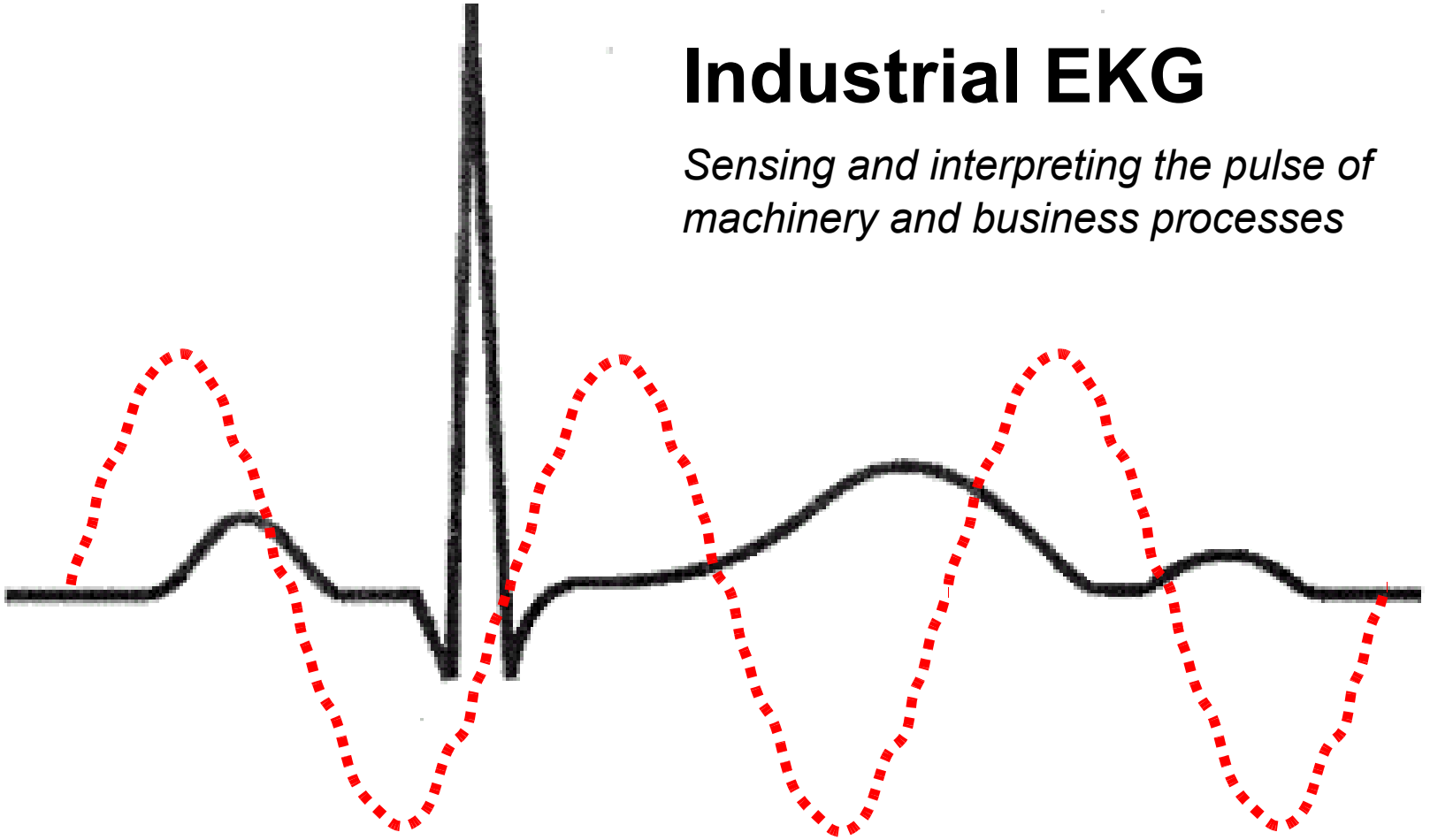
# Industrial EKG

*Sensing and interpreting the pulse of machinery and business processes*



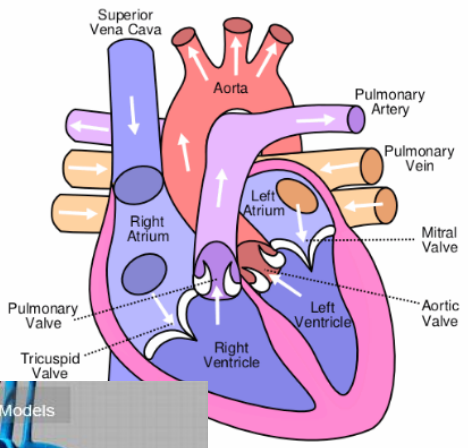
# What We Do

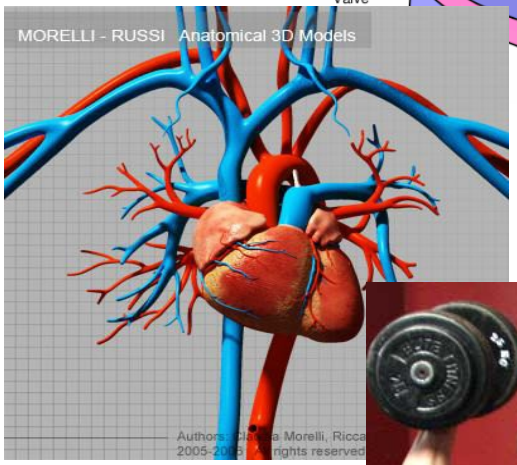
We help you reduce energy and operating costs by using EKGs to monitor the health of industrial equipment instead of people, like industrial cardiologists.

Our uniqueness:

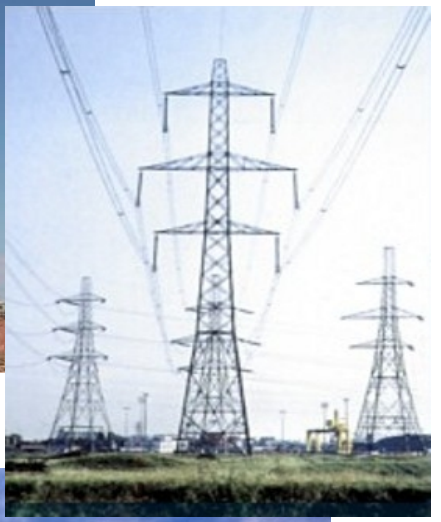
- we don't need sensors on the monitored machines, no cables to install;
- an experience database of over tens of thousands of motors to compare your equipment against;
- multiple monitors in one product – energy efficiency & consumption, power line condition, electrical and mechanical motor condition; and mechanical condition of driven equipment;
- we *directly* measure how even mechanical faults like unbalance, misalignment,and loose connections waste energy dollars, making ROI calculation fast, easy, clear and unambiguous.

# Electric Power

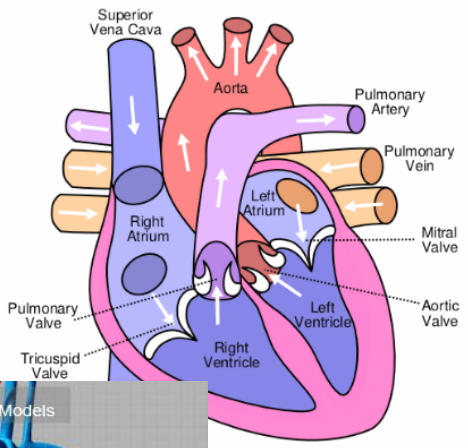


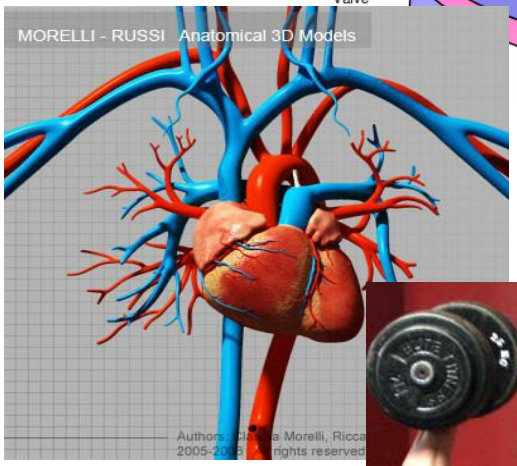







# Water

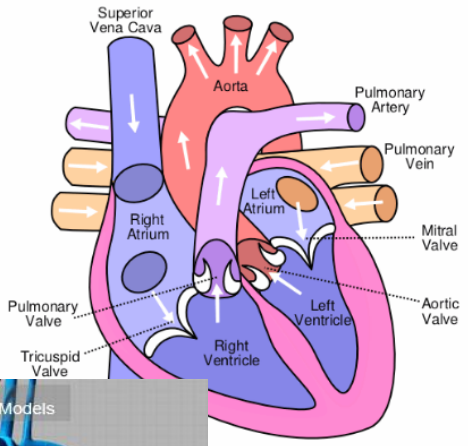

Superior
Vena Cava
Aorta
Pulmonary
Artery
Pulmonary
Vein
Left
Atrium
Right
Atrium
Mitral
Valve
Pulmonary
Valve
Aortic
Valve
Left
Ventricle
Tricuspid
Valve
Right
Ventricle


MORELLI - RUSSI Anatomical 3D Models


SGS


UPPER HUNTER
GLOUCESTER
DUNGOG
GREAT LAKES
SINGLETON
MAITLAND
PORT STEPHENS
CESSNOCK
NEWCASTLE
WATER TREATMENT PLANT
RAW WATER
TREATED WATER

# Shop Air


Superior
Vena Cava
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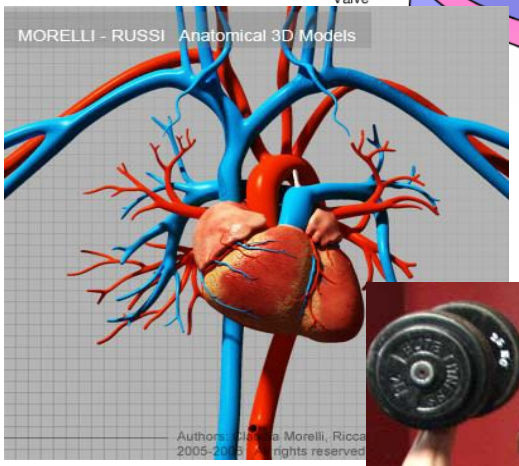
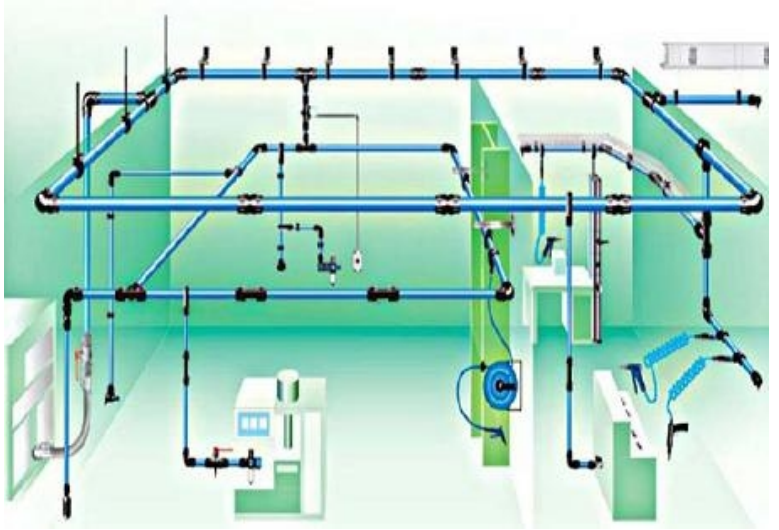
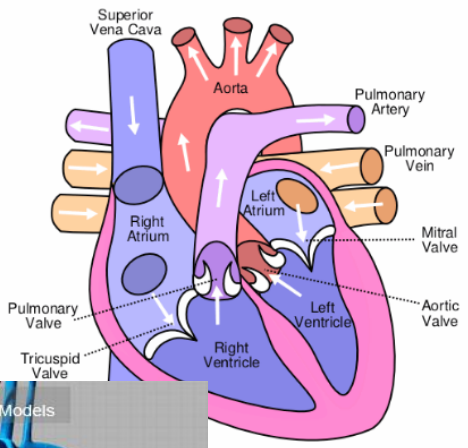
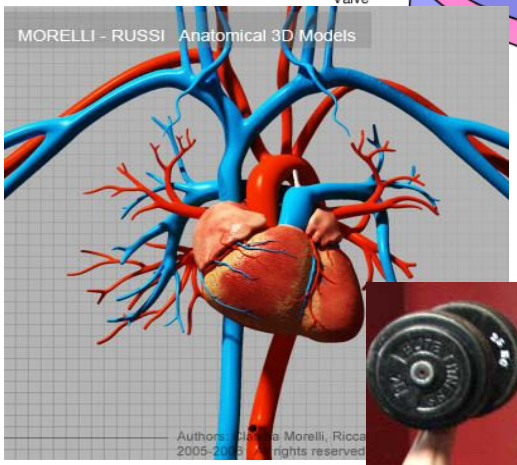

MORELLI - RUSSI Anatomical 3D Models


SGS

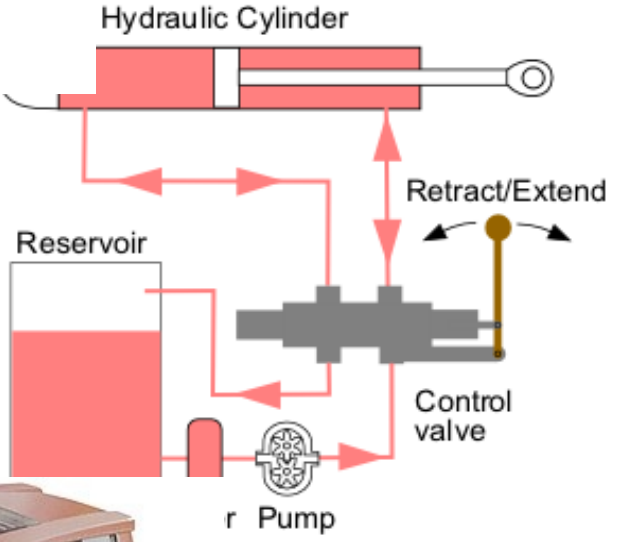


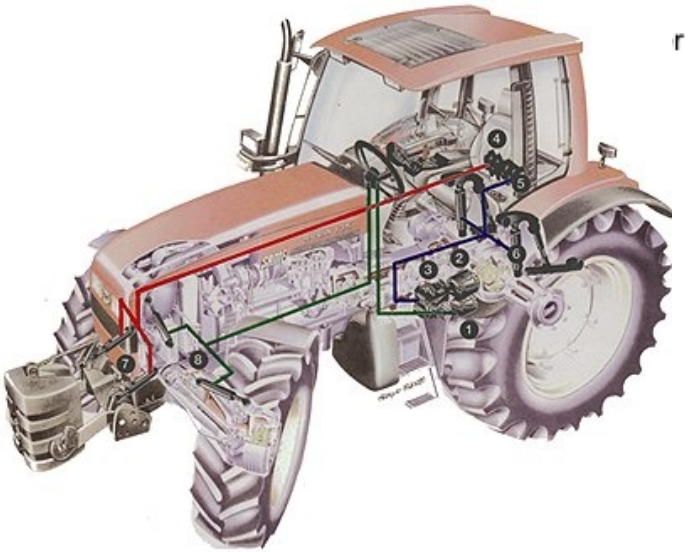
# Hydraulics


Superior Vena Cava
Aorta
Pulmonary Artery
Pulmonary Vein
Left Atrium
Right Atrium
Mitral Valve
Pulmonary Valve
Aortic Valve
Left Ventricle
Tricuspid Valve
Right Ventricle


MORELLI - RUSSI Anatomical 3D Models


SGS


Hydraulic Cylinder
Retract/Extend
Reservoir
Control valve
r Pump



| Man | Machine |
| --- | --- |
| Calories | Motor Kilowatts |
| Physical Balance | Phase Balance |
| Food | Coal, Oil, Gas, Wind |
| Blood Pressure | Motor Voltage |
| Blood Flow | Motor Current |
| Temperature | Temperature |
| Pulse Frequency | Line Frequency |

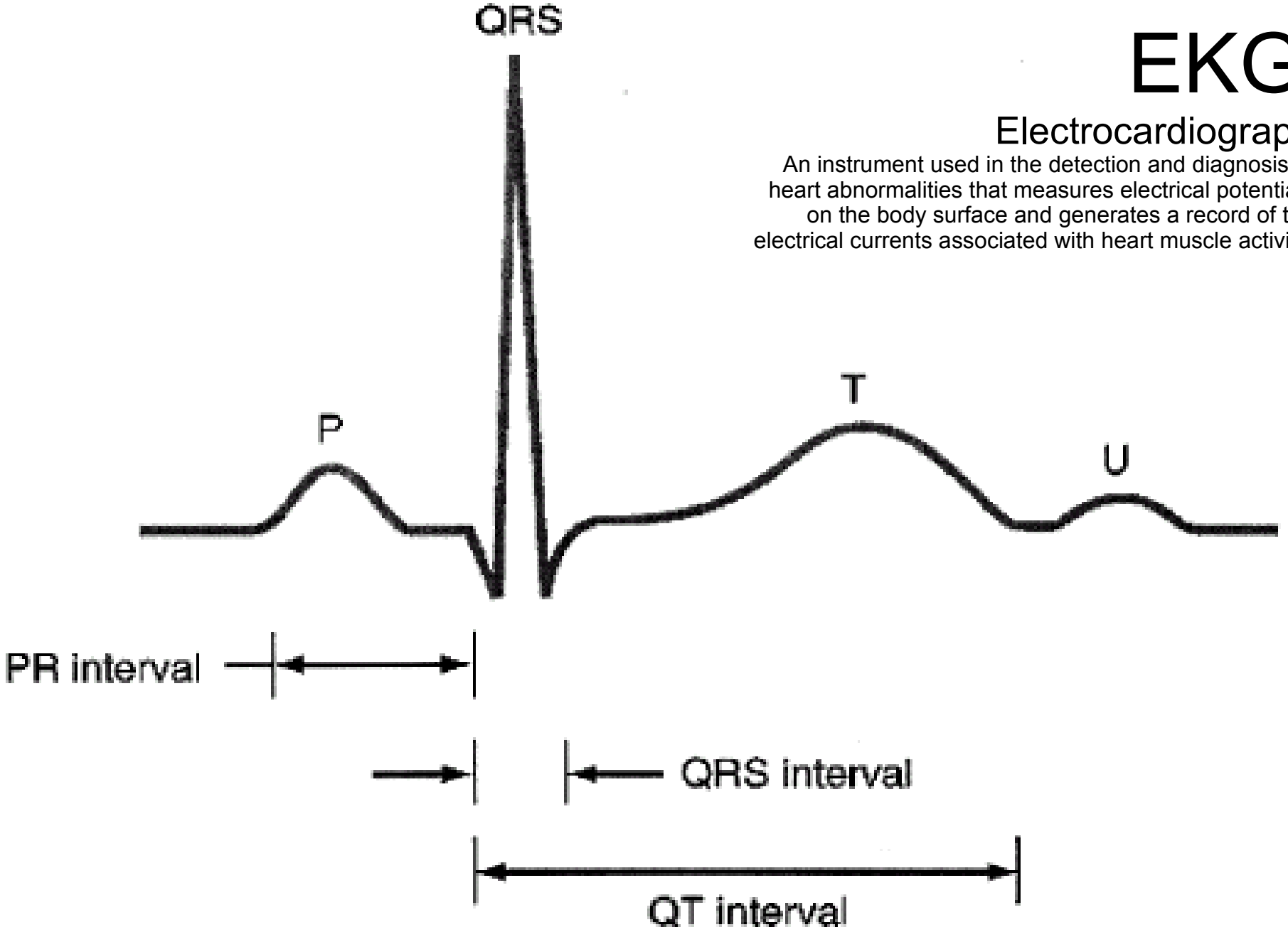
# Common Faults

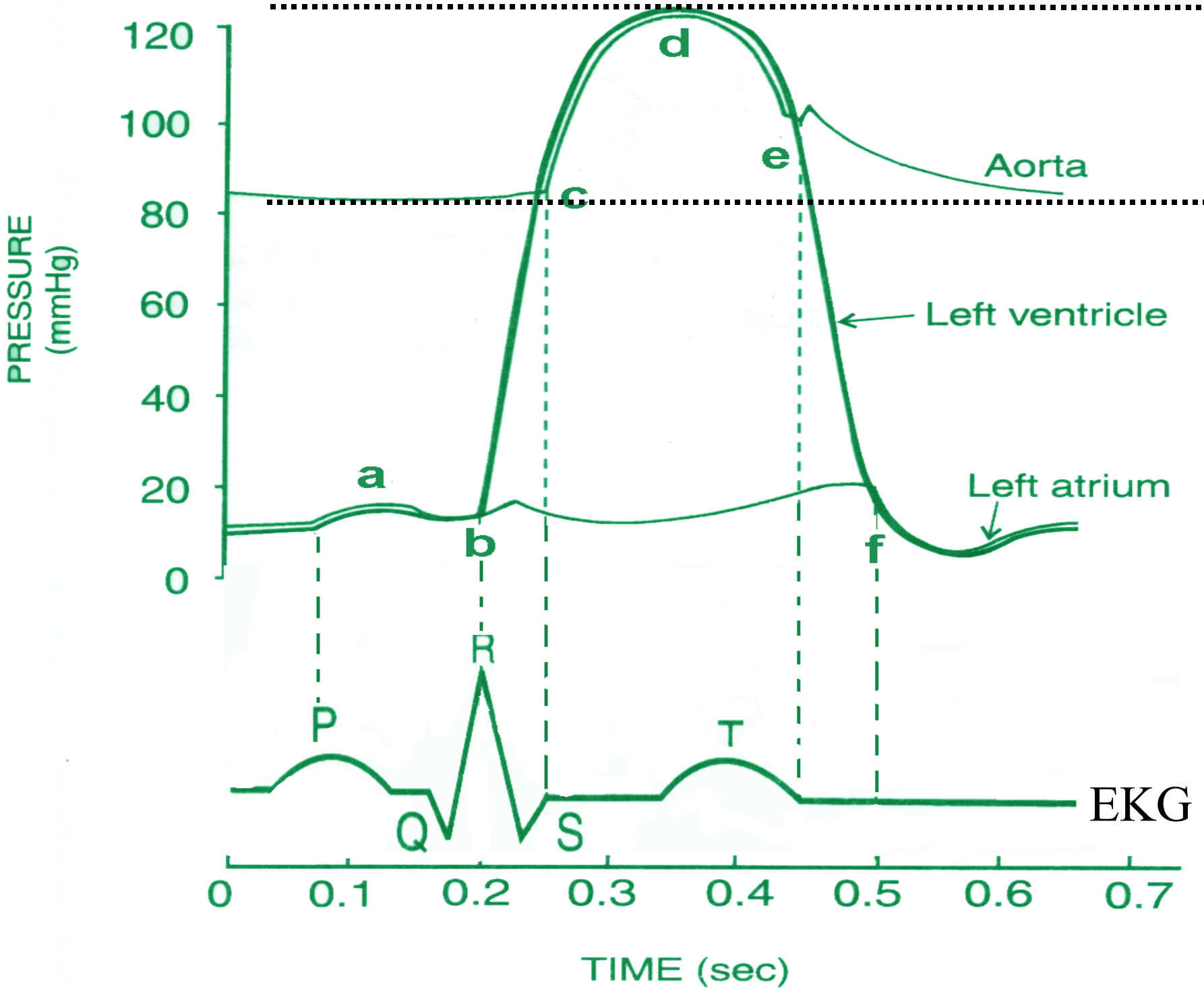
| **Man** | **Machine** |
| --- | --- |
| High blood pressure | Unbalance |
| Injured knee | Worn Out Bearings |
| Headache | Contaminated Oil |
| Heart valve failure | Misalignment |
| Kidney stones | Loose hold-down bolts |
| Blocked artery | Shorted Motor windings |
| Food Poisoning | Overheating |
| Blood disease | Fatigued fittings, connections |
| Hearing Loss | Unbalanced Volts, Amps |
| | Inefficient operating point |

# EKG

## Electrocardiograph

An instrument used in the detection and diagnosis of heart abnormalities that measures electrical potentials on the body surface and generates a record of the electrical currents associated with heart muscle activity.




120
100
80
60
40
20
0
PRESSURE (mmHg)
a
b
c
d
e
f
Aorta
Left ventricle
Left atrium
P
Q
R
S
T
EKG
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
TIME (sec)

# EKG = Electrical Measurement

Non-invasive

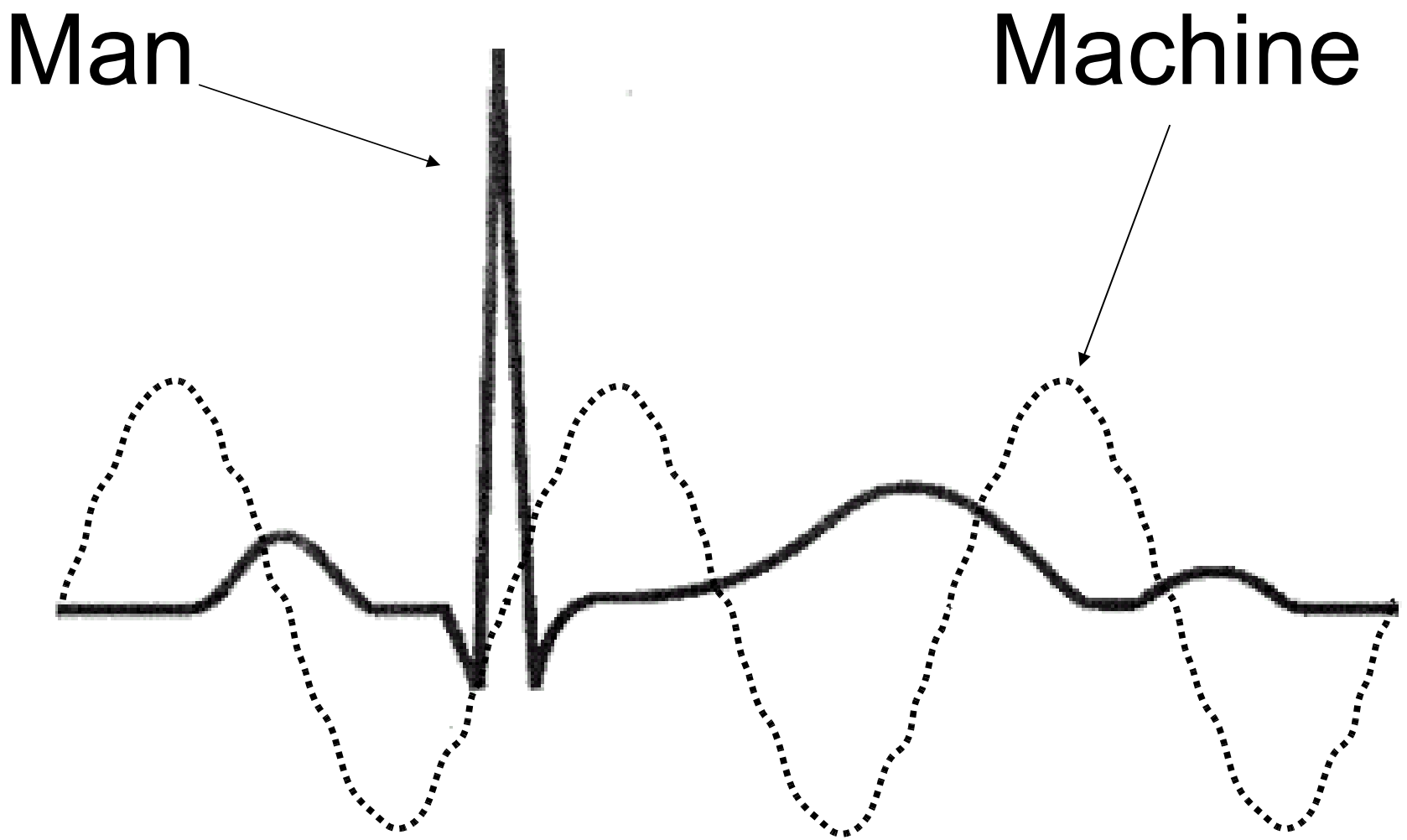
Easy to Measure, Trivial Procedure

Large Amount of Information

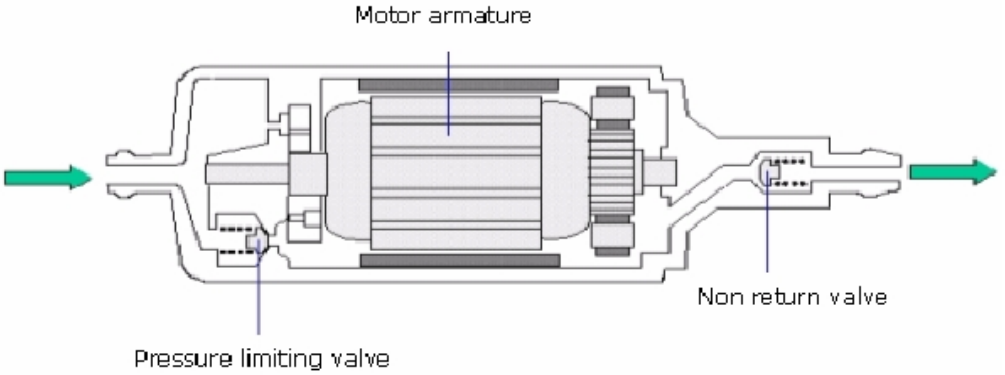
Directly Related to Condition

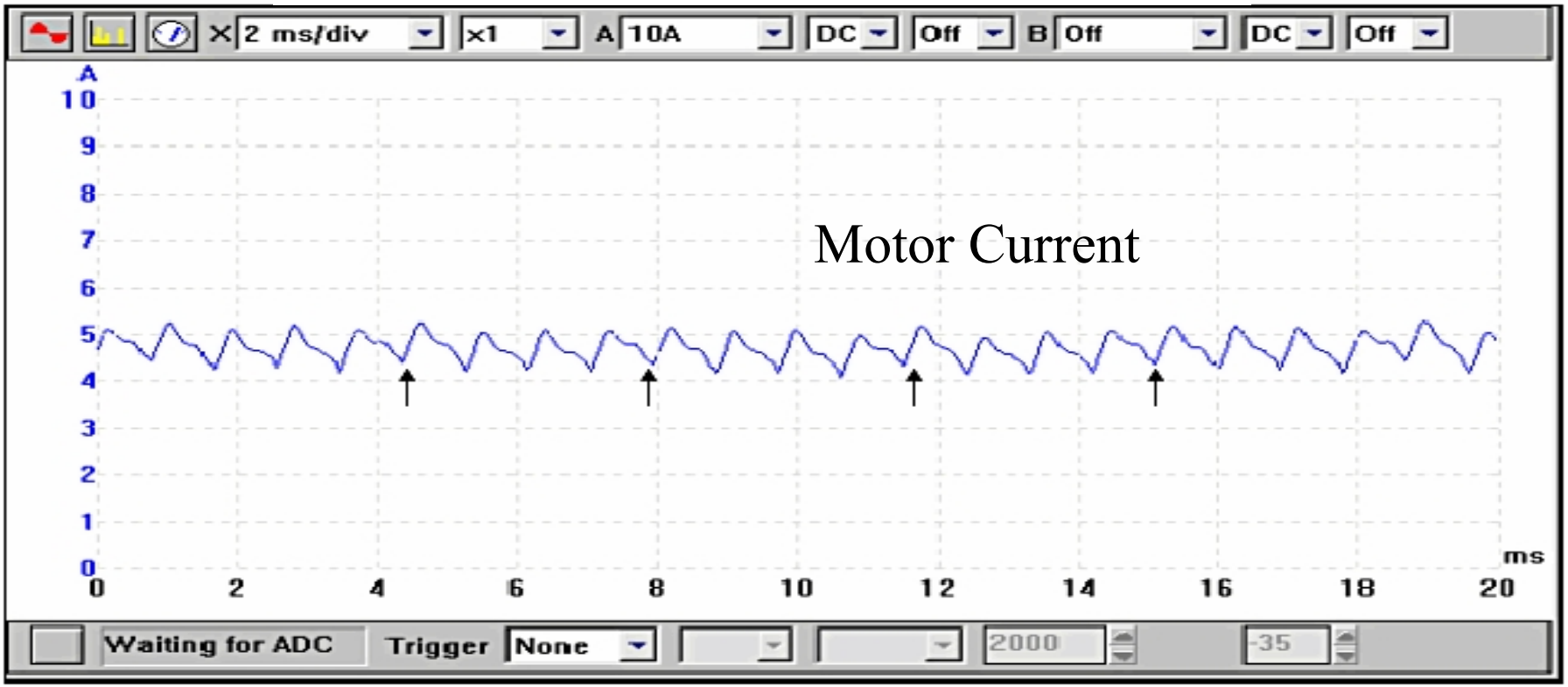
But - - ***difficult to interpret.***

A few examples....

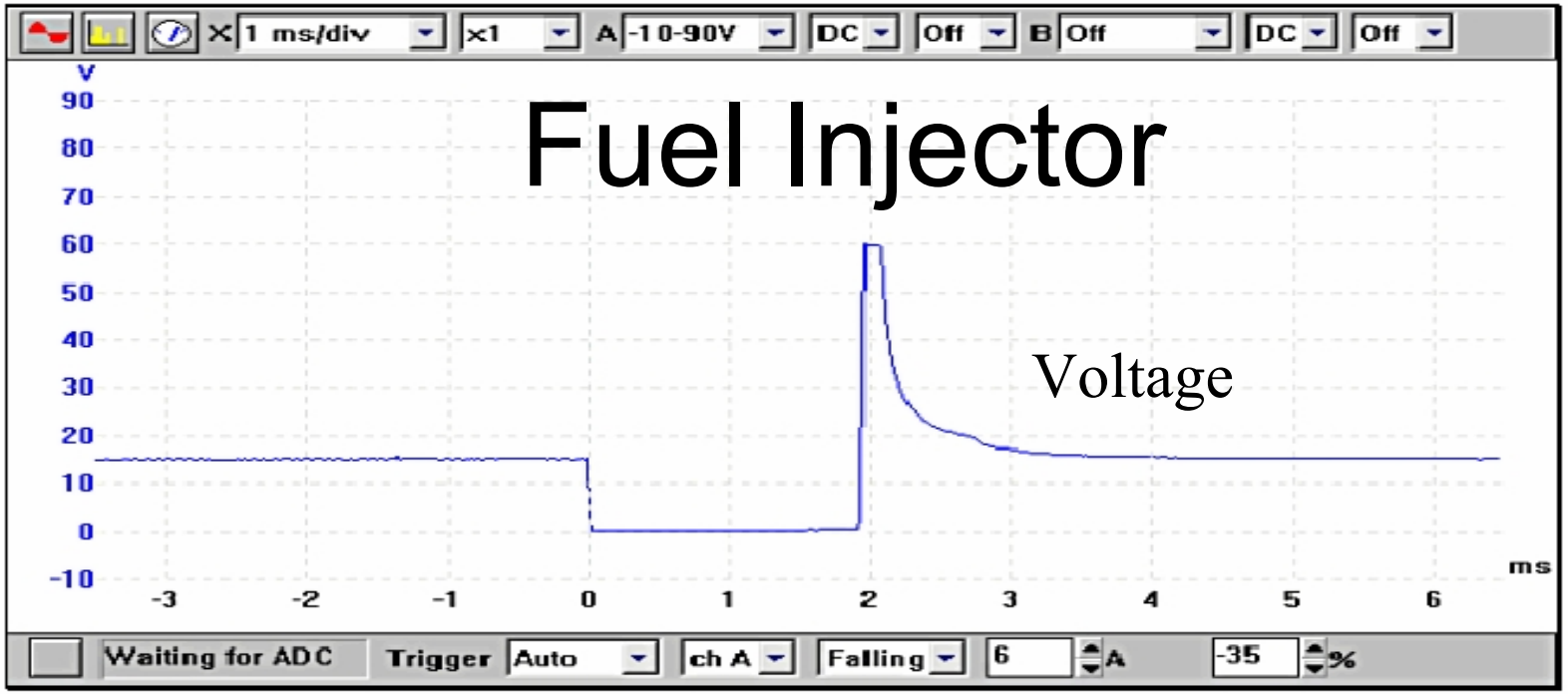

Man
Machine

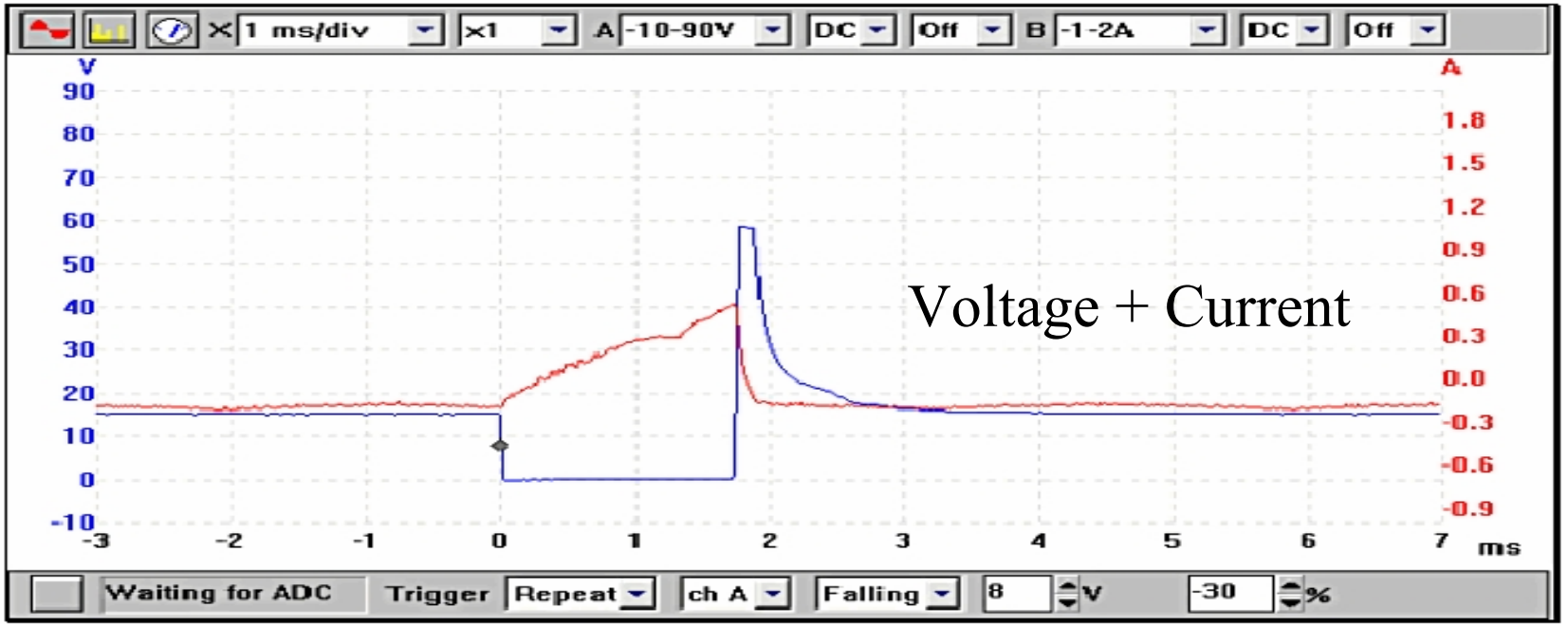
# Automotive Fuel Pump

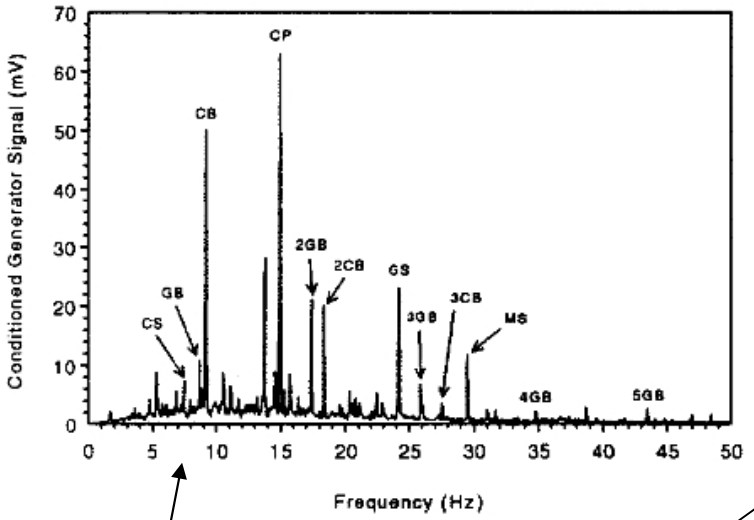


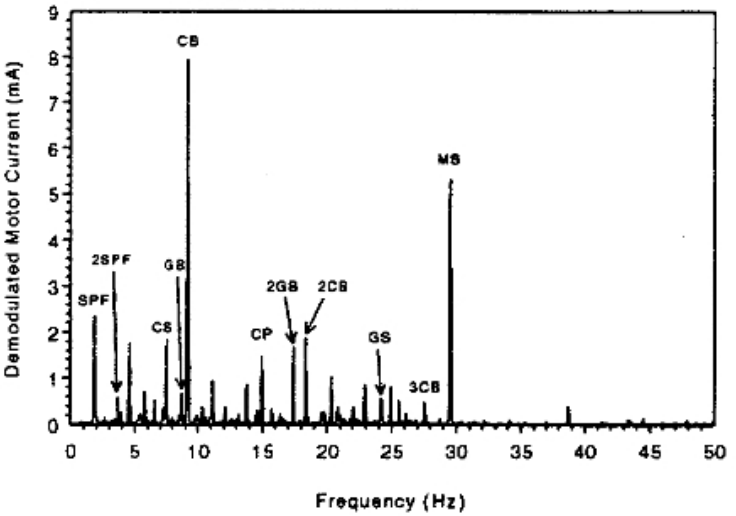



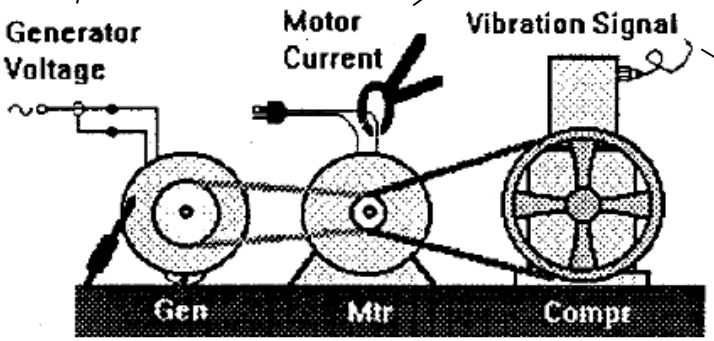
# Fuel Injector

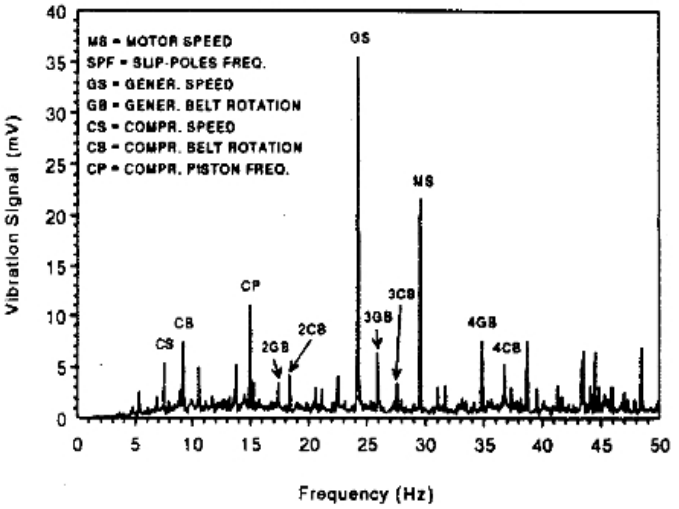


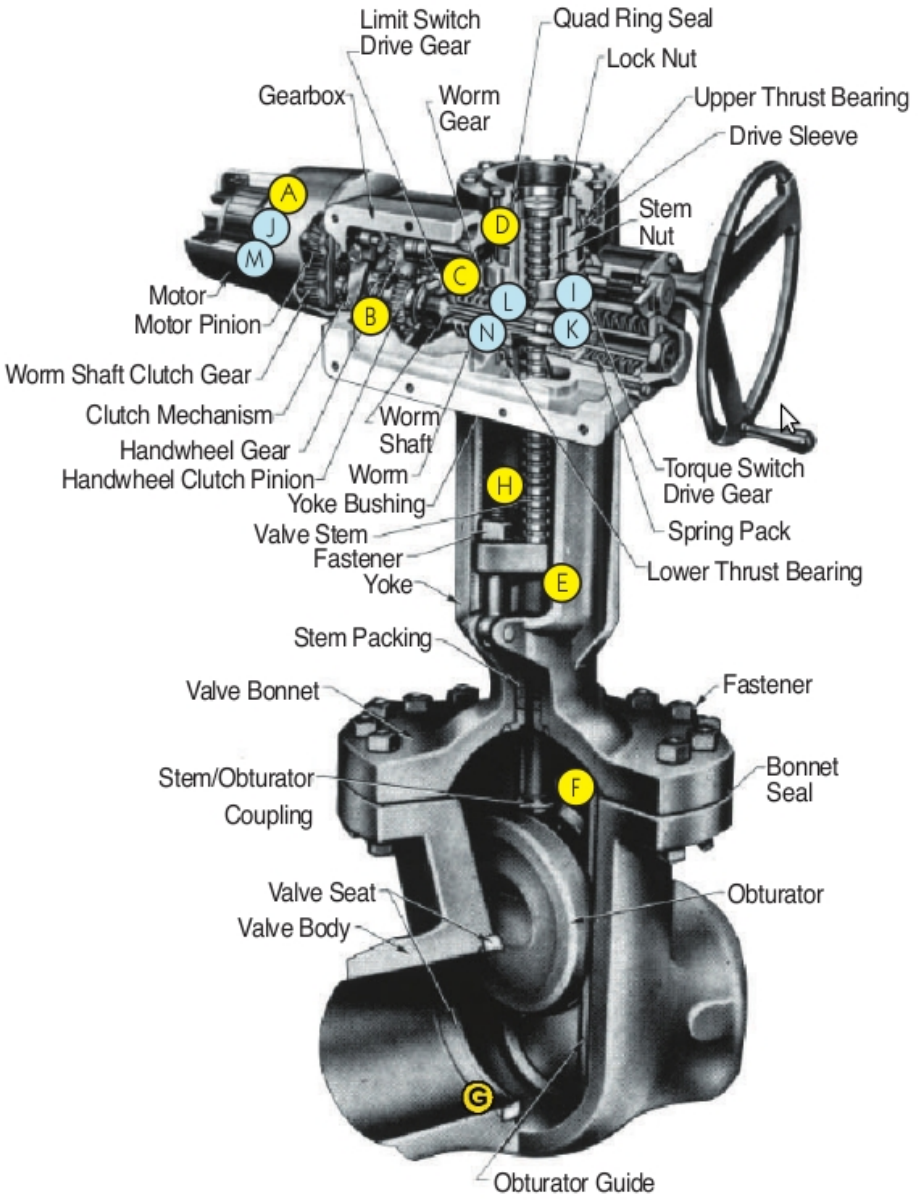


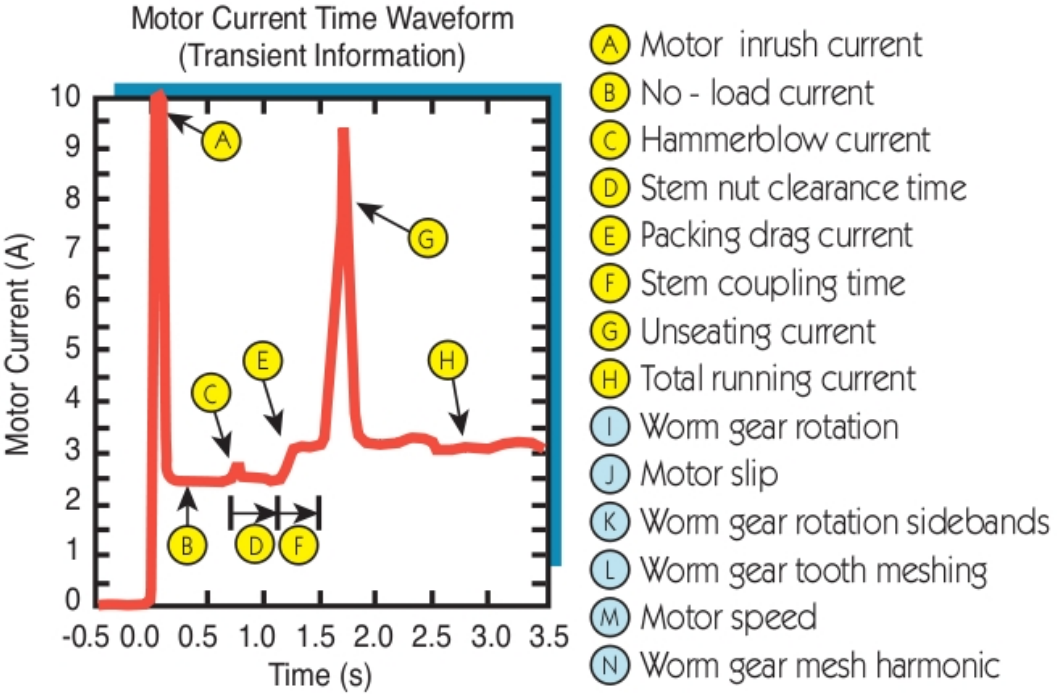



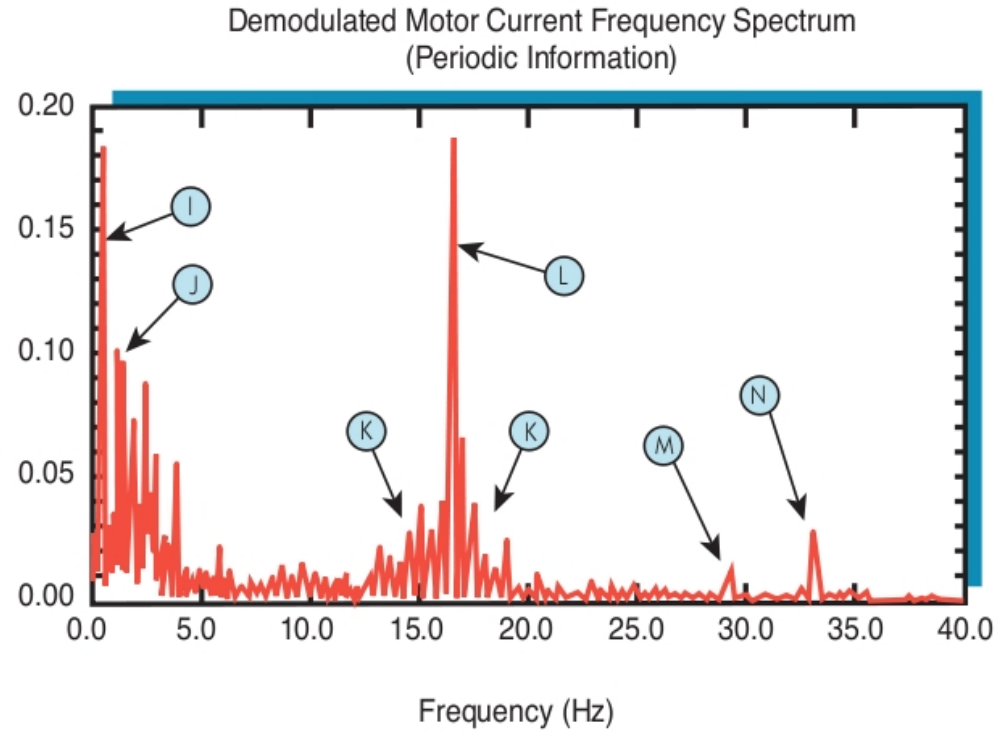




Courtesy Oak Ridge National Lab




Motor Operated Valve
(showing areas monitored by MCSA)




Courtesy Oak Ridge National Lab

# Machine Electrical Measurements

Non-invasive

Trivial Procedure – ***No sensors on, or instrument cables to, the machine***

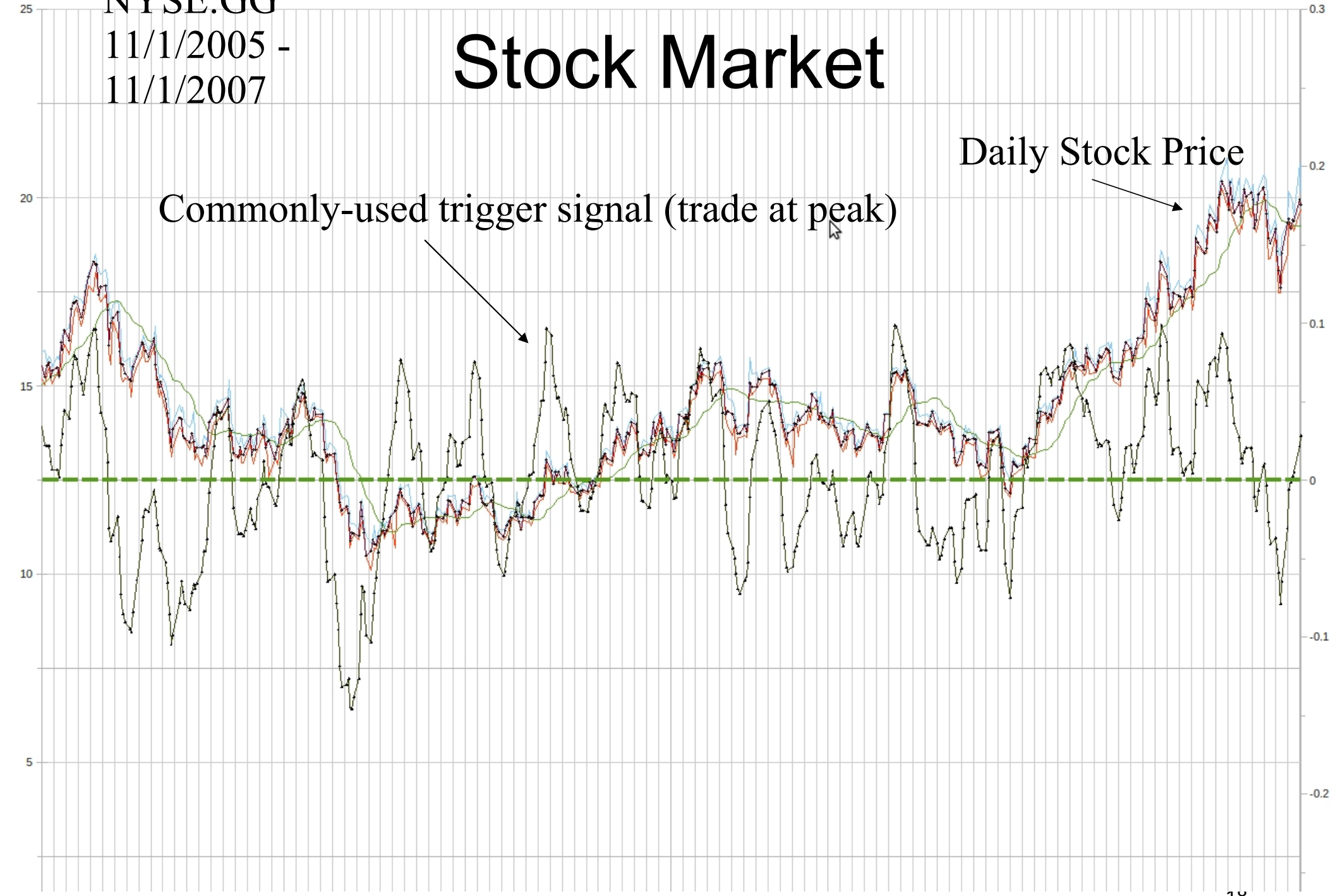
Large Amount of Information

Directly related to Machine Condition

But - - ***difficult to interpret***

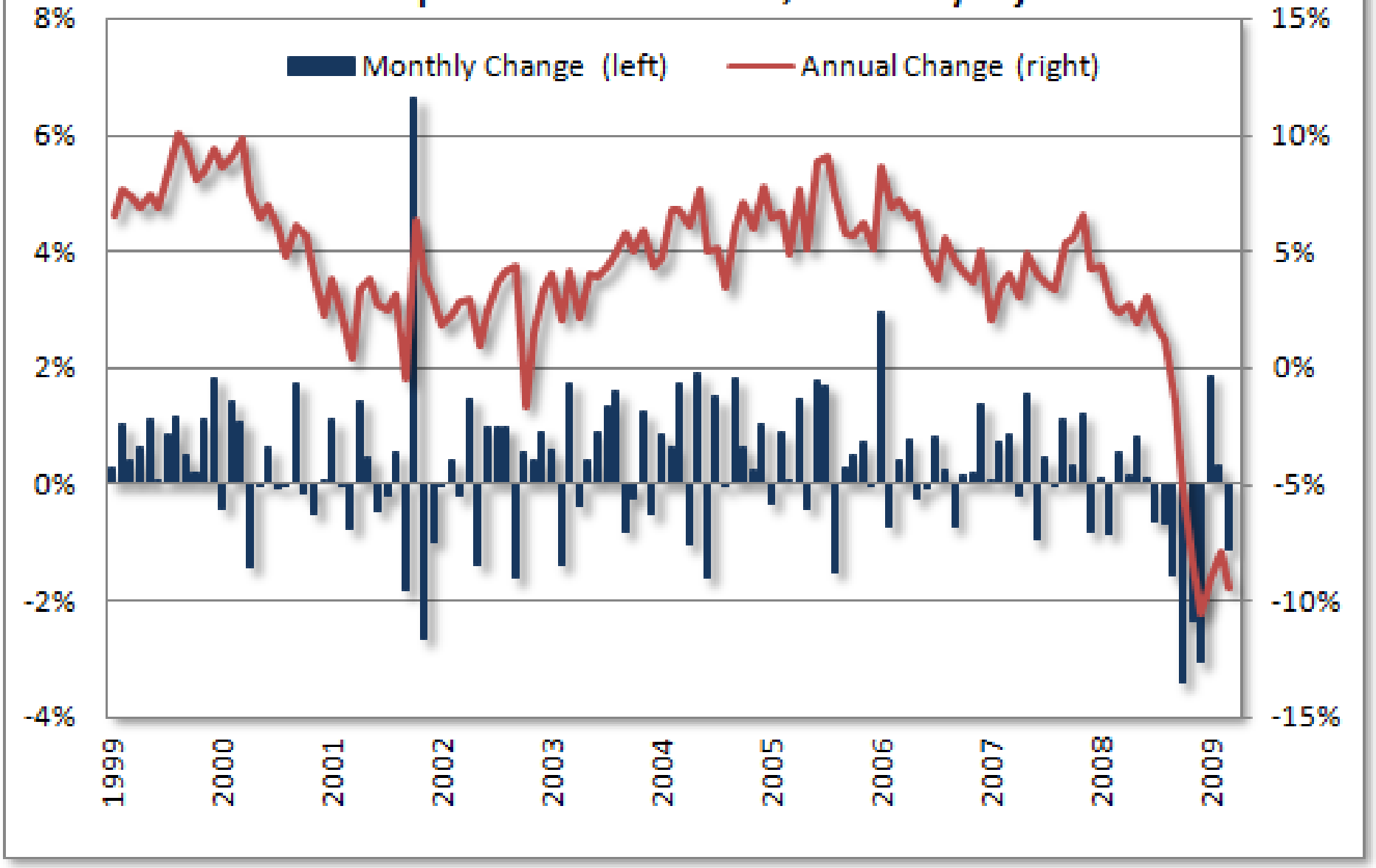
NYSE:GG
11/1/2005 -
11/1/2007

# Stock Market



# Retail Sales

Source: Department of Commerce, Seasonally Adjusted



# Business Data

Non-invasive

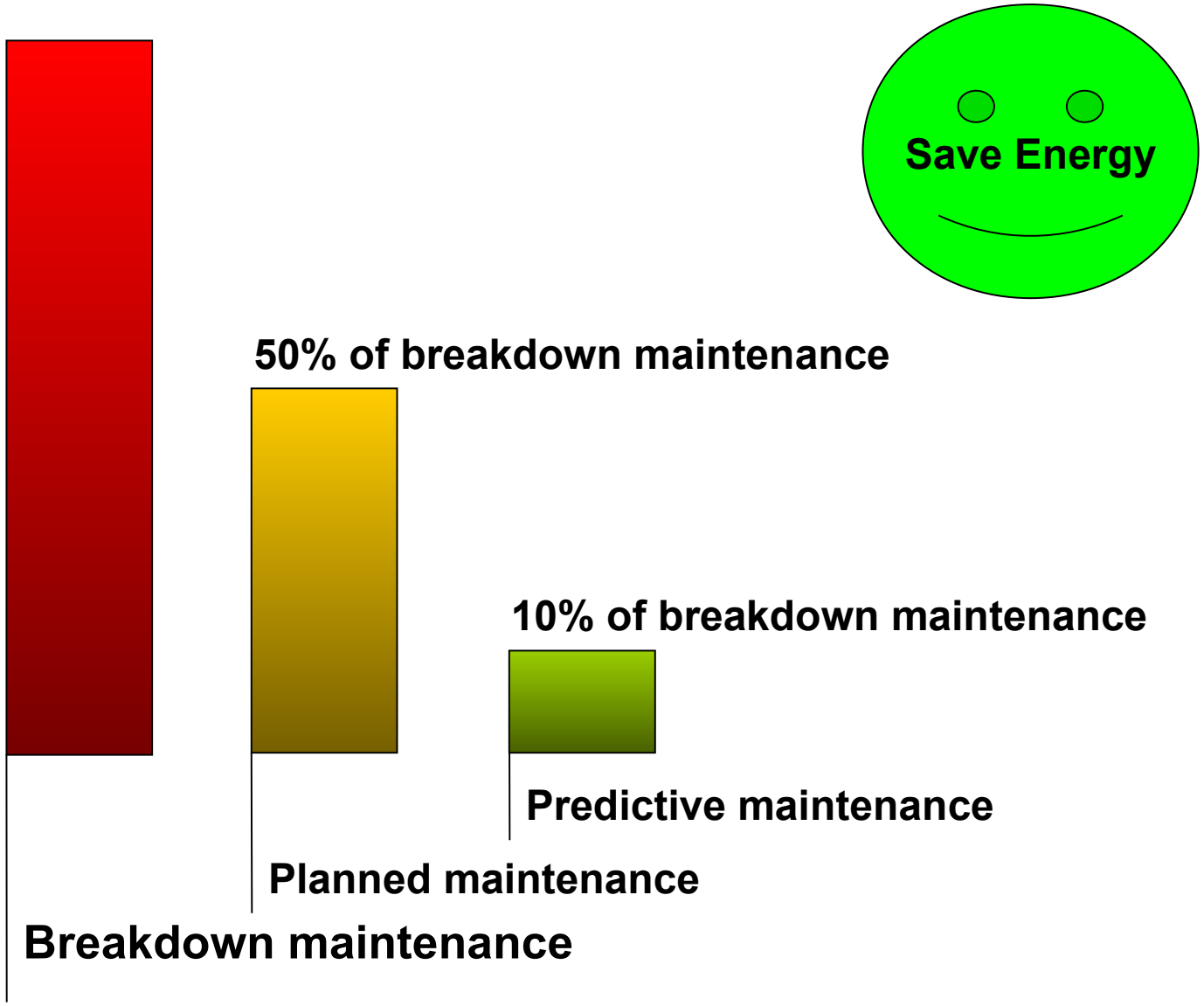
Easy to Acquire data

Large Amount of Information

Directly related to Condition

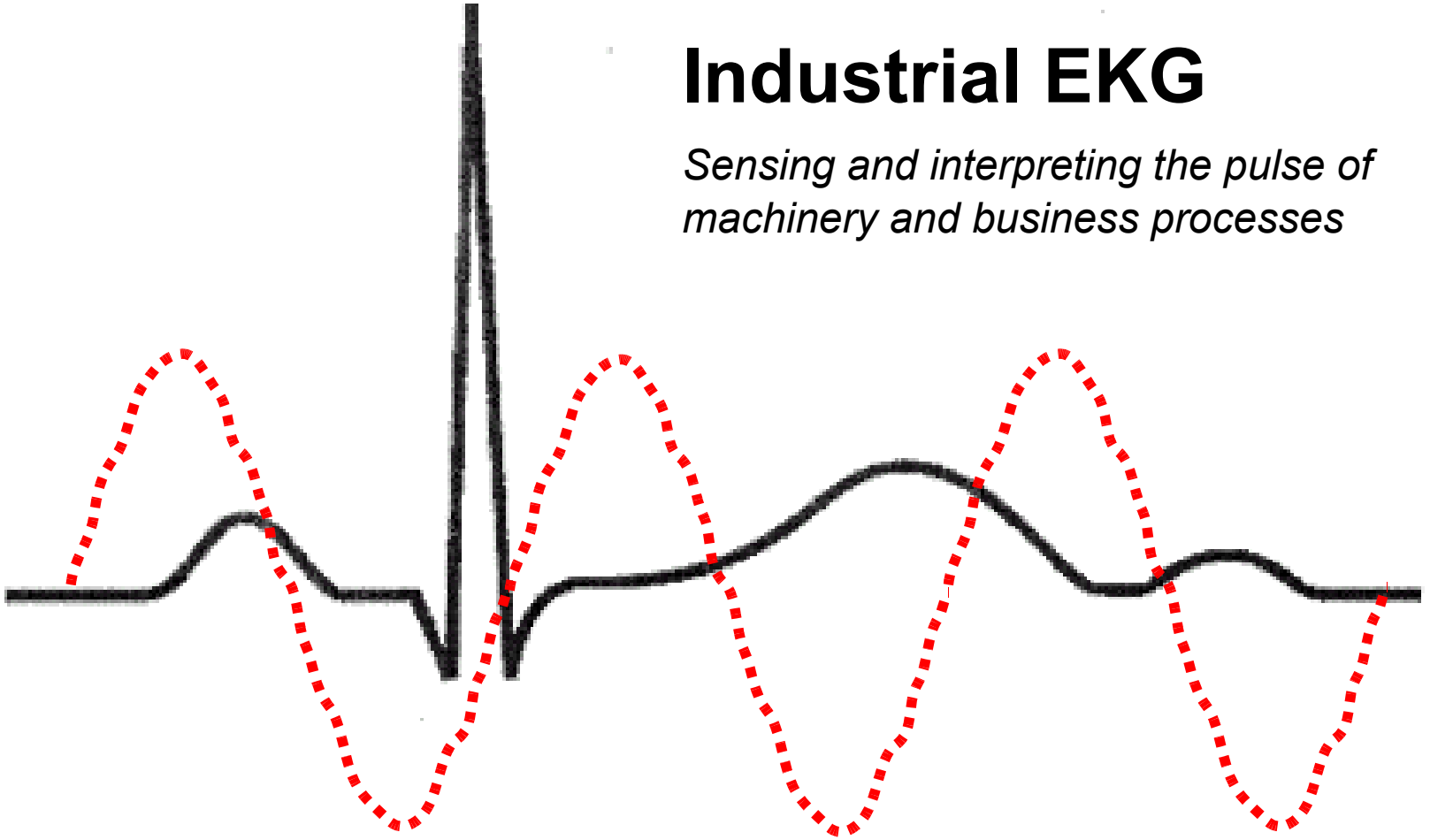
But - - ***difficult to interpret***

# Why Bother?
# Reduce Costs, Improve Availability.



# Industrial EKG

*Sensing and interpreting the pulse of machinery and business processes*



# Industrial Motors

62% of all electricity generated worldwide, powers industrial motors.

# There are a LOT of motors out there...

***One*** Chemical Plant in Louisiana, USA:

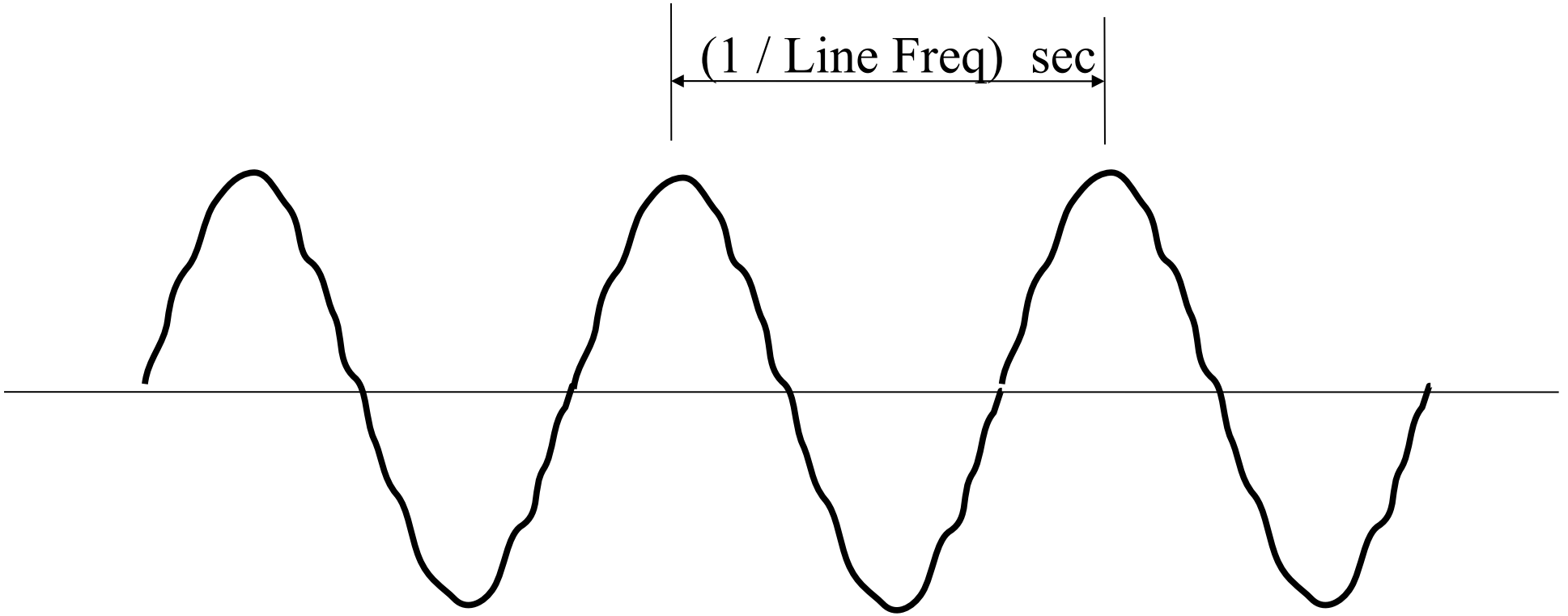
>2,000 motors

12,000 Horsepower to 1 Horsepower

10% of these are driving “Critical” systems

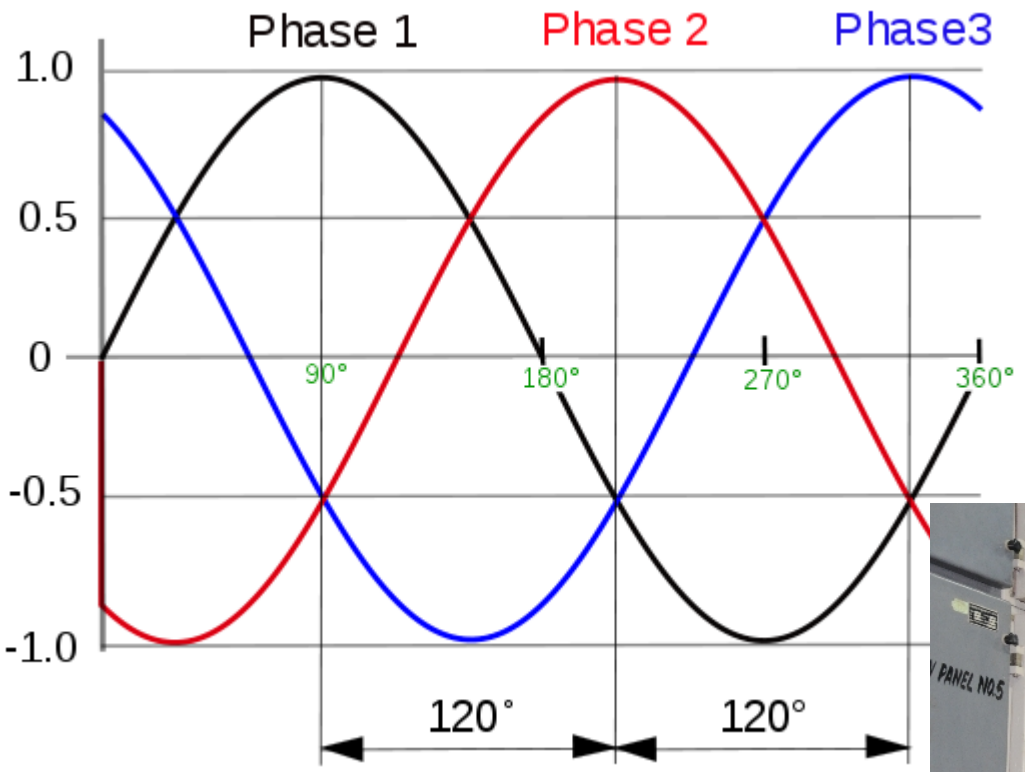
- Plant stops producing final product
- Widespread collateral damage if unexpected stop
- No spare, long lead time for replacement

# Fundamental Pulse, Induction Motor



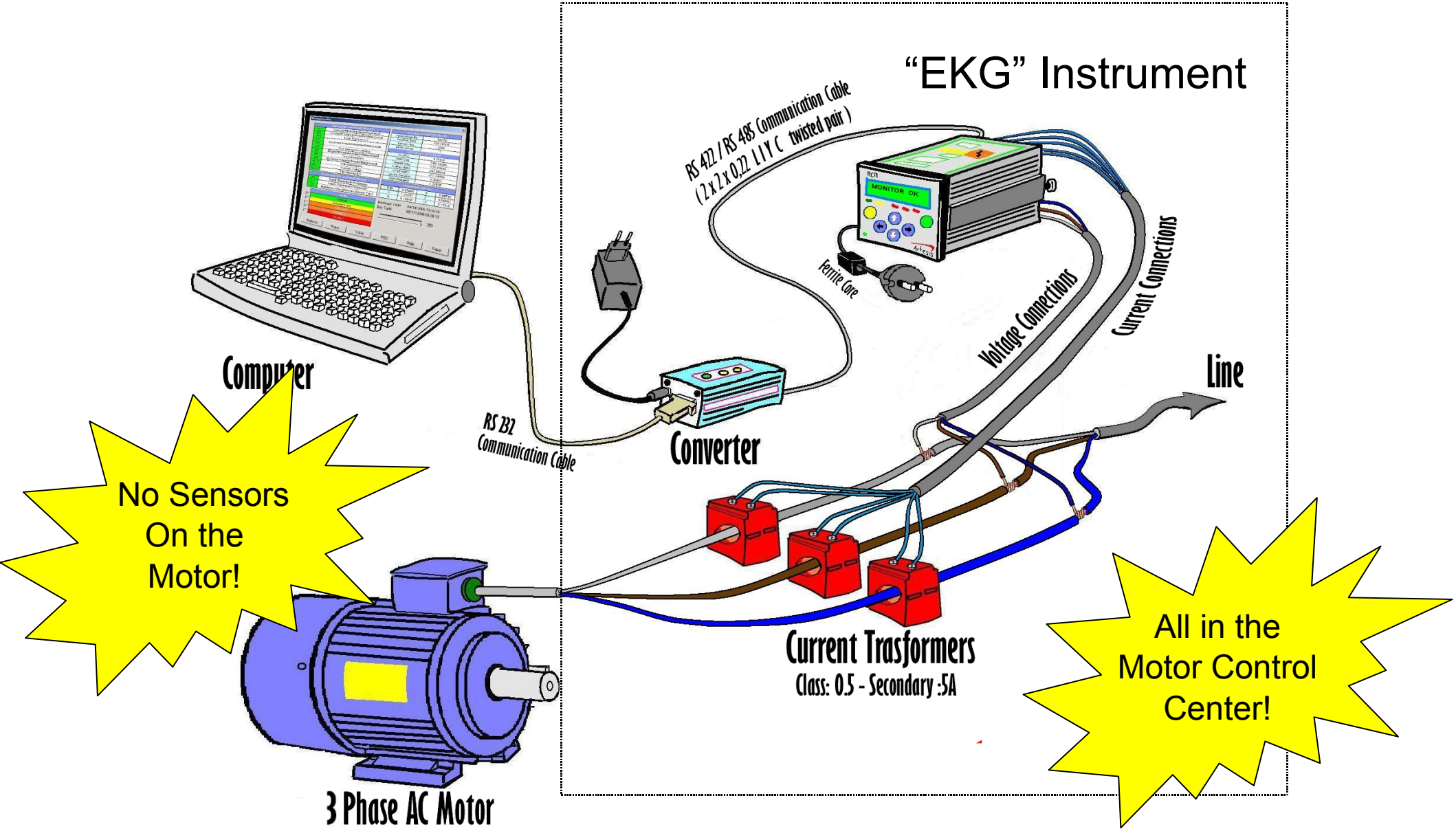

**Small Anomalies & Disturbances =**
**Clues to Supply, Motor, and Driven Equipment Condition**

# How to take a Motor's Pulse?

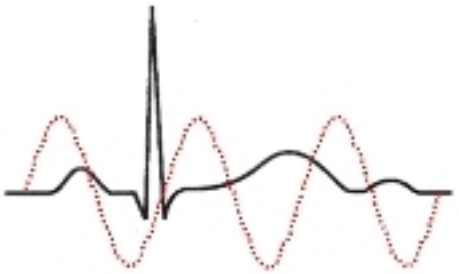



Motor Control Center (MCC)

# 3 Voltages, 3 Currents

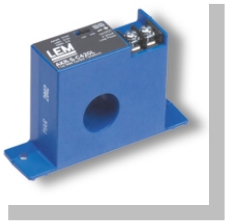


# Sensors

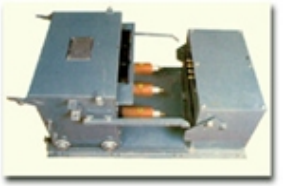


Fixed speed – Passive current transformers

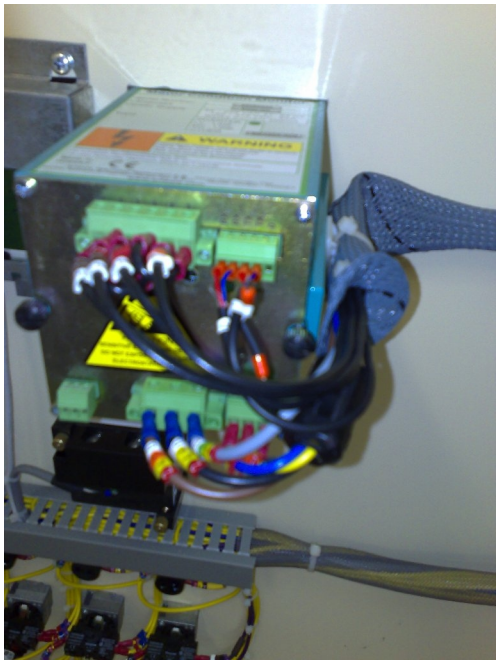
Variable speed – Hall-effect current transducers

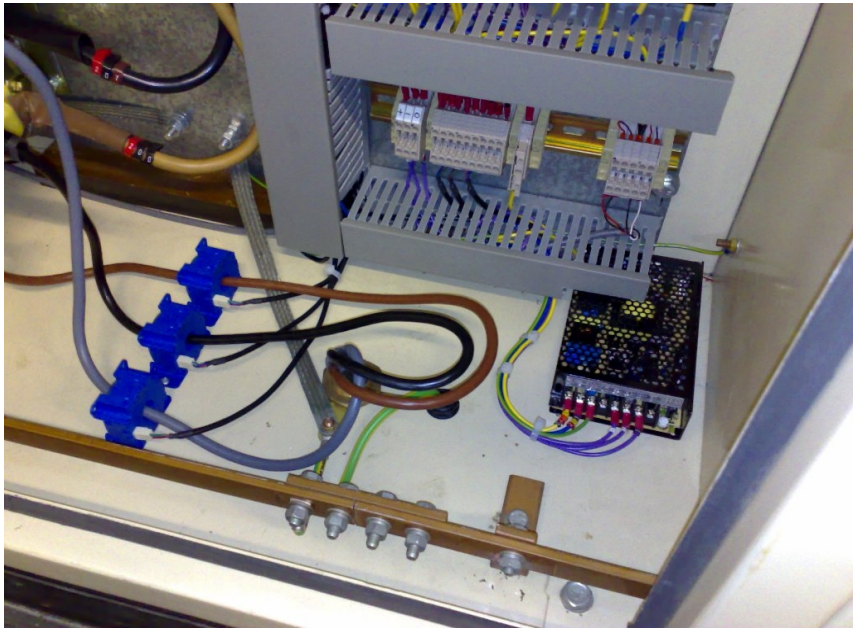


Medium/high voltage – potential transformers

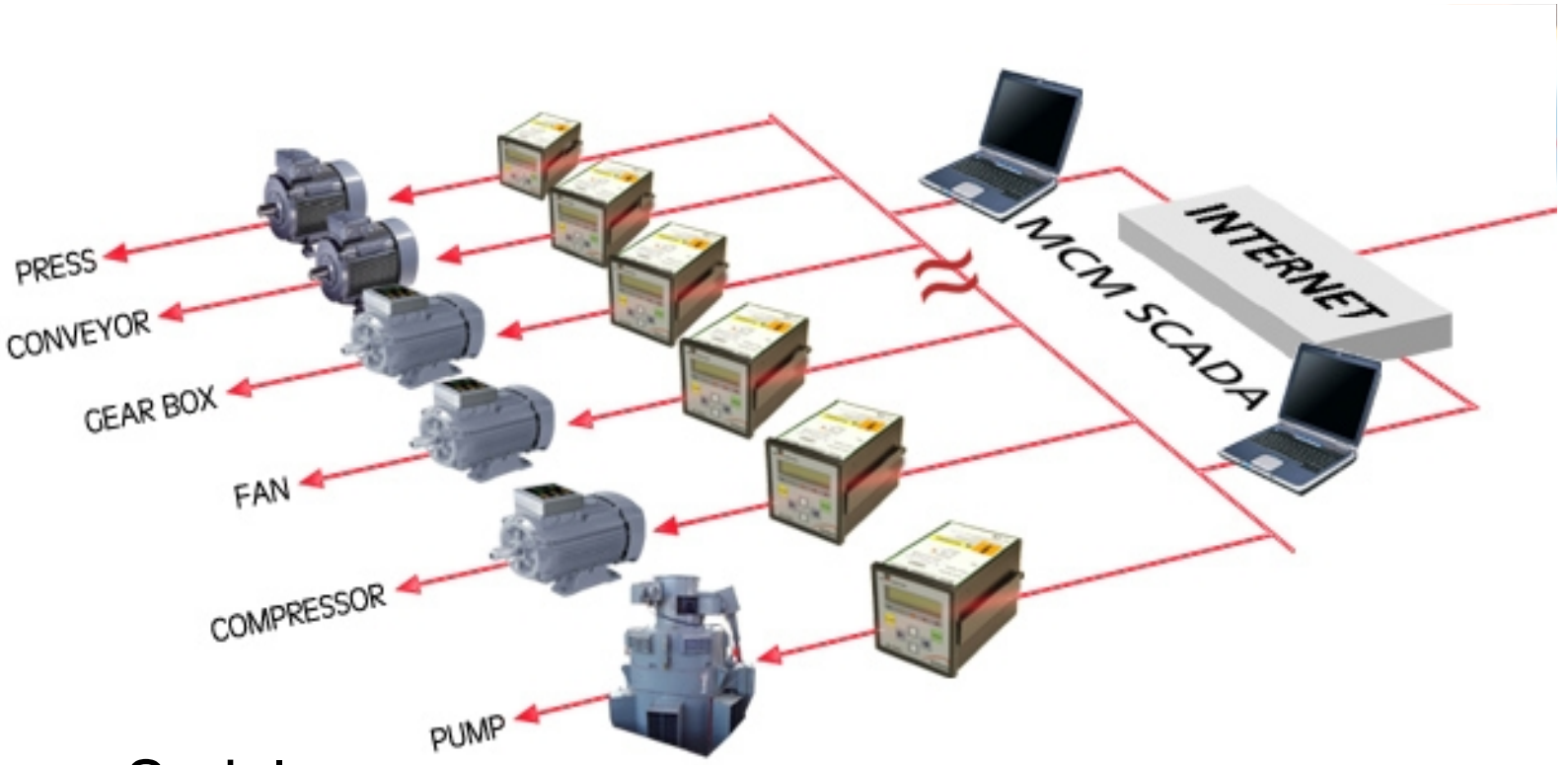


# Typical Installations



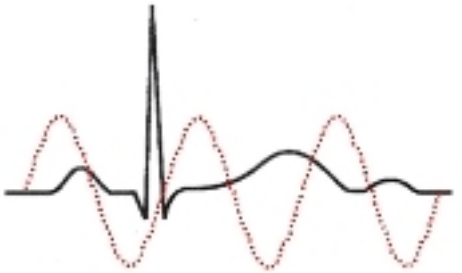



# Connects with other systems




- Serial
- Ethernet
- GPRS (cell phone network)
- Custom configuration

# What kinds of things can be monitored and diagnosed?



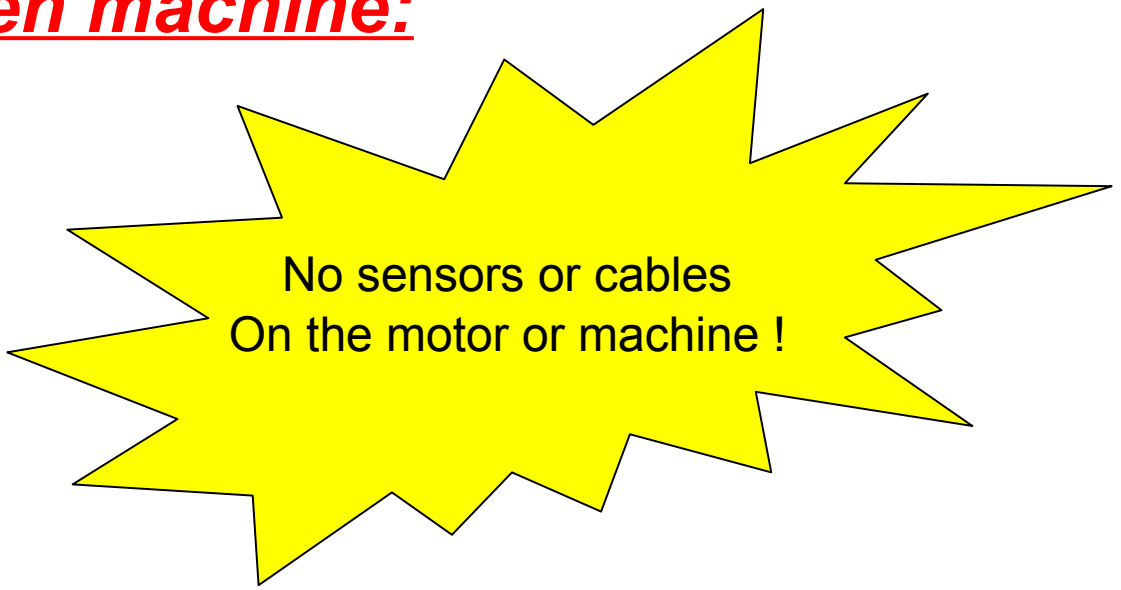
- ✓ Energy consumption
- ✓ Power line condition
- ✓ Electrical condition of motor
- ✓ Mechanical condition of motor
- ✓ Mechanical condition of driven load
- ✓ Process Variation

# What kinds of **Electrical faults** can be diagnosed?

- Unbalanced Voltage, Current
- Faulty Rotor Bars
- Energy + Power for individual phases
- Efficiency
- Insulation Breakdown
- Winding faults
- Capacitor Failure
- Weak / Loose Connections

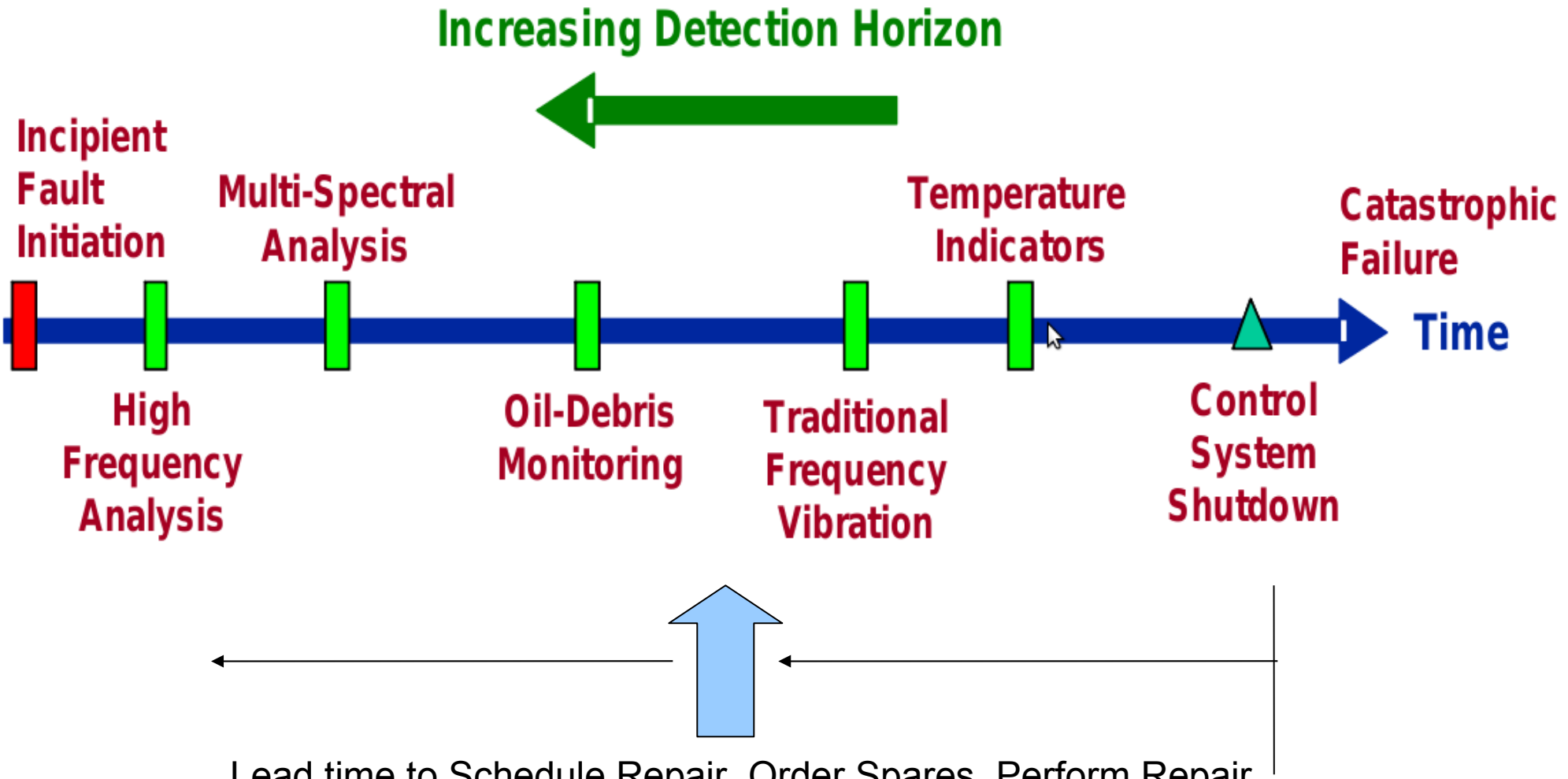
# What kinds of **Mechanical faults** can be diagnosed?

In the motor ***AND driven machine:***




- Unbalance
- Misalignment
- Bearing faults
- Looseness
- Drive belt, transmission, gearbox, coupling faults
- Impeller, blade, vane, piston degradation
- Motor rotor eccentricity
- Process anomalies

# How Early is Detection Required?



# 5 HP Industrial AC Induction Motor Phase Unbalance

| Characteristic | Performance | | |
|---|---|---|---|
| Average voltage | 230 | 230 | 230 |
| Percent unbalanced voltage | 0.3 | 2.3 | 5.4 |
| Percent unbalanced current | 2.4 | 17.7 | 40 |
| Increased temperature * rise ( ∞C) | <1 | 11 | 60 |

* *A 10 deg-C rise in operating temperature reduces motor life by 1/2*

Courtesy EPRI

# How Does it Work?

(Theory)

*Measured Current*

*Measured Voltage*

Compare

Differences

Internal Model

*Predicted Current*

Patented !

STOP

PERFORM MAINTENANCE

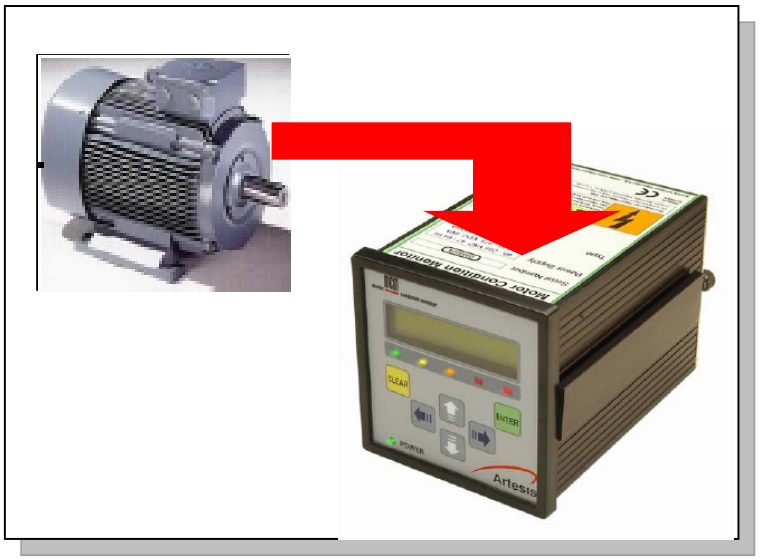
WATCH LOAD

WATCH LINE

OK

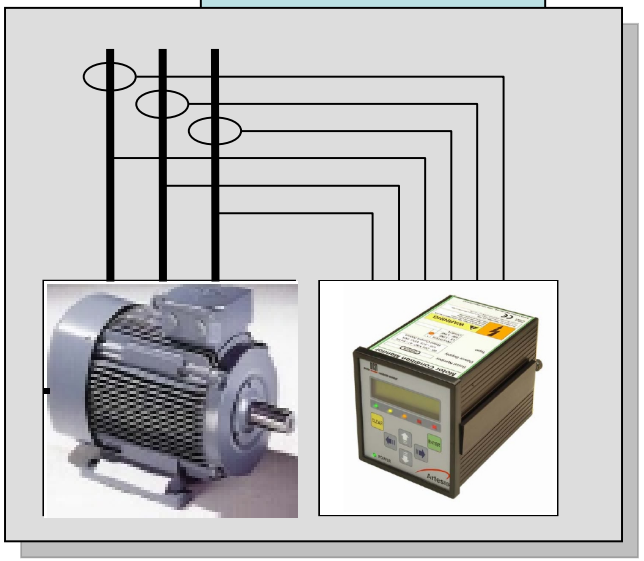
*Model is based on testing & analyzing* ***tens of thousands of motors***

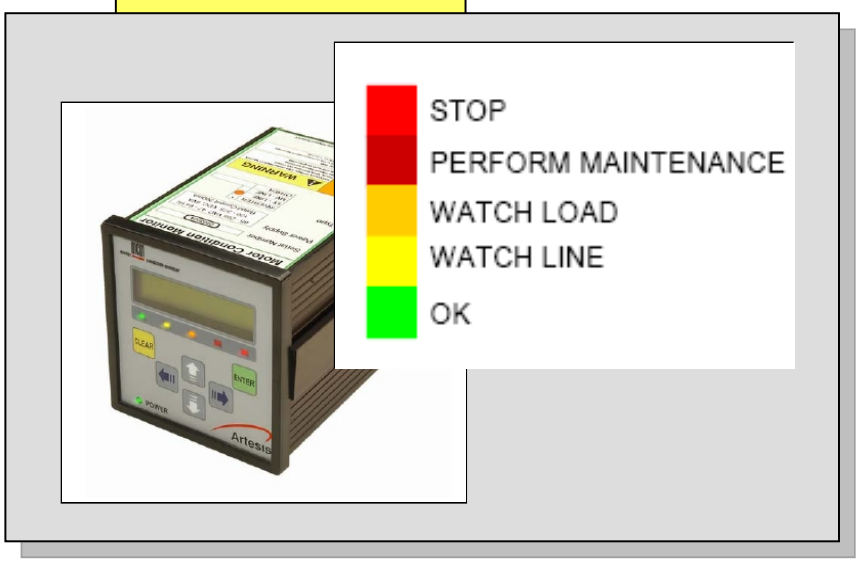
# How Does it Work?
(Operation)



*Unattended !*

**Install** → **Train** → **Run**

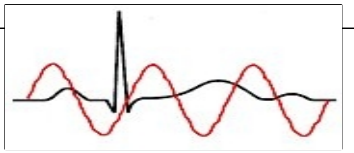




# Condition assessment reports

**Produced automatically after learning**

**Summary of current condition of equipment**



## CONDITION ASSESSMENT REPORT

Company : Exco Corp
Coordinator : Dan Jones
Equipment : Feed pump #3

Analyst : John Wood
Date : 25 August 08

**Performance Summary**

Motor and machine are operating normally.

WATCH LINE. Temporary changes in supply voltage cause this alarm. If alarm is persistent check: harmonic levels; capacitors; supply cable isolation; motor connector or terminal slackness; contactor connections.

WATCH LOAD. If the process has not been altered deliberately check: leakages; blade and vane adjustments; pressure gauge faults; manometer problems; and filter fouling. If the process has been altered deliberately, MCM/PCM should be updated.

PERFORM MAINTENANCE. There are indications of mechanical and/or electrical faults developing as shown below. Maintenance should be scheduled according to the severity level.

**Severity Level**

| Caution | Low | x | Medium | High | Urgent |
|---|---|---|---|---|---|

**Energy Efficiency**

Power factor (Cos Phi) is below 0.80.

**Current and Voltage**

The average RMS values of the current phases exceed 5% of the nominal current values. Monitor for increased hot spot temperature.

Voltage variation is beyond normal limits. Its source should be determined and corrected.

**Current Harmonic Distortion**

There is evidence of harmonic distortion. If Total Harmonic Distortion (THD) is more than 10%, this causes heating, and vibration. Increase of third harmonic causes heating in stator winding. If the fifth harmonic increases, this causes vibration. Harmonic filters can be used for very high values if appropriate and economical.

**Current and Voltage Unbalance**

Current unbalance is more than 5%. Motor or machine should be checked and remedied for regards stator, short circuit, isolation, partial discharge etc. faults.

Voltage unbalance is more than 5%. Voltage unbalance causes heating by increasing the current unbalance more. It should be checked and remedied.

**Electrical Fault Indications**

There is evidence of internal electrical fault. Motor or machine should be checked for rotor, stator, short circuit, isolation, winding slackness faults.

There is evidence of external electrical fault. Cables, contactor, compensation system, and motor connections should be checked.

Stator, short circuit, slackness, isolation, and partial discharge faults should be checked.

Rotor and rotor bars (such as slackness, or cracking) should be checked.

**Mechanical Fault Indications**

There is evidence of misalignment/unbalance. Motor or machine should be checked for misalignment, unbalance, bearing, coupling, and motor shaft faults.

Transmission elements; coupling, driven equipment, belt, pulley, gear box, and propeller of fan and pump etc. should be checked.

Bearing(s) should be checked.

Loose motor foundation and loose motor component should be checked.

**Action advice based on fault severity**

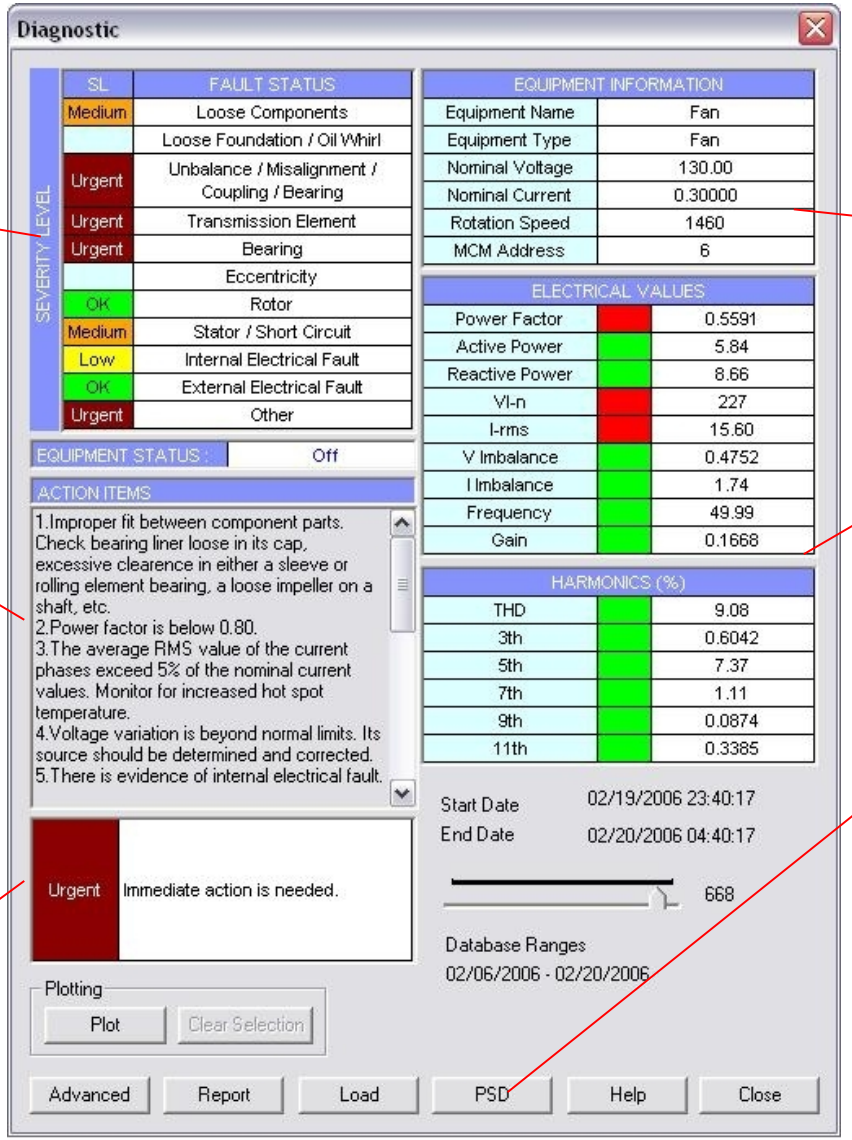
**Detailed fault descriptions**

# Diagnostic information

**Fault diagnosis and severity level**

**Condition assessment report**

**Action urgency**

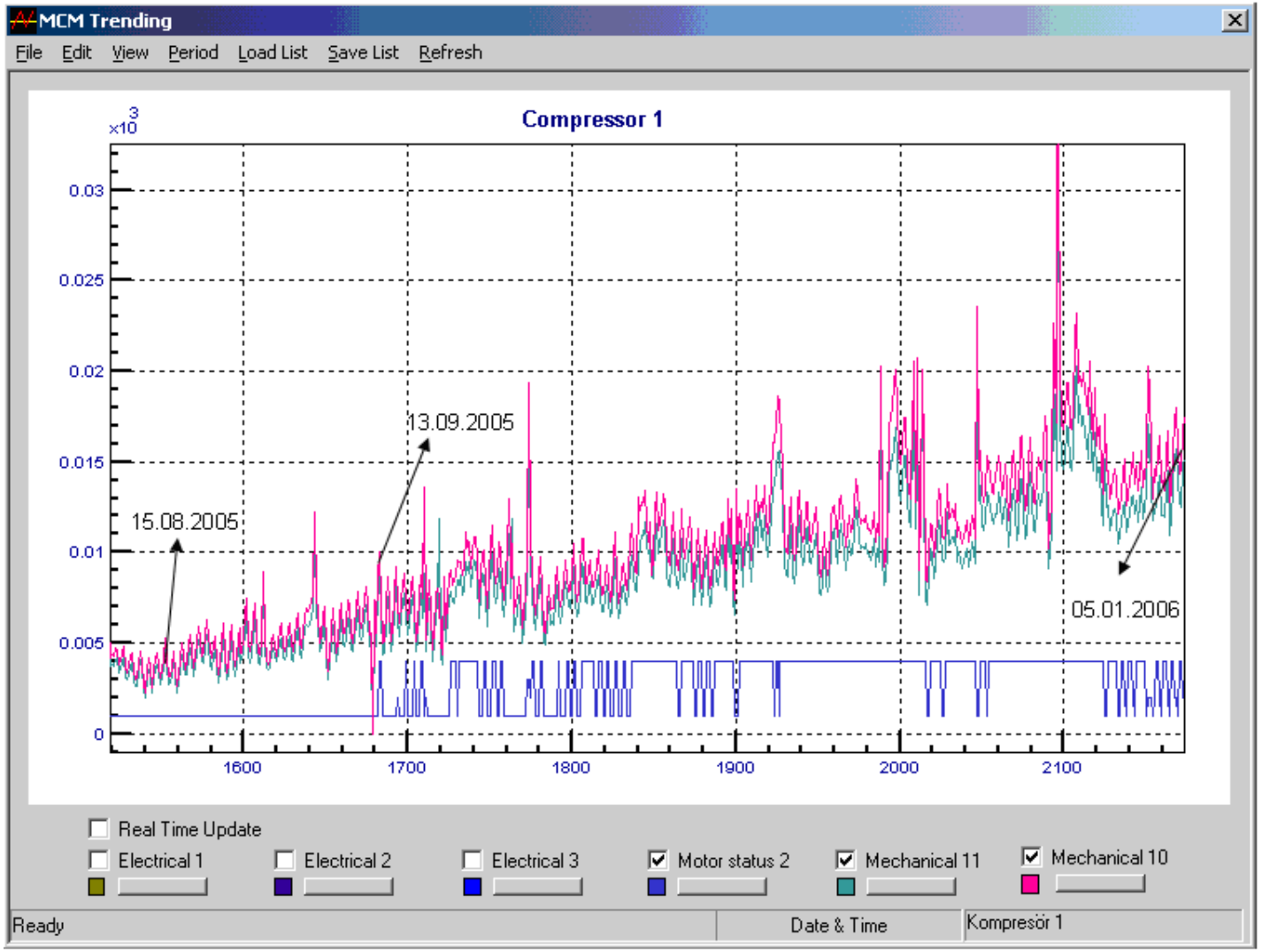



**Motor or generator data**

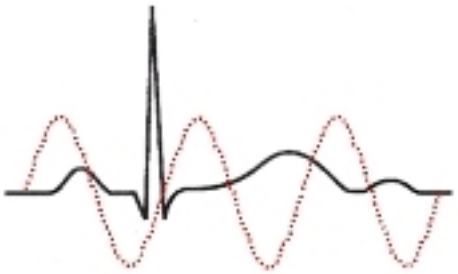
**Energy and power quality information**

**Advanced analysis**

# Detailed, Traditional Trends & Spectra If Required for Diagnosis



# Typical Data



- Motor nameplate information
- Model Parameters + Energy Use
- 20+ “RMS” condition indicators
- High-resolution time histories of V,A
- High-resolution Spectra
- Proprietary algorithm results
- Condition assessment report
- Diagnostic condition information summary
- Visual action urgency status bars

# What about Energy Monitoring?

- Over-sized motors = largest category of wasted energy; detectable via power factor measurement, this is the main driver behind conversion to Variable Frequency Drives
- EFF3 to EFF1 Motor Upgrade = 1-2 % energy gain
- Mechanical unbalance, misalignment = 1-2 % energy loss !
- Unbalanced voltages (usually due to unequal single phase equipment loads) result in 5-8x current imbalance, overheating, drastically reduced motor life
- Loose or poor electrical connections can cause several % energy loss
- Line Harmonics can cause several % energy loss
- KWH consumption is measured on all 3 phases

# What equipment can it monitor?

- Virtually all equipment driven by 3 phase motors, induction or synchronous
- Continuous or variable duty, including variable-frequency drive
- Generators and alternators
- Especially effective for remote or inaccessible equipment
- Especially effective on slow-speed equipment where vibration measurements are difficult or impossible (conveyors, crushers, transfer line motors...)

# Why is it Unique?

***Experience database*** >4000 installed, ***Proven*** technology

***No sensors or cables*** on the motor or driven equipment

***Multiple instrument*** functionality in one integrated, ***affordable*** unit

***Return on Investment*** calculation is fast, simple, clear and unambiguous

# What about Competition ?

Surprisingly, there are no direct competitors for this solution, there is nothing like it in the market. In fact, most people's first reaction is, “It's too good to be true.”

We appreciate that our customers have many alternatives for spending money to improve reliability and lower energy and operating costs. But they keep coming back....

# Some Existing Customers

## Water

SEVERN TRENT

Essex Water a YTL company

Thames Water

iSKi

Environment Agency

YorkshireWater

anglianwater

United Utilities

## Petrochem

bp

شركة مصفاة البترول الاردنية
Jordan Petroleum Refinery Company

Chevron

ارامكو السعودية
Saudi Aramco

VENTURE PRODUCTION COMPANY LIMITED

Sinopec 中国石油化工股份有限公司
CHINA PETROLEUM & CHEMICAL CORPORATION

## Energy

British Energy

Primary Energy

posco

BNFL

International Power

eDF ENERGY

AN ISO 9000 COMPANY KEPCO THE POWER SUPPLIER

## Food and Pharmaceutical

Unilever

NOVARTIS

Bayer CropScience

Tetra Pak protects what's good

FritoLay

ALGiDA

PHILIP MORRIS INTERNATIONAL

S&N

# Some Existing Customers

## Metals







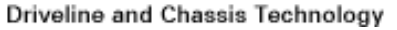


## Manufacturing












## Automotive










## Transportation




# How Much Does It Cost ?

Villa in the South of France

Week of lost production

Small used Learjet

New motor or machine

BMW 750i

Motor rewind

Ford F150 pickup truck

2-week family vacation in Mexico

Tata Nano

Bearing replacement

Weekend trip with your partner

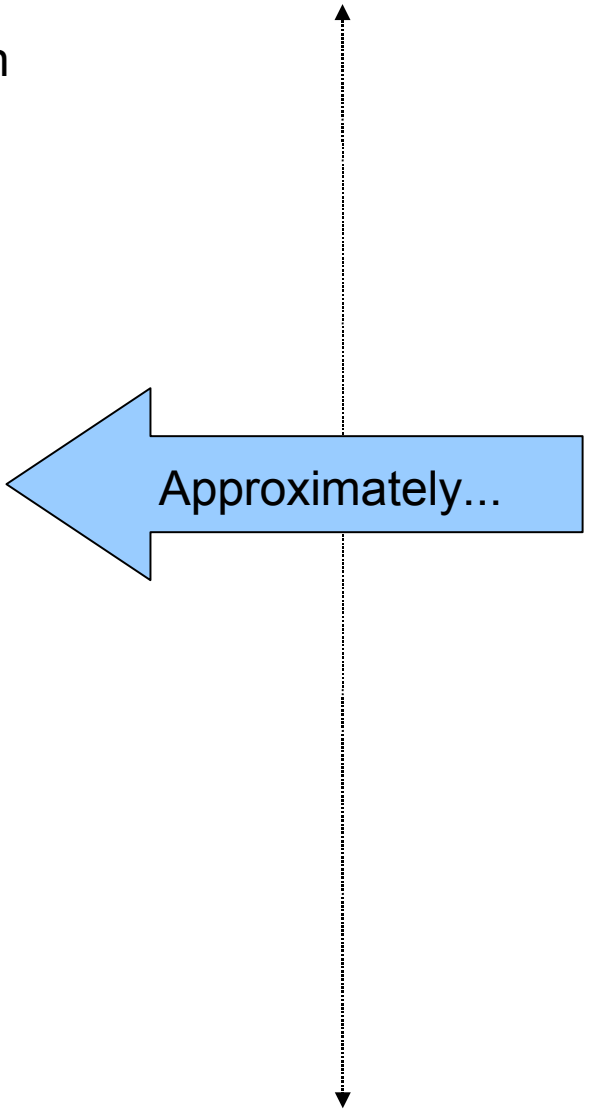
New bearing parts

Dinner at a fancy restaurant

Machine oil change

One night in a hotel room

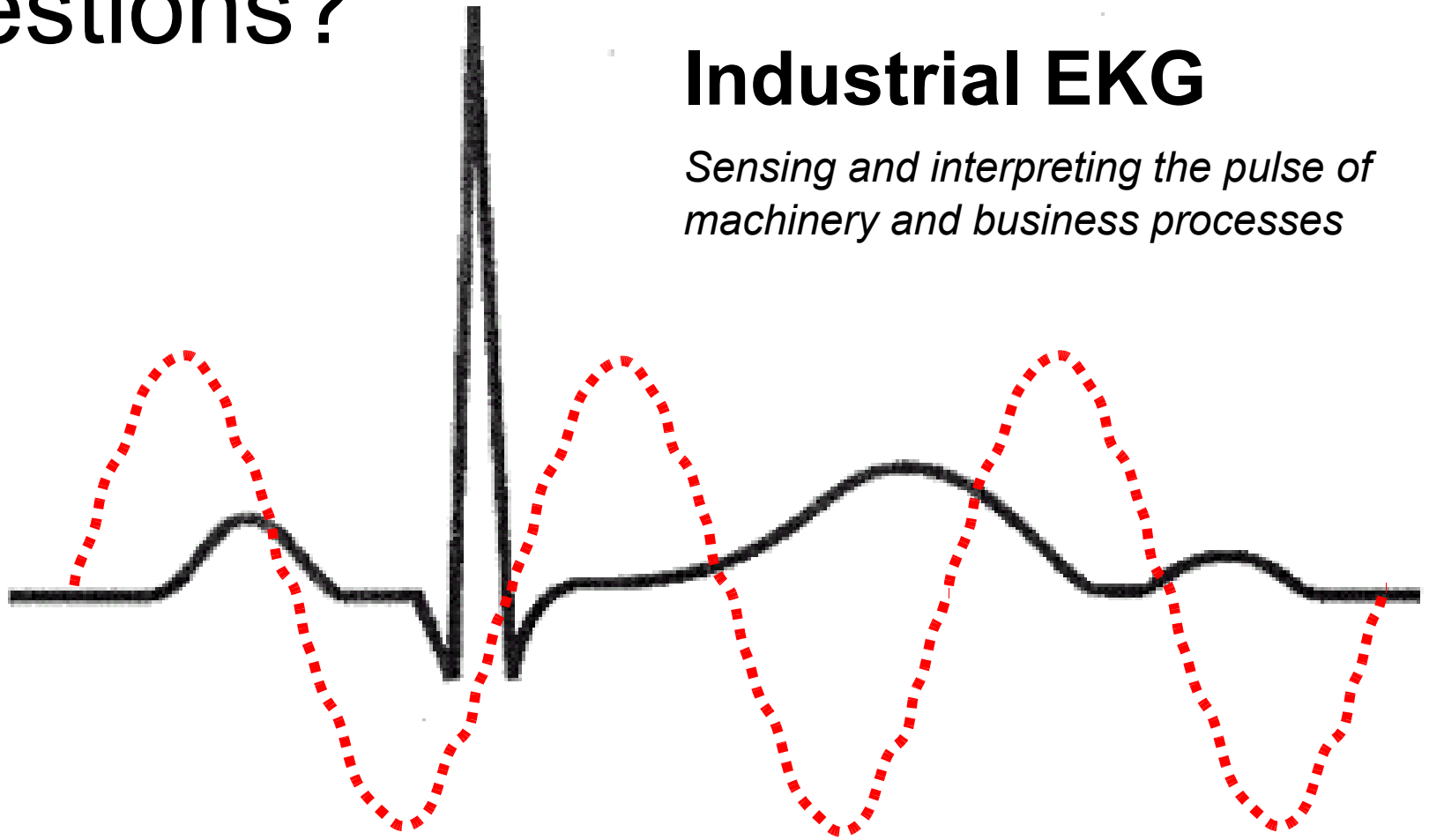
Fill your car with petrol



# Buying Models

- Rent for validation period or lease for long-term use.
- Buy and operate in-house. Integrate into your existing plant-wide monitoring and diagnostic framework. System integration service is available
- Contract as a monitoring & diagnostic service operated remotely or on-site.
- Small PC board available for OEM integration

# Questions?



## Industrial EKG

*Sensing and interpreting the pulse of machinery and business processes*

*info@industrialekg.com*