product category code allows categorizing all types of products and spare parts in various identified groups.

Shipping Identification Method.

Figure 45 shows the window used to identify the shipping methods used to receive or send products.

5. Activities Information.

All information required by the user to perform an activity (for example, repair 10 HP, 3 Phase dc motor model xx) is founde in an active window (figure 56). This window contains activity ID, references, activity total cost and needed man-hour, along with work instructions to perform this activity and the procedure flow diagram.

6. Work Instruction Information.

The Work instruction window includes all the information needed to perform the work instruction. It includes, work instruction ID, references, drawings, documents, required instruments, tools, machines, crew types, crew size, estimated costs and man hours, step-bye-step ,work recommended spare parts. A sub window shows the step-bye-step work as a movie film.

7. Assets Information.

Assets information can be found in the window (figure 60). It gives the equipment ID, depreciation method, depreciable life, salvage value, purchase price and total depreciation.

II. Maintenance Control.

1. Job Order Control (figure 26).

In the window presented (figure 58), the user can estimate job cost, man hour required to complete a job, demands to create a new job, put job in the schedule and to start a new job.

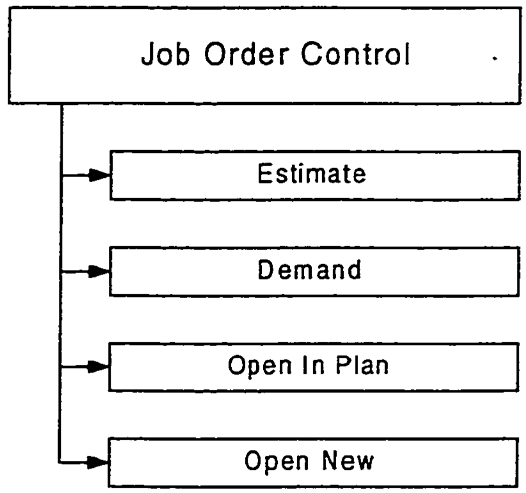

Figure 26: Job Order Control

2. Sub Job Order Control (figure 27).

This window (figure 59) is used to estimate sub job cost, man hour needed to complete a sub job, demand to create a new sub job, put job in the schedule and to start a new sub job.

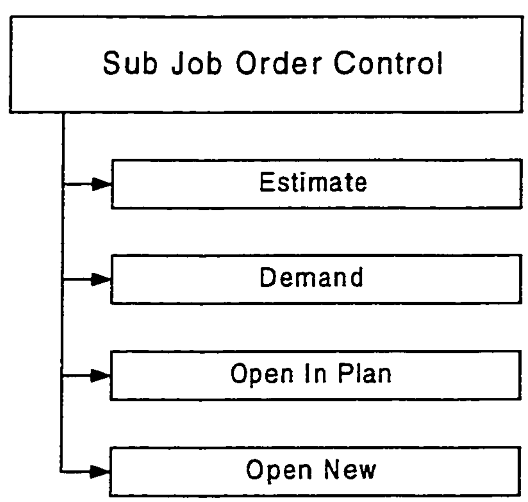

Figure 27: Sub Job Order Control

III. Value Engineering Control

This menu controls all the facility assets; calculate the present value, depreciation, maintenance costs, and the total value of company assets.

IV. Inventory Control (figure 28)

In the inventory control management the user can manage the spare part stock, issue parts to the sub job orders and receive parts from the suppliers.

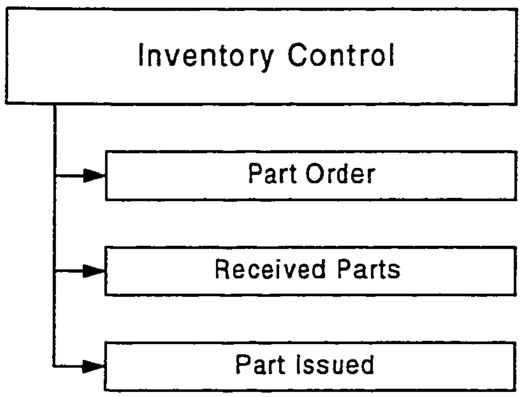

Figure 28: Inventory Control

V. Job Estimation (figure 29).

In this menu, the user can start the cost and man-hour estimations of the new job orders and sub job orders and define the needed spare parts to end the job.

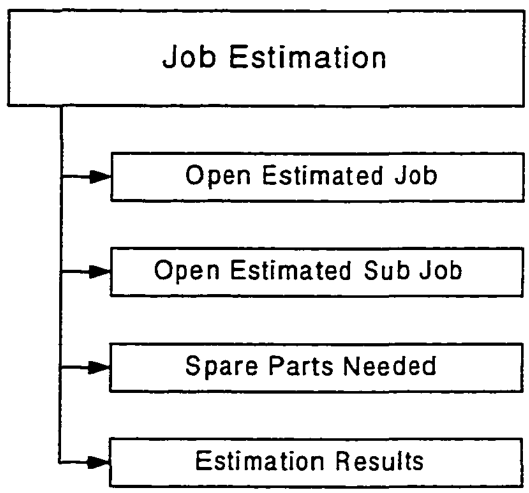

Figure 29: Job Estimation

VI. Report Control (figure 30).

The system offers different types of reports either predefined types of reports or custom designed reports. The later can be obtained by using the Microsoft Access program to build custom reports. All these reports can be found in Appendix A.

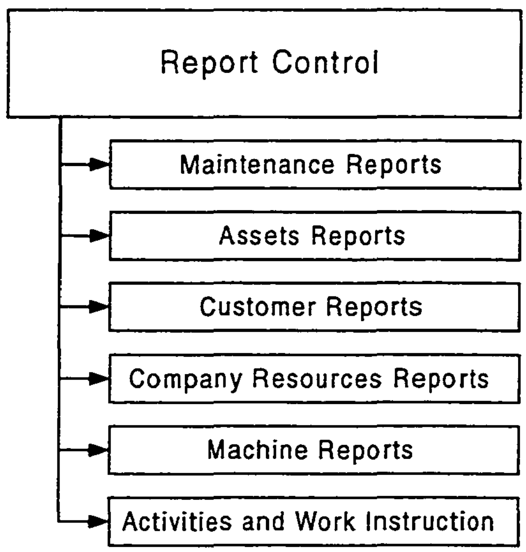

Figure 30: Report Control

4.3 Data Base and Tables Design

The application consists of a single Data Base file and 28 Tables. The Data Base file is named "Master". Figure 31 shows the Master Data Base and tables. Figures 32 and 33 show the relationships between these tables.

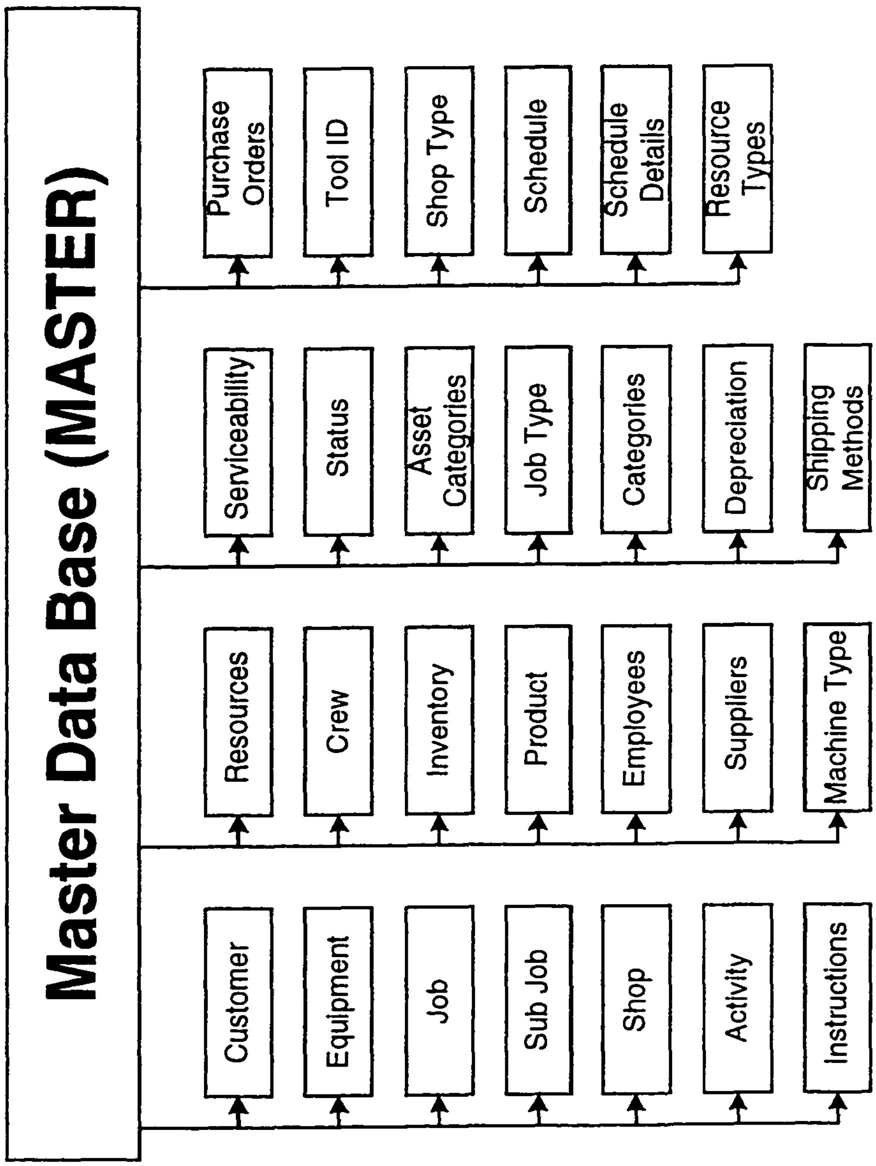

Figure 31: Master Data Base and Tables

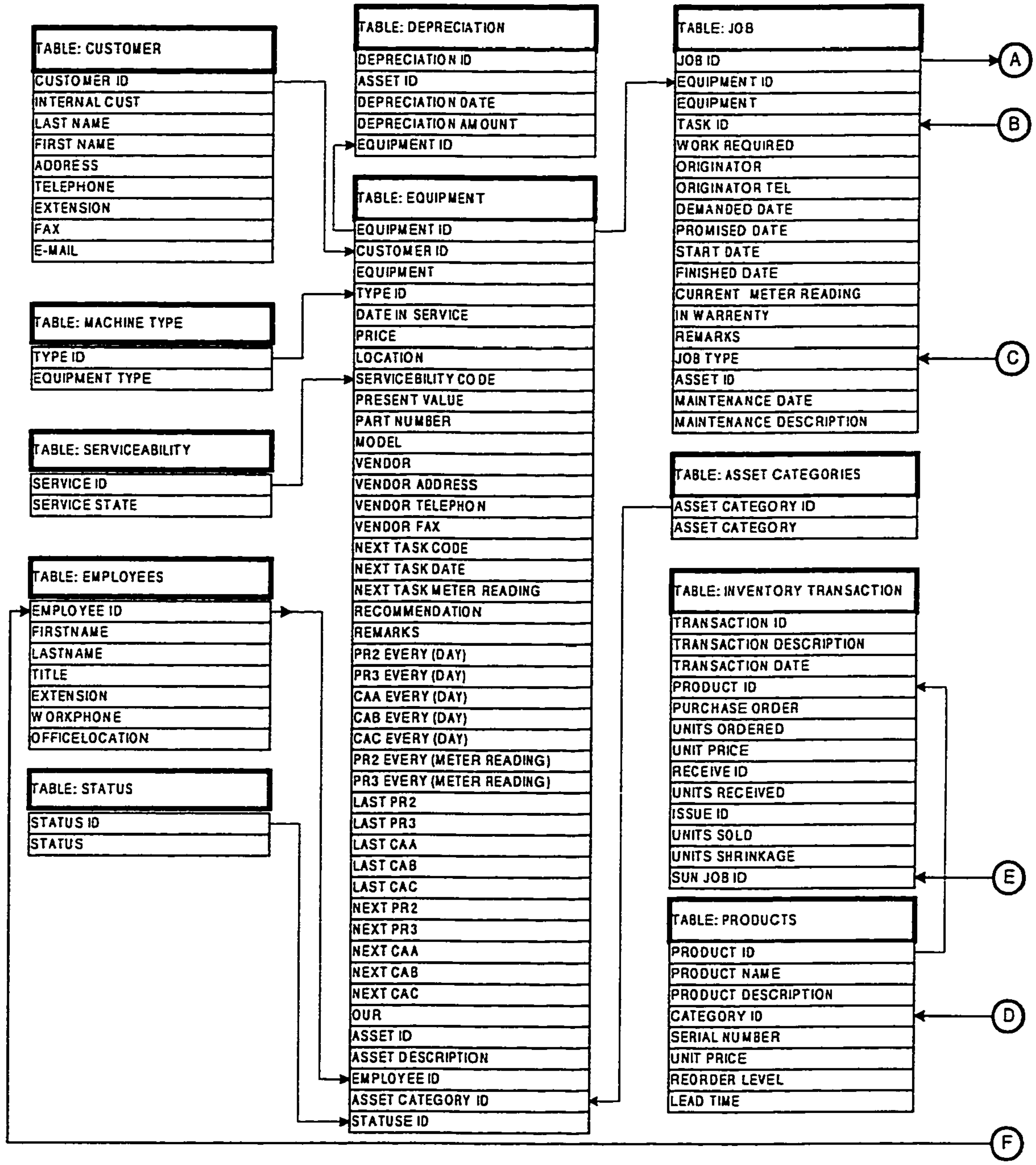

Figure 32: Relationships Between Tables (1/2)

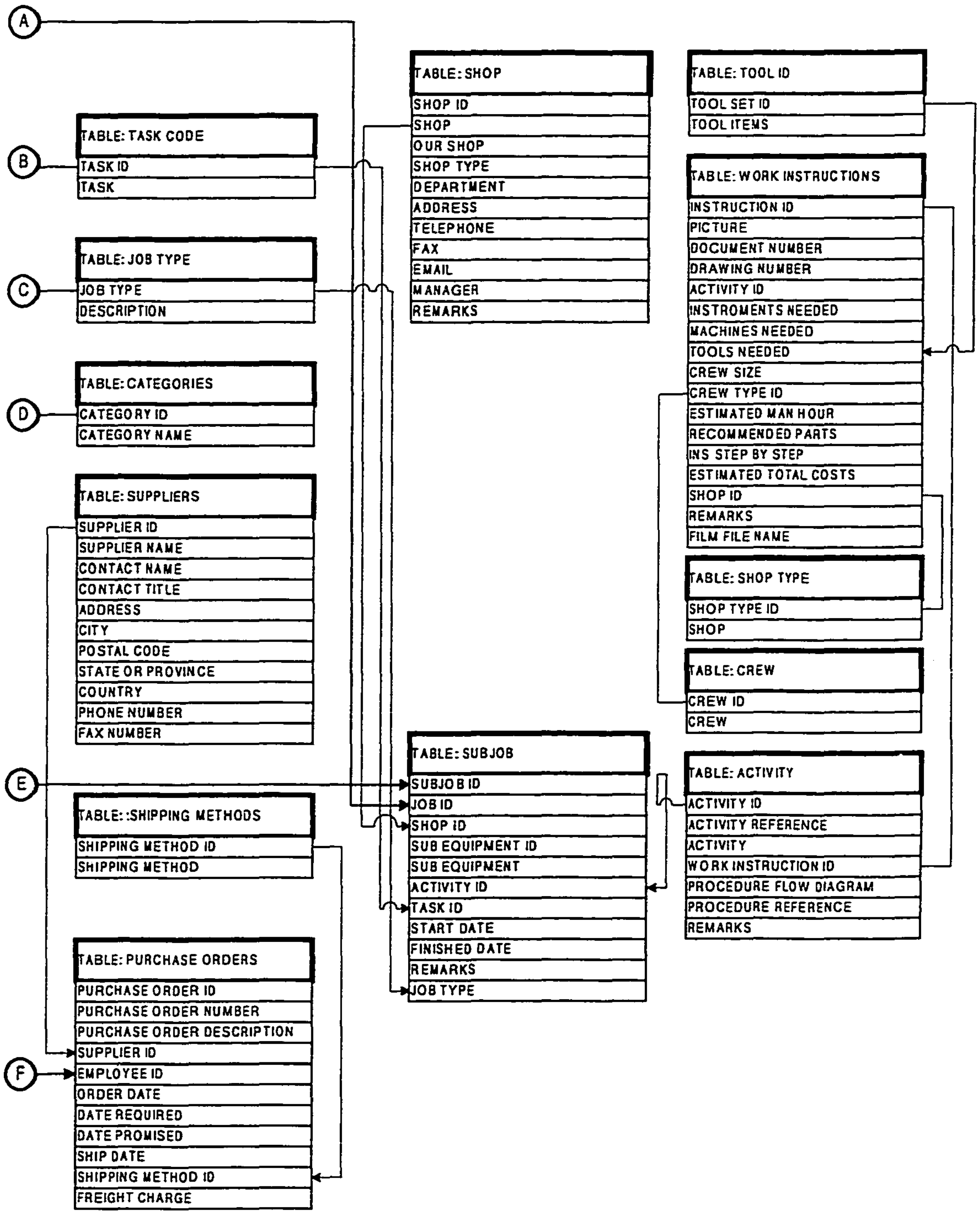

Figure 33: Relationships Between Tables (2/2)

4.4 Output Reports and Spread Sheets Design

The Application offers several types of reports and spreadsheets. At the same time, the end user can develop his own report or spread sheet. A list of built- in reports and spread sheets are as follows:

a. Reports.

Next (figure 34) are the different types of reports offered by the application MASTER.

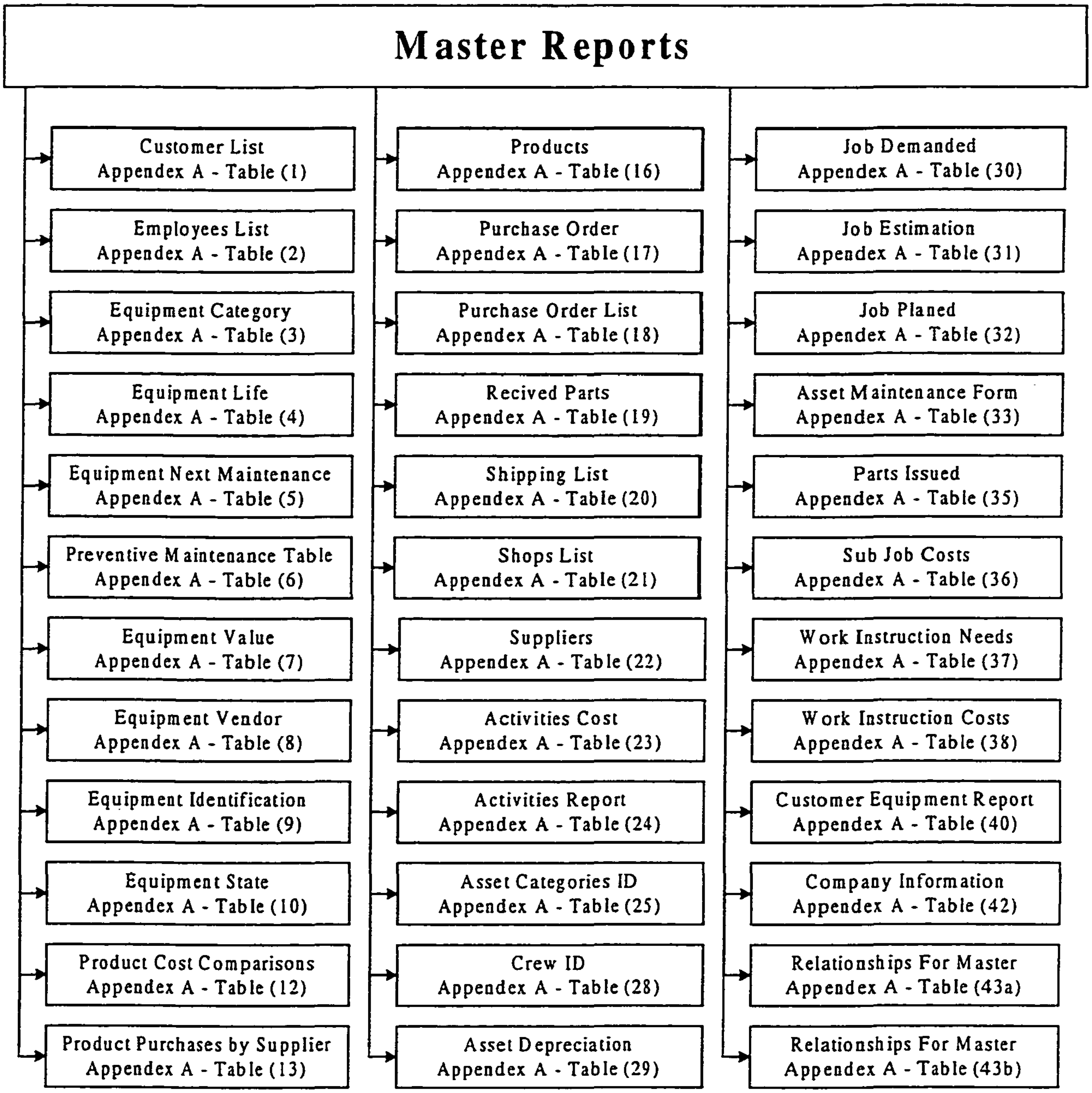

Figure 34: Master Reports

b. Spread Sheets.

Next (figure35) are the different types of reports offered by the application MASTER, spread sheet.

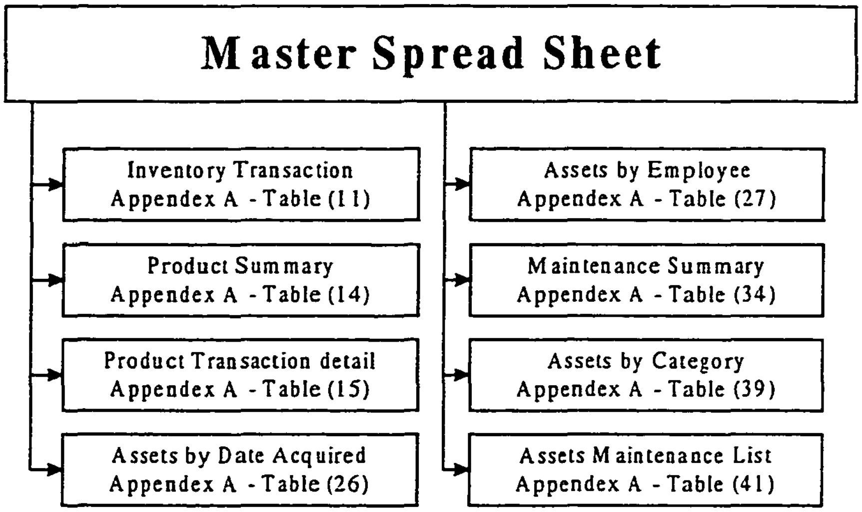

Figure 35: Master Spread Sheet

All the mentioned reports and spreadsheets can be found in Appendix A.

4.5 Application Input / Output Data Flow Design

The main objective of this software is to control all the activities in any electromechanical maintenance facility. For this reason, "**MASTER**" seems to be an appropriate name for the package. MASTER runs in a Windows 95 or 98 environment & Access97 and is friendly with all Windows applications. Figure 36 shows the data input and output flows.

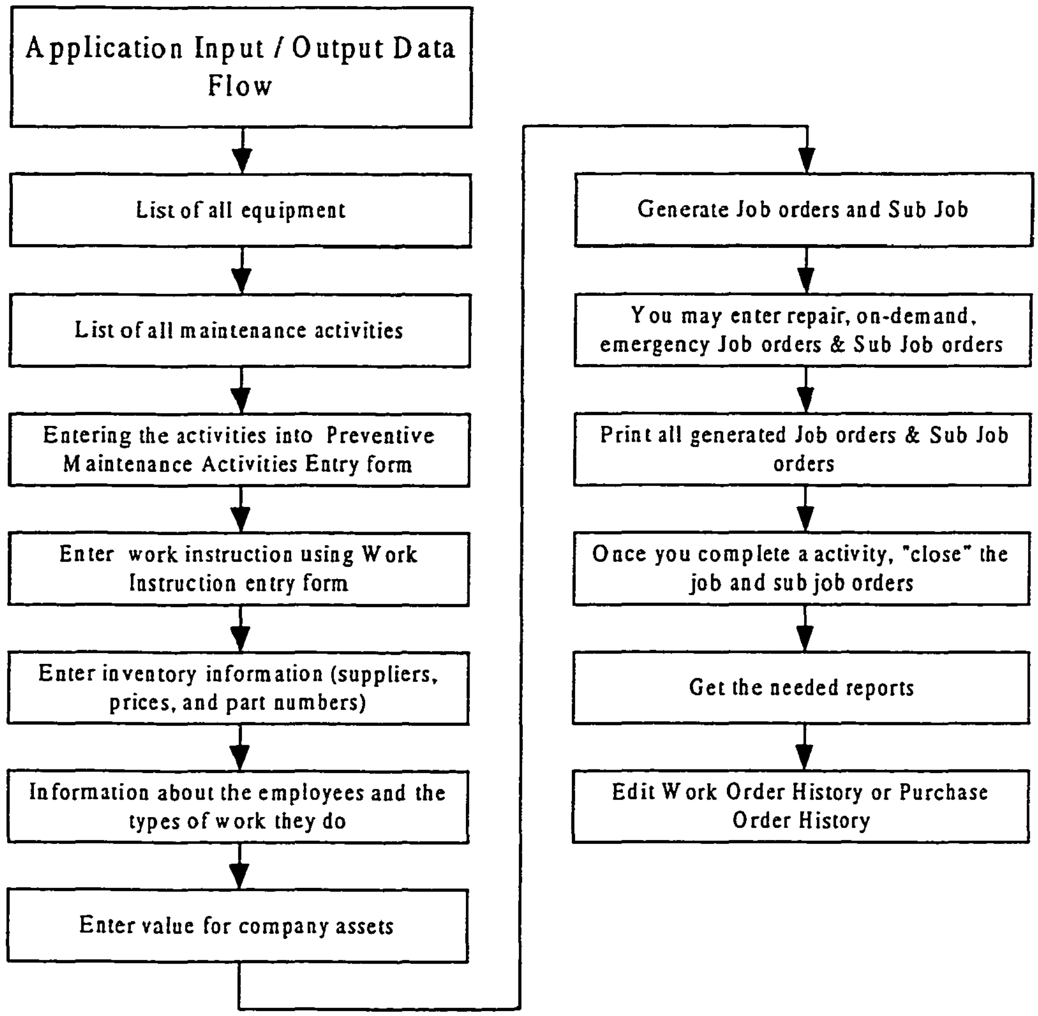

Figure 36: Application Input / Output Data Flow

a. List of all equipment, machinery, and facilities that require regular maintenance, such as vehicles, shop machinery, houses, business equipment, etc. MASTER refers to these items as equipments.

b. List of all maintenance activities regularly performed on each piece of equipment. Check with instruction or operating manuals included with the equipment for standard maintenance activities. For example, a car operating manual suggests that the oil be changed every 3 months or (3,000 kames).

c. Entering the activities into Preventive Maintenance Activities Entry form. You may perform each activity on numerous items. For example, you may enter Oil Change as an activity, and then schedule the activity on five different vehicles at five different times. You specify an activity schedule for each piece of equipment.

d. For each activity, there are work instructions for performing this activity. The user needs to enter this work instruction using the Work Instruction entry form.

e. Inventory management tracks inventory (including suppliers, prices, and part numbers) in order to prepare the maintenance activities. When you use an inventory item, one can efficiently manage your inventory by creating purchase orders with inventory management to print and distribute to your suppliers. It also tracks items ordered and received and adjusts inventory information accordingly.

f. If employees perform maintenance activities, you may enter information about the employees and the type of work they do. When one creates "Job orders & Sub Job orders", one may then assign a particular employee to complete the work.he system tracks time spent by the employees on activities, and it tracks labor cost based on individual salaries.

g. The system also tracks the value engineering for company assets and calculates the depreciation of the assets.

h. Generate "Job orders and Sub Job orders" for the activities. When one generates "Job orders & Sub Job orders", one should specify a date.The system then searches the database and locates all activities scheduled up to the specified date. The system must generate "Job orders & Sub Job orders" based on these activities.

i. You may enter repair, on-demand, emergency, or non-repetitive "Job orders & Sub Job orders" without setting up an activity. Simply access the Work Order Entry form and enter information about the work to be done.

j. Print all generated "Job orders & Sub Job orders" and refer to them when performing the activities. These printouts are visual reminders of the work. You may add information to these "Job orders & Sub Job orders" to enter into the system later .

k. Once an activity is complete, the job and sub job orders are closed with the "Close Job and Sub job Orders" form. A closed "Job order & Sub Job orders" means that the activity has been completed. . The system has several functions to help in controlling the maintenance activities.

l. The system has the capability to provide the appropriate reports for the facility.

m. Application records closed "Job orders & Sub Job orders" and purchase orders in history. One can access and edit Work Order History or Purchase Order History. One can use Work Order History and Purchase Order History in reports in order to track equipment maintenance and inventory stock replacement, to project equipment repair and replacement, and to perform cost analyses.

4.6 Application Windows & Screens Design

There are several windows and screens used to input and output the data. The screens are divided as follows:

a. Menus and Sub Menus.
b. System Identification codes.
c. Facility Basic information.
d. Daily work input and output data.

All Information and data are linked together in order to provide the processed and calculated information such as maintenance costs, man hours used, next scheduled maintenance ...etc.

4.6.1 Application Menus and Sub Menus Screen Design

The following Figures show the application main menu along with some of the sub menus. The purpose of this demonstration is to show the different tools used to control the work in any maintenance facility.

From this screen (figure 36) one can select between different options. The first option gives the user the tool to enter basic information required by the system to run (company information, suppliers, activities, etc) also user can identify company resources and process as shown in the next figure.

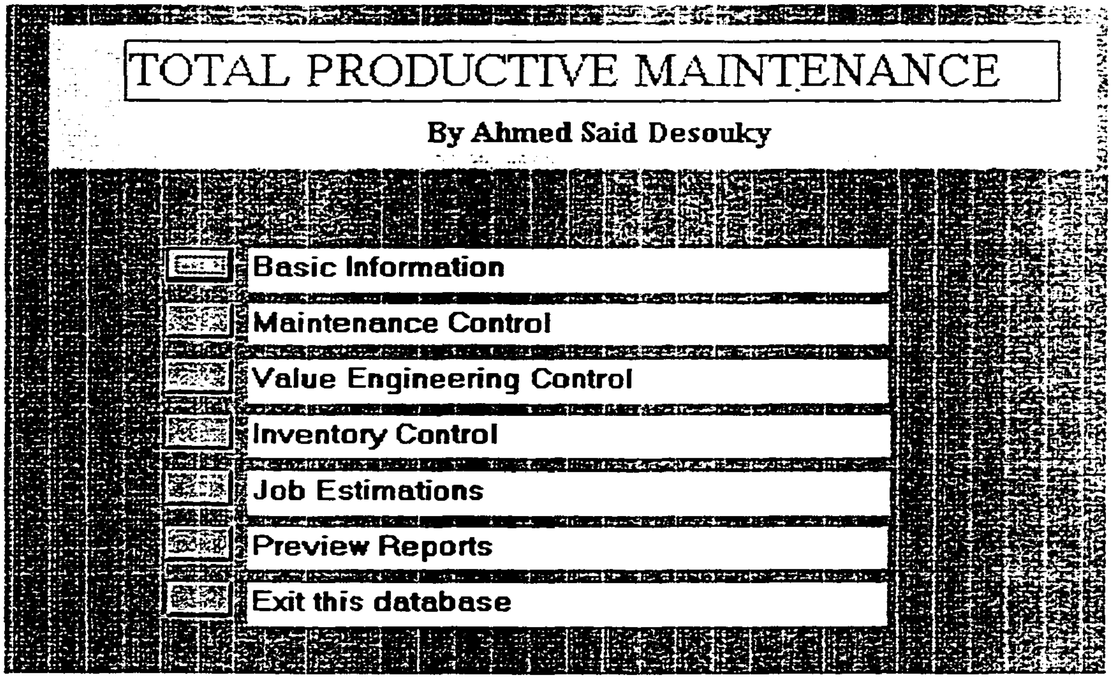

Figure 36: Application Main Menu

This screen (figure 37) allows the user to choose either to enter or to view the data. For example, the option number (7) gives the user the capability to classify the different crews (mechanic, general electrician, normal worker, etc).

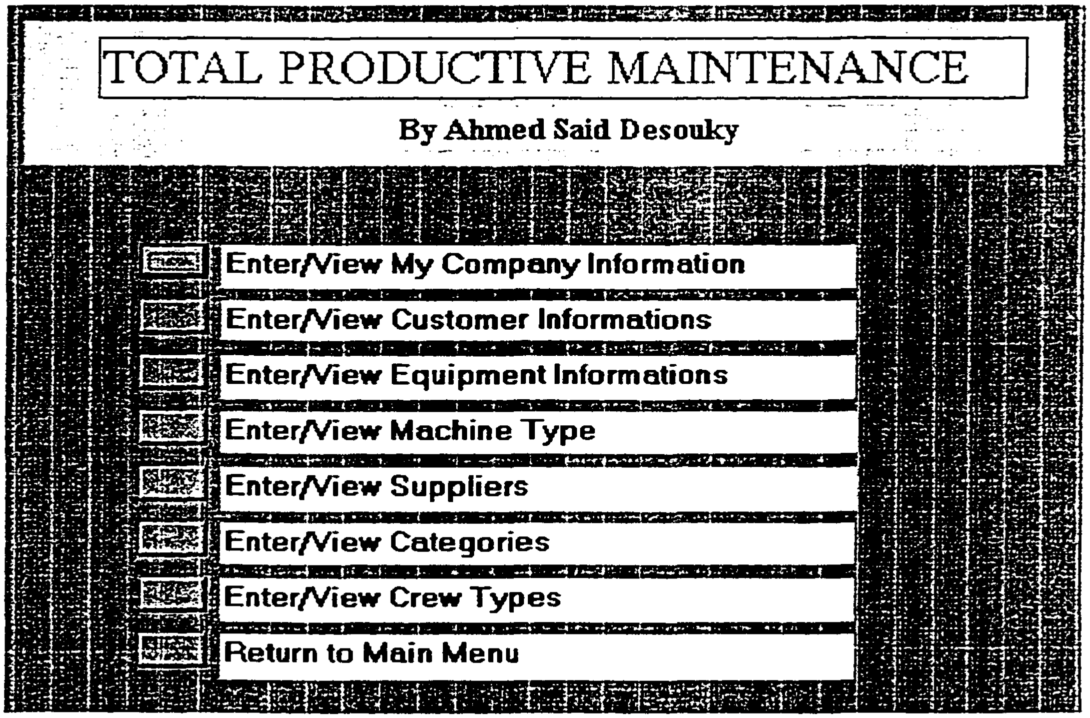

Figure 37: Basic Information Menu

One should take note that Customer information presented in the last two screens (figure 37 and figure 38), by opening jobs and sub jobs, the user needs to have the identification number of the customer and the equipment. In options 3 & 4, the system has the capability to enter a multimedia file into its field to show a process or work instruction (for example assembling and disassembling of an electric motor step-by-step).

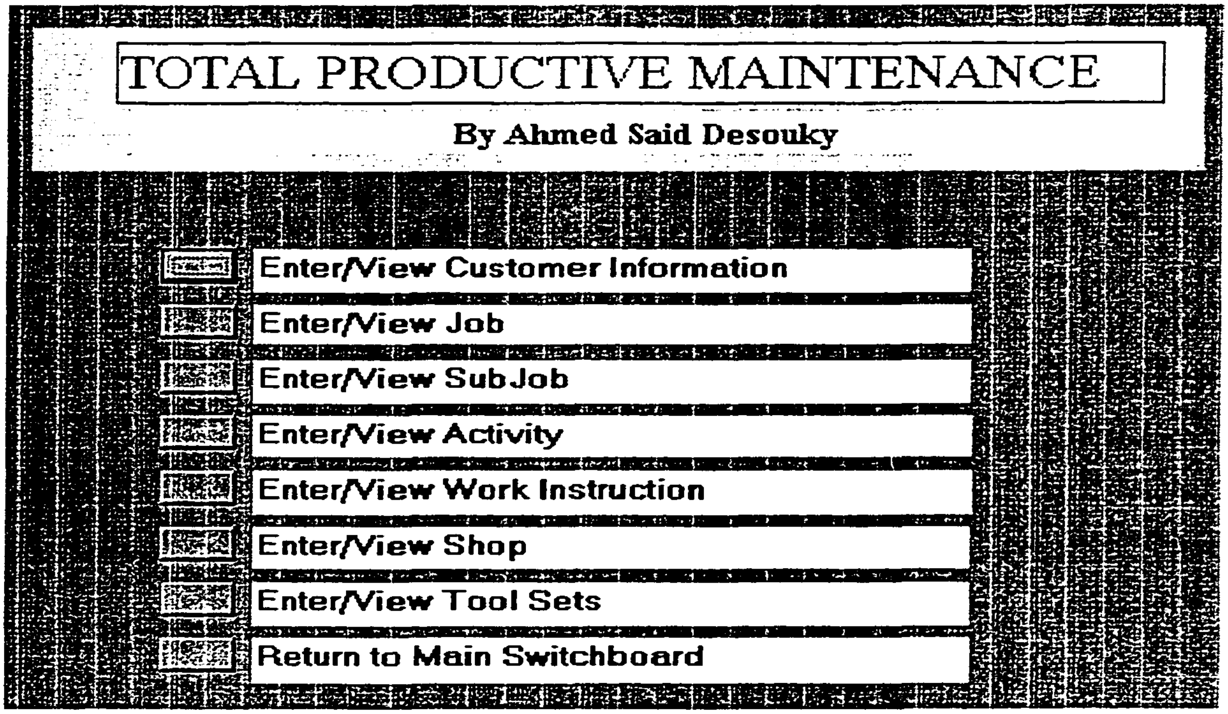

Figure 38: Maintenance Control Menu

In this screen (figure 39), the user has the capability to control all the company assets information, (entering or editing information).

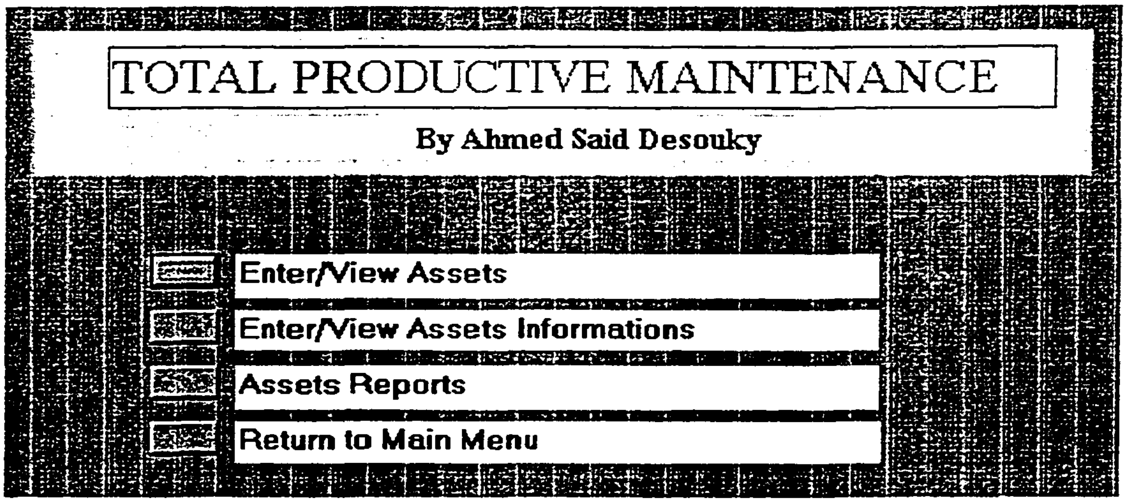

Figure 39: Asset Control Menu

4.6.2 System Identification Code Screen Design

There are several identification codes used by the system. This code is defined by the user and depends on his specifications.. The codes presented infigures 40 to 48 are only samples to allow the system to run. Without identification of this code system will not run.

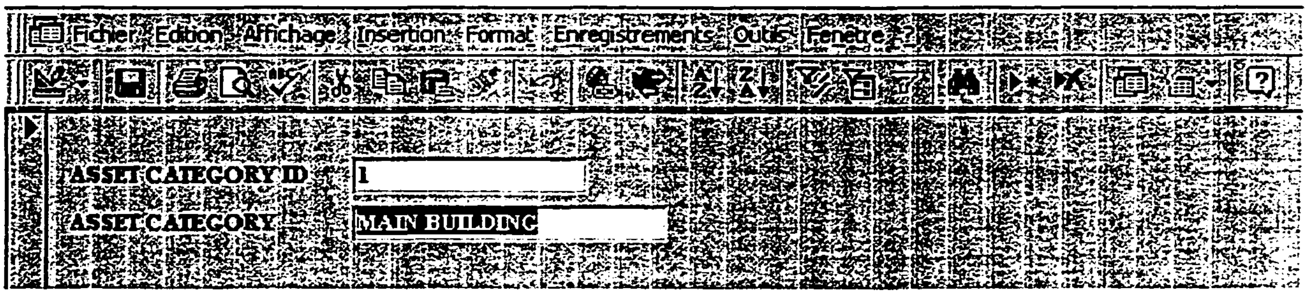

Figure 40: Asset Category Identification Code

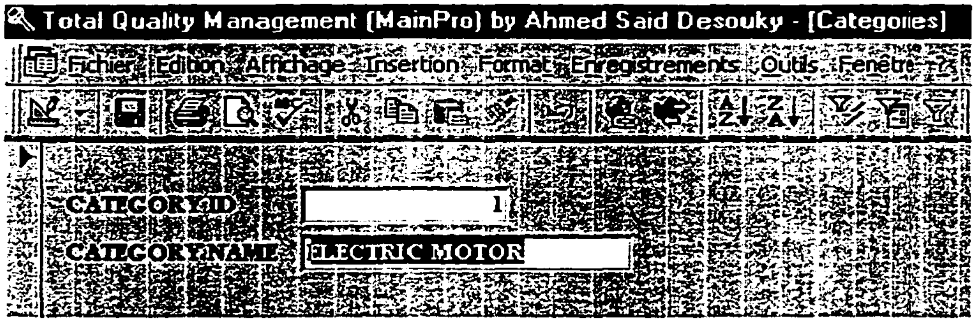

Figure 41: Equipment Category Identification Code

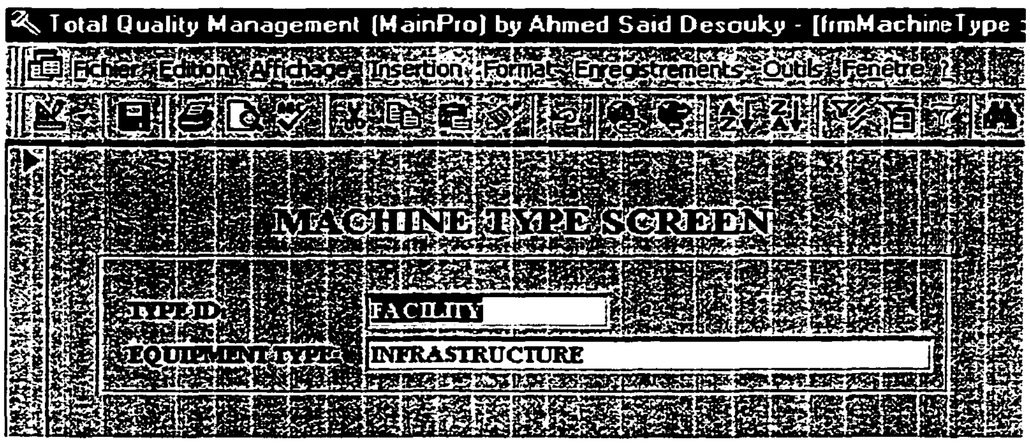

Figure 42: Facility Identification Type Code

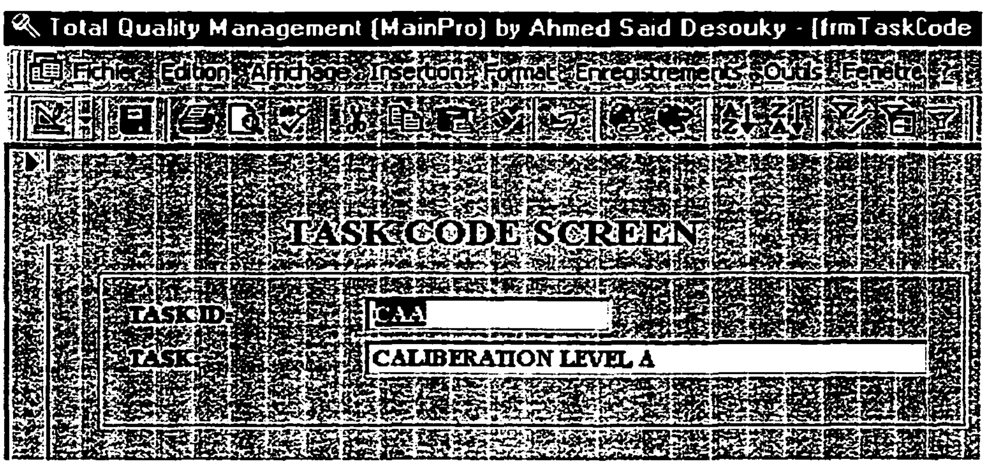

Figure 43: Maintenance Task Identification Code

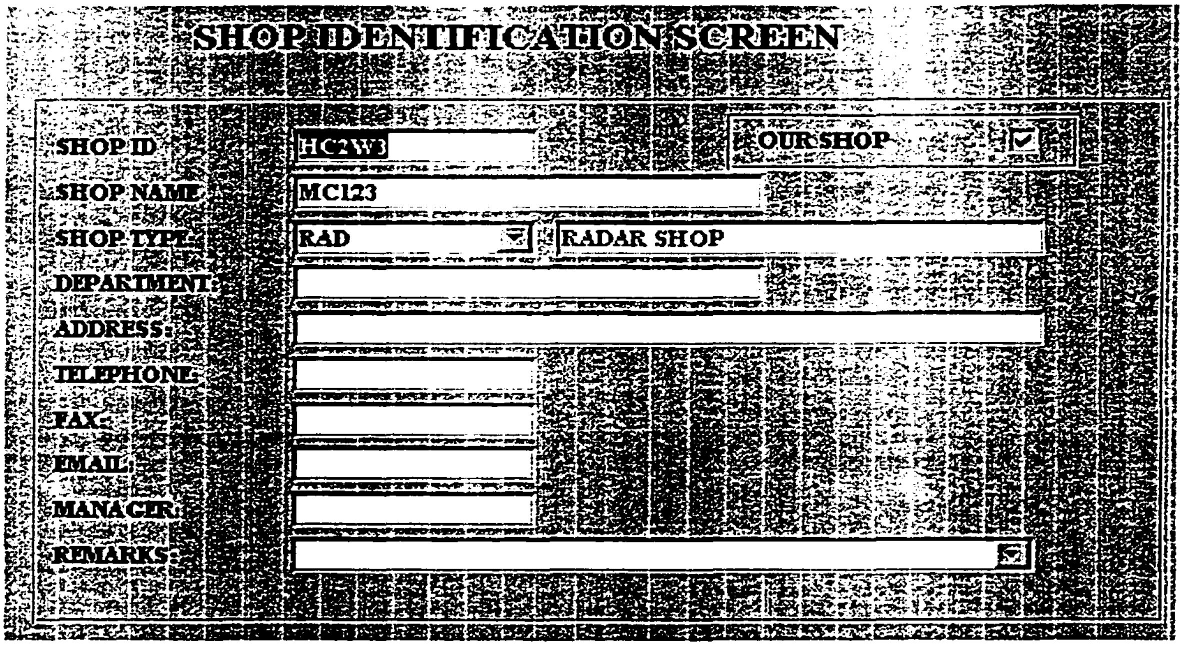

Figure 44: Shop Identification Window

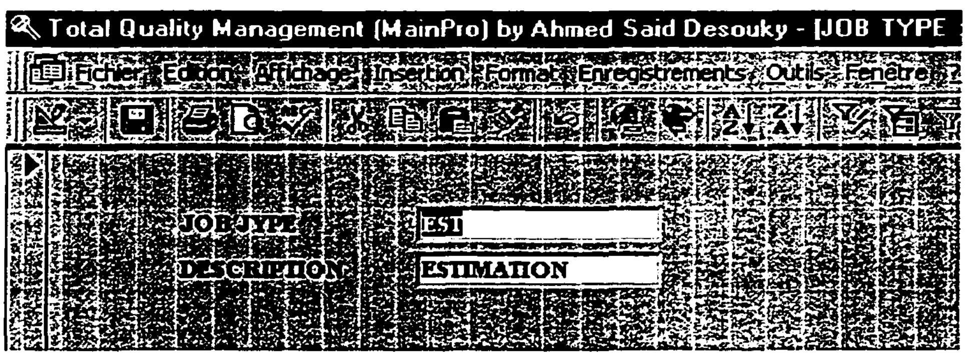

Figure 45: Job Type Identification Code

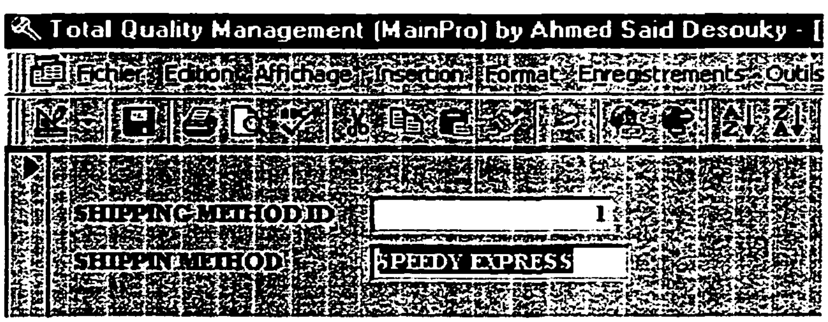

Figure 46: Shipping Method Identification Code

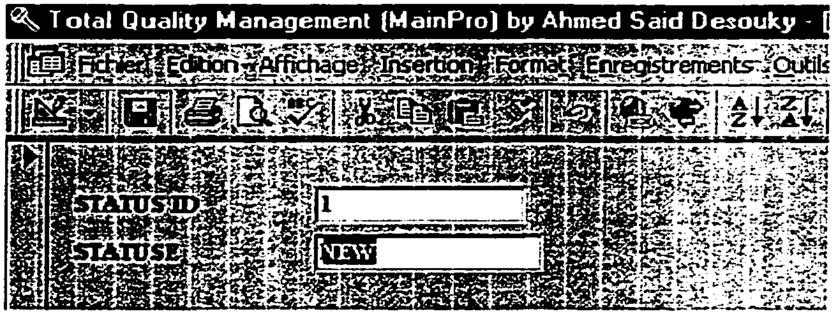

Figure 47: Equipment Status Identification Code

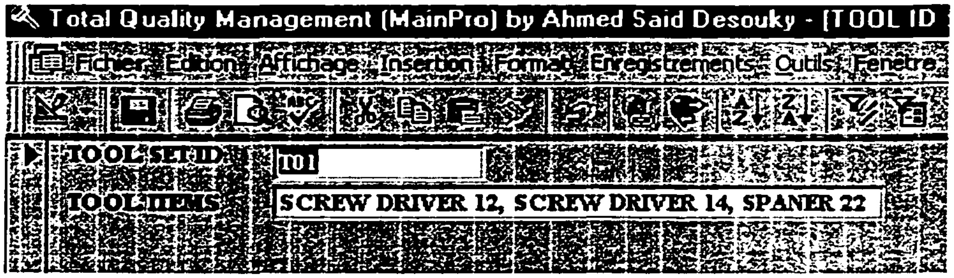

Figure 48: Tool Set Identification Code

4.6.3 Facility Basic Information Screen Design

There is some basic information required by the system to run. For example, company information (name, address, ...etc), customer information and so on. Some of the screens and Windows used to enter this data are shown in figures 49 to 51.

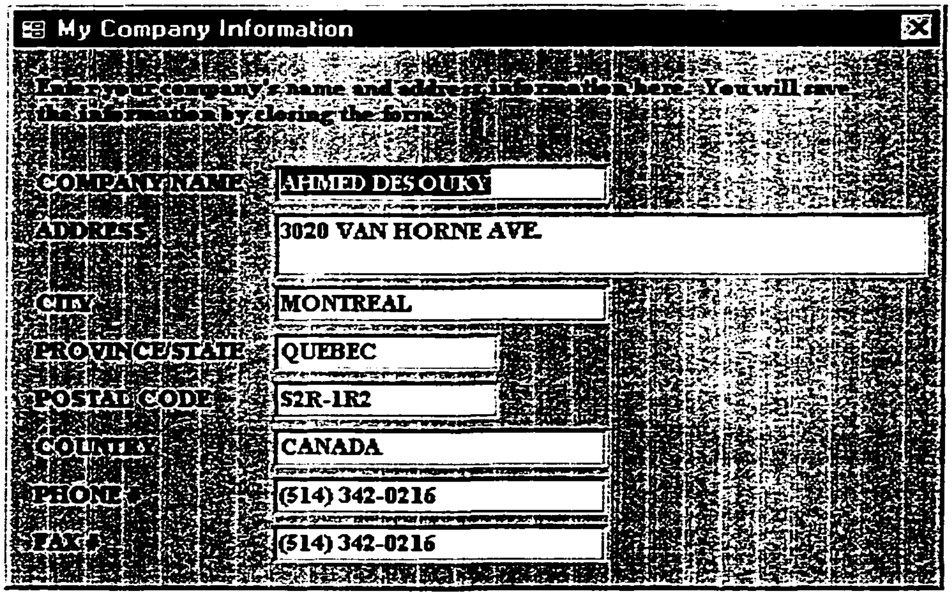

Figure 49: Company Information Window

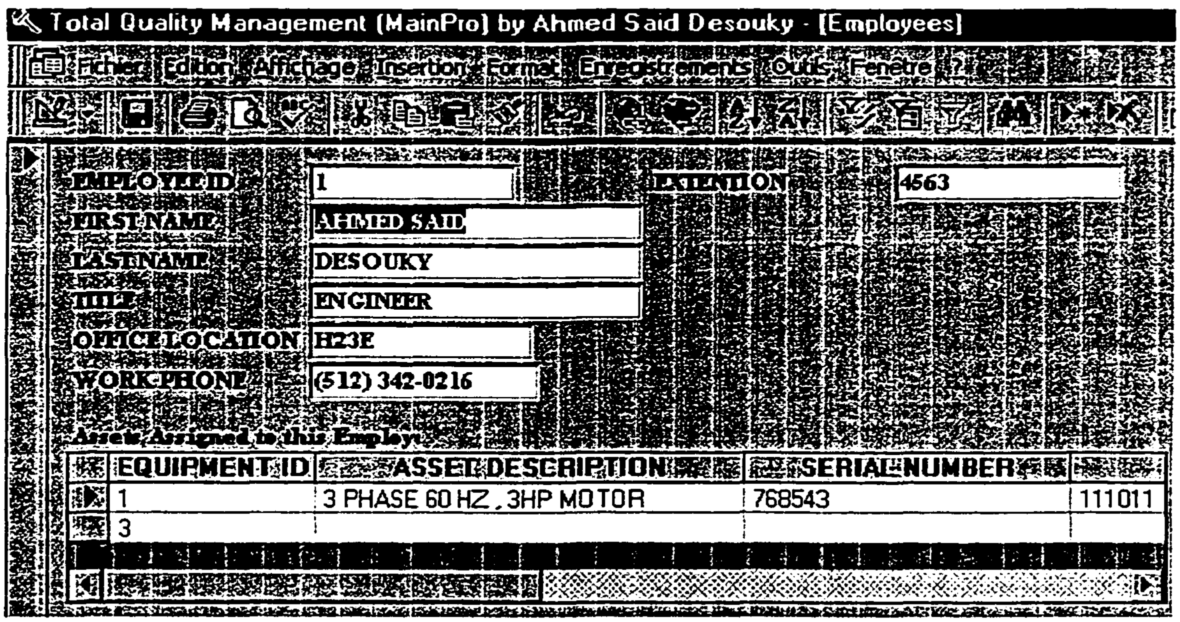

Figure 50: Employee Information Window

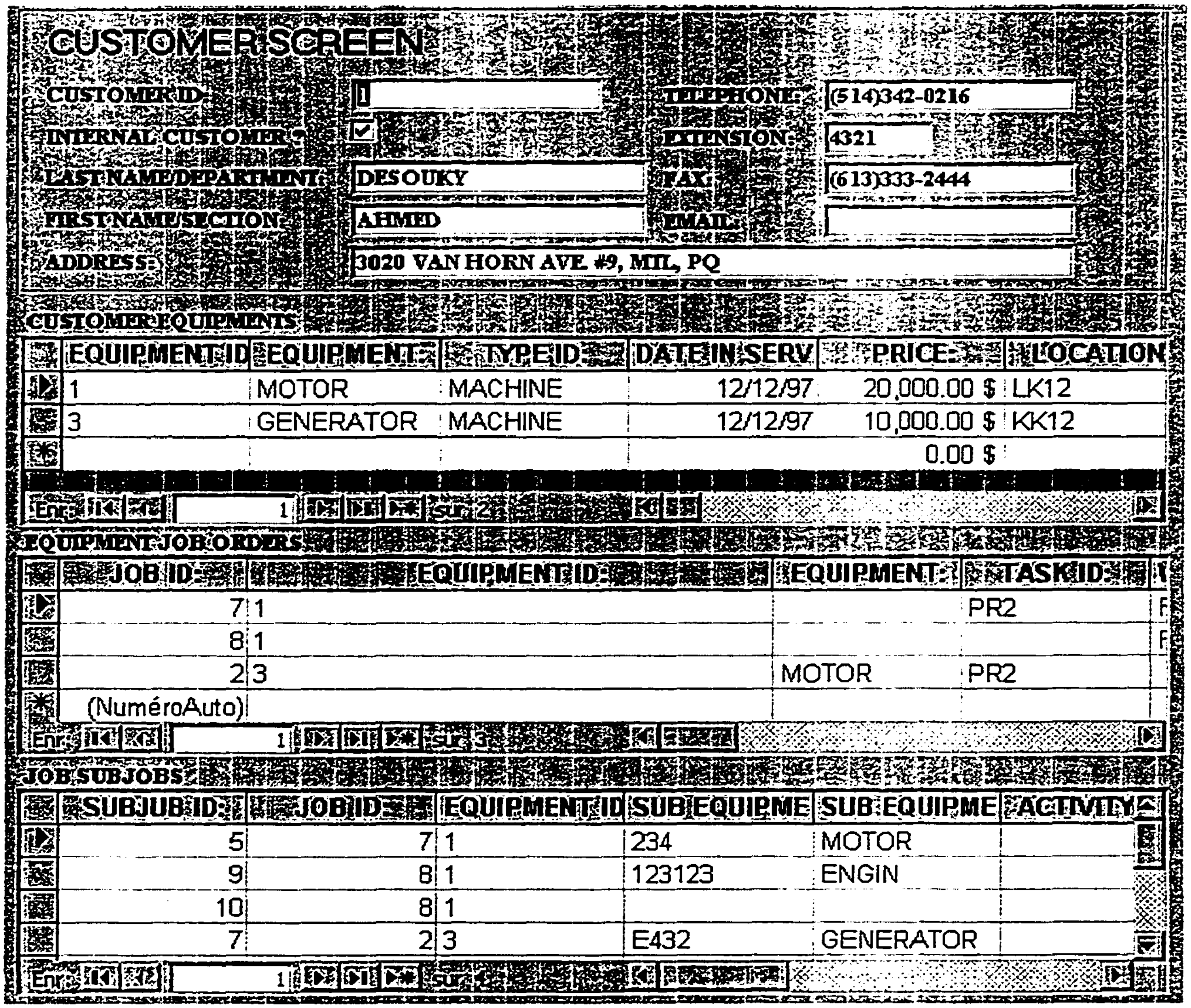

Figure 51: Customer Information Window

4.6.4 Daily Work Input and Output Data Screen Design

The daily input and output data entering windows are presented on figures 52 through 61. The next screen (figure 52) contains several memo field and drop in fields to accommodate the data and remarks.

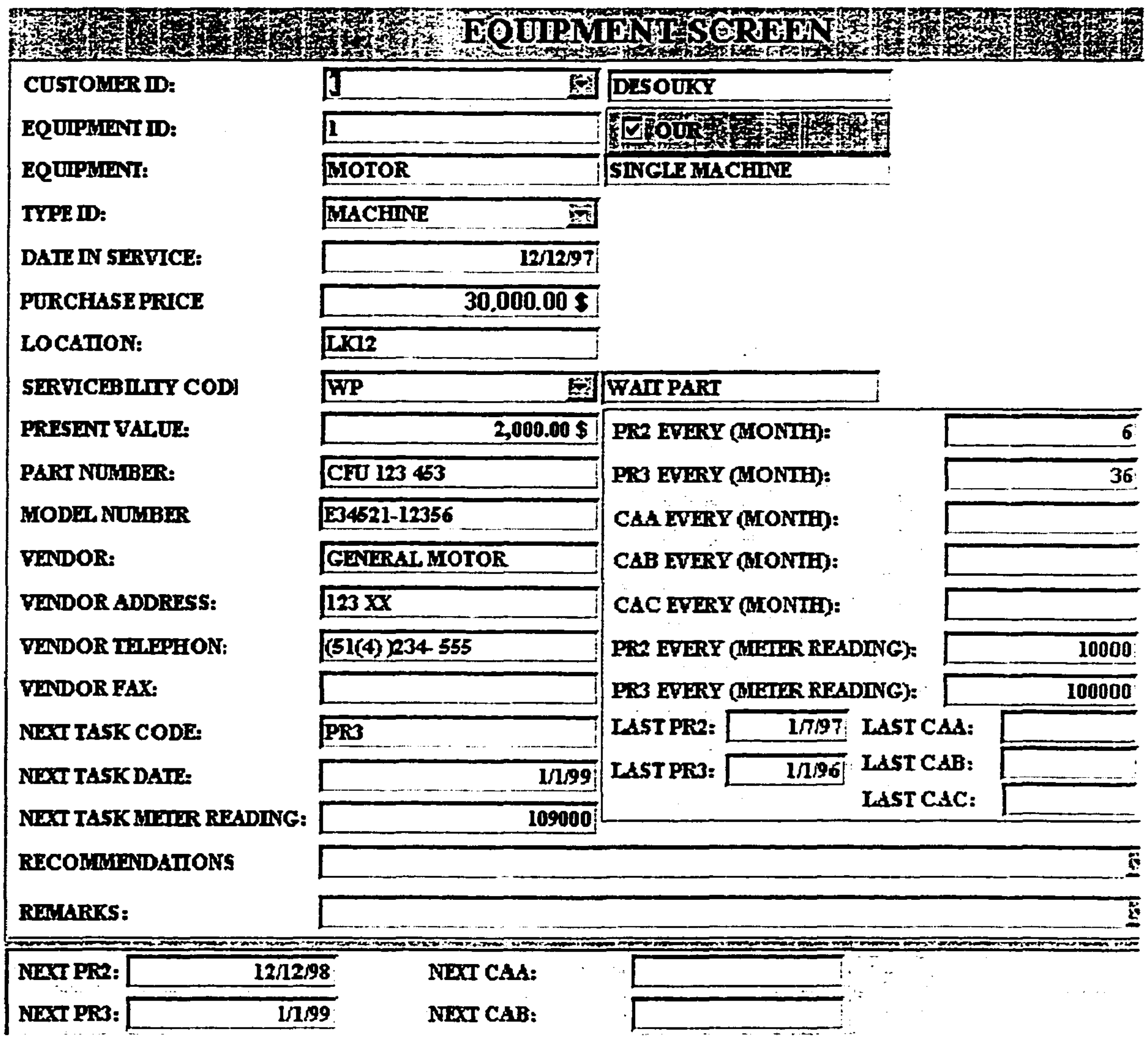

Figure 52: Equipment Interactive Window

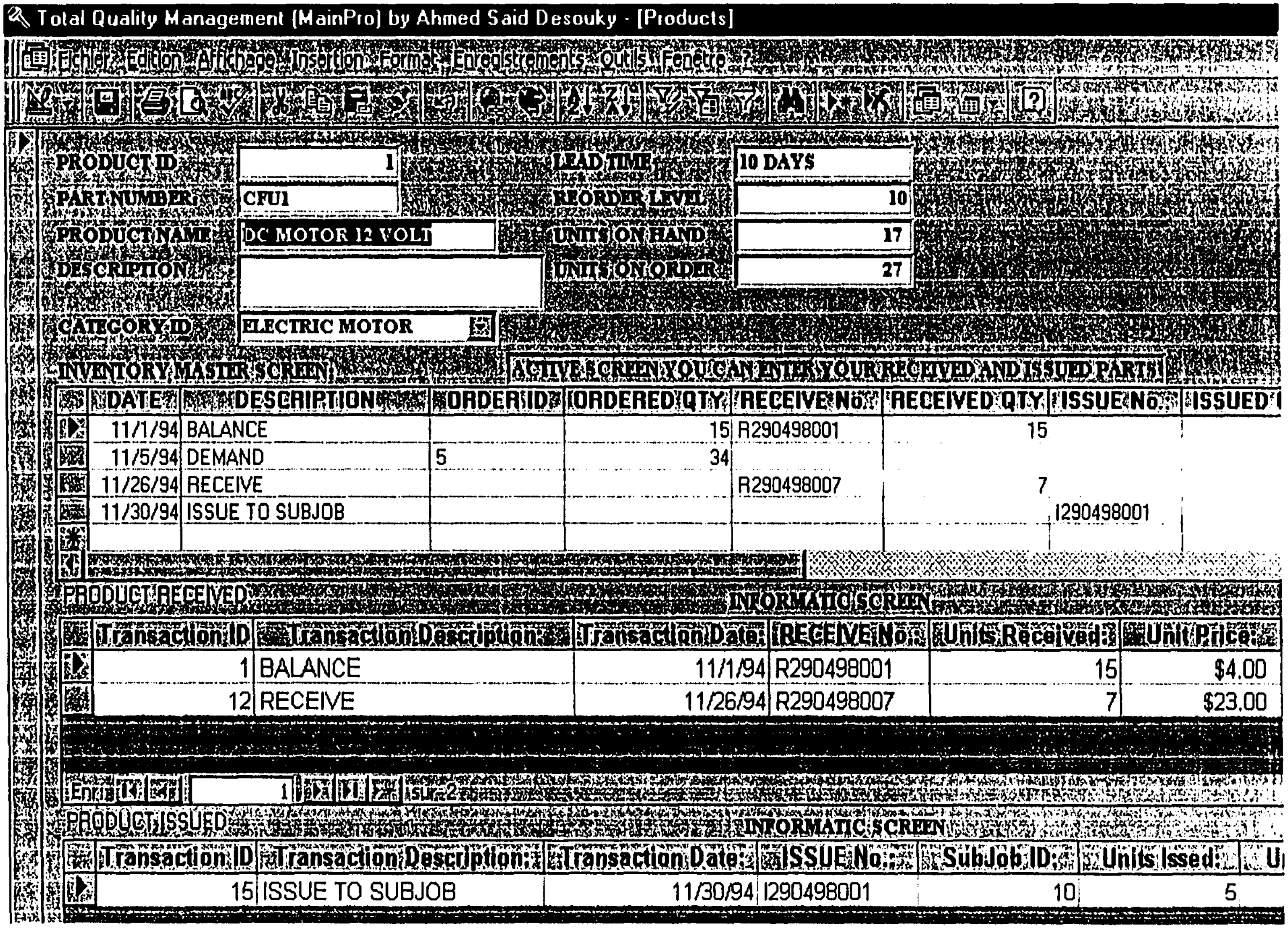

Figure 53: Product And Spare Parts Interactive Window

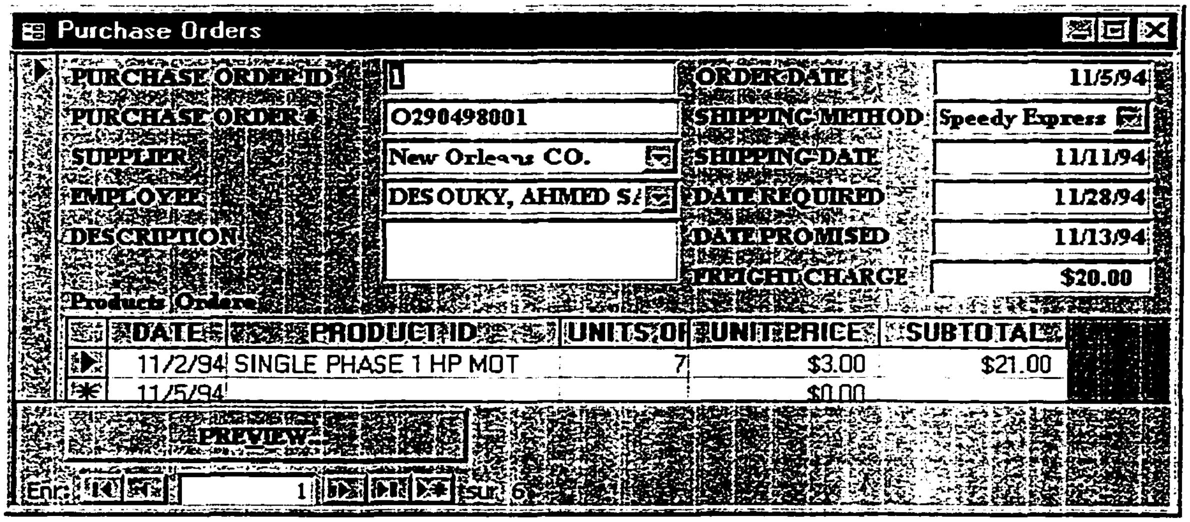

Figure 54: Purchase Orders Window

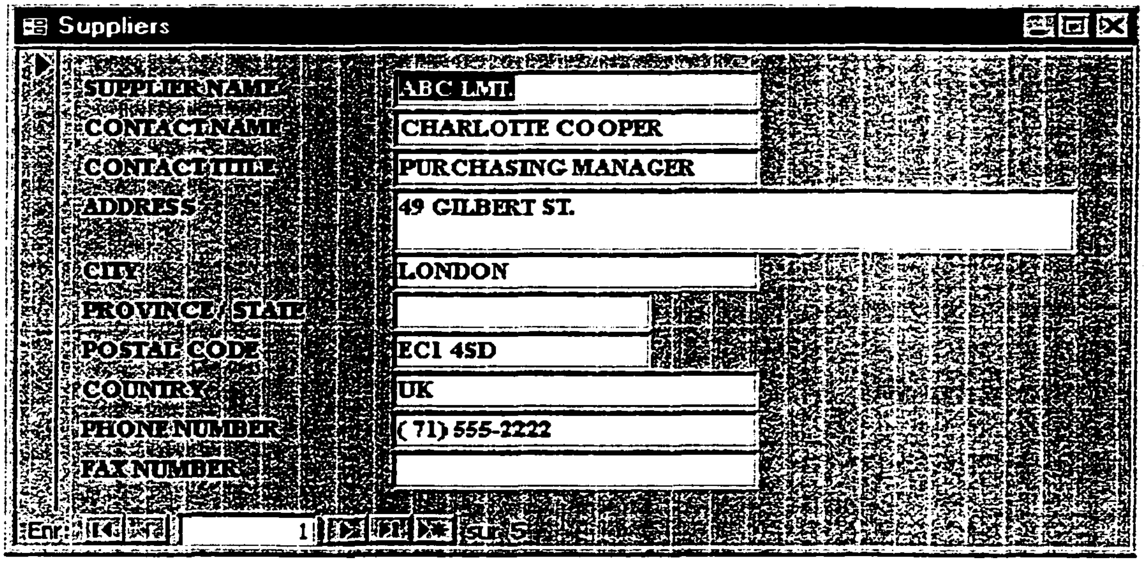

Figure 55: Supplier Window

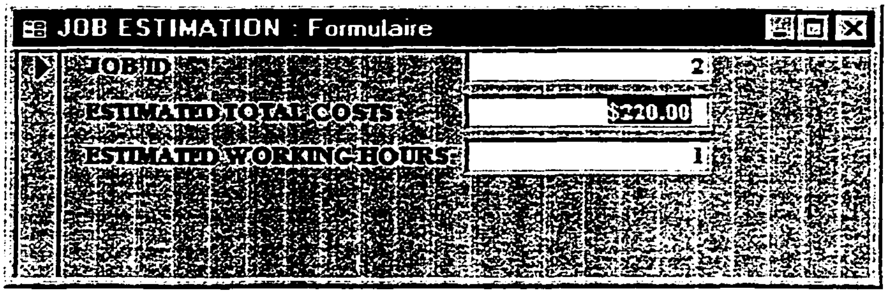

Figure 56: Job Estimation Calculated Data

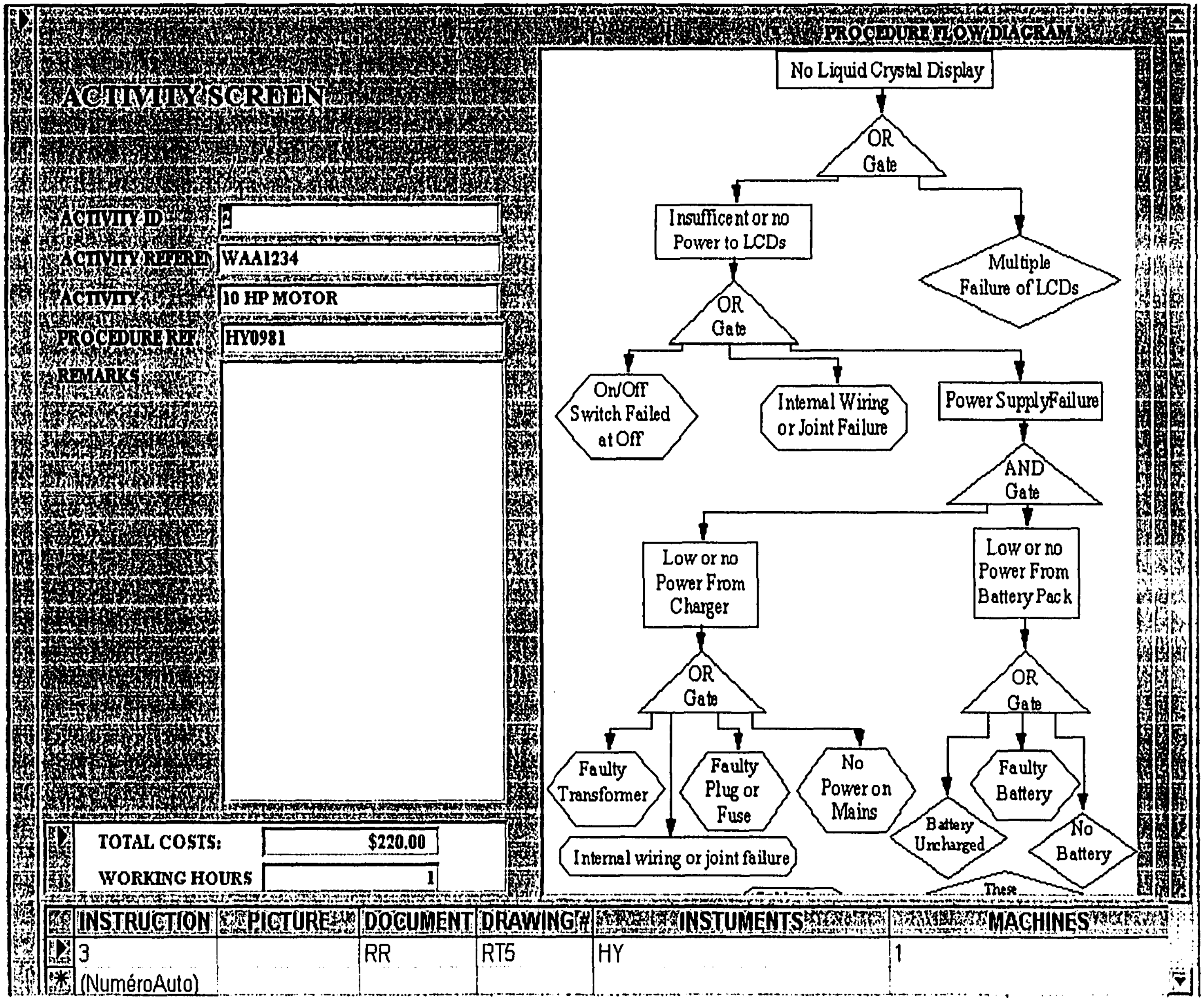

Figure 57: Activity Window Multimedia

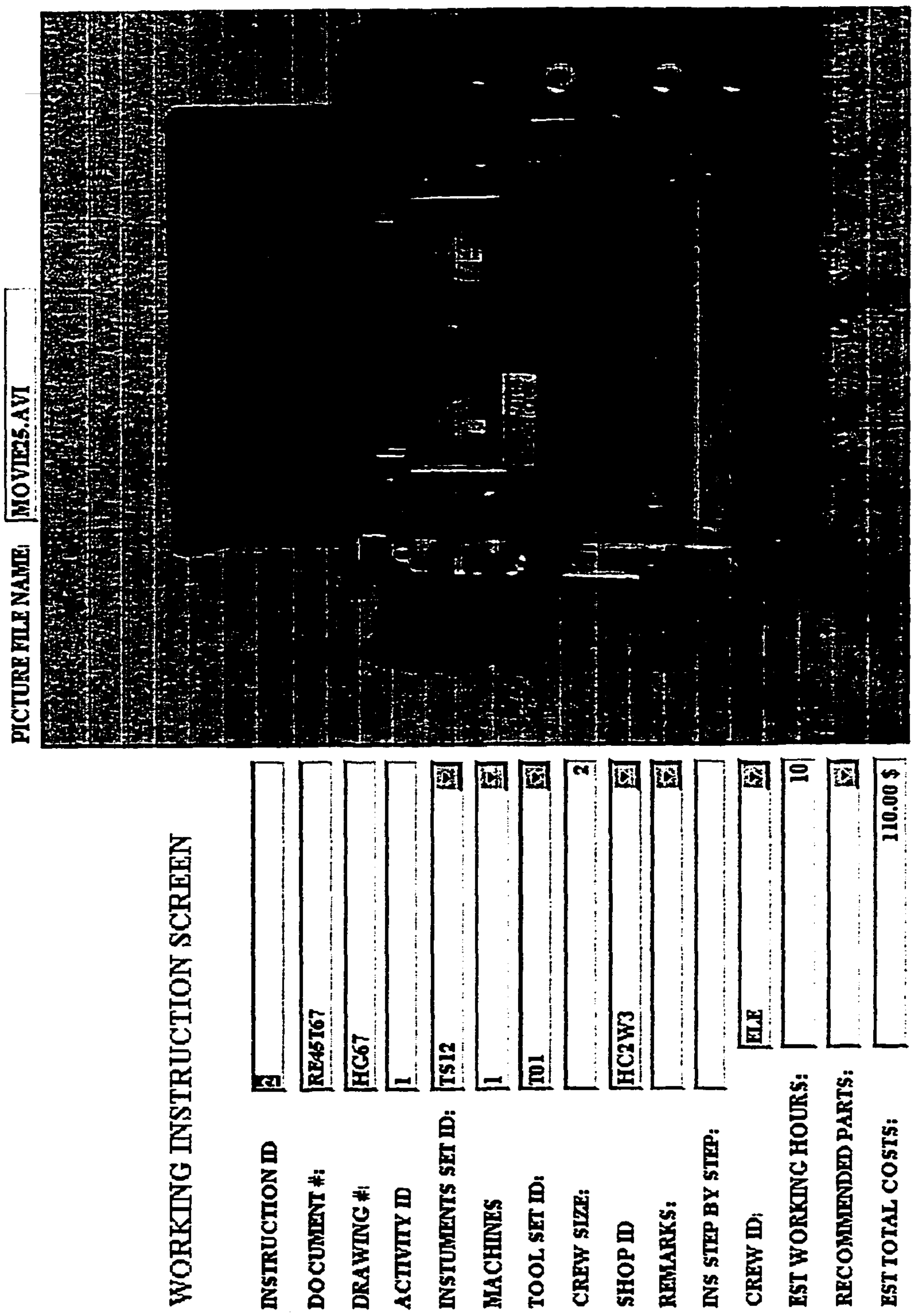

Figure 58: Work Instruction Multimedia Window

The last two windows (figure 57 & 58) accept various multimedia file formats (pictures, movies, video).

JOB ORDER SCREEN

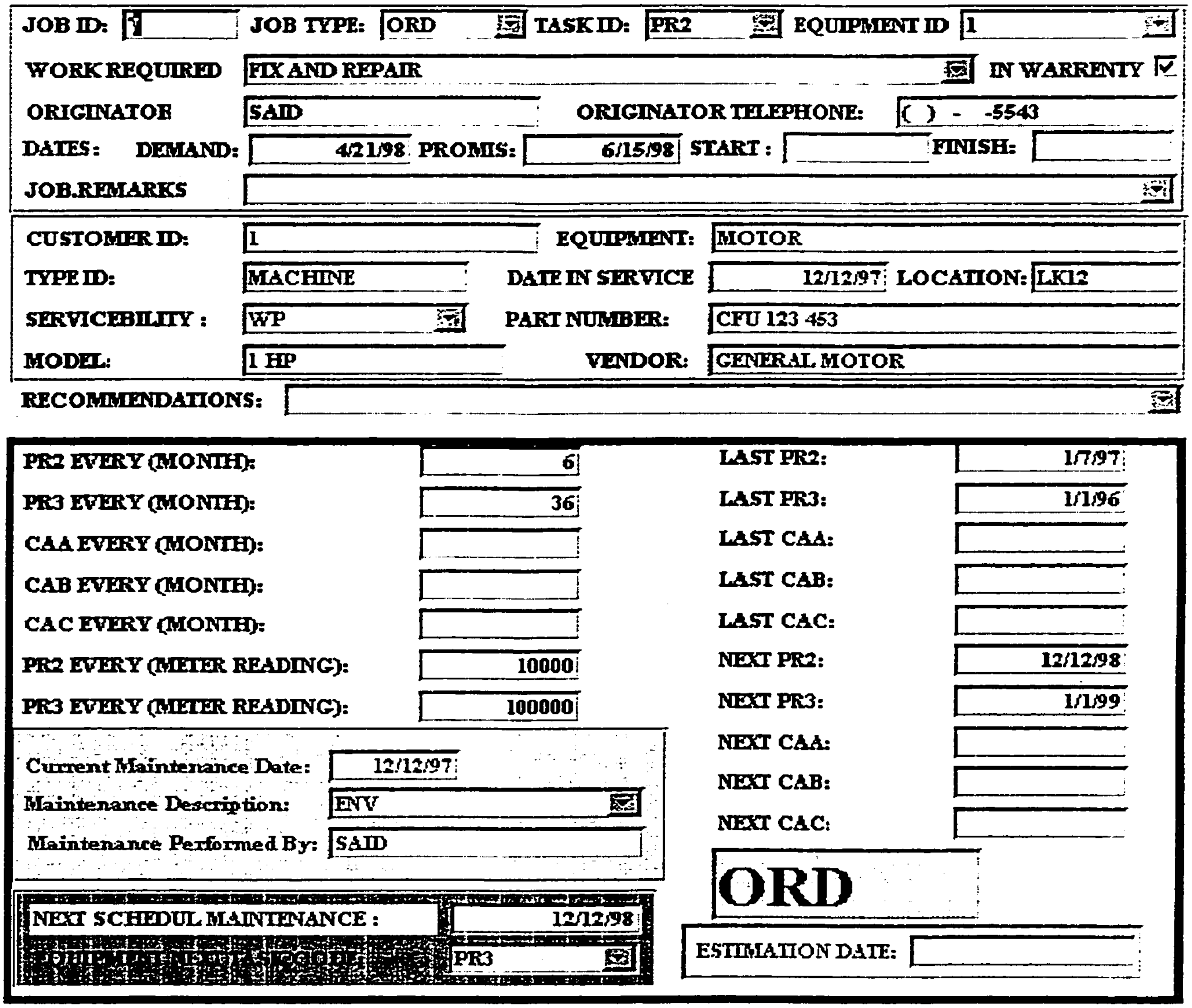

Figure 59: Job Order Form

With this next window (figure 59), the user can open the different types of jobs defined by the user. In this demo we select 3 types (estimation, demand and order). The estimated job calculates the costs; spare part required and the man-hours needed for the job. The demanded job is useful to put the equipment in the facility schedule for any future action. An order job is the order used to start a job. Also in this window, one can monitor all the maintenance activities that had been performed or that has to be performed.

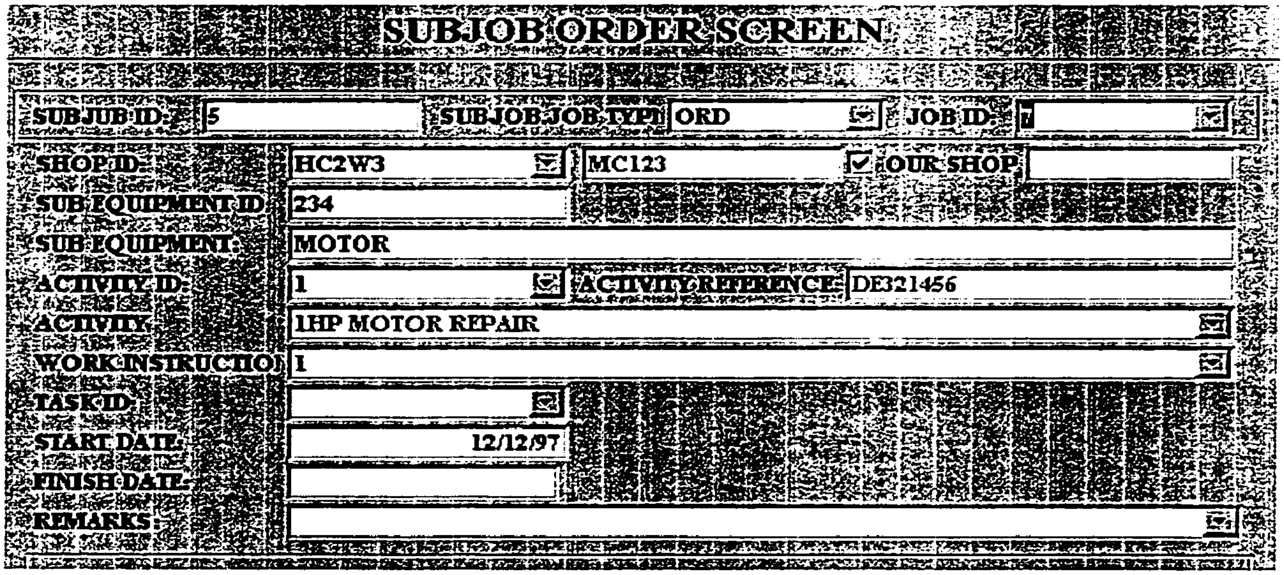

Figure 60: Sub Job Order Form

Any job can include several tasks to be performed (mechanical, electrical, etc). For this reason, a sub order is useful to process sub units to different shops for specific actions. This form is useful to identify all the sub jobs related to the original job and to trace costs, parts, and originals.

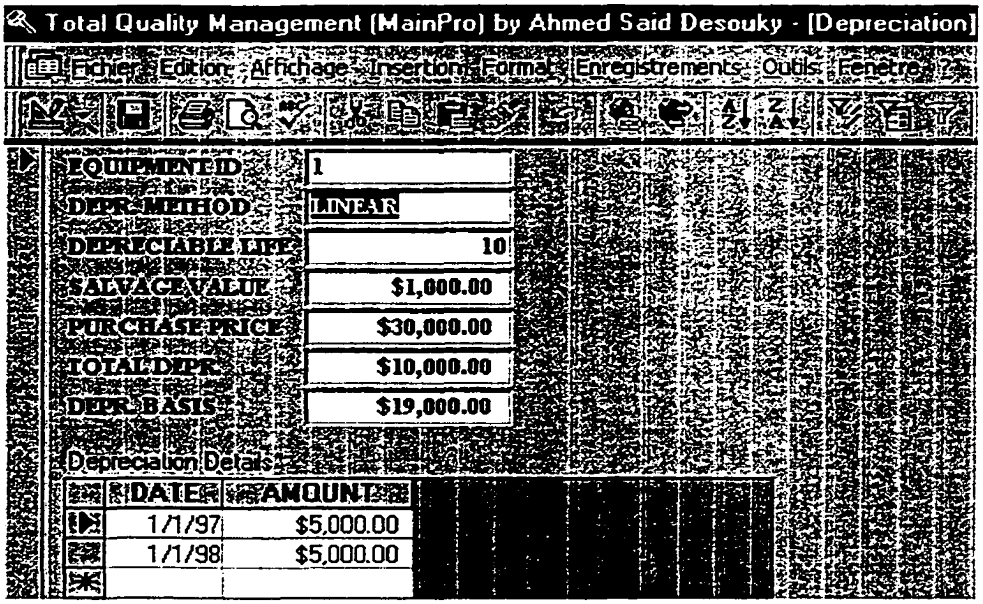

Figure 61: Asset Depreciation Window

Figure 61 shows the calculated depreciation, purchase price, salvage value, depreciable life and the method of depreciation calculation. All these values will help the system to calculate on line the overall values of the company assets.

4.7 Software Working Procedures

In this part, we will discuss how to enter the basic data and to create a new job order and sub job order. The following flow chart (figure 63) shows the working procedures used by the software package (MASTER).

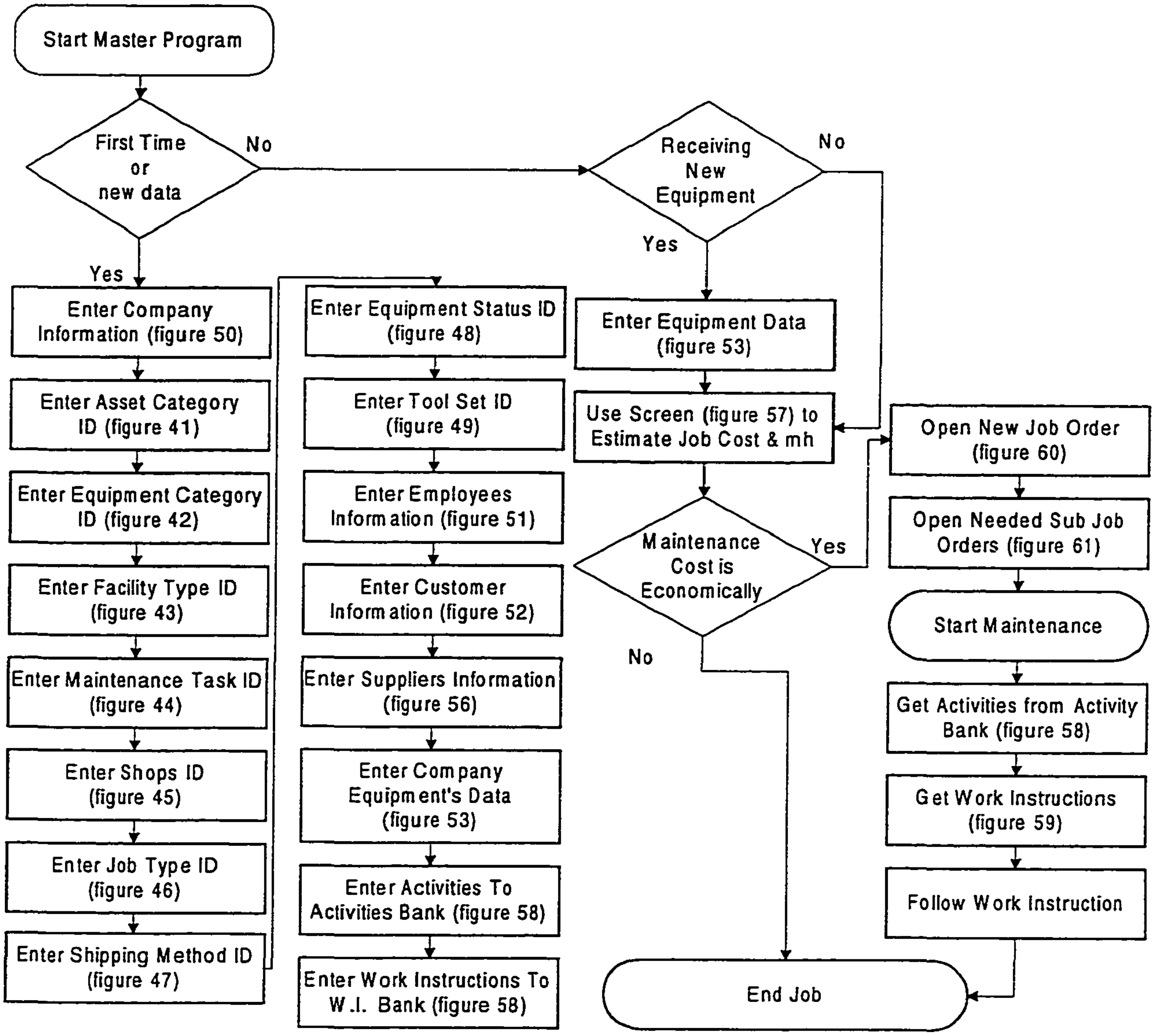

Figure 62: Working Procedure Flow Chart

4.8 Starting the Application (MASTER)

MASTER runs in a Windows 95 or 98 environment & Access97 or Access 2000. If a user is unfamiliar with Windows procedures, he should refer to the Microsoft Windows documentation before starting MASTER.

When starting MASTER, the user must follow these steps:

a. Start Windows. Program Manager displays the MASTER program group.
b. Double-click to the MASTER icon. MASTER displays the main window.
c. Operating the MASTER Main Window, which contains all the other sub windows.
   One needs to enter the next data to the system:
   - Entering Equipments Codes and Descriptions
   - Entering Department Codes and Descriptions
   - Entering Employee Information
   - Entering Inventory Information
   - Entering Purchase Order Setup Information
   - Entering Work Instruction Information
   - Entering Job & Sub job Order Information
   - Entering Maintenance Activity Information

d. Follow the instruction on the screen to use the deferent managements in the application. For example, to enter the equipment records, one may enter information on each piece of equipment we maintain and then set up preventive maintenance activities for that equipment. MASTER uses the information's from the equipment record and from the activity to generate "Job orders & Sub Job orders". For example, one may enter information's about a vehicle, including its current odometer or meter reading. One may then set up a preventive maintenance activity to change the oil in the vehicle every 3 months or every 3,000 miles, whatever comes first. When one generate preventive maintenance “Job orders & Sub Job orders”, MASTER searches the database, and if the last oil change is 3 months old or if the odometer has reached 3,000 miles, MASTER generates a “Job order & Sub Job orders” for the vehicle. If one schedules preventive maintenance by meter reading, one should updates the Current Meter Reading field for each equipment record either weekly or monthly.

In conclusion, an integrated Maintenance Function implies that such function crosses departmental boundaries. In traditional organizations, this can lead to serious problems in management and reduce both efficiency and effectiveness. These problems can be easily reduced by implementing the proposed Maintenance Software Program to protect the integrity of the function by properly planning and controlling its resources and by providing measurable parameters of performance.

CONCLUSION

The success of a maintenance facility requires a systematic identification and priority setting for all of the different activities of such facility. This must be done in relation to the particular timing and customer needs of every specific sector in the company.

Clear rules and procedures must be enforced to achieve the establishment of priority setting and the follow up of the completed activities. Management should increasing emphasis on completing high priority activities and on continuously making use of the available data and reports generated by the software. To ensure the availability of adequate resources and the realization of the planned timely results, proactive application of project management concepts and techniques must be used.

With the emphasis on satisfying ISO requirements, planned completion date and supporting timetable of activities shall be established for each job. The responsible team member must be informed when delays occur or are expected so that possible interventions or remedial actions may be considered. In this way the approved work is actively and fruitfully pursued to completion.

The software will devise ways to periodically re-evaluate the situation from the technical and administrative points of view. Existing mechanisms provided through the Technical Management Reports will be employed to expeditiously establish the contingency plan and reassign the job to the available or alternative working teams.

This thesis discussed how traditional and more advanced approaches, procedures and techniques could simplify the implementation of the Total Quality Management and the Total Productive Maintenance in an industrial facility. An intelligent computerized tool (MASTER) had been developed to manage the different activities in any maintenance facility based on the requirements of ISO 9000 and ISO 14000 standards. Since the input and output data can be classified into distinct categories, such tool will also be useful for a reliable and on-line evaluation of systems, equipmeent and components status. It will also provide the necessary updated data to all levels of users.

We strongly believe that this software will greatly assist maintenance personnel at the facility to accurately identify and act upon equipment problems. The software will help to statistically predict the remaining life and the value of all the facility assets. Therefore, the machines could be reliable and safely operated. For example, the software can provide valuable data on a timely basis to the maintenance engineer via his terminal to help him take the appropriate action at any time. Once fully implemented, such an approach and software tool would allow better fault detection and reduce equipment failures and down time.

Working under the ISO 9000 family of standards framework will give the facility the guidelines for continuous quality improvement. However, considering the ISO 14000 family will enable the facility to control the impact of its activities or services on the environment.

The implementation of the Total Quality Management in the maintenance facility wills provide an overall concept that fosters continuous improvement in the organisation.

It will focuses primarily on the total satisfaction of the needs for both the internal and external customers. This is achieved within a management environment that seeks continuous improvement of all functions and processes. It will stress on the optimal life cycle costs and the appropriate measurements within a disciplined methodology to achieve such improvements.

Using this software will assist maintenance personnel at the facility to accurately identify the equipment problems. The system will help to statistically predict the remaining life and the value of all the facility assets. Therefore, the machines could be reliable and safely operated. The output from the system would be available on a timely basis to the maintenance engineer via his terminal to take the action in time. Once fully implement, such an approach and system would allow improved fault detection and reduce its occurrence.

The objective of this thesis has been achieved by developing a means to determine system and machine health, while operating on-line (on line reports). The system inputs and outputs data can be classified into distinct categories that can reliably indicate the state of the equipments. An implemented system, based on this approach, will assist maintenance personnel at the facility to accurately identify the equipment problems and by implementing the Total Quality Management in the maintenance facility will provide the overall concept that fosters continuous improvement in the organization. It will focus primarily on total satisfaction for both the internal and external customers, within a management environment that seeks continuous improvement of all systems and processes. It wills stresses on the optimal life cycle costs and use measurements within a disciplined methodology in achieving improvements.

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APPENDIX A

CUSTOMER LIST

CUSTOMER	LAST NAME	FIRST NAME	ADDRESS	TELEPHONE
1	DESOUKY	AHMED	3020 VAN HORN AVE	(514)342-0216
2	DESOUKY	WALID	2121 RAMSES STREE	(412)333-5555
3	DESOUKY	CHERIF	396 RAMSES STREET	(614)324-5678
4	XXX	FFF		

Table (1)

EMPLOYEES LIST

ID	First Name	Last Name	Title	Work Phone	Office Location
1	AHMED SAID	DESOUKY	ENGINEER	(512) 342-0216	H23E

Table (2)

EQUIPMENTS CATEGORIE

Category ID	Category Name
1	ELECTRIC MOTOR
2	ELECTRIC GENERATOR
3	RESISTOR
4	ENGIN
5	GEAR
6	PCB
7	MECHANICAL SYSTEM
8	ELECTRICAL SYSTEM

Table (3)

EQUIPMENT LIFE

EQUIPMENT ID	DEPRECIABLE LIFE	LOCATION	PART NUMBER
1	10	LK12	CFU 123 453
3		KK12	CFU765 789

EQUIPMENT NEXT MAINTENANCE

A5

EQUIPMENT ID	NEXT TASK CODE	NEXT TASK DATE	LAST PR2	LAST PR3
1	PR3	1/1/99	1/7/97	1/1/96
3	PR3		12/12/97	1/1/96

PRIVENTIVE MAINTENANCE TABLE

EQUIPMENT I	PR2	PR3	CAA	CAB	CAC	All Periods in month
1	6	36				
3	6	36				

Table (6)

EQUIPMENT VALUE

A7

EQUIPMENT ID	EQUIPMENT	DATE IN SERVICE	PRICE	PRESENT VALUE
1	MOTOR	12/12/97	20,000.00 $	10,000.00 $
3	GENERATOR	12/12/97	10,000.00 $	10,000.00 $

Table (7)

EQUIPMENT VENDOR

VENDOR	EQUIPMENT ID	EQUIPMENT	VENDOR ADDRESS	VENDOR TELEPHON
ELECTRICA	3	GENERATOR	2121 VICTORIA AVE	(51(4)4)44–3333
GENERAL MOT	1	MOTOR	123 XX	(51(4))234- 555

Table (8)

EQUIPMENTS IDENTIFICATION

A9

TYPE ID	EQUIPMENT TYPE
FACILITY	INFRASTRUCTURE
INSTRUME	ADJUSTABLE INSTR.
MACHINE	SINGLE MACHINE
SYSTEM	COMPLETE SYSTEM
TOOL	REPAIRABLE TOOL

EQUIPMENTS STATE

SERVICEBILITY CODE	EQUIPMENT ID	EQUIPMENT	NEXT TASK	NEXT TASK DATE
SE	3	GENERATOR	PR3	
WP	1	MOTOR	PR3	1/1/99

Inventory Transactions

ID	Description	Date	Product ID	Order ID	Ordered	Price	RECEIVE ID	Received	ISSUE ID	Sold	Shrinkage
1	BALANCE	11/1/94	DC MOTOR 1		15	$4.00	R290498001	15			
2	OPENING BALANCE	11/1/94	3PHASE 10 K		25	$2.00	R290498002	25			
3	OPENING BALANCE	11/1/94	SINGLE PHA		35	$6.00	R290498003	35			
4	OPENING BALANCE	11/1/94	GEAR 12		45	$7.00	R290498004	45			
5	OPENING BALANCE	11/1/94	POWER AMP		55	$8.00	R290498005	55			
6	WEEKLY ORDER	11/2/94	SINGLE PHA	1	7	$3.00					
7	DEMAND	11/5/94	DC MOTOR 1	5	34	$11.00					
8	SUPPLIES	1/11/94	3PHASE 10 K	2	20	$19.00					
9	WEEKLY SUPPLIES	1/12/94	SINGLE PHA	3	23	$10.00					
10	WEEKLY SUPPLIES	1/19/94	GEAR 12	4	11	$22.00					
11	SHIPMENT RECEIVED	1/25/94	3PHASE 10 K			$18.00	R290498006	20			
12	RECEIVE	1/26/94	DC MOTOR 1			$23.00	R290498007	7			
13	SHIPMENT RECEIVED	1/27/94	SINGLE PHA			$14.00	R290498008	20			
14	SHIPMENT RECEIVED	1/27/94	GEAR 12			$25.00	R290498009	10			
15	ISSUE TO SUBJOB	1/30/94	DC MOTOR 1			$30.00			I290498001	5	
16	SALES	1/30/94	3PHASE 10 K			$32.00			I290498002	6	
17	SALES	1/30/94	SINGLE PHA			$14.00			I290498003	22	

Table (11)

ID	Description	Date	Product ID	Order ID	Ordered	Price	RECEIVE ID	Received	ISSUE ID	Sold	Shrinkage
18	SALES	1/30/94	GEAR 12			$23.00			I290498004	15	
19	SALES	1/30/94	POWER AMP			$13.00			I290498005	14	
20	SALES	1/30/94	SINGLE PHA			$12.00					2
31		1/19/95	3PHASE 10 K	5	100	$22.00				0	
32		4/29/98	GEAR 12	6	100	$24.00				0	
33	SUBJOB 7					$0.00				0	
34						$0.00				0	
35						$0.00				0	
36						$0.00				0	
37						$0.00				0	
38						$0.00				0	
39						$0.00				0	
40						$0.00				0	
41						$0.00				0	
42						$0.00				0	

Table (11)

Product Cost Comparisons

For Transactions Between: 1/1/90 and 1/1/99

Product Name	Supplier Name	Avg Unit Price	Total Units
DC MOTOR 12 VOLT			
	ASSIA LMT.	$11.00	34
Summary for 'ProductID' = 1 (1 detail record)			
Sum			**34**
3PHASE 10 KW GENERATO			
	ASSIA LMT.	$20.50	120
Summary for 'ProductID' = 2 (1 detail record)			
Sum			**120**
SINGLE PHASE 1 HP MOTO			
	New Orleans CO.	$3.00	7
	Tokyo Traders	$10.00	23
Summary for 'ProductID' = 3 (2 detail records)			
Sum			**30**
GEAR 12			
	ABC LMT.	$24.00	100
	GENERAL MOTORS CO.	$22.00	11
Summary for 'ProductID' = 4 (2 detail records)			
Sum			**111**
Grand Total			**295**

Product Purchases by Supplier

For Transactions Between: 1/1/90 and 1/1/01

Supplier Name	Product Name	Avg Unit Price	Total Units
ABC LMT.			
	GEAR 12	$24.00	100
New Orleans CO.			
	SINGLE PHASE 1 HP MOTO	$3.00	7
ASSIA LMT.			
	3PHASE 10 KW GENERATO	$20.50	120
	DC MOTOR 12 VOLT	$11.00	34
Tokyo Traders			
	SINGLE PHASE 1 HP MOTO	$10.00	23
GENERAL MOTORS CO.			
	GEAR 12	$22.00	11

Product Summary

Product Name	Reorder Level	Lead Time	# in Stock	# on Order
3PHASE 10 KW GENERATO	25	10 Days	39	100
DC MOTOR 12 VOLT	10	10 Days	17	27
GEAR 12	0	10 Days	40	101
POWER AMPLIFIER	0	10 Days	41	0
SINGLE PHASE 1 HP MOTO	25	10 Days	31	10

Product Transaction Detail

For Transactions Between: 1/1/90 and 1/1/02

Product Name	Date	Transaction Description	Unit Price	# Ordered	# Received	# Sold	# Shrinkage
DC MOTOR 12 VOLT							
	11/1/94	BALANCE	$4.00	15	15		
	11/5/94	DEMAND	$11.00	34			
	11/26/94	RECEIVE	$23.00		7		
	11/30/94	ISSUE TO SUBJOB	$30.00			5	
3PHASE 10 KW GENE							
	11/1/94	Opening Balance	$2.00	25	25		
	11/11/94	Supplies	$19.00	20			
	11/25/94	Shipment Received	$18.00		20		
	11/30/94	Sales	$32.00			6	
	1/19/95		$22.00	100		0	
SINGLE PHASE 1 HP							
	11/1/94	Opening Balance	$6.00	35	35		
	11/2/94	Weekly Order	$3.00	7			
	11/12/94	Weekly Supplies	$10.00	23			
	11/27/94	Shipment Received	$14.00		20		
	11/30/94	Sales	$14.00			22	

Product Name	Date	Transaction Description	Unit Price	# Ordered	# Received	# Sold	# Shrinkage
	11/30/94	Sales	$12.00				2
GEAR 12							
	11/1/94	Opening Balance	$7.00	45	45		
	11/19/94	Weekly Supplies	$22.00	11			
	11/27/94	Shipment Received	$25.00		10		
	11/30/94	Sales	$23.00			15	
	4/29/98		$24.00	100		0	
POWER AMPLIFIER							
	11/1/94	Opening Balance	$8.00	55	55		
	11/30/94	Sales	$13.00			14	

Products

Product ID	Product Name	Unit Price	Reorder Level	Lead Time
1	DC MOTOR 12 VOLT	$18.00	10	10 DAYS
2	3PHASE 10 KW GENERA	$19.00	25	10 DAYS
3	SINGLE PHASE 1 HP MO	$10.00	25	10 DAYS
4	GEAR 12	$22.00	0	10 DAYS
5	POWER AMPLIFIER	$21.35	0	10 DAYS

Purchase Order

A17

Ahmed Desouky
3020 Van Horne Ave.
Montreal, Quebec S2R-1-R2
Canada
Phone: (514) 342-0216 Fax: (514) 342-0216

Order Date	4/29/98	**Employee**	DESOUKY, AHMED SAID
PO ID	6	**Ship Via**	Federal Shipping
Date Required	12/12/98	**Description**	
Date Promised	12/12/98		

Ordered From:

Charlotte Cooper
ABC LMT.
49 Gilbert St.
London, EC1 4-SD
UK

Product ID	Product Name	Units	Unit Price	Subtotal
4	GEAR 12	100	$24.00	$2,400.00

Order Total **$2,400.00**

PURCHASE ORDERS LIST

SupplierID 1

urchase Order ID	PO Number	Order Date	ate Required	Date Promised
6	O290498006	4/29/98	12/12/98	12/12/98

SupplierID 2

urchase Order ID	PO Number	Order Date	ate Required	Date Promised
1	O290498001	11/5/94	11/28/94	11/13/94

SupplierID 3

urchase Order ID	PO Number	Order Date	ate Required	Date Promised
2	O290498002	11/18/94	11/21/94	11/21/94
5	O290498005	1/19/95	2/14/95	2/10/95

SupplierID 4

urchase Order ID	PO Number	Order Date	ate Required	Date Promised
3	O290498003	11/5/94	12/1/95	12/1/95

SupplierID 5

urchase Order ID	PO Number	Order Date	ate Required	Date Promised
4	O290498004	1/17/95	2/25/95	2/20/95

RECIVED PARTS

TRANSACTION ID	DESCRIPTION	RECEIVE ID	QTY	UNIT PRICE	TOTAL COSTS
1	BALANCE	R290498001	15	$4.00	$60.00
2	OPENING BALANCE	R290498002	25	$2.00	$50.00
3	OPENING BALANCE	R290498003	35	$6.00	$210.00
4	OPENING BALANCE	R290498004	45	$7.00	$315.00
5	OPENING BALANCE	R290498005	55	$8.00	$440.00
11	SHIPMENT RECEIVED	R290498006	20	$18.00	$360.00
12	RECEIVE	R290498007	7	$23.00	$161.00
13	SHIPMENT RECEIVED	R290498008	20	$14.00	$280.00
14	SHIPMENT RECEIVED	R290498009	10	$25.00	$250.00

SHIPPING LIST

Ship Date	PO Number	Shipping Method ID	Freight Charge
	O290498006	FEDERAL SHIPPING	$100.00
	O290498005	SPEEDY EXPRESS	$40.00
	O290498004	FEDERAL SHIPPING	$100.00
	O290498003	FEDERAL SHIPPING	$10.00
11/11/94	O290498001	SPEEDY EXPRESS	$20.00
11/19/94	O290498002	SPEEDY EXPRESS	$16.00

SHOPS LIST

SHOP TYPE: EOS

SHOP ID	SHOP	ADDRESS	TELEPHONE
HC2W3	MC123		

SHOP TYPE: MEC

SHOP ID	SHOP	ADDRESS	TELEPHONE
MC12D4	MECHANICAL	101 VAN HORNE AVE., MONTREAL,	((5)14)-222-4444

Table (21)

Suppliers

Supplier ID	Supplier Name	Contact Name	Address	City	Phone Number
1	ABC LMT.	CHARLOTTE CO	49 GILBERT ST.	LONDON	(71) 555-2222
2	NEW ORLEANS	SHELLEY BURK	P.O. BOX 78934	NEW ORLEANS	(100) 555-4822
3	ASSIA LMT.	REGINA MURPH	707 OXFORD RD.	ANN ARBOR	(313) 555-5735
4	TOKYO TRADER	YOSHI NAGASE	9-8 SEKIMAI	TOKYO	(03) 3555-5011
5	GENERAL MOTO	ANTONIO DEL V	CALLE DEL ROSAL 4	OVIEDO	(98) 598 76 54

Table (22)

ACTIVITIES COSTS AND MAN HOURS

ACTIVITY ID	TOTAL COSTS	WORKING HOURS
1	$2,120.00	21
2	$240.00	2
34	$1,110.00	20

ACTIVITIES REPORT

ACTIVITY ID	ACTIVITY REFEREN	PROCEDURE REFEREN	REMARKS
1	DE321456	W21221	
2	WAA1234	HY0981	
34	WE234	YT654	
35	WER543	TT543	
36	FR432	TY76	

Table (24)

ASSET CATEGORIES ID

ASSET CATEGORY ID	ASSET CATEGORY
1	MAIN BUILDING
2	MECHANICAL SYSTEM
3	RADAR

Assets by Date Acquired

Acquired	ID	Asset Description	Serial Number	Status	Purchase Price	Current Value
	2			NEW	$70,000.00	
	1	3 PHASE 60 HZ , 3HP MOTOR	768543	NEW	$30,000.00	$2,000.00
Grand Total					**$100,000.00**	**$2,000.00**

Assets by Employee

DESOUKY, AHMED SAID

ID	Asset Description	Serial Number	Acquired	Purchase Price	Current Value
1	3 PHASE 60 HZ , 3HP MOTOR	768543		$30,000.00	$2,000.00
2				$70,000.00	

Summary for 'Employee Name' = DESOUKY, AHMED SAID (2 detail records)

Sum	**$100,000.00**	**$2,000.00**
Grand Total	**$100,000.00**	**$2,000.00**

CREW ID

CREW ID	CREW
ELE	GENERAL ELECTRIC TE
MEC	GENERAL MECHANIST

ASSET DEPRECIATION

Asset ID: 1

Depreciation ID: 1

Depreciation Date: 1/1/97

Depreciation Amount: 5,000.00 $

Equipment ID:

Asset ID: 1

Depreciation ID: 2

Depreciation Date: 1/1/98

Depreciation Amount: 5,000.00 $

Equipment ID:

Table (29)

JOB DEMANDED

JOB ID	EQUIPMENT	WORK REQUIRED	ORIGINATOR	DEMANDED DATE
2	MOTOR		ALI	5/1/98
7		FIX AND REPAIR	SAID	4/21/98
8		FIX AND REPAIR		

Table (30)

JOB ESTIMATION

EQUIPMENT ID 1

JOB ID	SUBJUB ID	TOTAL COSTS	WORKING HOURS	JOB TYPE
2	7	$240.00	2	DEM
8	10	$240.00	2	EST
8	9	$2,120.00	21	EST

EQUIPMENT ID 3

JOB ID	SUBJUB ID	TOTAL COSTS	WORKING HOURS	JOB TYPE
7	5	$2,120.00	21	EST

JOB PLANED

EQUIPMENT ID 1

JOB ID	EQUIPMENT	PROMISED DATE	JOB TYPE
2	MOTOR	5/15/98	DEM
8			EST

EQUIPMENT ID 3

JOB ID	EQUIPMENT	PROMISED DATE	JOB TYPE
7		6/15/98	EST

ASSET MAINTENANCE FORM

A33

ASSET ID	
JOB TYPE	
JOB ID	
SUBJUB ID	
EQUIPMENT ID	
MAINTENANCE COSTS	
TOTAL HOURS	
MAINTENANCE DATE	
MAINTENANCE DESCRIPTIO	
MAINTENANCE PERFORMED B	

MAINTENANCE SUMMARY

A34

JOB ID	SUBJUB ID	EQUIPMENT	WORK$	PARTS$	TOTAL$	HOURS	JOB TYPE
2	7	1	$240.00	$0.00	$240.00	2	DEM
7	5	3	$2,120.00	$0.00	$2,120.00	21	EST
8	9	1	$2,120.00	$0.00	$2,120.00	21	EST
8	10	1	$240.00	$0.00	$240.00	2	EST
8	10	1	$240.00	$150.00	$390.00	2	EST

PARTS ISSUED

SUB JOB ID :

PRODUCT ID 2

ISSUE ID	TRANSACTION DESCRIPTIO	UNITS ISSED	DATE
I290498002	SALES	6	11/30/94

PRODUCT ID 3

ISSUE ID	TRANSACTION DESCRIPTIO	UNITS ISSED	DATE
I290498003	SALES	22	11/30/94

PRODUCT ID 4

ISSUE ID	TRANSACTION DESCRIPTIO	UNITS ISSED	DATE
I290498004	SALES	15	11/30/94

PRODUCT ID 5

ISSUE ID	TRANSACTION DESCRIPTIO	UNITS ISSED	DATE
I290498005	SALES	14	11/30/94

SUB JOB ID : 10

PRODUCT ID 1

ISSUE ID	TRANSACTION DESCRIPTIO	UNITS ISSED	DATE
I290498001	ISSUE TO SUBJOB	5	11/30/94

Table (35)

SUB JOB COSTS

JOB ID	SUBJUB ID	HOURS	WORK$	PARTS$	TOTAL$
2	7	2	$240.00	$0.00	$240.00
7	5	21	$2,120.00	$0.00	$2,120.00
8	9	21	$2,120.00	$0.00	$2,120.00
8	10	2	$240.00	$0.00	$240.00
8	10	2	$240.00	$150.00	$390.00

Table (36)

WORK INSTRUCTIONS NEEDS

CREW ID ELE

INSTRUCTION ID	INSTRUMENTS	MACHINES	TOOLS	SHOP ID
2	TS12	1	T01	HC2W3
3	HY	1	T2	
4	E324	1	TT543	
6	IT0909	3	TT678	MC12D4

CREW ID MEC

INSTRUCTION ID	INSTRUMENTS	MACHINES	TOOLS	SHOP ID
5	TOOL123	1	TOOL987	HC2W3
7	TT0234	MEC3F34	T01	HC2W3

WORK INSTUCTIONS COSTS

NSTRUCTION ID	DOCUMENT	DRAWING	CREW SIZE	WORKING HOURS	TOTAL COSTS
2	RE45T67	HG67	2	10	110.00 $
3	RR	RT5	1	1	220.00 $
4	DE34	SS321	2	20	1,110.00 $
5	AWSQ	WQER123	2	10	2,000.00 $
6	CFU 123456	DRW121134	1	1	10.00 $
7	DOC123	HRE345FRT	1	1	20.00 $

Table (38)

Assets by Category

MECHANICAL SYSTEM

ID	Asset Description	Serial Number	Acquired	Purchase Price	Current Value
1	3 PHASE 60 HZ , 3HP MOTOR	768543		$30,000.00	$2,000.00
2				$70,000.00	
Summary for 'AssetCategoryID' = 2 (2 detail records)					
Sum				**$100,000.00**	**$2,000.00**
Grand Total				**$100,000.00**	**$2,000.00**

CUSTOMER EQUIPMENT REPORT

CUSTOMER ID	EQUIPMENT ID	EQUIPMENT	DATE IN SERVICE	LOCATION
1				
	1	MOTOR	12/12/97	LK12
	3	GENERATOR	12/12/97	KK12

ASSETS MAINTENANCE LIST

JOB TYPE	ID	JOB	SUBJUB	EQUIP.	COSTS	HOURS	DATE	DESCRIPTION	PERFORMED BY

Company Information

SetupID	1
Company Name	AHMED DESOUKY
Address	3020 VAN HORNE AVE.
City	MONTREAL
State/Province	QUEBEC
Postal Code	S2R-1R2
Country	CANADA
Phone Number	(514) 342-0216
Fax Number	(514) 342-0216

Relationships for Master Maintenance Progra

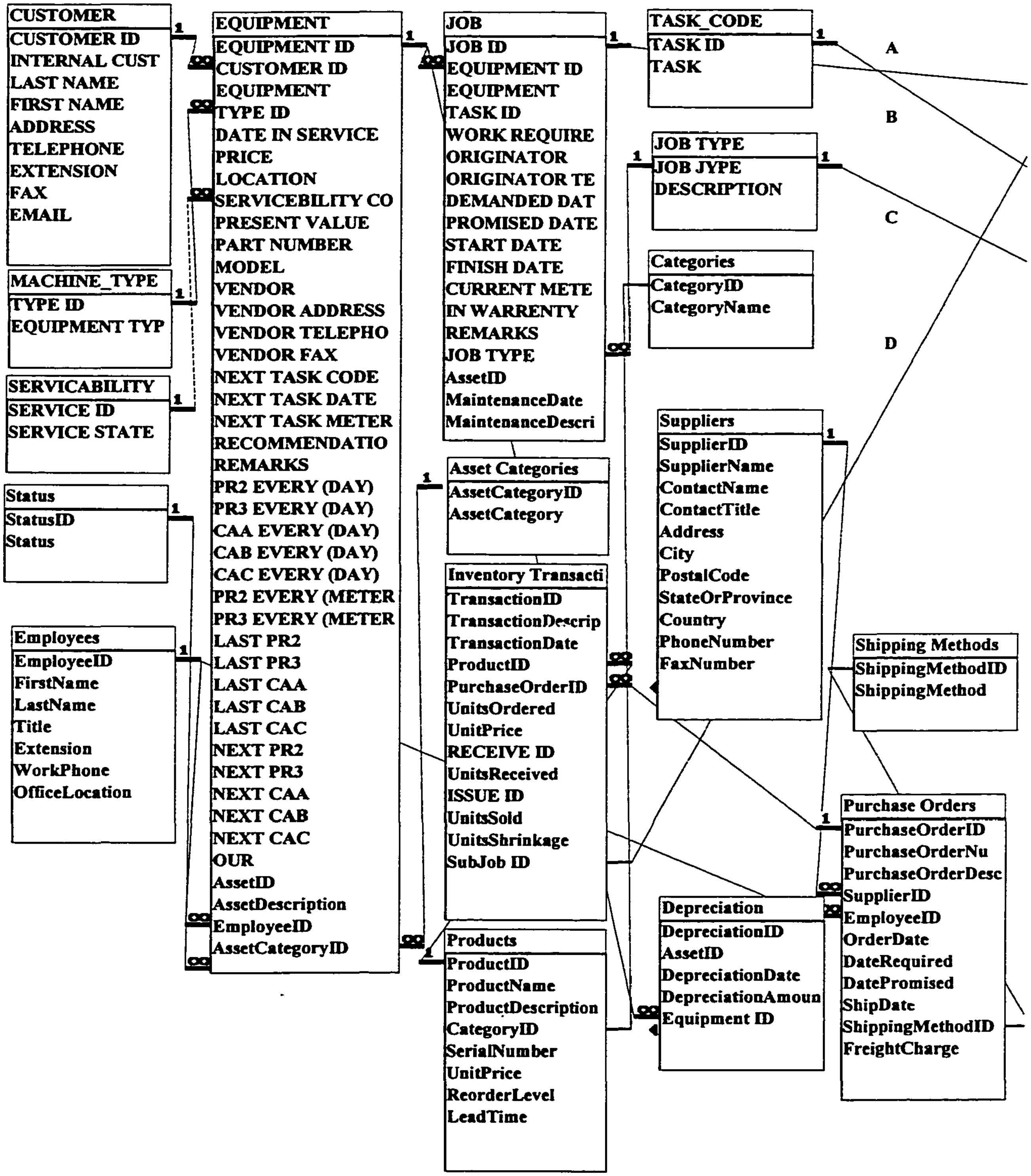

Table (43a)

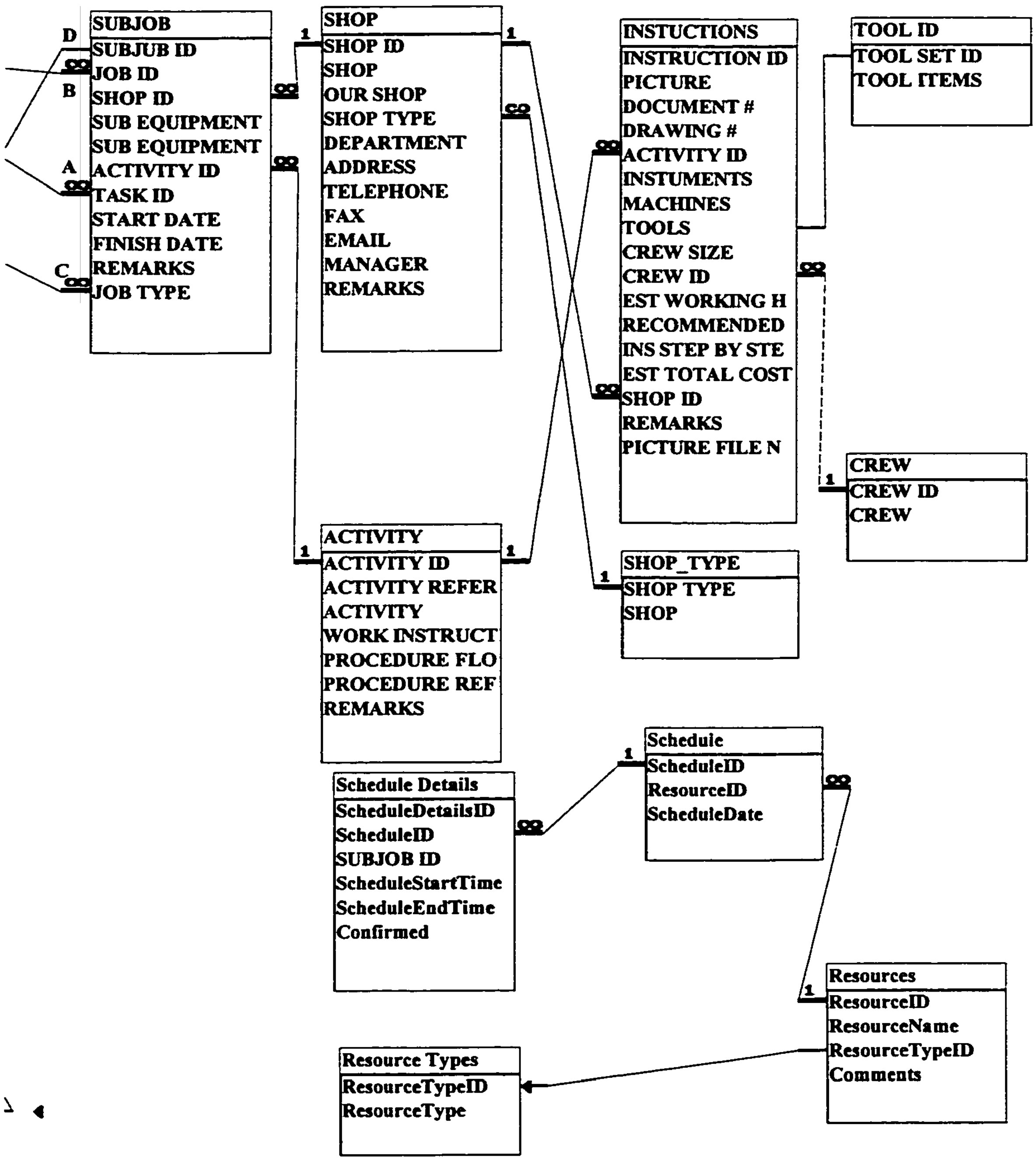
SUBJOB
SUBJUB ID
JOB ID
SHOP ID
SUB EQUIPMENT
SUB EQUIPMENT
ACTIVITY ID
TASK ID
START DATE
FINISH DATE
REMARKS
JOB TYPE
D
B
A
C
SHOP
SHOP ID
SHOP
OUR SHOP
SHOP TYPE
DEPARTMENT
ADDRESS
TELEPHONE
FAX
EMAIL
MANAGER
REMARKS
INSTUCTIONS
INSTRUCTION ID
PICTURE
DOCUMENT #
DRAWING #
ACTIVITY ID
INSTUMENTS
MACHINES
TOOLS
CREW SIZE
CREW ID
EST WORKING H
RECOMMENDED
INS STEP BY STE
EST TOTAL COST
SHOP ID
REMARKS
PICTURE FILE N
TOOL ID
TOOL SET ID
TOOL ITEMS
CREW
CREW ID
CREW
ACTIVITY
ACTIVITY ID
ACTIVITY REFER
ACTIVITY
WORK INSTRUCT
PROCEDURE FLO
PROCEDURE REF
REMARKS
SHOP_TYPE
SHOP TYPE
SHOP
Schedule
ScheduleID
ResourceID
ScheduleDate
Schedule Details
ScheduleDetailsID
ScheduleID
SUBJOB ID
ScheduleStartTime
ScheduleEndTime
Confirmed
Resources
ResourceID
ResourceName
ResourceTypeID
Comments
Resource Types
ResourceTypeID
ResourceType

Table (43b)