TT CLUB

The Importance of Maintenance
– a handbook for non-engineers

transport insurance plus

TT CLUB
IS MANAGED
BY **THOMAS MILLER**

The Importance of Maintenance – a handbook for non-engineers

First Edition January 2012

ISBN 978-0-9562704-2-9 (Printed)
ISBN 978-0-9562704-3-6 (PDF)

Designed & Printed in England by Evolution Digital Limited.

About the TT Club, ICHCA International and PEMA

TT CLUB

The TT Club is the international transport and logistics industry's leading provider of insurance and related risk management services. Established in 1968, the Club's membership comprises ship operators, ports and terminals, road, rail and airfreight operators, logistics companies and container lessors.

As a mutual insurer the Club exists to provide its policyholders with benefits which include specialist underwriting expertise and a worldwide office network providing claims management services and first class risk management and loss prevention advice. This publication is one of a number that seek to disseminate good practice throughout the industry.

For more information about TT Club and its services please visit:
www.ttclub.com

ICHCA International Ltd

ICHCA International is the only global association dedicated to the promotion of safety and efficiency in the handling and movement of goods by all modes and throughout the supply chain.

Originally established in 1952 and incorporated in 2002, the Association operates through a series of Local, National and Regional Chapters, Panels, Working Groups and Correspondence Groups and represents the cargo handling world at various international organisations, including the International Maritime Organization (IMO), United Nations Conference on Trade and Development (UNCTAD), International Labour Organization (ILO) and ISO, the International Organization for Standardization.

ICHCA International members include ports, terminals, transport companies and other groups associated with cargo handling and coordination. Members of its Panels represent a substantial cross-section of senior experts and professionals from all sectors of the cargo transport industry globally.
Members benefit from consulting services and informative publications dealing with technical matters, best practice advice and cargo handling news.

This document is assigned the number GS#8 in the ICHCA International General Series of publications.

For more information about ICHCA and its services please visit:
www.ichca.com

The Port Equipment Manufacturers Association (PEMA) was established in late 2004 to provide a forum and public voice for the global port equipment and technology sectors, reflecting their critical role in enabling safe, secure, sustainable and productive ports, and thereby supporting world maritime trade.
Chief among the aims of the Association is to foster good relations within the world port equipment and technology community, by providing a forum for the exchange of views on trends in design, manufacture and operation of port equipment and technology.

PEMA also promotes and supports the global role of port equipment and technology by raising awareness with customers, the media and other stakeholders; forging relations with other port industry associations and bodies; and contributing to best practice initiatives and information.

PEMA's growing membership represents a cross-section of port equipment OEMs, component suppliers, providers of software, systems and other advanced technologies, and expert consultants in the fields of port equipment and technology.

For more information about PEMA and its services please visit:
www.pema.org

Preface & Acknowledgements

This handbook aims to provide a general understanding of maintenance and its importance. Risk assessment engineers and non-engineering management will gain a better insight and appreciation of the need for maintenance. Although this handbook was initially drafted for container terminals, the principles shared relate to any operation with fixed or mobile assets.

The information has been collected over many years from many people with experience in engineering, maintenance and the operation of ports and terminals, as well as the TT Club's insurance and loss prevention experience. We are grateful for all these contributions. Similar advice can be found in many publications but the aim of this handbook is to simplify and condense the advice into a brief practical guide. The following have provided specific advice and support during its preparation.

ICHCA International Safety Panel (ISP)

Port Equipment Manufacturers Association (PEMA)

John Arnup – Head of Engineering, DP World

John Gibbons – Specialist Crane Services


NYK LINE
OOCL

Contents

	Page
Preface & Acknowledgements	**3**
Foreword	**9**
Introduction	**11**
Insurance claims resulting from maintenance issues	**13**
Crane Structural Failures	13
Quay Crane Gantry Brakes	15
Mobile Equipment Fires	17
Asset Life Cycle Management	**19**
Procurement	**21**
Ensure a collaborative approach	21
Considerations in the procurement process	22
Operations and Maintenance – balancing requirements	**25**
Asset Maintenance	**27**
Maintenance Policy	27
Maintenance Strategies	28
The role of the Maintenance Department	30
Projects and Technical Assistance	31
Equipment Failures and Damage	31
Maintenance Tasks	32
Civil Infrastructure Maintenance	32
Quay Deck Structure and Fittings	33
Pavements	33
General Civil Maintenance	34
Environment Tasks	34
Spill Response	34
Waste Management	35
Minimising Electricity Costs	36
Minimising Fuel Costs	36
Energy-saving Ideas	37

Computerised Maintenance Management Systems (CMMS) **39**
Overview 39
Asset Database 39
Forecast Jobs and Schedules 39
System Created or Forecast Jobs 41
Manually Created Jobs 41
Work Orders 41
Job Requests 42
Asset and Job History 42

Asset Management Organisation and Structures **43**
Manning Levels 43
Roles and Responsibilities 43
Technicians 43
Non-Technical Assistants 43
Procurement and Inventory Management 43
Planning and Maintenance Data Management 43
Supervision 44
Maintenance Management 44
Engineering Support 45
Quality Control 45
Training 45
Multi-Skilling or Cross-Skilling 45
Competence: Recruitment & training 46
Level of Supervision 46
Teamwork Philosophy 47
Team Principles 47
Team Ground Rules 48
Team Decision-making 48
Composition of Teams 50
Plant Ownership 50

Maintenance Key Performance Indicators (KPIs) **53**
Maintenance Performance Drivers 54
Engineering Executive Summary KPIs 55
Trend Graphs 58

Retirement of Assets **61**
Capability Obsolescence 61
High Operational Costs 61
High Maintenance Costs 61
Risk of Total Failure 61

APPENDIX 1 **63**
Maintenance Tasks and Out-sourcing Recommendations 63

APPENDIX 2 **69**
Minimum Standard Safety Specifications for Quay Container Cranes 69

Foreword

Most businesses have assets and efficient, effective control of those assets has a significant impact upon the bottom line. This handbook seeks to help your business to assert or improve its control over its assets in straightforward and cost-effective ways and, thereby, improve your business operations and make significant cost savings. The content has been derived from the TT Club's claims experience and, therefore, carries considerable weight.

The handbook concentrates upon two stages of the asset lifecycle – maintenance and monitoring – but gives a concise picture of the entire lifecycle. It was specifically written with non-engineers in mind and, therefore, not intended to be very technical. Rather, the aim was to emphasise certain key processes that will, ultimately, protect your bottom line and improve profitability. Thus, having dealt with effective maintenance, the handbook moves on to consider effective monitoring by the use of key performance indicators (KPIs) and their employment as benchmarks to monitor asset status, availability and fitness for purpose. In useful appendices, the handbook closes with recommendations about how specific maintenance tasks might be carried out and the recommended minimum standards for quay crane specifications, produced jointly with ICHCA International and PEMA.

Apart from specific practical advice, the text considers 'softer' issues, such as the importance of interdepartmental relationships and budgetary constraints, in the procurement process.

Maintenance is the bedrock of efficient and effective asset management. This handbook emphasises the importance of maintenance from the strategy/policy level through to the detail of the maintenance plan, its tasks and sub-tasks, task allocation and maintenance job history as well as more subtle ideas like 'teamwork philosophy' and 'plant ownership'.

The result is a concise and information-packed handbook that is commended to you as an invaluable asset in itself.

James Callahan,
Board Member , TT Club
Chairman, President & CEO,
Nautilus International Holding Corporation, Los Angeles


COSCO
tex
02
11
Nedlloyd

Introduction

Asset management is of great importance to any business and maintenance – the maintaining and monitoring of assets – is an integral and important part of asset management. This handbook addresses issues relating to the maintenance of infrastructure and equipment within a port facility.

The purpose of maintenance is to maximise an asset's useful lifetime and minimise its cost. Decisions are made regularly about how to sustain assets – from servicing intervals and frequency to a responsibility hierarchy. While software tools can aid in the administration of a planned, efficient, cost-based maintenance schedule, the fundamental issue is one of management attitude. If an asset is maintained more often than necessary, valuable time and resources are wasted. Maintenance performed too infrequently will also lead to a loss, resulting in unplanned down-time. Additionally, the cost of unexpected failure and repair can be up to six times that of planned, preventive maintenance. Costs saved by delaying routine servicing are short-term savings that may, eventually, incur financial loss.

Maintenance should only be carried out within the strictures of a documented plan, when all the required resources are readily available and at a time that will cause least disruption to customers. It may be performed by in-house employees or out-sourced to contractors. This decision is made based upon the degree of expertise and equipment which is required as well as the funds and time available.

It is important that there is a well-organised asset management structure. Front-line supervision, engineering/maintenance management, engineering support, training, participative teamwork, and planning and maintenance data management are all key aspects.

Key Performance Indicators (KPIs) which monitor how a site's assets are being maintained include the safety of personnel and the environment, the performance of equipment and the cost of engineering. Retirement, the final phase of an asset's life cycle, can be the result of a need for newer models, changes to operational requirements, high maintenance costs or the risk of total failure.

This handbook gives readers a general understanding of asset management and gives some insight about how to handle it efficiently and economically while, at the same time, maintaining customer service levels.

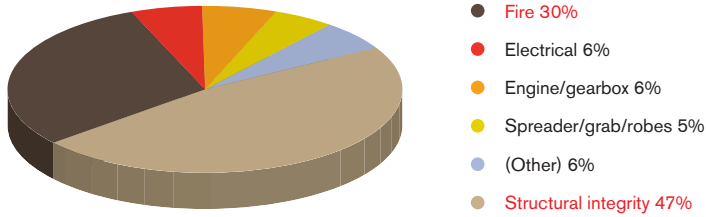

43
PNC
SWL
50LT FOR SINGLE CONTAINER
65LT FOR TWIN TWENTY
75LT FOR CARGO BEAM
ZPMC
42
PNC
SWL
41

Insurance claims resulting from maintenance issues

A key driver in the development of this handbook was the identification of maintenance issues resulting in costly insurance claims. Analysis of TT Club insurance claims has shown that, in the port and terminal industry, maintenance issues, resulting from the application of inadequate or incorrect procedures, cause about 25% of the cost of equipment damage. Weather issues cause a further 30% and various operational issues give rise to the remaining 45%.

Structural failures of equipment and fires alone cause 77% of the cost of claims arising directly from maintenance issues (see Chart 1 below). Furthermore, about 50% of quay crane claims arising from weather issues are the result of cranes being blown along their rails due to poor maintenance of gantry motors and brakes.

Chart 1: Cost of claims caused by maintenance issues



Crane Structural Failures

The TT Club's analysis reveals a disturbing number of major structural failures in port equipment in recent years. For the five years from 2006 to 2010, 47% of the cost of claims arising from maintenance issues reveal concerns with the structural integrity of cranes. Not only can this type of equipment failure be very costly, in terms of repairs and operational down-time, but it can also result in serious accidents and personal injuries.

It is essential that operators of ports and cargo handling facilities establish and follow a schedule of regular maintenance and thorough examination of all the lifting appliances it uses. Provisions for such examinations are specified in the International Labour Organisation (ILO) Convention 152 and its accompanying Code of Practice, and, together, represent the international standard for the port industry. The purpose of a thorough examination is to make sure that a crane can continue working safely, and effectively, and a crucial element of this, with regard to a quay crane, is the safety of its structure.

It is recommended that an independent examination is always performed when procuring any type of crane. The ILO Convention requires that, before being brought into commission for the first time, lifting appliances be tested and a thorough examination be carried out. It is also recommended that appropriate mechanical and electrical inspections are carried out, during construction and commissioning, to check for quality and for conformance to standards and specification – beyond any ILO Convention requirement. Once commissioned, a crane should be examined regularly during its operational, life regardless of how good its manufacturing pedigree. Damage resulting from relatively minor impacts, regular heavy-lifts close to or equal to the safe working load limits, intensive use or simply general wear and tear can affect the integrity of the crane's structure. Often, such operational issues can arise without anybody being aware of them so regular examinations need to be conducted. Any known incident should prompt an immediate examination of the crane's structural integrity. This advice applies equally to fixed and mobile cranes of any type.

The ILO standard calls for a competent person to carry out the testing and thorough examination. 'Competent person' is defined as 'a person possessing the knowledge and experience required for the performance of a specific duty or duties and acceptable, as such, to the competent authority'. It is recommended and common practice to use a specialist inspection company to check for quality and design conformance during manufacture and there are many companies that can provide such expertise. Thorough and regular examination during the lifespan of the crane should fall within a strict maintenance policy that aims to maximise its useful life and minimise unplanned down-time.

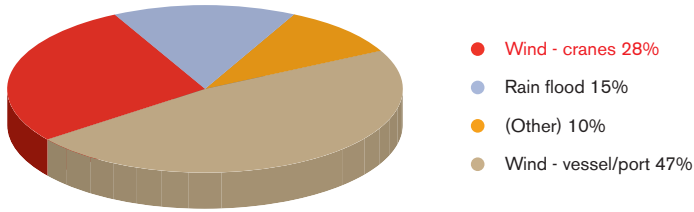
The ILO standard also defines a thorough examination as 'a detailed visual examination by a competent person, supplemented, if necessary, by other suitable means or measures, in order to arrive at a reliable conclusion as to the safety of the appliance examined' and an integral element of the examination should be the crane structure. The TT Club's research indicates that the actual structure, because of its size and complexity, may not always be examined as often as it should. The standard calls for such examinations to be conducted at least once every twelve months. Generally, as a crane gets older the examination frequency should increase. However, some countries have less stringent regulatory requirements or none at all. All regulatory requirements must be adhered to, but for those with no regulatory requirements a minimum examination period should be implemented based upon international standards. Furthermore, the regularity of examinations should increase based upon the degree of use and if operations are at or close to the crane's safe working load limits. Regular mechanical, electrical and painting maintenance should also be implemented to ensure safe and reliable operation.

Regular crane examinations will, in the long term, reduce down-time and cost. It makes economic sense but, more importantly, it may save lives.

Quay Crane Gantry Brakes

Analysis of the TT Club's claims has highlighted that wind damage to quayside cranes is the second biggest weather-related cost to terminals (see Chart 2 below). Commonly, this damage is caused by quayside cranes being blown over or along the crane rails. Due to their size, profile and location at the quayside, these cranes are particularly susceptible to wind and care must be taken, in their design and operating procedures, to protect against the crane being blown over or along the rails.

Chart 2: Cost of claims caused by weather issues



There are two major windstorm issues to be considered: protection against forecast strong winds and protection against sudden local winds, called micro-bursts.

In the case of forecast strong winds, storm pins and tie-downs of sufficient number and size to hold a crane structure stationary (and procedures to implement these) are required to protect quayside cranes.

The other situation of primary danger is the occurrence of micro-bursts. In the worst circumstance, unknown to the driver, a strong wind arises, blowing in the same direction in which the crane is travelling and the driver is unable to stop. To deal with these situations, suitable storm brakes or park brakes and service brakes are necessary and should be fitted to the crane. These are not however, an acceptable alternative to pins or tie-downs for forecast weather conditions.

Investigations of incidents involving sudden windstorms have shown that most were due to, or made worse by, many of the service brakes and park brakes being inoperative due to poor maintenance. Generally, a quay crane is designed to be able to stop with a maximum 35m/s wind blowing from behind and also drive against a 35m/s wind. For this reason, when wind conditions are light the cranes would still be able operate (gantry travel and stop) with only 50% of the motors and brakes functioning. Unfortunately, because of this, terminals may continue to operate cranes even though not all motors and/or brakes are working properly. While there is no wind there is no problem but a sudden windstorm could lead to tragedy.

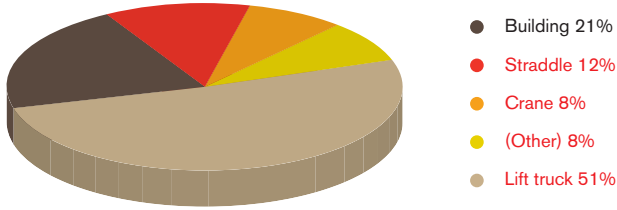
It is, therefore, imperative that all motors and brakes be maintained and be fully operational at all times.

Detailed information on weather issues can be found in a handbook available from the TT Club entitled "WindStorm II: Practical risk management guidance for marine & inland terminals".

Mobile Equipment Fires

All operators of mobile equipment to be should be aware of the risk of fires which, predominantly, are due to maintenance issues. In the TT Club's claims statistics, fires cause 30% of the cost of asset damage and nearly 80% of those fires are in mobile equipment (see Chart 3 below). Incidents of this type can also result in serious injury to workers and can be very costly in terms of repair and operational down-time.

Chart 3: Cost of claims caused by fires



The cause of such fires is often hydraulic oil coming into contact with hot machine components, having escaped through burst hoses or leaky connections. All mobile equipment using hydraulics is at risk, including reachstackers, lift trucks, fork lifts, straddle carriers, rubber-tyred gantry cranes, mobile cranes, tractor units and trucks.

The risk of fire can be reduced significantly when the manufacturer's maintenance instructions are followed – regular inspections, cleaning and maintenance of the engine space, and replacement of hydraulic hoses and connections. Only approved, high quality, hydraulic hoses and connections, complying with recognised international standards, should be used.

Given the frequency with which these fires occur, all mobile equipment operators should ensure appropriate maintenance procedures are in place and that machines should be inspected – and potentially modified – to segregate as far as possible all hydraulic hoses and connections and enclosed with a protective material to stop any hydraulic leaks spraying onto the electrical systems or hot components.

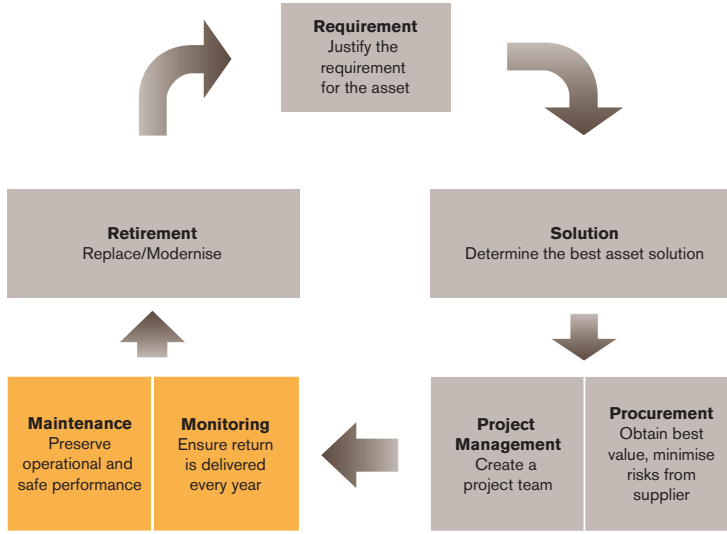
Fire suppression systems have not been commonly installed in equipment of this nature, although fire damage often leads to the unit being written-off. This is because, until now, the cost of a suppression system in, for example, a heavy lift truck could be prohibitive and uneconomic. However, the TT Club has, together with ICHCA International and a number of equipment operators, been evaluating recent technology developments which could enable fire suppression to be installed at a cost in the region of USD 500, depending upon the precise requirements. The unit, called Fire Foe™, uses patented technology that combines a special extinguishing gel (Envirogel®) inside heat-sensitive nylon tubes. There is no need for external sensor systems or a power supply. In addition, the design makes fitting or retro-fitting easy, minimising down time. The complete unit has been accredited by US Underwriters Laboratory and the US Coastguard. In addition, Envirogel® is also SNAP approved by the US Environment Protection Agency, who declared it an acceptable Halon substitute in streaming and flooding applications and safe for use in occupied spaces. Details of this new system can be found at www.quick-fire.com or email: sales@quick-fire.com. The TT Club believes that this type of development has significant potential to reduce the risk of injury and minimise handling equipment damage and consequential disruptions to operations.

It makes economic sense and the TT Club strongly recommends installation of an accredited fire suppressant system in mobile equipment engine compartments and in any confined space.

Asset Life Cycle Management

Assets are important to many business operations and in the context of this handbook include both infrastructure, such as jetties, wharves, warehouses and offices, as well as equipment including cranes and forklift trucks, mobile communication devices etc. The diagram below shows the different stages of an asset's life cycle.

Stages of an Asset's Life Cycle



Requirement

Efficient and profitable terminal operation depends upon its assets. Unsuitable equipment can lead to poor customer service.

Solution

Once the need has been established, it is possible to identify the best technical solution. A thorough and comprehensive analysis will point to the best solution – upgrade or replace – and may indicate other areas of inefficiency.

Project Management

An experienced project manager or project team is essential for successful acquisition. Terminals acquiring new assets have an opportunity to transform other aspects of their operation. Managers should also take the opportunity of acquisition to improve overall terminal performance.

Procurement

A rigorous procurement process and policy can deliver value and reduce risk. Procurement can include the purchase of large equipment as well as maintenance consumables.

Maintenance

After planned purchase and installation within a project, an asset's life cycle enters its longest and most important phase – operation – when it should deliver value and financial return as expected. The primary focus of this handbook – maintenance – will help ensure that an asset delivers optimal performance, at minimal cost, during its life.

Monitoring

A business must constantly try to improve its performance. Effective management means monitoring and measurement of actions and results. This increases control and enables continuous improvement. The monitoring process must continue throughout an asset's life and is an integral part of maintenance. After proper commissioning, newer assets require less maintenance and will breakdown less frequently than older assets. It is critical that maintenance effort is well-balanced across all assets. Prioritising preventive maintenance over breakdown maintenance maximises asset performance.

Retirement

Managing the asset's retirement is the final phase of its life cycle. Reasons for asset retirement include capability obsolescence as well as increasing maintenance costs.

This handbook focuses upon the stages of an asset's life cycle highlighted in the flowchart above – maintenance and monitoring. Monitoring is a very important part of maintenance – what you do not monitor and measure, you cannot manage. Other stages of the asset life cycle will be touched upon but not expanded. However, there is a brief section on procurement, as the quality and specification of the asset procured will greatly affect the life of the asset and the maintenance requirements.

Procurement

Ensure a collaborative approach

Generally, procurement of a product or a service is divided into three processes;

1. The specification, negotiation and tendering process
2. The transaction process through contract, purchase order and payment
3. The implementation process including construction/manufacture and commissioning

Item 2 is the primary role of the procurement and/or purchasing department and items 1 and 3 are generally the role of the engineering department. However all departments including operations, finance and engineering must be involved in all three processes to achieve best procurement practice.

If the operations department is not involved, for example, then a new quay crane may be purchased that has insufficient outreach to service the larger ships that are being scheduled in the future and, if the engineering/maintenance department is not involved then cheap, imitation spare parts may be purchased which, although less expensive may be less long-lasting and more prone to failure.

Case Study –

Hydraulic leakage is a root cause of about 90% of all equipment fires. Most of these fires are in/on lift trucks. Besides insufficient maintenance, a common factor is the use of inferior quality hydraulic hoses and connections sourced by a procurement department that thinks it is saving money. Unfortunately, inferior quality hoses and connections are often prone to failure, spraying hydraulic fluid throughout an engine compartment with a consequent fire risk.

In such situations, the saving of a small sum might cause a catastrophic loss – a false economy!

Considerations in the procurement process

As an example, we have based our considerations on a quay crane which is generally the largest single-cost item of equipment that a terminal will purchase. Businesses with multiple terminals, that regularly procure quay cranes, usually have experienced staff, detailed specifications, know their requirement and know how to manage a successful procurement process. Terminals that only purchase cranes infrequently may not have such experience to guide them and will find it beneficial to make use of consultants during the procurement process.

There are five basic crane geometry parameters:

- Outreach
- Span of wharf rails
- Back reach
- Lift height (above and below the wharf)
- Lift capacity

These parameters will be functions of the specification of the largest ship expected to dock under the crane and/or the characteristics of the wharf rail track in relation to high and low tides.

The operations and engineering departments must develop a technical specification highlighting all of the required parameters and minimum safety features.

There are many features available for quay cranes which, if selected, can dramatically improve crane safety but, often, they are not specified in new cranes. The TT Club, for example, has recommended installation of boom anti-collision electronic sensors. These have a proven safety record in preventing significant damage cost and business disruption, as well as enhancing crane driver, stevedore and ships' crew safety. Manufacturers often only provide a trip-wire system which is generally cheaper but less effective than electronic sensors.

Case Study –

The boom of a quay crane, at a terminal in Europe, collided with a ship's crane. The result was more than USD 2,000,000 damage to the cranes. The quay crane boom was bent and was out of service for six months.

This incident could have been prevented by the installation of a boom anti-collision sensor at a cost of about USD 13,000

Crane procurement is, inevitably, cost sensitive, requiring a significant budget, and potential buyers will not always be familiar with the most effective safety technologies. The procurement process is often complicated and any quote needs to be assessed carefully against an invitation to tender as any subsequent change requests can be costly. For these reasons, technical specifications should provide a standard safe baseline.

The TT Club together with the Port Equipment Manufacturers Association (PEMA) and the International Cargo Handling Coordination Association (ICHCA) have developed a minimum baseline safety specification for quay container cranes. This is detailed in full in Appendix 2. Features which have been proven to reduce injury and damage should be standardised. Crane manufacturers that include minimum safety features as standard in their initial quotations will be entitled to state in their tender quotation: "This tender quotation includes all the minimum standard safety features recommended by the TT Club, ICHCA International and PEMA".

A commercial specification is also required to be included with a technical specification. Both specifications make up the tender documents which are sent to the selected manufacturers. Assessing tenders is the final step before placing an order and signing a contract. All these steps should be managed by experienced staff or consultants.

Even if the tender and contract documents are adequate, close management of the manufacturing, delivery and commissioning is vital. Some manufacturers require closer monitoring than others. Quality control and compliance with specifications must be monitored throughout the entire process. We recommend the use of third party specialists for this work.

Operations and Maintenance – balancing requirements

Usually, the engineering department is responsible for asset life cycle management. The maintenance function is normally part of the engineering department and, in many terminals, they are the fully integrated and may be called either the engineering or the maintenance department. Apart from identifying the need for new equipment, the operations department seldom has any significant involvement in asset life cycle management except when liaising to ensure equipment readiness. However, this is a misguided strategy as they do have an integral part to play and must understand and be involved in every stage of an asset's life cycle.

Daily operations can have a significant impact upon asset maintenance strategy. Some examples:

- High levels of asset usage may lead to low levels of maintenance and lead to a greater frequency of consequential breakdowns
- Low levels of asset usage may mean higher, perhaps excessive, levels of maintenance implying a waste of resources
- Low revenue or throughput may create pressure to reduce planned maintenance for a short-term cost reduction but that may increase costs in the longer term

There is often a cultural difference between the operations and maintenance departments. Operations people sometimes see maintenance as more of a hindrance than a help but maintenance is like refuelling a car: if you don't do it then it will stop working!

Senior management must address two common issues that often disrupt efficient operations – task scheduling, or the allocation of assets to tasks, and budgetary constraints.

Task Scheduling

Operations and maintenance functions compete for access to assets. However satisfying short-term operational needs may lead to major asset down-time because of failure – postpone maintenance at your peril! Operations and maintenance personnel must understand the need for a balanced and non-competitive approach to equipment access.

Case Study –

A quay crane in Asia suddenly collapsed due to rope failure. The boom ropes had been checked several weeks earlier and found to have broken strands. Due to operational pressure the rope change was deferred. If the rope had been replaced earlier, the operator would have saved a lot of money and down-time.

Budgetary Constraints

A quick and easy way to cut costs is to defer or reduce the maintenance budget. If it must be done then make it a short-term solution! As an extended solution, it affects reliability and any costs incurred to regain reliability may substantially exceed any costs saved. Impacts upon future reliability may adversely affect service delivery with consequent loss of business. It is prudent to enforce a realistic maintenance budget and schedule.

Case Study –

Having lost business and revenue, the maintenance department at a terminal in Australasia was told to cut its budget by 20%. This, initially, helped finances, but, instead of being a temporary measure, the cost reduction was continued for over six months.

Due to planned maintenance jobs being deferred and repetitive tasks and inspection frequencies being extended, the number of equipment breakdowns increased dramatically. This severely reduced ship loading rates and more business was lost. Due to pressure from the operations department, access to equipment for repair and maintenance was further reduced due to the reduced operational availability of equipment resulting from the increased breakdowns.

In the end, the only way to bring the equipment back to acceptable availability levels was to engage numerous contractors and additional staff for nearly a year to address the maintenance backlog. The actual maintenance budget for that year was 200% above the norm.

With the added impact of lost business, the total cost to the terminal was enormous. This could all have been avoided if senior management had a better understanding of the need and importance of maintenance.

Asset Maintenance

Maintenance Policy

Every maintenance department should have a maintenance policy to maximise uptime and minimise cost. The following provides some guidance about developing such a policy.

Objectives

The principal objectives of an overall maintenance policy are to:

- Ensure a safe working environment for all terminal operations
- Protect the company's investment in infrastructure and equipment by introducing a framework for regular maintenance and routine inspections thus maximising useful life
- Provide a structured plan for cost-effective maintenance expenditure

There are two important objectives of an equipment maintenance policy:

- The short-term objective is to satisfy the day-to-day operational requirements by having the equipment available as required
- The long-term objective is to maximise the return on investment by performing ongoing maintenance to minimise whole-life cost – minimum overall cost is not necessarily achieved by maximising lifespan

Inspections

Routine inspections of all equipment and infrastructure should be planned and carried out at regular intervals in order to check the general condition of all components and should include general wear and tear, component failure and incidental damage.

The interval between inspections, and the level of detail required, should be determined using component wear and tear predictions. Components should be prioritised based upon their operational and safety importance.

There may also be regulatory requirements for periodic and non-destructive testing and inspections. These may sometimes represent a minimum, acceptable safety standard and, therefore, need to be reviewed and enhanced if necessary.

Auditing and quality assurance guidelines and regulations often require that suitably qualified personnel sign off each inspection.

Routine Maintenance

Regular maintenance, in line with the manufacturer's recommendations and operational best practice should be carried out upon all equipment and infrastructure in accordance with maintenance procedures. These procedures should range from regular scheduled maintenance to major overhauls. The interval between maintenance procedures should also be a function of operational and safety considerations.

A framework for inspections and routine maintenance should be prepared by the site maintenance department based upon manufacturers' recommendations. A Computerised Maintenance Management System (CMMS) would usually be used for the management and control of such maintenance activities. This is covered in more detail in a following chapter.

Maintenance Strategies

A maintenance strategy may be seen as the mission statement of the department and organisation. It must be supportive of, and be supported by, the business plan, must identify the needs and wants of customers, shareholders and other stakeholders and should identify the best maintenance tactics for the application and equipment. Such a strategy should:

- Maximise productivity
- Phase out ineffective and inefficient equipment
- Optimise expenditure against equipment availability and reliability

Maintenance tactics are the specific actions taken to minimise the consequences of unexpected equipment failure. There is a particular operational difficulty when deciding the appropriate maintenance tactic. How does one decide the most appropriate action taking into account cost, plant down-time and risk? There is a balance between insufficient maintenance, having to tolerate unexpected down-time, or doing too much, bearing unnecessary cost.

Examples of maintenance tactics:

- Breakdown or run to failure – maintenance is performed when the equipment fails
- Redundancy – have excess capacity to ensure a business process is fail-safe - if the primary unit fails a secondary unit is available
- Routine or preventive maintenance – based, typically, upon system measurements and expected load factors such as cycles, kilometres, throughput or run hours and carried out during inspections, cleaning, lubrication, minor adjustments and failure prevention activity
- Condition monitoring or predictive maintenance – plant maintenance is based upon its measured condition. Measurement methods can include specialised procedures such as oil sample analysis, vibration monitoring and thermography (infrared heat sensing) or simple measures such as sensory inspections where staff can listen for, feel, smell or see changes using real-time monitoring
- Corrective maintenance or scheduled repairs as a result of inspections – generally not critical to operations and, therefore, manageable in a planned way
- Redesign – designing out or significantly reducing maintenance is usually done for critical equipment where it is difficult to measure its condition or predict its imminent failure and for continuous improvements

The task of maintenance is to minimise an asset's life cycle cost, maintain its fitness for purpose and provide availability and reliability so that operational requirements are fulfilled. Reactive or breakdown maintenance will, generally, increase down-time and result in higher overall cost.

Implementation of a preventive maintenance schedule always reduces the number of unexpected failures. A preventive approach means more equipment down-time for inspecting, servicing, repairing and testing which leads to less equipment availability for operations which may become difficult to manage and may also have a detrimental operational impact. There is a balance to be had between the cost of breakdown maintenance and the cost of preventive maintenance. It will be necessary to monitor both to ensure they are applied appropriately (in relation to the equipment type and local conditions) and to measure the effectiveness of the proactive approach in reducing the number of unexpected failures. Assets that fail and do not immediately affect operations can often be maintained using

breakdown maintenance. However for most assets, preventive maintenance is the more prudent strategy – it can reduce costs and save lives!

It is important not to lose sight of the fundamentals of maintenance practice. No matter how sophisticated the condition monitoring or the scheduled maintenance strategy, it is the responsibility of management to ensure that basic procedures are followed. It is dangerous to assume. Always verify that work has been completed as reported and that inspections generate the appropriate action.

The role of the Maintenance Department

The site maintenance department is usually responsible for:

- Carrying out planned maintenance, repairs, minor installation and replacement of terminal equipment and other supporting equipment
- Administering and supervising the workforce
- Carrying out minor projects within the scope of the group
- Administering various other service facilities delegated to the group (eg. purchasing, stores, disposal, recycling, environmental protection etc.) and external contractors (eg. fire and air-conditioning systems) will vary between sites
- Providing technical feedback to operations staff about operational problems
- Establishing and maintaining adequate asset registers and accounting records covering plant equipment and property

The maintenance team is crucial to the implementation of a maintenance policy. Experience tells us that the most successful strategy is to employ local staff to undertake the core routine and out-of-service maintenance tasks. Efficiency is increased if a multi-skilled and cross-trained work force is available. Such a work force is enhanced by an ongoing training program to keep abreast of the latest advances in their fields of expertise. Task-specific training to be provided includes trouble-shooting in the fields of hydraulics, diesel engines, Programmable Logic Controller's (PLCs) and drive (motor) control systems.

Specialised maintenance requirements, such as major equipment overhauls for engines and transmissions, are often best out-sourced, through the local

representative of the original equipment manufacturer. Out-sourcing recommendations are listed in Appendix 1.

A maintenance team usually includes engineers, supervisors, planners, purchasing officers, stores personnel, mechanical and electrical technical personnel and unskilled workers for labouring assistance.

Projects and Technical Assistance

Most sites have a project management team as part of the engineering department that provide additional technical assistance to the maintenance group. If a site does not have such a group then it might often out-source or get support from a corporate team.

This group is usually responsible, where required, for:

- Assistance with day-to-day technical issues
- Preparation of specifications and technical requirements
- Cost-benefit analysis of proposed capital expenditure, to ensure the intended purchases are fit for purpose and represent appropriate levels of workmanship and technology for the site
- Project management of new equipment and infrastructure
- Carrying out site reviews to assess current asset management systems and practices, to identify best practice strategies that may be used elsewhere and to assess potential areas for improvement

Equipment Failures and Damage

Damage to plant and equipment can be a considerable cost to any terminal operation even if that cost is covered by insurance. Not only does damage have a specific cost associated with the loss of function but there may be significant additional costs and non-monetary losses which may not be realised eg. a piece of plant may not be available or may need funds from a previously allocated budget in order to execute repairs. During repairs the plant is adding no value to the business and forces a redeployment of resources, equipment and labour away from other, scheduled, tasks. Thus, the cost of an unexpected failure and repair may well be many times the cost of planned, preventive maintenance.

Some equipment failures and/or damage are covered by insurance. Whether the insurance policy covers equipment failure or not the maintenance strategy should be to reduce the frequency of equipment breakdown.

Even generous insurance cover cannot fully compensate for the total repair cost, lost management time and frustration, and customers' negative perceptions. You may also have to contend with injuries or workforce concerns.

Maintenance Tasks

There are many different maintenance activities and they require a variety of different skills and expertise. Multi-skilling, which is discussed in detail in a later section, has helped increase productivity but cannot provide all the skills, expertise and flexibility necessary for an efficient cost-effective maintenance operation.

Depending upon the availability of local contractor resources and labour/union work practices and relations, the type and level of maintenance task which might be performed by in-house staff or out-sourced to contractors will vary. Operations in very remote locations might need to have differently skilled employees based at the location. Operations near major cities have a greater scope for out-sourcing.

Out-sourcing all maintenance skills will usually be a more expensive option then using in-house skills. Usually, out-sourcing is only beneficial where inefficient labour/union work practices are difficult to change. Out-sourcing is the quickest way to change working practices. Today, with the variety and complexity of technology in use in all aspects of an operation, out-sourcing is often a necessity. But which maintenance tasks should be out-sourced? Appendix 1 lists the main maintenance tasks carried out at a container terminal and provides guidelines for whether those tasks are best performed in-house, out-sourced or either.

Civil Infrastructure Maintenance

Often, civil infrastructure maintenance is neglected since the day-to-day focus is always on operational equipment. The severe environmental conditions present at many marine facilities and intensive operational use by large items of equipment means that there is a potential for significant,

ongoing, maintenance of the civil infrastructure. However, a facility that is well designed and constructed and that incorporates good quality materials will require only minimal maintenance during its life. Maintenance of this nature can be scheduled to fit in with the other operational requirements of the terminal. Excessive maintenance can have a significant effect upon the operation of a terminal and can lead to consequential losses. The two main areas where critical maintenance is required are the quay deck and the pavements.

Quay Deck Structure and Fittings

Quay decks are exposed to the degrading effects of waves, tides and currents which can affect the integrity of the construction materials (metal corrosion, concrete degradation). They are also exposed to vessel impacts which can lead to structural damage. Although accidental impact is beyond our control, good design and construction and the use of appropriate materials might reduce the need for excessive maintenance. Steel pilings should be checked regularly for corrosion and should have cathodic protection systems installed and monitored. Even concrete piles and structures should be checked regularly for corrosion.

Pavements

Pavements, typically, have a shorter lifespan than a quay structure. This is usually because a cheaper construction is a more economical solution than a pavement with a fifty year lifespan. It also has the added advantage that the pavement design can be altered to suit changing operational requirements during the lifespan of the terminal.

Maintenance of the pavement may be needed due to rutting or surface breakdown in the main thoroughfares or differential settlement of the pavement in discreet areas or degradation of the surface at locations of container corner castings. Choosing an appropriate design and construction method can reduce future maintenance requirements and costs.

Case Study –

A terminal in Asia failed to repair cracks in its asphalt pavement. After heavy rain, damage to the pavement was so severe that repair costs were twenty times that which would have been required to repair the initial cracks.

General Civil Maintenance

A regular maintenance inspection of civil assets should be adopted at each terminal. Such inspections will identify any defects and enable appropriate repairs to be carried out in a controlled way. If defects are ignored then repair costs can rise exponentially.

Environment Tasks

The following tasks must be managed effectively and are usually the responsibility of the onsite engineering or maintenance team:

Spill Response

A major environmental issue confronting terminals is the possibility of a liquid, gas or even solid cargo escaping because of damage caused during ship-board stevedoring operations, when the cargo was loaded at a previous port or at the terminal. Regardless of when and how damage to cargo occurs, the terminal is often confronted with the need to take immediate action to contain the spill. Every terminal needs to have a spill response plan.

Another major spill concern that confronts many sites is oil or fuel spills from equipment and storage facilities. These assets must be checked regularly to reduce the risk of spills.

There are several effective methods for dealing with spills. These range from oversize, open-top bins that can hold a damaged container to terminals that use vehicles, trucks or even specially designed 20ft containers fitted out with spill containment equipment such as absorbent booms, granular absorbents, appropriate tools, protective clothing and waste container bins. This type of spill response unit can easily be moved within a terminal area and provides a very useful and versatile facility for spill containment.

Significant spills, or any involving dangerous goods, will invariably involve Port Authority Emergency Response teams and other authorities, who must be notified immediately whenever a spill occurs. All sites should have an Emergency Management Plan (EMP) which will describe how these notifications should be made and the actions that should follow.

Waste Management

Waste management involves the collection, recording and disposal of used waste materials such as oil, tyres, waste water and sewage.

Waste is defined, in Environment Protection Legislation, as any matter prescribed to be waste and any matter whether liquid, solid, gaseous or radioactive, which is discharged, emitted or deposited in the environment in such volume or manner as to cause an alteration of the environment.

Waste is something that is left over or no longer needed. If not properly managed it can pollute and affect the environment. Appropriate re-use, recycling or disposal of waste is cost-effective and should be given a high priority.

Environmental protection agencies work in partnership with all levels of government, industry and the community in order to facilitate sustainable solutions for waste management. All industries, businesses and consumers generate waste.

Types of waste that are of concern to a terminal are:

Commercial and industrial waste

Produced by commercial, industrial or trade activities, this waste is generally classed as a low-level hazard to the environment. This would include construction and demolition waste.

Prescribed wastes

These include hazardous waste and wastes that can affect amenities (eg. odour). Prescribed wastes are listed in most local Environment Protection Regulations. Most of this waste is produced by industry and may be referred to as Prescribed Industrial Waste.

Prescribed waste is the most hazardous category of waste. If not managed properly, this toxic waste may pose a threat to life because of its explosive, reactive or corrosive properties. Because of the hazardous nature of prescribed waste, strong emphasis should be placed upon reducing its quantity at source. Certain organic solvents and waste oils may be recycled or reclaimed and some may be suitable for biological treatment. Sometimes a significant proportion of liquid waste can be discharged to sewers, after appropriate treatment and with the permission of the local sewerage authority. Note that, in many countries, the disposal of liquid wastes to landfill is prohibited.

All prescribed industrial waste must be transported in accordance with local regulations which usually require the use of transport certificates for each consignment of waste. In many countries vehicles used to transport prescribed waste must hold a Waste Transport Permit unless they have an exemption.

All sites should maintain a register of prescribed waste collections and disposals, ensuring that only properly authorised waste collection agencies are used to provide this service.

Contaminated Water Containment

It is good practice, and in most countries the law, that contaminated water must not be released to waterways or to ground. Each terminal must ensure that it is able to trap first-flush run-off from workshops, container wash down areas etc. This is usually achieved by using appropriate filtration/separation equipment to remove contaminants before the water is discharged to the environment. Additional devices such as shut-off valves in storm-water outflows should also be used.

Minimising Electricity Costs

Electricity cost can be reduced significantly by the use of such methods as power factor correction, sensor switches for lighting levels and other common sense measures such as the judicious use of lighting and air conditioning. Handling refrigerated cargo is a major source of electricity consumption. Every effort should be made to monitor the temperature of an incoming reefer, to ensure that the number of "hot boxes" is kept to a minimum by regular liaison with offending clients, trucking companies etc.

Minimising Fuel Costs

Fuel is a major non-labour cost in a terminal. There are many common sense and specific operational or technical measures that can be employed to reduce fuel usage – storage tank monitoring, equipment usage monitoring, traffic plans and routing of equipment, engine shut-down timers, secure fuel dispensing points to avoid spills and theft. Fuel must be properly managed and audited to eliminate waste, reduce costs and minimise harmful effects to the environment. It is technically and economically viable today to convert many types of diesel fuelled equipment to electrical power. This will reduce fuel costs and reduce carbon emissions and is to be encouraged.

Energy-saving Ideas

A list of energy-saving ideas which includes minimising electricity and fuel use has been developed as a joint initiative of the TT Club, PEMA and ICHCA International. This list is continuously updated with new ideas and new technologies and is available to members of the above organisations.

Computerised Maintenance Management Systems (CMMS)

Overview

A CMMS is a management software tool. It is a relational database containing all known information about an asset and includes functionality and software tools to help manage the maintenance and life cycle of assets in an efficient, cost-effective manner in order to maximise asset availability and reliability. It includes asset history, maintenance job reminders and planning, inventory control and purchasing information.

Asset Database

A fundamental part of a CMMS is an asset database which contains a list of all assets at a site (infrastructure and equipment). All details relating to an asset are kept in the database (design specifications, financial data eg. book value and depreciation, performance details such as moves per hour and cost per move etc.).

Forecast Jobs and Schedules

To maintain an asset, certain information must be entered into the CMMS database. It is important to identify the asset or the components to be maintained and decide the maintenance strategy and maintenance frequency. There must be a balance between maintenance cost and asset availability. One can achieve very high reliability rates but at high cost and a potential reduction in asset availability. In the terminal business it is safe and cost-effective to accept some breakdowns within the bounds of acceptable business practice. Manufacturers' maintenance manuals contain recommendations for the maintenance of assets and components. During warranty periods, in order to keep a valid warranty, it is important to follow a manufacturer's recommendations or an agreed, alternative, maintenance regime. Once a warranty has expired, it is appropriate to optimise the maintenance strategy based upon CMMS data.

There is a maintenance strategy for each asset (and its components). Some assets, those that do not affect safety or adversely affect reliability, can run to failure but others require preventive or predictive maintenance. Once

maintenance strategies and jobs have been identified, the necessary jobs are created against an asset. The job contains all of the information necessary to carry out the regular maintenance tasks.

The frequency of maintenance jobs can be calendar-based (set time – weekly, monthly etc.), usage-based (run hours, distance covered or operation cycles), or both. It may be the case that some assets with varying usage, maintained using calendar-based jobs, will receive levels of servicing, under or over what is required, which might be detrimental to their life cycle or a waste of resources and might, subsequently lead to increased costs. For such assets you might decide to set up a maintenance schedule based upon usage or cycle frequencies. Many variables must be taken into account when deciding which policy to select. For example, when an item is exposed to the elements it usually requires maintenance even when idle, but less maintenance would be required than if it was working. In this case, one would set up both a calendar-based and a usage-based schedule so that a maintenance job might be done every 10,000 cycles or every 6 months, whichever comes first.

Forecast jobs are ones that the CMMS system has determined are due to be carried out within a selected forecast period. The jobs are reviewed and when all the parts, resources and information are available the job becomes ready to be scheduled. The commencement date and duration of each job is agreed and confirmed with all parties (eg. the operations department, the engineering department, external contractors) and the jobs are then considered to be scheduled.

Available resources must be used efficiently to achieve the desired outcome at the lowest possible cost.

The fundamentals of maintenance job planning and scheduling:

- The job should have a sequenced, documented plan with a description of what needs to be done along with drawings and all relevant documentation
- The job should start only when all the necessary parts and resources are on site
- The job should be scheduled for the best production window to achieve the least disruption to customer service

Often, job scheduling is a difficult procedure when the jobs are to be performed upon operational assets. The operations department needs equipment in order to do its job, but unless the maintenance team also gets the necessary access to the equipment to maintain it, then it may not perform satisfactorily. Often, there is an unstructured communication channel between the operations department and maintenance department. A good relationship and liaison between the two is essential in order to resolve conflicts and ensure a successful operation.

Constant postponement of scheduled maintenance jobs will lead to an increase in the number of breakdowns and the cost of repair. The operations and maintenance departments are part of the same business unit and, thus, should have the same objective – the smooth running of a profitable enterprise – and both need access to assets. Considerable costs are incurred when the maintenance department schedules a job and the operations department cancels it. Resources have to be reallocated with consequential costs and the job has to be rescheduled. Consultant cancellation costs can be significant but, of greater significance, and often overlooked, is the loss of maintenance productivity. Postponing essential maintenance work incurs greater long-term costs. A short-term cost saving may lead to a greater long-term cost, particularly if there is a breakdown.

System Created or Forecast Jobs

A system created work order is created from a repetitive job when it becomes due, based upon its frequency. Recall that jobs are set for action as calendar-based, usage-based or both. If a task is usage-based then previously-collected usage data enables the task to be triggered. Although this method helps to reduce the amount and, therefore, cost of over and under-servicing, when not automated, it does require a little more effort in order to collect accurate usage data.

Manually Created Jobs

Manually created jobs are for repairs, breakdowns or any non-repetitive activity. Such jobs can be created at any time and can be scheduled to be carried out at any time.

Work Orders

A work order provides the details of a particular job requirement. It contains all the information needed to carry out the work. The work

order lists the asset, the job description and what action is required. It lists things such as technician or labour type, estimated time to complete the job and other resource requirements such as spare parts and equipment. Attachments can be made such as detailed documents and drawings, safety requirements, isolation procedures and check lists. When a job has been completed, the work order is updated with duration, employee details, parts used and any comments in order to provide history data in the CMMS. The job duration is used subsequently to analyse performance and estimates.

Job Requests

A job request, paper or electronic, is a prompt for a particular piece of work to be carried out. It can be initiated by anyone requiring something to be done. It cannot become a job until signed off by a relevant authorised person, generated in the CMMS system and all necessary information has been entered into the job or work order.

Asset and Job History

Asset and job history consists of all the maintenance and financial history of an asset and is used for performance and cost analysis and for budgetary purposes.

The financial records of an asset, derived from the initial purchase cost and the subsequent maintenance and running costs are obtained from procurement transactions, inventory issues and work orders.

A job history is generated from all work orders each of which will have a maintenance type and status. The maintenance type could be things such as repetitive maintenance, scheduled repair, breakdown, damage or capital expenditure and the status shows whether the work was planned, issued or completed.

A maintenance budget and schedule can be created from the list of work if this has been set up with the estimated resources, costs and scheduled dates etc.

Asset Management Organisation and Structures

Manning Levels

Manning levels will be dependent upon such factors as asset numbers and types, skill levels, out-sourcing levels, productivity levels or rosters.

Roles and Responsibilities

A typical site maintenance organisation will usually have the following roles and responsibilities:

Technicians

The primary technician skill groups are electricians and mechanical fitters. There may be boilermakers and welders depending upon the site and the need. Such staff are responsible for the physical implementation of the maintenance task upon an asset. Remotely-located sites, where the contractors and services have limited availability will usually use more in-house staff.

Non-Technical Assistants

Un-skilled, non-technical assistants or labourers are also used to assist the skilled staff and/or perform non-technical tasks. Often, operations staff are used for this assistance.

Procurement and Inventory Management

Often, the engineering department manages the store's inventory and procurement functions, although at some sites the procurement function is done by the finance department. Procurement management is responsible for maximising value when purchasing items and ensuring that required items are on hand when required. Stores management is responsible for receiving and issuing items, stock control, stores housekeeping and also ensuring that required items are on hand when required.

Planning and Maintenance Data Management

Preventive maintenance practices require considerable planning and scheduling of related activities. There needs to be some capacity within the department to plan and monitor jobs and activities effectively.

Records and authentication of completed work must be kept. This function is also responsible for the Computerised Maintenance Management System (CMMS), which is the driving mechanism behind most maintenance management activities. A properly resourced planning function will lead to efficient job execution and high levels of asset availability. It is this function that is most often absent or understaffed at a site. Best asset management practice ensures that appropriate resources are provided for planning.

Case Study–

A European terminal's throughput had increased over a number of years but, although they had invested in a computerised maintenance management system, they did not employ adequate planning staff to make full use of the system. As volumes increased, equipment availability for maintenance decreased. Due to poor planning, maintenance backlogs kept growing and so did the number of equipment breakdowns.

Additional planning staff were, finally, employed to plan better and to schedule tasks more efficiently and this lead to an increase in equipment availability for both maintenance and operations and a 20% decrease in the total maintenance cost including labour.

Supervision

Front-line supervision is required to manage the day-to-day activities during a shift, such as timekeeping, day-to-day job planning, liaising with the operations department on a shift basis, allocating jobs to staff, monitoring workflow, coaching and developing and shift reporting etc. In the future, it is likely that more responsibility will be devolved to staff (trades people / technicians etc.).

Maintenance Management

Maintenance management is responsible for managing the department and takes overall responsibility for an asset's life cycle during its operating life. Apart from overseeing the maintenance staff, maintenance management usually develops and manages the maintenance budgets, sets targets, makes decisions about what needs to be done and looks at longer term strategies.

Engineering Support

There will usually be people within the engineering management group who can provide engineering support and technical assistance in mechanical and electrical disciplines. They will assist with day-to-day issues as well as project work.

Quality Control

Often performed by supervision or could be done by peers. Quality control of completed work is often overlooked.

Training

All persons should be trained and competent as appropriate. Management and supervision are responsible for assessing training needs. Often, adequate training is overlooked. Training should be given by in-house or external people depending upon requirements.

Multi-Skilling or Cross-Skilling

Multi-skilling or cross-skilling occurs when, for example, an electrician performs some task traditionally only done by a fitter. In the past, a fitter and an electrician may have been needed to do this job. The extent of multi-skilling will vary depending upon the skill levels and also union/labour demarcation issues. Union demarcation issues are often the main restrictions that limit multi-skilling.

The future should see more multi-skilling across different trades. It should also see more multi-skilling between technicians and supervisors and between technicians and operators. However, there does need to be careful monitoring so that multi-skilling does not result in technicians losing the specialist skills they need.

On many sites, operators are required to inspect and carry out minor servicing, such as checking air pressure and water levels in vehicles. This does not always happen, but it needs to be a standard work practice. Many industries have technicians who do everything – operate, maintain and repair the asset. This is good, but you will still need a specialist to perform certain more technical tasks.

Competence: Recruitment & training

When recruiting technicians, it is important that their skills are identified and matched to those of the department. Sometimes, it is difficult to recruit individuals who have had the heavy industry experience that is required at a terminal. General trade skills are a prerequisite and preference should be given to those that have the proven skills and an attitude to match.

Training is an important part of running a successful and efficient maintenance function. Training needs to cover all statutory requirements and target the specific skills lacking within the maintenance team. Training can take many forms of which formal instruction in a classroom environment is only a small part. Technicians often only see training as official instruction in a formal setting. This is only a minor part of training and development, however, and maintenance management has to recognise and respond to this perception. On-the-job training is the most successful and influential form of education. It quickly relates theory to practical application. Typically, a technician may need up to six months of site experience before achieving an acceptable level of competency. Some terminal equipment such as quay cranes, rubber-tyred gantry cranes and straddles are unique to a port environment and, therefore, specific knowledge of these pieces of equipment is not generally available in the wider engineering sector. This places great responsibility upon the maintenance department to provide necessary training.

Each terminal must determine the optimum balance between skills that should be available in-house (onsite training) and skills that should be sourced from external training organisations. The inherent reliability of modern electrical control systems, for example, reduces the opportunities for in-house staff to develop a detailed and up-to-date understanding of the systems. Often, because these systems are so reliable, in-house staff have little opportunity to undertake trouble shooting practice within these systems. This example highlights the fact that maintenance management must be able to draw upon a variety of skills and experience both from specialist contractors and their own people.

Level of Supervision

Supervision levels vary from site to site and are dependent upon the skill levels of technicians, the size of the workforce, the size of the operation, working practices or tradition, culture and union demarcations.

Teamwork Philosophy

Teamwork philosophy is something that has been shown to work in most situations. It may not work at all sites, but it is a concept worth investigating. It is detailed in this handbook to assist those interested in its implementation. Productivity can be dramatically improved within a team environment. The concept is based upon teams that are interdependent but which also work together as a 'team of teams'. These teams should work towards shared goals based upon the team members being rostered upon the same shifts for extended periods.

Cross-team roles and responsibilities need to be agreed upon so that common aims and expectations can be delivered. Teams need to support and co-operate with each other to ensure that all work gets done and that all teams achieve their individual team goals.

All teams need a representative supervisor or co-ordinator who will be part of the team, although may not be required to "work upon the tools".

Team Principles

Teams need to work according to the following guidelines:

- All members support and encourage safe working practices by the team, all other employees and others on site
- All members work together, using all their skills to get the work finished to a high standard (no demarcations)
- All members work to meet agreed goals, standards and procedures
- All members work to improve team skills and performance by measuring team performance, comparing targets and standards, and improving where required
- All members have a say in decisions that affect the team and its work
- All members answer to the team for their actions and performance
- The team supervisor, in consultation with team members, allocates tasks to individuals who then plan and carry out the work with help from others as necessary
- The team aims to improve that section of plant for which they have primary responsibility
- The team is given sufficient authority to complete the required work
- The team supervisor, in consultation with team members, organises the team's administration such as leave, rosters and time management

- All members support and coach each other
- Each team supports and helps other teams

Team Ground Rules

Each team needs to develop its own set of ground rules about how it will handle standard situations. Examples of topics, around which teams should develop ground rules, are:

- Work planning
- Task allocation
- Breakdown response procedures
- Meetings
- Tool box talks
- Safety focus
- Training plans
- Team administration
- Leave arrangements
- Team recognition
- Conflict resolution
- Handling poor performance

Team Decision-making

People like to have a say in decisions that affect them. The more a situation affects members of a team, the more it is desirable that teams have input in the decision-making process. In such cases, a team must also be prepared to accept proportional responsibility and accountability for any decision. Conversely, if a situation only affects a team indirectly and relates more to areas which are the responsibility of management, then decision-making correctly resides with management. Within the team structure of engineering, there is a need for different decision-making arrangements within a team, depending upon the issues under consideration. These will be based upon matching involvement and responsibility. Team members should be involved in the making of decisions which affect them. The extent of involvement in the decision-making process will depend upon the extent of responsibility and accountability accepted by team members. Generally, the more responsibility and accountability accepted by the team members the

more they will be involved in the decision-making process. There is a need to encourage team members to participate in decision-making about work issues for which they are responsible. The concept is not based upon replacing supervision but about enabling them to be freed from daily, routine, issues which can be decided, equally, by team members, releasing them to focus upon more strategic issues. The team supervisor involves team members in decision-making.

The concept is based upon each team member being progressively more involved in decision-making about work for which they accept responsibility and accountability. As their acceptance of responsibility and accountability increases, so does their level of involvement in decision-making. It should be understood that teams will progress at different rates in taking up this concept. The transition from a traditional way of working, to participative work teams, will require a cultural change and will take time and training. It is important that such change is implemented gradually and that participative involvement in decision-making proceeds at a pace acceptable to work teams, other teams and the company in order to achieve agreed team key performance indicators.

The participative work team concept is designed to be flexible and circumstances will change as team members accept more responsibility and accountability and develop the necessary skills to accept that extra responsibility. A key component of success will be the level of coaching and support provided by supervisors. They have to change their historical role of "cop" to that of "coach". Often, this is difficult and they will need team and maintenance management support. Incrementally, they should allow a team to take on more responsibility and accountability as its members' skills develop. This will have a beneficial effect upon team productivity.

Composition of Teams

The following criteria should be used to determine allocation of personnel:

- Personal choice
- Skill requirements to complete the work (including experience and job skills)
- Balance within the team
- Interpersonal mix
- Building upon existing teamwork
- Past performance

Plant Ownership

Introduction

Plant ownership is a philosophy where a team of technicians, and maybe others (supervisors, operators etc.), have responsibility for the maintenance and performance of various pieces of terminal equipment. If the teamwork concept exists then plant ownership can exist.

There are several benefits to this kind of practice:

- It reinforces the team concept and teams are able to influence the outcome
- Individuals feel as if they 'own' something and take extra steps to improve the way they work upon 'their' plant
- There is healthy competition between teams to achieve the best results for 'their' equipment
- Ownership can give a sense of purpose and responsibility. This extra responsibility has been proven to be effective in that it usually leads to a reduction in the need for direct supervision and task assignment. Individuals are more willing to take on a greater share of responsibility from their supervisor

Due to limited access to some operational equipment, teams cannot always carry out the scheduled maintenance upon 'their' asset. This creates a need for different teams to help each other further. However, where possible, all efforts should be made to ensure access by the ownership team. Overall, the

plant ownership philosophy has been shown to be very effective at many sites and usually leads to greater availability and reliability of equipment and increased maintenance productivity.

The desire to concentrate upon preventive and predictive maintenance can be assisted by giving teams ownership of discrete parts of the plant and other equipment.

Concept of Plant Ownership

- All teams should work upon all areas of the plant as required
- All teams carry out breakdown response to meet the business needs of the operation, regardless of plant area in order to maximise plant up-time
- Each team will have primary responsibility for specific areas of plant and equipment

Teams that have primary responsibility for plant or equipment will:

- Sponsor improvements
- Sponsor detailed history (managed centrally by day-team planning)
- Concentrate inspection effort to identify potential problems
- Contribute to preventive and predictive strategy
- Perform the majority of the preventive maintenance tasks depending upon availability
- Brief other shifts that are scheduled to work upon the plant or equipment
- Contribute to spares management (generally managed by the day-team)

Where possible a planner or supervisor will allocate scheduled work to be completed by the team. This will not always be possible because equipment might be unavailable. When scheduling prevents the work being completed by the primary team, other teams may carry out the work and their detailed planning should include liaison with the primary team. Areas which cannot be split sensibly should be owned by all shifts or owned by multiple shifts.

Teams should measure the performance of plant and equipment they have ownership of, and are to be responsible for, in order to ensure that they reach and maintain relevant standards and performance targets.

Process to Determine Team Allocation of Plant

All teams and management should be involved in determining how the plant is divided and allocated to teams in order to try and accommodate individual, team and company needs.

Case Study –

A terminal in Australasia implemented both the team and the plant ownership philosophies. Within six months, equipment reliability had increased from 92% to 98%, labour costs were the same but overall maintenance costs had been reduced by 15%.

Maintenance Key Performance Indicators (KPIs)

A business must constantly focus upon improving its performance. Effective management means measurement of actions and results. This leads to control, enabling continuous improvement.

Many companies view engineering, in general, and maintenance, in particular, as necessary evils, as an expense to the organisation or as a non value-added function.

Others view engineering as a way of reducing product or service delivery costs – in effect they use asset management as a competitive weapon. Often, such companies use the cost advantage to reduce their prices, improve their profit margins and deliver increased shareholder value.

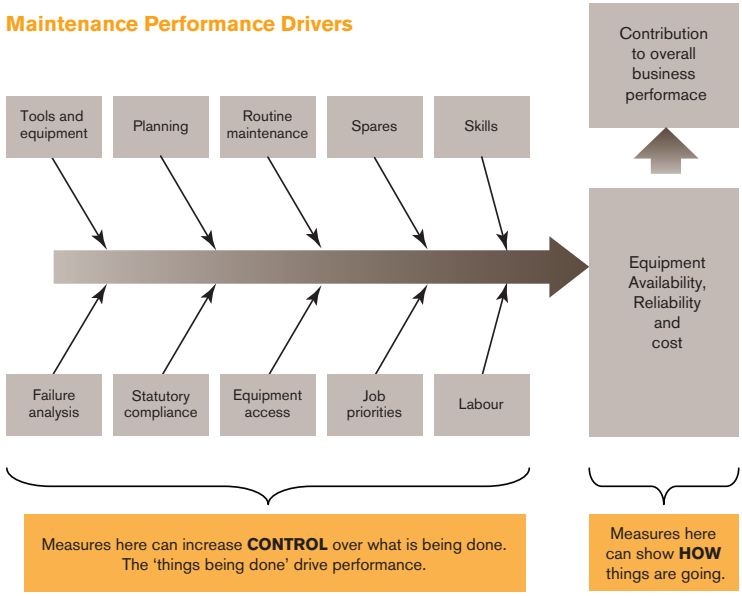
What is the difference between the two types of companies? The first sees little or no value in engineering and has never learned to measure it. Since it can't measure it, it can't manage it. This company may not understand what engineering is and how its future competitiveness hinges upon it. Companies have tried different organisational structures, changing reporting structures, upsizing, downsizing, contracting out and empowering their teams in an attempt to control engineering. Yet, most companies have not been able to manage engineering very effectively. The two largest contributory factors have been the lack of proper measurement and the absence of engineering control systems.

Companies need to recognise and appreciate the importance of engineering as an integral part of their success. They must ensure they have the appropriate systems and KPIs in place so that they can manage engineering effectively and control and improve performance and, thus, add value to the business. Such actions typify the culture of the second type of company identified above.

Most organisations are good at taking 'maintenance action', action that is associated with doing something to items of plant, but they are not, usually, very good at the 'plan', 'check' and 'act' parts of the maintenance cycle. Such actions are associated with large volumes of data, which are often of poor quality. These things are hard to see and understand. Businesses often don't see the benefit and so are reluctant to apply sufficient resources.

The first step to improvement is to know your situation. The following section focuses upon performance measurement (the check) or Key Performance Indicators (KPIs). Good organisations apply performance measurement techniques as an aid to continuous improvement. To improve performance, actions need to be measured, including the inputs or drivers as well as the results. The diagram below shows some of the maintenance drivers – the things that are done which drive maintenance. Are the correct tools and equipment available? Is the operations department providing access to equipment to perform the necessary maintenance tasks? How many tasks are planned tasks and how many are breakdown tasks? Are the causes of breakdowns being measured? The answers to these questions provide the drivers for effective maintenance management. Measuring and monitoring the drivers increases control over the actions.

Maintenance Performance Drivers



Two different levels of KPIs should be developed: for senior management, the executive summary, indicating performance and, for the engineering department, detailed engineering reports to analyse the things that drive the results. This leads to better understanding and greater control. In general, there are three main KPIs that are used to monitor maintenance performance at a site. They are the safety of the people and the environment, the equipment performance and the engineering cost. Safety is always a major focus and has specific measurements which we will not elaborate upon in this handbook except to say that safety should always be the highest priority.

Engineering Executive Summary KPIs

Some examples of engineering executive summary KPIs to measure performance.

Engineering Cost KPIs

- Engineering cost, per earning unit (eg. TEU)

This KPI is driven by the following measures:

- Engineering labour cost per earning unit
- Equipment running cost per earning unit
- Property maintenance cost per earning unit

Equipment Performance KPIs

- Availability

This KPI is driven by the following measures:

- Reliability
- Planned maintenance down-time as a percentage of total time
- Utilisation
- Mean time between failures

Detailed Engineering KPIs

Some examples of detailed engineering KPIs to help control performance:

Financial Indicators

- Total engineering costs as a percentage of total facility costs
- Total engineering costs (actual and budgeted)
- Total engineering costs per earning unit
- Engineering labour cost per earning unit
- Equipment running cost per earning unit
- Property maintenance cost per earning unit
- Total engineering cost as a percentage of the estimated replacement value of assets
- Stores inventory value as a percentage of the estimated replacement value of assets
- Fuel used in litres per earning unit
- Fuel cost per earning unit
- Electricity used in KWH per earning unit
- Electricity cost per earning unit
- Tyre costs
- Tyre costs per distance travelled
- Annual stores usage cost / stores inventory cost
- Damage costs

Efficiency Indicators

- Down-time caused by breakdowns / total down-time
- Man hours spent upon unplanned work / total man hours worked
- Man hours spent upon preventive work / total man hours worked
- Man hours spent upon corrective work / total man hours worked
- Equipment availability = (total time - down-time) / total time
- Equipment reliability = (operating time - breakdown time) / operating time

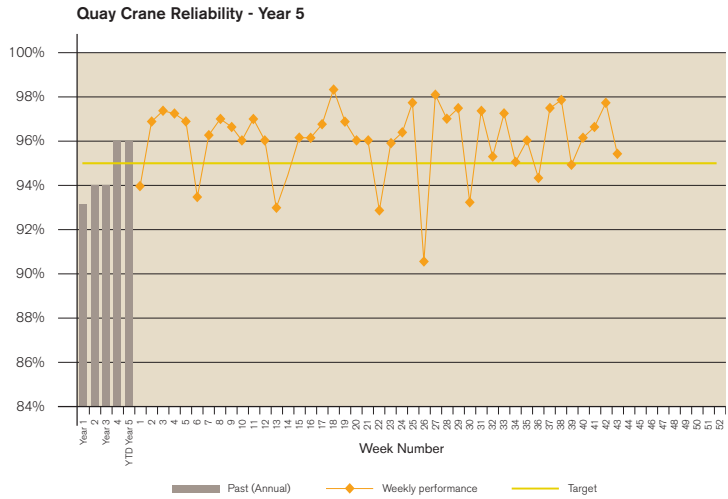
- Mean time between failures = breakdown time / number of breakdowns
- Number of repetitive equipment failures / number of equipment failures
- Hours worked as overtime / total hours worked
- Total down-time attributed to operational errors / total down-time
- Total down-time attributed to maintenance errors / total down-time
- Estimated lost time due to lack of knowledge or skills / total time worked
- Maintenance rework due to lack of knowledge or skills / total maintenance work
- Maintenance tasks or work orders completed / scheduled
- Total number of rush purchase orders / total number of purchase orders
- Inactive store items / total store items
- Maintenance work orders awaiting parts / total maintenance work orders
- Maintenance work orders planned / work orders received
- Maintenance hours scheduled / total maintenance hours worked
- Total hours estimated upon scheduled work orders / total hours charged to scheduled work orders
- Number of work orders completed taking 20% longer than estimated / total number of work orders
- Work orders overdue
- Absenteeism in days per employee per year
- Industrial stoppages in days per person per year

For sites with computerised maintenance management systems there are many other measures to monitor performance of the system itself.

The following are examples of how these KPIs are used to monitor performance and identify where improvements can be made.

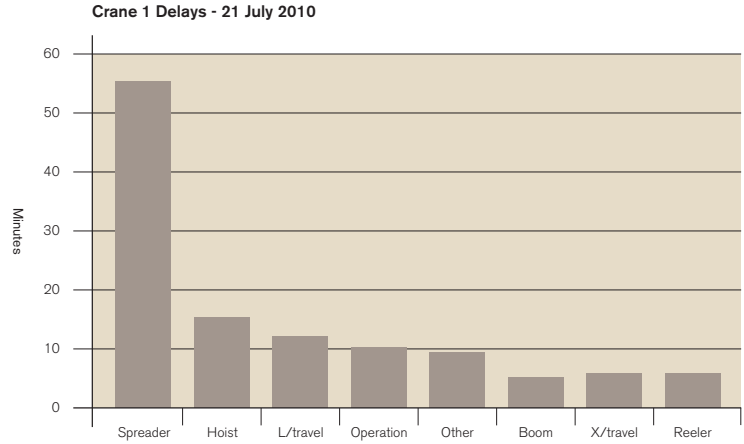
Trend Graphs

Most sites collect an enormous amount of data and, usually, do not have the time to use it for performance analysis. Graphs, particularly trend graphs, can show, quickly, if things are improving, stagnating or declining. The following are examples of trend graphs:

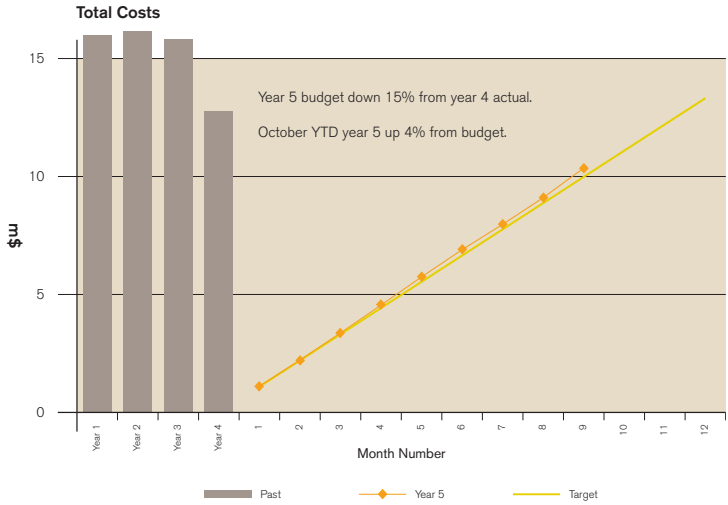


The above graph shows increased reliability over the year, but weekly reliability is not stable or consistent and is still too low. The site should increase its target to 98% and make reliability more consistent. To do this it would need to investigate the reasons for the low, inconsistent figures. An analysis of the breakdown reasons for each crane is required. Pareto charts are very good for this.

A Pareto chart is used to summarise and display the relative importance of groups of data. They allow you to analyse the issues and apply the 80/20 rule to focus upon the important ones. An example is given below:



The chart shows, clearly, that spreader problems are the main cause of breakdowns. Often, if delays are very short, but occur frequently, they do not get as much attention as a single long delay. In the above example a spreader problem, which was only 5 minutes long but was repetitive, might have been ignored if we hadn't analysed it using the Pareto chart. It caused more total delay than a single hoist problem of 15 minutes which everybody remembered. Further analysis of the reasons for spreader delays should be carried out.



This chart shows the cost trend over time and also cumulative current year costs. The example shows the yearly costs to be decreasing. But is that good or bad? We also need to compare to plant availability and also volume. Costs might be down only because volume is down. The reduced costs may have caused plant availability to decrease. The cumulative current year costs also allow us to identify increasing over-budget which might go unnoticed if monthly costs are only slightly above budget.

Retirement of Assets

The last phase of the life cycle of any asset is retirement. There can be several reasons for retiring an asset:

Capability Obsolescence

Shipping lines are currently taking delivery of vessels well in excess of 10,000 TEU and smaller vessels are being transferred to 'feeder' services or are being decommissioned. The influence of the newer, larger, vessels will mostly be felt by the transhipment terminals. In anticipation, many port authorities have started deeper dredging and many older cranes will become obsolete. In many terminals shipping lines will expect their larger vessels to have equal windows to other vessels. Crane outreach, lift capacity and speed of operation may be insufficient to service the larger vessels within the current windows and terminals need to anticipate this obsolescence and invest in new cranes or refurbish their existing models.

High Operational Costs

As technology advances, more modern equipment can offer a competitive advantage to terminal operators. This is a competitive advantage in slow moving technologies where an investment takes a long time to deliver a return. Successful companies, using new technology, excel at identifying sources of technological advantage and spreading them faster and more efficiently than their competitors. A new technology may make an existing asset, or its management, obsolete.

High Maintenance Costs

It is only to be expected that long-serving assets, despite good design, fabrication and regular maintenance, succumb to wear and tear and escalating maintenance costs and become candidates for retirement. Frequent breakdowns result in escalating costs – idle labour, poor service and expensive spare parts.

Risk of Total Failure

The final reason for asset retirement is the risk of total failure. There are three types of total failure risk:

- Control systems have a very short life cycle. It is not uncommon to find equipment in good mechanical condition controlled by electronic systems that are no longer being supported by their suppliers. This means

that you may no longer be able to obtain spare parts or support and this implies that, at some future electronic failure, the complete asset may have to be retired even though it is still in good working condition.

- Lifting equipment is designed to sustain fatigue after repeated stress upon critical components of the structure. Careful design incorporating safety factors, expert inspection during construction and regular inspection allows assessment and early detection of wear and tear. Needless to say, an asset that shows signs of potential structural failure should be retired.

- It may become difficult to ensure that each shift has the necessary skills to repair both old and new technologies. Some terminals have up to seven generations of straddle carriers. Despite constant training and refresher courses the increase in time to repair is often an early indication of the need to retire an asset.

APPENDIX 1

Maintenance Tasks and Out-sourcing Recommendations

The table lists the main maintenance tasks carried out at a container terminal and provides guidelines to tasks best performed in-house, out-sourced or either which will vary according to the availability of local contractor expertise and the labour/union work practices and relations.

- In-house – core maintenance tasks that are usually best done by site employees
- Either – tasks that may be done by either site employees or contractors depending on in-house skills and cost
- Out-sourced – tasks that are best done by contractors since it is not core business; requires specialist skills or equipment; random, short term or one-off tasks; where core tasks would be disrupted

Task Description	In-house	Either	Out-sourced	Comment
Initial breakdown calls and fault diagnosis and minor repairs				Must have own expert core workforce, familiar with the core equipment, to do this work so delays are minimised. Use of site employees should always be the first option for all breakdown / core maintenance tasks. Equipment that is maintained by contractors should be assessed, initially, by site employees to ensure there is no simple fault (eg. power turned off).
Spreader inspections				Spreaders are the main piece of equipment in the terminal and site staff should do the inspections
General preventive maintenance upon cranes, RTGs and Straddles				Preferable to have own workforce to do this work upon the core assets. It enables them to become familiar with the equipment which helps minimise breakdown delays. Need this type of work to maintain productivity of employees between breakdowns and to help promote teamwork and plant ownership.

Task Description	In-house	Either	Out-sourced	Comment
Minor spill response and clean-up				To ensure a prompt response it is often best to use site employees.
Major spill response and clean-up				Initial response should be by site employees but contractors' support should be arranged. Procedures and support for this should be discussed with the local Port Authority.
Refuelling of RTGs and other diesel operated cranes that can't travel to a fuel bowser				Cost decision.
Refuelling of Straddles, tractors, forklifts and other vehicles				Should be done by the driver of the machine where computerised fuel dispensing and recording systems are installed. When not installed, cost decision whether in-house or out-sourced.
Spreader repairs				If there are experienced contractors available with a quick response time, then this is often best out-sourced.
Rope changes				If there are experienced contractors available then this work is often better out-sourced. It is specialist and often dangerous work. Unless the size of the terminal is large enough such that rope inspections and rope changes can fully occupy your own trained dedicated staff that only does this work, then this should be out-sourced. If the job is not done often then it can be a dangerous job and take much longer so it should be always out-sourced or always in-house.
Rope inspections and testing				If there are experienced contractors available then this work should be out-sourced. It is specialist and often dangerous work. Unless the size of the terminal is large enough such that rope inspections and rope changes can fully occupy your own trained dedicated staff that only does this work, then this should be out-sourced.

Task Description	In-house	Either	Out-sourced	Comment
Wheel changes				If there are experienced contractors available with a quick response time, then this work is often best out-sourced.
Minor PLC software changes				If in-house staff have the skills it is often best to use them. This provides better experience to help with future trouble-shooting.
Major PLC software changes				Unless the site has an expert they should out-source. However they should try to involve their people to give them better experience to help with future trouble-shooting.
Minor modifications in general				Each job should be assessed to determine if terminal staff have the time, expertise and equipment otherwise it is best out-sourced.
Reefer connecting and disconnecting				The task occurs randomly and is time critical to operations, both yard and shipping so the people who do it must be on site at all times. Can be done by site employees who also do other work or contractors who also do other work like reefer monitoring. There are no formal qualifications required to do this work. Any site employee can be trained to do this.
Reefer monitoring				There are no formal qualifications required to do this work. This is a standalone operation which could be out-sourced completely or done by site employees. With modern containers and new technologies, automatic remote reefer monitoring is the ultimate goal. Reefers should be monitored at least once every 12 hours.
General preventive maintenance upon lift trucks				Apart from daily inspections, which the operator should carry out, regular servicing of these vehicles can be done by site employees or contractors depending upon cost.

Task Description	In-house	Either	Out-sourced	Comment
General preventive maintenance upon tractors and trailers				Apart from daily inspections, which the operator should carry out, regular servicing of these vehicles can be done by site employees or contractors depending upon cost.
General preventive maintenance upon other miscellaneous assets				Any required maintenance upon other miscellaneous assets should be assessed at the time to determine if the site has the time, expertise or equipment or if it is better to use a contractor.
Engine condition monitoring				If experienced engine mechanics are available this is often best out-sourced.
Collection of oil samples for external analysis				Due to random availability of equipment and the fact that site people would regularly be in a position to take an oil sample while they are doing other things, it is often better to do this work with site employees, but it does not matter either way. However this may be included as part of a condition monitoring contract.
Minor equipment refurbishments				Each job should be assessed to determine if the site staff have the time, expertise and equipment or if it is better to use a contractor.
Major cleaning of equipment				Each job should be assessed to determine if the site staff have the time, expertise and equipment or if it is better to use a contractor.
Yard and building lighting R&M				This job can be out-sourced depending upon time and cost.
Building / office / domestic 240/415V tasks				This job can be out-sourced depending upon time and cost.
Air conditioning R&M				Generally, this is specialist work. All air conditioning should be done by contractors depending upon time and cost.
Major equipment refurbishments				This job should be out-sourced. Amount and type of work will vary so better to utilise contractors with skills as required. Risk of over budgets and time over runs and performance requirements can be controlled contractually.

Task Description	In-house	Either	Out-sourced	Comment
Major modifications in general				This job should be out-sourced. Amount and type of work will vary so better to utilise contractors with skills as required. Risk of over budgets and time over runs and performance requirements can be controlled contractually.
Wheel and tyre repairs				If there are experienced contractors available then this work should be out-sourced. Costs are generally much less than using in-house labour.
Electric motor overhauls				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Gearbox overhauls				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Transmission overhauls				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Diesel engine overhauls and major repairs				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Hydraulic equipment repairs (cylinders, pumps, motors)				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Electronic card repairs				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
HV equipment R&M and calibrations				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Crane and equipment structural inspections				This is specialist work. This job should be out-sourced to qualified structural engineers experienced in crane design. To satisfy ILO requirements the crane inspections should be done at least once a year.
Condition monitoring of gearboxes and motor bearings - vibration analysis				This is specialist work and the correct equipment is costly, so is best done by experienced contractors. However, to provide interesting work for site people and foster plant ownership, site in-house staff should be involved in co-ordinating this work closely with the contractor.

Task Description	In-house	Either	Out-sourced	Comment
PABX and telephones				This is specialist work. This job should be out-sourced.
Radios R&M				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
CCTV R&M				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Computers, printers, facsimiles, copiers etc.				This is specialist work. If there are experienced contractors available then this work should be out-sourced.
Painting				This job should be out-sourced. Amount of work will vary so better to utilise contractors with required skills as required.
Gardening				This job should be out-sourced. It is not a core business task and costs will generally be much less than using in-house labour.
Building repairs / carpentry / fencing				This job should be out-sourced. Amount and type of work will vary so better to utilise contractors with skills as required.
Pavement repairs				This job should be out-sourced. Depending on the type of pavement, this is specialist work and the correct equipment is costly, so is best done by experienced contractors.
Quay structure, deck and fittings				This job should be out-sourced. Amount and type of work will vary so better to utilise contractors with skills as required.
Fire system inspections and maintenance				This job should be out-sourced. This is specialist work, so is best done by experienced contractors.
Plumbing				This job should be out-sourced. Amount of work will vary so better to utilise contractors with skills as required.
Other				Each job should be assessed to determine if the site staff have the time, expertise and equipment or if it is better to use a contractor.

APPENDIX 2

Minimum Standard Safety Specifications for Quay Container Cranes

The table below is not all-inclusive, but rather a shortlist of key safety features that are both practical and effective. Based upon experience, accident records and insurance claims analysis, this list covers the systems, structures, features, equipment and technology that have been proven to reduce injury or damage and which are currently not standard.

The aim is for suppliers to include, as standard, the features on this list in all their quotations. Terminals and buyers are also recommended to include these features in their tender specifications. Many, if not all, of these safety features can be retrofitted to existing cranes and this is also highly recommended. Any existing international, national and/or local regulatory standards must be also be satisfied.

The companies listed in the Appendix are those that have currently been identified to supply proven technologies which satisfy the functional requirements. Other suppliers may also have proven technologies which satisfy the requirements and, as they are identified, will be added to the supplier list.

More information about this joint initiative can be found at
www.ttclub.com or www.ichca.com or www.pema.org

#	Risk	Safety feature	Functional requirement
1	Boom colliding with ship	Boom anti-collision	A minimum of 2 detection zones: • warning or slow down • stop Detection range shall be such that it will allow enough time for the crane to come to a "normal" stop Suitable electronic sensors designed specifically for this application must be used. Lanyard or tripwire systems are not adequate.

#	Risk	Safety feature	Functional requirement
2	Gantry colliding with objects on rail tracks or near vicinity	Gantry travel anti-collision	A minimum of 2 detection zones: • warning or slow down • stop Detection range shall be such that it will allow enough time for the crane to come to a "normal" stop.
3	Adjacent cranes colliding	Crane to crane anti-collision	A minimum of 2 detection zones: • warning or slow down • stop Detection range shall be such that it will allow enough time for the crane to come to a "normal" stop.
4	Crane driver adversely affected by ship stack emissions or other air pollutants	Operator cabin air conditioning	The cabin shall be provided with a proven positive pressurized air filtration system with high efficiency particulate and gas absorbers or similar to protect the operator from harmful emissions from ship's stacks or other air pollutants.
5	Damage and injury caused by operating the crane in high winds	Wind speed detection and alarm to enable driver to stop the operation, park and shutdown the crane safely	An anemometer shall be installed in clear air at the top of the crane giving an indication in the driver's cab, both audible and visual, that the safe operating wind limit has been reached. An audible alarm shall also be installed to indicate to persons on the berth that this limit has been reached. The anemometer shall be rated well over the expected worst case windstorm. The wind speed, direction and time shall be recorded. The recommended maximum operating wind speed should be set at 22m/s. The crane must not shutdown automatically, even if the alarm sounds continuously. This allows the crane to travel to the storm pin/tie-downs.
6	Cranes being blown along the crane rails	Means to engage the crane horizontally on rails	Crane storm pins at the centre of the crane under the sill beams on both waterside and landside and one or more corresponding locking positions on dock in distance reachable within the expected time to high wind condition. The storm pins, the mounting upon the crane and also the pin sockets must all be designed to withstand the maximum forecast forces exerted.

#	Risk	Safety feature	Functional requirement
7	Cranes being blown over	Means to engage the crane vertically to prevent wheels being detached from rails	Crane tie-downs upon each corner and one or more corresponding locking positions on dock in distance reachable within the expected time to high wind condition. The tie-down connections upon the crane and also the anchor points in the quay structure must all be designed to withstand the maximum forecast forces exerted.
8	Runaway crane due to sudden high wind condition	Gantry braking	Gantry drive braking system shall be designed to stop and hold the crane with a wind speed of 40m/s wind from behind. Design shall take into account uneven weight distribution when the braking force is transferred to rails. This means no wheel skidding under normal braking.
9	Structural or lifting system damage caused by snagged spreader or container	Hoist snag load protection	Detection system to activate “fast stop” of the lifting system and a system to absorb or isolate the kinetic energy in the lifting system to prevent the exceeding of designed load in the lifting system.
10	Electrical or machine room fire	Temperature and smoke detection in the Electrical and Machine room	A temperature and smoke detection alarm system inside the electrical control and machinery rooms which give audible and visual alarms in the driver’s cabin, electrical and machinery rooms, outside the machinery house access door and upon the landside sill beam.
11	Electrical room fire	Fire suppression	A fully automatic fire suppression system mounted inside the electrical cubicles.
12	Falling or jamming between movable parts of the crane while personnel entering enclosed non-access or operating areas	Prevent unintended access to risk areas	Spring set self-closing gates with positive means of opening. Any access gates to risk areas (boom/trolley, cabin/boom etc.) shall be interlocked to prevent access when not in parked positions or when in operation and to prevent crane operation when open.
13	Overloaded or mis-declared container weights and eccentrically loaded containers causing risks: trucks overturning; road damage; ships sinking; containers collapsing.	Measure the weight and eccentricity of each container	System to indicate, measure and record the actual weight and eccentricity of each container. Data to be capable of being transferred to the terminal operating system (TOS)).

List of suppliers

Recommended suppliers of proven technologies which satisfy the functional requirements:

Safety Feature	Contact details
Boom anti-collision	• SICK Technologies (www.sick.com) • Nav-tech radar (www.nav-tech.com)
Gantry travel anti-collision	• SICK Technologies (www.sick.com)
Crane to cranes anti-collision	• SICK Technologies (www.sick.com)
Hoist snag load protection	• Malmedie GmbH (www.malmedie.de)
Hoist snag load detection	• Lasstec (www.lasstec.com) • Bromma Conquip (www.bromma.com)
Fire suppression	• Fire–Foe (www.quick-fire.com)
Twistlock load sensing system	• Lasstec (www.lasstec.com) • Bromma Conquip (www.bromma.com)

For further information contact the TT Club at one of its underwriting centres or at any point in the network.

The TT Club underwriting centres

London
Through Transport
Mutual Services (UK) Ltd
90 Fenchurch Street
London EC3M 4ST
United Kingdom

T +44 (0)20 7204 2626
F +44 (0)20 7549 4242
E london@ttclub.com
GMT 0

Hong Kong
Thomas Miller (Hong Kong) Ltd
Suite 1201-1204 Sino Plaza
255 - 257 Gloucester Road
Causeway Bay
Hong Kong

T +852 2832 9301
F +852 2574 5025 & 2574 5062
E hongkong@ttclub.com
GMT +8

New Jersey
Thomas Miller (Americas) Inc
Harborside Financial Center
Plaza Five, Suite 2710
Jersey City, New Jersey 07311
United States of America

T +1 201 557 7300
F +1 201 946 0167
E newjersey@ttclub.com
GMT -5

Singapore
Thomas Miller
(South East Asia) Pte Ltd
61 Robinson Road
#10-02 Robinson Centre
Singapore 068893

T +65 6323 6577
F +65 6323 6277
E singapore@ttclub.com
GMT +8

Sydney
Thomas Miller (Australasia) Pty Ltd
Suite 1001, Level 10
117 York Street
Sydney, NSW 2000
Australia

T +61 2 8262 5800
F +61 2 8262 5858
E sydney@ttclub.com
GMT +9

The TT Club Network

Antwerp
T +32 3 206 9250
F +32 3 206 9259

Auckland
T +64 9 303 1900
F +64 9 308 9204

Barcelona
T +34 93 23 09310
F +34 93 23 09311

Buenos Aires
T +54 11 4311 3407/09
F +54 11 4314 1485

Dubai
T +971 488 101 67
F +971 488 109 55

Durban
T +27 31 368 5050
F +27 31 332 4455

Genoa
T +39 010 83 33301
F +39 010 83 17006

Hamburg
T +49 40 36 98 180
F +49 40 36 98 1819

Moscow
T +7 495 935 8620
F +7 495 981 1529

San Francisco
T +1 415 956 6537
F +1 415 956 0685

Seoul
T +82 2776 4319
F +82 2771 7150

Shanghai
T +86 21 6321 7001
F +86 21 6321 0206

Taipei
T +866 2 2736 2986
F +866 2 2736 2976

Tokyo
T +81 3 5442 5001
F +81 3 5442 5002

£36.00 UK

ISBN 978-0-9562704-2-9 (Printed)
ISBN 978-0-9562704-3-6 (PDF)

www.ttclub.com