Undertaking 85

Re: PR-PUB-NLH-179. Review of its asset management practices in 2011,...including an analysis of the practices of other utilities across North America.

Undertaking to provide any reports generated in relation to:

a) practices at Holyrood.
b) preventative maintenance programs in general.

a) In 2010, an asset maintenance review was conducted for Holyrood. Attached as Undertaking 85 Attachment 1 is a draft asset maintenance strategy manual, which incorporated Hydro's review of the asset management practices across North America. Hydro's asset management programs and practices for Holyrood were built on this draft manual and are continually being improved, through the Office of Asset Management.

b) In 2011, asset maintenance reviews were conducted for the following asset classes:

- Communication systems
- Frequency convertors
- Diesel plants
- Distribution systems
- Energy management system
- Gas turbines
- Hydraulic structures
- Hydraulic generating stations
- Terminal stations

Attached as Undertaking 85 Attachment 2 is a draft asset maintenance strategy management program document, prepared in 2011, which incorporated Hydro's review of the asset management practices across North America. Hydro's asset management programs and practices were built on this report and are continually being improved, through the Office of Asset Management.

MAINTENANCE STRATEGY MANUAL

Holyrood Thermal Generating Station

June 28, 2010

	Electrical
	Mechanical
	Civil
	Protection & Control
	Transmission & Distribution
	Telecontrol
	System Planning

Approved for Release

Date

MAINTENANCE STRATEGY MANUAL

Holyrood Thermal Generating Station

June 28, 2010

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1 OVERVIEW

The purpose of this *Maintenance Strategy Manual* is to specify the **maintenance strategies** that will best enable the Holyrood Thermal Generating Station (HTGS) to contribute to the corporate mission of cost-effective, reliable energy, while maintaining high standards for safety, health and environmental responsibility.

This manual prescribes an overall **maintenance philosophy** for the Holyrood Thermal Generating Station and specific **maintenance strategies** for the systems and components that make up that facility. For most systems and components, the specified **maintenance strategies** validate existing **maintenance tactics**. For the remainder, **tactics** will need to be added, discontinued, or revised to suit the **strategies**.

This *Maintenance Strategy Manual* is created under the corporation's Asset Maintenance Strategy (AMS) Process, conceived in 2007. The detailed AMS process has been formally documented as the *Asset Maintenance Strategy Management Program*.

The process can be summarized as a consolidation of existing **maintenance strategies and tactics** for a given asset with comparison against:

A. original equipment manufacturer recommendations;
B. expert recommendations;
C. practices for similar assets in other parts of the corporation;
D. practices for similar assets of other utilities; and
E. maintenance decision tree analyses.

These comparisons are subsequently reviewed through round table discussions among experienced engineering and operations staff and conclusions are drawn regarding the best **strategy** going forward.

Using this process, **maintenance strategies** have been developed for all assets that fall within the Holyrood Thermal Generating Station. They are comprised of the following higher level systems and subsystems, consistent with the JD Edwards asset hierarchy:

1. <u>Assets Generation (Including Synchronous Condenser)</u>

    Turbine & Generator
        Turbine assembly
        Generator assembly
        Turbine Condenser

    Boiler Plant
        Boiler Structure
        Feedwater and Saturated Steam
        Superheater and Reheater Assemblies
        Boiler Air and Gas

Boiler Plant … cont'd
- *Boiler Fuel Firing*
- *Boiler Blowdown Drains*
- *Boiler Auxiliary Steam and Condensate*

Condensate & Feedwater
- *Low Pressure Feedwater*
- *Boiler Feedwater Pumping*
- *High Pressure Feedwater*
- *Condensate make-up*
- *Condensate Extraction*

Generation Services
- *General Service Cooling*
- *Turbine Generator Cooling*
- *Circulating Water Cooling*

Electrical & Controls
- *Turbine Governor*
- *Protection and Control*
- *Main Controls*
- *Generator Bus Ducting*
- *Unit Service Power*
- *Battery Banks / Chargers*
- *Burner Management*
- *Distributed Control System (DCS)*
- *Generator Transformer and Auxiliaries*
- *Turbine and Boiler MCC's*
- *Inverters (UPS)*
- *Turbine Supervisory System (TSI)*
- *Switchgear 4160V/600V*
- *Power / Control Cables and Raceways*

2. <u>Assets Common</u>

Water Treatment & Environment
- *Water Treatment Plant*
- *Environmental Monitoring*
- *Waste Water Treatment Plant*

Common Systems
- *Common Power & Motor Control Centres*
- *Heating & Ventilation*
- *Compressed Air*
- *Fire Protection*
- *Gas Storage*
- *Auxiliary Steam*
- *Heavy Oil and Fuel Additive*
- *Light Oil*

In terms of boundaries, this manual includes **maintenance strategies** for all of the Holyrood generation and common assets including auxiliary and support systems up to, but not including, the low voltage bushings of the main 230 kv power transformers.

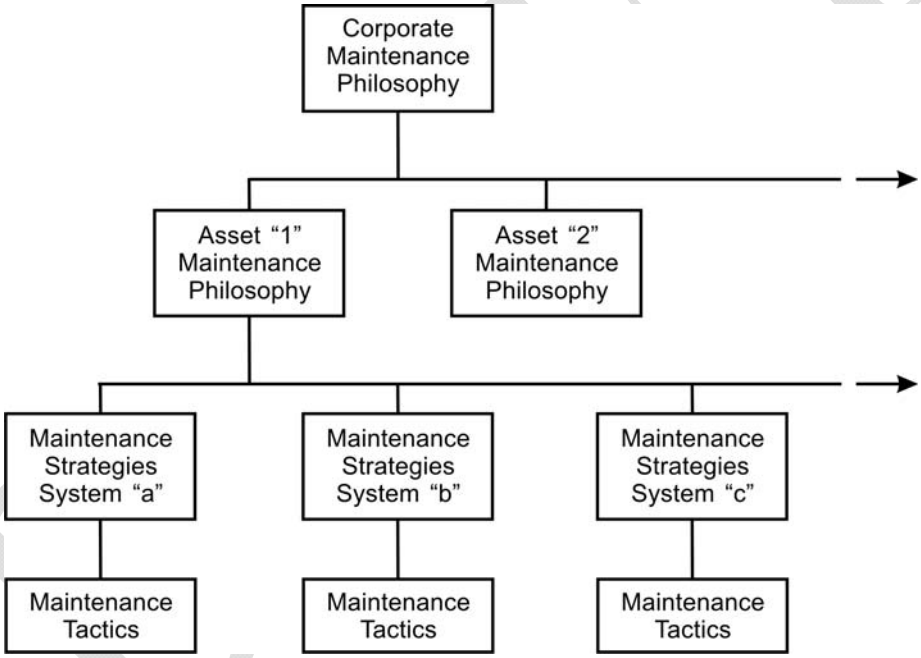
The development of **maintenance strategies** for the Holyrood Thermal Generating Station has been rigorously documented in a Microsoft® Excel Workbook titled *Maintenance Strategy Analysis*, hereafter referred to as the *Workbook*. While this *Maintenance Strategy Manual* contains a summary of the resultant **strategies** and the effort to develop them, the full analysis details are contained only within the Workbook.

The asset manager(s) will own this *Maintenance Strategy Manual* and *Workbook* and will be responsible for controlling and updating both, in consultation with Engineering Services. The Change Management section of this manual outlines the events that would trigger the need for such review and revision.

2 MAINTENANCE PHILOSOPHY

The entire maintenance effort can be seen as a means to control failure and its consequences. All failures have a cost to the corporation and, to varying degrees, hinder our progress in meeting the corporate goals and objectives, whether they are impediments to safety & health, environmental protection, production or financial performance.

But recognizing there is a trade-off between the cost of failure and the cost of *preventing* failure, we must make clearly guided decisions on the type and amount of preventive action to undertake. Such decisions are to be made within the confines of the following basic framework: **philosophy → strategy → tactic**.



Each major asset is to have a clear **maintenance philosophy** - a statement of mission, vision and key objectives for the maintenance function. The **philosophy** will guide the development of **maintenance strategies** - approaches to manage failure - for each system or component that makes up the major asset. From these **strategies** will be derived a set of **maintenance tactics** - the procedures and instructions to be used by workers to perform maintenance work.

The corporation's Asset Maintenance Strategy Process outlines a Corporate Maintenance Philosophy that should be applied across the corporation. This **philosophy** ensures that maintenance efforts align with the corporation's mission and goals.

Corporate Maintenance Philosophy

The objective of the maintenance functions within the corporation is to support the production of cost-effective energy with a high level of reliability, without compromise of safety, health, and environmental responsibility.

An effective maintenance program is a key element of becoming a leader in the areas of safety and the environment.

An effective maintenance program is a key element of providing exceptional value to all consumers of our energy.

An appropriate level of reliability for a given asset will depend on its contribution to the overall system reliability.

The optimum maintenance is that which will enable the appropriate level of reliability to be achieved for the planned economic life of the asset.

For a given major asset, the Corporate Maintenance Philosophy should be supplemented with statements that further refine the **maintenance philosophy** for the specific asset. In particular, the supplement should define the present and future contribution of the asset to overall system reliability and should declare the planned remaining life of the asset.

The following is the operating philosophy for the Holyrood Thermal Generating Station which, along with the Corporate Philosophy, will be used as the basis for formulating the maintenance strategies for the station.

Holyrood TGS Operating Philosophy

Holyrood units 1 and 2 have been in service since 1969 and Holyrood Unit 3 since 1979. These generating units have low operating hours in comparison to typical thermal units of their age. Their primary function has been megawatt generation (second only to hydraulic generation) coupled with frequency and voltage support for the Avalon Peninsula. The combined output of the Holyrood Thermal Generating Station is 500 Megawatts feeding into an isolated (island) grid totalling some 1635 Megawatts. System frequency and voltage support is achieved both in generation and synchronous condenser mode (Synchronous Condenser being provided by Unit 3 when system demand does not require generation from Holyrood). Based on system requirements, the three units operate primarily as base loaded units during the winter (load varying with demand), and are off-line during the summer months (Synchronous Condenser mode in the case of Unit 3). In the spring and fall, one or more units may be off-line or all may operate at low load depending on outage schedules and system requirements.

The planned remaining life of the Holyrood Thermal Generation Station is approximately another 5 years, until 2015. During that period it is expected to operate in an expanding role to meet predicted load growth. It must be noted that the length and type of service required could change for a variety of reasons. The 2015 target is based on the scheduled progression of the Lower Churchill Project (LCP) with its DC link to the island. If this DC link is pushed out or cancelled, the planned remaining life of the Holyrood Thermal Generating Station will have to be reassessed. After the potential DC link is placed in service, portions of the Holyrood Thermal Generating Station would have to remain operational into the foreseeable future in order to provide synchronous condenser capacity for the system.

The new operating philosophy would require significant changes and a need to review and adjust the existing **maintenance strategies**. Section 0 of this manual, *Change Management,* provides some guidance on the types of events that would trigger the need for a **maintenance strategy** review.

It is worth noting that by virtue of its operating function (seasonal and low base loading), there is no well defined manufacturer / industry maintenance model for the Holyrood Thermal Generating Station.

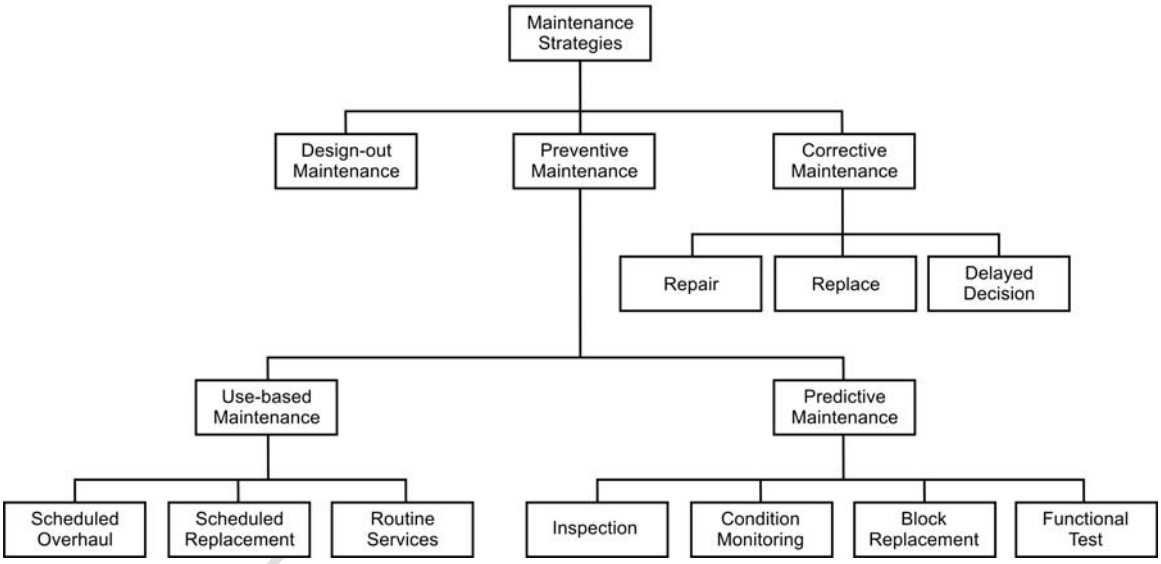
3 MAINTENANCE STRATEGIES

Failure and its consequences are best managed through the establishment of **maintenance strategies**, which can generally be framed into three high level categories:

- **Preventive Maintenance**: reduce the probability of failure through pro-active work;
- **Corrective Maintenance**: allow the equipment to run to failure and then repair or replace it; and
- **Design Out**: make a design change to remove the possibility of a failure mode.

Preventive and corrective maintenance are further divided into specific types of **strategies** as per the chart below. Formal definitions of each **maintenance strategy** are provided in Appendix B of this manual.

MAINTENANCE STRATEGIES



Adapted from *Maintenance*, Jasper L. Coetzee [1]

The AMS review and accompanying Workbook have been divided into two sections taking into account the proposed new operating philosophy:

1. **Generation & Common Systems …..** includes the majority of the strategies required for Megawatt generation (Turbine, Boiler, Condensate, Feedwater, Electrical, Controls and Common Systems). Generation will also require all strategies associated with the Synchronous Condenser operation with the exception of the run-up systems.

2. **Synchronous Condenser Systems ….** includes all the strategies necessary for the operation of the units in the Synchronous Condenser mode. The workbook has been structured with the assumption that the Cooling Water (CW) System is to be used in the Synchronous Condenser Mode. All related strategies are thus evaluated in that section of the workbook.

The remaining strategies (buildings, cranes & hoists, communications equipment, & roads etc.) have not been included in any detail in this review.

The following **maintenance strategies** were compiled from the accompanying workbook and are structured along the major asset groups outlined in the Overview section of this document.

Not every component of every system appears in these tables. It is implied that components not specifically listed have the "Corrective Maintenance" **strategy**. (i.e. They should be run to failure.)

Note that "Run to Failure" (RTF) is used as the "Interval" when Corrective maintenance is the strategy type.

3.1 Generation and Common Systems

The Holyrood Thermal Generating Station is a 500 Megawatt facility producing electricity by converting #6 Bunker Fuel into high pressure superheated steam for the turbine / generator operation. It is the only thermal generating station within the Hydro system and as such is unique in the type of maintenance strategies needed for reliable operation.

The station was constructed in two stages: Stage I in 1969 and Stage II in 1980. Stage I has two identical units each capable of producing 175 MW of power and Stage II, a single unit, capable of 150MW. Each unit consists of a power boiler producing superheated steam to supply the turbine / generator units which in turn converts rotating energy into electrical power.

The assets associated with the Generation and Common Systems, including those identified separately for Synchronous Condenser operation, are all necessary for the production of Megawatts from the station. The Generation and Common Systems Assets are separated from the Synchronous Condenser Assets in the event there is a change in the operating philosophy brought about by the development of the Lower Churchill Project.

The following maintenances strategies are a summary of those contained within the main working document " The Workbook" and are to be used for reference only. They do not contain all the workings and comments needed to do a full implementation of the maintenance strategies.

3.1.1 All Assets

The following **Maintenance Strategies** are to be applied against all *"Generation & Common Systems"* assets

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **All Generation & Common** Assets.	Review maintenance strategy "change management process" (AMS Guide) to identify triggers; then review and revise applicable sections of the Maintenance Strategy Workbook and Manual	1 Year	n/a
	Review and revise the entire Maintenance Strategy Workbook and Manual	5 Years	n/a
	Operations to complete Daily Equipment Reports as per procedure POI-89 (0776)	1 Day	Routine Service
	Operations to complete unit load test and record parameters as per procedure POI-92 (0718)	1 Week	Routine Service
	Operations to complete monthly running hour log sheets for 4kv & 600v equipment as per procedure POI-97 (0789) & associated check sheets.	Investigate if required	Routine Service
	Safety & Security officer to check "General Policy" postings monthly and ensure all displayed copies are current	1 Month	Routine Service
	Safety Leader to conduct "Planned General Inspections" of all Holyrood facilities monthly as per S&H policy	1 Month	Routine Service
	Safety Leader to conduct monthly group/safety meetings as per S&H policy	1 Month	Routine Service
	Safety Leader to inspect & maintain the Special Safety Systems at the Holyrood TGS as per Station & Corporate S&H Policy	6 Months	Routine Service
	Safety Leader to review orientation program to ensure it is updated and accounts for any safety items.	1 year	Routine Service
	Review the Holyrood Personal Protective Equipment policy to ensure it is pertinent. Update if required. S&H Policy 9.01	1 Year	Routine Service
	Review the pre-use equipment inspection policy Update if required. S&H Policy 2.03	5 Years	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **All Generation & Common** Assets…….Cont'd	Review the Tailboard Conferencing Policy Update if Required…S&H Policy 1.02	1 Year	Routine Service
	Perform inspection of the Fall Arrest & Restraining rescue equipment as per corporate policy.	1 Year	Routine Service
	Perform annual review of plant inventory for obsolete / unused items.	1 – 2 Years	Routine Service
	Drum Management…..Monitor usage of site storage drums against standard MSTD 095. Correct for any non-conformances	1 Year	Routine Service
	Review status of the Work Methods Analysis program against objectives. Review for any policy updates. S&H Policy 3.01.	1 Year	Routine Service
	Pre-permit inspection of pneumatic control valves (all zones) to determine outage maintenance repairs.	1 Year	Inspection & Functional Test
	Perform cold Start-up of Boiler / Turbine / Generator following an overhaul (with another unit on-line). As per procedure POI-04 (0324)	1 Year	Routine Service
	Blow down (controlling) process transmitter reference lines during pre-shutdown conditions. MSTD-144 & 147	1 Year	Routine Service
	Blow down (non-controlling) process transmitter reference lines during pre-shutdown conditions. MSTD-145, 146, 148 & IPM 368	1 Year	Routine Service
	Laboratory staff to perform standard activities associated with annual outages (all zones)	1 Year	Routine Service
	Review maintenance strategy "change management process" (AMS Guide) to identify triggers; then review and revise applicable sections of the Maintenance Strategy Workbook and Manual. (May change with implementation of this process)	1 Year	Routine Service
	Review and revise the entire Maintenance Strategy Workbook and Manual (May change with implementation of this process)	5 Years	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **All Generation & Common** Assets…….Cont'd	Starting a boiler after an eight (8) hour shut-down. POI-07 (0326)	As Required	Routine Service
	Drain all main steam lines to turbine during unit start-up. As per procedure POI-08	As Required	Routine Service
	Capture all pertinent information related to a unit trip. As per procedure ED-067	As Required	Routine Service
	Perform operational readings as per check sheet… #102.01.35/8	1 Day	Routine Service
	Perform plant equipment lubrication as detailed by the plant's maintenance schedule	To be determined	Routine Service
	Conduct vibration monitoring program for all plant rotating equipment identified as requiring data collection and analysis. SJP 1042, 1043, 1047	1 Month	Condition Monitoring
	Instrumentation department to conduct checks on plant common instrumentation equipment. IPM 99	1 Week	Routine Service
	Utility Department to perform weekly activities on plant common equipment (vehicles, garbage, bottled water , etc)	1 Week	Routine Service
	Utility Department to perform plant cleaning requirements as per schedule. MSTD 167	1 Day	Routine Service
	Drain all main steam lines to turbine during unit start-up. As per procedure POI-08	As Required	Routine Service
	Capture all pertinent information related to a unit trip. As per procedure ED-067	As Required	Routine Service
	Perform operational readings as per check sheet… #102.01.35/8	1 Day	Routine Service
	Perform plant equipment lubrication as detailed by the plant's maintenance schedule	To be determined	Routine Service
	Inspect & calibrate all controlling & tripping electronic process transmitters including DCS indication	5 Years	Functional Test
	Perform maintenance on all manually operated critical valves (6" & larger)	To be determined	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **All Generation & Common** Assets…….Cont'd	Perform maintenance on all manually operated critical valves (smaller than 6")	To be determined	Routine Service
	Inspect & Calibrate all process control & trip switches including DCS indication	1 Year	Functional Test
	Inspect & Calibrate all process alarm & indicating switches including DCS indication	5 Years	Functional Test
	Perform Insulation & Winding checks of all 600V motors. Exception those identified as requiring a more frequent electrical condition check	3 Years	Condition Monitoring
	Perform Insulation & Winding checks of all 4KV motors.	1 Year	Conditioning Monitoring
	Take Lube Oil samples of plant operating equipment. Send for analysis. MPM 416.	3 Months	Condition Monitoring
	Take EHC fluid samples of plant operating equipment. Send for analysis.	1 Month	Condition Monitoring
	Take EHC fluid samples of plant operating equipment for moisture content analysis	1 Week	Condition Monitoring

3.1.2 Turbine

The **Maintenance strategies** for the *Turbine* are summarized below

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Turbine** Assets	Function test Main Turbine Stop Valves **Note:** currently performed daily but industry standard is weekly. Plant asset & operations manager to review Workbook comments and confirm future strategy. (1 Week is recommended)	1 Week	Functional Test
	Perform & Record turbine & auxiliary checks as per Plant operational Instructions. POI – 89 & POI – 99	Daily/Weekly	Routine Service
	Record Turbine readings each Shift . POI – 100	4 Hours	Routine Service
	Perform Unit #3 Turbine Main Stop valve tightness test POI – 24	1 Year	Functional Test
	Perform Stroke & leakage tests of Motorized drains valves and report any deficiencies. MPM - 352 & MPM – 353	1 Year	Functional Test
	Perform back-up governor over-speed trip test to ensure unit will trip if emergency governor fails. Unit #3 POI – 25 & POP – 060.	1 Year	Functional Test
	Perform test of emergency governor and Emergency trip valves Unit #3. POI - 32	1 Week	Functional Test
	Perform Mark V off-line over-speed functional test to confirm turbine over-speed protection. Units 1 & 2. POI – 061	1 Year	Functional Test
	Test each of the EHC solenoids to ensure that the trip & the redundancy of the system are functioning. Units 1 & 2	1 Week	Functional Test
	Perform functional test of oil trip system to ensure all turbine & protective valves are completely closed. Unit #3 POI – 23	1 Year	Functional Test
	Perform functional test to confirm calibration of the Unit 3 over-speed emergency governor & control valves. POI – 29. (see workbook comments)	1 Year	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Turbine** Assets…Cont'd	Perform Solenoid Trip Test Unit #3 to ensure Master Trip Solenoid (MTS) operates properly. POI – 28	1 Year	Functional Test
	Exercise the Speed Governor Control Unit #3 to verify its operation. POI – 31	As Required	Functional Test
	Perform Turbine main control & intercept valve tightness test to determine if the valves can provide load limit speed control. Unit #3..POI – 26 & POI – 27	1 Year	Functional Test
	Perform functional test to ensure all turbine tripping devices are operational (vacuum, bearing oil, thrust bearing wear, bk-up over-speed & solenoid trip.) POI – 30	1 Year	Functional Test
	Inspect & Function test EHC System (Units 1 & 2). Clean & Vacuum cabinets, stroke valves, verify limits, check servo valves etc. (Co-ordinate with valve overhaul) IPM-81 & IPM-82	3 Years	Inspection & Functional Test
	Prime hydraulic pumps after extended outage or after a new pump is installed (whenever system has been drained). (Units 1 & 2)..Refer to ED-092	Directive should be validated	Corrective maintenance
	Check & clean EHC servo valve strainers. Review requirement after system has been flushed regularly. (Units 1 & 2)	1 Year	Inspection
	Record Main lube oil Full Flow Filter differential pressure to determine when filters need cleaning etc. (Units 1 & 2)	4 Hours	Routine Service
	Test and record alarms for standby AC, emergency, emergency seal oil, AOP, emergency bearing oil, and AC flushing oil pumps.	1 Week	Functional Test
	Function test main lube oil tank level switches (Hi / Lo, alarm & trip.) Unit 3 only	1 Week	Functional Test
	Visually Inspect vapour extractor line for plugging. Perform follow-up if required. (Unit 3)	1 Week	Inspection
	Verify proper installation of turning gear oil spray nozzle (performed during synch. Condenser change over unit #3)	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Turbine** Assets…Cont'd	Dismantle and clean unit #3 lube oil Centrifuge components. Check base oil level (subject to assessment by Operations)	2 Weeks	Routine Service
	Relay Oil Filters, Unit #3….Check operating differential and pump pressures. Change-over on high differential. Replace filters as required.	4 Hours	Routine Service
	Change out Lube Oil Bowser bags and cartridge filters. Units 1 & 2. Clean precipitation compartment.	6 Months	Routine Service
	Main Lube Oil Tank…..Tighten instrument fittings, gaskets and covers located in instrument cabinet at top of tank to eliminate possible oil leaks due to vibration. Revisit A/I to see if a PM is still required	n/a	n/a
	Remove LP Hood doors & temperature probes to facilitate Hotwell Inspection.	1 Year	Inspection
	Remove LP Hood doors & temperature probes to facilitate spray nozzle inspection.	3 Years	Inspection
	Inspect LP turbine hood sprays, Repair or replace as required	3 Years	Inspection
	Change the silica gel bags in the Hydraulic set reservoir	1 Month	Routine Service
	Verify the pressures in the Turbine EHC Hydraulic Accumulators (Units 1 & 2)	1 Year	Inspection
	Perform EHC hydraulic system chemical flush units 1 & 2. Lines & actuators	2 Years	Routine Service
	Check Gland seal exhauster Loop Seal for blockage. MPM 384, 385	2 Year	Inspection
	Assist DOL perform an exterior inspection of the gland seal condenser. OPM 26, 27, 28	1 Year	Inspection
	Inspect turbine steam seal regulators. 6 years when new units installed. Otherwise 2 years for existing units.	6 Years & 2 Years	Inspection & Functional Test
	Perform UT testing on start-up de-super heater UT 3015, MPM 217	1 Year	Condition Monitoring
	Test all bled steam NR check valves to confirm proper operation. POI 37 & 89.	1 Day	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Turbine Assets **Condenser System**	Perform complete Vacuum pump PM inspection. MPM 106, 107, 115, 116, 18, 19.	1 Year	Inspection
	Perform complete vacuum pump motor inspection. (Megger & Impedence checks) EPM 222, 223, 244, 245, 278, 279.	3 Years	Condition Monitoring
	Inspect & overhaul 600V vacuum Pump Breakers	6 Years. (3 Years for Unit 3)	Inspection
	Perform complete vacuum pump overhaul. Currently done by outside service provider. Should also consider running hours & pump performance.	7 – 8 Years	Scheduled Overhaul
	Inspect and function test vacuum pump valves Stage I (bypass, motive air, & diaphragm) IPM- 74, IPM- 75.	1 Pump per Year	Inspection & Functional Test
	Remove vacuum pump coolers, pressure test, clean, replace gaskets & reassemble. Also verify tank float & valve. Stage I & II	1 Year	Inspection
	Perform DOL exterior inspection of condenser flash tank OPM– 44, OPM- 45, OPM- 46.	1 Year	Inspection
	Perform NDE inspection of Condenser flash tank integrity. MPM- 403, MPM- 405, MPM- 406.	1 Year	Condition Monitoring
	Perform Hotwell inspection for pitting on horizontal bracing. Record dept measurements. Check coating.	1 Year	Condition Monitoring
	Perform Hotwell inspection & clean as required	1 Year	Inspection
	Consultant to perform inspection of hotwell. (see comments in workbook).	1 Year	Inspection
	Remove , clean and verify operation of hotwell level switches. IPM- 172	3 Years	Inspection & Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Turbine** Assets **Minor Overhaul**	Inspect and overhaul turbine main stop valve(s). Inspect & test cylinders. MPM 340, & 346	3 Years	Scheduled Overhaul
	Inspect and overhaul turbine blow down valve . Inspect & test pneumatic actuator	3 Years	Scheduled Overhaul
	Inspect and overhaul Left & Right Reheat stop & Intercept control valves. Inspect & test hydraulic cylinders. .MPM 341, 344, 339, 345	3 Years	Scheduled Overhaul
	Inspect & overhaul Turbine Top & Bottom main control valves. Inspect & test hydraulic cylinders. MPM 342, 343.	3 Years	Scheduled Overhaul
	Inspect & overhaul all bled steam NR check valves including pneumatic actuators	3 Years	Scheduled Overhaul

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Turbine** Assets **Major Overhaul**	Perform Major overhaul of Turbine, Generator and Auxiliary Systems	9 Years	Scheduled Overhaul
	Disconnect / Reconnect electrical & instrumentation equipment required for turbine (generator) major overhaul.	9 Years	Routine Service
	Inspect & Calibrate Turbine Supervisory System (TSI) & associated protection relays during Major Outage.. IPM 263, 264. Inspect all field devices and signal monitors	9 Years	Scheduled Overhaul
	Overhaul Seal Oil Vacuum Pump (Major Outage)	9 Years	Scheduled Overhaul
	Overhaul Vapour Extractor (Major Outage)	9 Years	Scheduled Overhaul
	Drain Turbine Main Lube Oil Tank., inspect & clean. Centrifuge oil back to tank. (Major Outage)	9 Years	Scheduled Overhaul
	Clean & overhaul Turbine Lube Oil Coolers. Replace gaskets. Pressure Test water side of coolers to 450 kpa for 1 hr. (Perform during Major Outage)	9 Years	Scheduled Overhaul
	Overhaul main lube oil pumps, measure impeller, check clearances, replace worn parts, check coupling. etc (Major Outage)	9 Years	Scheduled Overhaul
	Inspect Seal Oil Drain Enlargement & H2 Detraining Tanks & Lines for corrosion , dirt etc. Clean as required (Major Outage)	9 Years	Scheduled Overhaul
	Perform a Turbine oil system flush of all equipment following a major overhaul.	9 Years	Scheduled Overhaul
	Transfer turbine lube oil to temporary storage tank prior to major outage & back following outage.	9 Years	Routine Service
	Clean & Inspect EHC Hydraulic oil coolers Units 1 & 2.	9 Years	Inspection

3.1.3 Boiler Plant

The **maintenance strategies** for the *Boiler Plant* are summarized below

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Boiler Plant** Assets	Perform inspections of all boiler fans & exhausters including Warm Air Make-up fans. POI- 101, POI- 78 (see comments in workbook)	1 Day	Inspection
	Record Boiler operating parameter & data readings during load test.	1 Week	Routine Service
	Perform defective survey of Boiler, Manually Operated, High Pressure Steam Valves. OPM-163, OPM- 164, OPM- 165 & Valve List.	1 Year	Condition Monitoring
	Assist DOL perform internal & external inspection of the Power Boiler. OPM- 81, OPM-89, OPM- 95	1 Year	Inspection
	Overhaul Boiler safety valves as per pre-defined schedule. MPM- 407, MPM- 409, MPM- 410, ED- 108.	1 Year	Scheduled Overhaul
	EVT Boiler Safety Valves on start-up prior to boiler operation. MPM- 407, MPM- 409, MPM-410, IPM- 254, IPM-364, MSTD- 051, POP-080, POP- 092, POP- 094..	1 Year	Functional test
	All Boiler Manually Operated Valves: Check & tighten valve glands	Continuous	Routine Service
	Perform boiler support rod analysis as per defined engineering procedures. PM2, PM3, PM4. (This tactic to become part of new QA program)	To be determined	Inspection
	Inspect & repair safety valve drain pots & extension piping. MPM- 318, MPM-319, MPM-320	1 Year	Routine Service
	Perform furnace pre-outage inspection on the following equipment in preparation for outage work. Burner Tilts, Furnace Leaks, Sootblowers, Seal Air & View Ports	1 Year	Inspection
	Clean & Inspect all steam header enclosures & penthouse. Check refractory, Joints, insulation & supports	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Feed water and Saturated Steam**	Perform boiler service pressure test following annual overhaul. POP- 092 & POP- 094	1 Year	Functional Test
	Remove section(s) of boiler tube(s) for analysis as per QA requirement. (This tactic to become part of new QA program)	1 Unit per Year	Condition Monitoring
	Replace all boiler furnace door gaskets & seals. Check lugs & bolts. MPM-302	1 Year	Routine Service
	Clean internal waterwall tubes and inspect for damage. In particular the high heat zones. (see workbook comments)	1 Year	Inspection
	Inspect boiler downcomer & Header expansion joints and document for future repairs	1 Year	Inspection
	Remove, clean & repair. Observation Ports (Furnace & Windbox) OPM- 184, OPM- 185, OPM- 186..	1 Year	Routine Service
	Remove bottom furnace ash	1 Year	Routine Service.
	Clean and inspect steam drum (erosion, welds, attachments, nozzles, etc.) Collect samples (This tactic to become part of new QA program	1 Year	Inspection
	Remove steam drum internals (cyclones, baffles, separators etc) for inspection. (This tactic to become part of new QA program	To be determined	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Super-heat and Re-heat**	Perform NDE inspection & testing on all boiler tubes, supports and steam lines. Complete as per QA requirement. Inspections to be Staggered as per existing Bechtel report. (This tactic to become part of new QA program)	1 Year	Condition Monitoring
	Remove Steam Header Hand-hold caps. Clean & inspect (Boroscope). DOL inspection may be required. (This tactic to become part of new QA program)	1 Year	Inspection
	Clean & inspect all low & high temperature SH, RH & Econ elements. (see comments in workbook)	1 Year	Routine Service & Inspection
	Superheat & Reheat Steam Lines… (boiler through to turbine including drains) Perform NDE inspection as required under the new QA document	To be determined	Condition Monitoring
	Perform inspection of HR & Sootblower vent silencers at the roof including mounting bolts. (This tactic to become part of new QA program)	To be determined	Condition Monitoring
	Perform UT testing on Attemperator spray lines as per test sheets. UT1011, UT1012, UT2011, UT2012, UT3012.	1 Year	Inspection
	<u>Attemperator Thermocouples:</u> View DCS indication to verify that the thermocouples read ambient temperature during shutdown. Internal inspection not required.	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Air System**	Inspect & Function test all Auxiliary & Fuel Air Hagan Positioners & Dampers. (Units 1 & 2) Stroke dampers & check for air leaks. IPM-249A	1 corner per unit per Year	Inspection & Functional Test
	Inspect & Function test all Windbox Elevation Dampers & Positioners. (Unit 3). Stroke dampers & check for air leaks.	1 Year	Inspection & Function Test
	Function test Forced Draft Fan actuators on 11th elevation. OPM123, 122, 124, 125, 126, 127…	1 Month	Functional Test
	Perform annual maintenance on Forced Draft Fan 11th el. louvers. MPM 242, 243, 244, 245, 246, 247…	1 Year	Scheduled Overhaul
	Review vibration levels on Forced Draft Fans before unit outage to determine if balancing or related maintenance is required during the outage.	1 Year	Functional Test
	Record Forced Draft Fan East & West vibration levels before returning fans to service following an overhaul..	1 Year	Functional Test
	Check that FD fan motor heaters are "ON" during equipment shutdown. File # 102.01.35/6	Daily	Inspection
	Perform FD Fan ductwork inspection for cracking & internal supports	1 Year	Inspection
	Perform Annual minor FD fan inspection (coupling, bearings, blades, louvers, dorsal fins etc). MPM 110, 111, 22.	1 Year	Inspection
	Perform FD Fan Major Inspection using consultant	3 Years	Inspection
	Perform Air Preheater (East & West) checks necessary to reduce corrosion and differential pressure. OPM-404	1 Week	Inspection
	Perform visual checks for Air Preheater steam coil leaks	1 Day	Inspection
	Perform AH inspection and complete data sheet POI 84	1 week	Inspection
	Perform UT test on AH condensate lines to determine corrosion. UT1001, 2001, 3001. MPM172, 187, 202.	1 Year	Condition Monitoring

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Air System**	Perform UT test on AH control valve stations & lines to BD tank. UT1002, 2002, 3004. MPM173, 188, 206.	1 Year	Condition Monitoring
	Perform UT test on AH wash water lines to determine corrosion. UT1014, 2014, 3014. MPM186, 201, 216.	1 Year	Condition Monitoring
	Inspect piping supports on AH Wash Water Drains Lines	To be determined	Inspection
	Verify that the Air Heater 10" outlet drain valves are not plugged & water is flowing during AH wash	Prior to each wash	Inspection
	Perform UT test on AH Drains Tank Lines. MPM 203, 204	1 Year	Condition Monitoring
	Assist DOL inspector perform internal & external AH drains tank inspection. OPM 180, 85, 86, 77, 78.	1 Year	Inspection
	Perform service pressure test on those air preheater coils identified via corrective work orders during the operating season.	1 Year	Inspection & Functional test
	Conduct Air preheater steam traps performance survey	1 Year	Condition Monitoring
	Examine Air Preheater Wash Water Line Spray nozzles & bar. Replace if required	1 Year	Inspection & Routine Service.
	Function test the AH air drive motor by opening the bypass valve. POI 84	1 Week	Functional Test
	Perform emergency AH air drive solenoid & motor inspection. OPM 208	1 Month	Functional Test
	Prepare for AH Wash by installing enclosure & drain lines. Opening doors & removing plugs as per MSTD 026	1 Year (prior to outage work)	Routine Service
	Perform Air Heater inspection & washing as per POI 95	1 Year (prior to outage work)	Routine Service
	Inspect & Clean AH Air-Drive Lubricator	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Air System**	Perform PM inspection of AH main drive equipment. Oil levels, alignment, gearbox, bolts, leaks, bearings as per MPM 5 & 6.	1 Year	Inspection
	Perform AH bearing Inspections. Upper Guide & Lower Support bearings. Check oil level, leaks, hold-down bolts. MPM 123, 124, 125, 126.	1 Year	Inspection
	Inspect AH Baskets both Hot & Cold sides. Wash and/or replace as required	1 Year	Inspection
	Perform Inspection on Air heater casing, radial & circumferential seals, and pinion gear etc.	1 Year	Inspection
	Take Rotary Air-Heaters Lube Oil samples	3 Months	Condition Monitoring
	Check Air Heater upper & lower oil levels	1 Day	Inspection
	Check & clean boiler Air side reference lines as per check sheet IPM 132	2 Years	Routine Service
	Conduct boiler performance checks prior to any burner scanner adjustments. ED-094, MSTD-166	Continuous	Routine Service
	Inspect all burner flexible lines & clamps during outage & prior to start-up	1 Year	Inspection
	Perform burner scanner checks, optical lenses & cables. EPM 187	1 Year	Inspection
	Check and/or replace burner scanner fan air filters. EPM 186	4 Months	Routine Service
	Inspect all seal air rubber hosed & clamps	1 Year	Inspection
	Inspect seal air booster fan & check operation.	1 Year	Inspection
	Inspect & clean all seal air lines to boiler openings, viewports, burners etc.	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Gas System**	Complete inspection of Stack Breeching. Check for cladding leaks & stack to duct interface. Repair as required.	1 Year	Inspection
	Remove / Replace Boiler Oxygen Analyzers for annual boiler work. Calibrate during start-up. MSTD 163	1 Year	Inspection & Routine Service
	Overhaul Boiler Oxygen Analyzers. Calibrate on start-up	3 Years	Scheduled Overhaul
	Check & Calibrate both E & W O2 analyzers	3 Months	Functional Test
	Clean or Replace boiler gas side reference lines as per check sheet IPM 132	1 Year	Routine Service
	Inspect Stack Lightening equipment & mountings for deterioration	3 Years	Inspection
	Inspect Stack Hopper for wear & damage	3 Years	Inspection
	Inspect Stack Lighting (wiring & Conduit) for corrosion	3 Years	Inspection
	Inspect Stack Liner (SS & Iron) for corrosion, erosion, wear or damage.	3 Years	Inspection
	Perform inspection & calibration of stack Opacity Meter. ENV 115	3 Months	Inspection & Functional test
	Perform annual overhaul & calibration of Opacity Meter. ENV 115	1 Year	Scheduled Overhaul
	Perform sootblower operational checks for leaks, and proper operation of the chain drives, limits etc. POI 98, 10, 97, 78.	1 Week	Functional Test
	Fabricate crates to transport sootblower poppet valves to repair facility.	1 Year	Routine Service
	Conduct Sootblower steam trap performance survey. OPM 196, 195, 194	1 Year	Condition Monitoring
	Perform UT readings on sootblower warm up drains lines to BD tank. UT1003, 2003, 3003.. MPM 174, 189, 205.	1 Year	Conditioning Monitoring

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Gas System**	Perform pre-shutdown sootblower inspections as per check sheets to determine outage work. OPM 299, 300, 301.	1 Year	Inspection
	Snug up sootblower packing during start up after annual outage	1 Year	Routine Service
	Check & / or adjust all Sootblower pressures during start up. (Initial blow setting)	1 Year	Functional Test
	Perform PM on all retractable sootblowers. Also function test . MPM 82, 83, 84, 85, 86, 87, 88, 89, 9, 10, 11.	1 Year	Scheduled Overhaul
	Perform PM on all rotary sootblowers. Also function test MPM 90, 91, 92, 93.	1 Year	Scheduled Overhaul
	Perform PM on all AH sootblowers. Check pneumatic valves, blower lance & swing arm. MPM 94, 95, 12, 13.	1 Year	Scheduled Overhaul
	Check Operation of all AH sootblowers before & after operation to ensure cycle completion. POP 097	Each Operation	Inspection
	Remove and check water lance pump suction strainer.	2 Weeks	Inspection
	Perform sootblower operational checks. (advance, retract, pressure etc)	1 Week	Inspection
	Pressure set Sootblower safety valve as per DOL requirement	3 Years	Scheduled Overhaul
	Perform PM on thermoprobe once it is reconditioned & placed in service.	1 Year	Inspection
	Perform inspection of ductwork & supports for cracking in Economizer, Breeching, expansion joints etc.	1 Year	Inspection
	Clean & remove ash from Economizer, Air Heater & Stack Hoppers & perform inspection	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Fuel Firing System**	Inspect and replace worn burner tips using hole dimension criteria and no-go gauge. As per ED-093	1 Day & 1 Year (during boiler outage)	Inspection
	Clean, inspect & refill Antifreeze pots. Bleed lines to transmitters	3 Years	Routine Service
	Inspect & function test one-third of the burner pneumatically operated valves annually. Repair as required.	1 Year	Inspection & Functional Test
	Burners & Ignitors …. Perform shutdown function test to identify outage work. OPM- 402	1 Year	Functional Test
	Remove all burner guns & ignitors prior to major permit application. A/I- 97225	1 Year	Routine Service
	Set burner "tip to diffuser " dimensions during maintenance (Stage I)	2 Years	Routine Service
	Perform Start-up firing sequence for burner guns (Unit #3) ED- 061	During each boiler start-up	Routine Service
	Perform inspection & Calibration of Fuel oil pressure & temperature switched	1 Year	Functional test
	Ensure FO pump suction is at the required manufacturer temperature prior to starting pump. ED- 070	Prior to each pump start-up	Routine Service
	Inspect & calibrate all field devices (transmitters & switches) that provide trip signals to the BM system.	1 Year	Functional Test
	Inspect & test all heavy & light oil trip & recirculation valves Including limit switches & solenoids.	6 Years (1 Unit every 2 years)	Functional Test
	Remove burner assemblies to facilitate outage work. Replace & function test.	1 Year	Routine Service & Functional Test
	Check Light Oil differential pressure & clean pump strainers as required. OPM 149, 148, 150	1 Month	Routine Service
	Check operation of Light Oil flow meter and Calibrate if necessary.	1 Year	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Fuel Firing System**	Verify operation of light oil ignitor valves located in control boxes.	1 Year	Inspection & Functional Test
	Check operation of LO pump header switches & calibrate if necessary.	5 Years	Functional test
	Check pressure of Light Oil surge suppressor and fill if necessary	To be determined	Inspection
	Install ignitor oil guns as per OEM instructions. OPM 197, 198.	1 Year	Routine Service
	Perform annual inspection of ignitors (check spark plugs, wiring etc. Verify operation). EPM166, 167, 177	1 Year	Inspection
	Check ignitor sensing rods, o'rings, filters & fittings. Also air & oil valves. IPM 188	1 Year	Inspection & Functional Test
	Change & clean burners as per procedure. POP123, POI 83	One burner/unit/ shift	Routine Service
	Scavenge Burner oil guns as per POI 86	Daily	Routine Service
	Clean fuel oil duplex basket suction strainers. File #102. 01.35/6	Daily	Routine Service
	Check Fuel Additive pumping rate vs. fuel oil flow.	Daily	Inspection
	Perform FO flow transmitter "zero calibration" flow check as per OEM IPM 205, 206, 34	1 Year	Functional Test
	Perform all burner operating sequences and document problems prior to outage. (Burners & igniters) OPM 178, 179, 403	1 Year	Functional Test
	Exercise burner tilts through the full stroke. Set stroke as per ED 105. Reporting any problems OPM 142, 143	1 Week	Functional Test
	Check & calibrate burner front valves. Stroke & bench set. IPM 61 (2 corners stage I &1 Elevation stage II)	1 Year	Scheduled Overhaul
	Check burner cylinders & solenoids operation in situ. Check for leaks. IPM 254, IPM 339 (2 corners stage I & All burners stage II)	1 Year	Functional Check

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Fuel Firing System**	Check & clean all burner safety plungers. Verify operation. MPM 271.	1 Year	Routine Service
	Assist DOL perform FO Accumulator external Inspection OPM 170, 171.	1 Year	Inspection
	Perform check on FO Accumulator nitrogen bladder.	1 Year	Inspection
	Check Hydro-pad Pressure, refill as necessary. (Located upstream of short recirc valve)	3 Years	Inspection
	Check pressure setting of Minimum FO flow valve	1 Year	Inspection
	Check performance of each Fuel Oil pump to determine if and when replacement is required.. (during load test)	1 Week	Functional test
	Assist DOL perform external inspection of FO set heaters. OPM 14, 15, 16, 17, 18, 19.	1 Year	Inspection
	Prior to outage, drain FO strainers, clean & inspect cavities, check change over mechanism. OPM 175, 176, 177.	1 Year	Inspection & Routine Service
	Perform operational leak test on FO heaters to detect any fuel leak into condensate system.	Every Start-up	Inspection
	Function Test main FO trip valve on Hi & Lo drum level. OPM 193	1 Year	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Blow Down Drains**	Open, clean and inspect both Boiler Blowdown tanks. Inspect liners, welds, drains, legs & bolting. (This tactic to become part of new QA program	1 Year	Inspection
	Assist DOL perform internal & external inspection of Boiler blow down tanks. OPM 88, 94, 80, 92,84,76	1 Year	Inspection
	Perform Main Blowdown Tank NDE inspection to determine any corrosion etc. EPM 400, 401, 402.	1 Year	Condition Monitoring
	Inspect exterior condition of boiler vent silencer including mounting bolting. (Main blowdown tanks Units 1, 2 ,3) (This tactic to become part of new QA program)	3 Years	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Boiler Plant Assets…Cont'd **Boiler Auxiliary Steam & Condensate**	Conduct auxiliary steam trap performance survey prior to annual outage. OPM- 180, OPM- 191, OPM- 187	1 Year	Condition Monitoring
	Perform NDE inspection of auxiliary steam piping after control valve. UT1007, 2007. MPM179, 194.	1 Year	Condition Monitoring
	Assist DOL perform external inspection of Aux steam Moisture Separator.	1 Year	Inspection
	Perform overhaul of auxiliary / atomizing steam relief valves	3 – 5 Years	Scheduled Overhaul
	Inspect & Lubricate expansion joint on auxiliary steam line to tank farm. MPM 298	6 Months	Inspection

3.1.4 Condensate and Feedwater

The **maintenance strategies** for the *Condensate & Feedwater* systems are summarized below

System	Strategy	Interval	Strategy Type
Strategies to be applied against Condensate & Feedwater Assets ……Cont'd **Low Pressure Feedwater**	Perform UT inspections of AH drains piping to DA…. UT1008, 2008, 3008, MPM195, 182, 211.	1 Year	Condition Monitoring
	Perform UT inspections of recirc piping from BF pumps to DA…. UT1006, 2006, 3006. MPM178, 193, 209	1 Year	Condition Monitoring
	Perform function test of DA level critical alarm & trip switches. OPM206, OPM 207	1 Year	Functional Test
	Perform annual inspection of DA level switches. IPM 170, 165	1 Year	Inspection
	Assist DOL perform interior & exterior inspection of the DA. OPM 90, 83, 74	1 Year	Inspection
	Perform NDE inspection of the DA storage tank…. MPM169, 170, 171.	1 Year	Condition Monitoring
	Perform UT inspection of DA steam heater piping. UT1013, 2013, 3013. MPM185, 200, 215.	1 Year	Condition Monitoring
	Assist DOL perform interior & exterior inspection of DA storage tank. OPM 91, 82, 75.	1 Year	Inspection
	Perform UT inspection of #4 heater drains piping to DA. UT1010, 2010, 3010. MPM197, 180, 213..	1 Year	Condition Monitoring
	Perform UT inspection of #6 heater drains piping to DA. UT1009, 2009, 3009. MPM196, 181, 212..	1 Year	Condition Monitoring
	Overhaul DA safety valve for inspection & setting. MPM 414, 413.	3 Years	Scheduled Overhaul
	Perform visual inspection of the DA spray nozzles	1 Year	Inspection
	Perform Visual inspection of DA trays	1 Year	Inspection
	Remove trays for detailed inspection including inspection of the DA shell	6 Years	Inspection
	Clean & vacuum high, low & common reserve	2 Years	Routine Service

System	Strategy	Interval	Strategy Type
Strategies to be applied against Condensate & Feedwater Assets ……Cont'd **Low Pressure Feedwater**	FW tanks. GE / Betz to inspect all vessels Assist DOL perform exterior inspection of #1 LP Heater (OPM 20, 21, 22); #2 LP Heater (OPM 23, 24, 25); Interior 7 exterior inspection of LP Htr. drains tank (OPM 93, 87, 79)	1 Year	Inspection
	Check steam trap "Y" strainers for defects on lines to LP heaters. OPM190, 192, 193.	1 Year	Inspection
	Perform Condensate extraction pump overhaul. (Remove pump, inspect impeller, casing, seals, shaft & bushings.)	12 Years (taking into account pump performance & operating hours)	Scheduled Overhaul

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Condensate & Feedwater Assets **Boiler Feed water Pumping**	Check & clean BFP gland seal strainers . OPM 153, 152, 151	3 Months	Routine Service
	Function Test BFP motorized discharge valves prior to annual outage. OPM 401	1 Year	Functional Test
	Inspect BFP motor air filters and replace as required. EPM 1301, 1301A.	4 Months	Routine Service
	Lubricate BFP discharge valves stems	2 Years	Inspection & Routine Service
	Inspect the BFP discharge valve limits, wiring connections & torque switches.	6 Years	Inspection
	Perform minor inspection on boiler feed pumps. (oil level, coupling, bolting, glands & leaks) MPM 100, 101, 102, 103	1 Year	Inspection
	Replace all BF Pump pressure gauges (damaged as a result of pump vibration and gauge mounting arrangement) IPM 46, 47, 48, 49	3 Years	Routine Service
	Check calibration of BP pump pressure switches located behind BFP gauge panel	3 Years	Routine Service
	Major Overhaul of Boiler Feed Pump. Also clean & pressure test the lube oil cooler.	6 Years. (taking into account pump performance & operating hours)	Scheduled Overhaul
	Perform UT testing on BFP recirculation piping. UT1005, 2005, 3005. MPM176, 191, 192, 207, 208	1 Year	Condition Monitoring
	Take samples of BFP lube oil for analysis	3 Months	Condition Monitoring
	Remove & inspect BFP suction flow Elements, Unit #3 as per list. (Annubars, Controlling) see comments in workbook MPM- 283, IPM- 155	2 Years	Inspection
	Remove & inspect flow element orifice plates as per list. (in particular those use in control systems) IPM- 152 & IPM- 153	9 Years	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Condensate & Feedwater Assets **High Pressure Feedwater**	Perform bled steam trap survey as per performance check sheets.	1 Year	Condition Monitoring
	Perform UT readings on HP Feedwater & bled steam lines; Heater Vents & drain Lines…	1 Year	Condition Monitoring
	Assist DOL perform HP heater(s) exterior inspection	1 Year	Inspection
	Perform HP heater pre-shutdown electrical checks. EPM 197, 198, 199	1 Year	Functional Test
	Perform HP heater pre-shutdown leak test.	1 Year	Inspection
	Test HP heater level probes for alarm & trip functions. (Subsequent to the installation of the new test feature required by FM)	1 Week	Functional Test
	Overhaul HP heater shell side relief valves	3 Years	Scheduled Overhaul
	Exercise valves, check limit switches and report any problems with the Main & Low Load motorized Isolators prior to outage	1 Year	Functional test
	Test HP heater feedwater valves (water side) prior to annual outage. OPM409, 410, 411	1 Year	Functional Test

3.1.5 COMMON SYSTEMS

The **maintenance strategies** for *Common Systems* are summarized below

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets **Fire Protection System**	Perform plant fire system standpipe & hose station inspection. Procedure #0833. NFPA 14.	1 Month	Inspection
	Inspection & flushing of 30% of total standpipe & hose stations. Lubricate fittings. NFPA 14	1 Year	Functional Test
	Perform wet pipe sprinkler system flow switch test for each location. OPM 135	1 Month	Functional Test
	Operate main fire line water valves to ensure they are working properly. OPM 413	1 Month	Functional test
	Perform inspection of plant fire hydrants during the April – October period.. Procedure # 0834	1 Month	Inspection
	Visually check fire system deluge & sprinkler control valves. OPM 136	1 Week	Inspection
	Perform property loss & fire prevention inspections as required under FM Global 2.6.1	1 Week	Inspection
	Record air & water pressure & room temperature on dry pipe sprinkler systems. FM Global 2.3.4 (Table 3)	1 Week	Inspection
	Check priming water above clapper valve on the dry pipe sprinkler system. .FM Global 2.3.4 (Table 3)	1 Month	Inspection
	Perform water flow alarm test using hydraulic test connection at dry pipe valve riser. FM Global 2.3.2	3 Month	Functional Test
	Perform partial flow trip test on the dry type sprinkler system FM Global 2.3.4 (Table 3)	1 Year	Functional Test
	Confirm wet pipe sprinkler system roadway curb boxes are in the correct position. FM Global 2.3.1.3 (Table 2)	1 Week	Inspection
	Physically test for full open position on all wet pipe sprinkler valves FM Global 2.3.1.3 (Table 2)	1 Month	Inspection & Functional Test

Strategies to be applied against Common System Assets……Cont'd **Fire Protection System**	Conduct water flow alarm test on the wet pipe sprinkler system using inspectors test valve. FM Global 2.3.2	3 Month	Inspection & Functional Test
	Wet Pipe Sprinkler…..Perform roadway curb box valve full turn operation / 2" main drain flow test/ full system verification. FM Global 2.3.1.3 (Table 2)	1 Year	Inspection & Functional Test
	Record air & water pressure on the deluge & pre-action system FM Global 2.3.5 (Table 3)	1 Week	Inspection
	Check supervisory trouble signals on the deluge & pre-action system FM Global 2.3.5 (Table 3)	1 Month	Inspection
	Full System verification on the deluge & pre-action system FM Global 2.3.5 (Table 3)	1 Year	Inspection
	Full flow trip test on the deluge & pre-action system FM Global 2.3.5 (Table 3)	3 Year	Inspection
	Perform Hydrant flow testing FM Global 2.3.10	1 Year	Functional test
	Perform Flow test to verify pressure reducing valves & back flow preventers. FM Global 2.3.12 (Table 6)	1 Year	Functional Test
	Perform full flow trip test on dry pipe sprinkler system FM Global 2.3.2 (Table 3)	3 Year	Functional Test
	Perform full flow trip test of deluge and pre-action system FM Global 2.3.5 (Table 3)	3 Years	Functional Test
	Perform full flow test of underground hydrant mains FM Global 2.3.10	3 Years	Functional Test
	Perform Internal inspection of all fire protection systems. FM Global 2.3.3 / 2.3.12	5 Years	Inspection
	Perform flushing investigation of dry / deluge / pre-action fire protection systems. FM Global table 3	10 Years	Functional Test
	Test & record deluge system operation for unit service & station service transformers.	1 Year	Functional Test.

Strategies to be applied against Common System Assets……Cont'd **Fire Protection System**	Weigh nitrogen cylinders, inspect for caking & hydrostatic dates on portable fire extinguishers. NFPA 10	1 Year	Inspection
	Visual inspection & accessibility of fire alarm systems. CAN/ULC S536.	1 Month	Inspection
	Test the evacuation alarm system NFC of C 2005	1 Week	Functional Test
	Inspect & clean Gas Turbine smoke detectors EPM 306	1 Year	Inspection
	Perform full flow water testing of the site fire system	1 Year	Functional test
	Inspect & test fire alarm systems. CAN/ULC S536.	1 Year	Inspection & Functional Test
	Perform weekly test of the electric fire pump. OPM 134	1 Week	Functional Test
	Perform inspection & maintenance of the electric fire pump breaker EPM 162	1 Year	Inspection
	Perform electric fire pump full flow test & system verification. FM Global 2.3.14 (Table 6)	1 Year	Functional Test
	Perform inspection of the Service Water fire pump MPM 162	1 Year	Inspection
	Perform weekly test of the diesel fire pump OPM 133.	1 Week	Functional Test
	Perform mechanical inspection of the diesel fire pump	To be determined by R. LeDrew	Inspection
	Perform diesel fire pump full flow test & verification. FM Global 2.3.14 (Table 6)	1 Year	Functional Test
	Replace Diesel Fire Pump engine oil filter. FM Global 2.3.14 (Table 6)	6 Months	Routine Service
	Perform electrical inspection of diesel fire pump & controller. EPM 296	1 Year	Inspection & Functional Test
	Check diesel fire pump battery condition. FM Global 2.3.14 (Table 6)	1 Month	Inspection
	Perform electrical PM inspection of diesel fire pump. EPM 200	3 Month	Inspection & Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Oil Spill Response**	Inspect lock seal located on each spill kits. If intact then kit is considered adequate.	2 weeks	Inspection
	Inspection of Aluminum boat & trailer as part of spill response requirement	PM to be determined by ERT members	Inspection
	Inspect ERT equipment (SCBA, HAZMAT etc)	PM to be revised by ERT members	Inspect

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Compressed Air Systems**	Complete daily air compressor readings. POI 87	1 per shift	Routine Service
	Perform inspection of all rotary air compressors MPM 231, 230, 232.	6 Month	Inspection & Functional test
	Perform inspection of all rotary air compressors. MPM 284, 286, 285.	1 Year	Inspection & Functional test
	Overhaul Stage I & II Instrument air dryers. IPM 98	1 Year	Scheduled Overhaul
	Assist DOL inspectors perform inspection of Stage I & II Instrument air dryers. OPM 29, 30, 31, 32	1Year (legislation to be verified)	Inspection
	Assist DOL inspectors perform interior & exterior inspection of Stage I & II Instrument air receivers OPM 101, 102, 103, 104.	1 Year (legislation to be verified)	Inspection
	Assist DOL inspectors perform interior & exterior inspection of Stage I & II service air receivers OPM 97, 98, 99, 100..	1 Year (legislation to be verified	Inspection
	Assist DOL inspectors perform interior & exterior inspection of WT plant air receiver. OPM 106	1 Year (legislation to be verified	Inspection
	Verify PLC program & solenoids on Instrument & service air dryers & receivers.	6 Months	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Heating & Ventilation**	Conduct steam trap performance survey. OPM 188	1 Year	Condition Monitoring
	Assist DOL inspector perform internal & external inspection of plant heating condensate drains tank. (Stage I, location 2nd el)	1 Year	Inspection
	Complete check on plant heating system. Motors, valves, piping, heaters etc. OPM 64	1 Year	Inspection
	Assist DOL inspector perform external inspection of the WAM flash tank. OPM 166	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Warm Air Make-up**	Inspect and clean all warm air make-up enclosures in preparation for operating season.	1 Year	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Heavy Oil, Light Oil & Fuel Additive Storage**	Inspect and lubricate tank farm & dock valve stems	1 Year	Routine Service
	Perform inspection of the marine terminal loading arms. MPM 272	1 Year	Inspection & Routine Service
	Perform inspection of capstan motors, controls, and associated equipment. EPM 295	1 Year	Condition Monitoring
	Inspect all electrical connections in the marine terminal MCC.	2 Years (3yrs when new MCC installed)	Inspection
	Perform overhaul of the Marine terminal loading arms with technical assistance from OEM.	3 Years	Scheduled Overhaul
	Grease and /or check oil level on dock capstan gearboxes (two still require oil level check)	1 Year	Inspection
	Check nightly that all lights are operational at dock & shoreline	1 Day	Inspection
	Verify that all nitrogen operated valves trip close (dock fuel oil line)	Prior to each tanker.	Functional Test
	Pump out off-loading arms & fuel oil lines at dock before disconnecting from ship	After each tanker	Routine Service
	Monitor Electrical panel meters & fuel oil line thermometers to determine proper functioning of the heat tracing	Prior to each tanker.	Routine Service
	Clean floor trenches between day tank & pumping & heating sets. (Main drain thru to catch basin) UPM 32	2 Years	Routine Service
	Test operate main fuel oil supply trip valve to day tank.	1 Week	Functional Test
	Check calibration of Fuel Oil day tank level transmitter against tank dips. Verify all alarms and CR indications. OPM 341.	3 Years	Functional Test
	Perform fuel oil day tank high level checks to verify level trip switches. OPM 174	1 Year	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against Common System Assets……Cont'd **Heavy Oil, Light Oil & Fuel Additive Storage**	Assist DOL inspect exterior FO storage tank suction heaters. OPM 36, 37, 38, 39, 40, 41, 42.	1 Year	Inspection
	Function test (operate) Fuel Oil storage tank suction heater isolation valves	1 Month	Functional Test
	Check all drums at FO pumping & heating sets & dump into slops tank if required. Maintain two drums only at each set.	2 Weeks	Routine Service
	Inspect light oil storage tanks for visible leaks. Check vacuum gauges.	1 Week	Inspection
	Exercise light oil outdoor valves and lubricate as necessary.	1 Year	Functional Test
	Check operation of tank farm underground dyke valves	1 Year	Functional test

3.1.6 Water Treatment and Environment

The **maintenance strategies** for the *Water Treatment & Environment* are summarized below

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets **Water Treatment Plant**	Check & Calibrate Water & Waste Water Treatment Plant Sodium, Ph, turbidity & conductivity monitors IPM 347, MSTD 28.	1 Month	Routine Service
	Complete a back-up CD of Water Treatment Plant PLC software. EPM 139	As Required	Routine Service
	Perform PM maintenance of the WTP Hach silica analyzer. Hach rep to be at site. IPM 346.	1 Year	Functional check
	Check & calibrate WT plant analyzers & transmitters. IPM 348	5 Years	Functional Test
	Perform NDE inspections of Acid & Caustic storage tanks	As per new QA inspection program	Functional Test
	Inspect Clearwell tank for corrosion including NDE readings	As per new QA inspection program	Inspection & Condition Monitoring
	Perform clarifier & internal component inspection	2 Years	Inspection
	Recoat clarifier walls	10 Years	Routine Service
	Visually inspect demineralizer sand filter vents located in splitter box MPM 292, 291	1 Year	Inspection
	Inspect demineralizer sand filters where needed	To be determined from baseline	Inspection
	Perform UT thickness survey of acid transfer lines from WT Plant to polisher	As per new QA inspection program	Condition Monitoring

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Water Treatment Plant**	Change domestic water filters at the four locations listed on work order UPM 44	1 Month	Routine Service
	Remove fish-way stop logs at Quarry Brook . Remove in spring & replace in the fall. UPM 33	1 Year if required by DOE.	Routine Service
	Prepare and submit to DOE the raw water usage for previous year by March deadline.	1 Year	Routine Service
	Visually inspect Quarry Brook fish-way & timbre crib dam. EMS 65.	1 Year	Inspection
	Inspect Quarry Brook dam structure. (Civil Engineering)	1 Year	Inspection
	Inspect raw water pumps and sumps . MPM268, 269	2 Years	Inspection
	Check boiler blowdown PH sample flows & equipment	1 Day (day shift & night shift)	Inspection
	Check & calibrate Sodium & PH monitors located on the unit analytical racks. IPM 89, 90, 200	1 Month	Routine Service
	Perform all post shut down & start-up activities on the units analytical monitoring equipment. IPM 270, 271, 272, 267, 268, 269	1 Year	Routine Service
	Overhaul analytical rack flow meters, panels, gauges etc. IPM 352, 366, 367	1 Year	Scheduled Overhaul
	Clean out condensate polisher acid tank & remove sludge. UPM 102	6 Months	Routine Service
	Inspect and Calibrate condensate polisher analytical meters (conductivity & flow).	1 Year	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Environmental Monitoring**	Perform maintenance on the BAM 1020 Particulate Monitors located at the environmental sites. AQM 26, IPM 372, ENV 114	1 Month	Routine Service
	Complete and distribute ambient air monthly reports.	1 Month	Routine Service
	Perform PM on API dilution gas calibrator as per QA manual. IPM 253, ENV 112.	3 months	Routine Service
	Perform PM on spare NOx gas analyzer as per QA manual. IPM 382, ENV 111.	1 Month	Routine Service
	Perform PM on spare SO2 gas analyzer as per QA manual. IPM 252, ENV 110.	1 Month	Routine Service
	Perform PM on TSP Hi-Vol samplers at 5 environmental sites. TSP 7, IPM 210, ENV 113.	3 Month	Routine Service
	Perform checks on TSP Hi-Vol samplers as per IPM 107.	1 Week	Routine Service
	Arrange for calibration of Hi-Vol calibrator & orifice as per QA. IPM 215	1 Year	Routine Service
	Order & replace oxygen cell for Inst shop portable oxygen analyzer IPM 108	1 Year	Routine Service
	Order permeation tubes for SO2 & NOx analyzers (5 Sites). IPM 266	1 Year	Routine Service
	Perform stack emission testing at various loads for all 3 units.	1 Year	Condition Monitoring
	Prepare filters for TSP Hi-Vol sampler	1 Week	Routine Service
	Prepare TSP Hi-Vol sampler monthly report	1 Month	Routine Service
	Perform asbestos air sampling (6 samples X 2 hrs per sample)	1 Week	Routine Service
	Perform plant air sampling (one daily sample at various locations)	1 Day	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Environmental Monitoring**	Sample CW sea water at plant inlet & discharge	3 Months	Routine Service
	Perform dew point sample readings at the designated locations. IPM 69	1 Month	Condition Monitoring
	Calibrate Lab balances by external resource. Required for certification.	1 Year	Routine Service
	Calibrate & recertify Lab Spectrophotometer during February (annually)	1 Year	Routine Service.
	Inspect Bio-Green septic system for proper operation & alarm conditions	1 Week	Inspection
	Inspect Bio-Green system and sample effluent for TSS & BOD	1 Year	Routine Service
	Perform inspection of septic system lift station pumps & level switches etc. MPM 356	1 Year	Inspection
	Sewage disposal system: Open all yard man-hold doors & check for free flowing. UPM 56	1 Year	Inspection
	Vacuum out solid waste from septic system pumping station at disposal field.	2 Years	Routine Service
	Met Station Green Acers	PM Program needs to be developed for the various pieces of monitoring equipment	To be determined
	Maintain equipment & perform calibration of all the environmental site NOx analyzers. AQM 28, IPM 380, 381, 371, 378, 379 ENV 109, 105, 103, 101. 107	1 Month	Routine Service
	Maintain equipment & perform calibration of all the environmental site SO2 analyzers AQM 27 IMP 211. 212, 214, 213, 370 ENV 104, 100, 108, 102, 106	1 Month	Routine Service
	Perform checks on CEMs system monitoring equipment. IPM 376	1 Week	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Environmental Monitoring**	Replace Teflon diaphragm on CEMs system sample flow vacuum pump	6 Months	Routine Service
	Prepare CEMs monthly report for submission to NDOE	1 Month	Routine Service
	Replace the CEMs stack sample probe filters	1 Week	Routine Service
	Flush each stack bundle to reduce the build-up of sample contaminate and to maintain adequate flow during the operating season.	1 Year	Routine Service
	Perform Calibration & maintenance on CEMs Ametek SO2/NOx analyzers as per IPM 373	1 Month	Routine Service
	Perform calibration & Maintenance on CEMs Oxymat 61 O2 Analyzer. IPM 374	1 Month	Routine Service
	Perform Calibration & maintenance on CEMs Ultramat 23 CO & CO2 Analyzer. IPM 375	1 Month	Routine Service
	Replace capillary & male connector on CEMs Oxymat 61 analyzer	4 Years	Routine Service
	Replace IR source & chopper on CEMs Ultramat 23 CO / CO2 analyzer	4 Years	Routine Service
	Test gas alarm monitor for CEMs room.	6 Months	Functional Test
	Clean CEMs monitoring equipment sample flow meters	6 Months	Routine Service
	Rebuild CEMs monitoring equipment sample regulators	1 Year	Routine Service
	Complete CEMs monthly report for NDOE, central file & performance monitoring manager	1 Month	Routine Service
	Conduct back-up of previous years CEMs monthly reports to CD.	1 Year	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Waste Water Treatment**	Perform monthly inspection of the Leachate Pumping Station & Force Main to determine structural integrity. Also to check float & valves.	3 Months	Inspection
	High pressure wash the waste water treatment plant plate press	6 Months	Routine Service
	Clean out sludge & sediment from Periodic Basin	2 Years	Routine Service
	Inspect roof exhausters in WWTP and periodic basin	1 Year	Inspection
	Inspect reactor (rake, recirculator, associated equipment & coating)	3 Years	Inspection
	Perform galvanic monitoring checks on the underground oil/water separators. OPM 183	1 Month	Condition Monitoring
	Flush 5A/5B discharge lines back to pump & over to equalization basin	After each AH wash	Routine Service
	Verify oil/water separator tank probe operation. IPM 275	1 Year	Functional Test
	Sample the waste landfill surface water and leak detection manhole water for characterization. CWL-07	1 Month	Condition Monitoring
	Inspect the control waste landfill as per procedure CWL-07	1 Week	Inspection
	Take control waste landfill groundwater samples for characterization	3 Months	Condition Monitoring

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against WT & Env Assets …Cont'd **Buildings and Site**	Clean & inspect environmental site buildings	6 Months	Routine Service
	Check & replace burnt out lights in all buildings & outside areas. UPM 53	2 Weeks	Inspection
	Perform mechanical checks on stores yard gate	6 Months	Routine Service
	Inspection of all emergency doors	1 Month	Inspection
	Inspection of all non-emergency building doors	6 Months	Inspection

3.2 "Synchronous Condenser Systems" Introduction

These particular assets were identified as being a requirement for a unit to operate in the synchronous condenser mode. Currently Unit 3 is the only one capable of converting to this type of operation. Significant upgrading would have to take place to enable this option on Units 1 & 2. As stipulated in the station's operating philosophy, the planned remaining life of the HTGS is approximately another 5 years, until 2015. After the potential DC link is placed in service, these particular assets would have to remain operational into the foreseeable future in order to provide synchronous condenser capacity for the System.

In the sync condenser mode, the generator is converted to operate as a synchronous motor not mechanically attached to the turbine. It is rotated (run-up) to synchroneous speed (3600 rpm) and connected (synchronized) to the grid through the 16kv/230Kv main transformer. Its field is controlled by a voltage regulator to either generate or absorb reactive power as needed to support the system's voltage or to maintain the system power factor at a specified level. The sync condenser operation is identical to that of a large electric motor. Increasing the device's excitation results in it furnishing magnetizing power (Megavars) to the system. Its principal advantage is the ease with which a significant amount of correction can be applied when compared to other static devices such as capacitor banks.

Sync Condenser operation requires approximately 25% of the plant total assets including auxiliary equipment. Specifically these are: generator, turbine lube oil, general and turbine/generator cooling, main cooling water, unit and station service power, motor control centres, switchgear, inverter and battery systems, water treatement system, and controls.

3.2.1 All Assets

The following **Maintenance Strategies** are to be applied against all *"Synchronous Condenser"* Assets

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **All Synchronous Condenser** Assets	Review maintenance strategy "change management process" (AMS Guide) to identify triggers; then review and revise applicable sections of the Maintenance Strategy Workbook and Manual	1 year	n/a
	Review and revise the entire Maintenance Strategy Workbook and Manual	5 years	n/a

3.2.2 Synchronous Condenser

The Maintenance strategies for *Synchronous Condenser* are summarized below:

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Synchronous Condenser** Assets	Convert from Generation to Synchronous Condenser mode. Refer to conversion procedure.	1 Year	Routine Services
	Change lube oil filter for the sync condenser skid.	1 Year	Routine Service
	Verify operation of the Turning Gear lube oil spray bar.	1 Year	Routine Service
	Inspect SSS clutch (shear pins , bearings etc)	1 Year	Inspection
	Function Test Run-up Controller only. It is not practical to test run up the sync condenser to verify the controller and settings.	1 Year	Functional Test
	Convert from synchronous condenser to generation mode. Check coupling alignment. Refer to conversion procedure.	1 Year	Routine Services
	Inspect portable Sync Condenser CW pump & motor. Remove from sump & clean (when not in service)	1 Year	Inspection
	Remove and replace Keyphaser (Collector end) as required during the Sync condenser conversion process	1 Year	Routine Services
	Record synchronous condenser SSS clutch vibration levels. (when in operation)	Continuous	Condition Monitoring

3.2.3 Generator

The **Maintenance strategies** for the *Generator* are summarized below:

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Generator** Assets	Monitor lube oil drain, & bearing temperatures & vibration	Continuous while operating	Routine Services
	Trend / Record bearing Temperatures	4 Hour	Routine Services
	Verify accuracy of bearing oil drain RTD's by comparison to thermocouples & RTD's at same locations on the other bearings.	3 Years	Inspection
	Check Liquid Leak Detector & H2 Detraining Tank Level Detector Switches for accumulation of oil and / or water.	1 Day	Inspection
	Function Test Generator leak detector and H2 Detraining Tank level detector by filling with liquid to activate alarm. Record results	1 Month	Functional Test
	Record production readings. (Generator, Exciter, Unit Service, & Station Service).	1 Day	Routine Service
	Perform H2 Leakage Rate test using " Rate of Decay" method	1 Day	Condition Monitoring
	Perform PDA (partial discharge analysis) on Generator Stator at High loads twice a year.	6 Months	Condition Monitoring
	Perform PDA (partial discharge analysis) on Generator Stator at Low loads twice a year.	6 Months	Condition Monitoring
	Perform Rotor electrical inspection tests as per Holyrood standard. (Impedance & Bridge test etc)	2 Years	Condition Monitoring
	Perform Stator electrical inspection tests as per Holyrood standard. (Impedance & Bridge test etc)	2 Years	Condition Monitoring
	Check Hydrogen Cubicle Silica, change if required	1 Day	Routine Service
	Inspect Hydrogen Scavenge Flow Meter for clouding or malfunction. Replace filter/dryer if necessary. Replace annually during the outage	1 Month	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Generator** Assets …….Cont'd	Record level in seal oil float trap	4 Hours	Inspection
	Record H2 Purity, H2 Gas Pressure, Seal Oil Pressure, Differential Pressure, and H2 Gas Temperature.	4 Hours	Routine Service
	Inspect and Calibrate H2 Purity Meter. Verify DCS indication	3 Months	Functional Test
	Reactivate the H2 dryer weekly on a Monday, Wednesday, & Friday. Perform more frequently if H2 dew point is above acceptable limits	Daily (3 times per week	Routine Service
	Visually Inspect generator brush gear and replace filter	1 Week	Inspection
	Check, replace generator brushes. Check for contamination on brush gear. Check grounding brushes	1 Month (whenever unit off-line)	Inspection
	Remove & clean brush gear. Inspect holders, springs and housing. Replace worn brushes. Clean & inspect slip rings & area. Plus annual visual inspection	1 Year	Inspection
	Check H2 and bearing seals for leakage to round	3 Months	Condition Monitoring
	Perform a one time "Gas in Oil Test" on excitation transformer to determine the need for future testing.	1 Time Only	Condition Monitoring
	Remove and Replace H2 and CO2 Spool Piece for work protection permit.	1 Year or whenever required	Routine Service
	Check & Clean Exciter cabinets. Check ventilation system, louvers and fan transfers, check power supplies, high current systems and connections (Diodes & SCR's) . Torque where required. Simulate control system transfers (preferably pre outage)	2 Year	Inspection & Functional Test
	Overhaul Stage II exciter breaker. Clean, inspect, lubricate & check connections. Perform Ductor testing (have spare breaker on hand) (Dependent on exciter replacement in 2011).	6 Years (subject to exciter replacement)	Inspection & Functional Test
	Clean & Visually inspect grounding transformer. Check connections	4 Years	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Generator** Assets …….Cont'd	Inspect Generator flexible leads, joints & connecting Hardware	2 Years	Inspection
	Inspect stand-off insulators. Re-torque if necessary.	2 Years	Inspection
	Check Generator CT mounting hardware & connections. Wipe all accessible areas with a clean dry cloth. Visually inspect cables for cracks and mechanical damage.	2 Years	Inspection
	Generator PT Cubicle…..Clean, perform visual inspection, check connections, check for tracking. Check lights are working. Correct deficiencies. Record all on PM inspection sheet. Stage II only…Check resistance of all low voltage PT contacts with drawer in closed position	2 Years	Inspection
	Perform H2 Cooler gas outlet RTD calibration check.	3 Years	Functional Check
	Check oil level and condition of Seal Oil Vacuum Pump Tank	1 Day	Routine Service
	Check & drain water from Seal Oil Separator Tank	1 Day	Routine Service
	Record seal oil system pressure & vacuum	1 Hour	Routine Service
	Seal Oil Float Trap …. Check & clean internal float valve, linkage, and retaining ring.	3 Years	Inspection
	Stage I Seal Oil Filters…Install new filters during annual outage. Use corrective maintenance for the remainder of the year based on differential pressure.	Annually	Routine Service
	Stage II Seal Oil Filter.. Clean filter daily as part of operator activities.	Daily	Routine Service
	Clean seal oil vacuum tank & inspect float valve	3 Years	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against **Generator** Assets …….Cont'd **Major Overhaul**	Generator Major Overhaul & Inspection. (Dismantle end shields, measure air gap, remove rotor, Inspect / repair deficiencies. Inspect stator & rotor. Perform electrical tests. Inspect bearings & H2 seals. Inspect & test H2 coolers. Check sync condenser alignment. All readings verified against OEM requirements.)	9 Years	Scheduled Overhaul
	Clamps (grounding straps etc.)	9 Years	Inspection
	Remove, clean & pressure test water side Hydrogen Coolers	9 Years	Scheduled Overhaul
	Inspect Generator Hydrogen (H2) Shaft Seals	9 Years	Scheduled Overhaul
	Partial Discharge Analysis (PDA) equipment. Check coupler, mounting hardware, insulation cracking, co-axial cable for damage.	9 Years	Scheduled Overhaul
	Inspect bearings & clearances. Check Babbitt and Journal condition.	9 Years	Scheduled Overhaul
	Inspect & check bearing thermocouple connections. Check ambient temperature reading at DCS to verify. (calibration does not change so ambient temperature reading is sufficient to verify operation).. (complete during T/G major overhaul)	9 Years	Scheduled Overhaul
	Reverse Polarity of Generator Field	9 Years	Schedule Overhaul
	Remove rotor. Inspect bars & wedging etc. Perform electrical test. Inspect end shield. As per OEM requirements. (complete during major T/G overhaul)	9 Years	Scheduled Overhaul
	Inspect & measure wear of collector slip rings and compare to OEM recommendations for follow-up. (complete during major T/G overhaul)	9 Years	Scheduled Overhaul
	Inspect stator bars & wedging. Check for greasing and looseness. (complete during T/G major overhaul)	9 Years	Scheduled Overhaul
	Perform electrical DC HIPOT Test. (complete during T/G major overhaul)	9 Years (To be discussed for future)	Schedule Overhaul

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "**Generator**" Assets …….Cont'd **Major Overhaul**	Main & Emergency Seal Oil Pump …Check Impeller, clean, change bearings, check shaft run-out, overall inspection as per OEM requirements. (complete during T/G major overhaul)	9 Years	Scheduled Overhaul
	Bus Duct……Clean covers and check condition of supports and cover attachments	9 Years	Inspection
	Disconnect / Reconnect Generator Electrical & Instrumentation Equipment required for major overhaul.	9 Years	Routine Service
	Sync. Condenser Drive Skid ….Remove all mechanical & electrical connections. Remove skid & inspect components. Re-install & perform skid alignment. (Major Overhaul)	9 Years	Scheduled Overhaul
	Clean synchronous condenser lube oil sump and then determine the future PM requirement	9 Years	Scheduled Overhaul

3.2.4 Generation Services

The **Maintenance strategies** for *Generation Services* are summarized below.

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "Generation Services" Assets **Circulating Water System**	Grease all condenser valves at fittings provided. MPM – 366	3 Months	Routine Service
	Inspect & function test condenser backwash valves. Remove & replace packing. Clean & grease gland & shaft. Manually operate	1 valve / per unit / per year	Inspection & Function test
	Backwash condenser to prevent fouling of tubes. POP- 065	1 Week	Routine Service
	Inspect & replace condenser anodes as required.	1 Year	Scheduled Replacement
	Check condenser for tube leaks (dye test) & repair as required.	1 Year	Inspection
	Clean condenser tubes. Inspect each tube for fouling. Check condition of waterbox coating	1 Year	Inspection
	Perform Condenser Eddy Current Testing to establish a condition baseline. One unit per year for next 3 yrs to determine requirement & interval of any future testing.	To be determined	Condition Monitoring
	CW Screen Wash….Clean strainers. Check operating differential and pump pressures	1 Month	Routine Service
	Perform inspection of Amertap system. Unit #3….(screens, ball collector, actuator, observation ports)	1 Year	Inspection
	Recommend to remove Amertap Spool piece for inspection & refurbishing.	6 Years	Inspection
	CW Sump Inspection…… Arrange diver inspection to determine condition of sump & equipment. Arrange follow-up if required	1 Year	Inspection
	Dewater CW sump & clean out (if necessary, following diver inspection) Perform visual inspection.	1 Year	Inspection & Routine Service
	Connect & Disconnect portable CW sump pumps (if sump to be dewatered)	1 Year	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "Generation Services" Assets …….Cont'd **Circulating Water System**	Dewater, inspect & clean 60" CW inlet line to Condenser including line to TG coolers. Review condition in 2010 to see if Copper-Ion system is effective	1 Year	Inspection & Routine Service
	Diver to inspect seal pit inlet and outlet piping	9 Years	Inspection
	Inspect CW Pump Flow Switch and perform function test	On Start-up	Routine Service
	Remove, clean & inspect CW pump flow indicator	1 Year	Inspection
	Inspect CW pump coupling alignment & hold down bolts. Grease bearings, check glands & Inspect mechanical seal vent tube.	2 Year	Inspection & Routine Service
	Inspect and repair looseness or damage to CW pump lower casing, vortex plate and anode.	6 Years	Inspection
	Install and Remove Stop Logs for Annual Unit outage. (Dependent on diver inspection and need to dewater)	1 Year	Routine Service
	Verify CW Pump Motor heaters are "ON" when motors are shutdown down	1 Day (when down)	Routine Service
	Perform CW Pump Motor vibration analysis as part of plant monthly PM program	1 Month	Condition Monitoring
	Obtain CW Pump Motors Lube Oil samples for analysis	3 Months	Condition Monitoring
	Check and / or replace CW Pump Motor air filters	4 Months	Routine Service
	Inspect, exercise and report findings on CW system valves (non-specific). In particular the vacuum breaker butterfly valves & screen wash cross over valves.	6 Months	Inspection & Functional Test
	Function test Motorized CW Pump Discharge Valves to determine outage work. OPM-407 & OPM-408	1 Year	Function Test
	Rotate CW Travelling Screens manually & perform wash until clean	1 Day	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "Generation Services" Assets …….Cont'd **Circulating Water System**	Perform on-line CW Travelling Screens inspection & lubrication. Check spray nozzles, drive chain, coupling drive, oil level, chain tension, rollers, bearings. & structure. Grease as required. Complete Inspection forms	6 Months	Inspection
	Inspect CW Travelling Screens anodes & replace as necessary. (Could be performed during diving operation)	1 Year	Inspection
	Perform CW Travelling Screen major inspection (May also depend on findings of the 6 Month inspections)	6 Years	Scheduled Overhaul
	Remove / Replace ferrous sulphate skid to facilitate installation of the CW stop logs.	1 Year or whenever required.	Routine Service
	Apply Ferrous Sulphate mixture to CW sump	1 Day	Routine Service
	Dump bags of ferrous sulphate into holding tank, add water & mix as required.	1 Weekly	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "Generation Services" Assets …….Cont'd **T/G Cooling Water**	Inspect T/G head tank for debris & corrosion both internally and externally.	3 Years	Inspection
	Clean T/G cooler tubes (Sea Water Side)	1 Year	Routine Service
	Inspect T/G cooler anodes, replace as required	1 Year	Inspection
	Exercise 3 way valve from T/G to boiler feed pump G/S supply	6 Months	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against "Generation Services" Assets …….Cont'd **General Service Cooling Water**	Check pump strainers & clean as necessary. Also include the "Y" strainer.	1 Month	Routine Service
	Cooling Water Storage Tank …..Visually inspect for leaks. Clean interior and check for proper protective coating. Check exterior coating. Check manhole cover	2 Years	Inspection
	Inspect Heat exchanger Rotary Filter (Stage I) at this interval until it is proven that it can be extended or that the Auto-cleaning function is working.	6 Months	Inspection

3.2.5 Electrical and Controls

The **Maintenance strategies** for *Electrical and Controls* are summarized below:

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **DCS System**	Back-up DCS system software	3 Months	Routine Service
	Update DCS Point Listing and Terminations Database	6 Months	Routine Service
	Check & clean HMI cabinets and equipment	1 Year	Routine Service
	Check & clean DCS cabinets, controllers and I/O cards	5 Years	Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Protection & Control**	Inspect and calibrate all protective relays (Unit, Exciter, Buss, Black Start etc)	3 Years	Functional Test
	Check & calibrate KWH metering (performed by meter shop)	5 Years	Functional Test
	Function test Generator primary, stand-by & electromechanical protection	2 Years	Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Generator Main Transformer**	Record main power transformer winding temperatures (Not required until safe work method is approved)	n/a	n/a
	Test fire protection deluge system spray pattern	1 Year	Functional Test
	Perform electrical inspection tests as per Holyrood standard. (same time as generator electrical test)	2 Years	Condition Monitoring

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Turbine Supervisory System (TSI)**	Back-up TSI system data to ensure integrity Provide TSI trend readings to plant engineering for review & follow-up	1 Month 3 Months	Routine Service Routine Service

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Emergency Lighting**	Visual inspection. Check battery voltage and charger current. Test panel lamps. Perform functional test on charger. Verify operation of all emergency lighting systems	1 Month 3 Months	Functional Test Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Battery Banks**	Measure voltage of each cell. Check general appearance & cleanliness of batteries, battery racks and general area. Inspect electrolyte levels & evidence of leakage. Check for corrosion at terminals, connections or racks. Check ambient temperature & ventilation. Verify charger amps. Perform Specific Gravity check on each Cell	3 Months 1 Year	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **UPS System**	**Minor Inspection**: General: check filters, review menu screens, check front panel buttons, lamp test, & fan checks. Review unit menus, communication & monitoring. Electrical: Check voltage balance. Check DC link, ripple, equalize, float, DC to ground, filter current, KVA/KW load, frequency & AC battery ripple. Battery Bank: Impedance test each battery tray. Perform visual inspection **Major Inspection:** All items from the Minor inspection plus: Mechanical: Check cooling fans, power & control connections, AC & DC adapters, battery cabinets, clean unit. Operational: Verify transfer to bypass, verify static switch, verify MBP, verify generator with UPS, verify on-battery operation, Electrical: Verify all calibrations **Note**: Major inspection to be completed simultaneously with Minor inspection. Replace UPS batteries (The new continuous monitoring device, if proven successful, may allow extending the replacement to 7 years)	6 Months 1 Year 5 Years	Routine Service Routine Service Scheduled Replacement

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Bus and Enclosures (600V Switchgear)**	Minor: Visually inspect enclosure internals and bus work for dust & discoloration. Clean as required. Inspect & Re-torque discoloured hardware. Perform 1000V insulation test for each 'phase to phase' and each 'phase to ground'. Clean and re-test if either reading is less than 100 Megohms. Major: Re-torque all bus work & insulators. Perform insulation test as per the 3 year inspection.	3 Years 6 Years	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Switchgear Breakers (4KV)**	Minor Inspection & Overhaul (as per corporate standard developed by H. Ireland) Major Inspection & Overhaul. (Minor plus protection relaying as per corporate standard developed by H. Ireland)	3 Years 6 Years	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Breaker (Starter) Door Handles** (See check sheet list)	Inspect breaker handles for proper operation and to provide proper work permit isolations. Complete check sheet	1 Year	Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Transformers (Aux. 4160V / 600V) (Excitation) (Lighting)**	Perform following tests…2 min @ 1 KV megger on high side, 2 min @ 500V megger on low side. Clean cabinets & visually inspect. Check connections for corrosion & high temperature effects.	1 Year	Inspection & Functional Test

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Breakers (600V Power Centre)**	Minor Inspection & Overhaul (as per corporate standard developed by H. Ireland) Major Inspection & Overhaul. (Minor plus protection relaying as per corporate standard developed by H. Ireland)	3 Years 6 Years	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Switchboard (4160V)**	Perform Minor Inspection on Switchboard. (as per corporate standard developed by H. Ireland) Perform Major Inspection on Switchboard. (as per corporate standard developed by H. Ireland)	3 Years 6 Years	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Motor Control Centre (600V MCC)**	Perform Minor Inspection on 600 volt MCC (as per corporate standard developed by H. Ireland) Perform Major Inspection on 600 Volt MCC. (as per corporate standard developed by H. Ireland)	3 Years (1 Year for CW pump-house) 6 Years	Inspection Inspection

Equipment	Strategy	Interval	Strategy Type
Strategies to be applied against E & C Assets **Motor Control Centre (MCC SBB-3 Soot blower)**	Contactor assemblies: Remove, clean and lubricate contacts. Check for loose wires and rust. Paint if necessary. Main Panel: Check and clean bus bars, spacers, & connections. Check & clean cabinets inside & outside. Check for loose connections & rust. Paint if necessary. Perform 500V Megger on each phase to ground. (as per corporate standard developed by H. Ireland)	6 Years	Inspection

4 MAINTENANCE STRATEGY DEVELOPMENT

Maintenance strategies for the Holyrood Thermal Generating Station were developed in accordance with the corporation's Asset Maintenance Strategy (AMS) Process, which was conceived in 2007, and formally documented as the *Asset Maintenance Strategy Process Guide*.

The process to establish **maintenance strategies** for the systems and components of a given major asset includes the following steps:

1. Consolidation
   Collection and organization of existing **maintenance strategies and tactics**.

2. Manufacturers' Recommendations
   Collection of maintenance recommendations from the original equipment manufacturers (where available).

3. Expert Recommendations
   Collection of readily available expert recommendations for maintenance.

4. Practices in Other Areas of the Corporation
   Collection of maintenance practices for similar systems and major components in other areas of the corporation.

5. Practices in Other Utilities
   Collection of maintenance programs for similar assets of other utilities.

6. Maintenance Decision Tree
   Application of a reliability-centred maintenance decision tree, when there is insufficient information from other sources to arrive at a clear **maintenance strategy**.

7. Round Table and Further Study
   A series of round table meetings among experienced engineering and operations staff to review all collected information and determine the best **maintenance strategies** going forward. For systems and components for which **strategies** are not established at the round table meetings, further study is undertaken.

8. Documentation
   Documentation of the **maintenance strategies** in the Workbook and *Maintenance Strategy Manual*.

Following is a summary of the work performed in implementing this process for the Holyrood Thermal Generating Station.

4.1 Consolidation

- Most of the maintenance activity for the Holyrood station is driven through JDE work orders which are generated from PM's linked to model work orders. For this review, all JDE model work orders were documented and the information entered into the Workbook. Many of the model work orders reference check sheets and where possible these check sheets were used to supplement the work order information. Emergency work orders documented over the past five years were reviewed for recurring or significant problems. These were entered into the workbook.

There are other **tactics** that are managed outside JD Edwards, such as:

- Corporate Safety & Health Program
    - general safety inspections;
    - maintenance of special safety systems;
    - fall protection program equipment maintenance;
    - work methods;
- Environmental Standard Operating Procedures and Regulations;
- CEATI Statistics for station operating equipment
- Maintenance, Operational and Engineering Procedures
- Maintenance performed by contractors, in particular boiler, turbine, generator and other significant assets.

All of the above (model work orders, check sheets and other relevant documents) were reviewed and every **maintenance tactic** entered and organized in the Workbook.

- In addition to reviewing actual **maintenance tactics**, a number of other types of documents were reviewed for information which might assist in the determination of the **maintenance strategy** for each system and components. A complete list is contained within the *Documents Reviewed* tab of the Workbook.

In addition to the extensive documents review, an effort was made to collect knowledge from various experienced staff, especially the operations and maintenance employees.

4.2 Manufacturers' Recommendations

In the case of the Holyrood facility, to review every maintenance and operational manual would prove to be too onerous a task within the time frame to complete the review. However, a substantial effort was made to compile those manufacturer recommendations deemed to be the most significant. In particular those relative to the Turbine, Generator and Boiler. Where practicable, Manufacturers' recommendations were extracted from various operating and maintenance manuals. All identified maintenance recommendations from these sources were entered into the Workbook.

In many cases, the manufacturers' recommended maintenance does not align with our needs, particularly since we are not operating in a typical base loaded grid configuration. However, these recommendations did serve as a good baseline in the determination of the **maintenance strategies**.

4.3 Expert Recommendations

While there was no attempt to formally solicit expert recommendations for **maintenance strategies**, expert commentary was captured from various consultant reports. This were mostly information obtained from both the Alstom (boiler) and (General Electric) turbine/generator reports and recommendations.

4.4 Practices in Other Areas of the Corporation

Because Holyrood TGS produces power using thermal energy extracted from Bunger C fuel, it is unique when compared to the other generating sources within Hydro's operation. It is for this reason that the majority of Holyrood's maintenance strategies cannot be directly compared to these hydraulic installations. However there are a number of auxiliary systems where comparisons of maintenance practices could be made. In particular within the Bay d' Espoir and Churchill Falls plants. A list of those similarities was produced and comparisons made with those plants. The information was entered into the workbooks where applicable and discussed during the Round Table process

There are opportunities for further identification of 'best maintenance practices' within the corporation that could come to light as the **maintenance strategy** process is rolled out to other areas of the corporation. If identified, it is an opportunity to revisit certain systems for refinement of those **strategies**.

4.5 Practices in Other Utilities

As it was recognized early on that meaningful comparisons could only be made by obtaining maintenance tactics and strategies from other Thermal Generating facilities, a total of 24 such facilities were contacted. These were identified through various forums including:

- CEATI Thermal Generation Interest Group (TGIG);
- Canadian Electricity Association, Generation Council, Consultative Committee on Outage Statistics; and
- FOMIS (an electric power industry user group).
- Existing inter-utility relationships

Some of the maintenance plans received came from fellow members of the CEATI Thermal Generation Interest Group. In November 2007, the Maintenance Strategy team had the opportunity to present at one of their semi-annual meetings. This exercise provided some good feedback on the process and secured participation for both the gas turbine and the Holyrood Thermal Generating Station assessments. However, the time and effort required by some of these stations to compile the information could not be warranted on their part, nor could the AMS team hold up the review process to await for some responses. Three however did contribute to the process. They were OPG's Lennox station, ATCO Power's Battle River station and Manitoba Power's Brandon Station. Of those, the RCM analysis provided by the Brandon Station was the most informative.

4.6 Maintenance Decision Tree

Where a clear **maintenance strategy** could not be generated from a review of manufacturers' recommendations, expert recommendations, and practices in other parts of the corporation and other utilities, a Maintenance Decision Tree was utilized to arrive at an appropriate **strategy**. This decision tree was adapted from a reliability-centred approach. It is utilized to determine the **maintenance strategy** type (condition monitoring, time-based maintenance, run to failure, etc.) through a consideration of the failure mode and consequences.

4.7 Round Table and Further Study

After the existing maintenance program had been consolidated and entered in the Workbook along with relevant information from all other sources, round table meetings were convened to review the information. The round table was facilitated by the **maintenance strategy** team members and consisted of staff experienced with the Holyrood Operations and Maintenance processes, and various engineering disciplines. The purpose of the round table was to review all **maintenance tactics** in the Workbook, including existing as well as potentially new **tactics**.

Each **tactic** was considered in respect of the manufacturers' recommendations, any available expert recommendation, practices in other parts of the corporation, practices of other utilities, and decision tree analysis. With all of this information at hand, and with consideration of the importance of the system or component and its operating and maintenance history, consensus was reached on most items as to the best **strategy** moving forward. In total, some 900 **tactics** were discussed at the round table meetings.

It is worth noting that a by-product of this round table process was that a significant amount of knowledge was captured and documented. This will no doubt prove to be an important tool in the corporation's succession planning efforts.

For the items not resolved during the round table, the **maintenance strategy** team conducted further study and, in some cases, items requiring further review were highlighted. Round Table participants were also assigned follow-up tasks to clarify some of the maintenance strategy information.

4.8 Risk Analysis and Final Acceptance

As a final check that the recommended strategies adopted would reduce the risk to a tolerable level, a semi-quantitative risk analysis was conducted. The following Risk Matrix was the tool for this exercise.

Asset Maintenance Strategy
Risk Matrix

Probability							
	Frequent	P5	MEDIUM 5	MEDIUM 10	HIGH 15	HIGH 20	HIGH 25
	Probable	P4	LOW 4	MEDIUM 8	HIGH 12	HIGH 16	HIGH 20
	Occasional	P3	LOW 3	MEDIUM 6	MEDIUM 9	HIGH 12	HIGH 15
	Remote	P2	LOW 2	LOW 4	MEDIUM 6	MEDIUM 8	MEDIUM 10
	Improbable	P1	LOW 1	LOW 2	LOW 3	LOW 4	MEDIUM 5
			C1	C2	C3	C4	C5
			Negligible	Marginal	Moderate	Critical	Catastrophic
			Consequence				

DEFINITIONS

Risk Rank

LOW	**Low Risk (tolerable; 1 to 4)**
MEDIUM	**Medium Risk (undesirable; 5 to 10)**
HIGH	**High Risk (intolerable; 11 to 25)**

Probability

P1	Improbable	$P < 10^{-6}$ per year	so unlikely, it can be assumed that occurrence may not be
P2	Remote	$10^{-6} < P < 10^{-3}$ per year	unlikely but possible to occur in the life of an item
P3	Occasional	$10^{-3} < P < 10^{-2}$ per year	likely to occur some time in the life of an item
P4	Probable	$10^{-2} < P < 10^{-1}$ per year	likely to occur several times in the life of an item
P5	Frequent	$P > 10^{-1}$ per year	likely to occur often in the life of an item

Consequence

		POTENTIAL LOSS			
		S&H	**Env.**	**Property**	**Reliability**
C1	Negligible	no medical aid or disabling injuries	no env. damage	<$500	no effect on KPIs
C2	Marginal	X	minimal env. damage; no violation of law; non-reportable	$500 to $5000	minimal effect on KPI's
C3	Moderate	X	mitigatible env. damage; no violation of law	$5000 to $50,000	this event with others of similar impact may result in missed KPI target
C4	Critical	medical aid or disabling injury	reversible env. damage; no violation of law	$50,000 to $500,000	this event with others of similar impact will result in missed KPI target
C5	Catastrophic	death or permanent disability	irreversible, severe env. Damage; non-compliance	>$500,000	this event alone results in missed KPI target

For each recommended **maintenance strategy**, the AMS Project Team examined both the unmitigated and mitigated risk. The unmitigated risk was a determination of the consequence and probability of **failure** without taking preventive action. The mitigated risk was the consequence and probability of **failure** with the preventive action in effect. Through this exercise, all components that had Low unmitigated risk were deemed to have a Corrective Maintenance (run to **failure**) strategy. Components with Medium or High unmitigated risk were provided with Preventive **Maintenance strategies** that would reduce the mitigated risk to Low.

In determining the level of consequence, a range for each defined category was selected and the highest range was used. For example, if C4 was selected for safety, C2 for environment, C3 for property and C3 for reliability, then C4 was the overall consequence rating.

Because risk ranking via a matrix is a semi-quantitative method, the team members were conservative and in some cases choose to assume higher than actual **failure** probabilities. However, if it proves to be beneficial, a full-quantitative risk analysis could be completed during the implementation phase.

Where strategies did not reduce the risk to tolerable levels, or where risk was at tolerable levels without any PM, the AMS Project Team developed different strategies than those recommended during the Round Table.

Once each **maintenance strategy** was verified as appropriate from a risk perspective, the AMS Project Team documented the final accepted strategy in the Workbook. This was done by entering, for each row, the final accepted strategy in the column so named, as well as populate the justification column, indicating the primary reason for accepting that strategy. The unmitigated and mitigated risk levels were included in the Workbook in the form of the Risk Matrix cell numbers, for example:

Unmitigated Risk	Mitigated Risk
MEDIUM P3 x C3 = 9	**LOW P1 x C3 = 3**

4.9 Documentation

The development of **maintenance strategies** for the Holyrood Thermal Generating Station was rigorously documented in a Microsoft® Excel Workbook titled *HTGS Maintenance Strategy Workbook* . The outputs of the process - the **maintenance strategies** to be adopted - were summarized in this *HTGS Maintenance Strategy Manual*.

It should be noted that a great deal of additional **strategies** were reviewed, but only those recommended for adoption are presented in this guide.

5 CHANGE MANAGEMENT

The asset manager(s) will own the *Maintenance Strategy Workbook* and will be responsible for controlling and updating it, in consultation with Engineering Services.

The **maintenance strategies** in the Workbook are reflective of the present demands on the Holyrood Thermal Generating Station. This includes the assumption that the facilities will continue to be needed, as they are today, for generation and/or synchronous condenser operation for the foreseeable future. However, it is recognized that these requirements could change. Furthermore, there are a number of other factors which would require a revision of the **strategies**.

Listed below are events that would trigger a review of some or all of the **maintenance strategies**:

- change in equipment criticality or operating requirement;
- new, refurbished or retired equipment;
- new regulations, codes, or best practices;
- equipment failure investigations;
- condition assessments;
- loss of manufacturer support; or
- life cycle phase change.

In addition to reviews triggered above, it is recommended to conduct a complete review of the entire Workbook and *Maintenance Strategy Manual* every five years.

Appendix A – Observations & Recommendations

The following observations were noted during the AMS review process and are documented in this Maintenance Strategy Manual for discussion and follow-up.

1. Emergency work orders are not always coded to the correct asset. As the majority of these work orders bypass the planning process (as per procedure), it is more expedient to initially enter them at the highest asset level . This does allow the work to get started as quickly as possible but it introduces errors when associating emergency work to a particular asset. Consequently the majority of emergency work gets coded not against the equipment causing the problem but against a higher level asset. In future an effort should be made to recode these emergency work orders with the proper coding when they return to planning The same could be said for work orders of any priority when it comes to accurate tracking of an asset's history. Any completed work order should be coded as close as practicable to the asset in question**.**

2. There is very little feedback provided on many of the completed work orders especially those of a higher priority including emergencies. Consequently not a lot of information is available to do a proper historical review of an asset. If there is no feedback, it becomes unclear what the exact problem was or how it was resolved. An effort should be made to increase the level of documentation on completed work orders, in particular the 'as found' condition and the maintenance work done to repair the problem.

3. Many emergency work orders are not actually emergencies according to the Holyrood definition but rather a means to accommodate a work schedule. This could be resolved possibly during the up front planning of the scheduled work or by applying the Holyrood definition to emergency work orders. Other emergency work orders seem to be specific to areas rather than to actual plant production (as the guidelines stipulate). A couple of examples are: An emergency work order for the maintenance group to provide assistance during a scheduled Boiler Acid wash and an emergency work order requesting maintenance employees to be available for a unit start-up.

4. It was noted that some PM model work orders only exist in JDE for a specific unit rather than for all three units particularly when the same equipment is involved. It would seem then that the PM is only being performed on the unit identified and not on the other two. The workbook identifies the PM's and the units to which this applies. The JDE data base should be updated to include these maintenance tactics on all units.

5. There are multiple PM work orders generated for the same job in order to accommodate the various departments. This does not allow the equipment history to be readily accessible and consolidated. Also there are multiple work orders to complete a single job even for the same department. For example: One work order to remove an O2 analyzer, another to replace it by the same department, and yet another for a different department to perform some additional work. This creates an excessive number of work orders needed to perform work and an historical asset data base that requires significant effort to retrieve. There is also a long standing issue with JD

Edwards when it comes to providing information (work history & cost) using any specific asset number.

6. Some asset descriptions on one unit are not labelled the same for identical assets on another unit. This does not pose any problem from a maintenance viewpoint but does limit the ability to organize and sort JD Edwards information. It is recommended that future asset nomenclature be standardized among units.

7. Check sheets referenced in the model work orders are not available except as paper copies. These check sheets contain much of the historical information on a particular asset and should be available on-line to complement the work order history. An effort should be undertaken to see if software is readily available that would enable check sheets to be scanned into JD Edwards (or an alternate system). This would add significantly to equipment history documentation and review.

8. Some equipment on a unit (i.e. Unit #1) may have 2 PM work orders for the same job whereas another unit (i.e. Unit #2) does not have that PM (see unit #1 BF Pumps). Suspect the work orders are coded incorrectly. Also there are PM tactics for equipment such as the FD fans that exist for the East but not for the West. Similar also for some control valve maintenance

9. There would seem to be too many procedures for like equipment. For example 6 PM procedures to perform air heater inspections (one for each air heater drains tank to perform DOL inspections & likewise one for each NDE inspection). In reality that could be simplified by using the same procedure for all the drains tanks.

10. There are a good number of PM check-sheets still referenced but obsolete (not used). These references & sheets should be removed. Similarly there are many PM's without check-sheets that could be used to document the results.

11. A review should be made of all the existing check-sheet templates for accuracy & usage.

12. In order to continuously monitor the FD fan vibration levels, Vibration monitoring equipment should be installed and connected to the DCS system to provide trending, alarm & trip capability. This work began in 2008 and should continue to include all FD fans.

13. A review of procedures indicated that several could be combined. For Example: POP-080 (Carrying out Electronic Testing of safety valves) & POP-092 & 094 (Performing service pressure test) could be combined. And there are others. Also similarly identical procedures are entered on a unit basis. This could be reduced to just one procedure. Ex: POP-081, POP-082, & POP-083 refer to blowing down reference lines on the DA level transmitter on a per unit basis. They could be combined into one.

14. Work orders should have references to the procedures and check-sheets.

15. To ensure the correct procedures and check sheets get assigned to PM Work orders, all work orders should have references to their specific procedures and check sheets. Many of the actual check sheets themselves do not have a check sheet number.

Some have file numbers while others have no reference numbers at all. (Just the title of the check sheet).

16. For whatever reason, there are very few PM tactics and checks related to the Foxboro DCS, Modicon PLC, GE Mark V systems. This may be okay and will be a topic for the Round Table discussion.

14. Identical PM's for the same equipment (on a unit basis) have been assigned a different asset hierarchy number in error. For example, Unit #1 may have a PM for maintenance assigned to the CW Screen Wash whereas the same PM on Unit #2 could be assigned to the CW System, which is the next higher level in the asset structure. The Oxygen analyzers for Units 1 & 2 are located under " Boiler Gas Passes" whereas on unit #3 they are under "Common Systems". This does not create a maintenance issue but rather a cost accounting and historical documentation issue for respective assets..

15. For some reason, possibly within the JD Edwards structure itself, some PM's are listed under a specific Asset Number when viewed in the JDE Asset Management screens but when the PM is viewed in the Work Order screen it has a different asset number...

16. A significant amount of preventive maintenance work at the Holyrood TGS is performed by outside contractors. The largest of these are for the Boilers, Turbines, & Generators. Currently this work is managed outside the JD Edwards maintenance system. Hence work orders are not issued for specific work items nor is the completed work captured in JDE including costs. There are however very detailed maintenance reports completed by the major contractors including cost details. Some of the other smaller contracts do not provide such details. The asset manager should determine if performing this work outside the JDE maintenance system is the preferred method for these assets.

17. Oxygen analyzers for each unit are listed under common equipment. They should be changed to appear as assets under each unit.

18. There are PM's in the maintenance JDE system assigned to specific Assets on a particular unit (ie. Unit #1 BF Pump) but there does not exist similar PM's for the other units. When AMS review is implemented at plant, PM's need to be generated for all units where applicable

19. Identical PM's for the same equipment on a unit basis have been assigned (by manual entry) a different asset number in error. This does not create a maintenance issue but rather a cost accounting and documenting issue.

20. Many PM's need to have check sheets detailing what is required when maintenance is performed, especially when measurements or readings are involved. Many of the existing PM's refer to check sheets with specific numbers but upon furthet investigation, they are no longer used or even to be found. Either the check sheets need to be re-done for use or the references in the PM work orders removed.

21. For some reason there are PM's listed under a specific Asset Number when viewing the JDE Asset Management screens but when the PM is viewed in the Work Order screen it has a different asset number...

22. How to manage the contracts such as GE and Alstom etc under this AMS program. Currently they are not issued work orders from JDE nor is the completed work captured in JDE including costs. However very detailed reports are completed by both JDE & Alstom complete with cost details. Some of the other smaller contracts do not provide such details. Should Holyrood issue check-sheets and have Alstom & GE complete so they can be entered or filed in Planning. Or complete work orders to be entered back in JDE. Currently all maintenance work is in Detailer reports but not in JDE. DECISION ???

23. A review of maintenance strategies showed that some PM work performed by the Environmental Technologist and to some extent the Lab Technologists is completed outside the JD Edwards maintenance system. Scheduling and historical information is therefore not available to users of this system. It should be determined by the asset manager if this is the preferred process.

24. There are a good number of PM check sheets still referenced but now obsolete (not used). These references & check sheets should be removed. Similarly there are many PM's that require check sheets to document inspection results. A review should be made of all the existing check sheet templates for accuracy. Many of the existing PM's refer to check sheets with specific numbers but upon further investigation, they are no longer used or not to be found. Either the check sheets need to be re-done or the references in the PM work orders removed. There were in excess of 330 check sheets referenced in the PM model work orders for Holyrood TGS but not all were able to be located in planning. It would appear that these were created under the old MAXIMO maintenance system and imported into JDE in error.

25. Same or similar equipment on each unit are not located under the same asset structure per unit. The Oxygen analyzers for Units 1 & 2 are under " Boiler Gas Passes" where as on unit #3 they are under "Common Systems"

26. Existing PM's for unit control valves covers only the critical valves needed for unit operation. That leaves many non-critical valves subject to a run to failure situation with repairs carried our via corrective work orders. However this could lead to a non-desired situation where a number of these valves could fail and result in process upsets. Although they are considered non-critical they would still require operation of bypass valves or other compromising situations until repairs are complete. It is recommended that a certain number (10 - 12) of these non-critical valves be checked annually once the permit is installed to determine if failure is going to occur or if repairs are warranted. Otherwise a situation could develop where a number of these valves could malfunction over an operating season possibly resulting in loss of operation. Spare parts could also play a significant part in completing those repairs.

27. Any existing PM work orders that have been changed to CM (Run To Failure) during this AMS review should be deleted from the JDE maintenance system.

28. Check sheets are not dated as to when last reviewed. There is a revision on the POI but not on the check sheet. Unknown if the check sheet is current or not.. Also check sheets need to be referenced to the appropriate POI or POP or MSTD

29. Operational Equipment Checks: Please view Tab " Operator Daily/Weekly Checks" for other recommendations & Observations

30. There are many existing and new Fire System PM's that need to be reviewed by the Emergency Response Co-ordinator for accuracy and / or duplication before being added to the JDE preventive Maintenance program.

31. Remove Model Work Order references to check-sheets that are no longer used - such as old Maximo print-outs. Add additional info to Model Work Orders if applicable.

32. It is to be noted that PM programs not specific to any particular piece of equipment and listed only in one of the sections (Generation / Common or Synchroneous Condenser) will apply to both sections rather than listing them twice..... For Example: Vibration Monitoring, Lube Oil Analysis, Valve Maintenance and the like. When operating in the Generation mode, both sections of the workbook will apply.

33. Major overhaul supporting PMs are still listed as 6 years - They all need to be realigned with the 9 Year major scheduling.

34. The generator electrical checks (based on a long history of performing annual checks with mostly favourable readings) have been extended to a 2 year frequency. This change should be monitored and if again favourable should be extended to a 3 year frequency. This would then enable the PM to be done on a unit per year basis

35. Note: That all the Electrical MCC, Power Centre, and Switchgear PM's are located in the Sync Condenser section of the Worksheet. This was a conscious decision made by the AMS group to reduce the number of PM's. All the MCC breakers, for example, would be maintained as a unit rather than those related to " Generation" or "Sync Condenser".

36. Back some years ago, Hughie Ireland (Hydro Engineering) at Holyrood's request, performed an Engineering and Industry Best Practice review of maintenance performed on common electrical equipment found at Holyrood. His findings as well as his detailed inspection sheets are contained in another TAB of this Workbook. These inspections should be reviewed by plant Engineering & Electrical dept and adopted where applicable to plant equipment that had not been identified in the current PM program

37. Holyrood, using an external consultant, conducted an infrared scan in 2007 of plant electrical equipment to gauge the condition of wire terminations, bolted connections etc on all MCC's, Switchgear, and Power Centres. It is recommended that a review be carried out of the outcome to determine if future scanning is necessary and if so at what frequency.

38. This AMS Review was basically to review only the existing PM's for content & frequency. And although new PM's have been identified from RCM & existing

Procedures, There still exists equipment without any PM's identified. This may need to be addressed under the new Asset Structure.

39. NOTE: Any change in the annual boiler outage frequency (As speculated due to improved fuel quality) will also require related PM's (both Hydro & Contractor) to be adjusted as well.

40. Recommend that permanent analyzers be installed to monitor and trend Generator H2 Dew Point. See Workbook for more information.

41. Recommend that a spare battery charger be available as a temporary replacement for either of the 258V battery banks in case of a failure.

42. Holyrood's Condition Reporting Policy needs to be updated to reflect the new SWOP procedure

43. There are very few PM work orders in the JDE System for the Warm Air make-up system to cover Louvers, Automatic valves, Fans , Motors and NDE of piping. During the round table and subsequent meetings with the asset group it was stated that the operating philosophy for this system is to be changed to a more manual type. When this change is complete, new strategies should be developed and PM work orders entered into the JDE system.

44. It is to be noted that not all equipment and related PM work orders were reviewed during this AMR process (in particular those related to axillaries and those not required for generation). The Holyrood asset group will have to undertake the task to review all other asset PM's if it is considered necessary.

Round Table Recommendations

The following recommendations were tabled during the Round Table meetings held with various plant groups in October 2009.

An access platform should be provided to enable CW pump motor vibration readings to be taken in a manner conforming to corporate safety requirements.

Plant engineering to review all 4KV motor inspection readings annually (or more frequently if needed) for condition trending and expert advice on motor winding condition.

Plant engineering to investigate the installation of access platforms to facilitate lube oil sampling and vibration analysis

There are many small to midsize manually valves located throughout the plant. Should all be added to some type PM. ?

Investigate the option of upgrading control Valves to a digital positioner.

Recommendation to replace level switches with level transmitters for control and alarm. Would extend the maintenance to 5 yrs & improve reliability

Recommend that older type Pressure transmitters (Unit 3) be replaced with a more accurate and reliable type.

Investigate the feasibility of adding an alarm to indicate if cooling water flow exists when compressor is off

Damage to PVC piping from vibration and other stresses has resulted in unsafe conditions plus outages on operating equipment. Plant should investigate to determine what can be done to reduce such incidents.

Recommend that plant engineering be provided with a means to access the B/N data for vibration analysis

Investigate automating Generator KWHr etc readings for the end user

Investigate possibility of using DCS to continuously monitor the rate of H2 pressure decay and generate an alarm if exceeded.

Investigate installing temperature sensors on the Main Transformer that provide remote analog indication. Thermocouples could be the answer

Investigate if the H2/Bearing megger check could be automated so that the insulation readings could be recorded continuously and an analogue signal sent to the DCS for graphics and alarming.

Consider a permanent H2 dew point monitor to provide a DCS continuous indication and alarm. The current Monthly dew point spot check does not seem adequate

The 1 year scheduled interval for generator work should be reviewed further with examination of the insulators etc to determine if a 2 yr interval would be sufficient and then schedule it same time as the 2 yr stator megger testing

The CW system inspection PM interval could be extended depending on the diving inspection and condition of the Condenser & Coolers

Verify that the rotating cleaning action is working properly on the GSCW (new) system

Plant Operations readings changed in June 2009 to do once every 4 hours

Investigate how to perform electrical tests on the rotor (via the slip rings) at the same time as the stator testing

Recommend the installation of Rotor Flux probes on all Units to provide continuous indication of rotor performance… (Better equipment may now be available since 2005 when it was first investigated)

Recommendation to remove several Generator bus duct covers and inspect condition of the bus, insulators and supports and overall general condition. This will provide direction for future internal inspections

Recommend a permanent installation for all generating units Dew point readings

Review frequency of Centrifuge work following the installation of the new filtration unit. Currently a capital initiative for 2013.

Lube oil pressure alarm switches that are confirmed redundant by pressure transmitters should be removed.

Essential pressure switches to be identified via plant engineering review (trips, permissives, environmental) for annual calibration or replacement with transmitters.

Recommendation: Now that these local field devices (pressure & temperature gauges) are made redundant with the installation of new field devices to the DCS system). Plant maintenance should review which of these local field indications are not needed and possibly remove same. Also that operations report any field devices deemed RTF if suspected to be inaccurate.

Recommend to investigate replacing the current electromechanical P&C relaying with microprocessor based relays

Recommend to replace switches with a level transmitter (similar to stage I replacement) to improve control, alarming and DCS indication

An UPS battery monitoring device to monitor individual batteries has been installed. If this proves successful, the frequency of replacement could be increased to 7 years. Recommend also that the paralleling option be studied to see if it has a benefit to plant reliability.

Recommendation for engineering to investigate how to access the MCC's mounted back to back to allow access for the required maintenance

Recommend that fuses be added to protect the MCC starter coils from arc flash possibility. What did Stantec recommend in their MCC assessment

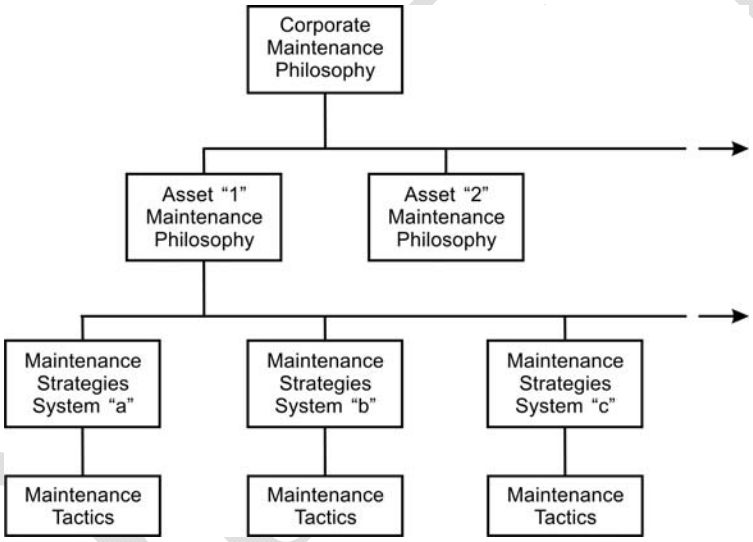
There are many strategies currently being completed by Operations (and some by Maintenance) that are listed as " not being done" or " a new strategy" simply because they are not identified in JDE or do not appear on check sheets. This can easily be rectified by adding a PM in JDE with appropriate check sheets.

There are new strategies developed that will need to be added to the 9 year Major overhaul in particular if it is to be performed by a contractor. Also that all the major outage work items should be captured on a JDE PM with appropriate check sheets

Appendix B Maintenance Definitions

Following are definitions of key terms used in the asset maintenance strategy process. Definitions have been adapted from *Maintenance* by Jasper L. Coetzee[2].

These definitions are for use in developing maintenance strategies and they do not necessarily correspond to definitions of similar terms in the J.D. Edwards work order module. There is no equivalence between maintenance strategy types and work order types. As an example, consider a component that has a "Corrective Repair" strategy, meaning we run it to failure without any attempt to prevent or predict that failure. Alternatively, the strategy for the component could be "Condition Monitoring" in which we endeavour to predict failure and replace the component before failure occurs. In both cases, failure can occur and a work order will be generated to replace the component. That work order will likely be classified as a "corrective type" work order, whether or not the strategy was "corrective".



Maintenance Philosophy

A statement of mission, vision and key objectives for the maintenance functions that will serve as a guide for the development of maintenance strategies. There is a general Corporate Maintenance Philosophy, and each major asset will have a more specific maintenance philosophy.

Maintenance Strategy

An approach to manage failure and its consequences. Maintenance strategies define the optimal amount and type of work, monitoring, testing and inspection on equipment.

Maintenance Tactic

The specific procedures and instructions used by workers to perform work on assets in order to apply a maintenance strategy.

Failure

An unsatisfactory condition.

Functional Failure

Inability of a system or component to meet a specified performance standard. This could be a total inability to perform a function or an inability to perform a function at the required level.

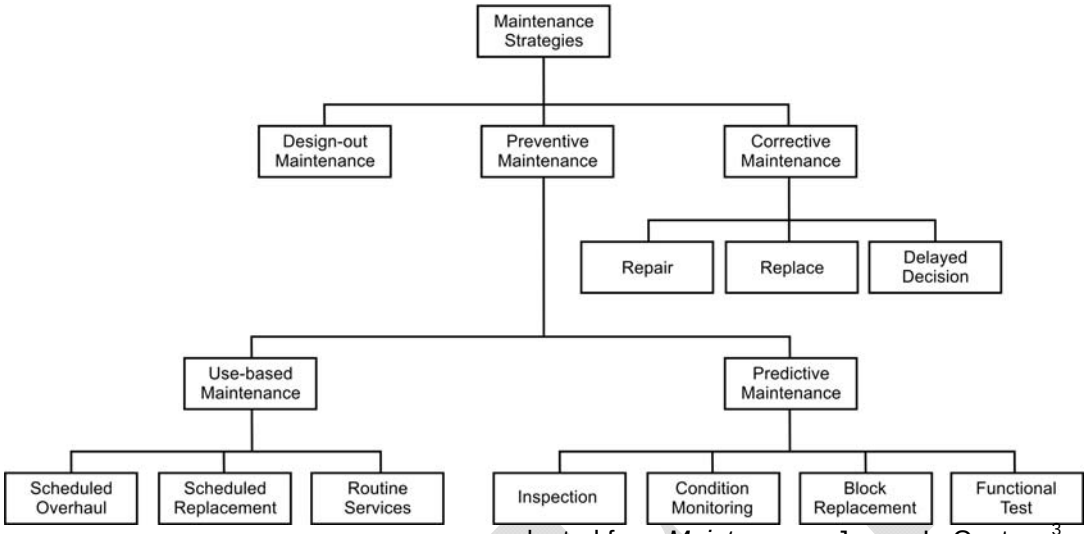
Potential Failure

An identifiable physical condition which indicates that a functional failure is imminent.

Hidden Failure

Failure of a component that could go undetected during the normal course of operation and, if and when called upon to perform its function, could result in failure of other components or the system overall. Hidden failures can be found through functional testing.

MAINTENANCE STRATEGIES



adapted from *Maintenance*, Jasper L. Coetzee[3]

MAINTENANCE STRATEGY TYPES

Design Out (DO)
A maintenance strategy in which the failure mode is effectively eliminated through the implementation of a design change to a system or component, eliminating the need for preventive or corrective maintenance. This is more accurately described as a method to eliminate a maintenance strategy.

Corrective Maintenance (CM)
A maintenance strategy in which a conscious choice is made to run the system or component to failure and then repair or replace the component. This implies that there is no proactive attempt to: (i) predict when failure might occur; (ii) prevent failure; or (iii) find any hidden failures. This strategy is employed when other strategies are either not technically feasible or are shown to be uneconomical compared to the cost of unabated failure. This strategy is never an option when there are potential safety & health consequences.

Corrective Replacement (CM1)
A corrective maintenance strategy in which it is predetermined that the system or component will be *replaced* after it fails.

Corrective Repair (CM2)
A corrective maintenance strategy in which it is predetermined that the system or component will be *repaired* after it fails.

Corrective Delayed Decision (CM3)
A corrective maintenance strategy in which the decision to replace or repair is deferred until a post-failure inspection of the system or component.

Preventive Maintenance (PM)
A collection of maintenance strategies that are aimed at preventing failure from occurring and includes pro-active attempts to find hidden failures.

Predictive Maintenance (PM1)
A preventive maintenance strategy in which: (i) the condition of a system or component is measured continuously or at pre-determined intervals in order to predict when the system or component might fail; or (ii) the functionality of a system or component is verified through a failure finding inspection or test. The prediction or discovery of failure then triggers a replacement or overhaul. This strategy applies primarily, but not exclusively, when the risk of failure is not expected to increase with age, since use-based maintenance is not effective.

Inspection (PM1a)
A predictive type of preventive maintenance in which the five senses are used to determine the condition of a system or component, which may be enhanced through instruments.

Condition Monitoring (PM1b)
A predictive type of preventive maintenance in which a parameter such as vibration, thermography, oil condition, shock pulse, acoustic emissions, and performance is monitored to detect signs of imminent failure.

Block Replacement (PM1c)
A predictive type of preventive maintenance in which the failure of a component can be considered an indication that similar components may soon fail.

Functional Test (PM1d)
A predictive type of preventive maintenance in which the component or system is function tested to determine if there are any hidden failures.

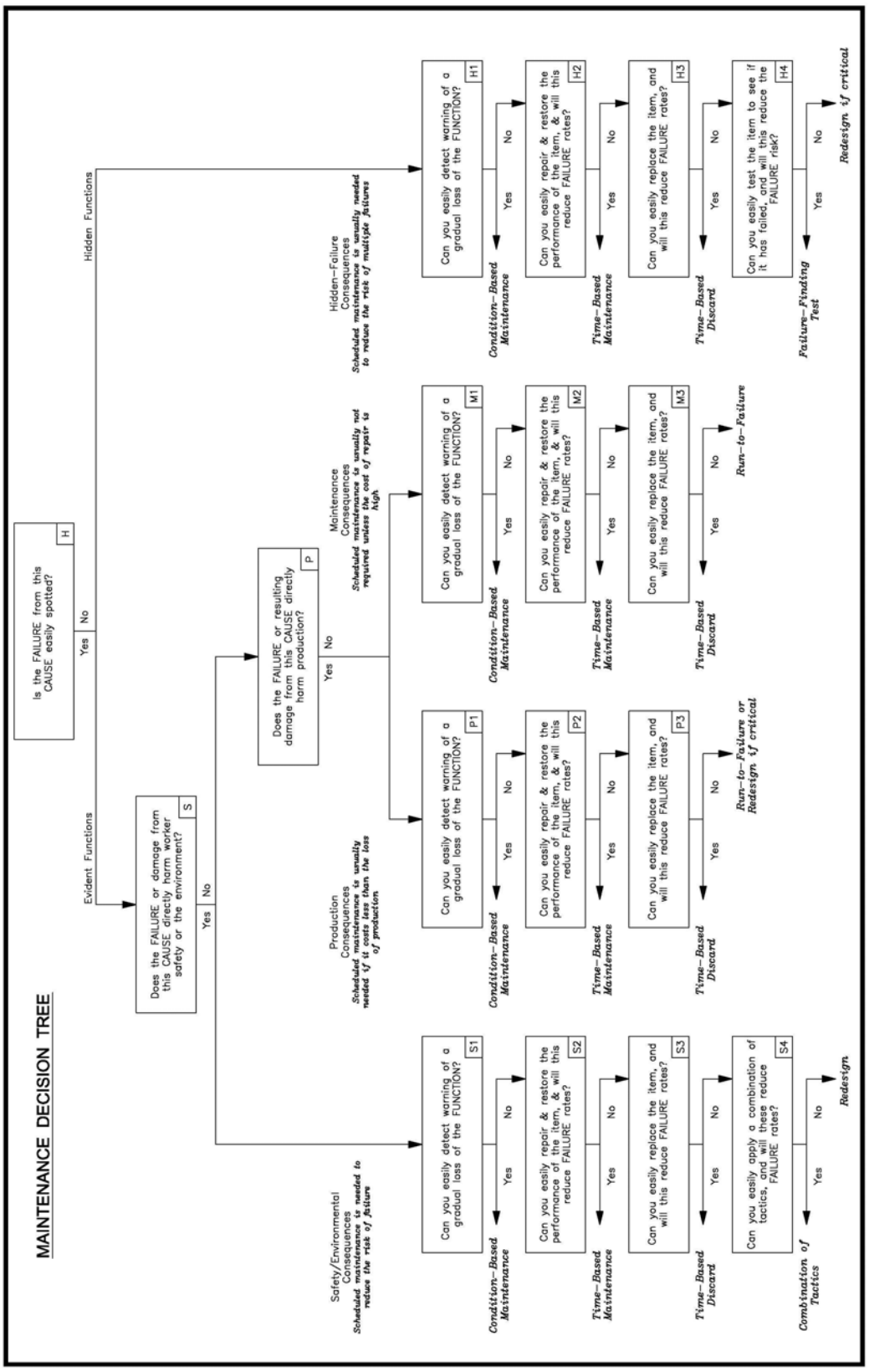
Use-based Maintenance (PM2)
A preventive maintenance strategy in which the system or component is replaced or re-conditioned at pre-determined intervals which are expected to proceed failure. The intervals may be based upon the calendar or some measure of usage such as operating hours, kilowatt hours or number of starts. This strategy is only applicable when the risk of failure is expected to increase with age.

Scheduled Overhaul (PM2a)
A use-based preventive maintenance strategy in which the system or component is stripped down and re-conditioned to as near to original condition as possible at some predetermined interval.

Scheduled Replacement (PM2b)
A use-based preventive maintenance strategy in which the system or component is discarded and replaced with a new system or component at some predetermined interval.

Routine Services (PM2c)
A use-based preventive maintenance strategy in which the system or component receives a service such as cleaning filters, replacing lubricant, and making adjustments at some predetermined interval.

Appendix C Maintenance Decision Tree



Appendix D Maintenance Strategy Analysis Workbook

The consolidation and validation of **maintenance strategies** has been rigorously documented in a Microsoft® Excel Workbook titled *HTGS Maintenance Strategy Workbook,* which includes the following work sheets:

- *Analysis* - a list of all strategies and tactics reviewed, with columns for manufacturer recommendations, other utility practices, maintenance decision tree, round table discussion, and final recommendations.
- *AMS Types* - the definitions of maintenance strategy terms.
- *Document Types* - a list of the types of documents reviewed.
- *Documents Reviewed* - a list of the documents reviewed.
- *Industry Contacts* - a history of utilities contacted.
- *Industry Submissions* - a list of maintenance programs submitted by other utilities.
- *Environmental Regulations* – a review of regulations pertaining to the operation of the Holyrood facility
- *CEA Statistics* – a review of the CEA Stats compiled over the past five years.
- *Asset Hierarchy* – A listing of the JDE Asset structures that were reviewed for this AMS review
- *Predictive Maintenance* – a list of the predictive maintenance strategies employed at Holyrood
- *Emergency Work Orders* – a review of the emergency work performed at Holyrood over the past five years
- *Observations* – A list of observations & recommendations compiled by the AMS team during their review of the workbook strategies including those provided by the round table attendees.
- *HTGS Electrical Standard* - Standards developed & recommended by Hydro Engineering (H. Ireland) on the maintenance of 600V & 4Kv systems

This Workbook will be provided electronically in two versions: Revision 0 and Revision 1.

Revision 0 of the Workbook is the state at the completion of the inaugural review of maintenance strategies. It documents the analysis of some 900 tactics, many of which are existing tactics, but includes others that were identified through manufacturers' maintenance literature, other utilities' maintenance plans, Round Table reviews etc. This revision will be provided to the HTGS Manager, Long Term Asset Planning for review and commentary.

Revision 1 of the Workbook is a refreshed version which restates the tactics to reflect any changes resulting from the HTGS review.. This version is created under the assumption that all maintenance strategy recommendations will be implemented in the near future. Revision 1 of the Workbook should be the baseline for any subsequent maintenance strategy reviews.

REFERENCES

[1] *Maintenance*, Jasper L. Coetzee, 2004, page 48.
[2] *Maintenance*, Jasper L. Coetzee, 2004.
[3] Ibid, page 48.

ASSET MAINTENANCE STRATEGY MANAGEMENT PROGRAM

Draft

Date: April 4, 2011

PLEASE NOTE

This is a draft document.
Significant elements of the AMS Management Program have not yet been fully developed.

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TABLE OF CONTENTS

Table of Figures

1.0 PROGRAM OVERVIEW

This manual outlines the Asset Maintenance Strategy (AMS) Management Program for Nalcor Energy's assets in all lines of business. This program contains all essential elements of a sound management program[1]:

- Objectives
- Framework
- Process and Procedures
- Responsibility and Accountability
- Verification and Measurement
- Continual Improvement Mechanisms

Section 2- PROGRAM OBJECTIVE outlines the purpose of the AMS Management Program and the fundamental principles that guide the formation of **maintenance strategies**.

Section 3 - MAINTENANCE FRAMEWORK provides the structure upon which **maintenance strategies** are built. This framework establishes the relationship between **maintenance philosophies**, **maintenance strategies** and **maintenance tactics**, and includes the hierarchy and definitions for the various types of **maintenance strategies**.

Section 4 – MAINTENANCE STRATEGY DRIVERS describes the types of information that is to be collected and reviewed to support the formation and adjustment of **maintenance strategies**. The drivers are **maintenance philosophies**, Nalcor Energy best practices, industry best practices, expert advice, manufacturer's recommendations and equipment history.

Section 5 – CHANGE MANAGEMENT outlines the process, tool and procedure required for the ongoing adjustment of **maintenance strategies**.

Section 6 – INTEGRATION OF MAJOR ASSETS outlines the process of forming **maintenance strategies** for new/acquired major assets.

Section 7 - RESPONSIBILTY AND ACCOUNTABILTY provides defined roles and responsibilities for the owner and participants for all aspects of the program.

Section 8 - VERIFICATION AND MEASUREMENT provides the means to measure success through reportable metrics.

[1] *Operations Integrity Management System*, ExxonMobil, January 2004, http://exxonmobil.com/Corporate/Files/Corporate/OIMS_brochure_2004.pdf.

Section 9 - CONTINUAL PROGRAM IMPROVEMENT establishes a mechanism for on-going improvement of the processes, procedures, and overall management of the program.

2.0 PROGRAM OBJECTIVE

The entire maintenance endeavour can be seen as a means to control **failure** and its consequences. All **failures** have a cost to the corporation and, to varying degrees, hinder our progress in meeting the corporate goals and objectives, whether they are impediments to safety & health (Corporate Goal No. 1), environmental protection (Corporate Goal No. 2), or business excellence (Corporate Goal No. 3). The purpose of the AMS Management Program, then, is to ensure that Nalcor Energy is employing **maintenance strategies** for its assets that best control **failure**, in a manner that supports business excellence, while maintaining high standards for safety, health and environmental responsibility. The AMS Management Program is directly driven by the corporate planning process for Corporate Goal No. 3 – Business Excellence.

The product of a fully established AMS Management Program is a current **maintenance philosophy** for each major asset (plant, transmission line, communications site, etc.) and a continually adjusted set of **maintenance strategies** for the systems and components that make up each major asset. Maintenance programs have traditionally been put in place when assets enter the system without formal mechanisms to ensure adjustment with time. But the AMS Management Program enables and compels long term asset planners to conduct a diligent, ongoing review of asset maintenance so that alterations are made based upon pertinent information.

While the primary objective is to control **failure** through application of appropriate **maintenance strategies**, the AMS Management Program will also serve as an excellent resource for operating budget justification as well as succession planning.

3.0 MAINTENANCE FRAMEWORK

All **maintenance strategy** analyses undertaken for Nalcor Energy assets are to be mapped to a framework to promote common understanding and consistent application through all lines of business. This framework establishes the relationship between **maintenance philosophies**, **maintenance strategies** and **maintenance tactics** and includes the hierarchy and definitions for the various types of **maintenance strategies**. This framework has largely been adapted from *Maintenance* by Jasper L. Coetzee[2].

3.1 Failure

Failure, as it pertains to Nalcor Energy's assets in the context of the AMS Management Program, is deemed to have a broad definition as follows.

Failure
An unsatisfactory condition.

> **Functional Failure**
> Inability of a system or component to meet a specified performance standard. This could be a total inability to perform a function or an inability to perform a function at the required level.
>
> **Potential Failure**
> An identifiable physical condition which indicates that a functional **failure** is imminent.
>
> **Hidden Failure**
> **Failure** of a component that could go undetected during the normal course of operation and, if and when called upon to perform its function, could result in **failure** of other components or the system overall. Hidden **failures** can be found through functional testing.

[2] *Maintenance*, Jasper L. Coetzee, 2004.

3.2 Philosophy → Strategy → Tactic

In the effort to control **failure**, there is a trade-off between the consequences of **failure** and the effort required to *prevent* **failure**. Therefore, we must make clearly guided decisions on the type and amount of preventive action to undertake. Such decisions are to be made within the confines of the following basic framework:

PHILOSOPHY → STRATEGY → TACTIC

Maintenance Philosophy
A statement of mission, vision and key objectives for the maintenance functions that will serve as a guide for the development of **maintenance strategies**. There is a general Corporate Maintenance Philosophy, and each major asset will have a more specific **maintenance philosophy**.

Maintenance Strategy
An approach to manage **failure** and its consequences. **Maintenance strategies** define the optimal amount and type of work, monitoring, testing and inspection on equipment.

Maintenance Tactic
The specific procedures and instructions used by workers to perform work on assets in order to apply a **maintenance strategy**.

Each major asset is to have a clear **maintenance philosophy** - a statement of the mission, vision and key objectives for the maintenance function. The **philosophy** will guide the development of **maintenance strategies** - approaches to manage **failure** - for each system or component that makes up the major asset. From these **strategies** will be derived a set of **maintenance tactics** - the procedures and instructions to be used by workers to perform maintenance work.

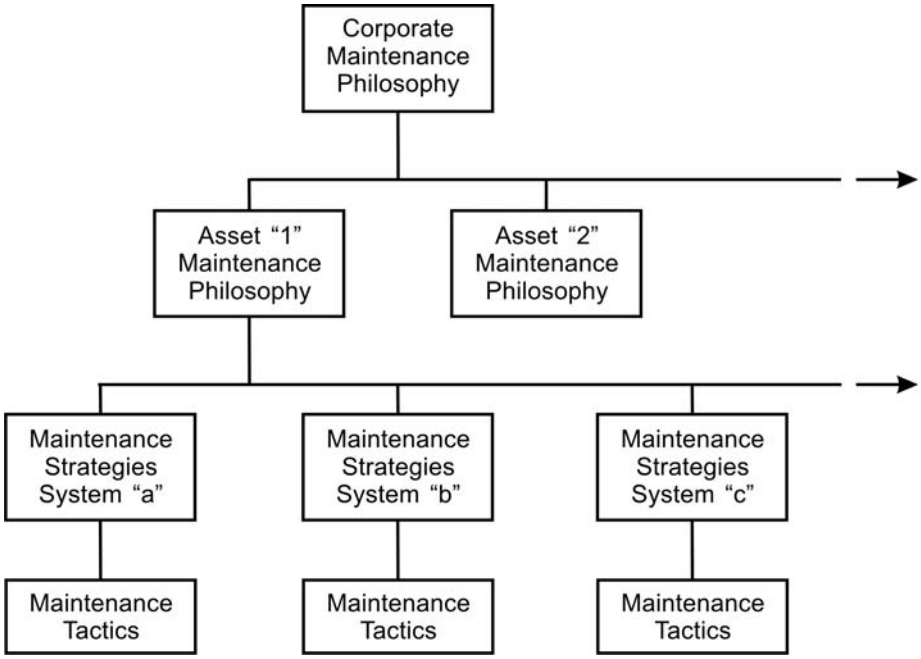

Figure 3.1 - Maintenance Framework

3.3 Maintenance Strategy Types

Failure and its consequences are controlled through the establishment of **maintenance strategies**, which can generally be framed into three high level categories:

- **Preventive Maintenance**: reduce the probability of **failure** through pro-active work;
- **Corrective Maintenance**: allow the equipment to run to **failure** and then repair or replace it; and
- **Design Out**: make a design change to remove the possibility of a **failure** mode.

Preventive and corrective maintenance are further divided into specific types of **strategies** as per the chart below. Formal definitions of each maintenance strategy type follow.

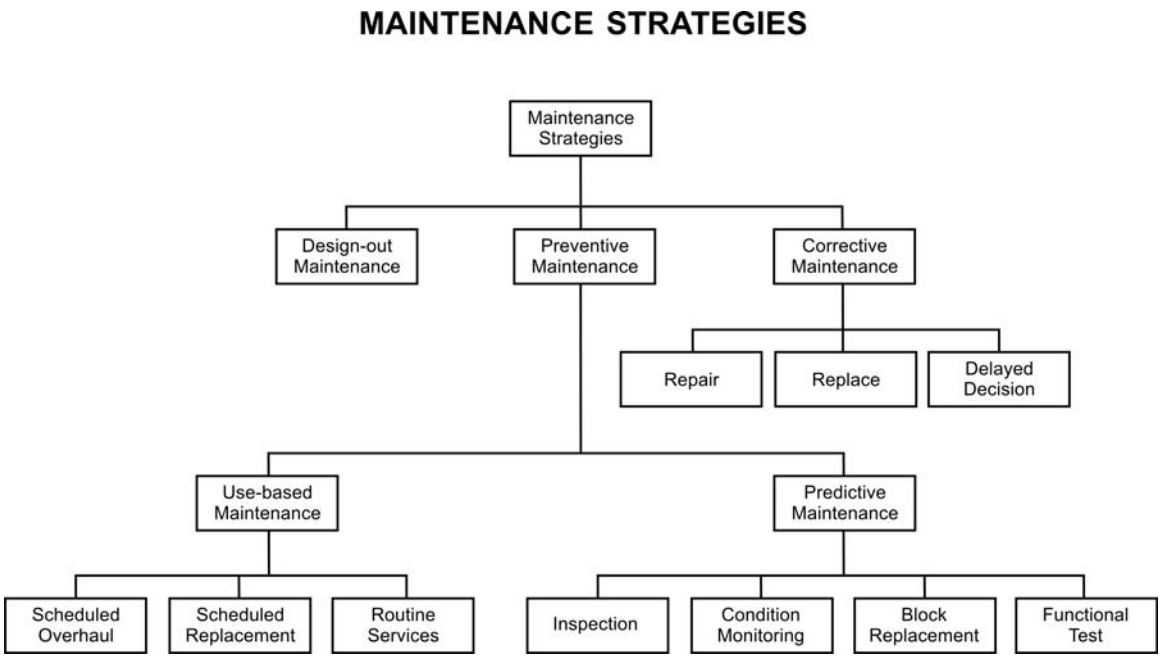

Figure 3.2 - Maintenance Strategies

adapted from *Maintenance*, Jasper L. Coetzee[3]

3.3.1 Design Out (DO)

A **maintenance strategy** in which the **failure** mode is effectively eliminated through the implementation of a design change to a system or component, eliminating the need for preventive or corrective maintenance. This is more accurately described as a method to eliminate the need for a **maintenance strategy**.

[3] *Maintenance*, Jasper L. Coetzee, 2004, page 48.

3.3.2 Corrective Maintenance (CM)

A **maintenance strategy** in which a conscious choice is made to run the system or component to **failure** and then repair or replace the component. This implies that there is no proactive attempt to: (i) predict when **failure** might occur; (ii) prevent **failure**; or (iii) find any hidden **failures**. This **strategy** is employed when other **strategies** are either not technically feasible or are shown to be uneconomical compared to the cost of unabated **failure**. *This **strategy** is only an option when the unmitigated risk is tolerable.*

Corrective Replacement (CM1)
A corrective **maintenance strategy** in which it is predetermined that the system or component will be *replaced* after it fails.

Corrective Repair (CM2)
A corrective **maintenance strategy** in which it is predetermined that the system or component will be *repaired* after it fails.

Corrective Delayed Decision (CM3)
A corrective **maintenance strategy** in which the decision to replace or repair is deferred until a post-**failure** inspection of the system or component.

3.3.3 Preventive Maintenance (PM)

A collection of **maintenance strategies** that are aimed at preventing **failure** from occurring and includes pro-active attempts to find hidden **failures**.

Predictive Maintenance (PM1)
A preventive **maintenance strategy** in which: (i) the condition of a system or component is measured continuously or at pre-determined intervals in order to predict when the system or component might fail; or (ii) the functionality of a system or component is verified through a **failure** finding inspection or test. The prediction or discovery of **failure** then triggers a replacement or overhaul. This **strategy** applies primarily, but not exclusively, when the risk of **failure** is not expected to increase with age, since use-based maintenance is not effective.

Inspection (PM1a)
A predictive type of preventive maintenance in which the five senses are used to determine the condition of a system or component, which may be enhanced through instruments.

Condition Monitoring (PM1b)
A predictive type of preventive maintenance in which a parameter such as vibration, thermography, oil condition, shock pulse, acoustic emissions, and performance is monitored to detect signs of imminent **failure**.

Block Replacement (PM1c)
A predictive type of preventive maintenance in which the **failure** of a component can be considered an indication that similar components may soon fail.

Functional Test (PM1d)
A predictive type of preventive maintenance in which the component or system is function tested to determine if there are any hidden **failures**.

3.3.4 Use-based Maintenance (PM2)

A preventive **maintenance strategy** in which the system or component is replaced or re-conditioned at pre-determined intervals which are expected to precede **failure**. The intervals may be based upon the calendar or some measure of usage such as operating hours, kilowatt hours or number of starts. This **strategy** is only applicable when the risk of **failure** is expected to increase with age or usage.

Scheduled Overhaul (PM2a)
A use-based preventive **maintenance strategy** in which the system or component is stripped down and re-conditioned to as near to original condition as possible at some predetermined interval.

Scheduled Replacement (PM2b)
A use-based preventive **maintenance strategy** in which the system or component is discarded and replaced with a new system or component at some predetermined interval.

Routine Services (PM2c)
A use-based preventive **maintenance strategy** in which the system or component receives a service such as cleaning filters, replacing lubricant, and making adjustments at some predetermined interval.

NOTE - These definitions are for use as a framework for developing **maintenance strategies** and they do not necessarily correspond to definitions of similar terms in the JD Edwards work order module. There is no equivalence between maintenance strategy types and work order types. As an example, consider a component that has a

"Corrective Repair" **strategy**, meaning we run it to **failure** without any attempt to prevent or predict that **failure**. Alternatively, the **strategy** for the component could be "Condition Monitoring" in which we endeavour to predict **failure** and replace the component before **failure** occurs. In both cases, **failure** can occur and a work order will be generated to replace the component. That work order will likely be classified as a "corrective" work order, whether or not the **strategy** was "corrective".

4.0 MAINTENANCE STRATEGY DRIVERS INFORMATION

The development and adjustment of **maintenance strategies** is driven by the collection and review of information pertinent to the asset and similar assets. This information is categorized into six areas, which are referred to as the **maintenance strategy** drivers:

- Maintenance Philosophy
- Practices in Other Companies
- Practices in Other Areas of the Corporation
- Manufacturers' Recommendations
- Equipment History
- Expert Recommendations

4.1 Maintenance Philosophy

The **maintenance strategies** for a major asset can not be developed without first establishing a **maintenance philosophy** - a statement of mission, vision and key objectives for the maintenance functions. A **maintenance philosophy** has two elements: (1) the Corporate Maintenance Philosophy which provides the understanding of why maintenance is important to the corporation; and (2) an asset **maintenance philosophy** which describes the importance of the specific asset to the overall system. Together, the overall **maintenance philosophy** will provide guidance in developing **maintenance strategies**.

The Corporate Maintenance Philosophy, shown in Figure 4.1, must be applied to all assets. This **philosophy** ensures that maintenance efforts align with Nalcor Energy's corporate goals.

For a given major asset, the Corporate Maintenance Philosophy must be supplemented with statements that describe the importance of the specific asset. In particular, the **philosophy** should define the present and future contribution of the asset to overall system reliability and should declare the planned remaining life of the asset. The **philosophy** should be developed with input from the long term asset planner, the relevant technical councils, and other stakeholders. For assets associated with the energy system, input should be acquired from the System Planning and System Operations Departments of Newfoundland and Labrador Hydro.

Corporate Maintenance Philosophy

"the right work, on the right assets, at the right time"

The objective of all asset maintenance activity is to control failure and its consequences to a degree that is aligned with the corporate goals of safety and health, environmental protection, and business excellence.

An effective maintenance program is a key element of becoming a leader in the areas of safety, health, and the environment.

An effective maintenance program is a key element of establishing business excellence.

The optimum maintenance is that which most cost effectively reduces risk of failure to tolerable levels, for all types of consequences, through the planned economic life of the asset. Consequence types include safety and health, environment, reliability, and property loss.

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Figure 4.1 - Corporate Maintenance Philosophy

4.2 Practices in Other Companies or Industry Common Practices

Collection of maintenance plans from other companies can provide a summary of typical industry practices. Companies with similar assets as those being reviewed should be targeted. The manufacturer may be able to provide a list of similar owners / operators. The most successful method of engaging other companies is through existing forums in which Nalcor Energy already participates, such as the Centre for Energy Advancement through Technological Innovation (CEATI) and Fossil Operations and Maintenance Information System (FOMIS).

It is recognized that the effort on the part of respondent companies can be quite large since maintenance plans may not be housed in a single document or format. They are likely buried within a computerized maintenance management system such as

JD Edwards in combination with a series of electronic or paper documents. Many companies are therefore unwilling to share. For those companies that do respond, the applicability, level of detail and overall value of responses can be expected to be quite variable.

It may also be possible to identify industry maintenance practices through review of research documents and information exchange of interest groups such as CEATI and FOMIS. The internet is another source for industry maintenance practices; for example, the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation have a wealth of technical information for hydraulic generation freely available.

4.3 Practices in Other Areas of the Corporation

For given systems and components, proven **maintenance strategies** may exist elsewhere in the corporation. For example, **strategies** are well developed for compressed air systems in terminal stations and diesel generators for isolated generation. For each system and component, it should be determined what similar assets exist in the corporation and **strategies** for those assets should be collected.

4.4 Manufacturers' Recommendations

Original Equipment Manufacturers' (OEMs') maintenance recommendations may be collected for review. These recommendations are normally found in the maintenance manuals provided with the new assets as well as service bulletins issued during the life of the asset. Particular attention should be paid to service bulletins, since they address known problems with equipment. Often manufacturers' recommended maintenance is over-prescribed and can be considered the maximum level of preventative maintenance, serving as a suitable baseline for discussion.

4.5 Equipment History

The historical information on assets can be an important consideration in the establishment of suitable **maintenance strategies**. For example, it may be learned that a particular component has a high **failure** rate, or that the physical condition of a component has deteriorated. Such information may lead to the development of more robust **maintenance strategies**. Following is a list of the historical information that may be collected and reviewed:

- reliability/**failure** data;

- inspection reports;
- condition assessments;
- studies;
- engineering and operations diaries or logbooks;
- work order history, especially emergency work orders;
- root cause **failure** analysis; and
- summary and conclusions of any previous maintenance reviews such as Reliability Centred Maintenance (RCM).

Use of reliability information will provide a feedback mechanism between actual equipment performance and **maintenance strategies**. Particular attention should be paid to emergency work orders, **failure** root cause analysis and equipment reliability data since these can all serve as indicators of weak areas of the existing maintenance program.

For Newfoundland and Labrador Hydro's generation and transmission assets, reliability data is available from reports generated by the System Operations Department. This data can be used to identify the relative contributions of system **failures** to overall plant reliability. For example, Table 8 of the report titled *Bulk Electric System Performance, Service Continuity System Performance, and Generation and Transmission Equipment Reliability Review 2006* shows that **failures** of the fuel supply systems contributed to 8.9% of all Newfoundland and Labrador Hydro's gas turbine forced outages for the period 2001-2005. Consult the System Operations Department to obtain the data and confirm understanding of same.

In some cases where little or no **failure** history has been kept, industry resources that provide **failure** histories for certain equipment could be sought out.

4.6 Expert Recommendations

Where expert opinions regarding **maintenance strategies** are readily available, they may be collected and reviewed. Such expert opinions may come in the form of Nalcor Energy employees, consultant reports, training manuals and conference papers.

In addition to industry experts, recommendations of our insurer may also be compiled. Specifically, the most recent FM Global Risk Report for the major asset, as well as all relevant FM Global Data Sheets, which typically contain maintenance recommendations should be reviewed.

5.0 CHANGE MANAGEMENT

Maintenance philosophies and **strategies** should not remain constant. Without significant attention to changes, **strategies** could quickly become ineffective or wasteful. It is therefore important that ongoing mechanisms be in place for the identification of change and a consequential review of the **philosophies** and **strategies**. The **Maintenance Strategy Workbook** (MSWB) is the tool used to manage the changes to equipment **maintenance strategies** and is provides an up-to-date summary of all equipment maintenance practices for a given asset.

5.1 Process

The change management process will ensure that all changes impacting an asset are identified, so that **maintenance philosophies** and **strategies** can be reviewed and revised as required. The process is summarized in flow chart form in Appendix A: Change Management Flow Chart and is described in more detail in this section. Responsibilities and accountability to manage this change lie with the various groups as outlined in the flow chart and summarized in Section 7.0 of this document.

Changes to **maintenance strategies** can be brought about for various reasons including any of the following triggering events:

- Change in asset function or criticality
- New, refurbished or removed assets
- New codes or regulations
- New industry best practices
- New Nalcor Energy best practices
- New technology
- Change in manufacturer support
- Change in critical spares
- Failure root cause analysis
- Updated reliability data
- Condition assessments
- New service bulletins
- 5 Year review of all strategies
- Change in corporate strategy
- Feed back from Work Execution
- SWOP Observation

Whenever a triggering event occurs, the Long Term Asset Planner (LTAP) records a Maintenance Observation (MO) and updates the maintenance driver information that has been previously collected for the applicable system or component. This observation and updated information is then reviewed by the Long Term Asset Planner in consultation with a Technical Council comprised of Nalcor Energy employees who are deemed as being technical experts in their knowledge and experience working with the particular asset(s) being reviewed. The purpose of the review is to determine if the existing maintenance strategy needs to change and, if so, to determine what the new strategy will be. It is recommended that quarterly Technical Council meetings be called to complete the reviews.

The MSWB is set up to manage **maintenance strategies** for multiple regions of the corporation to ensure that consistency exists across all lines of business with similar major assets. Managing changes to these regions can then be controlled without excluding one ensuring consistency throughout the corporation. The MSWB is also designed to assign status codes for the various steps involved in revising or changing a particular **maintenance strategy**. These status codes can be summarized in Table 5.1:

STATUS CODE	*STATUS CODE DESCRIPTION*
1x	**Maintenance Observation(s) Entered**
2x	**Collecting Information for Review**
3x	**Waiting for Review/Risk Analysis**
4x	**Waiting Budget Approval**
5x	**Ready to Change Tactic**
6x	**Tactic Revised (Waiting on other Regions)**
0x	**Tactic Revised (Not Pending)**

Table 5.1 **- Status Codes**

The letter succeeding the status code number indicates the applicable region. Each region is assigned a letter in the MSWB, the first region added being assigned ‘a’, the second region being assigned ‘b’ and so on, to differentiate each region’s status codes. A region, such as Hydro Generation might be assigned ‘a’ in one MSWB but ‘c’ in another, depending on the order regions are added to each MSWB.

Once an observation is made from any of the listed triggers, the LTAP will record the maintenance observation(s) using the tool as outlined in Section 5.3.1. The **maintenance strategy** will then become status code 1x within the MSWB.

After the maintenance observation is entered into the MSWB, the LTAP will collect **maintenance strategy drivers** that will be necessary for review of the impacted **strategies**. Once the information is collected and analyzed, the LTAP will update the

MSWB as per Sections 5.3.2 to 5.3.7 inclusive. During the review of this information, the affected **maintenance strategies** will become status code 2x. Once *all* the **maintenance strategy drivers** have been updated in the MSWB, the **strategies** progress to status code 3x.

The **maintenance strategies** that are at status code 3x will be evaluated by the LTAP with support of a Technical Council to determine how the **maintenance strategies** will change, if at all, based on the new maintenance observation(s) and revised **drivers**. During this review, a Risk Analysis will be completed by the Technical Council to ensure that the new **strategy** mitigates the risk to an acceptable level. This procedure is outlined in Section 5.3.8 and its completion will bring the **maintenance strategy** to status code 4x. If it is decided that the **strategy** will not change, the status code will need to be reverted back to 0x.

The LTAP will revise the budget to reflect changes to the **maintenance strategy**. This is shown in Section 5.3.9 and once completed the **strategy** becomes status code 5x. The LTAP will hand the changes over to the Short Term Work Planning & Scheduling (STWP&S), who will make the required changes to JD Edwards, associated check sheets and update the MSWB to indicate the **tactics** have been adjusted. At this point all applicable changes to the MSWB have been made and the status code will progress to 0x. However if one region is lagging behind on their progression through the Change Management Process, the **maintenance strategy** will become status code 6x until all regions have completed all steps, at which time the **strategy** becomes status code 0x. Outstanding status codes 6x's should be reviewed by the quarterly Technical Council to ensure that **strategies** are consistent across all regions.

All work completed by the Work Execution (WE) group is recorded in JD Edwards and any feedback required will be noted on the work order and will be classified as code 71. The LTAP will review these work orders and enter the feedback into the MSWB as maintenance observations for the applicable **strategies**.

5.2 Tool

The Maintenance Strategy Workbook (MSWB) is a Microsoft Excel spreadsheet that contains all the **maintenance strategies** associated with a major group of assets. The MSWB will be constantly reviewed and modified to reflect the changing needs of the assets. As assets are added, removed, replaced, repaired or gain **failure** history, the MSWB will be updated accordingly to handle these changes. The main objective of the MSWB is to ensure that the current **strategies** are consistent, organized and constantly reviewed, assuring the most accurate and efficient maintenance to manage **failure**. This section will describe how to operate the MSWB in accordance with the Change Management Process.

5.2.1 Getting Started

The macros for the MSWB Excel file must be *enabled* before it can be used. When the MSWB file is opened, the user may be prompted to enable macros as shown in Figure 5.1, highlighted by the red box.

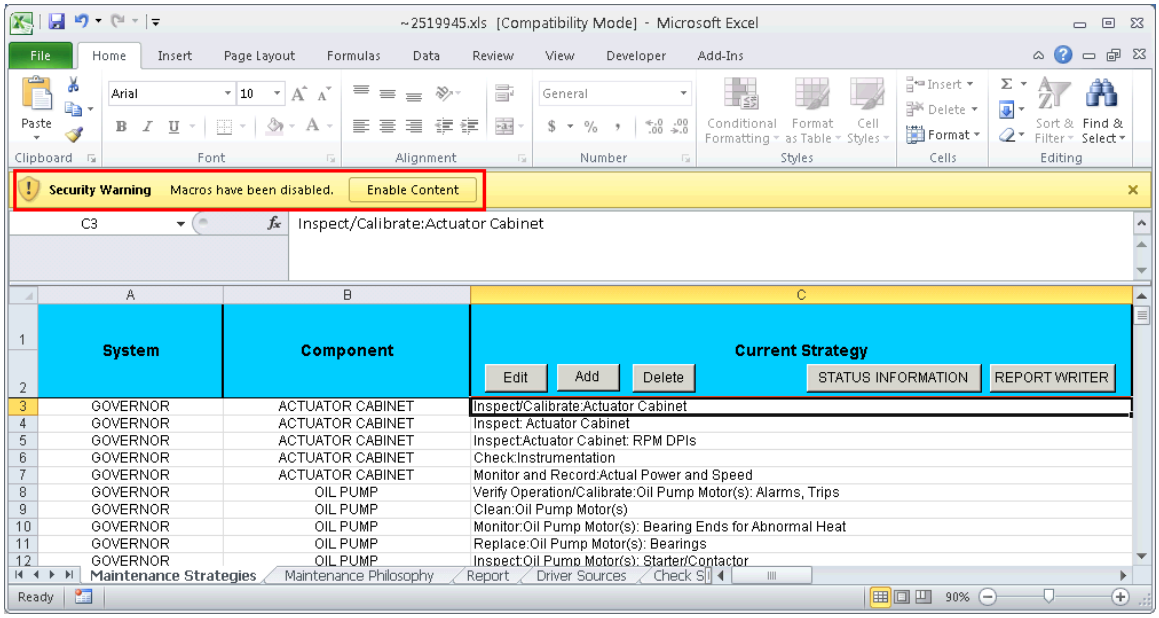

Figure 5.1 - Enabling Macros

5.2.2 Maintenance Strategy Workbook Functions

The MSWB contains multiple worksheets. The primary worksheet is the **"**Maintenance Strategies**"** Worksheet. All other sheets are used for recording supporting information and reference. The columns on the **"**Maintenance Strategies**"** worksheet, as shown in Figure 5.2, include:

- **Current Strategy:** Each entry in this column is a **maintenance strategy** currently in effect for a component.
- **Component:** An entry in this column identifies the specific piece of equipment for which the **current strategy** applies.
- **System:** An entry in this column identifies the system to which the component belongs. The name of the system should match the established asset hierarchy for the major asset.

The example in Figure 5.2 is taken from the MSWB for hydraulic units. A hydraulic unit is made up of several systems, one of which is the governor. The actuator cabinet and oil pump are two of many specific pieces of equipment within the governor system. In the example, there are five **strategies** for the actuator cabinet and four **strategies** for the oil pump.

Strategies in the MSWB that are shaded grey with bold text are inactive, meaning that they are not presently being applied to any assets. An inactive **strategy** is one that was active but is now discontinued, or one that was considered but never activated. Inactive **strategies** are kept in the MSWB as a way of retaining **maintenance strategy** history. This allows long term asset planners to gain some historical perspective, and also makes these **strategies** available for reconsideration at any time.

	A	B	C
1	**System**	**Component**	**Current Strategy**
2			Edit Add Delete STATUS INFORMATION REPORT WRITER
3	GOVERNOR	ACTUATOR CABINET	Inspect/Calibrate:Actuator Cabinet
4	GOVERNOR	ACTUATOR CABINET	Inspect: Actuator Cabinet
5	GOVERNOR	ACTUATOR CABINET	Inspect:Actuator Cabinet: RPM DPIs
6	GOVERNOR	ACTUATOR CABINET	Check:Instrumentation
7	GOVERNOR	ACTUATOR CABINET	Monitor and Record:Actual Power and Speed
8	GOVERNOR	OIL PUMP	Verify Operation/Calibrate:Oil Pump Motor(s): Alarms, Trips
9	GOVERNOR	OIL PUMP	Clean:Oil Pump Motor(s)
10	GOVERNOR	OIL PUMP	Monitor:Oil Pump Motor(s): Bearing Ends for Abnormal Heat
11	GOVERNOR	OIL PUMP	Replace:Oil Pump Motor(s): Bearings

Figure 5.2 - "Maintenance Strategies" Worksheet

The MSWB has four main functions (See Figure 5.2):

- **Edit:** Allows the user to make changes to the selected **strategy** (Section 5.2.2.1)
- **Add:** Allows the user to add a new **strategy** (Section 5.2.2.2)
- **Delete:** Allows the user to delete a **strategy** (Section 5.2.2.3)
- **Status Information:** Allows the user to collect and count the **strategies** at a particular status (Section 5.2.3)
- **Report Writer:** Allows the user to generate reports based on certain criteria (Section 5.2.4)

5.2.2.1 Edit Form

The Edit Form consists of three distinct areas as described in the sections listed below, and can be seen in Figure 5.3:

- Command Buttons (Section 5.2.2.1.1)
- Maintenance Strategy Timeline Tabs (Section 5.2.2.1.2)
- Maintenance Strategy Drivers (Section 5.2.2.1.3)

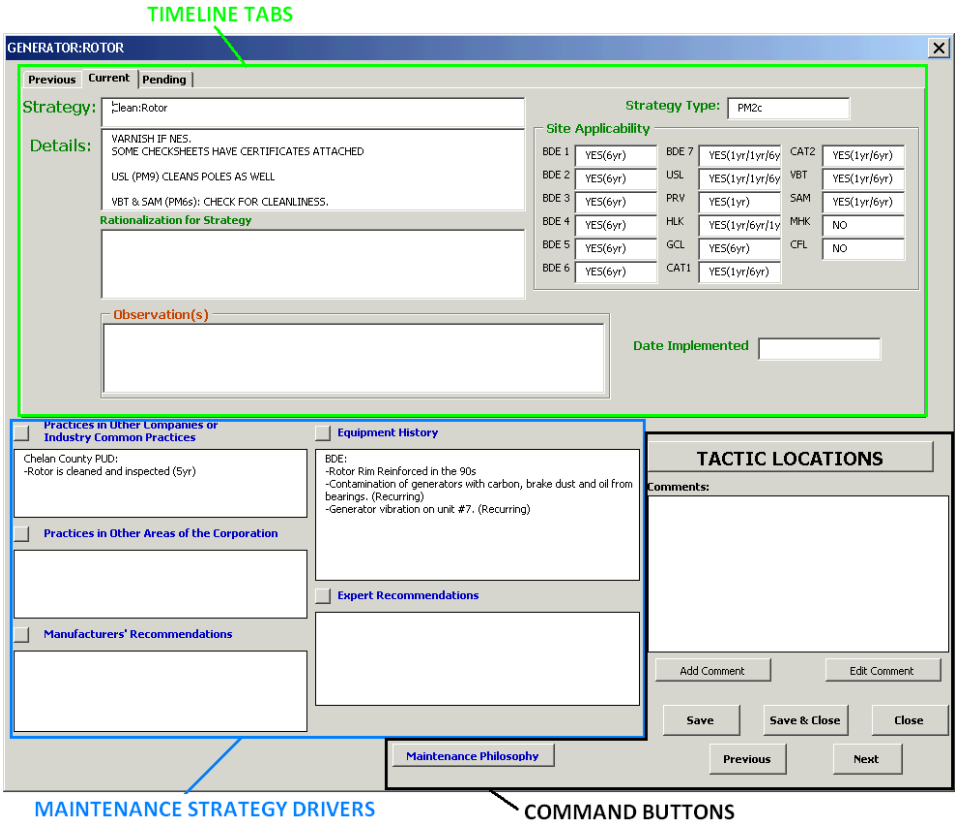

Figure 5.3 - Edit Form

The Edit Form is activated when a **Current Strategy** is selected and the **Edit** button on the **"**Maintenance Strategies**"** Worksheet is pressed. The Edit Form, shown in Figure 5.3, contains all information pertaining to the selected **strategy**.

The Edit Form contains three timeline tabs: **Previous**, **Current** and **Pending**, which are described in detail in Section 5.2.2.1.2. When the Edit button is pressed, the Edit Form will normally open to the **Current Tab**, to display the strategy currently in effect. Some of the cells in the **"Current Strategy"** column may state, **"**PENDING. THIS STRATEGY IS CURRENTLY NOT IN PLACE**",** which indicates this **strategy** is not yet active since it is in a review stage. Selecting a cell containing this and pressing the **Edit** button will open the **Pending Tab** of the Edit Form. In this case the **Current** and **Previous Tabs** will be blank.

5.2.2.1.1 Command Buttons

The command buttons on the Edit Form (Figure 5.3) are:

- **Save:** Saves all the information entered in the Edit Form to the "Maintenance Strategies" Worksheet.
- **Save & Close:** Saves all the information entered in the Edit Form to the "Maintenance Strategies" Worksheet and closes the Edit Form
- **Close:** Closes the Edit Form. The information entered will not be saved to the "Maintenance Strategies" Worksheet. A prompt will warn the user that this action will not save changes to that **strategy**.
- **Previous:** Displays the **maintenance strategy** that is located previous to the selected **strategy** on the Worksheet. All information entered in the Edit Form is saved to the "Maintenance Strategies" Worksheet.
- **Next:** Displays the **maintenance strategy** that is located next to the selected **strategy** on the Worksheet. All information entered in the Edit Form is saved to the "Maintenance Strategies" Worksheet.
- **Risk:** Displays the Risk Form for that **strategy** (See Section 5.2.2.1.4).
- **Maintenance Philosophy:** Displays the **Maintenance Philosophy**.
- **Tactic Locations:** Displays the list of tactic (work orders, check sheets, etc.), with associated frequencies, for each site for that strategy (See Section 5.2.2.1.5)

The COMMENTS textbox can be used as a white board for any general information pertaining to that **strategy**.

5.2.2.1.2 Maintenance Strategy Timeline Tabs

The Timeline Tabs are snap shots of the **strategy's** past, present and potential future states, which are labelled the **Previous**, **Current** and **Pending Tabs** on the Edit Form, respectively.

All three Tabs contain the following textboxes:

- **Strategy:** States the **maintenance strategy.**
- **Details:** States important details/exceptions with regards to the **strategy**.
- **Strategy Type:** Contains the Maintenance Strategy Type (See Section 3.3).
- **Site Applicability:** A series of textboxes used to show the applicability of the **strategy** to various locations.
- **Rationalization for Strategy:** Summarizes how it was rationalized that this is the best **strategy**.
- **Observation(s):** States the maintenance observation(s) that triggered the development of the **strategy**.

Note: When a textbox is highlighted in **RED** on the **Pending Tab**, this indicates that there is a difference between the current and pending information for that textbox.

5.2.2.1.2.1 Current and Previous Tabs

The structure of the **Current** and **Previous Tabs** are identical. The Current Tab displays the **maintenance strategy** information in the present, active state, while the **Previous Tab** displays the information of the previous version of the **maintenance strategy**.

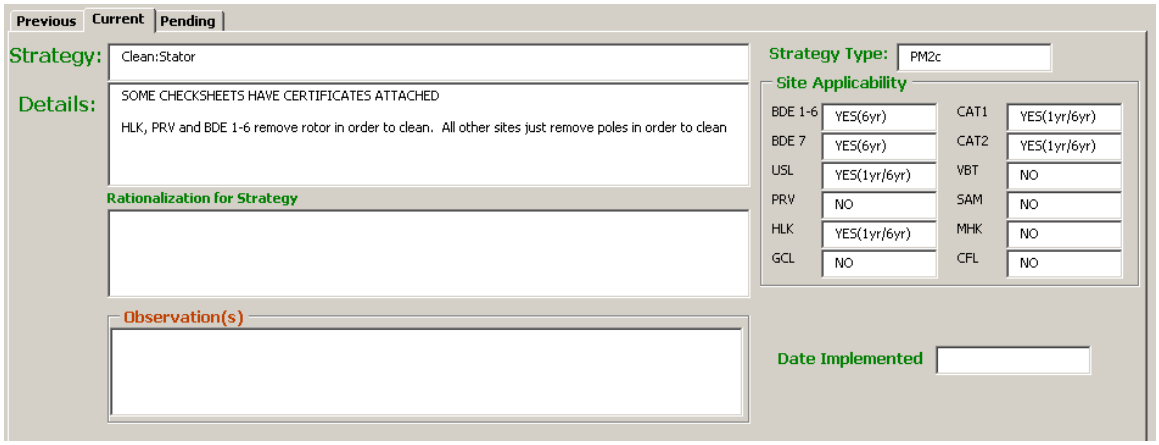

Figure 5.4 - Edit Form: Current Tab

5.2.2.1.2.2 Pending Tab

The **Pending Tab** contains all the information for the suggested change to the **maintenance strategy**.

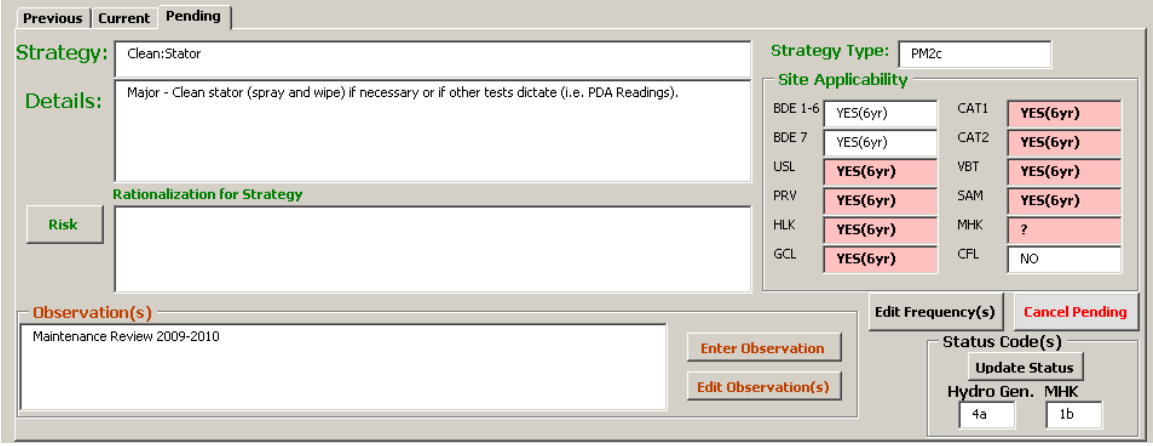

Figure 5.5 - Edit Form: Pending Tab

The **Pending Tab** includes some features that are not provided in the other Timeline Tabs. These are the **Status Code(s)** textboxes and command buttons: Update Status, Enter Observation, Edit Observation(s), Edit Frequency(s), and Cancel Pending.

Pressing the **Enter Observation** button will display the Observation Form in Figure 5.6, which allows the user to enter a maintenance observation as well as their name and date.

The **Edit Observation** button expands the Observation(s) textbox and allows the user to modify/remove any maintenance observation previously entered.

The **Cancel Pending** function allows the user to clear the pending information if it has been decided that the **maintenance strategy** will not be altered, resetting the **strategy** back to a status code 0.

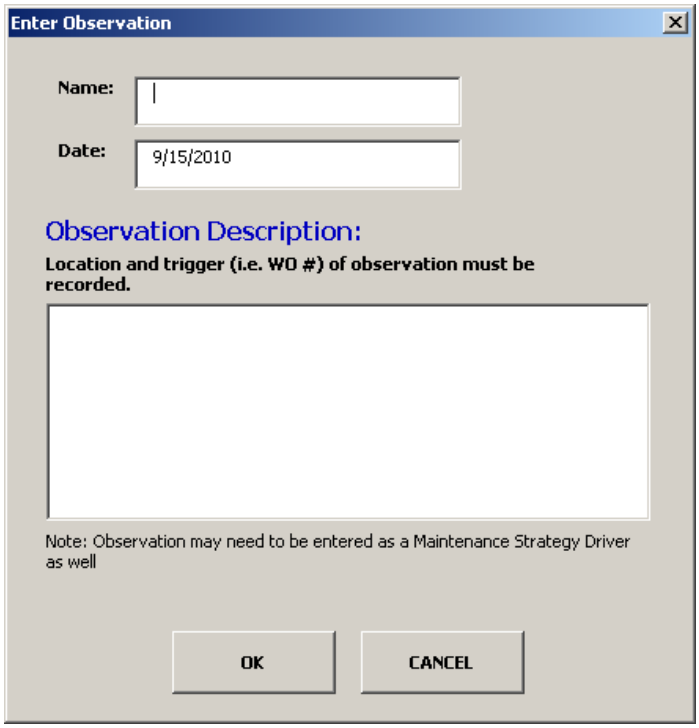

Figure 5.6 - Observation Form

The **Edit Frequency** button will display the Site Applicability Form, shown in Figure 5.7. This form allows the user to enter the frequency(s) for which the strategy should be performed, for the site that is selected from the "Site" drop-down menu.

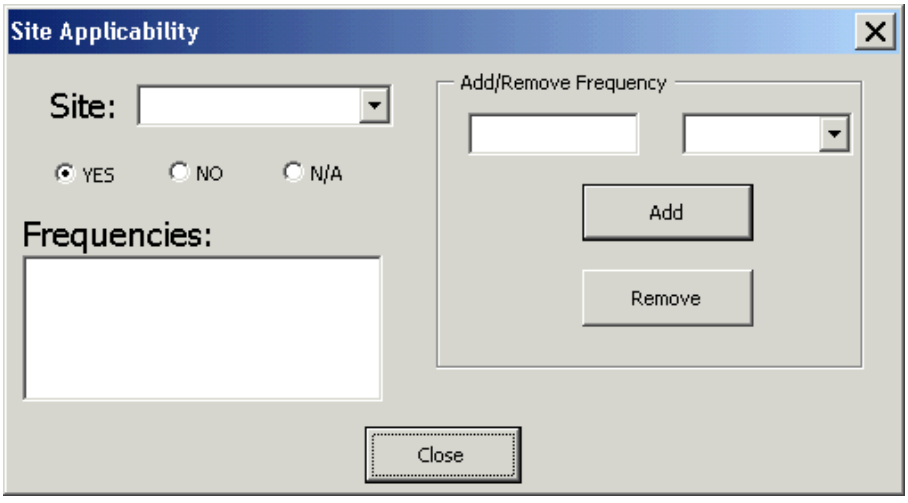

Figure 5.7 - Site Applicability Form

Note: For MSWBs with a large number of sites, the "Site Applicability" button will have to be pressed to display the Site Frequency Form in order to edit the frequencies.

Selecting the **Update Status** button on the **Pending Tab** activates the Status Form (See Figure 5.8). During each step of Change Management Procedure (Section 5.3) the user must update the status of the pending **strategy** by using the Status Form. For MSWBs will multiple regions, each region will have its own list of steps, allowing Long Term Asset Planners in each region to independently implement the Change Management Process. Although, it is highly recommended that all regions perform the Technical Council together, outlined in Section 5.3.8. The status code for each region is displayed on the bottom right hand corner of the **Pending Tab**.

Once all regions have completed the 10 steps, the user will be prompted for a password. When the password is correctly entered, the **Current Tab** information will be transferred to the **Previous Tab**, and the **Pending Tab** information transferred to the **Current Tab**. The information that was contained within the **Previous Tab** will be overwritten. The **Pending Tab** will be left blank until another maintenance observation is entered for that **strategy**.

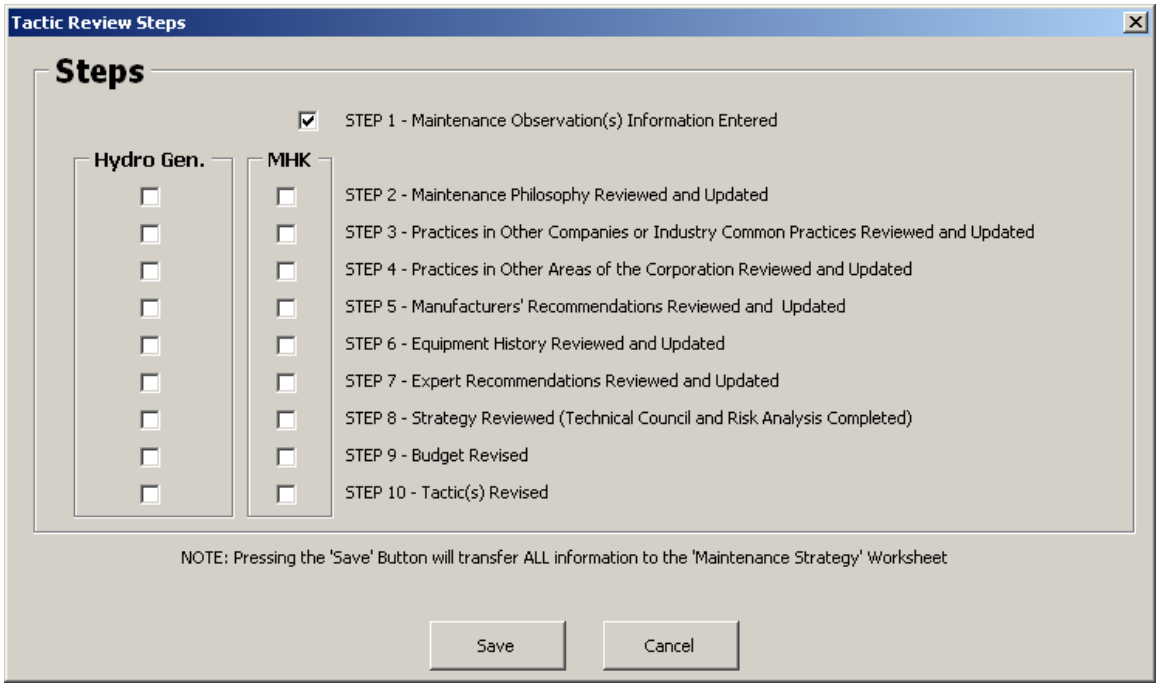

Figure 5.8 - Status Form

5.2.2.1.3 Maintenance Strategy Drivers

The **maintenance strategy** driver information section of the Edit Form (Figure 5.9) consists of the following textboxes:

- Practices in Other Companies or Industry Common Practices
- Practices in Other Areas of the Corporation
- Manufacturers' Recommendations
- Equipment History
- Expert Recommendations

Information can be added to the maintenance strategy driver textboxes by pressing the button preceding the title of each textbox, shown by the red boxes in Figure 5.9. Once a button is pressed, the Add Driver Form for that particular driver will be displayed and the user will be prompted to enter the necessary information. The Add Driver Form for Practices in Other Companies can be seen in Figure 5.10.

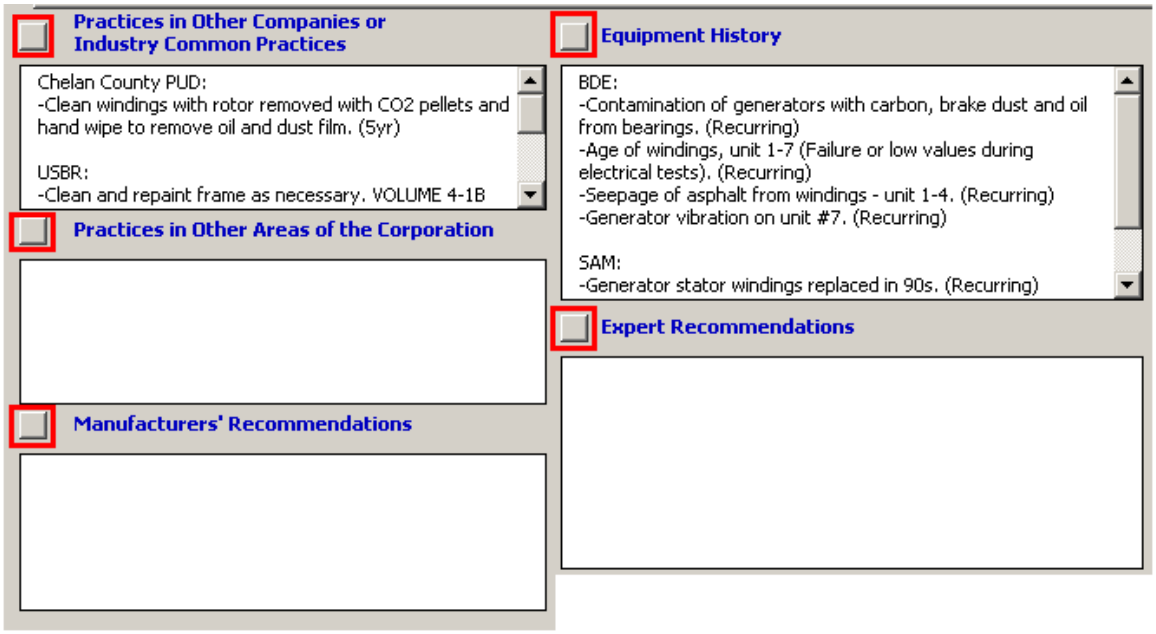

Figure 5.9 - Edit Form: Maintenance Strategy Drivers

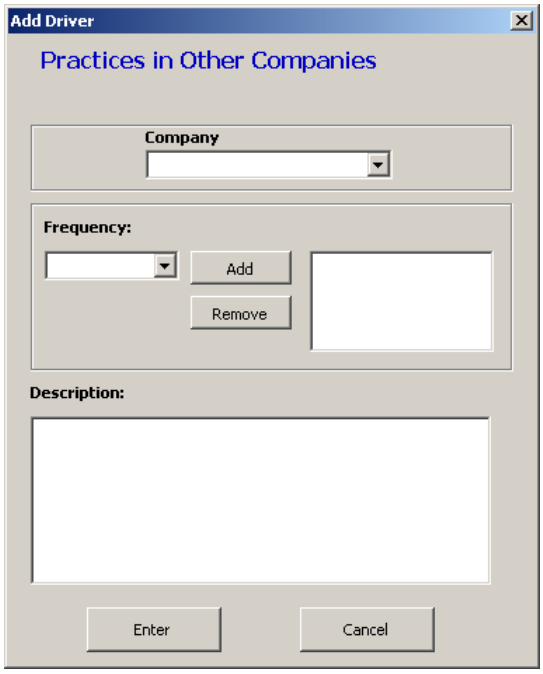

Figure 5.10 - Add Driver Form

5.2.2.1.4 Risk Form

The Risk Form is an interface used to perform the Risk Analysis on a particular **strategy**. An explanation of the process of Risk Analysis can be found in Section 5.3.8 and Appendix B. The Risk Form is divided into four sections:

- **Risk Calculator Input:** Consists of cells for the user to select consequence levels and probabilities. The user can toggle between unmitigated and mitigated risk by selecting the respective tabs.
- **Risk Calculator Output:** Calculates the total risk from the consequence and probability selections.
- **Risk Notes:** Consists of textboxes for each consequence category into which a user can record details to support the consequence and probability selections. Details that pertain to unmitigated and mitigated risk should be preceded with **"U:"** and **"M:"**, respectively. (i.e. U: Cause severe damage. M: Extend life of equipment).
- **Probability Definitions:** Displays the definitions for each probability (P1 to P5).

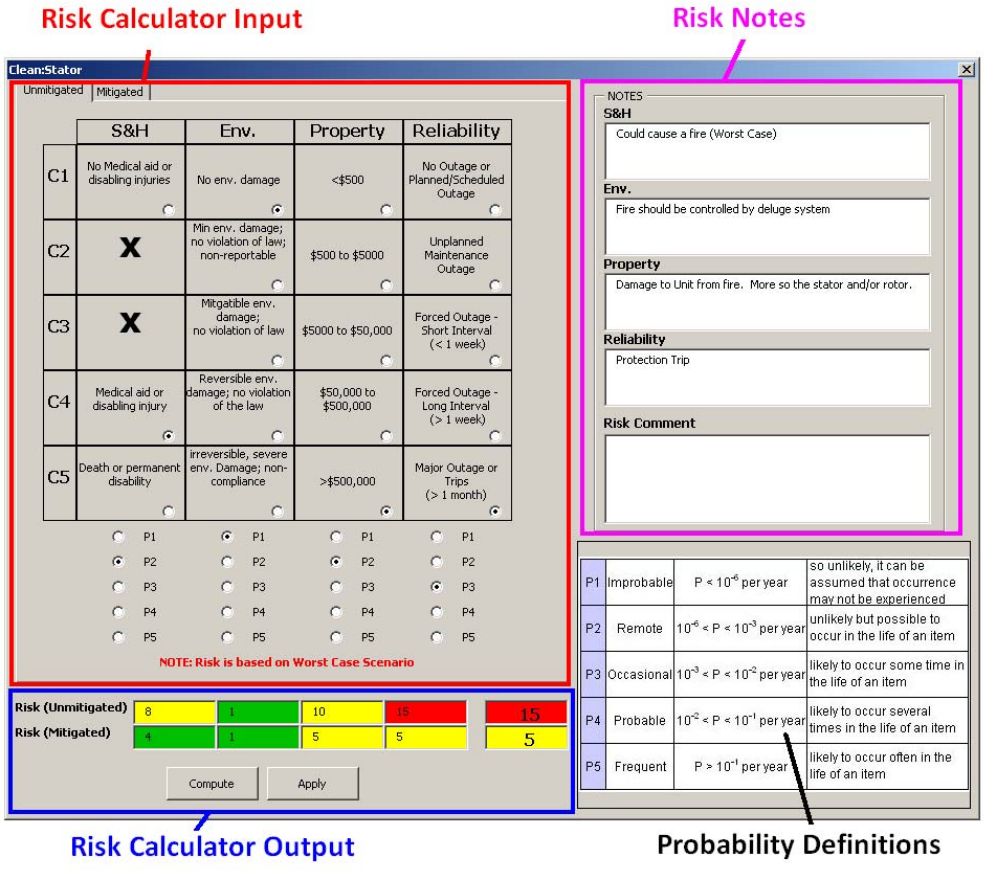

Figure 5.11 - The Risk Form

5.2.2.1.5 Tactic Locations

To view and manage the tactics associated with a **strategy**, press the Tactic Locations button on the Edit Form to display the Tactic Location Form, shown in Figure 5.12. When a site is selected from the "Site" drop-down menu, the Current and Pending applicability for that site will automatically be displayed. The user can then enter the corresponding MWO number, Check Sheet number and frequency(s). "Other Tactic Location" can be used instead of Check Sheet when the tactic is located elsewhere, for example, on a contract, Scada Screen, etc. Once entered, this tactic location is added by clicking the **Add** button. A tactic location can be removed by selecting it in the "Tactic Locations" list box and clicking the **Remove** button. When every site applicability frequency has at least one associated tactic location for the selected site and there are no tactics that do not have a site applicability frequency, the highlighted textbox shown in Figure 5.12 will become green. If those conditions are not met then the textbox will be red indicating that the tactic locations for the strategy at the selected site must be updated to match the pending site applicability.

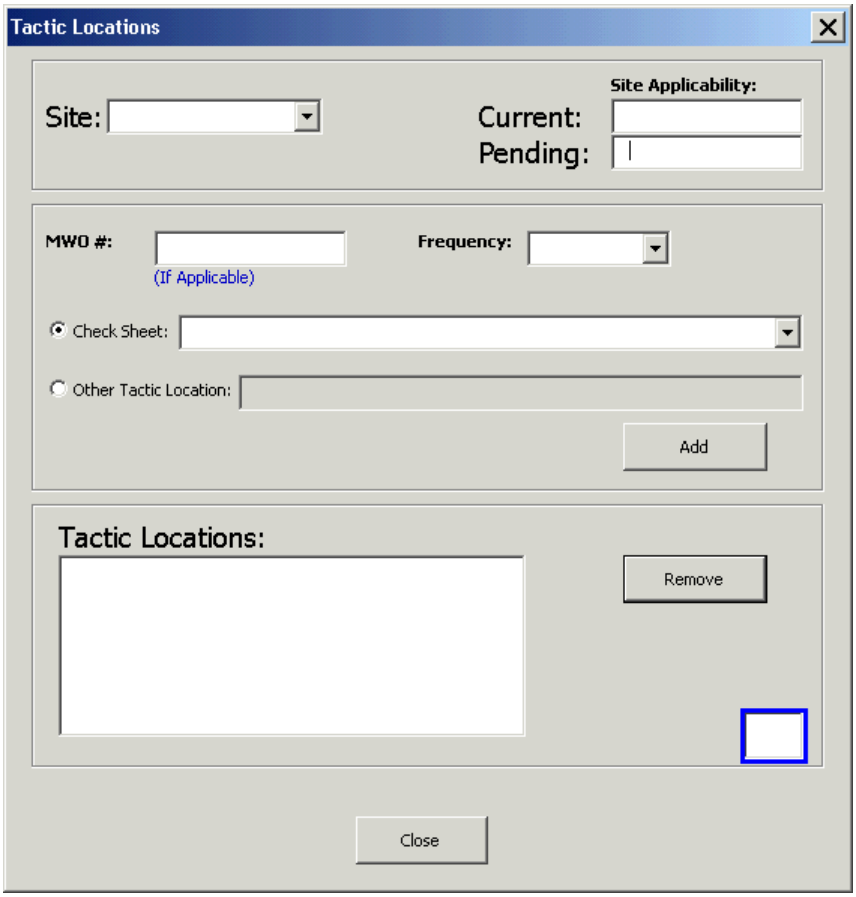

Figure 5.12 - Tactic Locations Form

5.2.2.2 Adding a Maintenance Strategy

Adding a **strategy** is done by pressing the **Add** button on the "Maintenance Strategies" Worksheet, shown on Figure 5.13.

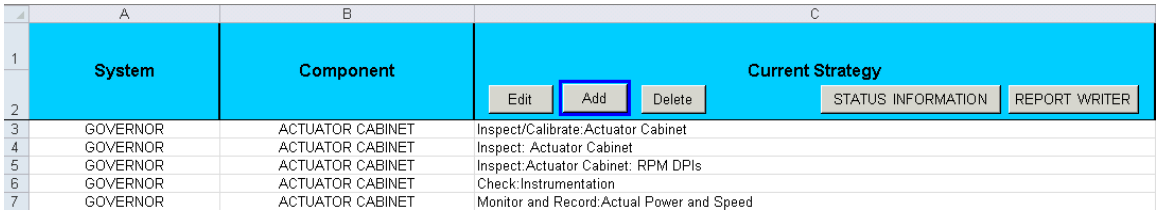

Figure 5.13 - Adding a Maintenance Strategy

Once the **Add** button is pressed the Add Strategy Form is activated, as displayed in Figure 5.14.

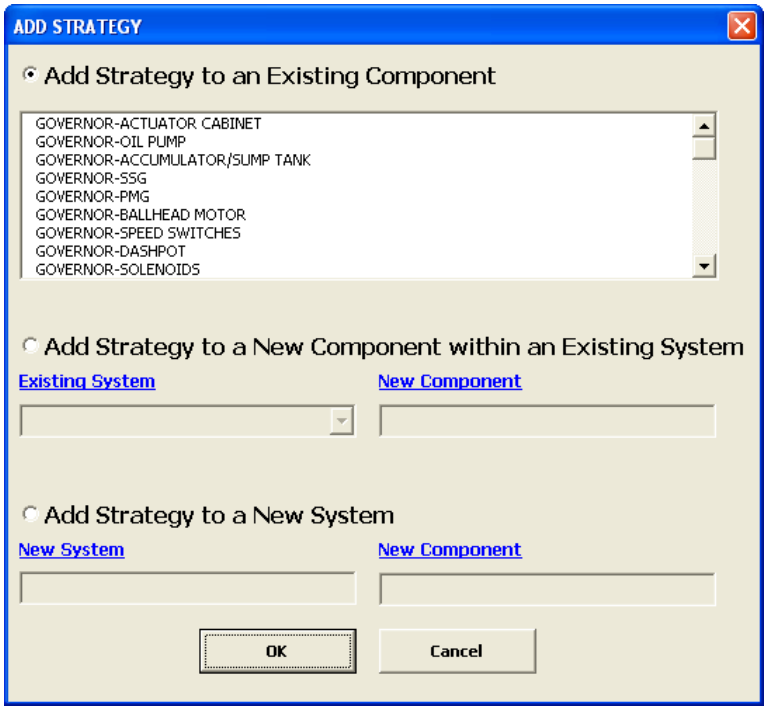

Figure 5.14 - Add Form

There are three different options when adding a **strategy** to the MSWB:

- Adding **Strategy** to an Existing Component (Section 5.2.2.2.1)
- Adding **Strategy** to a New Component within an Existing System (Section 5.2.2.2.2)
- Adding **Strategy** to a New System (Section 5.2.2.2.3)

5.2.2.2.1 Adding Strategy to an Existing Component

To add a **strategy** to an existing component, the user selects the existing component from the list and presses **OK**. The user would then be prompted with a blank Edit Form to enter the new **strategy's** available information in the **Pending Tab**, using the procedure in Section 5.3. For this information to be saved, the user must press the **Save**, **Save & Close**, **Next**, or **Previous** button on the Edit Form.

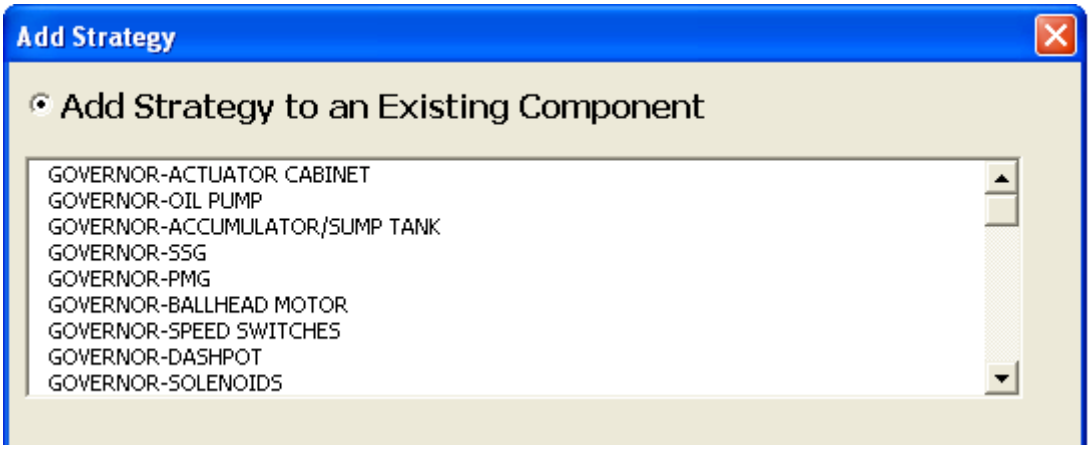

Figure 5.15 - Add Form: Existing Component List

5.2.2.2.2 Adding Strategy to a New Component within an Existing System

When adding a **strategy** for a component that does not appear in the MSWB, the user selects the option button for "Add **Strategy** to a New Component within an Existing System", shown in Figure 5.16. The user selects the existing system from a drop down list and enters the name of the new component associated with that existing system. After the **OK** button has been pressed, a blank Edit Form will appear where the user enters the new **strategy's** available information in the **Pending Tab** using the procedure in Section 5.3. For this information to be saved, the user must press the **Save**, **Save & Close**, **Next**, or **Previous** button on the Edit Form.

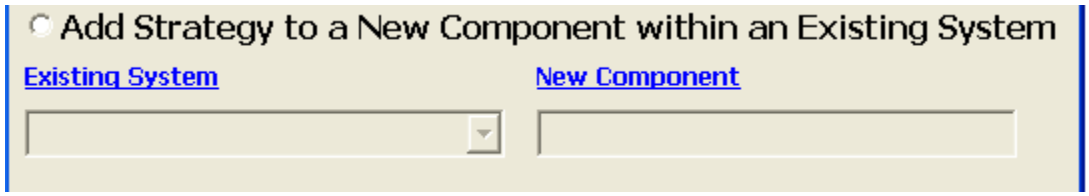

Figure 5.16 - Add Form: Add Strategy to a New Component within an Existing System

5.2.2.2.3 Adding Strategy to New System

In the rare case that a new **strategy** would be added to a new system, the MSWB has the capability to add a new system to the MSWB. The user must select the option button for "Add **Strategy** to a New System" and enter the name of the new system and component and press **OK**. Once the new system is added to the MSWB, the user will then be prompted with a blank Edit Form to enter available information for the new strategy in the **Pending Tab** using the procedure in Section 5.3. For this information to be saved, the user must press the **Save**, **Save & Close**, **Next**, or **Previous** button on the Edit Form.

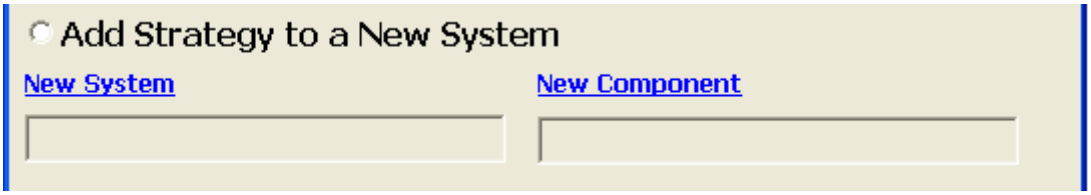

Figure 5.17 - Add Form: Add Strategy to a New System

5.2.2.3 Deleting a Maintenance Strategy

The **Delete** button is used to remove a **strategy** from the MSWB when it has been created in error. All **strategy** information will be lost. The user selects the **strategy** to be removed in the "**Current Strategy**" column and presses the **Delete** button. The user will then be prompted with a warning and asked for a password to ensure that this is the desired action. This action should only be performed if the user has made a mistake while adding a new **strategy.** Do not use the **Delete** button to remove a strategy which is to become inactive. **Strategies** that are to become inactive should remain in the MSWB for archiving and reference purposes and will be highlighted grey with bold text automatically when the Site Applicability boxes are marked "No" and "N/A" for all sites.

	A	B	C
1	System	Component	Current Strategy
2			Edit / Add / Delete / STATUS INFORMATION / REPORT WRITER
3	GOVERNOR	ACTUATOR CABINET	Inspect/Calibrate:Actuator Cabinet
4	GOVERNOR	ACTUATOR CABINET	Inspect: Actuator Cabinet
5	GOVERNOR	ACTUATOR CABINET	Inspect:Actuator Cabinet: RPM DPIs
6	GOVERNOR	ACTUATOR CABINET	Check:Instrumentation
7	GOVERNOR	ACTUATOR CABINET	Monitor and Record:Actual Power and Speed

Figure 5.18 - Deleting a Maintenance Strategy

5.2.3 Obtaining Status Information

The Status Information application is used to determine what **strategies** are pending at each of the various status codes. A detailed definition of the status codes can be found in Section 5.1. This feature will be particularly useful for users who typically deal with pending **strategies** at a particular status, so they can filter to a list of the **strategies** that are applicable to them.

To activate the Status Information Form, shown in Figure 5.20, the user must press the **Status Information** button on the **"**Maintenance Strategies**"** Worksheet, highlighted by the blue box in Figure 5.19.

	A	B	C
1	System	Component	Current Strategy
2			Edit Add Delete STATUS INFORMATION REPORT WRITER
3	GOVERNOR	ACTUATOR CABINET	Inspect/Calibrate:Actuator Cabinet
4	GOVERNOR	ACTUATOR CABINET	Inspect: Actuator Cabinet
5	GOVERNOR	ACTUATOR CABINET	Inspect:Actuator Cabinet: RPM DPIs
6	GOVERNOR	ACTUATOR CABINET	Check:Instrumentation
7	GOVERNOR	ACTUATOR CABINET	Monitor and Record:Actual Power and Speed

Figure 5.19 - Obtaining Status Information

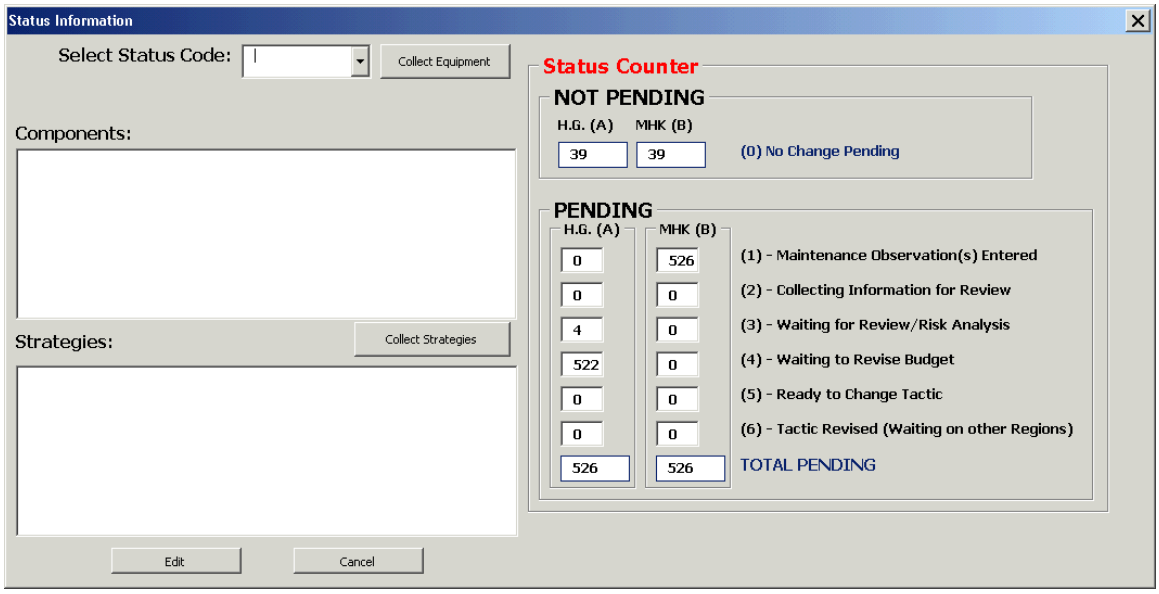

Figure 5.20 - Status Information Form

5.2.3.1 Status Counter

At the bottom of the Status Information Form is the Status Counter. The Status Counter keeps track of all the **strategies** at each status which indicates what duties are required for each group, outlined in Section 7.0 . Each region has its own Status Counter, because **strategies** can have different statuses for each region.

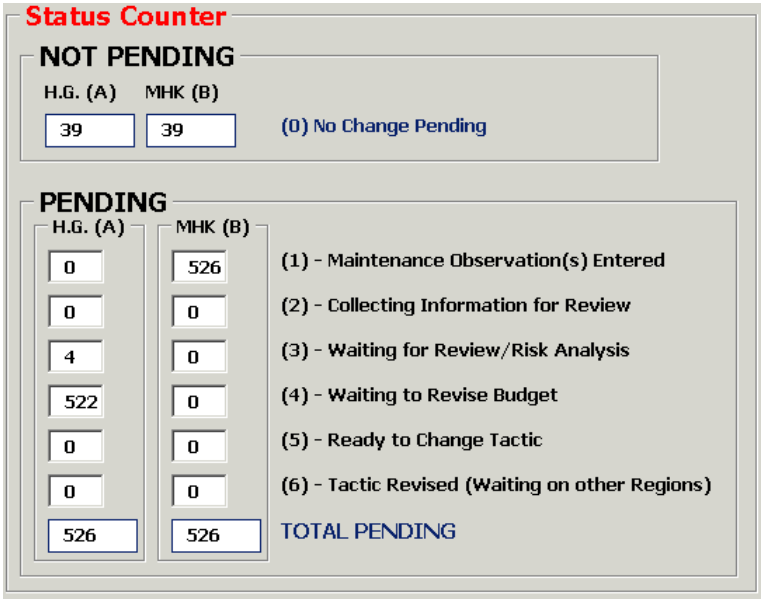

Figure 5.21 - Status Information Form: Status Counter

5.2.3.2 Collecting Strategies with Particular Statuses

The drop down list for Select Status Code at the top of the Status Information Form, contains all the status codes, which is shown in Figure 5.22. Once the user selects a code and presses **Collect Equipment,** the Components list box (Figure 5.23) below the drop down menu is populated with all the components which have **strategies** with that particular status code. To view all the strategies at that status code for a component, the user must select the desired component from the Component list box and click **Collect Strategies**, at which point the Strategies list box will be populated. More information regarding status codes can be found in Section 5.1.

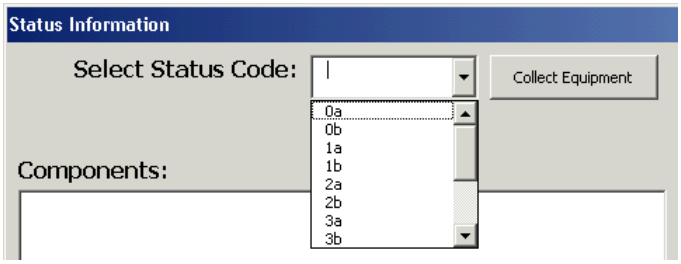

Figure 5.22 - Status Information Form: Selecting the Status Code

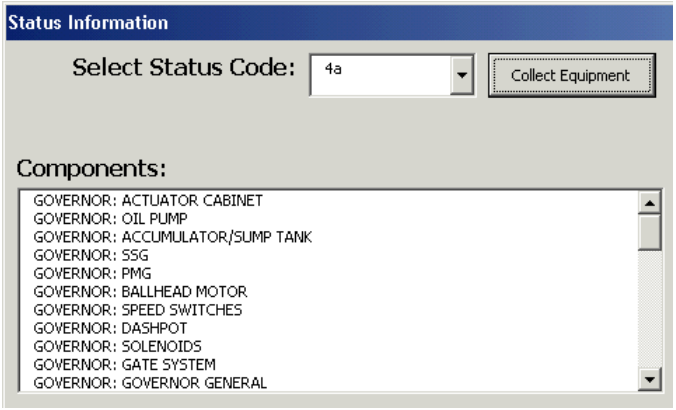

Figure 5.23 - Status Information Form: Getting List of Equipment for a Status Code

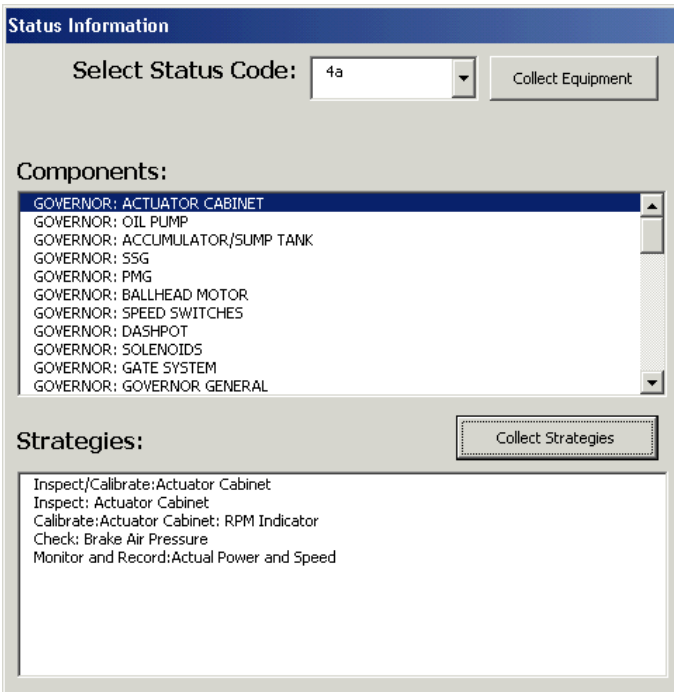

Figure 5.24 - Status Information Form: Getting List of Strategies a Component

The user can now select any of the **strategies** in the Strategies list box and press **Edit**, which will activate the Edit Form with all the information regarding that specific **strategy**. The Edit Form for that **strategy** allows the user to make any modifications, which could potentially result in a status update.

5.2.4 Report Writer

The Report Writer application is used to generate **strategy** reports based on a MWO Search (Section 5.2.4.2), Site Search (Section 5.2.4.3) or Risk Search (Section 5.2.4.4). This feature will be particularly useful for users who wish to view specific **strategies** based on common characteristics, such as high risk or all the **strategies** for a specific system or component at a specified location. Reports generated using this application appear in the "Report" Worksheet outlined in Section 5.2.4.1, in the MSWB.

To activate the Report Writer Form, shown in Figure 5.25, the user must press the **Report Writer** button on the **"**Maintenance Strategies**"** Worksheet, highlighted by the blue box in Figure 5.26.

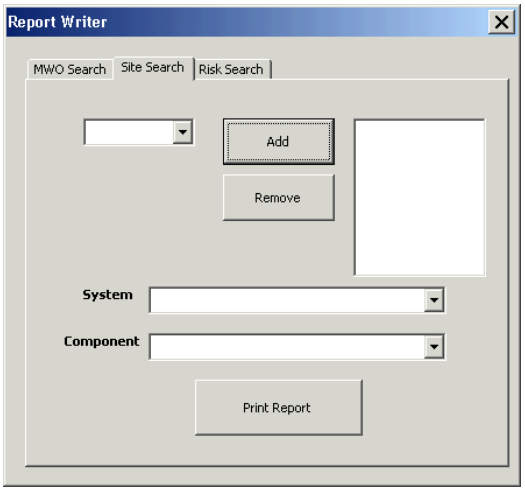

Figure 5.25 – Report Writer Form

	System	Component	Current Strategy
1			
2			Edit Add Delete STATUS INFORMATION REPORT WRITER
3	GOVERNOR	ACTUATOR CABINET	Inspect/Calibrate:Actuator Cabinet
4	GOVERNOR	ACTUATOR CABINET	Inspect: Actuator Cabinet
5	GOVERNOR	ACTUATOR CABINET	Inspect:Actuator Cabinet: RPM DPIs
6	GOVERNOR	ACTUATOR CABINET	Check:Instrumentation
7	GOVERNOR	ACTUATOR CABINET	Monitor and Record:Actual Power and Speed
8	GOVERNOR	OIL PUMP	Verify Operation/Calibrate:Oil Pump Motor(s): Alarms, Trips

Figure 5.26 – Generating Reports

5.2.4.1 Report Sheet

Reports generated by the Report Writer application appear in the "Report" Worksheet of the MSWB, which is shown in Figure 5.27. To view this sheet at any time, click on the "Report" Worksheet located at the bottom of the workbook. Any **strategy** in the report can be edited by first selecting the **strategy** and then pressing the **Edit** button, highlighted by the blue box as shown in Figure 5.27.

Once finished with the report the user can return to the **maintenance strategies** by clicking on the "Maintenance Strategies" Worksheet located at the bottom of the workbook.

	A	B	C	D	E
1	Site	System	Component	Edit Strategy	Frequency
2	BDE 1	GOVERNOR	PMG	Calibrate/Verify Operation:PMG Testing	(1Y/6Y)
3	BDE 1	GOVERNOR	PMG	Inspect/Clean:PMG Stator	(1Y/6Y)
4	BDE 1	GOVERNOR	PMG	Monitor and Record:PMG Stator: Voltage	(1Y/6Y)
5	BDE 1	GOVERNOR	PMG	Monitor and Record:PMG:Megger	(1Y/6Y)
6	BDE 1	GOVERNOR	PMG	Replace:PMG Stator Main Bearings	(6Y)
7	BDE 1	GOVERNOR	PMG	Inspect/Replace:PMG Upper/Lower Drive Pins and Drive Plate	(1Y/6Y)
8	BDE 1	GOVERNOR	PMG	Inspect/Clean:PMG Urethane Bushing Assemblies (Upper/Lower)	(1Y/6Y)
9					

Figure 5.27 – "Report" Worksheet

5.2.4.2 Generating a Report for A Specific Model Work Order

The MWO Search tab of the Report Writer form allows the user to create a report from a specific MWO and contains a textbox for a MWO number, shown in Figure 5.28. Once the user has entered a MWO number into the textbox and pressed the **Print Report** button, the user is brought to the "Report" Worksheet containing the newly created report.

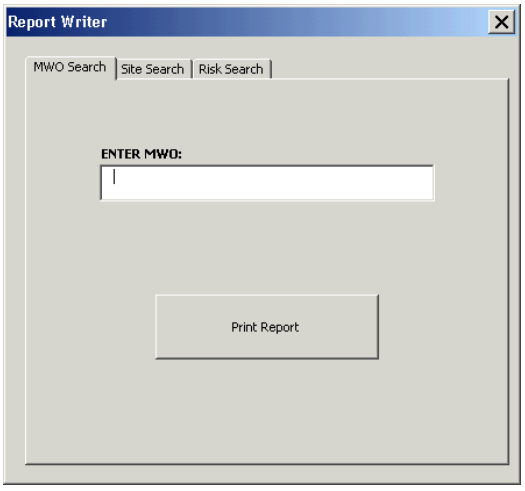

Figure 5.28 – Report Writer: MWO Search

5.2.4.3 Generating a Report for Specific Sites and Equipment

The Site Search tab of the Report Writer form contains drop down lists for Sites, Systems and Components, as shown in Figure 5.29. To generate a report the user must first add the desired site(s) to the site list box by selecting a site from the site drop down list and pressing the **Add** button. A site can be removed from the site list box by selecting that site in the list box and pressing the **Remove** button. The user can now select the desired System and Component from the respective drop down lists and press **Print Report**, at which point the user is brought to the "Report" Worksheet containing the newly created report.

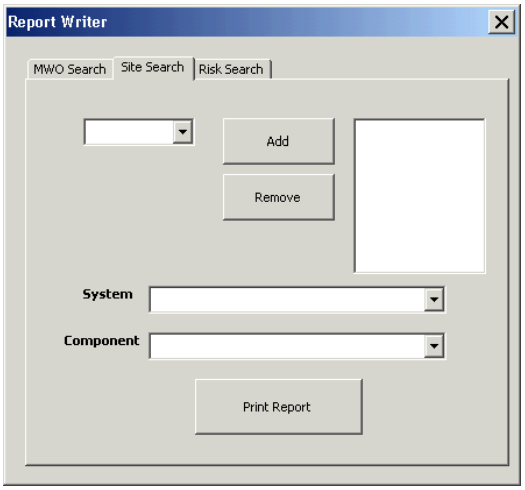

Figure 5.29 – Report Writer: Site Search

5.2.4.4 Generating a Report for a Risk Level

The Risk Search tab of the Report Writer form contains a drop down list of risk levels and option buttons for Mitigated and Unmitigated risk, as shown in Figure 5.30. Once the user selects the desired risk and presses **Print Report**, the user is brought to the "Report" Worksheet containing the newly created report.

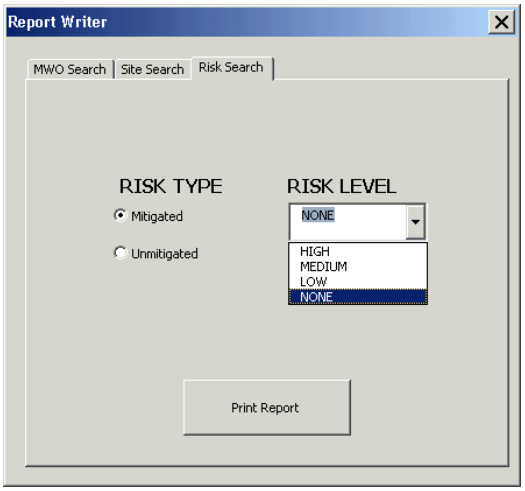

Figure 5.30 – Report Writer: Risk Search

5.3 Procedure

The overall management of **maintenance strategies** is an on-going program. The process to manage **maintenance strategies** for the systems and components of a given major asset includes the following steps:

- Enter Maintenance Observation(s) (Step 1)
- Review and Update Maintenance Philosophy (Step 2)
- Review and Update Practices in Other Companies or Industry Common Practices (Step 3)
- Review and Update Practices in Other Areas of the Corporation (Step 4)
- Review and Update Manufacturers' Recommendations (Step 5)
- Review and Update Equipment History (Step 6)
- Review and Update Expert Recommendations (Step 7)
- Review Strategy (Complete Technical Council and Risk Analysis) (Step 8)
- Revise Budget (Step 9)
- Revise Tactic(s) (Step 10)

5.3.1 Enter Maintenance Observation(s) (Step 1)

The first step in the Change Management Process is to observe any deficiencies that need to be corrected in the current maintenance system. The observation(s) can come from any of the triggers mentioned in Section 5.1, i.e. a Work Order (WO) coded 71 in JD Edwards.

When a maintenance observation is to be entered into the MSWB, it first must be determined which **strategy(s)** this will affect. Once established, the maintenance observation must be added to all applicable **strategies**. An observation may require that a new **maintenance strategy** be created within the MSWB; procedure to add a new **maintenance strategy** to the MSWB can be found in Section 5.2.2.2.

The maintenance observation will be entered for the affected **strategy(s)** by clicking the **Enter Observation** button on the **Pending Tab**, highlighted by a blue box in Figure 5.31.

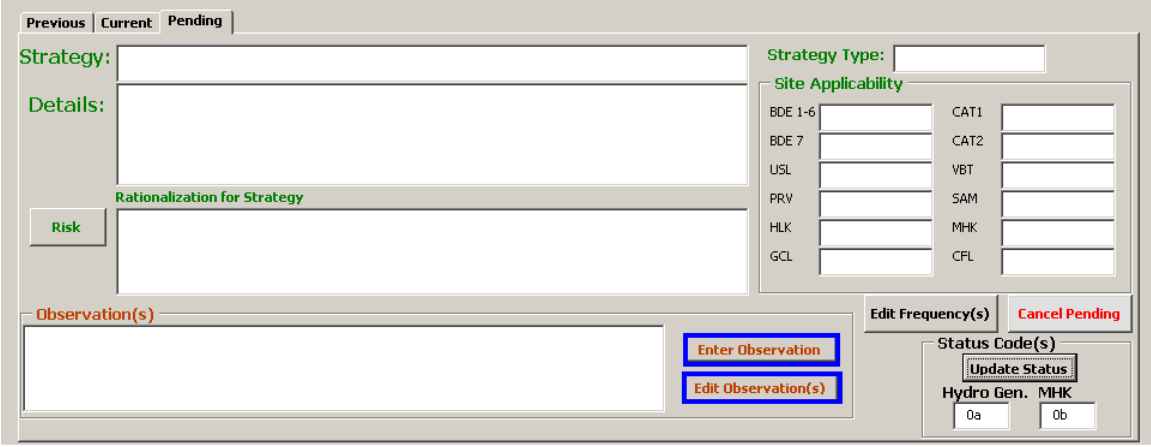

Figure 5.31 - Enter Observation, Edit Observation(s) and Update Status Buttons

Once the **Enter Observation** button has been selected, the Enter Observation Form will appear, as seen in Figure 5.32. In this form, the user will need to fill out their name, the date when the observation was detected and the details of the maintenance observation; as a default the date will be entered as the current date. In the Observation Description textbox, the location and/or source of trigger (refer to Section 5.1) must be recorded.

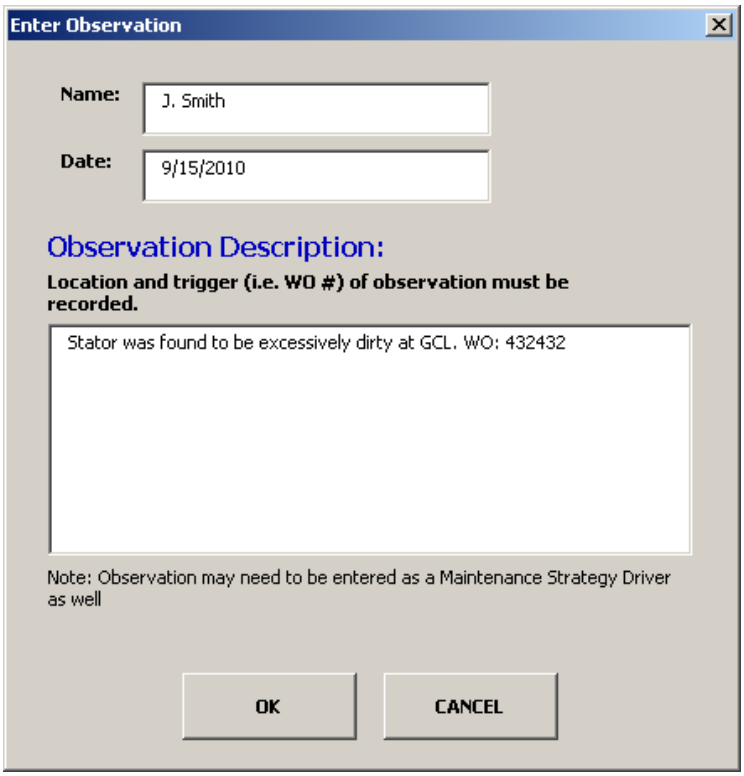

Figure 5.32 - Enter Observation Form

The location is the site at which the observation was noticed. For example, "Stator was found to be excessively dirty at *GCL*. *WO: 432432*".

The trigger in the previous example was the listed WO, type 71, which contained the maintenance feedback of "Stator was found to be excessively dirty" during work performed at Granite Canal. A list of common triggers can be found in Section 5.1.

Any additional supporting information should be entered in the Observation Description textbox.

Once the user has completed the Observation Form and selects **OK**, some information in the **Current Tab** textboxes will be transferred over to the **Pending Tab**. This information includes **Strategy**, **Site Applicability** and **Strategy Type.** During the rest of the Change Management Procedure the user will modify this information in the **Pending Tab** accordingly.

If there was a mistake in entering the observation, or if the observation should be removed for any particular reason, the user can select the **Edit Observation(s)** button, seen highlighted by a blue box in Figure 5.31. This button will expand the Observation(s) textbox and allow the user to edit the information.

Once the observation(s) has been entered, the status of the **strategy** automatically updates to a status code 1x . The variable x represents the assigned letter for that region in the MSWB, as shown in Figure 5.33. To obtain all maintenance strategies at status code 1x, the Status Information function can be used as described in Section 5.2.3.

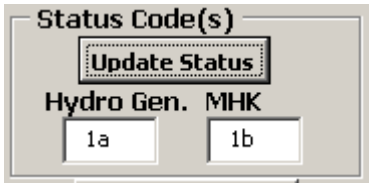

Figure 5.33 - Status Code 1x: Maintenance Observation(s) Entered

Note: In MSWB's which contain multiple regions, each region will have its own textbox for status codes, displaying the regions progression as shown in Figure 5.33.

Note: A maintenance observation may also be a Maintenance Strategy Driver as well, requiring the user to enter the information into the appropriate textbox.

5.3.2 Review and Update Maintenance Philosophy (Step 2)

As part of the Change Management Process, the **maintenance philosophy** will need to be reviewed and possibly updated. All **strategies** are driven by a **maintenance philosophy**, so any change in the **philosophy** could impact the review of a suggested **strategy**. An overview of **maintenance philosophy** is given in Section 4.1.

The **philosophy** can be displayed and reviewed by pressing the **Maintenance Philosophy** button on the Edit Form.

Once the **philosophy** has been reviewed, the LTAP, with respect to their region, is required to update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 2 – Maintenance Philosophy Reviewed and Updated'.

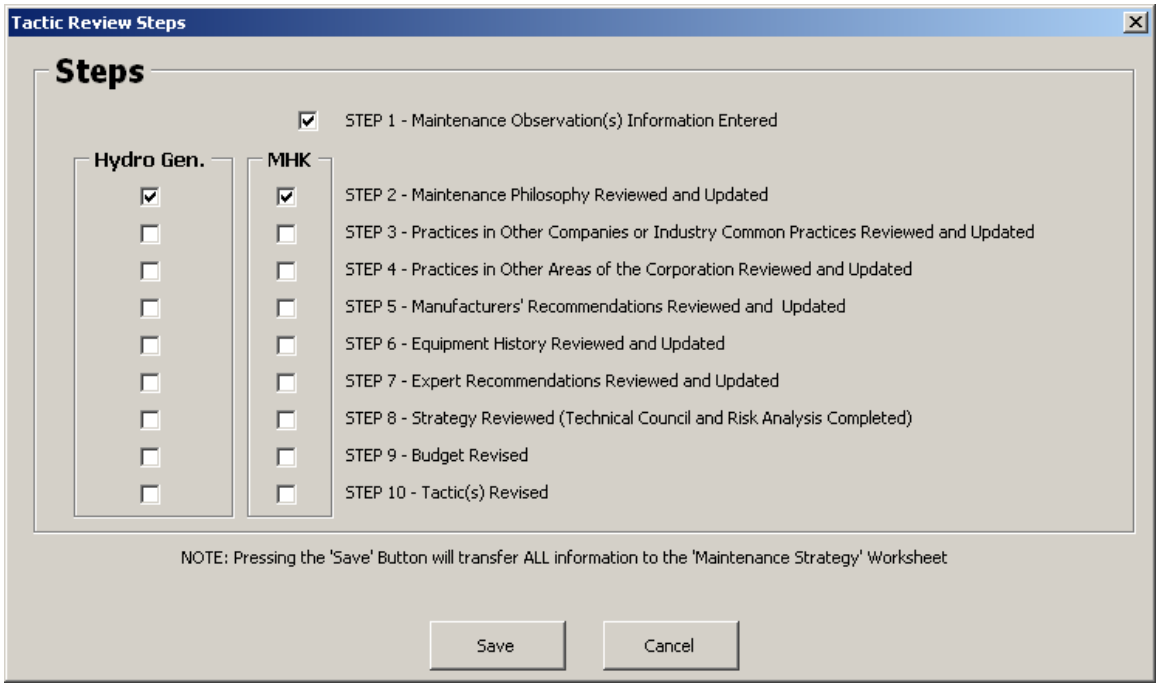

Figure 5.34 - Step 2 Selected

Once Step 2 has been saved, the status code should now read 2x for the respective regions indicating that the **maintenance philosophy** has been reviewed and updated and the **maintenance strategy drivers** are being collected for review. Steps 2-7 inclusive are status codes 2x. The status code will not change to 3x until all steps up to and including step 7 are selected and saved. Steps 2-7 do not need to be done in order and

can be reviewed simultaneously. To obtain all maintenance strategies at status code 2x, the Status Information function can be used as described in Section 5.2.3.

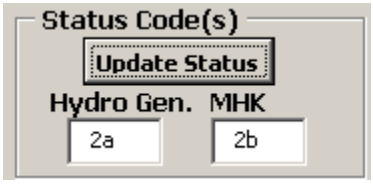

Figure 5.35 - Status Code 2x: Collecting Information for Review (Steps 2-7 Inclusive)

5.3.3 Review and Update Practices in Other Companies or Industry Common Practices (Step 3)

An overview of practices in other companies is given in Section 4.2.

Based upon information supplied by other companies, the MSWB may need to be updated, if the information supplied is similar to an existing **strategy**, it should be added to the **drivers** of that **strategy**. The appropriate textbox to enter this information is "Practices in Other Companies or Industry Common Practices", highlighted by the blue box in Figure 5.36. Information can be added to this textbox by clicking the button highlighted with the green box for the Add Driver Form, explained in Section 5.2.2.1.3.

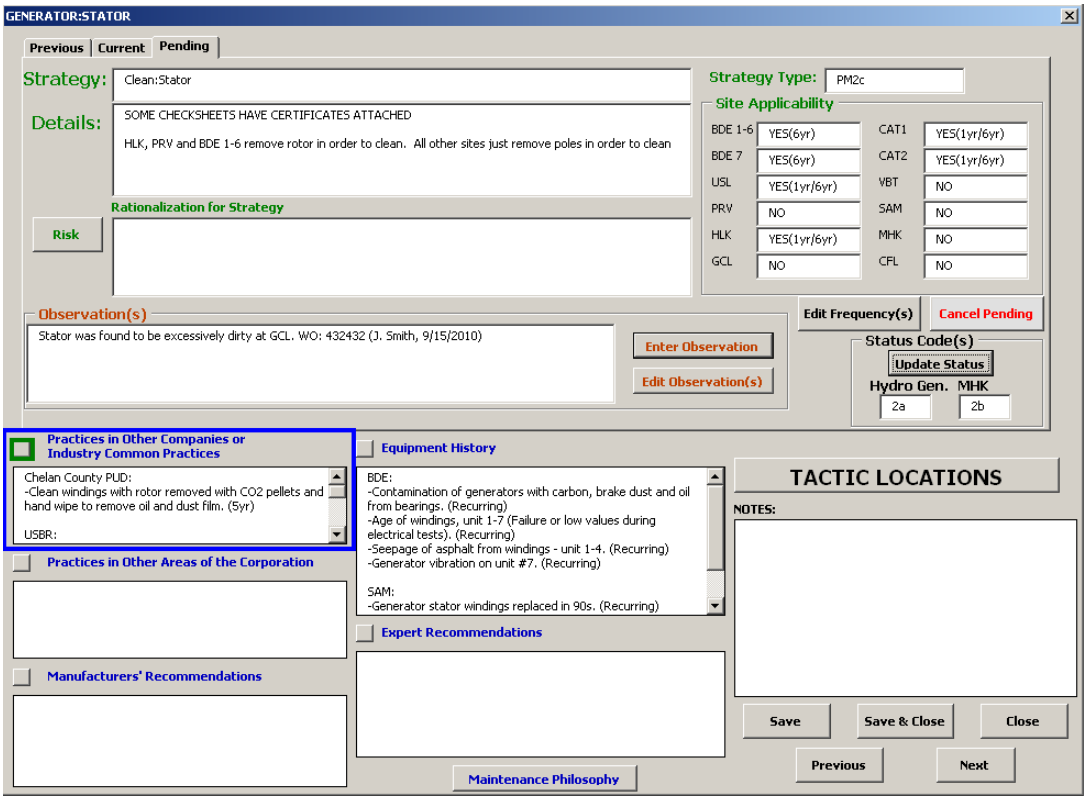

Figure 5.36 - Practices in Other Companies or Industry Common Practice Textbox

Once the LTAP has reviewed all the gathered practices in other companies, they are required to update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 3 –Other Companies or Utilities Reviewed and Updated'.

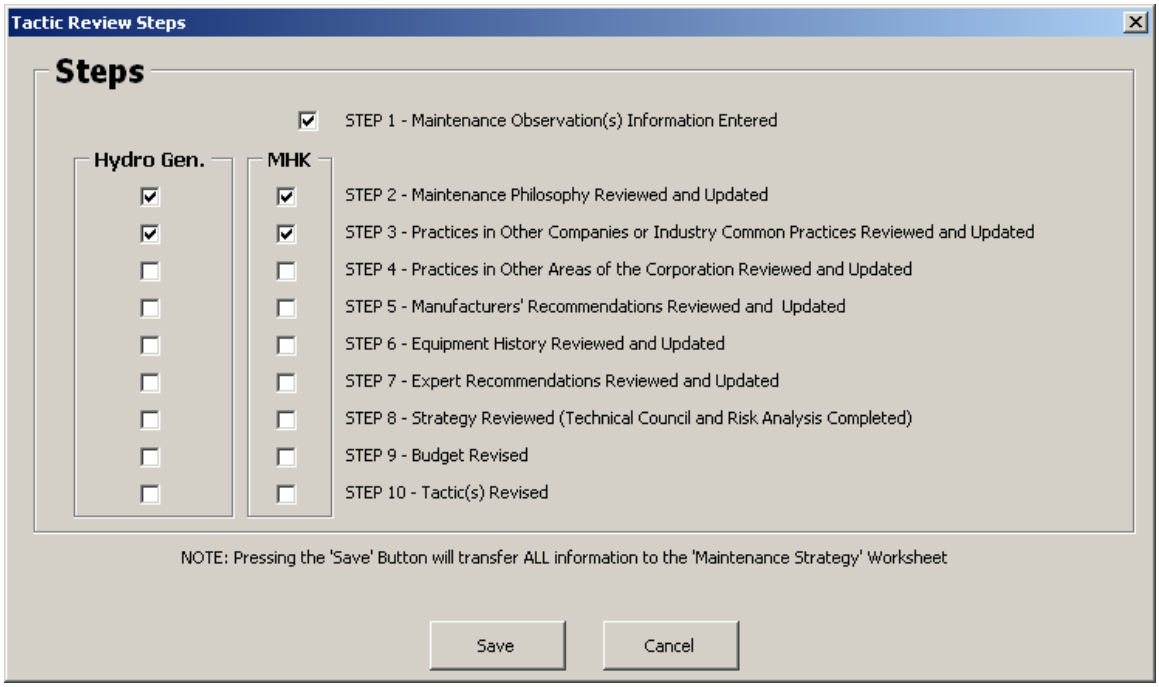

Figure 5.37 - Step 3 Selected

Note: The status code will remain at 2x as information is still being collected. To obtain all maintenance strategies at status code 2x, the Status Information function can be used as described in Section 5.2.3.

5.3.4 Review and Update Practices in Other Areas of the Corporation (Step 4)

An overview of practices in other areas of the corporation is given in Section 4.3.

Based upon information supplied by other areas of the corporation, the MSWB may need to be updated. If a **strategy** is similar to an existing **strategy**, it can be added to the **driver** of that **strategy**. The textbox to enter this information is "Practices in Other Areas of the Corporation" highlighted by the blue box in Figure 5.38. Information can be added to this textbox by clicking the button highlighted with the green box for the Add Driver Form, explained in Section 5.2.2.1.3.

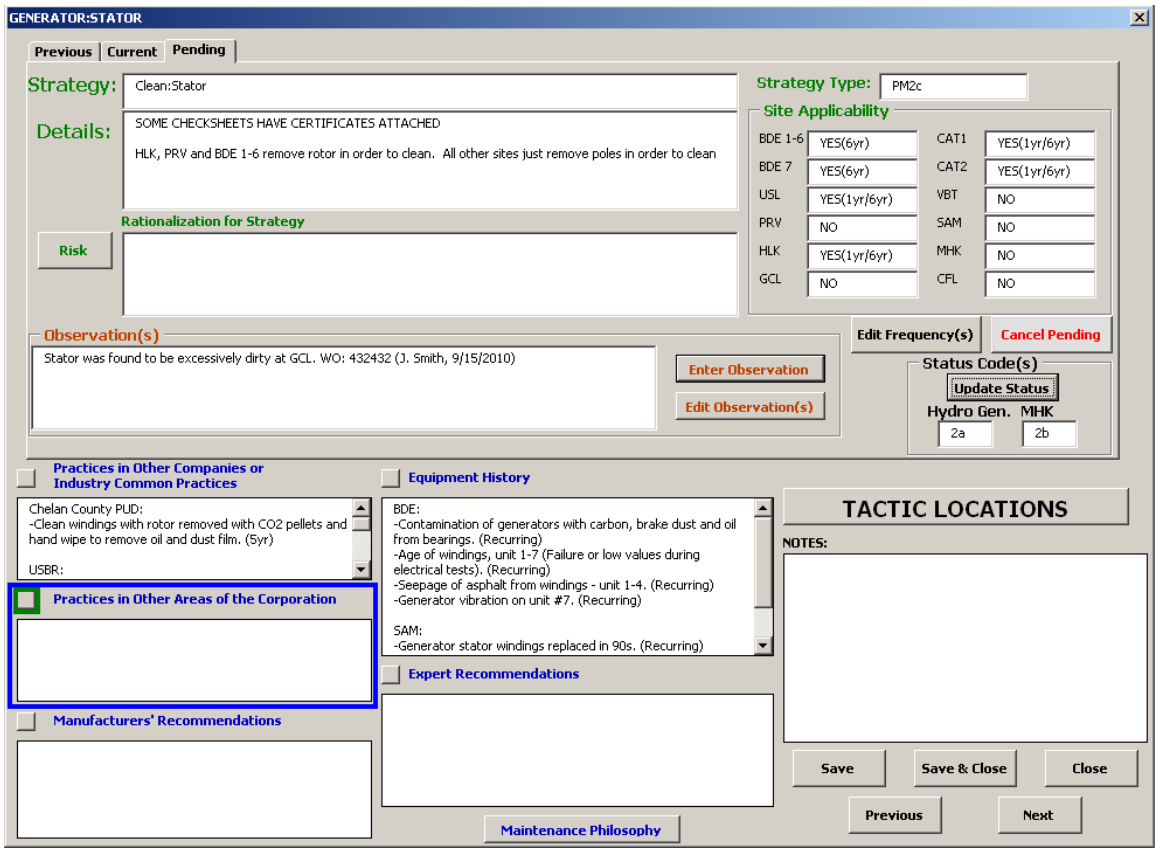

Figure 5.38 - Practices in Other Areas of the Corporation Textbox

Once all the practices in other areas of the corporation have been reviewed, the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 4 –Other Areas of the Corporation Reviewed and Updated' for their region.

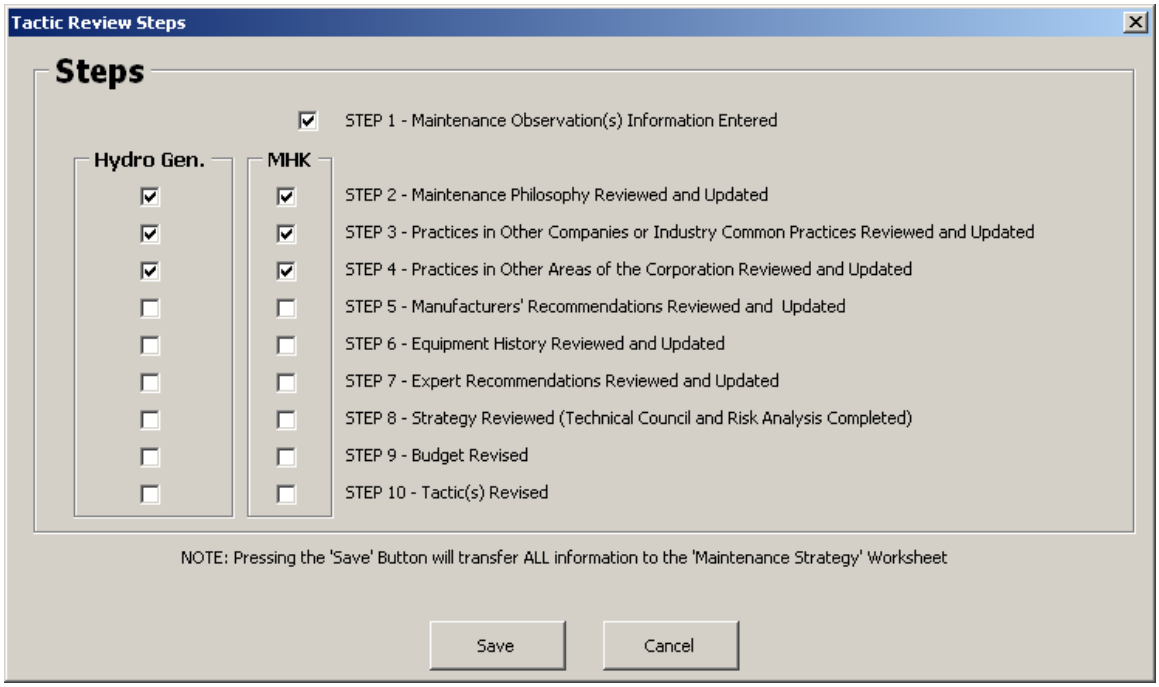

Figure 5.39 - Step 4 Selected

Note: The status code will remain at 2x as information is still being collected. To obtain all maintenance strategies at status code 2x, the Status Information function can be used as described in Section 5.2.3.

5.3.5 Review and Update Manufacturers' Recommendations (Step 5)

An overview of manufacturers' recommendations is given in Section 4.4.

Based upon information supplied by the OEM, the MSWB may need to be updated. The textbox to enter this information is "Manufacturers' Recommendations", highlighted by the blue box in Figure 5.40. Information can be added to this textbox by clicking the button highlighted with the green box for the Add Driver Form, explained in Section 5.2.2.1.3.

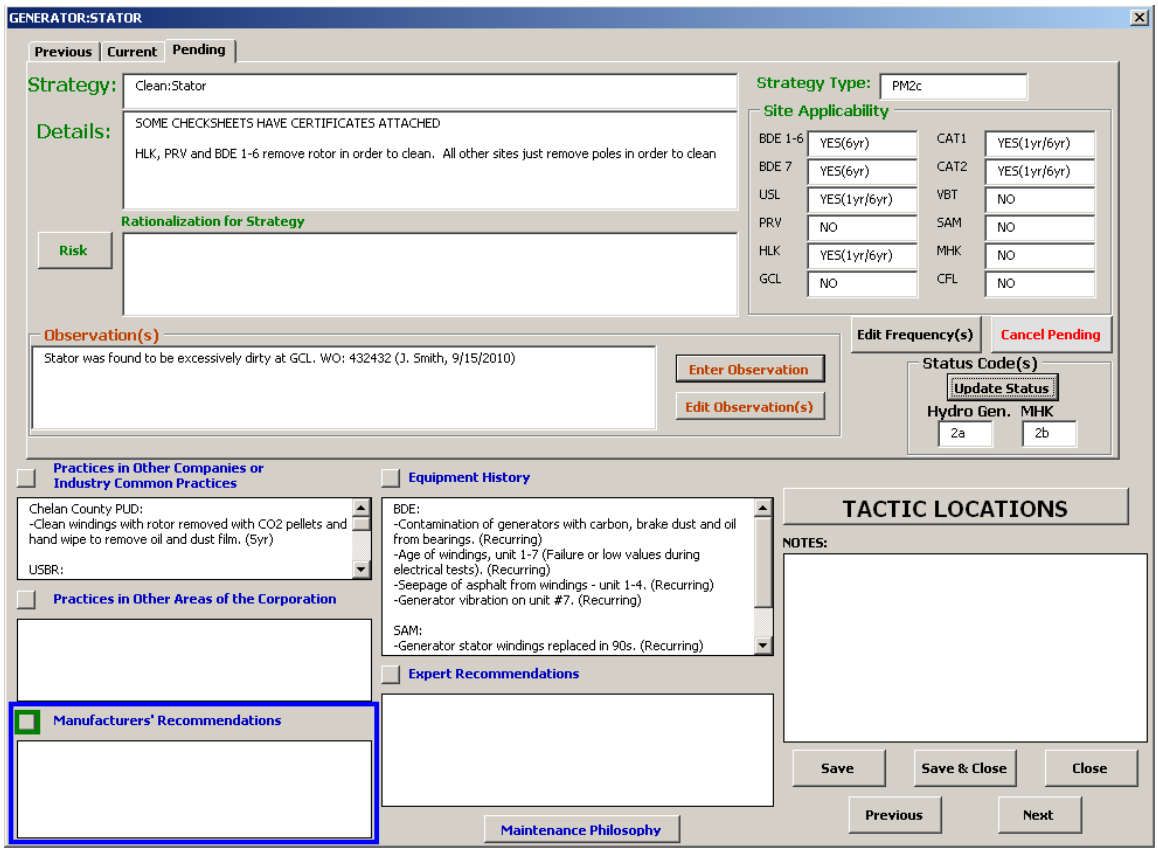

Figure 5.40 - Manufacturers' Recommendations Textbox

Once all the OEM recommendations have been reviewed, the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 5 –Manufacturers' Recommendations Reviewed and Updated', for their region.

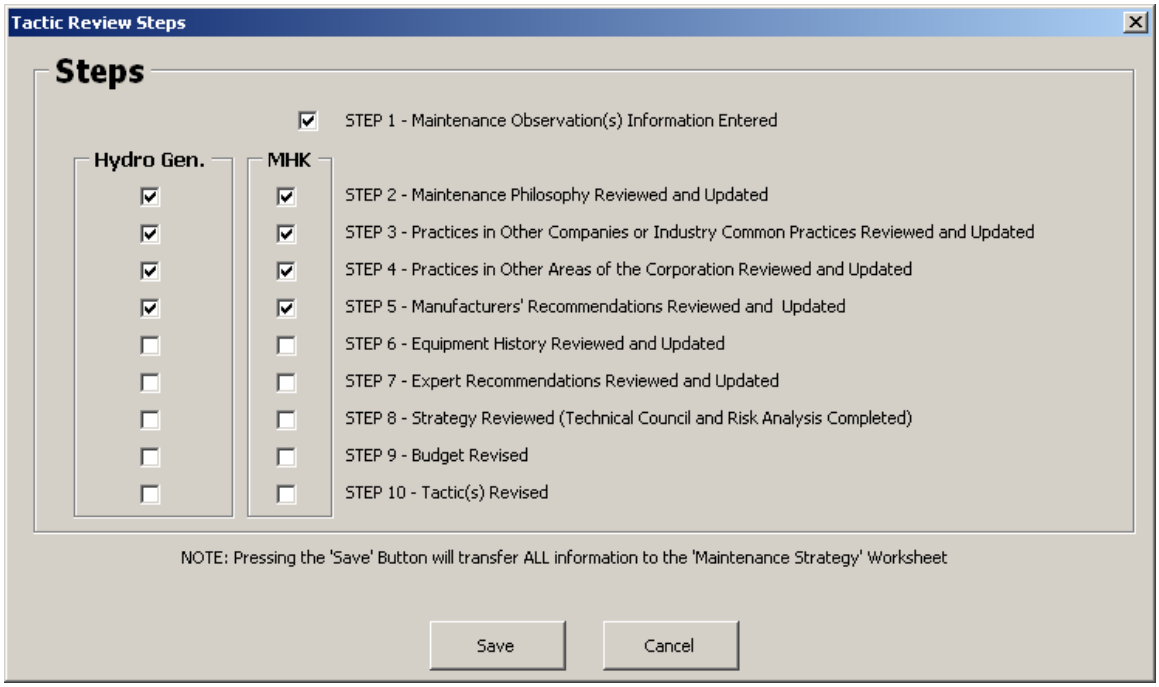

Figure 5.41 - Step 5 Selected

Note: The status code will remain at 2x as information is still being collected. To obtain all maintenance strategies at status code 2x, the Status Information function can be used as described in Section 5.2.3.

5.3.6 Review and Update Equipment History (Step 6)

An overview of equipment history is given in Section 4.5.

This information is to be entered into the "Equipment History" textbox, highlighted by the blue box in Figure 5.42. Information can be added to this textbox by clicking the button highlighted with the green box for the Add Driver Form, explained in Section 5.2.2.1.3.

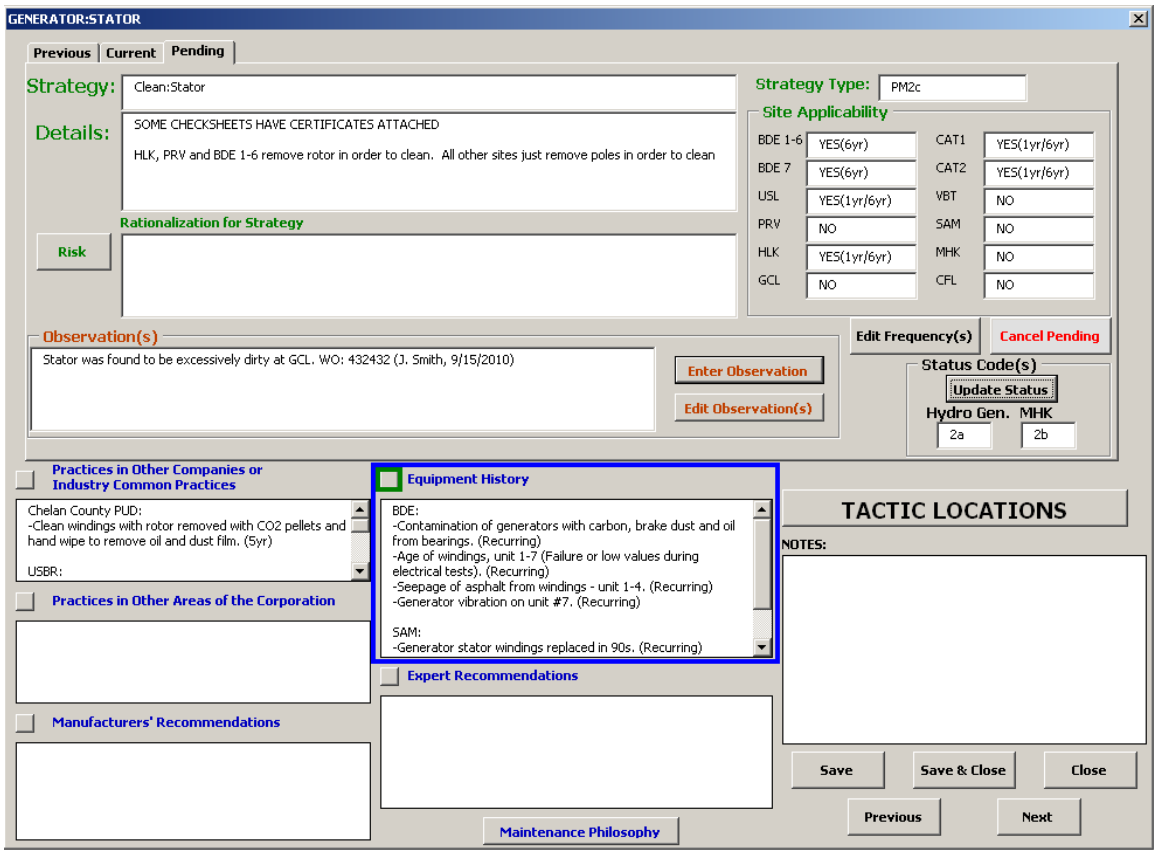

Figure 5.42 - Equipment History Textbox

Once all the equipment history has been reviewed the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 6 –Equipment History Reviewed and Updated', for their region.

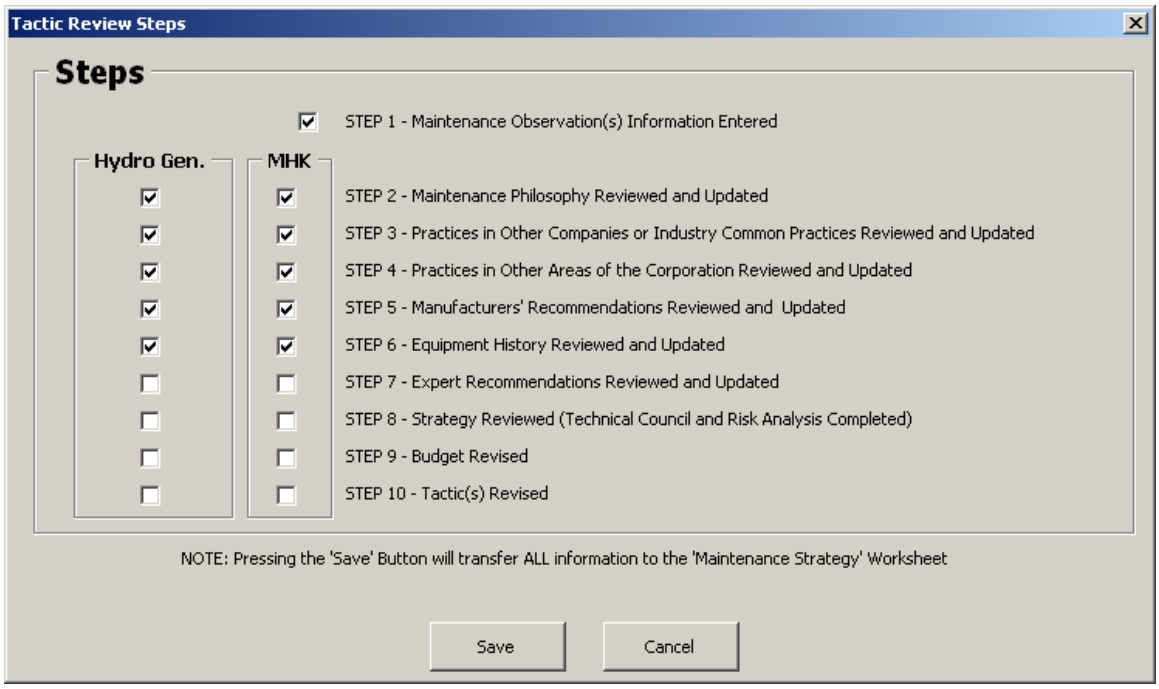

Figure 5.43 - Step 6 Selected

Note: The status code will remain at 2x as information is still being collected. To obtain all maintenance strategies at status code 2x, the Status Information function can be used as described in 5.2.3.

5.3.7 Review and Update Expert Recommendations (Step 7)

An overview of expert recommendations is given in Section 4.6.

The textbox to enter any information that is gathered during this stage is the "Expert Recommendations" textbox which is highlighted by the blue box in Figure 5.44. Information can be added to this textbox by clicking the button highlighted with the green box for the Add Driver Form, explained in Section 5.2.2.1.3.

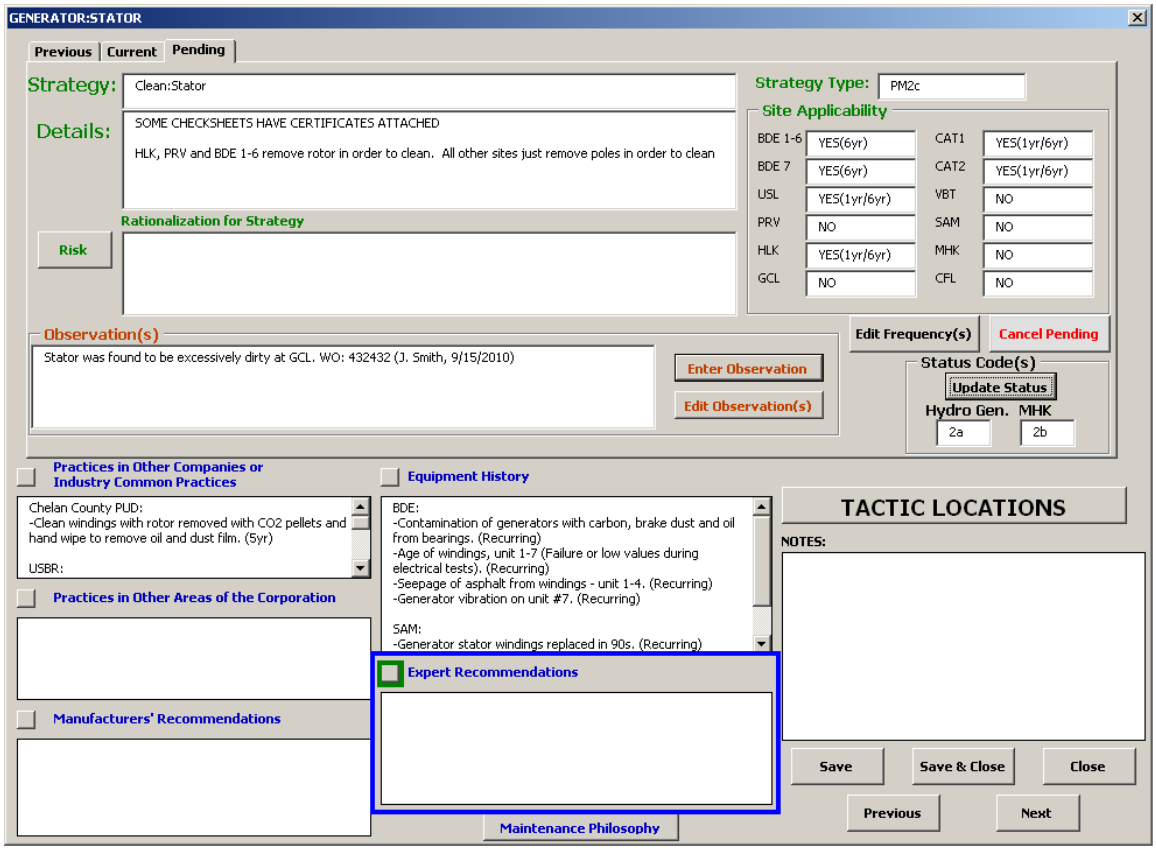

Figure 5.44 - Expert Recommendations Textbox

Once all the expert recommendations have been reviewed, the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 7 –Expert Recommendations Reviewed and Updated', for their region.

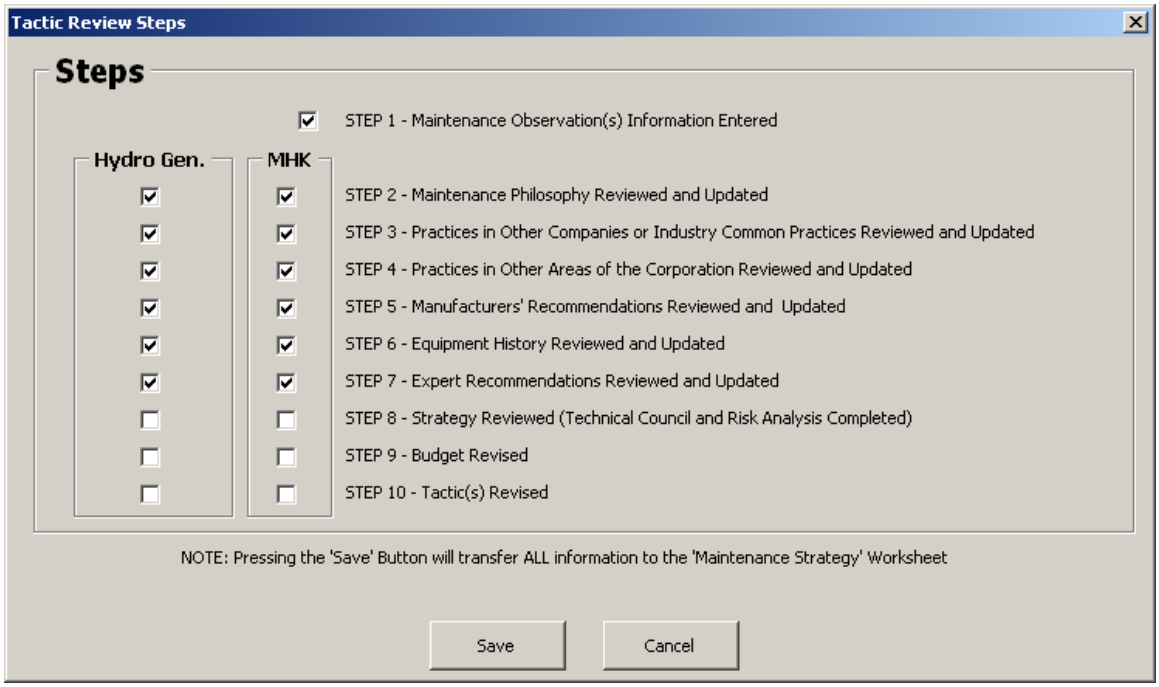

Figure 5.45 - Step 7 Selected

Once Steps 2-7 have been completed, the status code will read 3x, signifying the **strategy** is Waiting for Review/Risk Analysis per Table 5.1. To obtain all maintenance strategies at status code 3x, the Status Information function can be used as described in Section 5.2.3.

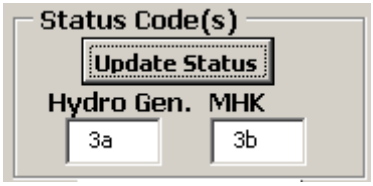

Figure 5.46 - Status Code 3x: Waiting for Review/Risk Analysis

5.3.8 Review Strategy (Complete Technical Council and Risk Analysis) (Step 8)

The process leading to this stage has consisted of the addition of relevant information from updated **maintenance drivers**. The most crucial step of the Change Management Process is to analyze that information, along with associated maintenance costs, and determine the best **maintenance strategies** going forward. All **strategies** at status code 3x are to be reviewed at this time by a Technical Council.

During the Technical Council the pending **strategy** is discussed and reviewed, including the details and frequency at which the **strategy** should be performed. Once the **strategy** is agreed upon by the Technical Council, the **strategy** and strategy type must be entered into the corresponding textboxes, shown by the green and blue boxes, respectively, in Figure 5.47. The reason for performing the **strategy** must be clearly stated in the "Rationalization for Strategy" textbox, highlighted by a yellow box in Figure 5.47.

Note: use the common terminology to align with maintenance strategy types:

Preventative Maintenance:	***Use-based Maintenance:***
Inspect (PM1a)	*Lubricate (PM2c)*
Monitor/Record (PM1b)	*Clean (PM2c)*
Verify Operation (PM1d)	*Replace (PM2b)*
	Oil Sampling (PM2c)
	Calibrate (PM2c)

An example of the standard way to write a strategy is:

Inspect: Wiring and Connections

When the frequency of the strategy is determined, this information must be entered into the Site Applicability textboxes by using the **Edit Frequency(s)** button, highlighted by a red box in Figure 5.47. When the **Edit Frequency(s)** button is selected, the Site Applicability Form will be displayed, shown in Figure 5.48. This form is used to populate the Site Applicability textboxes on the Edit Form. Using this form, the user can select the frequency(s) at which the strategy should be performed for each site. For example, for Hydro Generation, if Upper Salmon (USL) is cleaning their Generator Stator on a 6 year basis, the user would select 'USL from the "Site" drop-down menu, click the "YES" option button, find "Y" in the drop down menu and type "6" into the frequency textbox, in the Add/Remove Frequency section, and click the **Add** button. Once finished with updating the site applicability, the user must click the **Close** button to close the Site Applicability Form.

Any specifics or exceptions concerning the **strategy** must be noted in the "Details" textbox, highlighted by a orange box in Figure 5.47. The "Details" textbox can be edited throughout all stages of the Change Management Process.

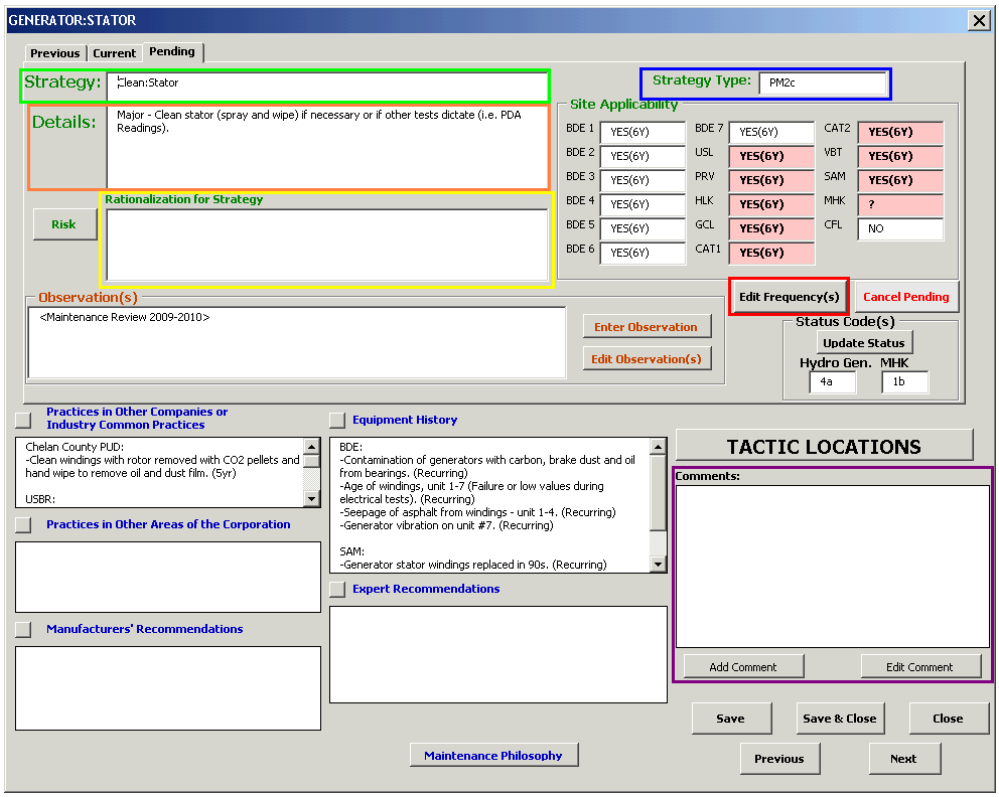

Figure 5.47 - Details, Rationalization for Strategy, Strategy Type, Comments and Site Applicability Textboxes

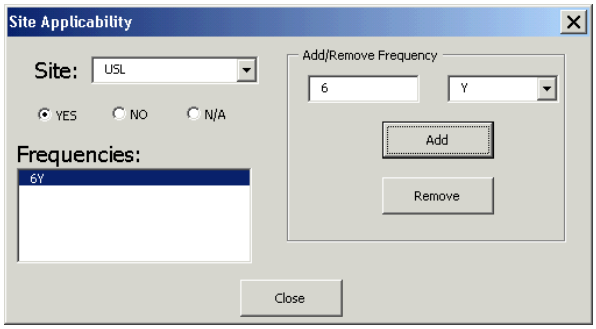

Figure 5.48 - Site Applicability Form

Note: For MSWBs with a large number of sites, the "Site Applicability" button will have to be pressed to display the Site Frequency Form in order to edit the frequencies.

In some cases, there may not be enough information to reach a consensus on the best **maintenance strategy** for a system or component. In these cases, further study will need to be undertaken after the Technical Council. If an item needs to be addressed after the Technical Council, the user may write the details in the Comments textbox, highlighted by the purple box in Figure 5.47. For example, information pertaining to budgeting information or cost analysis may be entered into this textbox. Once sufficient information has been gathered, the **strategy** must be reviewed again by the Technical Council.

If a consensus cannot be reached by the Technical Council, the Maintenance Decision Tree can be utilized (Appendix D). This tool has been adapted from the Reliability Centred Maintenance (RCM) process and is used to determine the maintenance strategy type (condition monitoring, time-based maintenance, run to **failure**, etc.) through examining the **failure** modes and consequences.

To justify that the recommended **strategy** is sufficient, a Risk Analysis will be conducted during the Technical Council. When the **Risk** button is selected, highlighted by the blue box in Figure 5.49, the Risk Matrix Form will be displayed, shown in Figure 5.50.

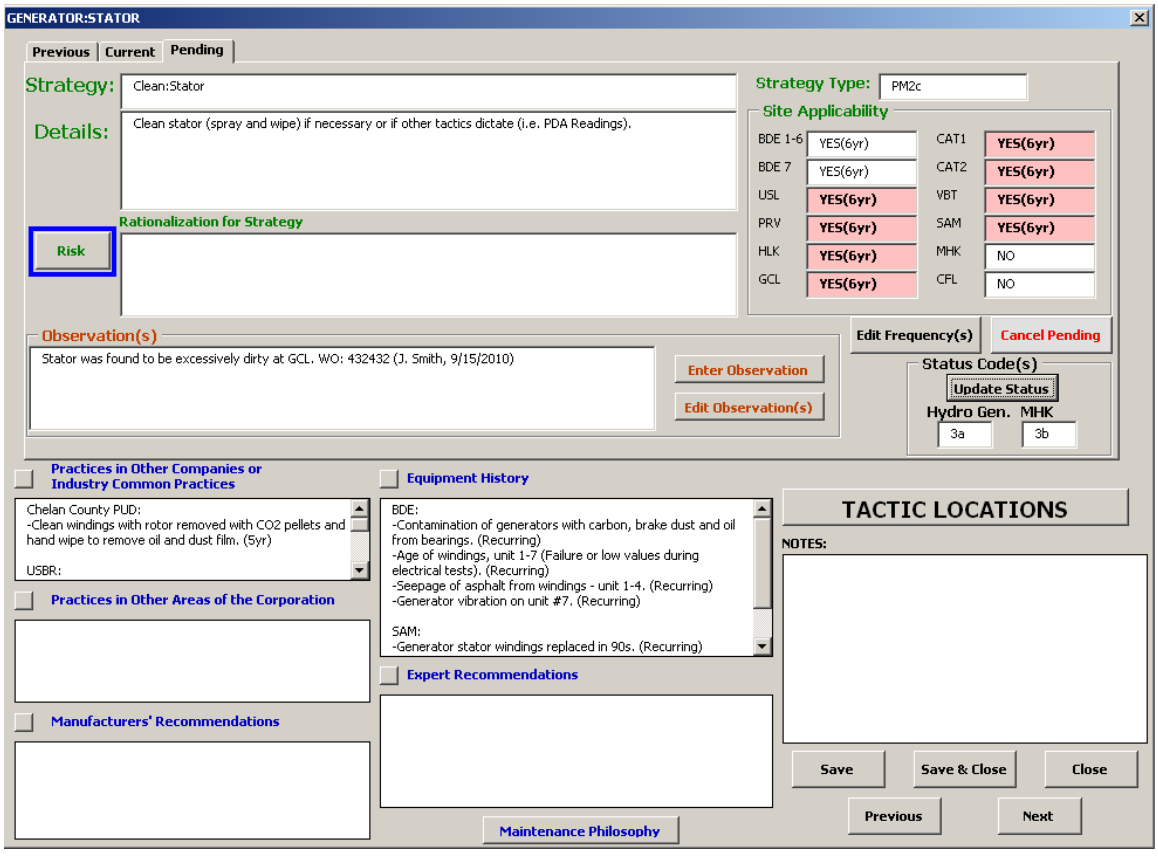

Figure 5.49 - Risk Button

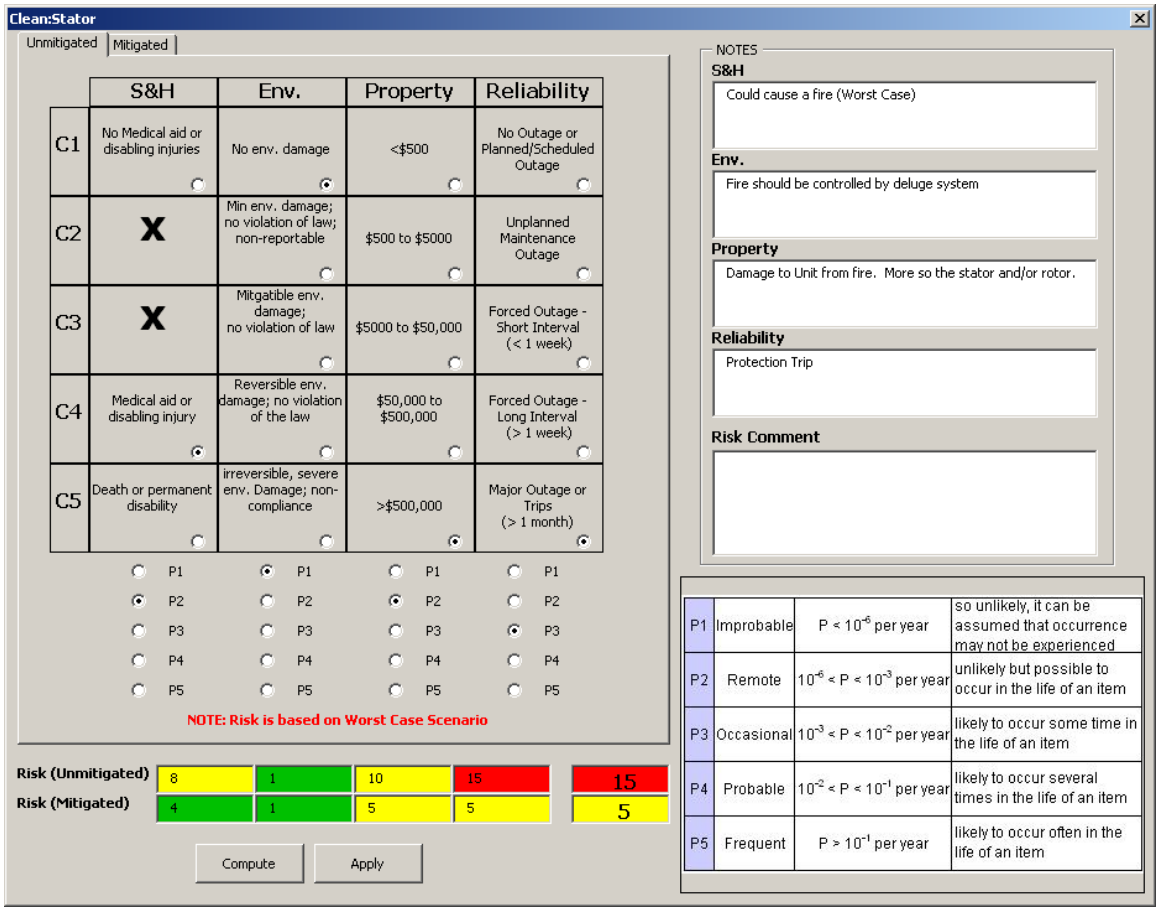

Figure 5.50 - Risk Form

For each recommended **maintenance strategy**, the Technical Council should determine both the unmitigated risk and the mitigated risk. The unmitigated risk is a determination of the consequence and probability of **failure** without performing that **maintenance strategy**. The mitigated risk is the consequence and probability of **failure** performing the pending **maintenance strategy**. Through this exercise, it is expected that all components that have low unmitigated risk to have Corrective Maintenance (run to **failure**) **strategies**. Components with Medium or High unmitigated risk should have Preventive Maintenance **strategies** and the mitigated risk with these **strategies** in place should be reduced to acceptable levels.

The Notes section is available to capture all information regarding why a certain consequence and probability was chosen for the particular **strategy**. Details that pertain to unmitigated and mitigated risk should be preceded with **"U:"** and **"M:"**, respectively. (i.e. U: Cause severe damage. M: Extend life of equipment)

Once the Technical Council and Risk Analysis is completed, the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 8 –**Strategy** Reviewed (Technical Consultation and Risk Analysis Completed)', for their region.

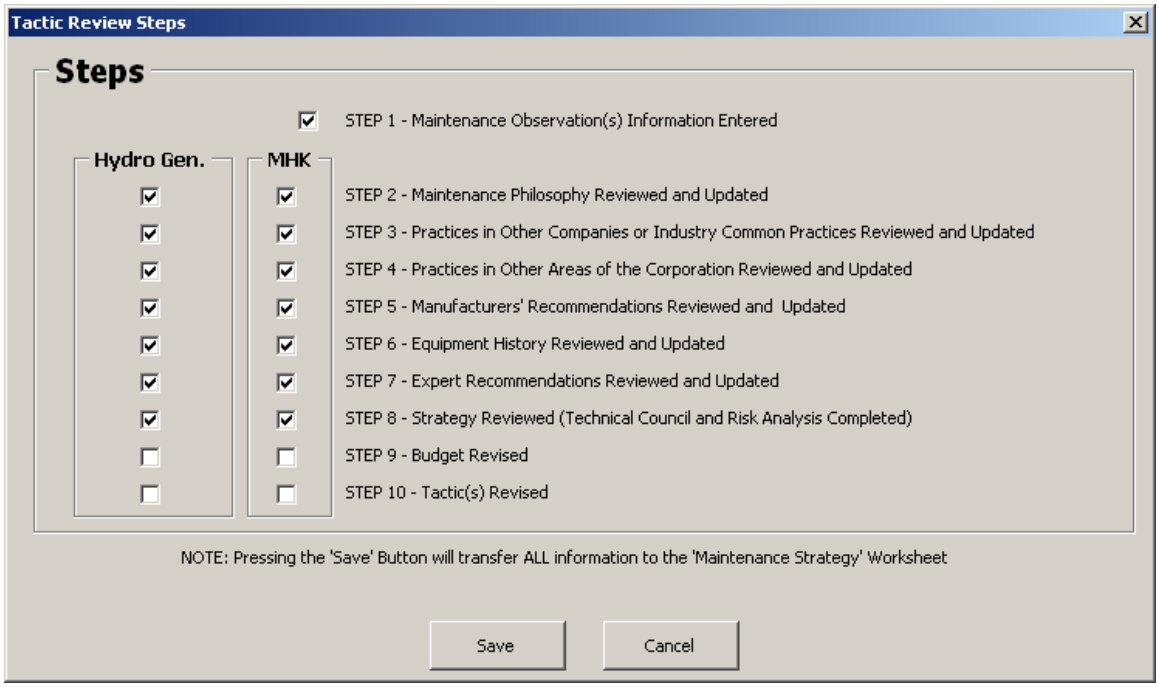

Figure 5.51 - Step 8 Selected

Once Step 8 has been completed, the status code will read 4x, indicating the **strategy** is waiting for the budget to be revised. To obtain all maintenance strategies at status code 4x, the Status Information function can be used as described in Section 5.2.3.

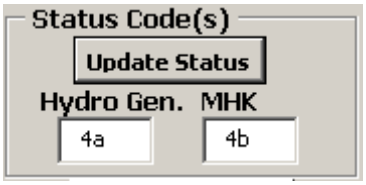

Figure 5.52 - Status Code 4x: Waiting to revise budget

If it is decided through Technical Council or Risk Analysis that the **maintenance strategy** is not to be changed, for whatever reason, the **Cancel Pending** button may be used. This button will remove all information in the **Pending Tab**. It should be noted that if this button is used, the observation should be placed into one of the **Maintenance Strategy Drivers** textbox before canceling (i.e. Equipment History, Expert Recommendations,

Practices in Other Companies, etc). **Cancel Pending** button and **Maintenance Strategy Drivers** are shown in Figure 5.53.

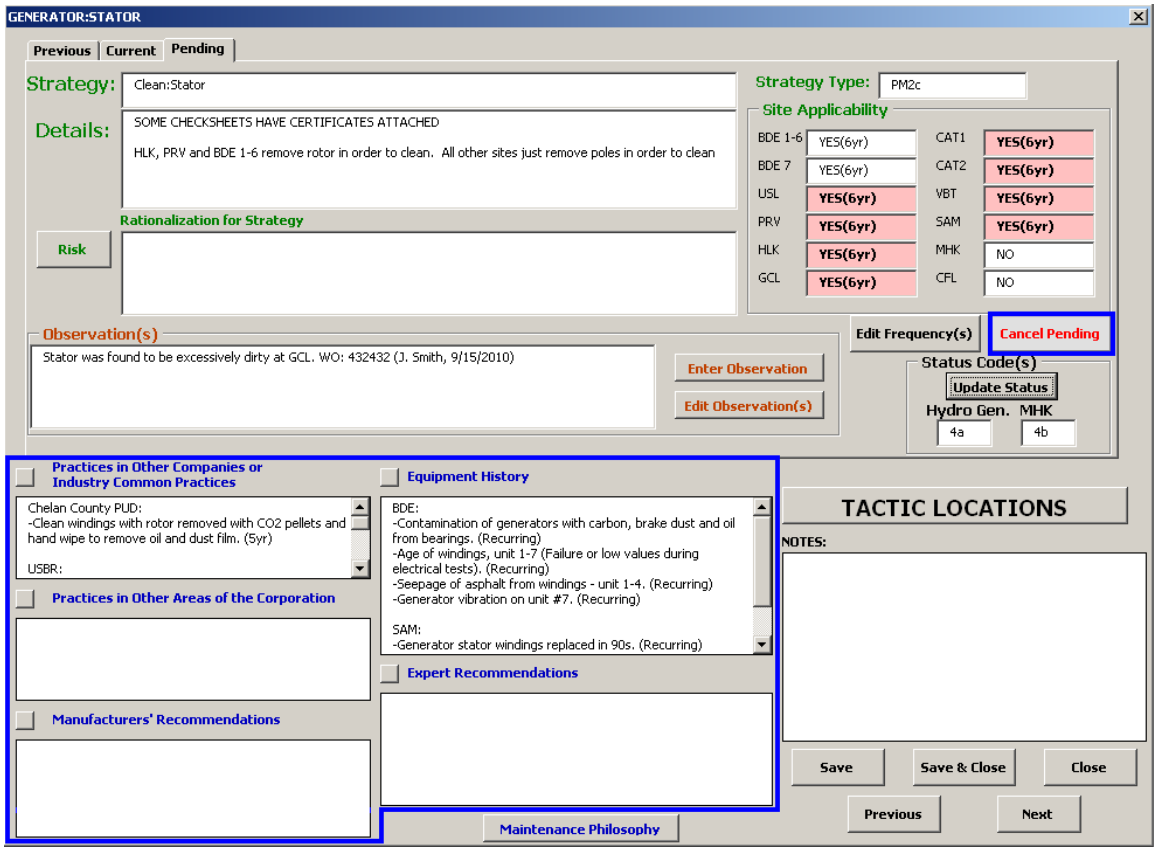

Figure 5.53 - Cancel Pending Button and Maintenance Strategy Drivers

5.3.9 Revise Budget (Step 9)

After Technical Council and Risk Analysis have been performed and the **maintenance strategy** has changed, the budget will need to be reviewed and updated to accommodate resources for the new **strategy**.

The LTAP is required to revise the budget to include this new scope of work, procure tools or spares, or initiate any projects that need to take place to perform the **strategy**.

Once the budget has been revised to allow the new **strategy** to be performed, the LTAP will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 9 – Budget Revised' for their region.

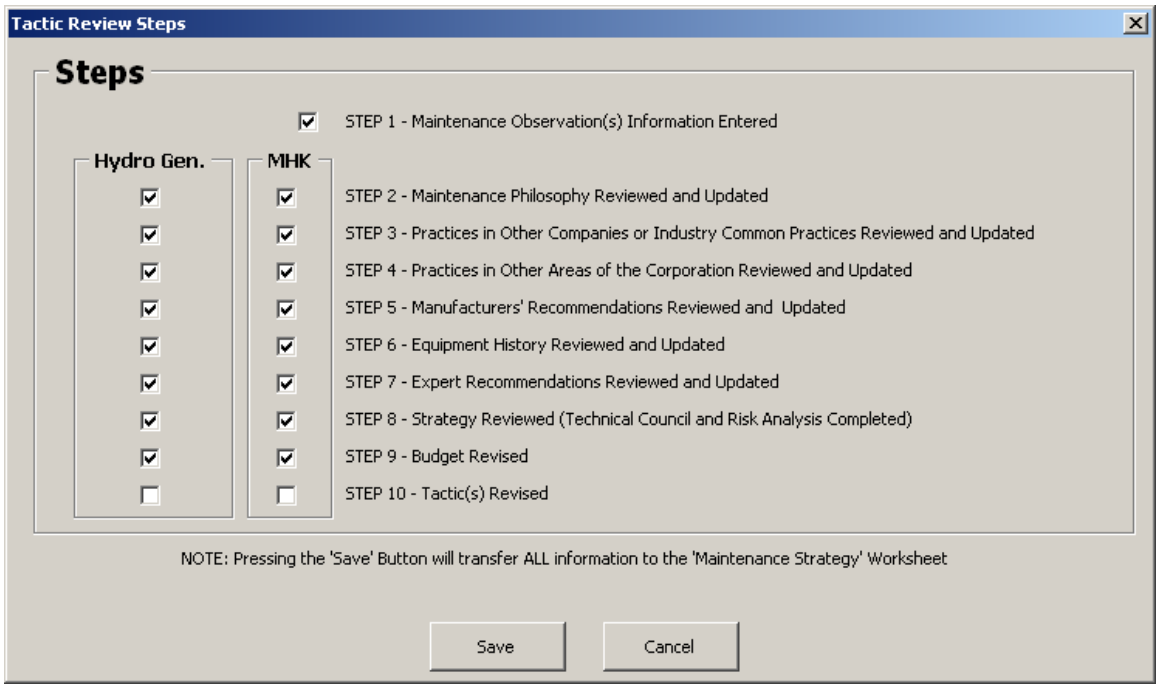

Figure 5.54 - Step 9 Selected

Once Step 9 has been completed, the status code will read 5x. At this point, the **tactics** associated with the **maintenance strategy** are ready to be changed. To obtain all maintenance strategies at status code 5x, the Status Information function can be used as described in Section 5.2.3.

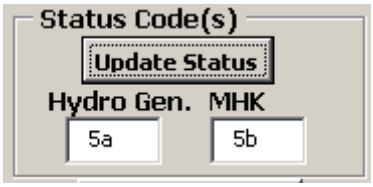

Figure 5.55 - Status 5x: Ready to Change Tactic

If the budget cannot be revised to allow for a change to a **maintenance strategy**, then the **strategy** will need to go back to status code 3x. To accomplish this, click the **Update Status** button and deselect Step 8, indicating that the **strategy** is waiting for another Technical Council review and status code will automatically revert to status code 3x.

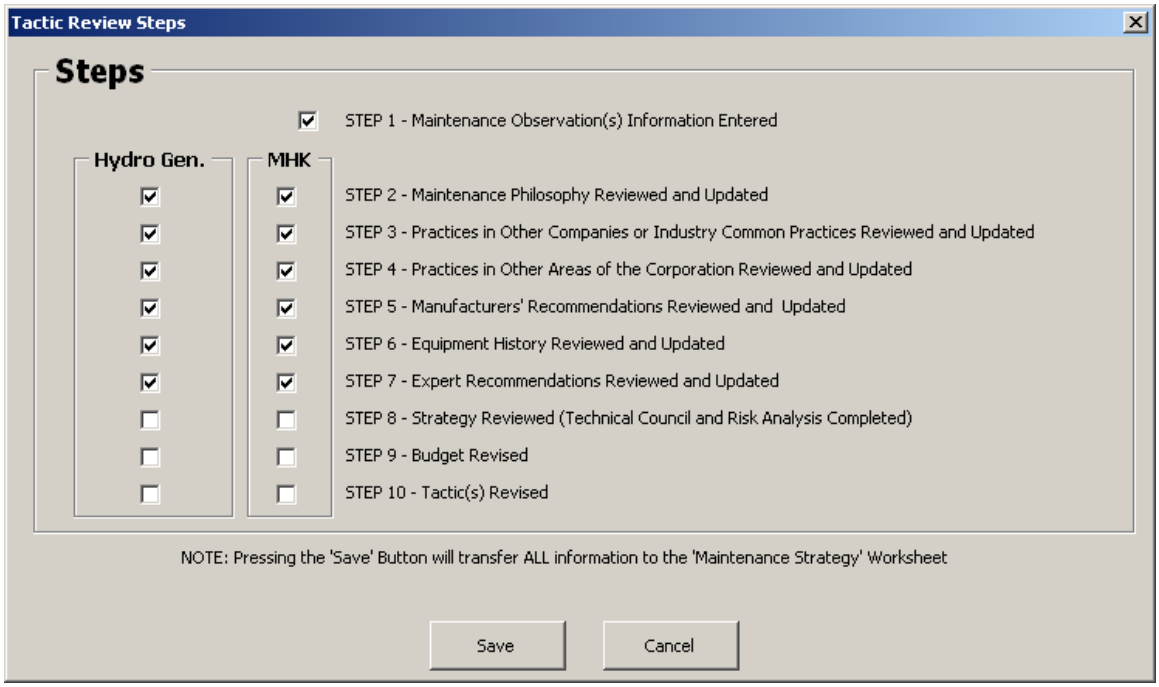

Figure 5.56 - Step 8 Deselected to Show Strategy Ready for another Technical Council

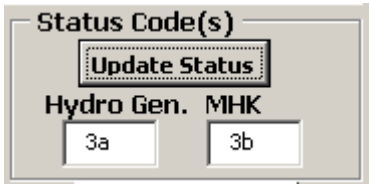

Figure 5.57 - Status 3x: Waiting for Review/Risk Analysis

5.3.10 Revise Tactic(s) (Step 10)

When the budget has been revised and the maintenance strategy has become status code 5x, the new **strategy** is now ready to be put into place. To obtain all maintenance strategies at status code 5x, the Status Information function can be used as described in Section 5.2.3. Short Term Work Planning & Scheduling (STWP&S) group are responsible for editing all **tactics** in check sheets, MWOs and JD Edwards that represent the new **strategy**.

When updating the sources of tactics; ie Check Sheets, MWOs, JD Edwards, etc, the MSWB must also be updated to represent this information. To do this, the **Tactic Locati**ons button (Section 5.2.2.1.5) must be selected, shown in Figure 5.58. When editing the Tactic Locations form, shown in Figure 5.59, and the sources of tactics, it is important to review the information in the "Details" textbox, highlighted by a blue box in Figure 5.58, as there may be some exceptions or vital information that will need to be captured on the check sheets or MWOs.

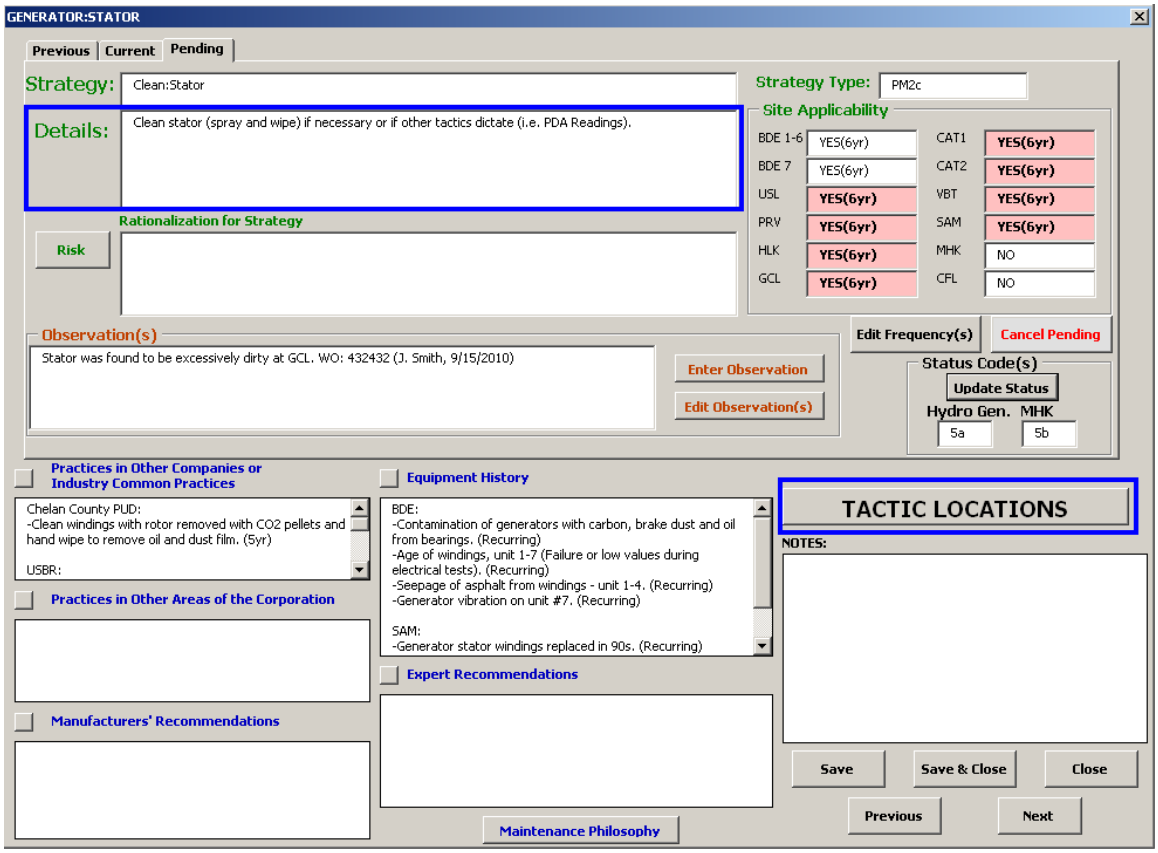

Figure 5.58 - Tactic Locations Button

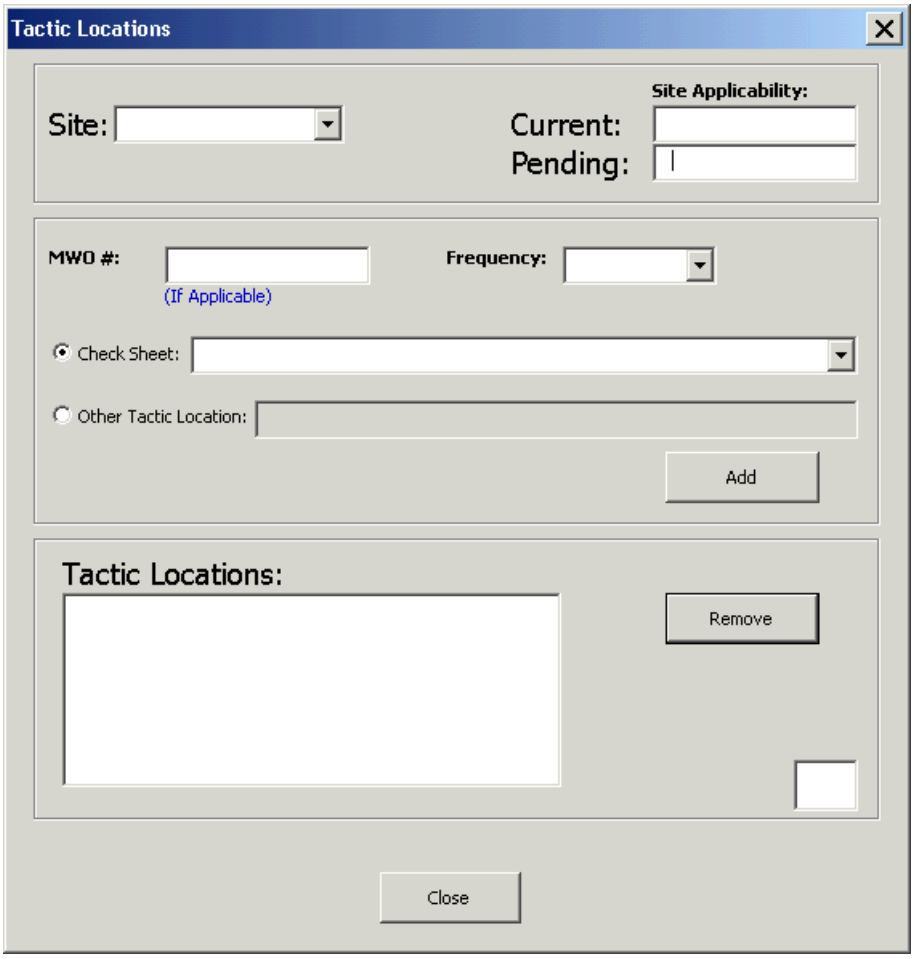

Figure 5.59 - Tactic Locations Form

Once the check sheets, MWOs, JD Edwards and Tactic Locations Form have been updated to represent the new **strategy**, STWP&S will update the status of this **strategy**. This is performed by selecting the **Update Status** button on the **Pending Tab** and selecting 'Step 10 – Tactic Revised' for their region.

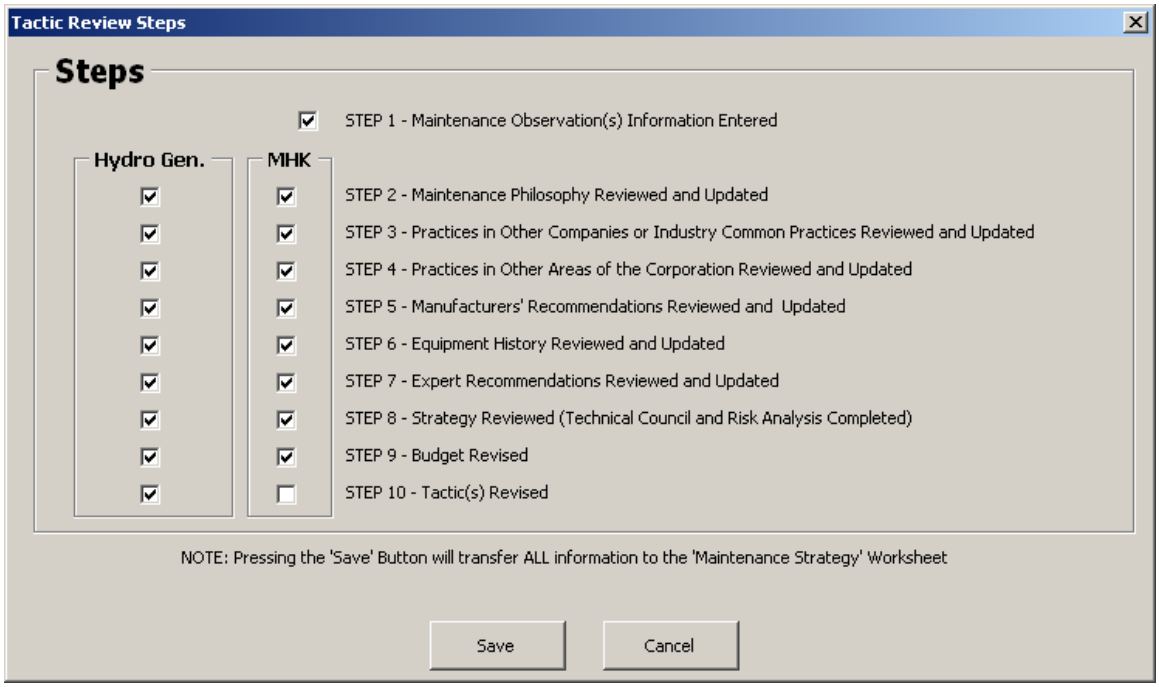

Figure 5.60 - Step 10 Selected

When Step 10 has been completed for only some but not all regions in a MSWB with multiple regions, the status code will read 6x for those regions. To obtain all maintenance strategies at status code 6x, the Status Information function can be used as described in Section 5.2.3. This means the **strategy** has changed for that region(s), but the other regions are not updated yet.

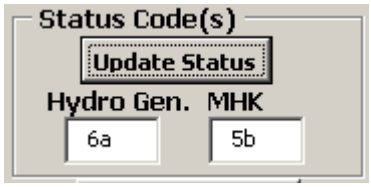

Figure 5.61 - Status Codes 5x and 6x

When Step 10 has been completed for a region, a message will be displayed prompting for a password. This is required to change that region's pending **strategy** to current. By entering the password, the user is confirming that all information has been collected and that previous steps have been completed; once entered, the strategy name, details, type and rationalization along with that regions site applicability are transferred over to the **Current Tab**. Any information that was in the **Current Tab** will be transferred over to the **Previous Tab**, overwriting any existing information in the **Previous Tab**. When all regions have completed Step 10, all status codes will become 0x and the **Pending Tab** will be cleared.

6.0 INTEGRATION OF MAJOR ASSET(S)

The maintenance program will have to be reviewed and updated if it is decided to incorporate an already existing Nalcor Energy asset(s) into the program and if Nalcor Energy obtains a new/acquired asset(s). If the maintenance program requires an update due to a major asset(s), several steps need to be followed to ensure that asset(s) is incorporated into the maintenance program correctly. First, it needs to be determined if this asset(s) belongs to an already developed Maintenance Strategy Workbook (MSWB). For example, if Nalcor Energy acquires a hydro generation plant, this asset will belong in the Hydraulic Units MSWB. If the asset(s) does not belong to an already developed MSWB, then a MSWB will have to be created for that particular group of asset(s). For example, if Nalcor Energy acquires Wind Turbines and integrates them into the Asset Maintenance Strategy (AMS) Management Program, a MSWB will have to be developed for that group of major assets.

Once it is decided which MSWB the asset(s) belongs to, the Information Systems (IS) Department will need to be contacted to develop/update the MSWB to include the major asset(s). Once created/updated, the following steps must be performed to develop a maintenance program for those asset(s):

- Preparation and Kick-off
- Create Maintenance Philosophy
- Consolidate Existing Tactics
- Collect and Enter Practices in Other Companies
- Collect and Enter Practices in Other Areas of the Corporation
- Collect and Enter Manufacturers' Recommendations
- Collect and Enter Equipment History
- Collect and Enter Expert Recommendations
- Perform Technical Council and Risk Analysis
- Revise Budget
- Implement Tactic(s)

6.1 Preparation and Kick-off

The first step in the development of **maintenance strategies** for a given major asset(s) is to prepare a plan.

6.1.1 Scope

The scope of an Integration of Major Asset(s) Project can be defined by listing the systems and components that comprise the new major asset(s) and identifying which of these will be reviewed. All systems and components that are critical to safety, health, environment or overall reliability of the asset(s) must be included in the scope.

To add further clarification to the scope, describe the physical boundaries of the major asset(s) or specific systems. For example, Hardwoods Gas Turbine can be described as: "all gas turbine generating and auxiliary equipment up to, but not including, the low voltage bushings of the power transformer".

For an asset(s) that is already owned by Nalcor Energy, but has not yet been included in the maintenance program, these systems must be listed in a manner consistent with the asset naming and hierarchy in JD Edwards, since this will facilitate the identification of existing preventive **maintenance tactics** (Section 6.3).

A complete asset hierarchy can be created in Excel by using the following procedure.

6.1.1.1 Asset Hierarchy Procedure

To create a completed asset hierarchy for a major asset(s) in an excel format:
Note: Asset Report.rpt is a Showcase Strategy file, the Showcase Strategy Program must be run prior to the following steps.

1. Using the Citrix Windows Explorer, run "Asset Report.rpt" located on the network drive folder: "H:\Engineering\Asset Maintenance Strategy Management Program\Program Manual & Tools\".
2. Enter JD Edward's username and password when prompted and run the program by clicking on the run icon:  .
3. In the popup window, enter the asset number for the major component. Once the hierarchy has been populated, save the file as an excel file using "Save As" and selecting "Excel Files (*.xls)" from the "Save as type:" drop down.
4. Open the newly created Excel file in Excel. This file may require some formatting.
5. To merge the text of two cells use merge function '&' in the formula line as per the following example:

   Cell i2 contains "BALANCE OF GENERATOR - STAGE 2 – B" and cell j2 contains "AY D'ESPOIR". In cell k2 enter the formula "=i2&j2", the output will be "BALANCE OF GENERATOR - STAGE 2 – BAY D'ESPOIR".

6. If desired, the output text of the merge formula can be pasted into another cell using the “Paste Special” command and selecting “Values” in the popup window. Paste Special appears in the Edit drop down menu. Continuation of previous example:

Cell k2 is copied and paste special – values is used to paste the output “BALANCE OF GENERATOR - STAGE 2 – BAY D'ESPOIR” into cell i2. The cells j2 and k2 can now be deleted.

6.1.2 Resources

Once the scope has been established, the resources required to develop the **maintenance strategies** should be identified and estimated. The Office of Asset Management (OAM) is required to determine those responsible for setting up the maintenance program for the major asset(s), hereafter called the AMS Development Project Team.

A number of resources will be called upon during the analysis of the major asset(s). For example, an asset specialist or plant operator could be called upon to assist with the collection of Original Equipment Manufacturer (OEM) recommendations (Section 4.4), and an audience of experienced operations and engineering staff will be expected to attend the Technical Council discussions (Section 5.3.8).

6.1.3 Engagement of Team and Stakeholders

To engage the AMS Development Project Team and stakeholders, the established scope and resource requirements, along with a schedule, should be detailed and approved by means of a Project Design Transmittal. A sample Design Transmittal is provided in Appendix C.

Shortly after approval of the Design Transmittal, the project manager should hold an on-site kick-off meeting to engage the team and operations staff. This meeting will provide an opportunity to confirm understanding of the scope, resource requirements, schedule and methodology and to establish some early momentum.

Following the kick-off meeting, and while on site, the project team should gain an understanding of the purpose and function of each system and should commence the collection of information.

6.2 Create Maintenance Philosophy

For a major asset(s) new to the maintenance program, a **maintenance philosophy** will have to be created/updated. If the asset(s) belongs to an existing MSWB, the **philosophy** for that maintenance plan will need to be reviewed and updated. If the asset(s) belongs to a new MSWB then a new **maintenance philosophy** will need to be created. An overview of **maintenance philosophy** is given in Section 4.1.

6.3 Consolidate Existing Tactics

Maintenance strategies for existing assets need not be re-built from the ground up, since there are existing maintenance programs in place. It is assumed that existing maintenance programs are generally of good quality for existing assets.

Not every component of every system will be reviewed using this methodology. It is implied that components not specifically identified are presently run to **failure**.

This step involves the assembly of all existing **maintenance tactics** into one list. Unfortunately, the existing **tactics** are not conveniently compiled in a single location nor are they in a single format. Following is a list of the types of **maintenance tactics** that must be compiled and the likely location:

- Preventive Maintenance (PM) Schedule and associated Model Work Orders (MWO) – JD Edwards;
- PM check sheets – Lotus Notes or local planning office;
- Condition monitoring – drawings, manuals, operator consoles;
- Operators daily / weekly check sheets – operations;
- Standard Operating Procedures – Lotus Notes;
- Environmental Standard Operating Procedures – Lotus Notes;
- Safety and Health Program – Lotus Notes;
    - general safety inspections (Segment 2);
    - maintenance of special safety systems (Segment 2);
    - fall protection program equipment maintenance (Segment 3);
    - work methods (Segment 3); and
- Service contracts and maintenance agreements – Asset Manager.

All **maintenance tactics** from the various sources are to be consolidated in a MSWB.

If Nalcor Energy already owns the asset(s) but it is new to the maintenance program, the bulk of the existing preventive maintenance activities are triggered through “PMs” in

JD Edwards, which automatically generate work orders at set intervals. These work orders are generated from MWOs. Typically, when the **maintenance tactic** can not fully be defined within the Model Work Order description field, there is a reference to a PM check sheet. Procedures (6.3-A and 6.3-B) or 6.3-C will assist with the identification of all relevant Model Work Orders and associated check sheets.

Procedure 6.3-A

To identify all model work orders (MWOs) for a given major asset:

1. From the JD Edwards main screen, select the Work Order Back Log (WOBL) screen.
2. Enter "M" in the Status From and Thru fields. This identifies model work orders which are templates for the automatic creation of preventive work orders.
3. Enter the asset number and hit Enter to display a list of MWOs. (See example below for Hardwoods Gas Turbine.)
4. Double click on any work order to get more details.
5. Repeat Steps 3. and 4. for every subsidiary asset number on the hierarchy.

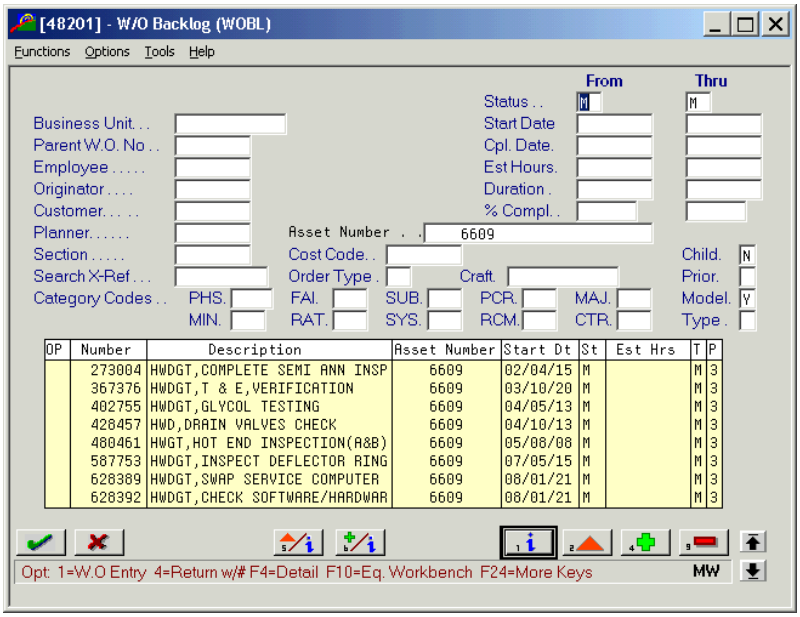

Figure 6.1 - Work Order Backlog Screen Shot

Note: This search may result in some model work orders that are no longer in use. To determine which MWOs are in use, search for PMs as per Procedure 6.3-B:

Procedure 6.3-B

To identify all PMs (MWOs in effect and the intervals at which they generate work orders) for a given major asset:

1. From the JD Edwards main screen, select 19 Planners Menu.
2. Select 23 Advanced Planning Menu 2.
3. Select 17 Item PM Schedule.
4. Enter the Asset Number and press the Enter key.
5. Press the F4 key for full detail. Page Down as necessary. (See example below for Hardwoods Gas Turbine.)
6. Repeat Steps 4. and 5. for every subsidiary asset number on the hierarchy.

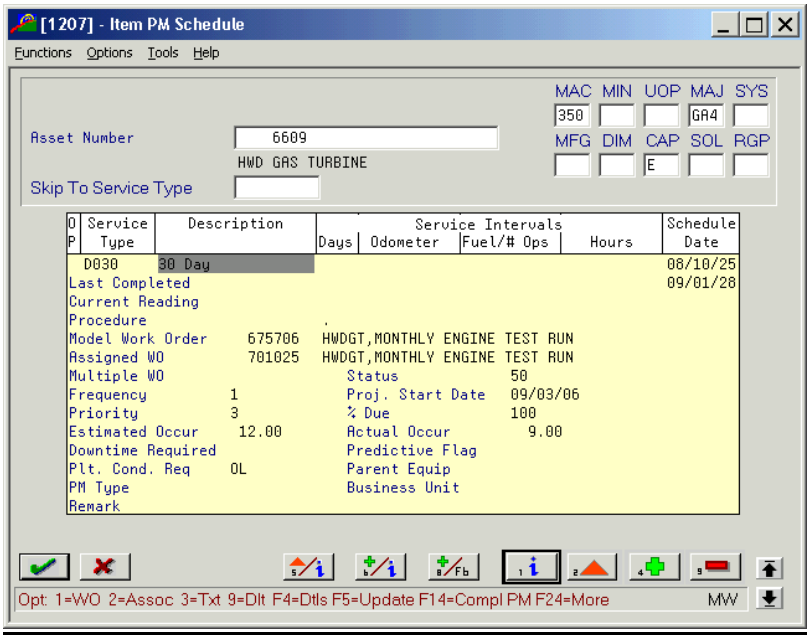

Figure 6.2 - Item PM Schedule Screen Shot

Procedure 6.3-C

To create a completed list of MWO's for a major asset(s) in an excel format:

1. Using the Citrix Windows Explorer, run "Get Work Order 2.xls" located on the network drive folder: "H:\Engineering\Asset Maintenance Strategy Management Program\Program Manual & Tools\".
2. From the ShowCase pulldown menu, click "Refresh All Queries".
3. Enter JD Edward's username and password when prompted and select "NLHPRD73" in the "Change Library List Environment".
4. In the "Prompt" popup window, enter the asset numbers for the major components and their children gathered from the Asset Hierarchy generated using the procedure in Section 6.1.1.1. The query will only retrieve the MWO's for the child of the asset number entered. Multiple asset numbers can be entered at one time for a complete list of MWO's for a major asset.

When all **maintenance tactics** have been gathered for an asset that will be incorporated into an existing MSWB, all **strategies** within the MSWB will have to be examined to check applicability with respect to the new asset. Any **tactics** that were found in the consolidation step that are not already covered in the MSWB, must be added requiring use of the Add function covered in Section 5.2.2.2.

If an asset is incorporated into a new MSWB or an existing MSWB, the Location of Current Tactic textbox and the Site Applicability textbox for the new asset will need to be updated at this point. JD Edwards will also need to be updated to represent this information as well.

6.4 Remaining Process to Integrate Major Asset(s)

The remaining steps to integrate a major asset(s) are:

- Collect and Enter Practices in Other Companies
- Collect and Enter Practices in Other Areas of the Corporation
- Collect and Enter Manufacturers' Recommendations
- Collect and Enter Equipment History
- Collect and Enter Expert Recommendations
- Perform Technical Council and Risk Analysis
- Revise Budget
- Implement Tactic(s)

The procedure to incorporate these steps into a MSWB can be found in Sections 5.3.3 to 5.3.10 inclusive.

7.0 RESPONSIBILTY AND ACCOUNTABILTY

NOTICE! This Section has not yet been fully developed.

For any management program to be successful there must be clarity with respect to the owner and steward of the program. This includes clearly defined roles and responsibilities to ensure accountability.

The Change Management Process, as outlined in Section 5.1, has several involved parties, each with various responsibilities critical to its success. Described below are the responsibilities of each role as well as a Responsibility/ Accountability/ Consulted/ Informed (RACI) chart to highlight the interactions between each of the involved parties.

Long Term Asset Planning (LTAP):

- Enter maintenance observation(s) based upon maintenance strategy feedback
- Gather information for review of maintenance observation(s)
- Review/implement **maintenance strategy** changes
- Update budget
- Review work performed (JD Edwards Code 71 MWO's)

Short Term Work Planning & Scheduling (STWP&S):

- Change **tactics** as per changed **maintenance strategies**
- Update the Maintenance Strategy Workbook once **tactics** have been changed

Work Execution (WE):

- Execute work
- Provide maintenance strategy feedback

Office of Asset Management (OAM):

- Oversee/update Change Management Process
- Quarterly Technical Council to collect and review triggers for change
- Provide recommendations for participants of the Technical Council when maintenance observation(s) are to be reviewed, if scope of effected equipment extends to multiple regions/divisions

Information Systems (IS):

- Create, update and support Maintenance Strategy Workbooks

Technical Council:

- Analyze **maintenance strategy** information and make recommendations on the best **maintenance strategies** going forward
- Perform Risk Analysis

Role / Task	LTAP	STWP&S	WE	OAM	Technical Council
Quarterly Technical Council to Collect and Review Triggers	R			A	C
Enter Maintenance Observation	A			(I)	
Review/Implement **Maintenance Strategy** Changes	A			C	C
Change **Tactics**, per Changed **Maintenance Strategies**	I	A	(I)		
Schedule, Execute Work		I	A		
Generate Maintenance Observation	I		A		

Table 7.1 - RACI Chart

Responsible: Are responsible to perform the work required for completion of the task.
Accountable: Accountable for completion of the task. If there is no role assigned to be Responsible for a task, the Accountable party performs the work required for the task.
Consulted: Input is gathered from the party for use in completion of the task; communication is two-way.
Informed: Is informed of progress and completion of the task; communication is one-way. (I) indicates that party may only be informed when scope requires, such as larger scale tasks or maintenance observation(s).

At each status code, outlined in Section 5.1, each party has responsibilities to perform for the Change Management Process. This is shown in Table 7.2:

Status Code	Action Required
0x	Any maintenance observations or triggers for change to be entered into the MSWB by the LTAP.
1x	Start to collect and enter **Maintenance Strategy Drivers** into MSWB by the LTAP.
2x	Finish entering the **Maintenance Strategy Drivers** by the LTAP.
3x	Review the maintenance observation by the LTAP and the Technical Council.
4x	Revise the budget to reflect the updated **maintenance strategy** by the LTAP.
5x	Update the **maintenance tactics** in JD Edwards and/or check sheets by the STWP&S.
6x	No tasks are required to be done by the region with a **maintenance strategy** at status code 6x. The region which has not progressed to status code 6x must complete any required work to allow the **maintenance strategy** to revert back to status code 0x.

Table 7.2 - Status Code Responsibilities

*To be developed…….*roles and responsibilities for each element of the program. Establish authority for approval of **philosophy** and **strategies**. Identify responsibility for management of the overall program (this manual) as well as application of the program for specific assets.

8.0 VERIFICATION AND MEASUREMENT

NOTICE! This Section has not yet been developed.

Verification determines that the processes and procedures are functioning and are being effectively implemented. Measurement confirms the quality of processes and determines the extent to which the objectives are being met.

The Status Information function (Section 5.2.3) of the Maintenance Strategy Workbook can be utilized to track the ongoing Change Management Process. If a large number of **strategies** exist for a status code, it could be an indication of an issue within the Change Management process. Periodic examination of the Status Information function would allow the Office of Asset Management to target bottlenecks and ensure effectiveness. This should take place during the Quarterly Technical Council, along with the review of associated triggers for changes to **maintenance strategies**. Status codes are outlined in Section 5.1.

*To be developed…….*a **strategy** for verification, measurement and reporting to ensure that **maintenance strategies** are developed and implemented. Metrics need to indicate the degree of success in meeting the objectives, including the quality of both the process and the deliverables.

9.0 CONTINUAL PROGRAM IMPROVEMENT

NOTICE! This Section has not yet been developed.

Every successful management program includes mechanisms to ensure continual improvement. This could include surveys or other means to collect feedback from users of the program, post implementation reviews by the Office of Asset Management, periodic internal or external audits of the program and its processes, and/or comparison to industry best practices.

*To be developed……*mechanisms for ongoing identification and implementation of improvements to enhance the suitability, capability and effectiveness of the AMS Management Program.

Appendix A Change Management Flow Chart

Appendix B Risk Analysis Matrix

Asset Maintenance Strategy
Risk Matrix

Probability							
	Frequent	P5	MEDIUM 5	MEDIUM 10	HIGH 15	HIGH 20	HIGH 25
	Probable	P4	LOW 4	MEDIUM 8	HIGH 12	HIGH 16	HIGH 20
	Occasional	P3	LOW 3	MEDIUM 6	MEDIUM 9	HIGH 12	HIGH 15
	Remote	P2	LOW 2	LOW 4	MEDIUM 6	MEDIUM 8	MEDIUM 10
	Improbable	P1	LOW 1	LOW 2	LOW 3	LOW 4	MEDIUM 5
			C1	C2	C3	C4	C5
			Negligible	Marginal	Moderate	Critical	Catastrophic
			Consequence				

USE OF THIS MATRIX:

For a given failure scenario of a system or component, determination of the unmitigated failure probability and consequence will allow the asset maintenance strategist to determine if the risk level is low, medium or high. The strategist can then evaluate how various mitigation techniques can reduce the medium and high risks to low risk.

Because risk ranking via a matrix is a semi-quantitative method, the strategist should be conservative and in some cases assume higher than actual frequencies of failure scenarios. In those cases, it may be beneficial to conduct a full quantitative risk analysis prior to investing considerable resources to mitigate that risk.

In determining consequence, select a consequence range for each defined category and use the highest range. For example, if one selects C4 for safety , C2 for environment, C3 for the others, then C4 is the overall consequence rating.

DEFINITIONS

Risk Rank		
	LOW	**Low Risk (tolerable; 1 to 4)**
	MEDIUM	**Medium Risk (undesirable; 5 to 10)**
	HIGH	**High Risk (intolerable; 11 to 25)**

Probability

P1	Improbable	$P < 10^{-6}$ per year	so unlikely, it can be assumed that occurrence may not be experienced
P2	Remote	$10^{-6} < P < 10^{-3}$ per year	unlikely but possible to occur in the life of an item
P3	Occasional	$10^{-3} < P < 10^{-2}$ per year	likely to occur some time in the life of an item
P4	Probable	$10^{-2} < P < 10^{-1}$ per year	likely to occur several times in the life of an item
P5	Frequent	$P > 10^{-1}$ per year	likely to occur often in the life of an item

Consequence

		POTENTIAL LOSS			
		S&H	**Env.**	**Property**	**Reliability**
C1	**Negligible**	no medical aid or disabling injuries	no env. damage	<$500	no outage or planned/ scheduled outage
C2	**Marginal**	**X**	minimal env. damage; no violation of law; non-reportable	$500 to $5000	unplanned maintenace outage
C3	**Moderate**	**X**	mitigatible env. damage; no violation of law	$5000 to $50,000	forced outage - short interval (<1 week)
C4	**Critical**	medical aid or disabling injury	reversible env. damage; no violation of law	$50,000 to $500,000	forced outage - long interval (>1 week)
C5	**Catastrophic**	death or permanent disability	irreversible, severe env. Damage; non-compliance	>$500,000	major outage or trip (>1 month)

Appendix C Sample Project Design Transmittal

Project Design Transmittal

[*Name of Asset – ex. Gas Turbines*] - Maintenance Strategy Development

[*Date*]

[*Name*] **Asset Manager**		**[*Name*]** **Project Manager**	

[*This is a template / sample design transmittal for all Asset Maintenance Strategy development projects. Remove all text in square brackets.*]

General Project Description & Deliverable

- This project is the development of maintenance philosophies for each [gas turbine] and maintenance strategies for all types of critical systems and components that make up the [gas turbines].

- These philosophies and strategies will be applicable to the following [gas turbines:
  - Hardwoods;
  - Stephenville;
  - Happy Valley; and
  - Holyrood.]

- The Maintenance philosophy and maintenance strategies will be developed by applying Nalcor Energy's process described in the *Asset Maintenance Strategy (AMS) Management Program*.

- The AMS process includes a consolidation of existing maintenance strategies and tactics (preventative maintenance work orders, check sheets, etc.) and the following additional information:

  - original equipment manufacturer recommendations;
  - expert recommendations;
  - equipment history, including reliability data;
  - practices for similar assets in other parts of the corporation; and

- practices for similar assets of other companies.

- The consolidated maintenance tactics and additional collected information will be reviewed through technical council meetings, which will include experienced engineering and operations staff. At these meetings, conclusions will be drawn regarding the best strategies going forward, using a risk analysis.

- The major deliverable will be a *Maintenance Strategy Workbook,* [*Gas Turbines*] specifying the maintenance strategies that will best enable the major asset[s] to contribute to the corporate mission of cost-effective, reliable energy, while maintaining high standards for safety, health and environmental responsibility.

Scope & Deliverables

- Maintenance strategies will be developed for all systems and major components which comprise the [gas turbines:

Jet Engine	Fuel	Lube Oil
Cooling	Compressed Air	Switch Gear
Electrical	Fire Protection	A.C. Electrical
D.C. Electrical]		

- In terms of physical boundaries, the scope includes [all gas turbine generating and auxiliary equipment up to, but not including, the low voltage bushings of the power transformer.]

- This project <u>does not include the gap analysis and implementation</u> of the maintenance strategies, i.e. modifications to the work orders and check sheets. Following completion of this project, [TRO Labrador] will be tasked with determining the gaps between the existing program and the established strategies, estimating the cost of the required changes and then implementing the changes. This is expected to take place in [2010-2011].

Resources and Budget

- The AMS Development Project Team will consist of:
  - [name, Electrical Engineering
  - name, Civil Engineering
  - name, Mechanical Engineering
  - other?
  - name, Asset Manager.]

- The following Operations staff will be called upon to assist with collection of information and technical council meetings. The effort required from each person is estimated in number of weeks of actual timesheet charges.

  - [name Manager, Generation & Terminals # weeks
  - name P&C Supervisor # weeks
  - name Electrical/Mechanical Supervisor # weeks
  - name Electrician/Operator # weeks]

- The following Engineering Services staff will be called upon to assist with collection of information, analysis, and technical council meetings. The effort required from each person is estimated in number of weeks of actual timesheet charges.

  (a) [name Project Manager & Mechanical # weeks
  (b) name Project Team - Electrical Engineering # weeks
  (c) name Project Team – P&C Engineering # weeks
  (d) name Engineering Services – Mechanical # weeks
  (e) name Engineering Services – Electrical # weeks
  (f) name Engineering Services – P&C # weeks

- This project has no budget allowance. All labour, travel and sundry expenses associated with this project will be charged to each employee's home business unit.

- For the purpose of tracking effort for this project, the following standing work orders have been created in the respective business units:

  [xxxxxx *Parent Work Order*
  xxxxxx Engineering Services Mechanical (BU 2086)
  xxxxxx Engineering Services Electrical (BU 2085)
  xxxxxx Engineering Services P&C (BU 2088)
  xxxxxx TRO Labrador (BU xxxx)]

Schedule

Activity	Start Date	End Date
Project Initiation (Design Transmittal and Kick-off Meeting)	March 200	March 2009
Philosophy Development	April 2009	April 2009
Collection & Consolidation of Existing Maintenance Program	April 2009	July 2009
Collection & Entry of OEM, Expert & Other Company Information	May 2009	September 2009
Technical Council Review	October 2009	October 2009
Further Study (Technical Council Action Items)	November 2009	December 2009
AMS Manual Preparation	December 2009	January 2010
Gap Analysis and Implementation of Strategies	2010	2010

Confirmations

The project team signatures indicate confirmation of this design transmittal. The Manager signs the transmittal as final quality assurance check.

Electrical Engineering	Date	Civil Engineering	Date
Mechanical Engineering	Date	T&D Engineering	Date
P&C Engineering	Date	Telecontrol Engineering	Date
System Planning	Date	Environmental	Date
System Operations	Date	I S	Date
Operations Labour Manager	Date	AMS Program Lead	Date
		Manager	Date

Appendix D Maintenance Decision Tree

MAINTENANCE DECISION TREE

Is the FAILURE from this CAUSE easily spotted? H

Yes — Evident Functions

No — Hidden Functions

Does the FAILURE or damage from this CAUSE directly harm worker safety or the environment? S

Yes

No

Does the FAILURE or resulting damage from this CAUSE directly harm production? P

Yes

No

Safety/Environmental Consequences

Scheduled maintenance is needed to reduce the risk of failure

Can you easily detect warning of a gradual loss of the FUNCTION? S1

Condition–Based Maintenance — Yes

No

Can you easily repair & restore the performance of the item, & will this reduce FAILURE rates? S2

Time–Based Maintenance — Yes

No

Can you easily replace the item, and will this reduce FAILURE rates? S3

Time–Based Discard — Yes

No

Can you easily apply a combination of tactics, and will these reduce FAILURE rates? S4

Combination of Tactics — Yes

No — *Redesign*

Production Consequences

Scheduled maintenance is usually needed if it costs less than the loss of production

Can you easily detect warning of a gradual loss of the FUNCTION? P1

Condition–Based Maintenance — Yes

No

Can you easily repair & restore the performance of the item, & will this reduce FAILURE rates? P2

Time–Based Maintenance — Yes

No

Can you easily replace the item, and will this reduce FAILURE rates? P3

Time–Based Discard — Yes

No — *Run–to–Failure or Redesign if critical*

Maintenance Consequences

Scheduled maintenance is usually not required unless the cost of repair is high

Can you easily detect warning of a gradual loss of the FUNCTION? M1

Condition–Based Maintenance — Yes

No

Can you easily repair & restore the performance of the item, & will this reduce FAILURE rates? M2

Time–Based Maintenance — Yes

No

Can you easily replace the item, and will this reduce FAILURE rates? M3

Time–Based Discard — Yes

No — *Run–to–Failure*

Hidden–Failure Consequences

Scheduled maintenance is usually needed to reduce the risk of multiple failures

Can you easily detect warning of a gradual loss of the FUNCTION? H1

Condition–Based Maintenance — Yes

No

Can you easily repair & restore the performance of the item, & will this reduce FAILURE rates? H2

Time–Based Maintenance — Yes

No

Can you easily replace the item, and will this reduce FAILURE rates? H3

Time–Based Discard — Yes

No

Can you easily test the item to see if it has failed, and will this reduce the FAILURE risk? H4

Failure–Finding Test — Yes

No — *Redesign if critical*