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**B. F. Sule
M. K. Garba**

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Computer Application for Maintenance Management of Hydropower Plants

K. R. AJAO AND H. A. AJIMOTOKAN

Department of Mechanical Engineering, University of Ilorin, Ilorin, Nigeria

1. INTRODUCTION

In the nature of things, virtually nothing made by man is indestructible, but the useful life can be extended by carrying out routine repairs. A combination of any action carried out to retain an item in or restore it to an acceptable condition is known as maintenance. Maintenance plays a fundamental role in manufacturing practice, and is influenced by a variety of factors such as workforce skills and commitment, the effectiveness of plant and the utilization of technology. It plays an important role in supporting plant and strategies, and therefore contributes to the overall performance of the plant. Experience of running hydropower station reveals that even after detailed project planning and quality control measures taken at various stages from inception to commissioning, several unforeseen problems do take place during operation which would result in forced outages, low generation or load shedding. The necessity for maintenance management arises when a group of people tackle tasks that are too large or complex for any individual or group to cope with. When faced with such situations, the need to define task and allocate roles in order to proffer a solution arises. Maintenance management involves the breaking of tasks or problems down into key elements.

2. OBJECTIVES OF MAINTENANCE MANAGEMENT

Routine maintenance at predetermined time interval is managed to ensure the following objectives:

- i. Quality and reliable operation of equipment on long term basis through organised periodic inspection of components and subsequent rectification/replacement of parts where necessary,
- ii. The optimum availability of installed equipment for production or service with least number of shut downs by ensuring that the rate of deterioration of any component does not exceed the life expectancy of the equipment at any stage,
- iii. Operational readiness of all equipment required for emergency use at all times such as standby units, firefighting, rescue units etc,
- iv. The eradication/non-repetition of operational problems by timely analysis of the cause of faults/problems and replacement of short term solutions by long lasting and permanent ones,
- v. That maximum possible return on investment is obtained, and
- vi. The safety of personnel.

3. TYPES OF MAINTENANCE

Reactive Maintenance

This is sometimes called crisis maintenance or hysterical maintenance. This has been dominant form of maintenance for long time and its costs are relatively high because of unplanned downtime, damaged machinery and overtime expenditure. Run to failure should be a very small part in a modern maintenance programme. Planned maintenance is preferred over this type so as to reduce downtime of machine and avoid uncalled for outages.

Preventive Maintenance

Preventive maintenance is planned maintenance of plant and equipment. It is designed to improve equipment life and avoid any unplanned maintenance activities. Preventive maintenance is the inspection, replacement, repair of any piece of equipment or component based on time and set parameters. It includes painting, lubrication, cleaning, adjusting and minor component replacement to extend the life of equipment and facility. Its main purpose is to minimize break down and excessive deterioration.

Predictive Maintenance

This sort maintenance ensures ability to judge when a piece of equipment is going to fail and replace the same before it does. Usually it requires some form of testing and analysis which helps predict an imminent failure. Predictive maintenance can be used in conjunction with preventive maintenance practices. In a hydro power station there are many monitoring systems, which can be used to predict problems and possible failures. These include vibration monitoring, oil analysis, temperature, and systems ampere readings, resistance readings of motors, efficiency in power output, leakages of oil and water. All of these things can be captured and tracked by computer system.

Proactive Maintenance

This is the most recent innovation in maintenance. It utilizes techniques known as "root failure analysis". In this type of maintenance, primary cause of failure is sought and corrected. Figure 1 shows proactive maintenance as an element of planned maintenance.

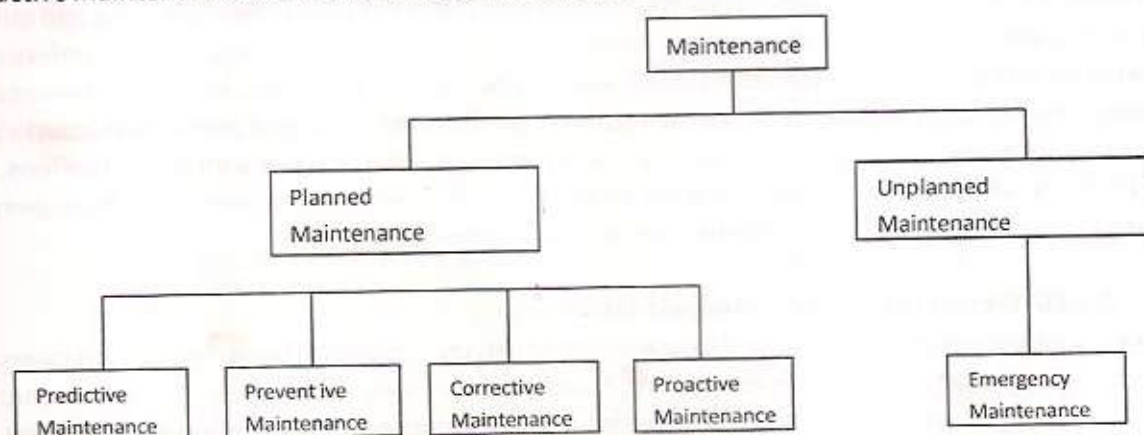


Figure 1: Types of Maintenance

4. MAINTENANCE PLANNING

In planning for maintenance, the question of how frequent a machine should be serviced is important because almost all industrial equipment deteriorates with age, except if apt routine maintenance is undertaken. Maintenance can be carried out on a single machine or entire group of machines simultaneously. By conducting a coordinated maintenance on a group of machines, the total fixed cost associated with individual or separate overhauls of the machine could be saved. Maintenance planning involves deciding in advance the jobs, methods, materials, tools, machines, labour, timing and time required. A planned maintenance system is organized and carried out with fore-thought, control and records to a pre-determined plan. It administers the company's maintenance policy by providing the means to technically and financially direct and control the maintenance operation with the objectives of higher plant maintenance standards and greater cost effectiveness. It should be simple to administer, involves shop-floor personnel and minimum amount of paper work.

a. Planned Maintenance Procedure

The first step is to establish what is to be maintained. This involves the preparation of *equipment register*. Next is to decide how this equipment is to be serviced or maintained.

A *maintenance schedule* which is a comprehensive list of maintenance and its incidence must be prepared for every item of plant or equipment which requires application of planned maintenance.

Having prepared our maintenance schedule, the next is the *job specifications* compiled from the maintenance schedules as means of communicating plant engineer's requirements to the technician. In order to apply these job specifications and control their usage, a *maintenance programme* is drawn up, usually for one year, setting down when the machines are to be inspected. It is necessary to plan preventive maintenance on a weekly basis for which a planning programme must be drawn up in collaboration with the production department. Figure 2 shows the various elements of a planned maintenance system. The principal purpose of planned maintenance is to raise maintenance standards and cost effectiveness. This can only be done by critical analysis of the results of maintenance and designing-out maintenance resulting from such analysis.

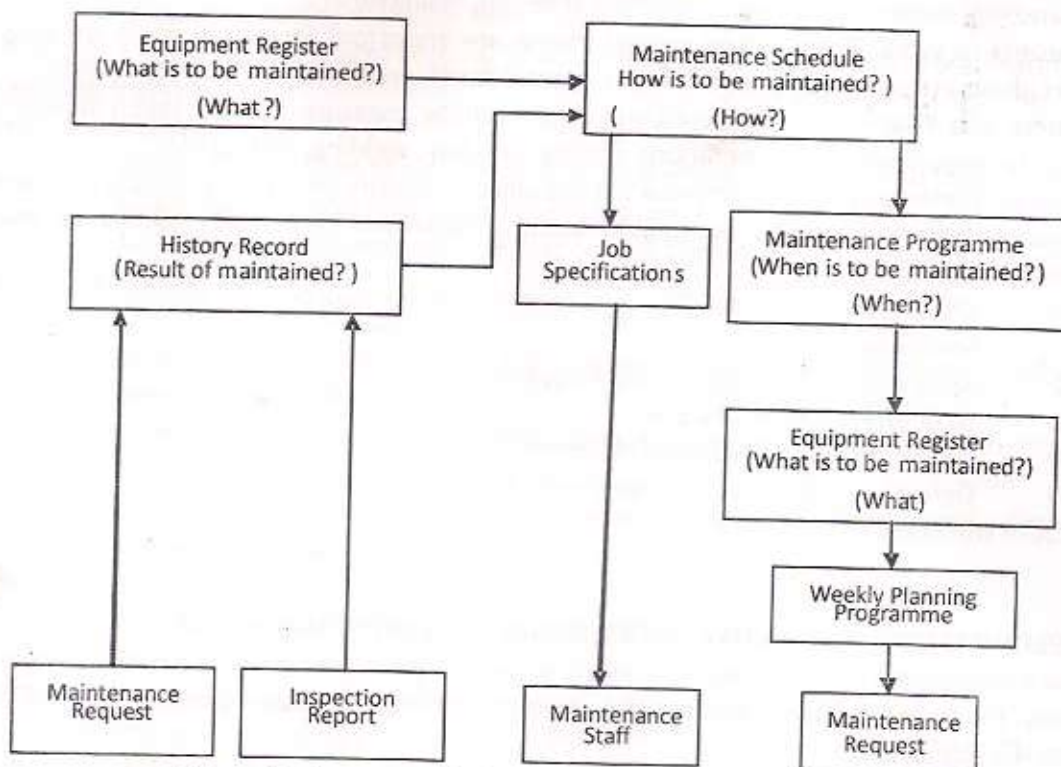


Figure 2: Elements of Planned Maintenance Procedure

a. Effects of Poor Plant Maintenance Practice

Where there is lack of or inadequate maintenance planning and management; the consequences are not usually palatable. This may include:

- ❖ Excessive machine breakdown
- ❖ Frequent emergency maintenance work
- ❖ High downtime
- ❖ High turn-over of spare parts and overall maintenance cost
- ❖ Poor utilization of maintenance staff
- ❖ Loss in production output
- ❖ Lower quality of product or service

b. Planned Maintenance Record

This is the act of keeping the records of activities carried out on daily, weekly, monthly, quarterly or yearly basis. Also, the record of different breakdown, are always taken and how repairs are made to act as future guide for any similar breakdown.

The most important single document in the organizing of maintenance is the maintenance request. It has been variously called work order, work requisition, job card or work ticket depending on the company's preferences. As a prerequisite for planning the maintenance function, it is necessary to know exactly what the labour force is doing and how long each task takes. Downtime is the period a plant/machine in question is unable to perform its expected duty.

c. Safety

A success strategy of any company is to exceed expectations of customers by improving products or services while protecting personnel and the environment in which they work. Through this commitment to quality, the company endeavours attaining the ultimate goal of a zero-defect culture. Some industrial safety measures include:

- i. Use of Personal Protective Equipment (PPE): The use of PPE such as chemical suits, respiratory protection, special footwear, fall arrestor to special task e.g. chemical

handling, confined space entry, working at height, falling objects.

- ii. **Fitness to Work:** Physical and mental fitness are important for safety while working. Many accidents are caused by physical illness, mental stress, drugs etc.
- iii. **Tools and Machinery:** Get enlightened on safety measures to be taken during forklift operations, crane/lifting operations, drilling, grinding, welding, cutting etc.
- iv. **Fire and Emergency Exit:** Learn how to raise alarms, identify emergency signals, exits, assembly points, fire extinguisher, flammable liquids, hazardous materials, radioactive materials, explosive etc.
 - ❖ Obtain Work Permit: This is a formal written approval. It should include but not limited to:
 - ❖ Review of all safety aspects of the operation
 - ❖ Definition of scope of work
 - ❖ Definition of validity period of permit
 - ❖ Definition of chain of command and communication
- vi. Close work order.

5. REQUIREMENT OF EFFECTIVE MAINTENANCE OF HYDROPOWER PLANT

In addition to planning maintenance and allotting suitable time interval on the basis of water supply availability, the following items also require close monitoring otherwise it may become difficult to adhere to the schedules.

- i. Manpower planning and arrangement is most essential as without experienced and skilled staff any well planned maintenance programme will not achieve the desired result.
- ii. Planning and arrangement of spares and consumable in advance.
- iii. The maintenance engineers should have in his possession all commissioning log sheet document to establish a record of installed clearances, parameters, alignment results, test characteristics of all the power plant equipment.
- iv. Log sheets of the previous maintenance exercise carried out on the machines. These may be required to compare with the clearances/ settings/characteristics achieved during present maintenance.
- v. History registers of various machines duly recorded with all the abnormalities observed on the machine and details of action taken to provide a guide line for future maintenance exercise must be maintained at the power station.
- vi. Logging of the performance characteristics of the power plant on daily basis recording all the abnormalities of the total plant observed during its generation programme from one maintenance exercise to another.

6. GUIDELINES FOR MAINTENANCE OF HYDROPOWER PLANT

In most of hydropower plants preventive maintenance approach is preferred over other approaches. The following inspection checks are done in this type of maintenance:

- ❖ Daily checks
- ❖ Weekly checks
- ❖ Monthly checks
- ❖ Quarterly checks
- ❖ Half yearly checks
- ❖ Annual inspection and maintenance of components of plants
- ❖ Overhauling or Capital Maintenance

Daily Checks

Foundation parts and Expansion Joints

- ❖ Checks for any leakage in draft tube manholes, spiral casing manhole, expansion joint.

Vacuum Breaking Valve/Air Admission Valve:

- ❖ Checks the working of both vacuum breaking valve and see that there is no abnormality in the springs, seats etc.

Water Seal and Air Seal

- ❖ Checks the position of water leakage of the water seal to see that there is no excessive splashing and water level do not rise in top cover,
- ❖ Note water pressure of water sealing or under sealing.

Turbine Guide Bearing

- ❖ Checks the oil level (stand still machine or running machine),
- ❖ Note the temperature of bearing and check that the temperature of oil and guide bearing pads are within limits,
- ❖ Note the maximum and minimum temperature and compare with readings of the previous day,
- ❖ Checks for any oil leakage from the bearing housing and check that oil is flowing above the bearing pads.

Guide Apparatus

- ❖ Check any leakage from GV servomotor and its piping.

Oil Leakage Unit

- ❖ Check any leakage from pipe line joints,
- ❖ Check its satisfactory running on 'Auto'.

Top Cover Drain System

- ❖ Vibration noise in the pump motor,
- ❖ Any leakage from the water piping,
- ❖ Working and water pressure of the ejector.

Centralized Grease Lubrication System

- ❖ Check for any leakage from grease pipes, unions and nipples,
- ❖ Check grease container and fill grease, if required.

Oil Header: (For Kaplan)

- ❖ Check from perspex sheet manhole any splashing of oil from top and bottom bush,
- ❖ Check any oil leakage from the joints,
- ❖ Note the pressure difference of opening and closing side of runner.

Oil Pressure System

- ❖ Check if there is any abnormal sound in the running of the motor and pump units,
- ❖ Check the oil level in pressure accumulator,
- ❖ Check any oil leakage from oil piping and its valve,
- ❖ Check for over heating of motor.

Mechanical Cabinet of Governor

- ❖ Pressure in transducer,
- ❖ Check any oil leakage from joints of piping.

Weekly Maintenance Checks

Greasing of guide vanes and servomotor with centralized grease lubrication system and manually:

- ❖ Oil in the gear box shall be checked.
- ❖ Check for any leakage
- ❖ Working of end pressure relay and solenoid valves, if defective, should be reported.

Cleaning of OPU filters

Cleaning of throttle filters in the governor mechanical cabinet

Cleaning of governor compressor air filters and checking of oil levels

Checking physically oil of OPU of the running machine, after taking sample through the sampling cock, do the crackle test for detecting presence of water. Take remedial measures

Check oil level of all the bearings

Check wobbling of shaft at coupling flange and at oil header servo tube

Monthly Maintenance Checks

All the checks covered in weekly maintenance as above are carried out monthly also. But while carrying out these checks more attention is paid and short shutdowns, if required, for rectification are taken.

Annual Inspection and Maintenance

After every five years it is necessary to inspect the machine more critically for abnormalities like fatigue defects for excessive wear and tear of some parts or any change in original parameters or clearances etc. This exercise becomes very essential in cases where performance level has been observed to have gone down in 5 years operation.

The checks for annual and five-yearly maintenance designed for a hydropower station are listed below:

Foundation Parts

- ❖ Check condition of water path system. The damage due to cavitations and wear should be rectified
- ❖ Check painting of spiral casing.

Runner

- ❖ Check the condition of the surfaces of the runner hub and the blades. The damage due to cavitations and wear should be rectified by welding and grinding.
- ❖ Check the runner blade seals by pressurizing the system, change seals if necessary. No oil leakage is to be allowed.
- ❖ Check the runner sealing for hermetic tightness, leakages of water in the runner hub is not to be permitted

Guide Apparatus

- ❖ Check the presence of rubber sealing cords and the tightness of the rubber sealing between the adjacent guide vanes in fully dosed position of guide apparatus.
- ❖ Change oil in the regulating ring.
- ❖ Replace damaged shear pins.
- ❖ Check cup sealing of guide vane journals and replace, if necessary.
- ❖ Check the bushes of guide vanes and change the worn out bushes of guide vanes journals.
- ❖ Inspect the servomotor and change the seals, if these are worn out.

Guide Bearing

- ❖ Check the condition of rubbing surfaces of guide bearing. Clean the surface and polish it with the help of chalk powder.
- ❖ Adjust the clearances of moving the segment with the help of adjusting bolts.

Major Maintenance Problems of Hydro Turbines

Some of the major problems encountered in the hydro turbines are damage in runners due to erosion, cracking and cavitation due to pressure pulsation in draft tube, instability of operation at partial gate opening, failures of turbine bearings, leakages of water through of turbine guide bearings, leakage of water through guide vane seals and turbine gland seals.

Runner

Erosion due to silt

The problem of erosion of turbine runners guides vanes and other under water parts has assumed serious proportions especially in some of the run-of-river schemes. Greater attention should, therefore, be paid to effective desilting arrangement in such power station.

The wear due silt occurs so fast that the unit has to be taken out for reconditioning every few years in some stations. The remedy appears to lie in effective desilting arrangements and manufactures of turbine parts with harder and erosion resistant material like stainless steel of higher grade and also

design of runner for such conditions.

At surface power stations with open channels following measures of desilting are taken:

- ❖ Silt extruders have been provided near under sluice gates of the barrage.
- ❖ About half a kilometer downstream of the head regulator a silt ejector has been constructed in the bed of the power channel
- ❖ In some projects desilting basin is constructed.
- ❖ Fore bay is also used as desilting basing with flushing conduits

Cavitation and Cracking of Runner

The problem of cracking of runner and Pelton buckets can be due to following reasons:

- ❖ Faulty design
- ❖ Poor metallurgy
- ❖ Metal fatigue

Cavitation phenomenon occurs due to the vaporization of flowing fluid in a zone of excessive low pressure. Cavitation is inherent even in the best designed turbines and cavitation damage occurs under unfavourable operating conditions, limits of metal removal have been specified beyond which cavitation becomes harmful and requires repair. To minimize cavitation following steps are necessary:

- ❖ Periodically inspect the runner and other turbine parts and take remedial measures.
- ❖ Operate the machines as per guidelines given by manufacturers. The unit should not be run below certain load to avoid cavitation prone zones.
- ❖ As a result of draft tube pulsation and surges at no load or part gate opening excessive

nose, vibrations and cavitation is experienced. To minimize pulsation of draft tube following measures must be taken:

- i. Air admission through air admission and vacuum braking valve installed at top cover.
- ii. Provision of fins or flow splitter in draft tube to break the vortex flow.
- iii. Provision of a bye-pass arrangement for releasing the pressure built up below the top cover.

Precaution in welding of runners

- i. Surface should be prepared by chipping or grinding.
- ii. To locate cracks, die penetration test must be carried.
- iii. Avoid any localized excessive heating. This can be achieved by welding for a short time in any one particular area and then moving to a diametrically opposite area to continue with the work.
- iv. The parent material about 70 to 75 mm. from the weld, should not be allowed to get too hot to be touched with bare hand.
- v. Plenty of time should be allowed for the welded area to cool down since forced cooling may cause distortion due to locked in stresses.
- vi. A close check should be made at least two to three times per day during the repair of runner to runner chamber clearances.
- vii. After welding all the welded areas should be properly ground to match with the desired profiled.
- viii. Die penetration tests should once again be carried out to ensure crack free welding.
- ix. If extensive welding on the runner is required, it will be desirable to do static as well as dynamic balancing of the rotating parts and stress relieving before re-commissioning to prevent problem of cracking of blades and excessive vibrations in machines.

7. MAINTENANCE COORDINATOR SYSTEM

Maintenance Scheduler Module

This is the heart of any Computerized Maintenance Management System. The scheduler Module can create maintenance type tasks as well as standard work orders. Detail of completed work orders can be saved to equipment history logs, and it is easy to track full labour costs, materials used, and more on a per week order basis.

Handson Air Dryer (HAND00001) Planned Maintenance: Scheduled/Weekly 0909:108

Overview | Details | Instructions | Reports

Task Type: **Planned Maintenance**
Task Priority: **Low**

Personnel Assigned:
Albright, George
Griggs, Fred
Richards, Gary

Equipment: **Handson Air Dryer**
HAND00001
Select Equipment

Frequency: **Semi-Annually**
Every XXX Criteria: **0**
☒ Generate New When Done
☐ Use Next Maintenance After 1 day

Estimated Down Time: **1 hour**

Color Scheme: **1327**
Support Equipment: **Support Equipment**

Actions: **Edit Work Order Parts**, **Edit Work Order Labor**

Equipment and Machinery Module

In Equipment and Machinery Module, information about equipment, machinery and other assets are recorded. Other information such as asset numbers, warranty information, leasing information, and more are maintained.

Equipment Log

Overview View | **Details View** | Equipment Log

Reference: **PALL0002** ✓ REF Building: **Building**
Description: **Case Palletizer** Room: **Room**
Manufacturer: **Stack It Right, Mtg** Account: **Account**
Model No: **CAPAL-99T4** Classification: **Production**
Serial No: **6670436905** Vendor: **Vendor**
Assigned To: **Albright, George** Meter Reading: **475** ☐ Use Meter
Location: **John Nelson - Stratton Rd** Meter Type: **None** ☐ In-Service
Safety Instruction: **General Safety Instructions** Special Field: **Special Field**

Leasing and Warranty: **Leasing and Warranty** | **Appraisal** | **Vehicle** | **Barcode** | **Property Assignment** | **User Fields** | **Attachments**

Owned/Leased: **Leased**
Company: **John Nelson and Associates**
Start Date: **Start Date**
End Date: **End Date**
Warranty Info: **Warranty Info**

Parts and Inventory

The parts and inventory module was designed for inventory control purposes. The user can record part information such as description, manufacturer, part number and also setup stock levels for the inventory items as well as storage locations.

Part groups allow for the easy lookup of spare parts and each item can belong to a countless number of groups.

Part Identification	BRAS00001	ID	Classification	Pipe, Tubing and Supplies
Description	1/4 Brass Ball Valve		Equipment	
Manufacturer	Easy Tube		Used On	
Part Number	MSB-BAL-VAL01		Specifications	
Primary Vendor	Easy Tube Company			
Storage Location	Main Storeroom			
Account No	General Maintenance			

Qty in Stock	2	Unit Type	each
Minimum Level	3	Items Per Unit	1
Maximum Level	5	Unit Price	14.75
Reorder Quantity	2		

Tools Database

With the Tools Database module, information as to who has a tool checked out, and when that tool is scheduled for return are recorded. User can setup inspection record about each of your tools, create reports on tools that are due for return, and report on tools that are coming for inspection.

Reference ID	ANG100001	ID
Tool Description	Angle Grinder - 4in	
Storage Location	Cabinet 1	
Building	Main Building	
Serial Number	77000012	
Asset Number	ANG1-0001	
Manufacturer	Stan and Lee Mfg.	
Model	GR19976	
Purchase Price	124.75	
Next Inspection	06/06/2003	

Checkout Name	Albright, George	Due Date	04/09/2007
Reference	ALBR00001	Date Returned	04/09/2007
Check-Out Date	03/09/2007		

Browse Clear

Check Out

Forms and Permits Module

Forms and Permits are to be used in day-to-day operations of a plant. This module gives the user the ability to create your own forms and permits.

CUTTING - WELDING - HOT WORK PERMIT

This permit must be maintained in a conspicuous location during work

DATE: _____

BUILDING: _____

FLOOR & DEPARTMENT: _____

WORK TO BE PERFORMED: _____

START TIME: _____ COMPLETED: _____

PERMIT EXPIRES: _____

The precautions listed below have been completed. Permission is therefore granted for this work.

SIGNED: _____ TITLE: _____

FINAL CHECKUP

Work area and all adjacent areas to which sparks could spread (including floor above and below and on opposite sides of walls) were inspected 30 minutes after the work was completed and was found fire safe.

SIGNED: _____ [Supervisor or Fire Watch]

Purchasing and Receiving Module

Purchasing and Receiving module is used to buy and receive the goods needed to conduct everyday business. With this module, it is possible to create quotation request, purchase requisitions, and purchase orders.

Purchasing and Receiving Module

Date: 10/10/2002 Hours: 10:11:33 Requester: Abhijit George

Date Needed: Classification: Department:

Company: Contact: Bus. Phone: Look Up

Project: Cost Center: Date Ordered: Credit:

Item: Confirmation No. Date Promised: Used On:

Qty	Part No.	Description	Unit Price

Part Lookup View Part Add New Stock Remove Item

Taxes: 00 Tax: 00

Freight Cost: 00

Other Costs: 00

Calculate Total

Safety Management Module

This module allows the user to fully track and analyze incidents in your work place. The built-in charts and reports helps to pinpoint where frequent types of accident occur, thereby assisting in the prevention of these issues.

8. CONCLUSION

Maintenance and its proper management play a fundamental role in a manufacturing plant particularly a hydropower plant by supporting plant effectiveness and strategies, and contributing to the overall performance of the plant. The experience of running hydropower station reveals that even after detailed project planning and quality control measures, several unforeseen problems may occur during operation which could result in forced outages, low generation or load shedding. Thus, the necessity for maintenance management to define task, and assign roles to tackle challenges that are too large or complex for any individual or group to cope with. Maintenance coordinator system, a computer application for maintenance management does the function of breaking into key elements for proper routine maintenance managements.

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