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On

MAINTENANCE GUIDELINES FOR COLD CHAIN EQUIPMENT (CCE)

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CONTENTS

References:

1. GAVI CCE IN-COUNTRY LANDSCAPE ANALYSIS- FEBRUARY 2016
2. GAVI CCE COSTING FRAMEWORK, CONSIDERATIONS AND GUIDANCE-FEBRUARY 2016
3. GAVI CCE CASE STUDIES ON BEST PRACTICE CCE MAINTENANCE-FEBRUARY 2016
4. GAVI-COLD CHAIN EQUIPMENT (CCE) OPTIMIZATION PLATFORM
5. PATH TOTAL COST TO OWNERSHIP MODEL 'TCO TOOL V1 0 2 DRAFT FOR TECHNET 17112015'
6. PRIVATE SECTOR ENGAGEMENT: UNITED NATIONS COMMISSION ON LIFE-SAVING COMMODITIES FOR WOMEN AND CHILDREN, TECHNICAL REFERENCE TEAM ON SUPPLY AND LOCAL MARKETS, REVISED, DECEMBER 2015 A GUIDANCE DOCUMENT FOR PUBLIC HEALTH SUPPLY CHAINS.
7. TRANSAID: GAVI STUDY – OUTSOURCING THE DISTRIBUTION COMPONENT OF VACCINE AND MEDICINE SUPPLY CHAINS: DECEMBER 2015.
8. THE GAVI SUPPLY CHAIN STRATEGY 2015 IMPLEMENTATION PLAN NOVEMBER 2014.
9. EPI COLD CHAIN MANAGEMENT.
10. LAST MILE PARTNERSHIP (LMP) COLD CHAIN UPTIME PROJECT-COCA-COLA'S REFRIGERATION EQUIPMENT MAINTENANCE MODEL-JULY 2013
11. MAINTENANCE OF REFRIGERATION EQUIPMENT - TECHNICAL SUPPLEMENT (WHO)
12. MAINTENANCE OF STORAGE FACILITIES - TECHNICAL SUPPLEMENT (WHO)
13. REPORT TO THE BOARD - CCE OPTIMIZATION PLATFORM (GAVI)

1. Background

The Gavi Alliance Vaccine Supply Chain Strategy establishes that an effective cold chain is a prerequisite to achieving the Alliance's coverage and equity goals. Appropriately deployed, high-performing and well-maintained cold chain equipment (CCE) is a critical component of the supply chain, and vital to ensure that vaccines are available and potent, in order to protect all children reliably, efficiently and sustainably. The Supply Chain Strategy identified poorly maintained CCE as a major challenge of immunization supply chain that needs to be addressed. Subsequently, the creation of the Cold Chain Equipment Optimization Platform (the Platform) was approved by the Board in June 2015 to strengthen country cold chain systems and advance the Alliance's Supply Chain Strategy, coverage and equity goals. The platform will look to address cold chain equipment challenges, with a focus on promoting the right technologies and ensuring reliable and robust equipment performance. The platform will support the purchase, delivery and installation of higher-performing CCE devices, and the training of personnel.

Both the Supply Chain Strategy and CCE Optimization Platform recognize that the public sector can benefit greatly from private sector collaboration to address these supply chain challenges and help create a long-term sustainable model. The private sector has developed market driven, efficient supply chain operations and advances that the public sector can learn from. Stimulating the collaboration of local private sector partners in the public domain supports the development of proficient, sustainable models.

1.1 Guidance document

This guidance document provides country decision makers who are either planning the procurement of CCE or who have already installed CCE with fundamental principles for seeking and maintaining CCE. The guide identifies key decision points encompassed in determining cold chain equipment maintenance services and how best to manage these services. The guide defines the various options, advantages and disadvantages when using either an insourced, outsourced or a combination of both (hybrid) solutions for CCE Maintenance.

The document describes the CCE maintenance approaches namely: reactive, preventative and predictive maintenance identifying the use scenarios. Risk and Asset management are described as they form key tools which should be used during the CCE maintenance decision making process.

This guide focuses on implementing an efficient cold chain equipment maintenance environment aligned to the GAVI CCE Optimization Platform mechanism.

2. Overview

2.1 Rationale for cold chain equipment (CCE) maintenance

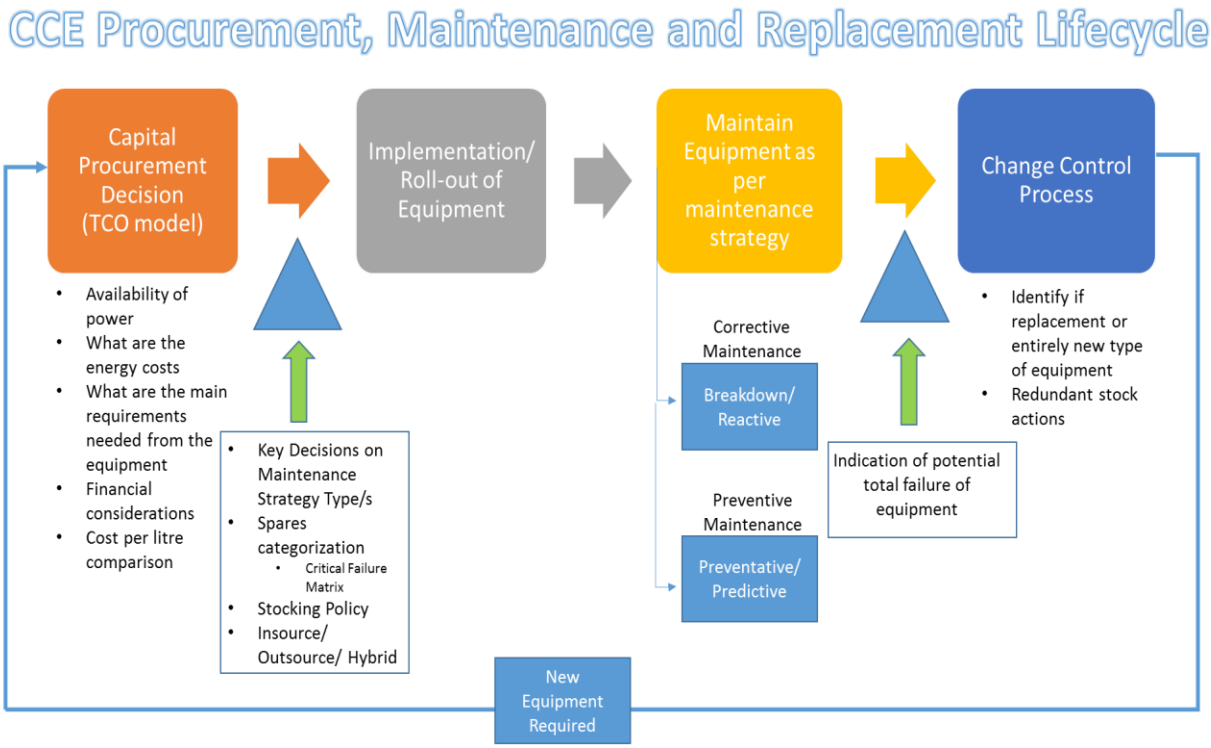
A “cold chain” is a temperature-monitored and controlled supply chain. The goal of the cold chain is to keep a vaccine or other material within a certain temperature range during all stages of delivery, processing and storage. Cold chains are widely used to ensure the integrity of products in the pharmaceutical, food and agricultural sectors, and are critical components of vaccination programs.

To maintain cold chain effectiveness and integrity it is imperative that the CCE is kept in good working order by implementing an effective maintenance system.

Maintenance effectiveness can be defined as the appropriate combination of preventative and repair work to deliver the lowest unit cost in terms of operating cost whilst maintaining cold chain integrity.

3. The CCE Lifecycle and Key Elements to Effect Maintenance

The maintenance equipment lifecycle depicted below indicates the relationship between the initial decision to procure an asset and the maintenance of the asset for its useful life, until it becomes uneconomical to maintain. When procuring CCE equipment, the capital equipment (CAPEX) costs must be considered together with the total cost of ownership. A reference tool for total cost of ownership model (TCO) is available to assist with this process: PATH, Total Cost to Ownership Model 'TCO tool v1 0 2 DRAFT for TechNet 17112015'



Too little preventative maintenance could result in a corrective maintenance philosophy, with high unit costs. Too much preventative maintenance, on the other hand, will lead to over-maintaining, with its associated labor costs and reduced availability also causing unit costs to rise.
The optimum balance of planned maintenance versus repair work changes throughout the life of an asset, and to achieve this, a balanced approach in the application of maintenance techniques should be adopted. In the case of critical CCE with or without backup facilities, regular maintenance checks and condition monitoring would be appropriate, right through to a corrective maintenance philosophy for low cost, low risk items, where it is cheaper to replace than refurbish.

3.1 Procurement of the Asset

Depending on the specific requirements in terms of volumes to be stored, the availability of power, the up time required, the options for disaster recovery in the event of failure and using the TCO model the decision of which equipment to procure can be made.

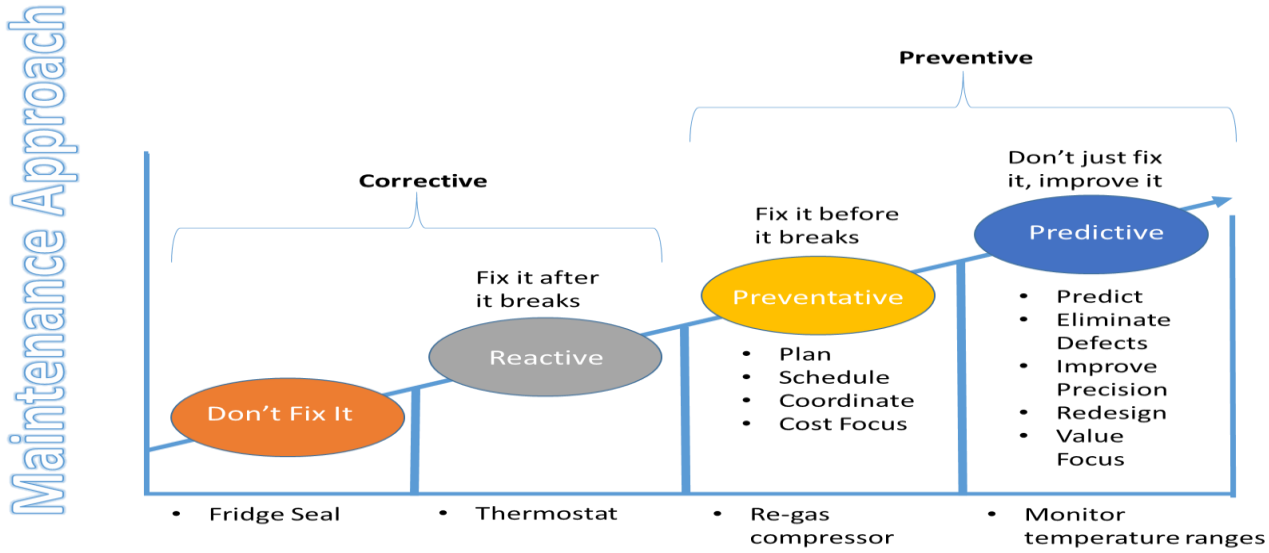
3.2 Maintenance Approach

There are three main approaches to maintenance within the categories of corrective and preventative maintenance. These are:

- REACTIVE
- PREVENTATIVE, and
- PREDICTIVE

There is a decision point of "Don't fix it" under the corrective action approach based on relevant information and standards.

When conducting maintenance it is often necessary to follow all of the above maintenance approaches as indicated in the diagram below:



REACTIVE

Reactive maintenance (also known as "breakdown maintenance") is repairs that are done when equipment has already broken down. Reactive maintenance focuses on restoring the equipment to its normal operating condition. The broken-down equipment is returned to working order within service specifications by replacing or repairing faulty parts and components.

Emergency repairs typically cost 3 to 9 times [1] more than planned repairs, so maintenance plans that rely on reactive maintenance are generally the most expensive and pose the most cold chain integrity challenges. Two key disadvantages of this approach are:

- Time: Reactive maintenance can quickly impact the integrity of the vaccines as the reaction time to correct an issue can be greater than the allowable time for each vaccine type to be outside the temperature range associated with the vaccine.
- Cost: The delivery of emergency spare parts often incurs higher fees, as opposed to the regular, periodic delivery of spare parts to be held in storage. There are also increased costs for CCE technical staff working overtime to repair the CCE and get it operational again in the shortest possible time.

PREVENTATIVE

Preventative maintenance is maintenance that is performed regularly (or scheduled) on CCE, to reduce the risk of it failing. It is undertaken while the equipment is still working, so that it does not break down unexpectedly.

Preventative maintenance is planned so that any required resources, including technical skills and budgets, are available.

The maintenance is normally scheduled based on a time or usage trigger. Examples of an asset with time based preventive maintenance schedules are a) air conditioners, which are serviced before summer every year, and b) a walk in freezer in which the water filter is changed monthly. A typical example of an asset with a usage based preventive maintenance schedule is a motor vehicle, which might be scheduled for service every 10,000km.

Preventive maintenance is more complex to coordinate than reactive maintenance because the maintenance schedule must be planned. It is, however, less complex to coordinate than predictive maintenance because monitoring strategies do not have to be planned nor the results interpreted.

PREDICTIVE

The aim of predictive maintenance is firstly to predict when CCE failure may occur, and secondly, to prevent the occurrence of the failure by performing maintenance. Monitoring for future failure allows maintenance to be efficiently planned before the failure occurs and provides for the identification of failure points between preventative maintenance schedules.

[1] Maintenance Assistant™ https://www.maintenanceassistant.com/reactive-maintenance

Ideally, predictive maintenance enables the maintenance frequency to be as low as possible while still preventing unplanned reactive maintenance, but without incurring costs associated with doing too much preventative maintenance.

Failure can be predicted using available industry techniques. The chosen technique must be effective at predicting failure and must also provide sufficient warning time for upcoming preventative maintenance. Some techniques include Mean Time Between Failure (MTBF) analysis, temperature analysis and equipment observation. Choosing the correct technique for performing condition monitoring is an important consideration that is best done in consultation with CCE manufacturers and condition monitoring experts.

When predictive maintenance is working effectively as a maintenance strategy, maintenance is only performed on CCE when it is required. That is, just before failure is likely to occur. This brings several cost savings:

- Minimizing the time the CCE is being maintained
- Minimizing the breakdown hours lost to maintenance, and
- Minimizing the cost of spare parts and supplies.

These cost savings need to be considered and balanced against the cost requirements for the implementation of condition monitoring techniques with the relevant specialist and experienced personnel.

3.3 Spare Part Availability (and impact of failure)

The ability to maintain equipment either through reactive or preventative maintenance will depend on the availability of spare parts. The availability of spare parts is therefore a key element of whether CCE can be maintained. No matter which maintenance approach is used it is important to understand which parts may result in a catastrophic, significant or insignificant failure, based on the frequency and impact of such a failure.

Part Criticality										
		Catastrophic			Significant			Insignificant		
Frequency of Failure	Frequent	100	100	100	95	85	80	75	70	65
		100	100	95	85	80	75	70	65	60
		100	90	85	80	75	70	65	60	55
		90	85	80	75	70	65	60	55	50
		85	80	75	70	65	60	55	50	45
	Moderate	80	75	70	65	60	55	50	45	40
		75	70	65	60	55	50	45	40	35
		70	65	60	55	50	45	40	35	30
		65	60	55	50	45	40	35	30	25
		60	55	50	45	40	35	30	25	20
	Infrequent	55	50	45	40	35	30	25	20	15
		50	45	40	35	30	25	20	15	10
		45	40	35	30	25	20	15	10	5
		40	35	30	25	20	15	10	5	0
		35	30	25	20	15	10	5	0	0

It is on this basis that it may be necessary to hold spare parts in stock as the cost of a failure may have a greater impact than the cost of holding the stock. However one may reach a time in the lifecycle of the CCE where the particular spare part has never failed and a decision is made to change technology and the part never gets used, and is therefore obsolete at the end of the assets life. The table below indicates a calculation to establish whether the spare part should be held in stock or not. The cost of the Breakdown would be the value of the loss of cold chain items stored in the CCE at any one time

Extra cost per breakdown without the spare part in stock (C)	50000
Probability that the spare part will be used (P)	86 %
Expected downtime cost without the spare part (=C*P)	**43233**
Expected holding cost of the spare part (H)	17030
Expected obsolescence cost if the spare part never will be used (O)	1353
Total spare part costs (=H+O)	**18383**

A controller or thermostat may be defined as a critical part because catastrophic failure could result if it were faulty. If it were faulty the temperature range would not be maintained or the fridge would stop working. A fridge seal may be significant, and one would not repair but rather replace it.

Finally if the decision is not to hold inventory of the spare parts, it is key to understand the supply chain of the spare parts from their source to the point of use, as this too might influence the decision to hold inventory and if not held at the point of use may affect the response time to any failure.

3.4 Resource Requirements for Maintenance Approach

The maintenance approach decided may influence the decision on the number and type of resources required, but it is ultimately the maintenance strategy that will impact on the number of resources required and the skill required.

4. The decision making process

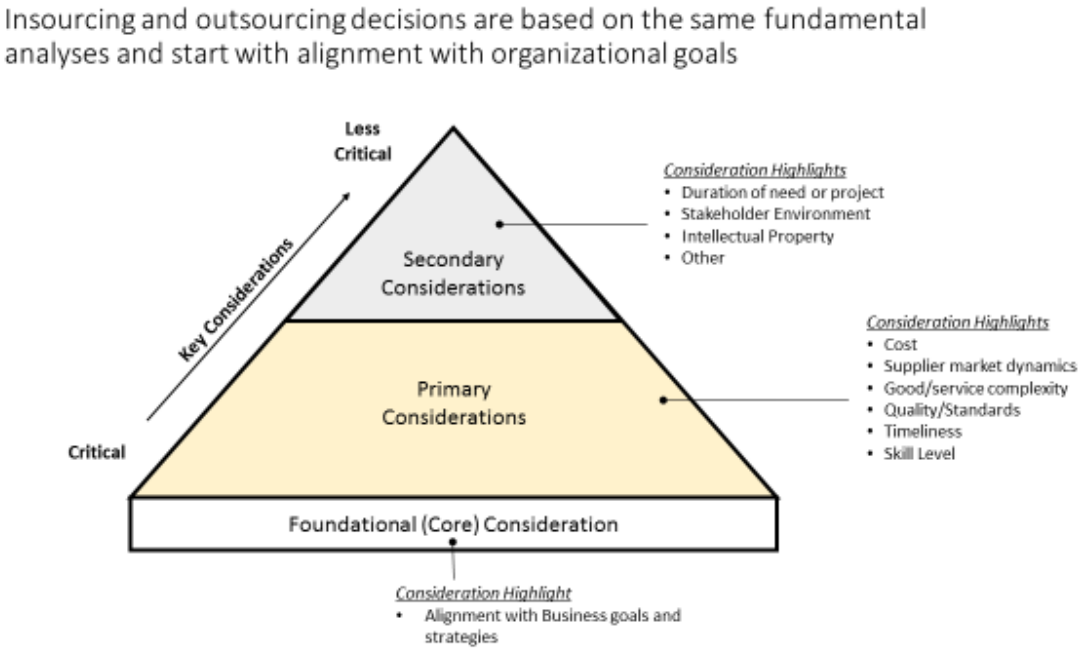
4.1 Maintenance management strategies

The decision on whether to adopt an insourcing, outsourcing or a hybrid CCE maintenance strategy must be aligned with organizational goals. The context of the services, the skills and budget of the organization must also be considered.

A key consideration that organizations use to determine whether to have ownership and management within the business is whether the operation or function is core, primary or secondary to their

organizational goals. Non-core activities may support the essential functions that an organization delivers, but they do not necessarily have to be managed by the organization and can be considered for outsourcing to organizations for which it is a core business.

The diagram that follows depicts the process of determining which activities are less critical to the core business: [2]



Before deciding whether insourcing, outsourcing or a hybrid approach is the best option, it is important to first define business goals. Poorly aligned goals may result in neither option being beneficial. Particular attention should be paid to the advantages and disadvantages of insourcing and outsourcing as the cost, resources, management, quality and accountability are different in each option.

4.1.1 Insourcing

Definition: Insourcing is when a business function is performed internally.

Insourcing can involve bringing in specialists to fill temporary needs or training existing personnel to perform tasks that would otherwise have been outsourced.

[2] Source FP&A Analysis

4.1.2 Hybrid Solution

Definition: This mixed approach leverages both insourcing and outsourcing of activities, with responsibilities clearly defined.

4.1.3 Outsourcing

Definition: Outsourcing entails contracting out a business process or activity to another party with which the organization has a service level agreement for the performance of the required services.

Outsourcing an activity or function does not absolve the organization of the need to supervise and manage the non-core function. The activity is undertaken by experts outside the organization, but the operation must still be managed to ensure that quality standards are adhered to and service levels are met.

5. Maintenance management options

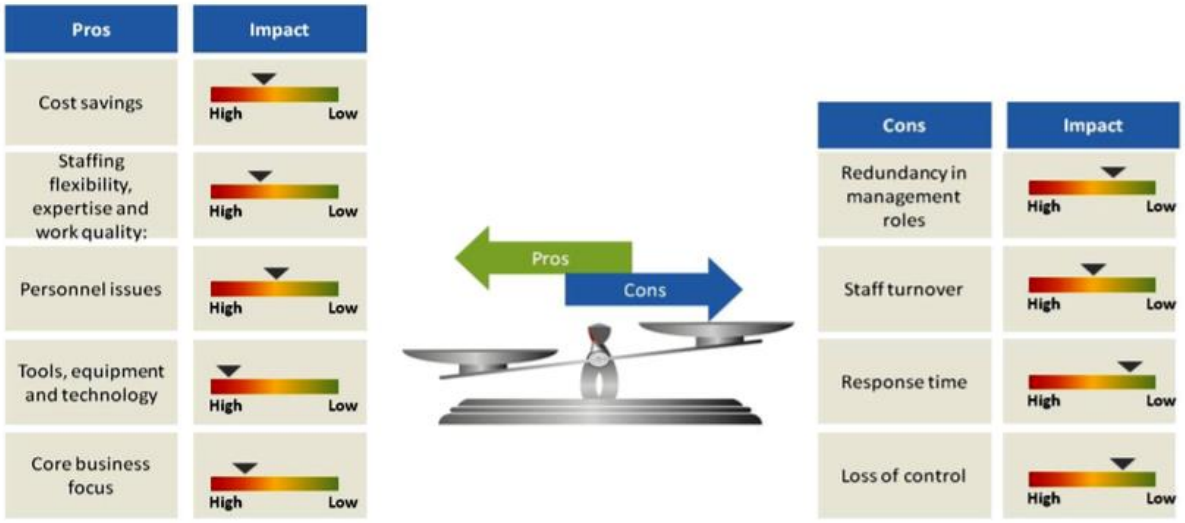
5.1 Advantages and disadvantages of CCE maintenance outsourcing[3]

Any maintenance improvement solution, either internal or external, should measure the cost, skills and equipment down time consequences, in order to devise an action plan to reduce risks. When revising the strategy, the focus must shift away from the labor cost of maintenance towards the total cost of maintenance and its productivity improvements and cost savings.

An ideal third-party maintenance service provider would be focused on staffing the site, developing the needed skills and leveraging their organization's broad skills to reduce the need for and dependency on outside help. Appropriate outsourcing can yield a valuable return on investment.

Outsourcing maintenance services and changing focus from cost to other areas could bring about more effective results, as depicted in the diagram.

[3] http://www.chem.info/article/2014/05/pros-cons-outsourced-vs-house-maintenance



The list below highlights the key advantages and disadvantages of outsourcing maintenance, with particular reference to the following key factors: cost, work quality, obtaining expertise, tools, equipment and technology, risk reduction and management focus on core business.

Advantages

Cost savings: Cost control is a driving issue for most industries and a prime motive for outsourcing. In-house staff wages and benefits (such as pension, medical and vacation) may have become too costly for the company to subsidize. Cost is also a function of a service provider's ability to flex up and down faster than in-house staff; additionally, hiring costs are absorbed by the service provider. An outsourced service provider assumes the burden of these and other financial liabilities associated with staff.

Staffing flexibility, expertise and work quality: An outsourced CCE service provider can offer flexibility in delivering the proper staffing level and required skill set quickly, with less cost and time investment, as well as providing expertise that may not be available, or is inadequate, within the in-house staff. This expertise will also positively impact the quality of the work being performed. It provides the flexibility to utilize specialized services as needed, instead of incurring the cost of developing in-house competencies that are not needed on a permanent or continuous basis.

However, it should be remembered that this is also a potential weakness. Dependent upon location, and in certain markets, the craft pool may be limited and the required skill sets may not be easily obtained. Or, if they are acquired, they may command top dollar and cost more in the long run.

Personnel issues: In the majority of instances, when an organization completely outsources its maintenance function, personnel grievances, disciplinary actions and issues become the responsibility of the service provider. Former in-house activities such as payroll, time keeping, labor relations, HR and

benefits are handled by the service provider, releasing management from the responsibility and time requirements of doing so.

Tools, equipment and technology: An outsourced service provider can provide staffing well-versed in the usage of the most current technology, without the need for the company to provide training to the in-house staff in its use, or the cost of acquisition of the technology/equipment. The same holds true for specialized tools and equipment, in that the service provider would be required to supply the tools and equipment to perform the work required.

Core business focus: Outsourcing allows management to concentrate on their core proficiencies and critical objectives to drive the business.

Disadvantages

Loss of control: Outsourcing the maintenance function may be cost-effective, but there are restrictions when working with service providers, such as the host company's inability to directly manage and instruct the workforce. Another example is it may be difficult for a service provider to fulfill all of a client's requirements, such as staff flexibility or craft availability, within the host company's expectations. Also, the client and contractor may have different approaches, management styles and philosophies, which can lead to conflict.

Staff turnover: In-house employees are inclined to have more years of service at a facility than employees of a service provider and know the business and its expectations better. This is a common issue for clients, as outsourced staff do not, as a rule, possess as much allegiance to the company. As such, the intellectual knowledge they possess in regards to a site's maintenance function, equipment and business model is more readily lost if/when they leave, as their loyalty is more tenuous.

Redundancy in management roles: Roles may be duplicated within a client and service provider, contributing to overall cost. Overlapping roles and responsibilities can lead to inefficiencies within the maintenance organization and contribute to the appearance of too many bosses and not enough workers, creating conflicting priorities and confusion.

Response time: When dealing with specialty contracts such as PLCs (programmable logic controllers), refrigeration and complex compressors, a response time to problems may be handled more rapidly in-house when compared with a phone call to an offsite vendor. The host company must balance the needs of the site against the decision to outsource this work and negotiate an acceptable response time, such as 24 or 72 hours. Since a longer response time equates to more downtime and lost production, this response time must be clearly defined in the contract, or the host company may be unable to meet their goals and objectives.

In conclusion, it is up to the end user to determine the cost-effectiveness, control, flexibility and focus required at their unique site to properly manage their maintenance function within their particular budgetary constraints. Outsourcing does not mean abdication of management responsibilities, on the

contrary, outsourcing requires dedicated management personnel tied into the CEE maintenance process. Only with a detailed examination of these factors can it be realistically established whether outsourcing is a viable option or not.

Before deciding whether insourcing or outsourcing is the best option, it is important to first define business goals. A poorly defined objective may result in neither insourcing nor outsourcing being beneficial.

5.2 Why outsource?

More frequently, governments are considering contracting out different aspects of supply chain management to the private sector, in order to free up human and financial resources. Outsourcing can take many forms. Contracted services can be tailored to address start-up costs or initial barriers to private sector engagement. Outsourcing has often been used effectively for warehousing and distribution of commodities in order to leverage professional SCM expertise to optimize distribution routes, improve efficiency, increase data visibility, improve fleet utilization and handle seasonal peaks.

Capacity building to increase the capabilities of health care workers has also been outsourced successfully. Private sector organizations can provide training and supervision at the point of service delivery, or can train the trainers on the administration of commodities, moving away from a silo approach. Universities can be engaged for pre-service training of health care personnel. Private sector engagement initiatives can also strengthen contracting skills in the public sector.[4]

Typical benefits sought through outsourcing usually include reduced costs. Cost savings can sometimes be achieved when service providers take responsibility for investment in cold chain equipment, refrigerated vehicles, fuel, and skilled technicians, for which the government pays an agreed fee

There is no single position regarding maintenance outsourcing that is correct for all organisations. With this in mind though, there is tremendous value in retaining core maintenance competencies and developing internal maintenance expertise on equipment that is key to the cold chain process.

In this case, maintenance contracting refers to an organisation hiring external resources to perform CCE maintenance, while the maintenance being performed remains under the direction of the hiring organization. Maintenance outsourcing requires handing over accountability and responsibility for the entire maintenance process to a third-party service provider.

The caution, however, is that it is quite probable if externally owned and controlled, the personnel and therefore the expertise could be lost if and when the supply contract comes up for renegotiation. A consideration when outsourcing would be the service provider's staff turnover rate, which could impact on their ability to service the equipment that they are responsible for.

[4] United Nations Commission on Life-Saving Commodities for Women and Children, Technical Reference Team on Supply and Local Markets, Revised, December 2015

5.3 Critical criteria for service provider selection

There are 10 key questions to consider when assessing service providers for outsourced CCE maintenance:

There are 10 key questions to consider when assessing service providers for outsourced CCE maintenance:

How does the service provider recruit maintenance technicians?
Does the service provider provide key metrics or KPIs?
Is there any provision made for guaranteed cost savings?
Is the service provider a company that embodies a continuous improvement culture?
Will the service provider provide ongoing technical training to its employees?
Has a site visit been conducted where this company is currently working?
How difficult will it be to recreate the maintenance department if outsourcing fails?
Is maintenance one of the organization's core competencies?
Should repairable parts be included in the outsource contract?
Is the company being considered up to speed with the organization's enterprise software?

5.3.1 Track Record

While each one of these points is important, it's critical to know that the organization will be working with a company that has a good track record with major national or regional cold chain manufacturers or wholesalers.

The staff employed at the outsourced company need support as well, including ongoing training and room for career path advancement. A professional maintenance service provider should provide this, which also means that recruiting serious maintenance talent is much easier, and the retention of these skilled individuals is much higher.

A clear cut performance plan needs to be set up with the service provider. Many of these companies promise productivity improvements so any guaranteed savings should be built into the contract.

How well the service provider blends into the organization's culture is also important to their success. If the organization has a lean, continuous improvement culture that emphasizes safety, then a service provider should shares the same ideals.

To be successful in any outsourced venture, the organization's management must allow the service provider to perform what they have been hired to do. A good service provider will have a strategy map that will drive the process of improvement.

5.3.2 Area of support available

The service provider should be able to provide for a maintenance plan that covers all locations. If an individual company cannot cover all locations then there is a need to identify multiple service providers in order that a total service is created.

5.3.3 Scoring Mechanism

Company Evaluation Criteria	Rating	Description
Company Name:	4	Essestial
Scope: Fully outsourced/ Hybrid	3	Important
	2	Preferable
	1	Not important

COMPANY EVALUATION CRITERIA	Rating		
	Company 1	Company 2	Company 3
Quality System for deliverables:	0	0	0
Technical Competance:	0	0	0
Planned Mainteneace Software/ System:	0	0	0
Past Performance/ References:	0	0	0
Warehouse/ Storage capabilites	0	0	0
Supply Chain Capability (Import, Clearing)	0	0	0
Strategic:	0	0	0
Innovation:	0	0	0
Financial viability:	0	0	0
Risk and Insurance:	0	0	0
TOTAL	0.00	0.00	0.00

5.4 Outsourcing risk factors

There are a number of key factors that are essential to consider before making any maintenance management decisions, to avoid derailing maintenance operations:

6. Procurement of outsourcing services

The agreement and implementation of a comprehensive, practical service level agreement (SLA) with the selected outsource service provider is fundamental to the oversight and management process post selection stage. The SLA is a working document that includes the details which:

- Establish realistic expectations for the selected service provider.
- Inform the provider what is important in maintaining the up-time of the CCE to ensure cold chain integrity for the vaccines.

- Indicate how the provider should focus and prioritize.
- Detail Key Performance Indicators (KPI) against which the provider's performance is measured.
- Provide clarity on the responsibilities of both parties.

Creating the SLA provides a solid foundation upon which to build a productive partnership with your service provider and the document should include:

6.1 Minimum Requirements for a Service Provider

- Define the minimum requirements for preventive and routine maintenance in accordance with the relevant equipment manufacturer's recommendations.
- Set minimum requirements, but ensure that the maintenance plans and task sheets take into account the individual particulars of the CCE concerned in terms of its condition, age and type.
- Establish the number of visits per annum to be carried out for maintenance on all the CCE listed.
- Include the provision and application of all consumables and minor adjustments within the price.

6.2 Geographical Areas to be covered

- Provide comprehensive details and reflect the location of all CCE so that the service provider can select or define those areas where they have support.
- Dependent on the longevity of a contract, the service provider may need to create the support for those areas where they currently have no support.
- Include detail of the number of CCE technicians and their qualifications/levels of experience that should be provided for each of the designated areas supported by the service provider.

6.3 Assets to be maintained

- In line with the CCE Inventory Form shown in Appendix 1, the agreement with the service provider should include an exhaustive list of all CCE, including the manufacturer's details, the equipment's location, age and condition.

6.4 Schedules for maintenance

- Each type of CCE should be maintained according to the manufacturer's conditions of use. General maintenance required on an ongoing basis should also be included. This information should be sought from the manufacturer and covered in the SLA, as it will form the basis for the establishment of the schedules of annual maintenance for each location and area.

6.5 Service levels required

- The minimum support level should be included in the SLA, and should define response time periods - from reporting a fault to completing the relevant corrective action.
- Support must be available 365 days a year for critical equipment.

6.6 Customer References

- In addition to visiting known customers of the service provider, written references should be obtained, in order to confirm that the service provider adheres to contractual service level terms, and to get the opinion of other customers on the technical abilities of the service provider and its technicians.

The eight main steps in creating a practical SLA are outlined on the following pages:

Assess the current situation	•Review the current situation. Ask yourself if the maintenance program you're providing is enough to satisfy the needs of maintaining cold chain integrity throughout the supply chain. If it is, then you may only need to "tweak" this service to boost the maintenance program beyond its stated objectives. •If it's not, then you need to create a realistic plan for achieving the level of cold chain integrity that will boost the maintenance program beyond its stated objectives. Base the plan on feedback from cold chain integrity evaluations; health facility reports; assessment of the needs for ongoing maintenance and repairs
Define the level of service	•Include elements like the scope of service required, the purpose of the service, and all key information as well as the specific operational processes. Also include the impact of cold chain integrity loss, so the provider gets a sense of what's at stake.
Define the terms of the agreement	•Having defined the service levels, define the provider's roles and responsibilities and its duties, the agreement's duration, and the applicable service times. For cold chain integrity this has to be set at a 24 hour; seven days a week support for the full year of 52 weeks. •It is essential to define that there cannot be any exceptions to the service times, such as holidays, maintenance periods, and so on. Defining this lack of exceptions is critical to judging a provider's performance.
Set performance levels	•Make sure both the minimum AND the expected levels for service are included, as well as any times the service is considered either unavailable or limited. •Here the "expected level" is what is being paid for while the "minimum level" is what would be considered poor—that is, borderline unacceptable service. •Examples for instance would include: response times to call-outs, availability of spare parts, resolution time to eliminate problems, costs incurred, levels of acceptable downtime for CCE caused by poor response times

Record escalation procedures	•Having set service standards, indicate the steps to be taken when service levels fall below these standards. These steps should include two things: (1) the reason for missed activities and (2) the reporting time and the problem resolution within a specified time.
Define the project's metrics	•The key to defining metrics is using ones that can be easily tracked and fit the situation. •Metrics commonly used include: Mean time between failures (MTBF), Mean time between service incidents (MTBSI), Mean time to restore service (MTRS), Turnaround time, Uptime •It would also be prudent to include time-to-restore service, the time service is considered to be unavailable, availability and reliability targets, and Maintenance downtime.
State conditions and fees	•State both the conditions and fees (if any) clearly. Also state the exact circumstances under which the fees may apply as well as any exceptions. •The clearer these statements are the less chance for disagreement and the better the provider's performance.
State SLA exclusions	•Provide a list of exclusions in which time is not enforced against the SLA measurement, such as scheduled and emergency maintenance. Also include in the SLA provisions for failure of a third party that the provider has no control over. •This is also a good place to state when the "CCE is down"—technically, any time that the CCE is deemed unusable by any of the central stores or the health facilities.

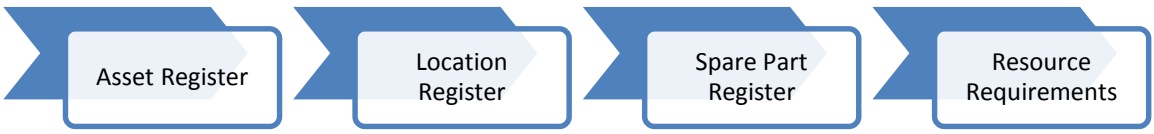
Developing a comprehensive yet practical SLA is a key step in implementing an outsourcing project that succeeds. It sets realistic expectations for the service provider and outlines what is critical to maintain the cold chain integrity for the vaccines. An effective yet practical SLA also tells the provider what the expected service levels are and how its performance will be judged.

7. Tools and systems for use with CCE maintenance

Whether a CCE maintenance system is insourced, outsourced or using a hybrid model, tools are required to supervise and manage the maintenance. These are standardized methods and systems to monitor performance and inform continuous improvement actions. The tools, methods and systems provide mechanisms to gather data and information from which the management can review and analyze root causes for challenges, in order to define corrective actions and successful interventions that can be replicated.

A number of these tools, methods and systems are identified here:

Having established the business strategy and aligned goals for operational principles, the next priority is to understand the extent of the CCE maintenance activities that need to be performed. To gain a comprehensive understanding of the requirements, the following steps should be followed:



7.1.1 Manual asset and parts management system

1. Asset register or database

- Create an asset register of each type of CCE in each location (reference Appendix 1 Cold Chain Equipment Inventory Form)
- Identify and record the manufacturer's recommended maintenance requirements for each of the CCE assets.
- Identify and record the manufacturer's recommended maintenance intervals for each of the CCE assets.

2. Location register

   - Determine the number of locations and the number of CCEs per district. The geographic spread will not only determine the in-house CCE technicians required but also provide a base for negotiations for any future outsourcing negotiations.

3. Spare parts register:

   - Identify the spare parts required for the maintenance of the assets
   - Classify spare parts as either critical or non-critical. (The primary components of the refrigeration cycle are the compressor, the condenser, the evaporator or cooling unit, and the thermostat that controls the cycle.)
   - For critical parts, define the impact should a part fail, as indicated below, by taking into account the frequency and impact of the failure.

4. Support resource requirements:

   - Using the register database and the application of the maintenance program intervals, the required resources can be established to deliver maintenance support.
   - Determine what human resources are available as an in-house option and the extent of their technical knowledge.
   - If the resources are insufficient to meet the preventative maintenance program then there is a need to research other options, including:
     - Employing more CCE technical staff,
     - Outsourcing the maintenance and repair function to a third-party service provider
     - Or determining what tasks can be carried out by the CCE technicians already employed together with the local health facility staff and then offering the balance of the tasks to a third party service provider – thereby creating a hybrid solution.

   There must be a level of technical skill, however minor, at all levels throughout the cold chain. The tasks to be carried out will depend on the technical knowledge available with the current CCE staff but it could be sufficient to create a repair function in the event of CCE breakdown with an external third-party service provider, leaving all routine tasks for the organization's staff.

   Where cold stores are to be maintained at either central or regional levels, requiring walk in cold rooms or freezers, the skill level and expertise needed is of a much higher level.

7.1.1 Maintenance and fault reporting systems

To facilitate the oversight control of an in-house CCE maintenance function, the implementation of a computerized maintenance management system (CMMS) should be considered. The following are examples of the functionality that should be available within such a package.

- Asset Tracking

The organization must be able to track an unlimited number of assets in various locations, whether they are in warehouses or health facilities. The software should be flexible; to allow it to be adapted to any type of asset that requires preventative maintenance.

- Maintenance Notifications

Automated preventative and repair maintenance alerts control what needs to be done when. These alerts should be a mix of visual indicators, pop-ups, and email notifications, so that management and the maintenance staff can be alerted when maintenance is due.

- Preventative Maintenance

The software should allow management to configure the preventative maintenance tasks by date, hours, mileage, kilometers, revolutions or a customized definition. Automated maintenance alerts should be provided on-screen or via email to facilitate control of the CCE maintenance requirements.

- Spare Parts Inventory

Categorization of spares is important in order to have the appropriate inventory on hand to maintain or repair the equipment at the time of a breakdown or scheduled maintenance. Balancing the cost of holding spares and the possibility of being "out of service" should also be considered.

Once the spares are categorized, the decision can be made through a defined stocking policy on what the inventory levels should be, where they are stored and who carries the cost, depending on the approach to insourcing/outsourcing the service.

As part of the CCE maintenance function, a software package should provide for the maintaining of a spare parts inventory that Itemizes and tracks usage of the CCE parts when maintenance is performed.

- Repair Maintenance

The software must effectively manage breakdowns or unexpected issues that occur with the CCE assets. The recording of potential problems must be allowed so that the problems can be rectified before costly breakdowns occur.

- Work Orders

To control work effort and consequent costs, the software should generate work orders based on preventative maintenance due or repair requests. It should provide for the monitoring of the work order's status, from start to completion, and should easily indicate parts and labor required.

- History Recording

It is important that the management is able to evaluate the efficiency of the CCE assets in relation to what they are costing in maintenance and up-time. A detailed maintenance history helps decrease downtime and provides vital statistics to aid the organizations management in decision making.

- Reporting & More

As with any other software system, it should offer print and email functionality, or be able to export from a wide range of reports - from simple asset listing reports to detailed cost analysis reports. In order for the management to create specific reports, a report-generator should be part of the software, to enable the Medical Stores management to adjust any report to meet their needs.

See Appendix 10 for examples of the types of screen formats and data requirements for such models.

During the landscape analysis in DRC, the project team member witnessed firsthand the use of a CMMS software package called Dimo Maint (http://www.dimomaint.com/). There are many CMMS software solutions available. The top-ten rated solutions, by Capterra (http://www.capterra.com) are:

		Customers	Users
1	Facility Dude	6,798	2,000,000
2	ManagerPlus	10,000	450,000
3	DPSI	6,250	50,000
4	eMaint	6,140	35,000
5	FaciliWorks	6,500	42,000
6	Maintenance Connection	1,500	250,000
7	Corrigo	5,500	22,000
8	MicroMain	5,000	30,000
9	MPulse	2,700	15,000
10	eWorkOrders	300	60,000

7.2 Asset management tools

In many communities, assets are increasingly stressed from over-use, under-funding, poor maintenance and aging, with no replacement policy in place. Public Health sector managers have been managing assets for decades. However, it is becoming clear that what they have been doing in the past will not be sufficient to address the growing and increasingly complex challenges that lie ahead.

Practical, advanced techniques for better managing physical assets have been developed and refined over the past several decades around the world, and can be leveraged by the public sector.

Asset management is a body of management practices:[5]

- That is applied to the entire portfolio of assets at all levels of the organization;
- That seeks to minimize the total cost of acquiring, operating, maintaining and renewing the assets within an environment of limited resources;
- While continuously delivering the service levels the health facilities desire and regulators require at an acceptable level of risk to the organization and the health facilities.

Appendix 1 sets out the extent of data required to be stored in the asset register described under the Maintenance Management Requirements section 5.

7.3 Depreciation methodology

It is imperative that the financial consequences of any maintenance and repair system are recorded, not only in terms of spares, wages and capital cost, but also in terms of the write-down values of the CCE. Therefore, the estimated life of each type of CCE asset has to be estimated and this value used to determine the depreciation cost of each of the assets.

What is depreciation?

The monetary value of an asset decreases over time due to use, wear and tear or obsolescence. This decrease is measured as depreciation. It may also be caused by a number of other factors, such as unfavorable usage conditions. CCE and refrigerated vehicles are some examples of assets that are likely to depreciate over a specific period of time.

Some accounting practices take the level of depreciation for each asset and then create a procurement reserve to replace the asset at the end of its useful life.

[5] Sustainable Infrastructure Management programme Learning Environment

7.4 Change control system

When, at any point during the CCE procurement, maintenance and replacement lifecycle, a decision is considered to replace equipment or buy new equipment, a formal approach to change management should be followed, to ensure that the information and approvals are captured.

A change control system should be formalized within an organization, defining the procedures to follow and stakeholders to include in the decision process. The oversight by relevant stakeholders is required to ensure that changes are introduced in a controlled and coordinated manner. Risk reviews are a key part of the process, to avoid introducing action that may derail current operations, to ensure minimal disruption to services and to maintain cost-effective operations.

Appendix 4 Change Control form provides the necessary framework and guidance when conducting any changes to CCE.

7.5 TCO (Total Cost of Ownership) model[6]

Total Cost of Ownership (TCO) is an analysis meant to uncover all the lifetime costs that follow from owning certain kinds of assets. For this reason, TCO is sometimes called life cycle cost analysis.

Ownership brings purchase costs, of course, but ownership can also bring substantial costs for installing, deploying, operating, upgrading and maintaining the same assets. For many kinds of acquisitions, TCO analysis finds a very large difference between purchase price and total life cycle costs, especially when viewed across a long ownership period.

TCO analysis begins when the owner or analyst identifies (a) the specific resource or asset to be acquired, and (b) specifies the ownership life as described in the previous section. The ownership life is given as a number of years with a known starting date and ending date.

TCO analysis continues when the owner or analyst identifies all the cost categories that can be expected to have cost impacts from ownership. TCO analysis is successful when the owner includes two major kinds of cost categories that will see cost impacts across ownership life; these are obvious costs and hidden costs.

[6] PATH Total Cost To Ownership Model 'TCO tool v1 0 2 DRAFT for TechNet 17112015'

Obvious costs in TCO analysis	Hidden costs in TCO analysis
Obvious costs in TCO are the costs familiar to everyone involved during planning and vendor selection, such as: • Purchase cost i.e. the actual price paid. • Maintenance costs such as warranty costs, maintenance labor, contracted maintenance services or other service contracts.	The so-called hidden costs are the less obvious cost consequences that are easy to overlook or omit from acquisition decisions. Costs of this kind can be very large and real, nevertheless. All belong in the TCO analysis if they do indeed follow from the decision to own something and they are material (large enough to matter).

Comprehensive acquisition cost analysis needs to be identified and considered for all cost aspects of identifying, selecting, ordering, receiving, inventorying or paying for a commodity, including:

- Upgrade / enhancement / refurbishing costs.
- Reconfiguration costs.
- Set up / deployment costs: costs of configuring space, transporting, installing, setting up and integrating with other assets and outside services.
- Operating costs: for example, human (operator) labor, or energy/fuel costs.
- Change management costs: for example, costs of user orientation, user training and workflow/process change design and implementation.
- Infrastructure support costs: for example, costs brought by the acquisition for heating/cooling, lighting.
- Environmental impact costs: for example, costs of waste disposal/clean up, pollution control or the costs of environmental impact compliance reporting.
- Insurance costs.
- Physical security: for example, security additions to a building, including new locks, secure entry doors, closed circuit television and security guard services.
- Financing costs: for example, loan interest and loan origination fees.
- Disposal / decommission costs.
- Depreciation expense tax savings (a negative cost).

TCO brings out the hidden costs of ownership, and should be carefully understood and utilized, with the selection of cost elements that reflect the costs associated with the usage and life of the CCE asset. It must also be understood that TCO facilitates the development of cost comparatives when procuring replacement CCE which, if cost is an issue, assists in creating an additional support in the decision-making process.

7.6 Maturity modelling tools

Developing an understanding of the organization's capability and capacity to manage CCE maintenance delivery will enable the stakeholders to determine where potential gaps may exist, in order to

determine the necessary supportive actions. One of the tools often used to do this is a maturity model which assesses the capability of select activity to impact the service delivery

To enable the rapid analysis of the organization, this table was defined as an example, indicating across 5 levels the maturity the expected capability for 10 area of competence, namely:

Rating Level	Area of Competence
5. Inadequate	• Strategy • Organization management • Data management • Maintenance tactics • Materials management • Planning & scheduling • Performance measures • Reliability centered maintenance • Autonomous maintenance • Process redesign
4. Awareness	
3. Understanding	
2. Competence	
1. Excellence	

While this tool does not manage bias and is not statistical in its calculation of maturity, it is a mechanism for the organization to complete an assessment to determine areas of strength and weakness for greater analysis as necessary.

* SEE Appendix 11 – Equipment Maintenance Maturity Model

8. Risk management

Risk management is an increasingly important business driver and stakeholders have become much more concerned about risk. A successful risk management initiative should be proportionate to the level of risk in the organization (as related to the size, nature and complexity of the organization), aligned with other corporate activities, comprehensive in its scope, embedded into routine activities and dynamic by being responsive to changing circumstances.

8.1 Intended benefits of risk management

For all types of organizations, there is a need to understand the risks being taken when seeking to achieve objectives and attain the desired level of reward. Organizations need to understand the overall

level of risk embedded within their processes and activities. It is important for organizations to recognize and prioritize significant risks and identify the weakest critical controls.

8.2 Recording risk assessments

Risk assessment involves the identification of risks followed by their evaluation or ranking. It is important to have a template for recording appropriate information about each risk. Table 1 shows a typical RAG (Red, Amber, and Green) risk table. The objective of a template (Table 2) is to enable the information to be recorded in a table, risk register, spreadsheet or a computer-based system. Although a simple description of a risk is sometimes sufficient, there are circumstances where a detailed risk description may be required in order to facilitate a comprehensive risk assessment process.

Table 1

Inherent Risk	
Extreme	5
High	4
Moderate	3
Low	2
Insignificant	1

Table 2

Category / Inherent Risk	Extreme	High	Moderate	Low	Insignificant	Total
No technical resources		4				
No scheduled maintenance		4				
No critical spares	5					
Budget and costs not considered			3			

8.3 Identification of risks

Common risks in cold chain equipment maintenance

In any cold chain maintenance process there are usually a number of common elements, or items that will exist. These could include:

- No regular checks performed on CCE
- Insufficient equipment and infrastructure
- No back-up system or redundancy
- Availability of in-country spare parts
- Access and availability of competent services and resources

8.4 Risk profile

Risk profiling entails analyzing the threats to which an organization is exposed. The risk profile will outline the number of risks or threats, the type of risks and their potential effects on the organization. This outline will enable the organization's management to anticipate additional costs or disruption to the deployment of vaccines

Examples of risk associated with the deployment of vaccines and the associated CCE are:

- Staff lacking sufficient technical knowledge needed for installation and maintenance.
- Lack of robust maintenance plans and budgets for equipment maintenance.
- Too many different brands and types of refrigerators installed in rural health centers across the country. With such diversity in equipment, the Ministry of Health is challenged to store all of the spare parts necessary and to ensure there is requisite technical knowledge to conduct maintenance and repairs.
- New vaccine introduction that also increases the country's cold chain needs.

Lack of adherence to appropriate vaccine stock management practices:

- Over-stocking of vaccines in cold storage and poor shelving of packages leads to restricted air flow, which can present freezing risks or increased exposure to heat.
- Overstocked or poorly stored vaccines can complicate adherence to the earliest-expiry-first-out (EEFO) principle, running the risk of excessive discarding of expired vaccines.

There are a number of risks associated with staff:

- High staff turnover, particularly in rural settings, impedes knowledge on and adherence to stock management and cold chain maintenance.
- Trained health workers will often be transferred to other geographic areas and health departments; new personnel coming into the immunization department do not receive proper training in these areas.
- This turnover exacerbates issues with stock management and other poor practices, such as using the refrigerators for personal food or beverage items.
- Additionally, there is a common misconception that as long as vaccines are kept cold their viability cannot be compromised, resulting in misinformed health center staff setting vaccine refrigerators at lower than optimal temperatures.
- The temperature monitoring form should be manually completed twice a day by the health workers, to record refrigerator temperature. These forms are often improperly completed. *There is anecdotal information of the forms being filled out at the end of the week or just before a supervisor's visit.*
- Insufficient technical personnel.

8.5 Risk mitigation

Develop a **mitigation** strategy. This is an overall approach to reduce the **risk** impact severity and/or probability of occurrence. It could affect a number of **risks** and include, for example, increasing staffing or reducing scope. Identify actions and steps needed to implement the **mitigation** strategy.

The following recommendations should be considered:

- Create a team of knowledgeable staff who can assist in identifying the risks associated with CCE failure as they relate to the country's vaccine deployment.
- Obtain from all CCE manufacturers their stated estimate of the "Mean Time Between failure" (MTBF) statistics for the makes and models acquired and planned to be acquired.
- Prepare a schedule that highlights the MTBF for each and every item of CCE by location.
- Determine the age of all CCE.
- Develop a forecast of when the manufacturers' assess that failure for their CCE will occur.
- Determine the actual response times between notification of CCE failure and the response of the maintenance engineer (getting to the location) – whether that be in-house or an outsourced service provider.
- Establish the types of equipment failure that have occurred and establish the reasons for the failures.
- Establish where cold chain integrity has been compromised and when it has related to equipment failure or misuse.
- Evaluate all standard operating procedures (SOPs) relevant to CCE and its usage. Determine where there are shortfalls when comparing the SOPs to the CCE failures and rectify the SOPs.
- Ensure that maintenance plans are robust and are being actioned according to the requirements for each item of CCE.
- Ensure that the response times to CCE failure are within the prescribed times from notification of the failure.
- Ensure that maintenance budgets are "ring-fenced" and not able to be diverted into other activities.

9. APPENDICES

APPENDIX ONE	COLD CHAIN EQUIPMENT INVENTORY FORM
APPENDIX TWO	TEMPERATURE RECORDING FORM
APPENDIX THREE	FAULT AND BREAKDOWN REPORTING FORM
APPENDIX FOUR	CHANGE CONTROL FORM
APPENDIX FIVE	COLD CHAIN VALIDATION LOG
APPENDIX SIX	TEMPERATURE LOGGER'S LOG
APPENDIX SEVEN	IN-HOUSE MAINTENANCE CHECKLIST
APPENDIX EIGHT	DIAGNOSTIC PROTOCOL
APPENDIX NINE	OUTSOURCING CHECKLIST
APPENDIX TEN	TYPICAL MAINTENANCE SOFTWARE SCREEN SHOTS
APPENDIX ELEVEN	EQUIPMENT MAINTENANCE MATURITY MODEL

Appendix one COLD CHAIN EQUIPMENT INVENTORY FORM

COLD CHAIN EQUIPMENT INVENTORY												
Information Relating to the Location					Information Relating to the Cold Chain Equipment							
Name	Type of Facility	Total Population	Electricity (Y/N)	Electricity >8 hours in 24 hours	Manufacturer	Model	Serial Number	Current Working Status	Date of Last Assessment	Energy Source (G = Gas K = Kerosene E = Electric S = Solar	Year of Installation	Year of Planned Replacement

If this form can be computerized for populating with the required data by each district or regional technician then it will make analysis that much easier.

APPENDIX TWO – TEMPERATURE RECORDING

TEMPERATURE LOG						
SITE:						
REFRIGERATOR ID#				REQUIRED TEMPERATURE:		
FREEZER ID#				ACCEPTABEL RANGE:		
ENTER TEMPERATURE AND INITIALS DAILY!						
	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
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29						
30						
31						

APPENDIX THREE – FAULT & BREAKDOWN REPORT

COLD CHAIN EQUIPMENT FAULT REPORT		
Submit by Email	**Print Form**	**Reset Form**
Fault Reported By - Name		
Facility Name		
Contact Telephone Number		
Email Address		
Faulty Equipment Details		
Make:		
Model:		
Type of cold store/ refrigerator/freezer		
Serial number		
Date fault occurred		
Type of Fault		
Action Taken		**Results of Action**
Signature of technician		**Date of work**
Parts supplied and fitted		

This form can either be generated from a computer or can be printed for submission via mail.

APPENDIX FOUR – EXAMPLE of a CHANGE CONTROL FORM

Standard Change Request Template:

Change Request	
Project:	**Date:**
Change Requestor:	**Change No:**
Change Category (Check all that apply): ☐ Schedule ☐ Cost ☐ Scope ☐ Requirements/Deliverables ☐ Testing/Quality ☐ Resources	
Does this Change Affect (Check all that apply): ☐ Corrective Action ☐ Preventative Action ☐ Defect Repair ☐ Updates ☐ Other	
Describe the Change Being Requested:	
Describe the Reason for the Change:	
Describe all Alternatives Considered:	
Describe any Technical Changes Required to Implement this Change:	
Describe Risks to be Considered for this Change:	
Estimate Resources and Costs Needed to Implement this Change:	
Describe the Implications to Quality:	
Disposition: ☐ Approve ☐ Reject ☐ Defer	
Justification of Approval, Rejection, or Deferral:	

Change Board Approval:		
Name	**Signature**	**Date**

APPENDIX FIVE - COLD CHAIN VALIDATION LOG

Equipment/Cold Chain Box	Test No.	Purpose of validation

APPENDIX SIX - TEMPERATURE LOGGER'S LOG

Position _____ Month _____	Logger Number	Min Max Thermometer	Alarm Tested
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
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22			
23			
24			

APPENDIX SEVEN - MAINTENANCE CHECK LIST & WALK-IN CHILLER/FREEZER DIAGNOSTIC

ACTIVITY	FREQUENCY	ACTION
SET-UP		
Update of CCE Log	Every 6-months	Ensure CCE log is up-to-date
Review of maintenance procedures	Annually	Produce revised SOPs
Re-calculation of maintenance schedules	Every 6-months	Produce revised schedule
Division of maintenance	Every 6-months	Establish local vs central work
MAINTENANCE - CENTRAL & REGIONAL		
Temperature performance	Twice daily	Review the temperature logs
Alarm system	Twice daily	Check that it is operational
Problem diagnosis	As required	Review faults against the diagnostic list
Obtain manufacturers' recommended spare parts list	6-monthly	Review revised list against spare parts inventory
Check the spare parts inventory	Weekly	Parts inventory system
Manufacturers' check on spare parts	6-monthly	Ensure that spares are not obsolete
Mean Time Between Failure (MTBF)	Annually	Review MTBF for constituent parts of the chiller/freezer
Chiller/life assessment	6-monthly	Review chiller life to determine likelihood of failure
Preventative maintenance	As required	Replace spare parts as and when the MTBF deadline approaches
MAINTENANCE – HEALTH FACILITY		
User manuals	Always	Ensure user manuals are available and plasticised
Refrigerator maintenance	Weekly	Follow the task list
Clean & check the seal/gasket	Weekly	
Check the temperature	Daily	
Adjust the refrigerator temperature to 6^0 Celsius	Weekly	
Clean the condenser coils	Weekly	
Clean drain hole & drip pan	Weekly	
Make sure the appliance is level	Weekly	
Remove and clean the kick plate	Weekly	
Change the water filter	Monthly	
Dump the ice bucket, clean and start fresh		
Make sure there is adequate room around items for air circulation		
In the event of problems, call-in the regional CCE maintenance person	As required	

APPENDIX EIGHT - WALK IN COOLER/FREEZER DIAGNOSTIC PROTOCOL[7]

Walk-in Cooler/Freezer Diagnostic Protocol		
MALFUNCTION	POSSIBLE CAUSE	SOLUTION
Power is on, but control board does not display	Phase loss or fuse blown Power phase open or transformer shorted Control board failure	Check wiring for breaks and replace fuse Check Transformer output voltage (12V) Replace cold storage room control board
Control board displays, but compressor does not run	Compressor relay tripped. Hi-Lo pressure safety switch shut down. Defective contactor or coil Cold room temperature is lower than operation setpoint Internal thermal overload tripped. Compressor malfunction	Determine reason and take correct action Determine type and cause of shutdown and correct it before resetting safety switch. Repair or replace Reset operation temperature setpoint Wait until compressor cools down for reset Check compressor motor winding
High discharge pressure	Dirty condenser coil Fan not running System overcharged with refrigerant	Clean walk-in cooler and walk-in freezer condenser coil Check fan motor and its electrical circuit Reclaim excess refrigerant
Low discharge pressure	Insufficient refrigerant in system. Low suction pressure	Check for leaks; repair and add charge. See corrective steps for low suction pressure
High suction pressure	Excessive load. Expansion valve overfeeding	Reduce load Regulate superheat
Low suction pressure	Lack of refrigerant Plugged suction filter Evaporator dirty or iced. Fan not operate Expansion valve underfeeding	Check for leaks. Repair and add charge Replace suction filter Clean and defrost Check fan motor and circuit control Regulate superheat
Large difference between actual cold storage room temperature and set point on control panel	Incorrect room temperature Sensor placement, wire too long, Sensor contactor open	Re-position sensing point of temperature sensor Enlarge wire section Reconnect sensor
Heavy frost builds up on evaporator fins	Too much time between defrost cycles or incomplete defrosts	Manual defrost and adjust defrost cycle
High temperature alarm	Overload and door open door excessively Bad refrigeration performance Heavy frost build-up on evaporator	Reduce load and door opening See corrective steps for discharge and suction pressure malfunctions Manual defrost and adjust defrost cycle
Coil not clearing of frost during defrost cycle.	Heater malfunction Not enough defrost cycles per day	Check heater operation. Adjust defrost control
Ice accumulating in drain pan	Defective heater. Drain line plugged.	Check heater; replace if necessary Clean drain line
Display screen flashes, unit emits humming noise	Observe alarm indicator	See alarm indicator for remedy

[7] NHS Maintenance Walk-In Chiller/Freezer Diagnostic Protocol

APPENDIX NINE - OUTSOURCING CHECKLIST

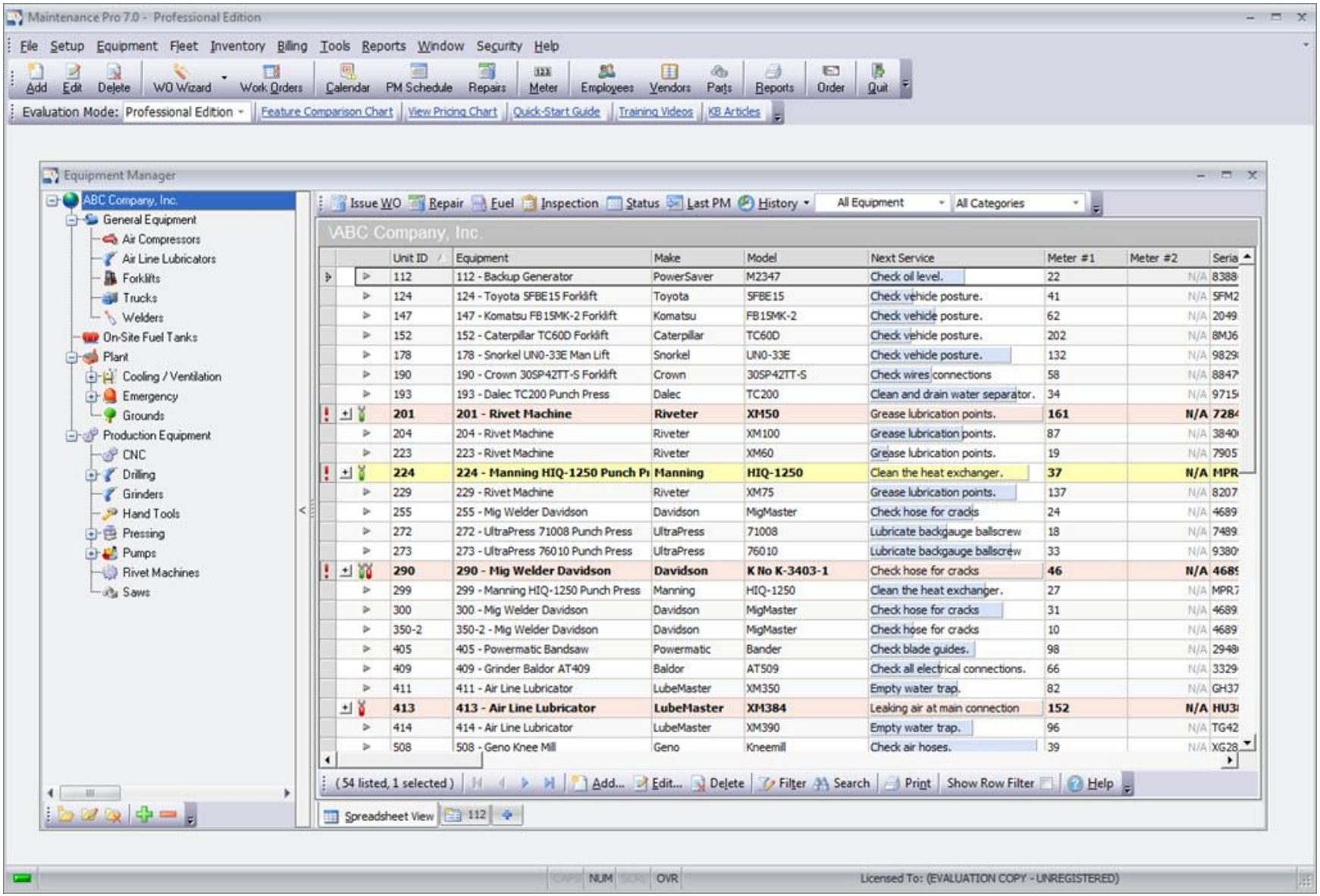
ACTIVITIES TO BE UNDERTAKEN & COMPLETED	Yes	No
Maintenance program objectives and broad scope of work defined		
Geographic areas for maintenance support determined		
Specific maintenance support required is identified		
Specialized expertise requirement determined		
Availability of internal resources checked		
Assessment made of cost and value of outsourcing		
Decision made/approved to outsource		
Maintenance contractor selection criteria defined and prioritized		
Total cost of proposed maintenance program determined		
Purchasing consulted; roles and responsibilities agreed		
Request for Proposal (RFP), including milestones, completed		
Prospective maintenance contractors identified and checked for availability		
Prospective maintenance contractors briefed on program details		
Allow prospective contractors to check the CCE to be maintained		
RFP sent out to final candidates		
Closing date for submissions; proposals reviewed		
Reference checks completed. Due diligence carried out on financial strength		
Preferred maintenance contractor(s) checked for compliance with objectives		
Most suitable maintenance contractor(s) selected		
Unsuccessful candidates notified		
Selected maintenance contractor(s) notified and meeting(s) arranged		
Agreement with maintenance contractor(s) on milestones, SLAs and scope of work		
Maintenance program work plan developed (e.g. Gantt chart)		
Evaluation criteria and metrics agreed for maintenance contractor performance		
Purchase Order(s) created and approved		
Contract(s)/agreement(s) drawn up in conjunction with Purchasing		
Contract(s)/agreement(s) signed by both (or all) parties		
Maintenance program processes established		

ACTIVITIES TO BE UNDERTAKEN & COMPLETED	Yes	No
Program review/status meeting schedule established		
Kick off meeting with team planned and scheduled		
Kick off meeting held for all team members, contractor(s), sponsor and stakeholders		
Create strategy and plan for transition and review contingency plan to ensure smooth transition		
Ensure reason(s) and conditions for hand-over are communicated in writing and agreed to by the maintenance contractor(s)		
Ensure all relevant CCE responsibility and documents are recorded and handed over		
Make payment contingent upon meeting the requirements		
Audit the planned spare parts inventory and ensure its availability		
Ensure maintenance contractor(s) acquit delivery or service obligations		
Ensure that performances are in line with agreed metrics.		
Ensure that a log is completed for all maintenance and repair work undertaken		
Maintain a failure log and the response time analysis		
Undertake periodic meetings with the maintenance contractor(s) to resolve any issues and to monitor progress		

APPENDIX TEN - TYPICAL MAINTENANCE PROGRAMME SCREEN SHOTS

FROM THE MAINTENANCE PRO SOFTWARE SYSTEM

ASSET TRACKING



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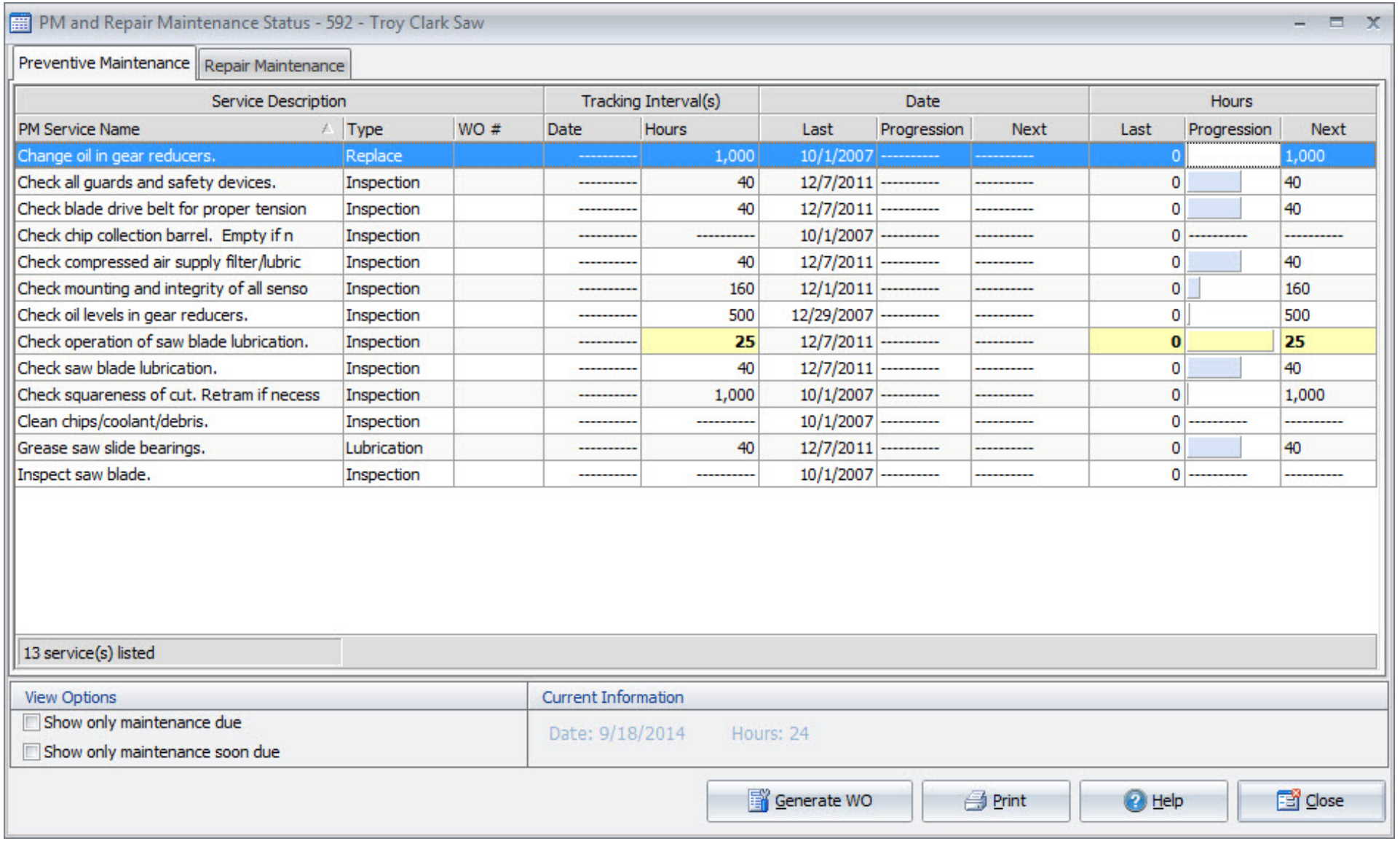
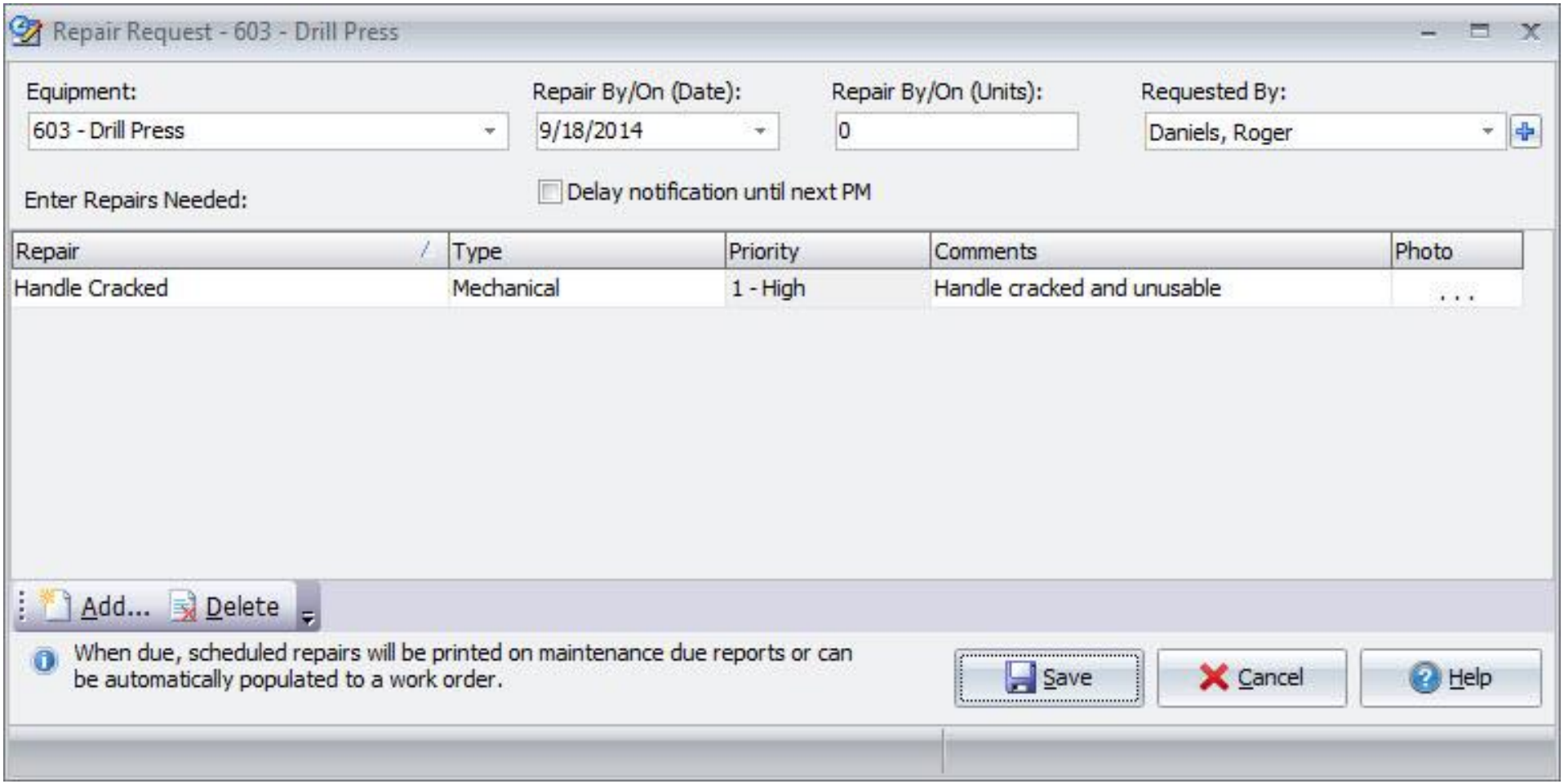
PREVENTATIVE MAINTENANCE STATUS



Service Description			Tracking Interval(s)		Date			Hours		
PM Service Name	Type	WO #	Date	Hours	Last	Progression	Next	Last	Progression	Next
Change oil in gear reducers.	Replace		----------	1,000	10/1/2007	----------	----------	0		1,000
Check all guards and safety devices.	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check blade drive belt for proper tension	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check chip collection barrel. Empty if n	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------
Check compressed air supply filter/lubric	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check mounting and integrity of all senso	Inspection		----------	160	12/1/2011	----------	----------	0		160
Check oil levels in gear reducers.	Inspection		----------	500	12/29/2007	----------	----------	0		500
Check operation of saw blade lubrication.	Inspection		----------	**25**	12/7/2011	----------	----------	**0**		**25**
Check saw blade lubrication.	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check squareness of cut. Retram if necess	Inspection		----------	1,000	10/1/2007	----------	----------	0		1,000
Clean chips/coolant/debris.	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------
Grease saw slide bearings.	Lubrication		----------	40	12/7/2011	----------	----------	0		40
Inspect saw blade.	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------

REPAIR MAINTENANCE TRACKING



MAINTENANCE DUE NOTIFICATION

PM and Repair Maintenance Status - 592 - Troy Clark Saw

Preventive Maintenance | Repair Maintenance

Service Description			Tracking Interval(s)		Date			Hours		
PM Service Name	Type	WO #	Date	Hours	Last	Progression	Next	Last	Progression	Next
Change oil in gear reducers.	Replace		----------	1,000	10/1/2007	----------	----------	0		1,000
Check all guards and safety devices.	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check blade drive belt for proper tension	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check chip collection barrel. Empty if n	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------
Check compressed air supply filter/lubric	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check mounting and integrity of all senso	Inspection		----------	160	12/1/2011	----------	----------	0		160
Check oil levels in gear reducers.	Inspection		----------	500	12/29/2007	----------	----------	0		500
Check operation of saw blade lubrication.	Inspection		----------	**25**	12/7/2011	----------	----------	**0**		**25**
Check saw blade lubrication.	Inspection		----------	40	12/7/2011	----------	----------	0		40
Check squareness of cut. Retram if necess	Inspection		----------	1,000	10/1/2007	----------	----------	0		1,000
Clean chips/coolant/debris.	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------
Grease saw slide bearings.	Lubrication		----------	40	12/7/2011	----------	----------	0		40
Inspect saw blade.	Inspection		----------	----------	10/1/2007	----------	----------	0	----------	----------

13 service(s) listed

View Options

- Show only maintenance due
- Show only maintenance soon due

Current Information

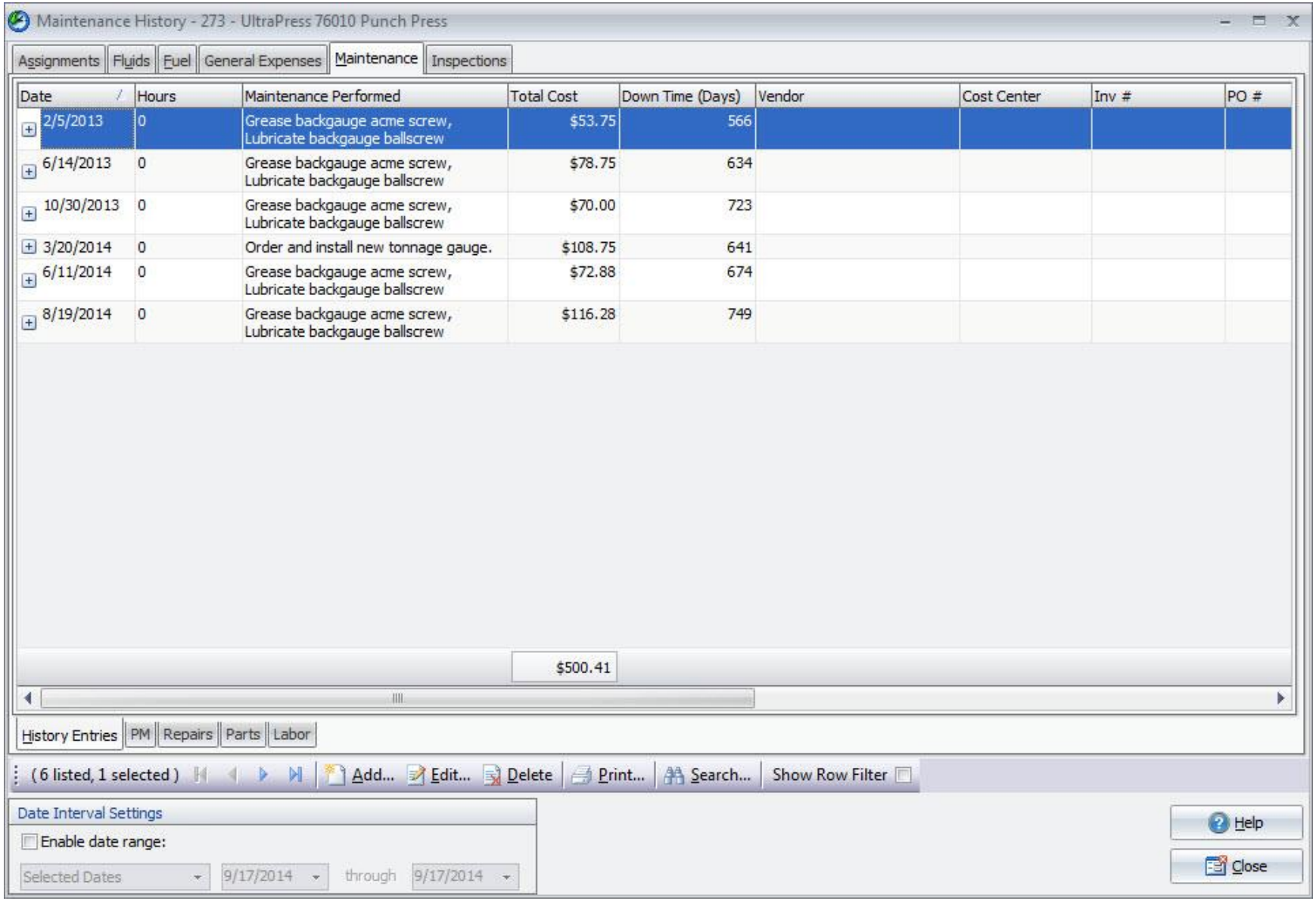
Date: 9/18/2014 Hours: 24

Generate WO | Print | Help | Close

IMPERIAL HEALTH SCIENCES

STRATEGNOS® BUILDING BUSINESS THROUGH STRATEGY & KNOWLEDGE

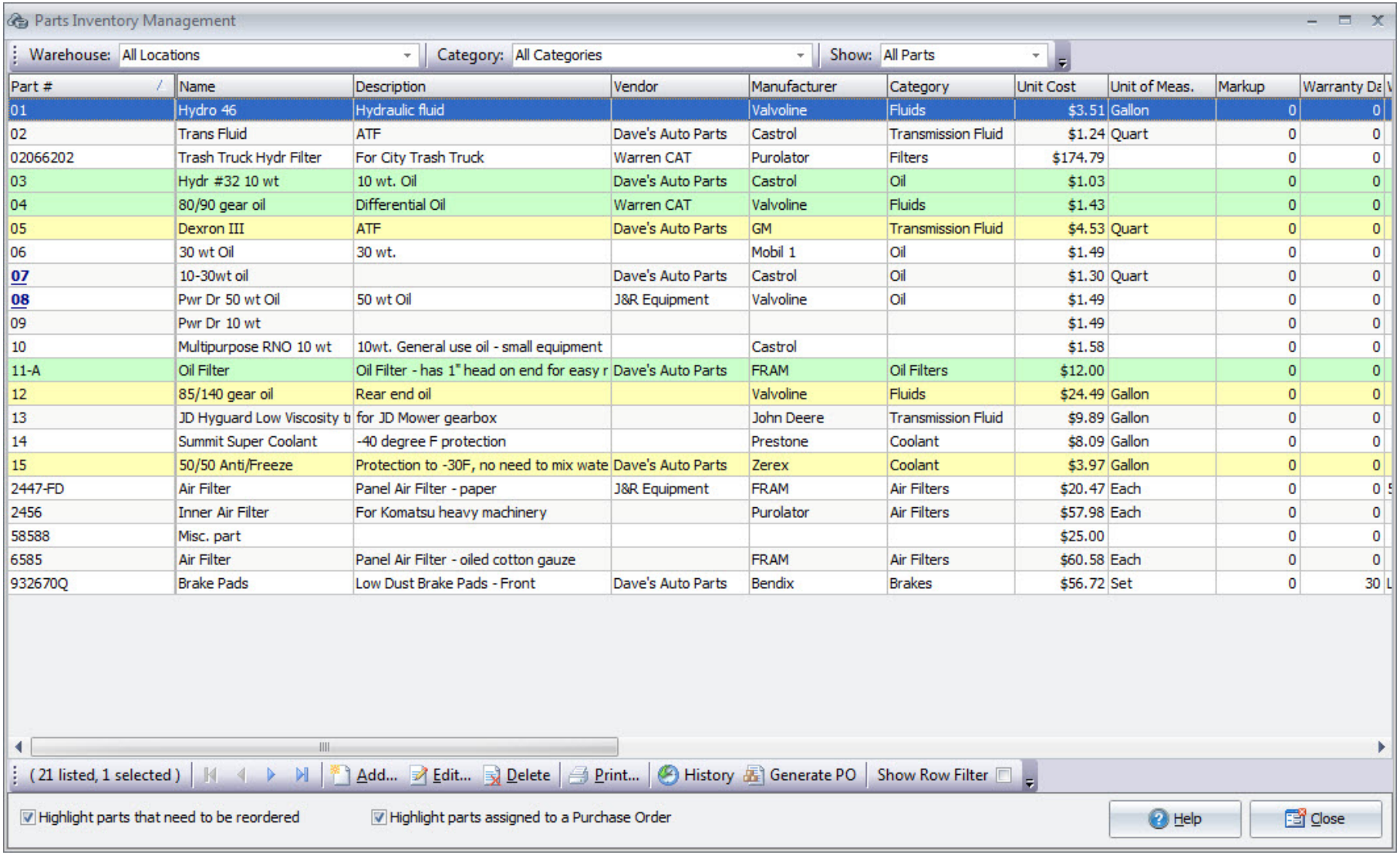
PREVENTATIVE & REPAIR MAINTENANCE HISTORY



IMPERIAL HEALTH SCIENCES

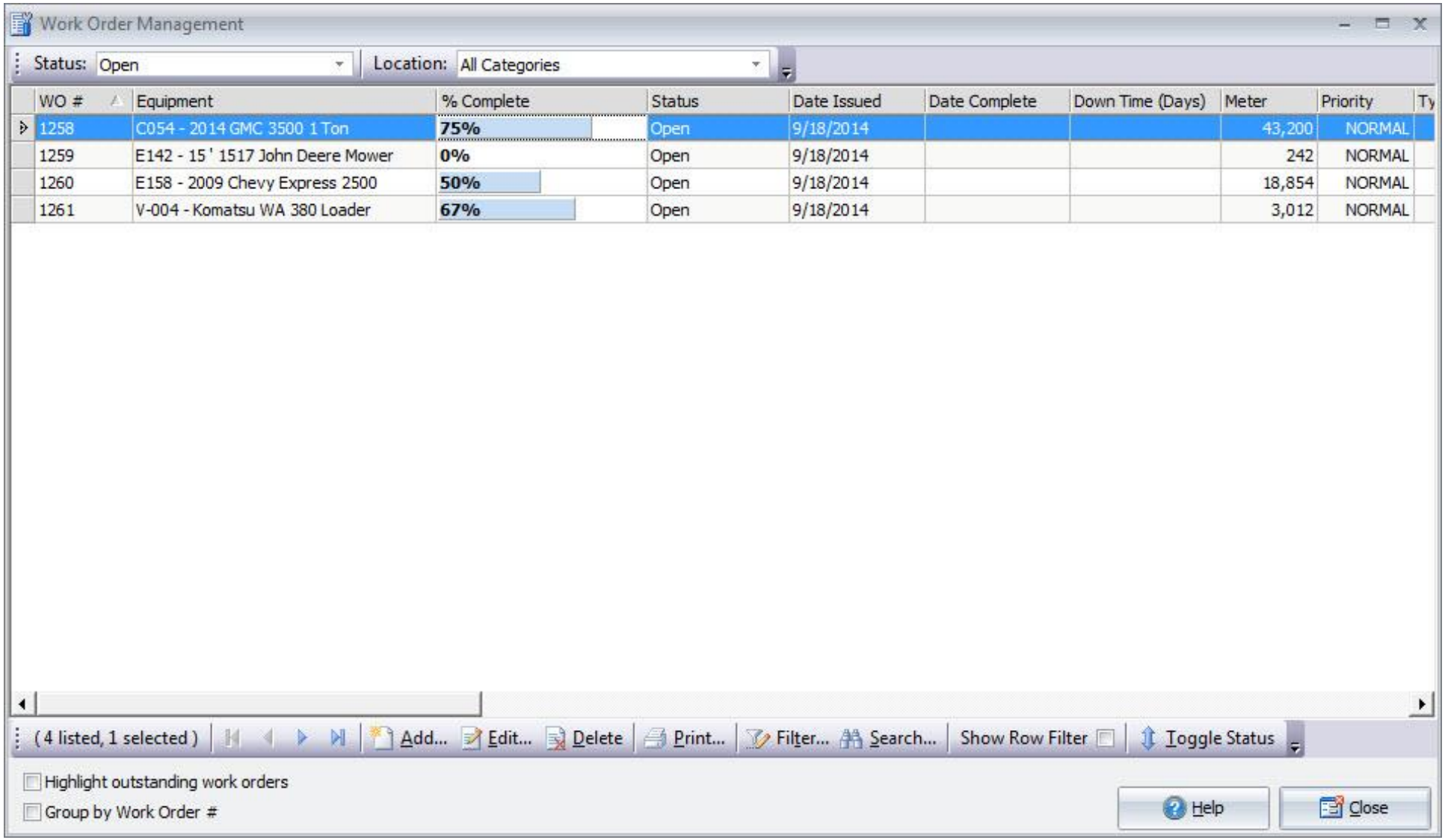
STRATEGNOS® BUILDING BUSINESS THROUGH STRATEGY & KNOWLEDGE

SPARE PARTS INVENTORY MANAGEMENT



Part #	Name	Description	Vendor	Manufacturer	Category	Unit Cost	Unit of Meas.	Markup	Warranty Da
01	Hydro 46	Hydraulic fluid		Valvoline	Fluids	$3.51	Gallon	0	0
02	Trans Fluid	ATF	Dave's Auto Parts	Castrol	Transmission Fluid	$1.24	Quart	0	0
02066202	Trash Truck Hydr Filter	For City Trash Truck	Warren CAT	Purolator	Filters	$174.79		0	0
03	Hydr #32 10 wt	10 wt. Oil	Dave's Auto Parts	Castrol	Oil	$1.03		0	0
04	80/90 gear oil	Differential Oil	Warren CAT	Valvoline	Fluids	$1.43		0	0
05	Dexron III	ATF	Dave's Auto Parts	GM	Transmission Fluid	$4.53	Quart	0	0
06	30 wt Oil	30 wt.		Mobil 1	Oil	$1.49		0	0
07	10-30wt oil		Dave's Auto Parts	Castrol	Oil	$1.30	Quart	0	0
08	Pwr Dr 50 wt Oil	50 wt Oil	J&R Equipment	Valvoline	Oil	$1.49		0	0
09	Pwr Dr 10 wt					$1.49		0	0
10	Multipurpose RNO 10 wt	10wt. General use oil - small equipment		Castrol		$1.58		0	0
11-A	Oil Filter	Oil Filter - has 1" head on end for easy r	Dave's Auto Parts	FRAM	Oil Filters	$12.00		0	0
12	85/140 gear oil	Rear end oil		Valvoline	Fluids	$24.49	Gallon	0	0
13	JD Hyguard Low Viscosity ti	for JD Mower gearbox		John Deere	Transmission Fluid	$9.89	Gallon	0	0
14	Summit Super Coolant	-40 degree F protection		Prestone	Coolant	$8.09	Gallon	0	0
15	50/50 Anti/Freeze	Protection to -30F, no need to mix wate	Dave's Auto Parts	Zerex	Coolant	$3.97	Gallon	0	0
2447-FD	Air Filter	Panel Air Filter - paper	J&R Equipment	FRAM	Air Filters	$20.47	Each	0	0
2456	Inner Air Filter	For Komatsu heavy machinery		Purolator	Air Filters	$57.98	Each	0	0
58588	Misc. part					$25.00		0	0
6585	Air Filter	Panel Air Filter - oiled cotton gauze		FRAM	Air Filters	$60.58	Each	0	0
932670Q	Brake Pads	Low Dust Brake Pads - Front	Dave's Auto Parts	Bendix	Brakes	$56.72	Set	0	30

WORK ORDERS


Work Order Management
Status: Open
Location: All Categories
WO # | Equipment | % Complete | Status | Date Issued | Date Complete | Down Time (Days) | Meter | Priority | Ty
1258 | C054 - 2014 GMC 3500 1 Ton | 75% | Open | 9/18/2014 | | | 43,200 | NORMAL
1259 | E142 - 15 ' 1517 John Deere Mower | 0% | Open | 9/18/2014 | | | 242 | NORMAL
1260 | E158 - 2009 Chevy Express 2500 | 50% | Open | 9/18/2014 | | | 18,854 | NORMAL
1261 | V-004 - Komatsu WA 380 Loader | 67% | Open | 9/18/2014 | | | 3,012 | NORMAL
(4 listed, 1 selected)
Add... Edit... Delete Print... Filter... Search... Show Row Filter Toggle Status
Highlight outstanding work orders
Group by Work Order #
Help
Close

APPENDIX ELEVEN - EQUIPMENT MAINTENANCE MATURITY MODEL

EQUIPMENT MAINTENANCE MATURITY MODEL					
Rating Levels	**V Inadequate**	**IV Awareness**	**III Understanding**	**II Competence**	**I Excellence**
1. Strategy	Mostly reactive breakdown maintenance	Preventative maintenance improvement program	Annual improvement plan	Long term improvement plan	Established and communicated maintenance and asset strategy
2. Organization / Management	Highly centralized	Partly centralized for some of the activities	Decentralized engineering support teams	Small level of multi-skilled CCE engineering staff	Multi-skilled and independent CCE engineering support
3. Data Management / IT	Manual or ad hoc specialty systems	A "system" that allows for some scheduling and parts tracking	Fully functional asset management stand-alone system	Fully functional asset management system linked to financial and/or Inventory systems	Fully integrated to common databases Data standards in place
4. Maintenance Tactics	Annual inspections only	Time based inspections	Time and use based inspections including allowances for age	Some condition based maintenance Some preventative maintenance Few surprises	All tactics and plans based on data analysis
5. Materials Management	Lack of inventory management practices	Some inventory controls Lack of performance measurement s Stock-turns less the 1.0	System computerized Stock levels set No maintenance team input No lead time and safety stock levels set	Streamlined processes Parts delivery process established Automatic matching of invoices Computerized inventory management system	Service levels 95%+ On line parts and materials requisitioning Stock-turns exceed 1.5
6. Planning and Scheduling	Little or no formal planning, or engineering support	Some trouble shooting support Inspection scheduling	Maintenance planning group in place Still ad hoc engineering support	Solid general planning and scheduling. Job planning with CCE engineering support	Long term major project planning for maintenance and CCE engineering support
7. Performance Measures	No systematic approach. Maintenance cost not available	Some downtime / reliability records Maintenance costs not applied to each CCE location	Downtime analysis by cause Maintenance costs available	Mean time to failure / repair records available. Separate maintenance costs	OEM benchmarking Full cost database (Total Cost of Ownership model)
8. Reliability Centered	No failure records	Collects failure data but	Failure incidence and nature	Some failure mode, effects	Reliability centered

Maintenance		makes little use of it	established and used for analysis	and criticality analysis (FMECA) used. Risk analysis undertaken	maintenance program in place. Risk and root cause analysis widely used
9. Autonomous Maintenance	Directed workforce No teamwork	Directed workforce No teamwork	Directed workforce No teamwork	Self-directed teams Team work at organization levels	Decentralized CCE engineering teams. Vaccine integrity based decisions
10. Process Redesign	Processes not documented Some procedures available High reactive work percentage	Some process documents. Moderate amount of procedures available	Processes documented. Planning and scheduling disciplines are prevalent. Medium amount of reactive and planned maintenance workload	Processes documented Evidence of periodic review Processes well organized	Processes documented and coordinated with support areas (Inventory / Purchasing) Evidence of periodic review