Technology Training that Works

Presents

Practical Balancing, Alignment and Condition Monitoring of Rotating Equipment

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Acknowledgements

IDC Technologies expresses its sincere thanks to all those engineers and technicians on our training workshops who freely made available their expertise in preparing this manual.

Technical Information that Works

Who is IDC Technologies?

IDC Technologies is a specialist in the field of industrial communications, telecommunications, automation and control and has been providing high quality training for more than six years on an international basis from offices around the world.

IDC consists of an enthusiastic team of professional engineers and support staff who are committed to providing the highest quality in their consulting and training services.

The Benefits to you of Technical Training Today

The technological world today presents tremendous challenges to engineers, scientists and technicians in keeping up to date and taking advantage of the latest developments in the key technology areas.

- The immediate benefits of attending IDC workshops are:
- Gain practical hands-on experience
- Enhance your expertise and credibility
- Save $$$s for your company
- Obtain state of the art knowledge for your company
- Learn new approaches to troubleshooting
- Improve your future career prospects

The IDC Approach to Training

All workshops have been carefully structured to ensure that attendees gain maximum benefits. A combination of carefully designed training software, hardware and well written documentation, together with multimedia techniques ensure that the workshops are presented in an interesting, stimulating and logical fashion.

IDC has structured a number of workshops to cover the major areas of technology. These courses are presented by instructors who are experts in their fields, and have been attended by thousands of engineers, technicians and scientists world-wide (over 11,000 in the past two years), who have given excellent reviews. The IDC team of professional engineers is constantly reviewing the courses and talking to industry leaders in these fields, thus keeping the workshops topical and up to date.

Technical Training Workshops

IDC is continually developing high quality state of the art workshops aimed at assisting engineers, technicians and scientists. Current workshops include:

Instrumentation & Control

- Practical Automation and Process Control using PLC's
- Practical Data Acquisition using Personal Computers and Standalone Systems
- Practical On-line Analytical Instrumentation for Engineers and Technicians
- Practical Flow Measurement for Engineers and Technicians
- Practical Intrinsic Safety for Engineers and Technicians
- Practical Safety Instrumentation and Shut-down Systems for Industry
- Practical Process Control for Engineers and Technicians
- Practical Programming for Industrial Control – using (IEC 1131-3;OPC)
- Practical SCADA Systems for Industry
- Practical Boiler Control and Instrumentation for Engineers and Technicians
- Practical Process Instrumentation for Engineers and Technicians
- Practical Motion Control for Engineers and Technicians
- Practical Communications, SCADA & PLC's for Managers

Communications

- Practical Data Communications for Engineers and Technicians
- Practical Essentials of SNMP Network Management
- Practical Field Bus and Device Networks for Engineers and Technicians
- Practical Industrial Communication Protocols
- Practical Fibre Optics for Engineers and Technicians
- Practical Industrial Networking for Engineers and Technicians
- Practical TCP/IP & Ethernet Networking for Industry
- Practical Telecommunications for Engineers and Technicians
- Practical Radio & Telemetry Systems for Industry
- Practical Local Area Networks for Engineers and Technicians
- Practical Mobile Radio Systems for Industry

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Electrical

- Practical Power Systems Protection for Engineers and Technicians
- Practical High Voltage Safety Operating Procedures for Engineers & Technicians
- Practical Solutions to Power Quality Problems for Engineers and Technicians
- Practical Communications and Automation for Electrical Networks
- Practical Power Distribution
- Practical Variable Speed Drives for Instrumentation and Control Systems

Project & Financial Management

- Practical Project Management for Engineers and Technicians
- Practical Financial Management and Project Investment Analysis
- How to Manage Consultants

Mechanical Engineering

- Practical Boiler Plant Operation and Management for Engineers and Technicians
- Practical Centrifugal Pumps – Efficient use for Safety & Reliability

Electronics

- Practical Digital Signal Processing Systems for Engineers and Technicians
- Practical Industrial Electronics Workshop
- Practical Image Processing and Applications
- Practical EMC and EMI Control for Engineers and Technicians

Information Technology

- Personal Computer & Network Security (Protect from Hackers, Crackers & Viruses)
- Practical Guide to MCSE Certification
- Practical Application Development for Web Based SCADA

Technical Information that Works

Comprehensive Training Materials

Workshop Documentation

All IDC workshops are fully documented with complete reference materials including comprehensive manuals and practical reference guides.

Software

Relevant software is supplied with most workshops. The software consists of demonstration programs which illustrate the basic theory as well as the more difficult concepts of the workshop.

Hands-On Approach to Training

The IDC engineers have developed the workshops based on the practical consulting expertise that has been built up over the years in various specialist areas. The objective of training today is to gain knowledge and experience in the latest developments in technology through cost effective methods. The investment in training made by companies and individuals is growing each year as the need to keep topical and up to date in the industry which they are operating is recognized. As a result, the IDC instructors place particular emphasis on the practical hands-on aspect of the workshops presented.

On-Site Workshops

In addition to the quality of workshops which IDC presents on a world-wide basis, all IDC courses are also available for on-site (in-house) presentation at our clients' premises. On-site training is a cost effective method of training for companies with many delegates to train in a particular area. Organizations can save valuable training $$$'s by holding courses on-site, where costs are significantly less. Other benefits are IDC's ability to focus on particular systems and equipment so that attendees obtain only the greatest benefits from the training.

All on-site workshops are tailored to meet clients' training requirements and courses can be presented at beginner, intermediate or advanced levels based on the knowledge and experience of delegates in attendance. Specific areas of interest to the client can also be covered in more detail. Our external workshops are planned well in advance and you should contact us as early as possible if you require on-site/customized training. While we will always endeavor to meet your timetable preferences, two to three months' notice is preferable in order to successfully fulfil your requirements. Please don't hesitate to contact us if you would like to discuss your training needs.

Technical Information that Works

Customized Training

In addition to standard on-site training, IDC specializes in customized courses to meet client training specifications. IDC has the necessary engineering and training expertise and resources to work closely with clients in preparing and presenting specialized courses.

These courses may comprise a combination of all IDC courses along with additional topics and subjects that are required. The benefits to companies in using training are reflected in the increased efficiency of their operations and equipment.

Training Contracts

IDC also specializes in establishing training contracts with companies who require ongoing training for their employees. These contracts can be established over a given period of time and special fees are negotiated with clients based on their requirements. Where possible, IDC will also adapt courses to satisfy your training budget.

References from various international companies to whom IDC is contracted to provide on-going technical training are available on request.

Some of the thousands of Companies worldwide that have supported and benefited from IDC workshops are:

Alcoa, Allen-Bradley, Altona Petrochemical, Aluminum Company of America, AMC Mineral Sands, Amgen, Arco Oil and Gas, Argyle Diamond Mine, Associated Pulp and Paper Mill, Bailey Controls, Bechtel, BHP Engineering, Caltex Refining, Canon, Chevron, Coca-Cola, Colgate-Palmolive, Conoco Inc, Dow Chemical, ESKOM, Exxon, Ford, Gillette Company, Honda, Honeywell, Kodak, Lever Brothers, McDonnell Douglas, Mobil, Modicon, Monsanto, Motorola, Nabisco, NASA, National Instruments, National Semi-Conductor, Omron Electric, Pacific Power, Pirelli Cables, Proctor and Gamble, Robert Bosch Corp, Siemens, Smith Kline Beecham, Square D, Texaco, Varian, Warner Lambert, Woodside Offshore Petroleum, Zener Electric

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Introduction

1.1 The mission of maintenance

In earlier days, different organizations followed different types of maintenance programs. The prime concern was usually the downtime required to put the machine back into service, or the quality and cost of the maintenance, or else safety and environmental security.

Though the above maintenance methods are sound, they lack in one important aspect i.e., the elimination of periodic maintenance services. This is because the older methods stress only how and when to maintain the machine. However, they are not concerned with design changes, which, when implemented, could eliminate the need for further maintenance. Moreover, organizations need to understand that every physical asset is put into service as it is intended to fulfil a specific function. So, it is essential that the machine remain in a condition of satisfactory performance on a continuous basis throughout its expected life.

Hence, the mission of maintenance can be defined as "*to preserve the function of physical assets throughout their life period to the satisfaction of their owners through selecting and applying the most cost-effective techniques for managing failures and their consequences.*"

The new role of maintenance

The above mission statement gives us an insight to into the new role of maintenance. According to this new mission statement, we can conclude that synchronization is required in the functions of design and maintenance teams of the organization. The experience gained by the maintenance team should be continuously incorporated into the design. Regular maintenance activity should be integrated into operations as well.

How to manage the consequences of breakdowns?

When it comes to managing the consequences of breakdowns, we should go far beyond the traditional thinking that "failures are inevitable, and all failures and breakdowns are similar". We should realize that failures lead to consequential damage to other parts of the machine. Failures incur consequences in terms of repair costs. Failures also affect the safety and environment in which the machine was operating at

the time of failure, product quality, customer service and loss of protection, etc. Also, the types of failures that lead to fatal accidents with personnel are not tolerable. We should accept the fact that design flaws of machinery lead to machinery breakdowns and hence, care should be taken at the design level to ensure the machinery functions satisfactorily throughout its intended life period.

Where does PM and predictive maintenance fit into the new roles?

There is a notion that the preventive methodologies (PM) and predictive maintenance methodologies (PdM) involve high cost in terms of men and materials to maintain the machines. This is due to the cost of consequences of failure not being weighed against the cost of maintenance.

PM and PdM methodologies can be implemented in organizations to reduce the risk of fatal breakdowns and consequent damages. These methodologies are also helpful in case the cost of consequential damages is higher than the cost of maintenance.

The PM and PdM methods fit well in the new structure as they can be used in such situations where the organizations do not have time, resources or methodologies to find out the actual cause of the breakdown. Organizations can also use these methods along with other alternative maintenance methods when breakdown and consequential damages are severe.

1.2 Maintenance Philosophies

Organizations follow various maintenance practices and there has been a gradual improvement in these methodologies from time to time. These philosophies are:

1. **Breakdown or Run-to-Failure Maintenance**: This is the earliest type of maintenance where the machine is run until it fails due to a fault. This is an expensive method as it is very difficult to predict the condition of the machine at the time of failure.
2. **Preventive or Time-Based Maintenance**: The preventive maintenance or periodic maintenance method was introduced, with the expectation that machines would not break down in service if overhauled periodically.
3. **Predictive or Condition-Based Maintenance**: According to the predictive philosophy, the machine is repaired only when it is known to have a fault. Machines that are running without any problems are not maintained.
4. **Pro-active or Prevention Maintenance**: The pro-active maintenance philosophy is an innovative methodology, which is being followed by many organizations in recent times. According to this method, the main cause of the machine failure is studied and corrective measures are taken. This method is also known as “root cause failure analysis”.

The above maintenance philosophies are discussed in detail below.

Breakdown or Run-to-Failure Maintenance

Breakdown maintenance or run to failure maintenance is also known as "crisis maintenance" or "hysterical maintenance". Although cost of breakdown maintenance is high, this method has been in practice since a long period. The disadvantage of this approach is the organizations cannot properly plan the time and cost required to put the machine back into service.

The breakdown maintenance method can work in some cases where there are a number of machines available in the organization that are not very expensive to repair; and also when as one machine is being repaired, a similar machine can be put into service as a stopgap arrangement to continue production.

Preventive or Time-Based Maintenance

Preventive maintenance has been popular since the early 1980s when small computers started being used for planning and tracking maintenance. Preventive maintenance is also known as historical maintenance, where the history of the machine is studied and machines are overhauled according to the schedules prepared based on the previous failure analysis of the machines. This schedule is drawn on the basis of calendar time, operating hours of the machine, number of parts produced, etc.

This method is also not the right approach, as in most cases, maintenance schedules cannot be estimated properly. The schedules can indicate necessary maintenance earlier or even later than the actual failure occurs. If it is earlier than the actual failure, then the machines are overhauled unnecessarily, causing production delays. Also, the parts are sometimes replaced before the expiry of their life period, which adds up to the cost of maintenance. Sometimes, overhauled machine fails to function properly due to improper overhauling and also due to replacement of parts with defective parts. It was found that periodic maintenance causes 20% to 25% of start-up failures and 10% of these cases are due to wrong or defective parts fitted during overhauling.

However, preventive maintenance method can be used to maintain machines in which failure due to wear is predominant.

Predictive or Condition-Based Maintenance

Predictive maintenance method involves regular check-ups of the machine. In the case that any part of the machine is found to be functioning abnormally, it is scheduled for maintenance.

The benefits of predictive maintenance are:

1. It increases the reliability of the equipment
2. The overhauling scheduling can be done in a planned manner
3. The productivity of the machines increases by at least 2% to 10%
4. It reduces maintenance cost in terms of spare parts and labour
5. It reduces the need for a large inventory of spare parts, as the parts can be procured as per the planned schedule.
6. It provides increased safety to operators of the machines

However, the predictive maintenance philosophy is not so reliable, as the basis for prediction of failures can be incorrect due to mistaken assessment of the wear and tear of machines. Also, it takes skilled and properly trained professionals to monitor the machines accurately. A proper understanding is required between the maintenance and production teams and they should all work as a team.

Pro-active or Prevention Maintenance

Pro-active maintenance is based on root cause failure analysis. The root cause failure analysis is a study of possible reasons for different mechanisms to fail. Through this approach, the fundamental causes of failures can be corrected gradually over a period of time. Pro-active maintenance techniques involve design modifications of the machinery so that the failures are not repeated.

Pro-active maintenance can be implemented easily where predictive maintenance is already in practice. This is because the pro-active maintenance techniques are basically extensions of the predictive maintenance procedures.

1.3 The role of precision maintenance

In this book we will focus on the role that precision maintenance plays within the general maintenance function of a company. Precision maintenance involves planned maintenance tasks to improve overall plant efficiency and avoid costly breakdowns. It is important to remember that precision maintenance should not be the only focus of a maintenance team, but rather should be used in addition to other maintenance tasks to refine the operations of a plant. Precision maintenance also includes general tasks such as balancing, aligning, lubricating, cleaning, adjusting and replacing parts. The focus of this text is on the alignment and balancing of rotating machinery, with mention of other related precision maintenance tasks, such as vibration monitoring, oil analysis, thermography, performance monitoring and failure analysis. Many of these tasks can also be classified as predictive maintenance tasks. Generally, an overall maintenance program should consist of preventive, predictive and precision tasks. Managing a complete maintenance program should take all of these into account and should have adequate management and shop floor support to succeed. Furthermore, there should be effective communication between the different parties involved in the maintenance program. The most important requirement is that personnel be trained to perform precision maintenance. Vibration analysis plays a major role in precision maintenance and collecting and interpreting vibration data is not always a simple task. In fact, many vibration monitoring programs don't succeed due to a lack of knowledge in how to collect quality data. Other tasks, for instance oil analysis, are contracted to outside parties because it requires specialist instrumentation. Today, most reliability managers are aware of the fact that planned maintenance can save a lot of money and also improve the morale of the floor personnel. In a global economy where companies strive to offer world-class services, precision maintenance is a definite requirement.

We can conclude that organizations need to have a mix of all of the above maintenance philosophies in a balanced and appropriate manner to suit their requirements.