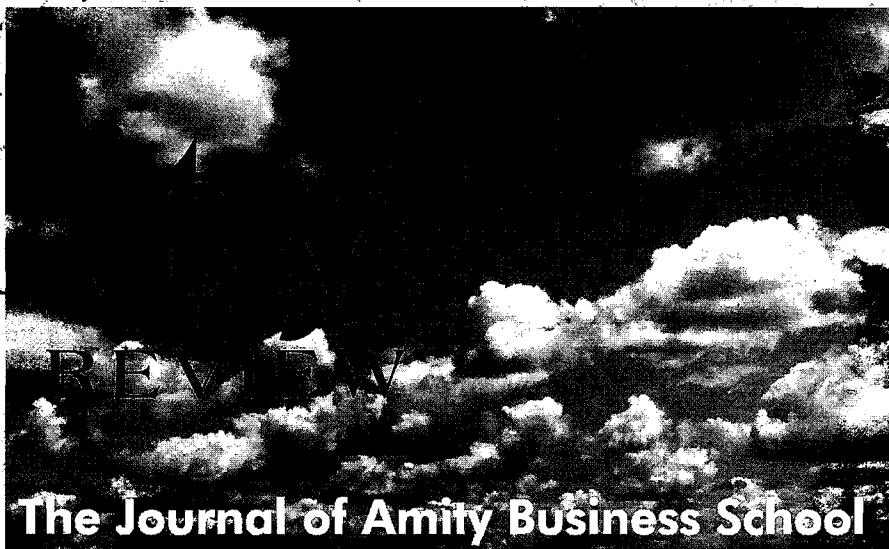


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# ENHANCED EFFICIENCY AND RESPONSIVENESS, IN CONSUMER FOOD SUPPLY CHAINS: ILLUSTRATIVE CASE STUDIES

Anita Kumar, Seamus O'Reilly & Frederick Adam

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## Purpose:

Over recent decades we have witnessed an evolution in the structure of the food industry from a 'push to pull' driven model as food manufacturers, suppliers and retailers have tried to adjust to increasing consumer demands, broad product variety and decreasing product lifecycles and delivery lead times. The option of Fisher's (1996) framework of either "*physically efficient/Lean*" or "*market responsive/Agile*" supply chain does not really suit the present day challenging business environment. Customer order driven production has to be both responsive and efficient in order to be viable and competitive.

A review of Lean thinking over the last decade reveals a tendency to view it as a 'tool box' suitable only for achieving operational efficiency in supply chains with stable demand. This approach neglects the broader transformational orientation of Lean philosophy that focuses on organisational capabilities, decision-making and management of relationships along the supply chain. This gap provides a compelling argument for studying the possibility that Lean strategy can be leveraged towards achieving both enhanced efficiency and consumer responsiveness. Hence, we investigate the following research question: "**Can both process efficiency and consumer responsiveness be achieved using Lean tools and techniques in consumer food supply chains?**"

## Research approach:

In-depth case study and action research methodology was adopted to investigate the research question in two Irish Small and Medium-sized food Enterprises (SMEs). This methodology supports both theory testing and applied problem solving. Participant-observer approach was used by the researchers to understand the current state of the supply chain, analyse the issues, propose and implement solutions and track the progress of the process improvement initiative. These initiatives were not limited to operational level but also involved strategic planning and management thinking. Data collection tools included: semi-structured interviews with managers at different organisational functions and levels, analysis of the company's documents and mapping key processes.

## Findings and Originality:

The results of this research indicate that both companies have shown substantial improvements in enhancing their operational efficiency. These included: reduced supplier lead time, higher conformity to production plan, rationalised product variety and decreased inventory levels. At the same time there was no negative impact on customer service level or lead time (performance measures for consumer responsiveness). The complementary nature of Lean and agile tools was evident. This supports the argument that both are holistic and cross-functional in nature and enhance strategic capability.

In the first case study, enhanced information flow between various departments and key members of the supply chain (packaging supplier) led to an improvement in adherence to production plan. This supports the view that lean processes reinforce the need to develop the capabilities of supply chain partners. The second case study demonstrated the need to empower and develop, rather than control, the workforce as people are responsible for all value added activities. These findings support the fundamental principle of lean philosophy: viewing all work from a process perspective, creating value for the customer and active involvement of people at intra and inter organisational levels (Womack and Jones 1990; 1996).

## Keywords

Food Supply Chains, Lean and Agile

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information sharing between all the members of the supply chain. These gains have been incremental and considerable efforts have been made by the management and work-force of the case study companies. The results indicate that food companies can adopt lean manufacturing as a working philosophy within their organizations and furthermore use of a range of Lean tools and techniques support responsive supply chain practices.

These findings support the fundamental principles of lean philosophy: viewing all work from a process perspective and creating value for the customer. Lean applies to the total enterprise, from the shop floor to senior management level, and from the supplier to end customer. It is a constantly evolving, dynamic process of change driven by a systematic set of principles and best practices aimed at continuous improvement (Womack and Jones 1990; 1996).

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# DISCLOSURE OF INTELLECTUAL CAPITAL IN ANNUAL REPORTS: AN EMPIRICAL STUDY OF THE INDIAN IT CORPORATIONS

**Madan Lal Bhasin & Mahendra Reddy**

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At present, disclosure of intellectual capital (IC) information by the companies, across the globe, is done by few leading companies purely on a "voluntary" basis. Unfortunately, the omission of IC information may adversely influence the quality of decisions made by shareholders, or lead to material misstatements.

This study attempts to provide an insight into the "narrative" style of IC disclosures done by Indian companies. Initially, a longitudinal study was carried out to analyze how Indian firms--Reliance Industries Limited, Balrampur Chini Mills and Shree Cement Limited--measure and report their IC reports. In order to survey the recent IC disclosure scenario, we conducted another study of 16 Indian IT companies in which the 'content analysis' was done on their 2007 to 2009 annual reports. The results of this study confirmed that IC disclosure in these IT companies is almost negligible and its disclosure had not received any preference from the mentors of these corporations. IC reports may initially be used for 'internal' management purposes; but an 'external' stakeholder-focus of IC report should be the ultimate goal.

**Keywords:** Intellectual capital, disclosure scenario, IT companies, India, IC reports.

## INTRODUCTION

Business dynamics of the 21st century are increasingly determined and driven by Intellectual Capital (IC) elements. The future drivers of any economy will no longer be capital, land or equipment, but the "people" and their "knowledge" reservoir. A knowledge-intensive company leverages their know-how, innovation and reputation to achieve success in the marketplace (Jose et al., 2010, p.3). Market participants, practitioners and regulators alike argue that there is an important need for greater investigation and understanding of IC disclosure (or reporting) as the usefulness of financial information in explaining firm profitability continues to deteriorate. Bukh (2005, p.715), for example, asserts that traditional disclosure mechanisms are not able to cope adequately with the disclosure requirements of new economy firms. He observed an increasing dissatisfaction with traditional financial disclosure and its ability to convey to investors the wealth-creation potential of firms. Despite growing interest and demand for IC information, prior research till date suggests a persistent and significant variation, both in the 'quantity' and 'quality' of information reported by firms on this pivotal resource. As existing economic and business metrics track a

declining proportion of the real economy, the deficiency and inconsistency in the disclosure of IC-related information is creating growing information "asymmetry" between 'informed' and 'uninformed' investors. This provides a fertile ground for informed investors to extract higher abnormal returns (Chiucchi et al., 2008, p.220). Thus, IC is increasingly being recognized as having much greater significance in creating and maintaining competitive advantage and shareholder value. This clearly calls for a refreshed understanding of business principles, information disclosure, and decision-making processes.

The concept of IC measurement, management and disclosure is still relatively new. Accountants, business managers and policy makers have still to grapple with its concepts and detailed application. As expected, definition of IC varies substantially. According to Stewart (2002, p.6): "It has become standard to say that a company's IC is the sum of its human capital (talent), structural capital (intellectual property, methodologies, software, documents, and other knowledge artifacts), and customer capital (client relationships)." One of the most comprehensive definitions of IC is offered by the Chartered Institute of Management Accountants (CIMA, 2001, page 6): "The possession of knowledge

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# ANALYZING CRITICAL SUCCESS FACTORS IN IMPLEMENTATION PHASE OF ERP PROJECTS IN INDIA

Vikas Prasad

Enterprise Resource Planning acronym ERP has become a lifeline of every enterprise of the present Business era globally, be it an Indigenous, MNC or Public Sector enterprise. Every organization requires enterprise-wide cross-functional business information for increasing the business value chain. The concept of an ERP evolved somewhere around 1990 but in India it started the pace after a decade around 1999-2000. The Indian ERP market experienced compounded annual growth rate of 25.2 during the period 2004-09. The market was \$83 Million in 2004 and was projected to be over \$250 Million in 2009 [1]. Based on the ERP survey conducted by Meta Group in 2002, the average cost of ERP ownership was \$15 Million ranging from \$0.5 Million to \$300 Million. The average cost per user could be as high as \$20000 [2]. Research has shown that majority of ERP implementation fails due to number of Internal and External factors. If the important Critical Success Factors (CSF's) for different ERP implementation phases are known well in advance the ERP clients as well as ERP vendors can save lots of money and manpower effort involved in ERP implementation, since the unawareness at the other side can spoil the ERP project and can make it a failure. This Research Report discusses the CSF's responsible for success of ERP Projects during implementation phase, the first research of its kind in Indian context.

**Keywords:** Enterprise Resource Planning, Critical Success Factors

## INTRODUCTION

Enterprise Resource Planning acronym ERP has become a lifeline of every enterprise of the present Business era globally, be it an Indigenous, MNC or Public Sector enterprise. Every organization requires enterprise-wide cross-functional business information for increasing the value chain. ERP is the answer, as it can provide enterprise-wide solution by seamlessly integrating the entire business processes thus providing real time uniform information throughout the organization. The concept of an ERP evolved somewhere around 1990 but in India it started the pace after a decade around 1999-2000.

According to observations made by some experts in the field, the ERP market started showing solid growth since 2004 as Information Technology spending improves. The Indian ERP market experienced compounded annual growth rate of 25.2 during the period 2004-09. The market was \$83 Million in 2004 and was projected to be over \$250 Million in 2009 [1].

Based on the ERP survey conducted by Meta Group in 2002, the average cost of ERP ownership was \$15 Million ranging from \$0.5 Million to \$300 Million. The average cost per user could be as high as \$20000 [2].

The cost of ERP implementation varies on the basis of software, hardware, customization, integration, data conversion, testing and training. Research has shown that majority of ERP implementation fails due to number of Internal and External factors. A research on Critical Success Factors has revealed that there are 27 identified factors that are responsible for ERP Project success at different levels of ERP implementation. If the organization can realize the importance of these CSF's prior to implementation, they can avert the Project failure and can save the expenses made on ERP implementation.

If the important CSF's for different ERP implementation phases are known well in advance the ERP clients as well as ERP vendors can save lots of money and manpower effort involved in ERP implementation; the unawareness at the other side can spoil the ERP project and can make it a failure.

The objective of this Research is to use the data of Indian Companies using ERP software to evaluate the CSF's important for the implementation phase of ERP projects and to determine the inherent relations among these factors.

Earlier Research has suggested that over half of ERP



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# BARRIERS AND MOVERS IN INDIAN MOBILE BANKING — A STUDY OF RAJASTHAN

M.S. Dulawat & Pranoti Kothari

## INTRODUCTION

Telecommunication sector is now universally recognized as one of the prime movers of the modern economy. The availability of adequate infrastructure facilities is critical for acceleration of economic development of any country.

Expansion of Mobile phones in India is phenomenal. In addition to this, 7-8 million consumers are added each month. On the other hand, the penetration of internet in India is abysmally low at 2.5%. The penetration of mobile phones is 4-5 times that of personal computers.

As the fastest growing telecommunications industry in the world, it is projected that India would have 1.159 billion mobile subscribers by 2013. Projections by several leading global consultancies indicate that the total number of subscribers in India would exceed total subscriber count in China by 2013. The industry is expected to reach a size of 344,921 crore (US\$ 76.23 billion) by 2012 at a growth rate of over 26 per cent, and generate employment opportunities for about 10 million people during the same period. According to analysts, the sector would create direct employment for 2.8 million people and for 7 million indirectly. In 2008-09 the overall telecom equipments revenue in India stood at 136,833 crore (US\$ 30.24 billion) during the fiscal, as against 115,382 crore (US\$ 25.5 billion) a year before.

With more and more features being packed into the handsets and the additional services provided by the mobile service providers like GPRS, MMS etc. there has been changes in the expectations that consumers had from their mobile and the way in which the consumers has started to use their mobiles.

M-commerce was an emerging area of opportunity, particularly in the high-value markets. PVR media

Entertainment Company with the launch of PVR mobile ticketing were already providing service to a customer base of over 90,000, (with 75 per cent repeat usage). Both airline and train ticketing can be increasingly made available to mobile consumers.

Money transfer is slated to be an important offering in the immediate future. Services would enable mobile users to pay any post-paid mobile bill using the mobile phone, prepaid top-ups and landline bill payments can also be one of the most upcoming strategies in the field of m-commerce. Person-to-person money transfer (from one bank account to another) via the mobile Banking will become an important offering in the mobile space.

In the months to come, innovative products including exclusive handset bundling opportunities, content and distribution innovations and offerings specifically aimed at both rural and high-value markets would be increasingly available in the market.

We were aware that consensus within business and industry of future applications of mobile banking is still in its infancy. However, we are interested in examining those future applications and technologies that would form the next frontier of mobile banking.

## *Emerging Services of Mobile Banking In India*

1. Increased mobile penetration and use of GPRS on handsets has resulted in the digital downloads market to cross Rs.4.55 Billion by end of March 2010.
2. Monetary transfers or transactions through mobile phones are found to be much cheaper than traditional bank transfers as the transaction

7. People in India still relish doing physical shopping rather than shopping online.

## CONCLUSION

Riding on a wave of increasing growth, the mobile telephony in India is expected to rise to a consumer base of over 1 Billion by 2015, making the telecommunication sector one of the most lucrative markets for global mobile phone manufacturers & cell phone providers.

With the rapid growth of the telecom sector in India and India becoming one of the largest potential markets for many global players to enter in to, the plethora of product offerings to the end consumers have seen a drastic change in the past few years. With this intense competition in the market place and the consumer having option of choices, service providers are adding a range of services to their basket to not only attract new customers but also retain the existing ones.

According to the research customers consider the mobile banking option to be a good reason but still there are apprehensions in customers to go for mobile banking services.

It is found that people who love shopping would always go for physical shopping rather than doing shopping through mobile. Also there is a relation between age and services used by the people. Therefore companies should target customers on the basis of age and should introduce new and exiting offers especially in the youth category as India has the biggest youth population.

It also viewed that there is a significant effect of income on mobile banking services being used; therefore companies should try to reduce the transaction fee of using mobile banking service from the lower income group so as to stimulate them to buy.

Lastly I would like to conclude just by saying that India is a rapidly growing country and mobile banking has the capability to produce huge revenue for a country like India because of various reasons like huge population, techno savvy people etc. therefore companies should try to reduce or remove the barriers of mobile banking in India and try to

emphasize more on the movers or stimulators of mobile banking.

## RECOMMENDATIONS

1. A judicious mix of incentives and SMS advertising should be used for mobile banking services as different people have different views on these, it would be a challenge to segregate consumers on this basis.
2. Security concerned consumers have negative attitude towards mobile banking shopping and they can be a tough challenge for the banks. We recommend that security concerns related to mobile transactions should be handled by the banks in the initial communication with the Consumers i.e. Security should be emphasized while launching the service and at every consumer interface to reinforce the fact that mobile transactions are secure.
3. Positioning of mobile banking services should be based on providing convenience rather than as a substitute of traditional banking.
4. The price for using mobile banking services should be fixed by the companies in such a way that it does not exploit the customers and they are motivated to use the service again.
5. As physical banking has a different experience mobile banking should be projected as complimentary to it.
6. Transaction fee of mobile banking transaction should be reduced further so as to stimulate the Indian population, as Indians give due weightage to monetary aspect.

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# THE DETERMINANTS OF CORPORATE DIVIDEND DECISIONS: A STUDY ON BSE SENSEX FIRMS

Gayathri Devi A & T Mallikarjunappa

This study attempts to identify the factors influencing the dividend policy decisions of firms by taking Sensex firms as sample. The study finds that interest cover ratio (ICR) is a strong variable significantly influencing the dividend policy of companies, followed by PAT/Sales (PAT/S), PBIT/total assets (PBIT/TA), ROCE, cash profits/sales (CP/S), debt-equity ratio (D/E), current ratio (CR) and depreciation scaled by net fixed assets (D/FA) for individual companies. Similarly, the study finds that lagged dividend (LD/P), followed by lagged PAT (LPAT/S) and lagged PBIT (LPBIT/TA); and market price (MP) and book value (BV) per share followed by P/E and P/B are significant variables affecting the dividend policy of companies. In the case of pooled data, we find that PBIT/TA, D/FA, MP, P/B, LD/P, LPBIT/TA and LPAT/S emerge as the significant variables. In the multiple regression, we find that models with PAT/S and LD/P; CP/S and LD/P; PAT/S, LD/P and D/FA; PAT/S, LPAT/S, D/FA, and CR; MP, P/E, P/B and BV; MP, P/E, and P/B; and P/E, P/B and BV are significant and therefore, are the determinants of dividends of companies, both at company level and aggregate level.

**Key words:** Dividend Decisions, Dividend Determinants, Sensex Companies, financial statement ratios, market related ratios.

## INTRODUCTION

Dividend decision has been a subject of enquiry for financial analysts, academicians and researchers for about six decades since Lintner (1956) first proposed his dividend model. The dividend decision is an integral part of a company's financial decision as it is explicitly related to the other two major decisions -- the investment decision and the financing decision. Dividend policy determines the portion of earnings to be paid out to the shareholders and the portion to be retained in the business to finance long term growth. Both dividends and growth are desirable but are conflicting to each other. This situation is an existing challenge for the financial managers and necessitates the need to establish an optimum dividend policy that has no adverse effects on the future progress of the firm. The dividend policy of a firm has an important information effect. It indicates the health of a firm and is a vital input in current and potential investors' decision making regarding their investment in the shares of that firm (Mathew (1999)). From the practitioners' point of view, dividend policy of a firm has implications for investors, managers, lenders and other stakeholders.

Factors influencing dividend policy decision of a firm is a debatable issue which has engaged academicians for more than five decades. Several

studies have been conducted on this subject, after the landmark studies of Miller and Modigliani (1961) that established the irrelevance of dividend policy. Despite several decades of study, we are yet to understand completely the factors that influence dividend policy and the manner in which these factors interact. The present study concentrates on identifying the factors which are important in influencing the dividend policy of firms. The remaining portion of this paper is organised as follows: Section 2 sets forth a survey of the literature. The selection of sample, period of study, data source, variables and methodology are given in Section 3. Section 4 contains empirical results and analysis of the results. Section 5 presents the conclusions of the study.

## LITERATURE REVIEW

Many studies have been conducted on dividend policy and fundamental security analysis in India and outside. Several studies have proved that the dividend policy of a firm depends upon the current profits, lagged profits, lagged dividends, cash flows, corporate tax, depreciation, liquidity position, debt equity ratio, P/B ratio, and P/E ratio.

Lintner (1956) conducted an empirical research over dividend pattern of 28 companies for the period of

(1994) in which case PAT/S is a significant determinant of dividend policy. Also, our findings are consistent with those of Brittain (1966) and Mahapatra and Sahu (1993) where cash flow is an important determinant of dividend policy. However, we find significant and negative relationship between Current dividends and D/E which is not consistent with the findings of Adedeji (1998). When the data of all the companies is pooled, we find that PBIT/TA, D/FA, LD/P, LPBIT/TA, LPAT/S, MP, and P/B positively influence the dividend decisions and PAT/S, CP/S, CR, D/E, P/E, and BV are insignificant. In case of multiple regression results, we find that PAT/S, CP/S, D/FA, LD/P, LPAT/S, CR, MP, P/E, P/B and BV emerge as the explanatory variables. As the dividend decision can affect firm value and, in turn, the wealth of shareholders, dividend policy is worthy of serious management attention. This study considered only the Sensex companies for analysis. There is a scope to study other companies to find out whether the same set of factors is appropriate.

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# IMPACT OF DEMAT ACCOUNT ON ITS HOLDER'S- AN EMPIRICAL STUDY OF HIMACHAL PRADESH

**Manoj Sharma**

The Stock Markets plays an important role in planned growth of any economy. The purposes of a Stock Exchange, like any other organized market is to enable buyers and sellers to effect their transactions more quickly and cheaply. Stock exchanges (markets) are intricately inter-woven in the fabric of a nation's economic life. Without a stock exchange, the saving of the community-the sinews of economic progress and productive efficiency-would remain underutilized. Stock exchange means any body of individuals, whether incorporated or not, constituted for the purpose of regulating or controlling the business of buying, selling or dealing in securities. India has the privilege of having the oldest stock exchange in Asia. Trading through securities began about 200 years ago, the first stock exchange came into existence some time in 1875 at Bombay followed by the Calcutta stock exchange in 1908. But, with the span of time a chain of continuous frauds/scams has been recorded in the Stock Market, where investors are cheated by presenting rosy pictures. Therefore, to control the unscrupulous activities of the broker's and other concerned SEBI made DEMAT Account mandatory to every one who wants to deal in the Stock Market. To know the changes which took place in the Stock Market after introduction of DEMAT Account, through this present study an attempt has been done to assess that. The present study is confined to one year period starting from October 2009 to October 2010. Every effort has been made to make the study executed for the stipulated time period. The present study has been undertaken with the objective of knowing the Impact of DEMAT Account on its holders and to know the changes that took place in the investing habits of investors after adopting the concept of DEMAT Account. On the basis of analysis made from collected data through questionnaire the study reveals that DEMAT Account is able to built more confidence and awareness among the investors. But, at the same time reach and awareness among women, students and rural people needs to be strengthen. Further, while summarizing the study, it was found that SEBI should impose more strong regulations on Depository Participants (DPs) to improve their services towards their clients.

**Key words:** Demat Account, Depository Participants, SEBI, Stock Exchange

## CONCEPT OF DEMAT ACCOUNT

Under Companies Act, 1956 sec. 68(b), provision for DEMAT Account is prescribed. DEMAT refers to Dematerialized Account. Just as an account with the bank. If you want to buy or sell stock you need to open a DEMAT account. So, it is just like a bank account where actual money is replaced by shares. When opening an account with a bank, a minimum balance is needed, not so with a DEMAT Account. A DEMAT Account can be opened with nil balance of shares, and there is no minimum balance to be maintained either. To open a DEMAT Account, you have to approach DPs (Depository participants) (they are like bank branches). Let's assume your portfolio of shares looks like this: 40 of infosys, 25 of wipro, 45 of HLL and 100 of ACC. All these will be shown in your DEMAT account. So, you don't have to possess any physical certificates showing that you own these shares. They are all held electronically in your account. As you buy and sell the shares, they are adjusted in your account. Just like a bank passbook or statement, the DP will provide you with

periodic statements of holding and transactions (SEBI Guidelines, 2008).

## *Procedure to Open a DEMAT Account*

Once you approach your DP, you will be guided through the formalities of opening an account. You must fill up an account opening form and sign an agreement with your D.O. The D.P. will ask for some documents as proof of your identity and address such as Pan Card, Voter's ID, Passport, Ration Card, Driving license, Electricity/landline Phone Bill etc. Lastly, you will have to submit a passport size photograph on which you sign across.

## *Benefits of DEMAT Account:*

- A safe and convenient way to hold securities;
- Immediate transfer of securities;
- No stamp duty on transfer of securities;
- Elimination of risks associated with physical certificates such as bad delivery, fake securities, delays, thefts etc.;



7. Depository Participants (DPs) should employ dedicated and separate contact numbers especially during peak hours - for trading over the phone as well as for customer care.
8. If you sold a physical lot, presumably you would deliver the older set to minimise the payout. But in case of a DEMAT, there is an extremely grey area about which CGT rate should be levied. The Central Board of Direct Taxes hasn't worked out a clear procedure for distinguishing the earlier lot from the later lot. You could find yourself locked in a dispute and facing a demand for short-term capital gains tax. This is obviously of major significance.
9. None of these problems are insurmountable. But it will require a coordinated effort from various agencies to sort them out. SEBI and RBI have to come up with a way of streamlining the DEMAT process and regularising the status of deposits accepted, if any. The NSDL and CSDL will have to speed up their registration procedures and devise a more foolproof system of receipt and transfer. Banks and stock exchanges will have to

coordinate working hours and the use of temporary entries. The Central Board of Direct Taxes (CBDT) will have to come up with clear tax guidelines.

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# RELIABILITY IMPROVEMENT OF AC PLANT ACCESSORIES THROUGH CONDITION DIAGNOSTIC TECHNIQUES- A SUCCESS STORY



S. P. Garnaik

In today's globally competitive economy, maintaining plant asset's health and protecting critical assets have assumed paramount importance and major cause of concern. Advancements in equipment maintenance management technologies are targeted at achieving enhancements in productivity, reliability, availability, higher performance level, higher comfort, loss minimization and enhanced safety concerns. Maintenance management approach have seen tremendous changes since last three decades thanks to overwhelming technological advancements of machine health management in terms of engineering analysis (diagnosis) and instrumentation.

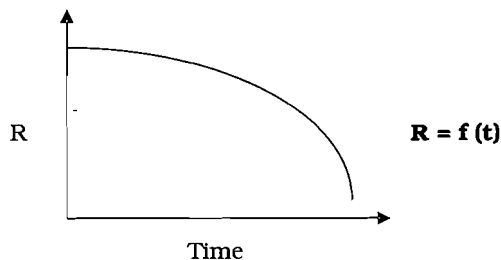
Air Conditioning (AC) plants are very critical equipment in many of the process industries like fertilizers, pharmaceuticals etc. It is equally critical in commercial buildings, hospitals, hotels, research establishments and office buildings. The availability & reliability of AC plant and its accessories are to be ensured for desired output or requirement. Therefore, it is also vital to judge the condition of AC plant accessories to avoid any unwanted shutdown. It is also equally important in terms of operational efficiency and energy conservation.

This paper deals with a condition diagnostic approach that could be successfully implemented in AC plant accessories in order to achieve higher reliability. The operational reliability could be enhanced to 100% from a low 24%. Few of the technologies have been justified by real life case studies as established through different diagnostic studies.

**Keywords :** Air Conditioning, Condition Diagnostic Approach, Maintenance Management, Operational Reliability

## CONCEPT OF RELIABILITY

Reliability is a probabilistic term. Higher reliability of any equipment means the equipment is able to perform or deliver the desired output (termed as Function) in a time frame. So, reliability decreases with increase of time (Figure 1).



**Figure 1 : Reliability & Time Relationship**

On the other hand, reliability is also dependent on failure rate ( $\lambda$ ) which normally increases as the time goes on. In maintenance management, higher mean-time-between-failure (MTBF) suggests less failure rate. Mathematically it is expressed as

$$\lambda = 1 / \text{MTBF}$$

$\lambda$  can be very well obtained from past failure data. In case of unavailability of past failure data, published hand book data can be considered. Reliability engineering says that, Reliability(R) is exponentially related with and time(t) which is mathematically expressed as

$$R(t) = e^{-(\lambda t)}$$

Hence, it is clearly understood that in order to achieve higher reliability, failure rate ( $\lambda$ ) of any equipment should be reduced to minimum. Predictive Maintenance (PdM) through condition diagnostic technique is such an approach aimed at zero break down, hence 100% reliability. Of course, the desired output of the equipment is also to be ensured at the same time.

## THE PROBLEM

A high-rising office building in the northern India has a total of 300 TR centralized air-conditioning (AC) plant. The plant has 2 chillers (150TR each), 4 chilled-water pumps, 4 condenser water pumps and