


# **Implementing A Basic Maintenance Program for Water and Wastewater Systems**

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# **Implementing A Basic Maintenance Program for Water and Wastewater Systems**



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# Introduction

- A good maintenance program is a must in order to maintain successful operations of any treatment plant or system.
- A preventive maintenance program anticipates the lubrication, cleaning and repair of equipment and schedules work on equipment before equipment failure.
- A good maintenance program will extend the life of equipment and keep emergency repairs and their costs to a minimum.

# **Implementing A Basic Maintenance Program for Water and Wastewater Systems**

## **Why Have A Maintenance Program?**

**A good maintenance program will extend equipment life and reduce equipment and plant/system breakdowns., and help in cost reduction and control.**

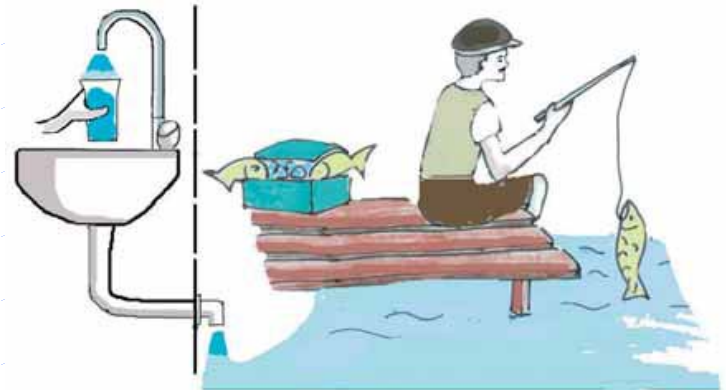
# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Why Have A Maintenance Program?

It's required under the SDWA and RGPWS

**RGPWS 15A NCAC 18C .0307 ENGINEER'S REPORT, WATER SYSTEM MANAGEMENT PLAN AND OTHER PLANS (C) (8) (d) Operation and Maintenance Plan....** The Operation and Maintenance Plan shall include, at a minimum, a description of the location and routine operation and maintenance procedures for: (1) components of the treatment facility; (2) pumps, meters, valves, blowoffs, and hydrants; (3) backflow devices; (4) storage tanks; and (5) all other appurtenances requiring routine operation and maintenance.

**RGWSOs 15A NCAC 18D .0701 OPERATOR IN RESPONSIBLE CHARGE (b) The operator in responsible charge is actually in charge of the daily operation and maintenance of the facility ... shall be readily available for consultation on the premises of the facility in case of an emergency, malfunction or breakdown of equipment or other needs.**

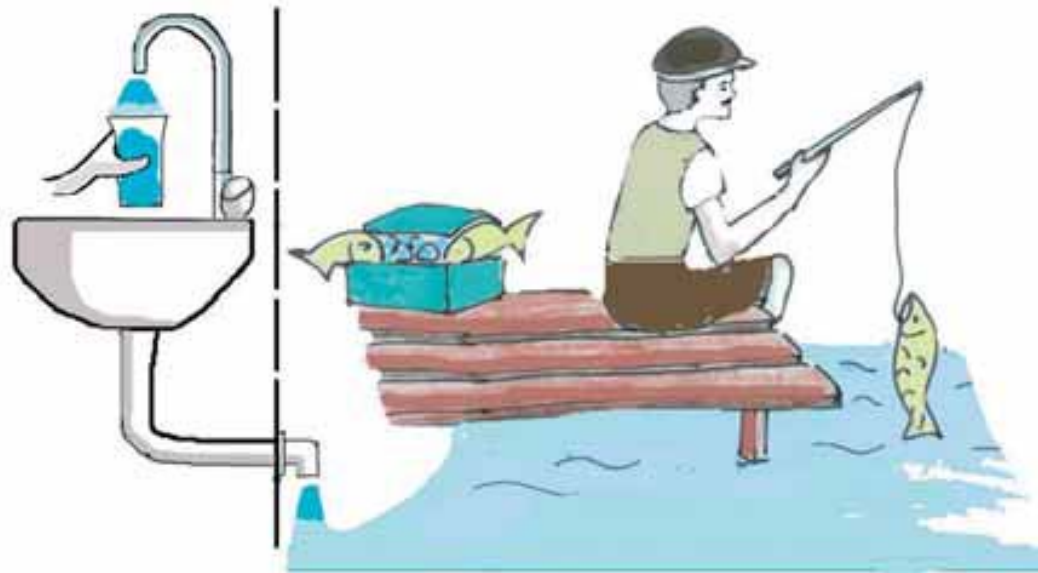


# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Why Have A Maintenance Program?

It's required under the Clean Water Act

NPDES language- The Permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the Permittee to achieve compliance with the conditions of this permit.



# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Program Organization

A maintenance program (based on either computer software or some alternative system) can be self-generated or purchased.

No two operations are alike, and each program will be site specific. Purchased programs must be flexible, user friendly, and adaptable to accommodate the local application. (i.e.-One size does not fit all?)

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Developing a Program

Many managers of water or wastewater treatment plants have the attitude that developing a maintenance program is beyond their capabilities or that they do not have the time. This is not necessarily true, and a predesigned computer package or other purchased maintenance program could help accomplish the task.

### Disadvantages

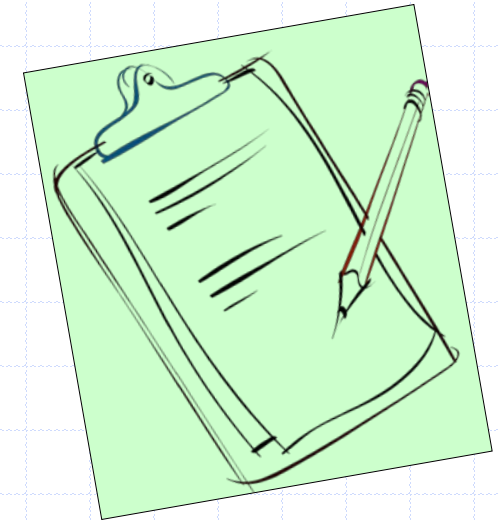
A package can provide basic procedures, charts, and other paperwork needed to get started. Its format must be followed, and it may not be flexible enough to be modified or adapted to an operation even though it may be user friendly. And in many cases, the program allows only limited space for each item of maintenance.

Two additional disadvantages are they generate large amounts of paper (some of which is useful for permanent records and storing inventory data, and some of which is simply redundant). Second, certain computer programs may be so complex that they require a full-time operator.



# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Developing a Program



Developing a maintenance program is not as complex as it may appear, because plant personnel already have knowledge of the facility's equipment. All that is required to get this information into a usable form is to organize and schedule work activities. This organization is based on the inventory priority list and should be accomplished as three separate tasks:

- 1- Acquire as much name plate data as possible from each piece of equipment. Utilize reference manuals, catalogs, drawings, and other manufacturers information.**
- 2- List all items for each piece of equipment that will require maintenance, and note a maintenance frequency for each. Refer to the manufacturers literature for guidance.**
- 3- Develop a spare parts list for each piece of equipment. This list can be included as part of the machinery history.**

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Developing a Program

Motor Nameplate data



# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Establishing Maintenance Frequency

The frequency at which a piece of equipment or machine should be maintained is governed by its type, location, the hours it runs, and the type or level of maintenance to be accomplished. Two types of maintenance have to be considered—routine and scheduled.

Routine maintenance - comprises the periodic inspections and tests performed on equipment at regular intervals. Included are daily, weekly, monthly, quarterly, semi-annual, etc., inspections during which minor routine maintenance tasks are carried out. Lubrication, vibration tests, packing adjustments, and other activities are part of this program.

Scheduled maintenance - is carried out on a time basis, but not a daily, weekly, or other timed schedule. Instead, it can be defined as the systematic and periodic removal from service of a piece of equipment for the replacement of parts, or for reconditioning and overhaul. The time cycle is based on wear and the expected life cycle of the equipment's individual components.

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Establishing Maintenance Frequency

While routine maintenance is underway, housekeeping chores (including landscaping if applicable) can become a part of the routine and is helpful if the plant covers a large area. Bringing all operating logs/records up to date can be done at this time.

Routine maintenance can be organized in several ways: by types of equipment, location, time required to complete the work, maintenance frequency, available personnel, etc. If most of the equipment is located in a general area, the easiest way to schedule maintenance is by equipment type.

Otherwise, if the work sites are scattered, then grouping the work tasks for several different pieces of equipment situated relatively close to each other is probably more effective. In this case, several different tasks may be scheduled for the same period. For example, some 30- or 90-day checks might be done along with hourly or daily checks.

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Establishing Maintenance Frequency

A maintenance frequency schedule based on time can be changed depending on how the life cycle of the equipment progresses. For example, if electronic maintenance tests are performed at 30-day intervals, perhaps these could be extended to 45 or 60 days if the equipment has demonstrated satisfactory performance without any apparent need for the 30-day checks.

Many plant personnel believe it may be cheaper to wait until a piece of equipment breaks down before it is repaired. This is false economy. Scheduled overhaul is less expensive because only parts showing normal wear are replaced, and the time required to accomplish the work can be managed by scheduling around other activities. Planning such activities avoids emergency overtime, or having to recall personnel from other routine work. Another advantage of scheduled maintenance is that equipment can be removed from service during off-peak operations when it is not needed, and more time can be devoted to thorough inspection.

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Records and Forms

A preventive maintenance program requires a variety of records and forms.

They should be developed locally to suit the specific organization. Experience has shown that the better the records, the more up to date and effective the maintenance program will be.

Predesigned maintenance programs usually come with forms included.

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Records and Forms

Work order forms should be developed to assist in scheduling and completing maintenance tasks. A side benefit of the work order is that it provides a place for the notation of equipment and building discrepancies or additional work required. This can be added to future routine work orders or handled separately as scheduled maintenance.

A work order also serves as a check on the maintenance activity, the time required to complete the task, and as a reference for work accomplished and materials used.

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Records and Forms

Task analysis sheets should be completed for every maintenance activity. This task is time consuming and may not be necessary for some plants to perform. But if there is a large staff, or one prone to turnover, the need to perform each maintenance task properly and in the same manner each time requires documentation.

The description of the work to be done does not have to be elaborate, but should be concise and clear. It should also include any tools needed to complete the task and can be included on the work order.



# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Records and Forms

### MAINTENANCE WORK ORDER

ELECTRICAL:	MECHANICAL:	OTHER:	DATE:
REPORTED BY:			BUILDING:
ATTENTION OF:			EQUIP. NO.
			JOB ORDER NO.:
COMPLAINT:			
WORK DONE:			
WORK ASSIGNED BY:		DATE STARTED:	
WORK ASSIGNED TO:		DATE FINISHED:	

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FIGURE NO. 10

Courtesy of Mr. Carl M. Schwing  
Charles County Community College  
LaPlata, Maryland

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Records and Forms

Log books can be kept at each location if buildings are separated, or beside any piece of equipment. This log can be used by maintenance or operating personnel to record any repair work or machine adjustments made. A log provides other persons with a historical record and aids in decision making.

Inventory records are helpful, especially if parts are kept at different locations or if large numbers of spare parts are required. This record need not be too detailed, but should include where the parts are stored and to what piece of equipment they belong. (Stored parts also should carry this identification.) If possible, for future reference, the parts inventory also should show where the parts were purchased.



# Implementing A Basic Maintenance Program for Water and Wastewater Systems

## Maintenance Budgets

- A maintenance budget can best be established by reviewing the past years expenditures on maintenance of equipment and reviewing the status of existing equipment.
- In some cases it is more appropriate and cost effective to purchase new equipment rather than keep spending money on old, used, worn-out equipment.



# **Implementing A Basic Maintenance Program for Water and Wastewater Systems**

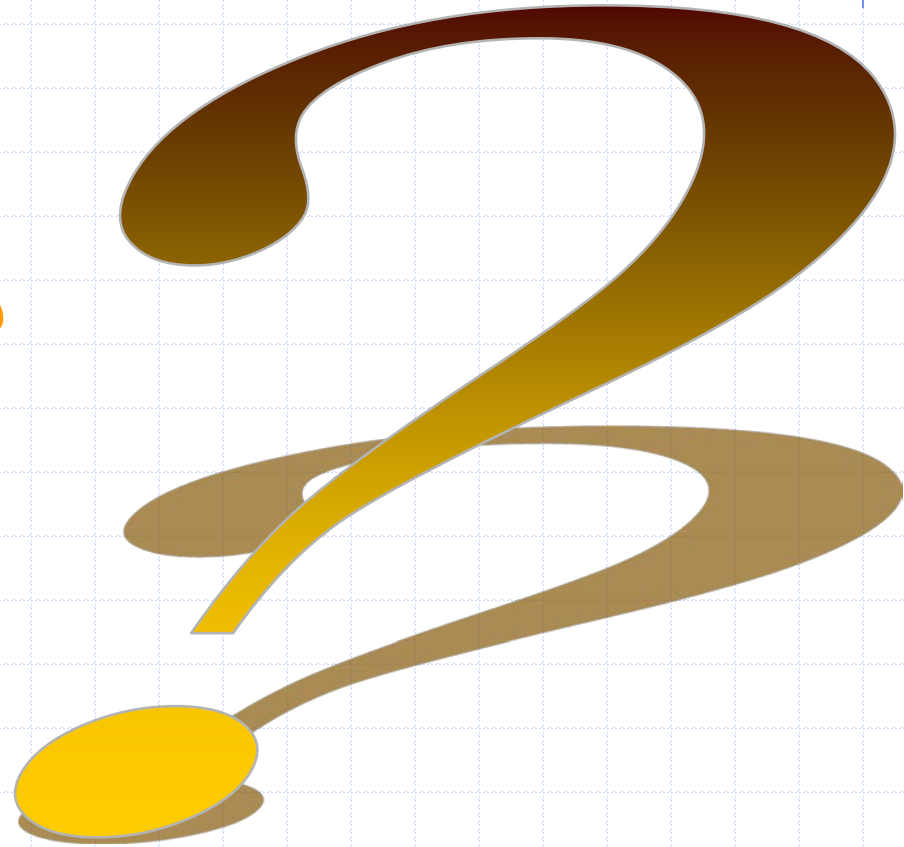
## **What It Takes for Success**

**A preventive maintenance program is a product of careful thought and contains much detail. Every water or wastewater treatment facility is different and requires a site-specific approach to how maintenance should be undertaken.**

**The skill level of the maintenance personnel, the complexity of the equipment, and many other factors all influence the development of a program and its ultimate success.**

# Implementing A Basic Maintenance Program for Water and Wastewater Systems

Questions

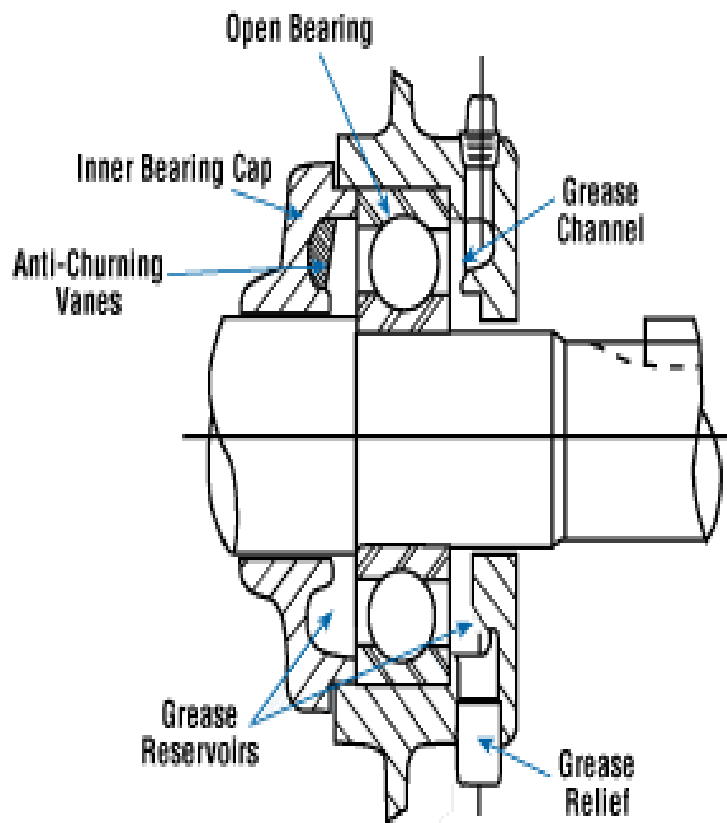


# Motor Maintenance

- ◆ Visual/tactile inspection
- ◆ Coupling inspection
- ◆ Greasing
- ◆ Voltage and Amperage Unbalance
- ◆ Primary insulation
- ◆ Temperature
- ◆ Vibration analysis



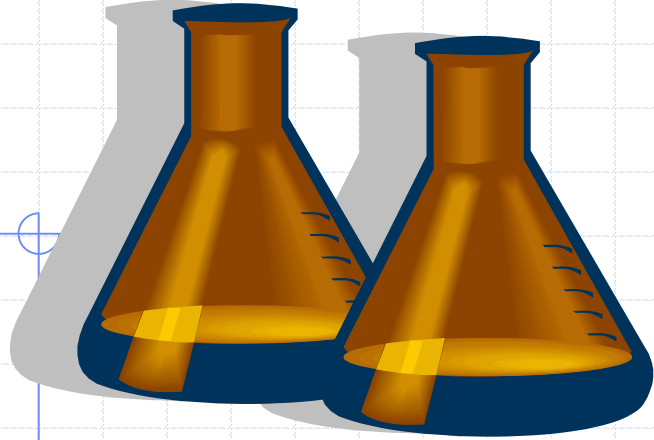
# Greasing motor bearings



- ◆ No grease is better than too much grease
- ◆ *Less is more!*
- ◆ Always follow manufacturer recommendations



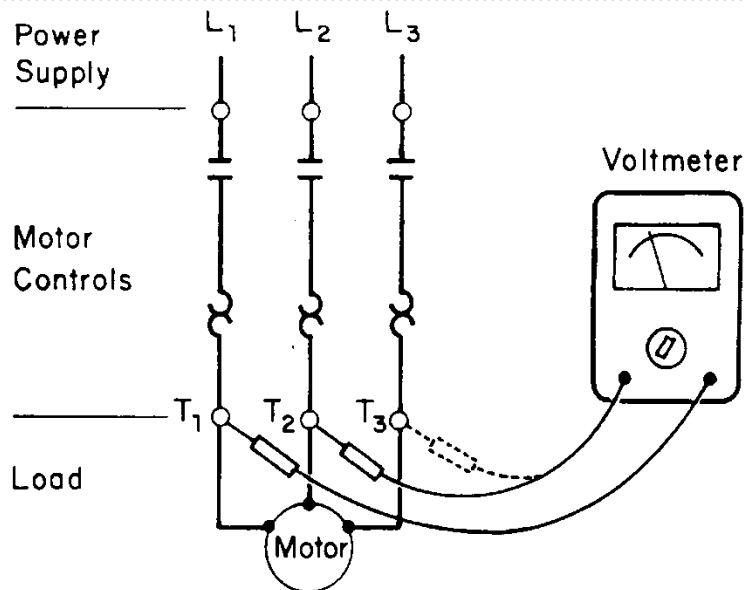
# Oil Analysis



- ◆ Tests for additives, wear metals, water, etc.
- ◆ Do baseline testing to know what is in new oil.
- ◆ Large gear drives - prime candidates.
- ◆ Do not void warranties.

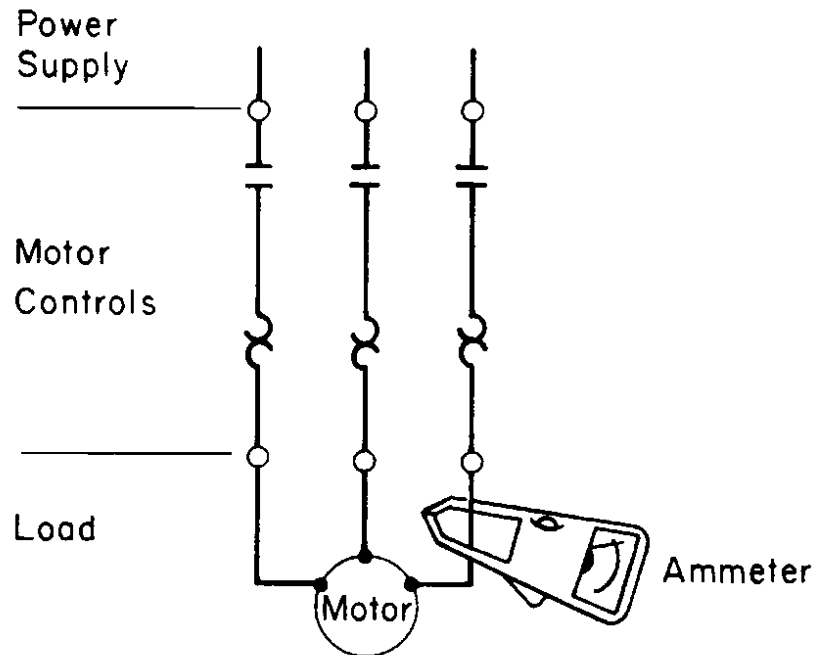
# Voltage Unbalance

- ◆ Voltage between legs
- ◆ Voltage less than 1%



# Amperage Unbalance

- ◆ Amperage between legs
- ◆ Amperage less than 5% at full load



# Voltage Unbalance

- ◆ Shortens life of three phase motors
- ◆ Increased vibration and mechanical stresses
- ◆ Motor overheating

# Calculating V and A Unbalance

$$\text{Percent Unbalance} = \frac{\text{Maximum Deviation from Average}}{\text{Average of 3 Readings}} \times 100$$

Voltage		Amperage	
L1-L2	462	L1	76
L1-L3	465	L2	72
L2-L3	465	L3	74

# Calculating Voltage Unbalance

Voltage	
L1-L2	462
L1-L3	465
L2-L3	465

$$\begin{aligned} \text{Percent Unbalance} &= \frac{2V}{464V} \times 100 \\ &= 0.4\% \end{aligned}$$

# Causes of Voltage Unbalance

- ◆ Faulty operation of power factor equipment
- ◆ Unbalanced or unstable electric supply
- ◆ Unbalanced transformer bank supplying a three-phase load that is too large for the bank

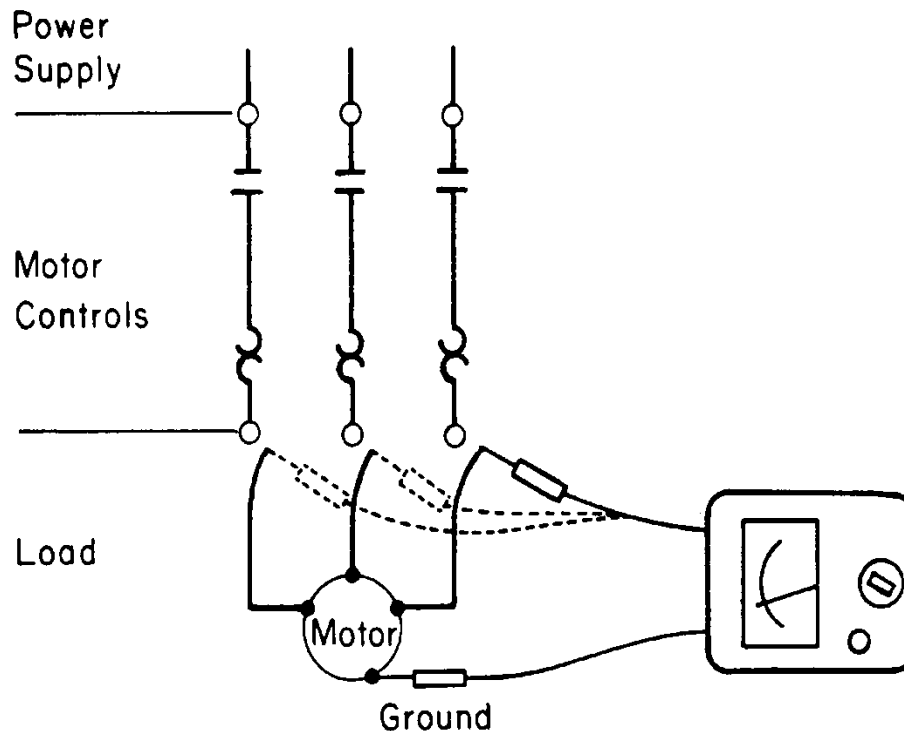
# Causes of Voltage Unbalance

- ◆ Unevenly distributed single phase loads on same power system
- ◆ Unidentified single phase to ground faults
- ◆ An open circuit on distribution system primary



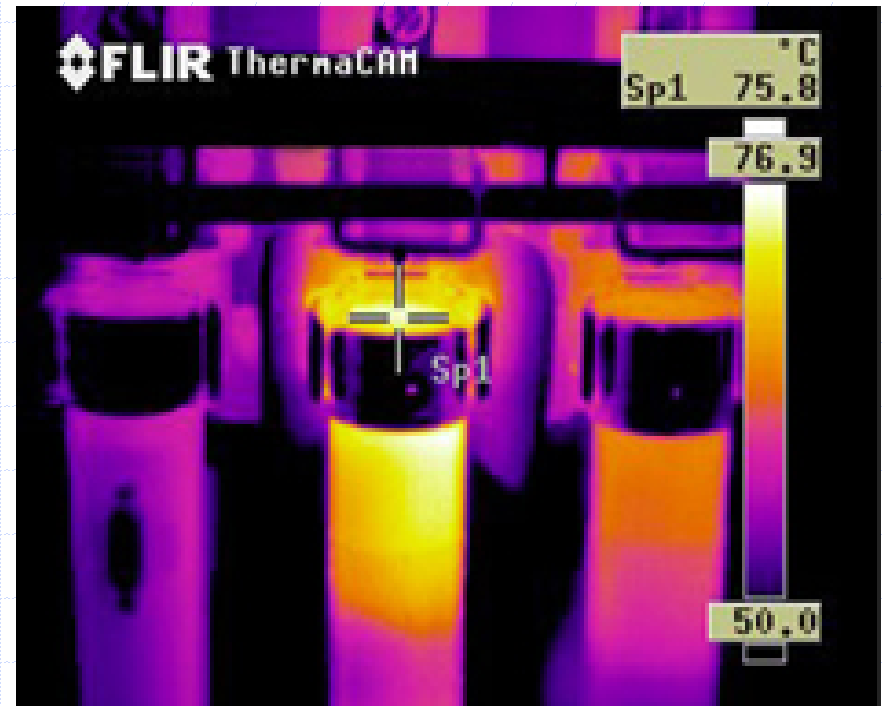
# Primary Insulation Test

- Megohms measure insulation quality
- Primary insulation



# Temperature

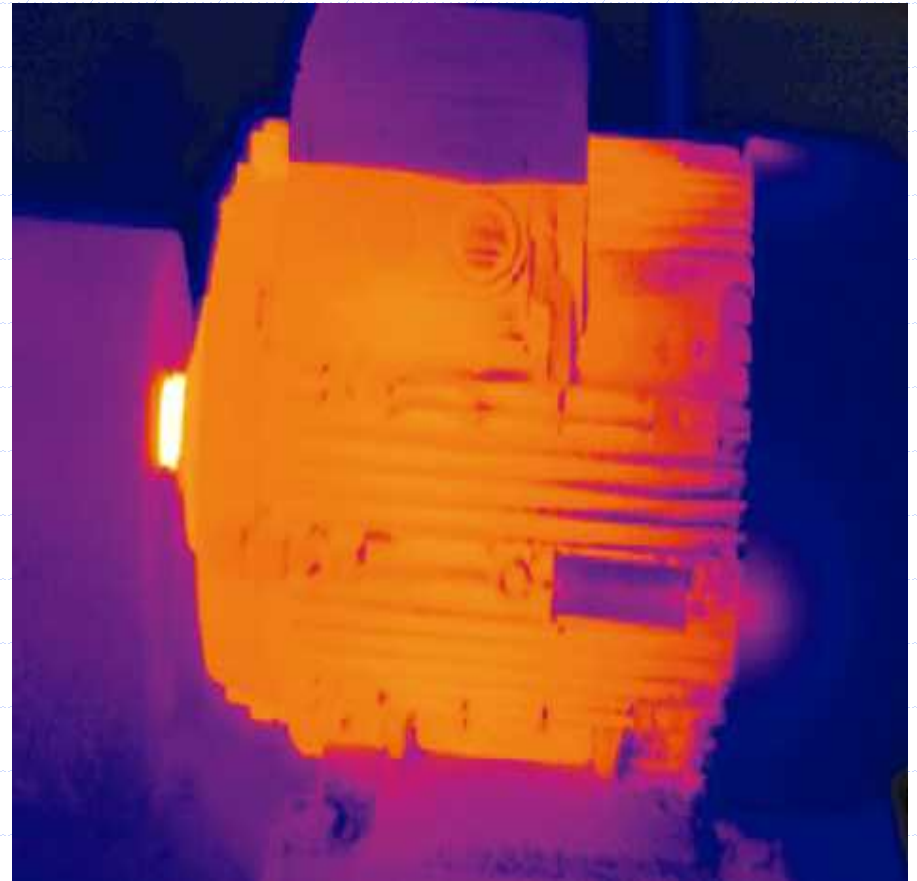
## ◆ Infrared thermometers and thermography



Voltage or amperage unbalances, dirty contacts,  
unstable electric source

# Thermography Diagnostics

- ◆ Motor bearings and other heat sources.



# Infrared Thermometers



# Vibration Analysis

- ◆ All equipment vibrates
- ◆ Sources of vibrations have signatures
  - 120Hz indicates possible voltage unbalance
- ◆ Document normal vibration patterns
- ◆ Keep data stored in maintenance software

# Maintenance Summary

Collect and use equipment operating data.

- Frequent equipment inspection.
- Correct lubrication.
- Electrical condition of motors.
- Pump performance and application.
- Thermography
- Vibration analysis



# Proper Generator Maintenance

## Keys to proper maintenance

- Weekly Checks
- Quarterly Maintenance
- Yearly Maintenance
- Other Maintenance that will help extend the life of you Generator Set
  - ◆ Load Banks
  - ◆ Fuel Polishing
  - ◆ Thermal Imaging

# Weekly Checks

What should I do weekly to service my Generator?

- Check the overall condition of the unit
- Check the Cooling System
- Check the Fuel System
- Look at the air induction and exhaust for any blockages
- Monitor the lube oil fluids
- Test the Starting system
- Power the generator
- Run an Operational Check



# Quarterly Services

Contract a trained Technician to check the following systems:

- Cooling System
- Fuel System
- Air Induction and Exhaust System
- Lube Oil System
- Starting System
- Engine Monitors and Safety Controls
- Power Generator
- Control Panel

# Yearly Service

Maintenance to be completed by a trained Technician on a yearly basis includes all of the checks done quarterly as well as:

- Replace Fuel Filters
- Replace Engine Oil and Oil Filters
- Take an Oil sample and have it analyzed
- Inspect and clean the Crank Case Breather
- Replace Air Filters
- Check and adjust valves
- Inspect the turbocharger

# Yearly Service Continued

- Check Gauge Accuracy
- Check Sending Unit Switches for leaks, function and operation
- Lubricate and Service Rear Bearing
- Check Vibration Isolators for proper adjustment and condition
- Check for tightness and abrasions in the Power Cables
- Inspect Circuit Breakers
- Vacuum, clean and inspect the Control Panel
- Inspect and test Transfer Switch for proper operation

# Other Maintenance Opportunities

There are a few other tests and checks that should be done to a generator during its life.

- Load Bank Test
- Megohmmeter Test
- Thermal Imaging
- Fuel Polishing

# Load Bank Test

- ◆ Many generators are oversized for future expansion, are not called into service on a regular basis or do not run to a 100% when they are called into service.
- ◆ Over time this can lead to problems.
- ◆ Load Banking will help alleviate these Problems
- ◆ A load bank test will put a 100% load on the generator for 4 hours.
- ◆ All data will be collected and the operation monitored by a trained Technician to ensure your generator is performing up to expectations.
- ◆ Load Banking can also be used to diagnose problems within the Generator set
- ◆ It is recommended to Load Bank your generator every 3 years or as needed.

# Megohmmeter Test

A Megohmmeter test will test the main stator, main rotor, exciter stator and exciter rotor.

A trained Technician will record and maintain Data for a future comparison.

This test will help to ensure proper function of the Generator components.

It is recommended that this test be done every 3 years or as needed.

# Fuel Polishing

- Many failures of Diesel Engines are attributed to “bad fuel”.
- The leading cause of “bad fuel” is bacteria, algae and other microorganisms.
- A trained Technician can be contracted to remove these contaminants through a system called Fuel Polishing.
- The operation literally takes the fuel, filters out all contaminants and scrubs the fuel clean for future use.

This should be done on a periodic basis.

# Thermal Imaging

- Thermal Imaging will check for hot spots on connections for breakers, lugs and switchgear.
- This testing can determine if there may be a short developing before a failure occurs.
- It is recommended that this test be performed periodically to ensure the connections on your equipment.



# Emergency Planning

- Even if you do everything you can possibly to keep a generator well maintained, from time to time emergencies will arise.
- It is important during these times to have a plan to minimize downtime.
- Make sure you have phone numbers for the service department you contract through.

# Contingency Plan

- ◆ Work on a plan of action to prepare for a situation where there would be no backup power.
- ◆ Look for a company that has sales, service and rental all under one roof.
- ◆ Many Rental Houses will work with you to make a contingency plan.
- ◆ Contingency Plans will ensure that your downtime is minimized.