EMERGING INTERNATIONAL QUALITY SYSTEM STANDARDS:
The Role of the Maintenance Function

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Companies prospering in the global economy of the 1990's and beyond will share a common attribute: a systematic focus on and commitment to quality at all levels of operation. A new way of thinking will be imperative, one in which issues of productivity, profitability, and quality are regarded as the inextricably intertwined key components of successful commercial enterprise they truly are. No longer will it be possible to regard quality assurance activities as they have too often been viewed: expendable luxuries charged to "indirect manufacturing overhead" on the chart of accounts, or non-productive busywork tolerated merely for conformance to contractual or regulatory requirements.[1]

When we examine the particulars of the major progressive quality assurance models, two fundamental themes emerge with respect to processes and products: 1) a systematic organization-wide emphasis on defect prevention, and 2) decision-making processes based on continuing critical analyses of objective data. For example, the scoring criteria applied to entrants in the U.S. Malcolm Baldrige National Quality Award competition refer in part to "the degree to which the [quality management] approach is prevention-based" and "the degree to which the approach is based on quantitative information that is objective and reliable."

Similarly, the specifications contained in the ISO-9000/ANSI/ASQC-Q90[2] "Quality Management and Quality System Elements" series of international and domestic quality standards contain repeated references to an orientation "towards the reduction, elimination, and most importantly, prevention of quality deficiencies." (ANSI/ASQC Q94-1987 Section 0.2) Indeed, there are no fewer than a dozen references to "preventive" measures in the Q90 series guidelines. Addressing the importance of objective data, it is noted in Q94 that "quality records and charts pertaining to design, inspection, testing, survey, audit, review, or related results are important constituents of a quality management system" (Q94 Section 5.3.4).

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[1] The evidence indicates quite the contrary; a recent General Accounting Office study (GAO/NSIAD-91-190) of major U.S. corporations administering Total Quality Management (TQM) systems consistent with emerging international standards concluded that significant benefits accrued in four basic areas: 1) greater customer satisfaction, 2) increased market share and profitability, 3) improved product quality and lower production costs, and 4) better employee relations, including increased job satisfaction and lower turnover. The GAO report emphasized that TQM programs provide no quick fix, but rather must properly be regarded as an investment having, on average, a two to three year payoff cycle.

[2] The ANSI/ASQC-Q90 series standards are the U.S. technical equivalents of the ISO-9000 international quality standards.

The ISO-9000 Series of Quality Management standards was developed by the Technical Committee (TC176) of the International Organization for Standardization (ISO) in an effort to promote a uniform yet flexible and forward-looking model of Quality Management and Quality Assurance applicable to an increasingly borderless global economy. 1992 is the target year for implementation of the ISO standards within the European Economic Community (EC). Vendors wishing to do business with EC customers will find ISO-9000 quality certification initially a marketing plus, and eventually a requirement. The intent of ISO-9000 is to provide all participants in international commerce with a universal, objective set of standards assuring the quality of goods and services, irrespective of supplier location.

Defect Prevention in the Manufacturing Sector: A New Perspective on Process Control

Process control techniques have historically relied on statistical sampling inspection methods for the assessment of process and product quality. While valuable for input acceptance or output verification purposes, inspection is essentially "reactive" in nature. Dr. W. Edwards Deming, internationally acclaimed "father" of the modern quality assurance principles that form much of the basis of the Baldrige Award and ISO-9000 criteria, long ago tersely observed that "you can't inspect quality in."

It has become generally accepted in industry that quality is enhanced by the application of preventive maintenance measures ("PM") to manufacturing processes. Indeed, where the consequences of process or product defect or failure entail significant operator, consumer, or public safety hazards, preventive measures are normally mandated by legislation and/or regulation.

Traditional preventive methods, however, suffer a variety of limitations. The typical application of preventive measures in manufacturing environments involves the familiar scheduled maintenance approach. But when we look to the domain of Reliability Engineering for guidance in the setting of maintenance schedules, we find a field of theoretical study often only loosely grounded in empirical evidence; we enter a discipline where "bathtub curves" and "Weibull distributions" induced from distant, aggregate research data provide at best equivocal probabilistic counsel for the avoidance of failure in markedly dissimilar plant environments. Indeed, should we wish to employ proper statistical methods with which to set preventive maintenance intervals, we are often left with ambiguous failure rate distributions requiring the application of Chebyshev's Inequality. For example, achieving a 99% confidence level of "failure avoidance" might dictate maintenance intervention at 10 standard deviations below the "MTTF," or "Mean Time To Failure!"[3]

[3] The administrative obstacles to accurate and complete recordkeeping regarding the performance histories of numerous complex industrial machines comprised of hundreds of often unruly components tend to force overworked plant reliability engineers scurrying back to the smooth distribution curves of the textbooks and the MIL-STD tables.

Upon reflection, it should be apparent that when we set preventive maintenance schedules we are faced with two sub-optimal alternatives: 1) acceptance of a certain level of losses owing to premature failures falling in the "lower tail" of an often ambiguous MTTF probability distribution, or 2) an increase the frequency of preventive interventions sufficient to preclude all but the most rare of failure events. The equation simply becomes one of relative costs. Conservative, high-frequency PM schedules inevitably result in higher labor and downtime costs, as well as the wasteful replacement of perfectly operable components, while lengthier PM intervals risk random, sometimes catastrophic failures, with all that they imply.

There is, however, a better approach.

The Science of Predictive Maintenance: A Methodology For The Global Future

A recent report issued by the National Research Council of the National Academy of Sciences, *"The Competitive Edge: Research Priorities for U.S. Manufacturing,"* points out that Predictive Maintenance (PDM) can "detect conditions that might eventually lead to equipment failure. Predictive maintenance is a little used approach that has great potential." As stated in Maintenance Technology,[4] an industry journal commenting on the NRC report, "Well-maintained equipment holds tolerances better, reduces the need to rework parts, and improves the quality of whatever product is being made." According to the Maintenance Technology article, the NRC report concluded that "Manufacturers need to shift from breakdown and preventive maintenance to predictive maintenance to keep up with competitors worldwide..."[5]

Predictive Maintenance is the practice of monitoring industrial equipment during routine operations--without disturbing production--for indications of conditions adverse to quality (or potentially so) or for signs of malfunction which, if left uncorrected, are likely to cause machinery failure. The principal method employed in a PDM program involves machinery vibration analysis. Ailing components such as bearings, gears, belts, fans, pumps, rotating shafts, and the like may be detected through analysis of the characteristic vibration patterns they emit during operations. Additional techniques involve thermal, acoustic, lubricant, and electrical eddy current analyses. The characteristic energy "signatures" of equipment components have been studied in detail

[4] *MAINTENANCE TECHNOLOGY, An Applied Technology Publication,* September 1991, Page 13.

[5] PDM technologies are typically marketed as productivity tools, with an emphasis on the maintenance cost reductions achievable through the adoption of predictive maintenance programs. There is, however, a mostly overlooked yet extremely important Quality Assurance aspect of the PDM methodology. A machine "fails" to the extent that its ailing performance results in defective output even in the absence of imminent or actual breakdown. PDM techniques provide means for timely monitoring and interventions that can be genuinely "preventive," without having to await the emergence of nonconforming output to spur corrective actions. See *"The PDM-QC Connection: A Proactive Approach to Quality Control"* by the author for a further discussion of the Quality Assurance relationship to Predictive Maintenance.

for decades and are by now quite well defined. Through the placement of transducers on strategic locations on machines, vibration or other types of energy signatures are easily collected and digitized for computer-assisted storage and analysis. Personal computer (PC) based applications and specialized portable data collection and diagnostic tools exist for the acquisition, management, and analysis of machinery condition information.[6] A relative handful of firms develops and markets PDM products of one kind or another. Of these, Computational Systems, Inc. (CSI) provides the most comprehensive line of instruments, software applications, and services available, domestically and internationally.

CSI: An International Partner in Quality

From its 1984 founding by CEO Ron Canada in Knoxville, Tennessee to the present, CSI has grown from a one-man shop into an international full-service corporation with facilities in Knoxville, Houston, Texas, and Brussels, Belgium. The firm now employs more than 200 highly skilled and motivated individuals involved with instrumentation and software research and development, engineering, manufacturing, training, technical services, marketing, and customer support. CSI provides a complete line of equipment and software for both predictive maintenance programs and industrial engineering research laboratories. To say that the company is customer-driven is to understate the case; CSI employs a full staff whose sole function is to solicit and maintain active contact with customers for up-to-date feedback on user needs and recommendations.

In the 1990's and beyond, CSI will be a major global force in industrial diagnostic technologies. The firm recently contracted with a major Canadian gas pipeline company to install the CSI Model 3100 Continuous Monitoring System at the client's vast network of remote turbine compression stations. These natural gas pumping stations range from the Canadian Rockies to the Atlantic Provinces, and are critical to the success of the client's operation. CSI was chosen after an exhaustive, four-year vendor selection process. In the end, it was not only CSI's technology that won the day, but also the firm's commitment to customer success. CSI has every confidence that its products and services will make significant contributions to the quality and productivity of its customers' businesses.

Quality Testing and Documentation Systems

It is worth noting that, in addition to repeated citation of "preventive" measures

[6] An increasingly complex technological age--one in which machine operators will primarily function as machine tenders--means that the assignable causes of product and process nonconformance will more commonly be those of equipment dysfunction rather than worker inadequacies. PDM methods enable maintenance staffs to administer effective defect prevention programs that at once improve quality, productivity, and profitability by helping to assure that plant equipment performs optimally.

as being appropriate and necessary for progressive and effective quality policies, the Baldrige and ISO-9000/Q90 series quality guidelines strongly recommend the application of special diagnostic technologies and objective documentation systems to product and process control. CSI's line of portable dynamic signal analyzers and its continuous monitoring systems provide convenient and accurate data acquisition and analysis capabilities.[7] CSI's MasterTrend and MachineView PDM software[8] bring sophisticated analytical power and complete database management and reporting functions to the PC, Local Area Network (LAN), and Wide Area Network (WAN). In short, the PDM tools available from CSI enable plant management to apply precise, proven diagnostic measures to manufacturing and process equipment. These predictive maintenance tools also provide powerful and inclusive database management and reporting capabilities with which to document programs of defect prevention.

Quality Assurance at CSI

CSI is committed to practicing what it preaches; senior management recently invited a major outside Quality Management audit team in to perform an assessment of the company based upon Baldrige criteria. The findings were discussed at length with the company employees, and a Deming-like atmosphere of "continuous quality improvement" is alive and well throughout the company. CSI intends to become an ISO-9000 certified vendor in 1992, revising its current Quality Assurance program to comply fully with the provisions of the emerging international quality system standards.

- The Author -

Robert E. Gladd joined CSI in June 1991 to serve as a technical writer and editor in the Marketing Department. From 1986 to 1991 he served as a quality control statistician and systems analyst for the Oak Ridge Laboratory of IT Corporation, where he was an author of several technical papers on the subject of laboratory quality assurance. His 1989 paper on radioanalytical counting instrument reliability appears in the fall 1990 issue of *Radioactivity & Radiochemistry: A Journal of Applied Measurements.* Mr. Gladd is a graduate of the University of Tennessee and is a member of the American Society for Quality Control.

[7] CSI instruments undergo extensive burn-in testing conforming to ANSI standards, and receive NIST-traceable calibration.

[8] MasterTrend, and MachineView are Trademarks of Computational Systems, Inc.