EPRI ROOT CAUSE ADVISORY WORKSTATION "ERCAWS"

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ABSTRACT

EPRI and its contractor FPI International are developing Personal Computer (PC), Microsoft Windows based software to assist power plant engineers and maintenance personnel to diagnose and correct root causes of power plant equipment failures. The EPRI Root Cause Advisory Workstation (ERCAWS) is easy to use and able to handle knowledge bases and diagnostic tools for an unlimited number of equipment types. Knowledge base data is based on power industry experience and root cause analysis from many sources - Utilities, EPRI, US government, FPI, and International sources. The approach used in the knowledge base handling portion of the software is case-study oriented with the engineer selecting the equipment type and symptom identification using a combination of text, photographs, and animation, displaying dynamic physical phenomena involved. Root causes, means for confirmation, and corrective actions are then suggested in a simple, user friendly format. The first knowledge base being released with ERCAWS is the Valve Diagnostic Advisor module;
covering six common valve types and some motor operator and air operator items. More modules are under development with Heat Exchanger, Bolt, and Piping modules currently in the beta testing stage. A wide variety of diagnostic tools are easily incorporated into ERCAWS and accessed through the main screen interface.

ERCAWS is designed to fulfill the industry need for user-friendly tools to perform power plant equipment failure root cause analysis, and training for engineering, operations and maintenance personnel on how components can fail and how to reduce failure rates or prevent failure from occurring. In addition, ERCAWS serves as a vehicle to capture lessons learned from industry wide experience.

The wide variety of equipment types and failure mechanisms requires that engineers who pursue root cause analysis to prevent recurrence be cognizant of many different disciplinary fields such as:

1) Tribology
2) Mechanical Engineering and Design
3) Thermal Hydraulics
4) Flow Induced Vibration
5) Fracture Mechanics
6) Stress Analysis
7) Material Science
8) Erosion
9) Corrosion
10) Gear Design
11) Polymer Science
12) Electrical Engineering and Design
13) Semiconductor Theory
14) System Operation and Interactions
15) Instrumentation
16) Control Systems
17) Magnetomotive Force Theory
18) Chemistry
19) Human Factors Engineering
20) Regulatory Issues

Typical problem solvers at power plants are usually good field engineers, knowing specific component characteristics, but many times
in need of additional knowledge in one or more of the above technical areas.

An additional concern for many power plants is the need for equipment knowledge, root cause analysis, corrective action, and historical system and component information and lessons learned to be retained over the life of the plant. This is difficult to maintain when an expert retires or experience is lost by staffing reductions. Using ERCAWS knowledge bases to retain this knowledge and experience information base can help power plants avoid repeating past problems as well as correct or prevent reproduction of expensive problems that have occurred at other power production facilities.

4) Use of computer animation to dynamically illustrate failure mechanisms for engineer training and symptom identification.

5) Provide possible root causes, means to confirm root causes, and suggest effective corrective actions based on industry experience and the identified failure symptoms.

ERCAWS uses the following steps to find the root causes of equipment failure:

1) Choose the general equipment type

2) Identify the more specific equipment type

3) Identify the failure symptoms

4) Determine the failure modes

5) Identify possible causes

6) Confirm which is the root cause(s)

7) Identify the appropriate corrective actions

All the above steps use information derived from industry experience. The knowledge bases are of course not all-inclusive. As new failures occur continually, not all possible means of equipment failure can already be known. This means that the data in the knowledge bases will need to be updated occasionally. Due to limits in what computers, AI and knowledge bases are currently capable of, the user must make the final decision as to the applicability of the available knowledge base.

EPRI ROOT CAUSE ADVISORY WORKSTATION

Based on power industry experience in root cause analysis, EPRI has considered the following to be essential to development of a state of the art root cause workstation:

1) Use of Artificial Intelligence / Expert System Knowledge Bases to cover required information to diagnose component failures.

2) Use of a transparent heuristic approach to introduce the necessary steps for effective root cause analysis.

3) Use of photographs and diagrams to illustrate historical equipment failure cases to assist in failure symptom identification.
information in his or her particular case. Because of the open-endedness of industry experience, provisions for expanding the knowledge bases are inherent to ERCAWS. There is no limit theoretically as to how many equipment types could be covered or how large or numerous the ERCAWS knowledge bases can become. As the knowledge bases expand, ERCAWS will become increasingly useful, even to the most experienced, broad-based, and expert personnel.

Digitized photographs, diagrams and animation provide a rapid means for matching knowledge base information to failed equipment or system symptoms by the "case study" method. The same approach can be used to enhance the diagnostic skills of new personnel concerning equipment problems.

AVAILABLE ERCAWS MODULES:

ERCAWS is now available to requesting utilities with the Valve Diagnostic Advisor module included. Additional modules are being prepared. Currently, the following are available to participating utilities for Beta Testing (and for general release by the end of 1993):

1) Heat Exchangers module
2) Fasteners (Bolting) module
3) Piping module

The Valve module includes information on six common valve types:

1) Swing Check Valves
2) Globe Valves
3) Gate Valves
4) Safety Relief Valves
5) Diaphragm Valves
6) Butterfly Valves

in addition, the Valve module contains information on:

1) Motor Operators
2) Air Operators

An update to the Valve module is planned to contain additional information on the above valve types and operators as well as additional valve types and other operator varieties.

The 1993 Beta Test modules have information in the following areas so far:

1) Heat Exchanger:
   Types
   Shell Problems
   Overpressure
   Erosion, Corrosion
   Cracking
   Tube Failures
   Fatigue, Vibration
   Erosion, Corrosion
   Overpressure
   Plugging
   Heat Transfer
   Degradation
   Tube Support and Baffle Problems
   Mechanical Tube Plug Failures

2) Bolting:
   Types
   Fatigue
   Overload
   Corrosion
   Materials
   Embrittlement
3) Piping:
   Types
   Wall Thinning
      (Corrosion, Erosion)
   Pressure Wave
   Hammers (many kinds)
   Water Slug Water Hammers
   Thermal Growth
   Interference
   Cracking
   Support and Restraint
   Problems

(The Piping module's water
hammer information conforms to
EPRI's Water Hammer Prevention,
Mitigation and Accommodation
Guidelines)

Additional modules being
designed and written with
release schedules determined by
utility participation include:

1) Diesel Generator module
2) Welding module
3) Motor module
4) Pump module
5) Fabrication and Material
   Defects module
6) Instrumentation module
7) Control System module
8) Integrated Circuit Card
    module
9) Breaker module
10) Reactor Internals module
11) Cable module
12) Boiler module
13) Transformer module
14) Main Generator module
15) Turbine module
16) Bearing module

Other modules will be generated
and scheduled according to
participating utility
requirements.

ADDITIONAL DIAGNOSTIC TOOLS

The EPRI Root Cause Advisory
Workstation is expandable with
add-on diagnostic tools that can
provide additional logic,
predictive capabilities,
knowledge base creation and
editing tools, equipment and
system diagnostic calculations,
root cause analysis methodology
and report generation,
equipment examination guides,
or on-line data acquisition.
These expansions are accessed
through the "Special
Operations" menu. Special
Operations tools are being
developed for later release,
but the means for working with
them is already built into the
ERCAWS.

HARDWARE AND SOFTWARE
ENVIRONMENT REQUIREMENTS FOR
THE EPRI ROOT CAUSE ADVISORY
WORKSTATION (Version 1.0,
January 1993)

Minimum Requirements
ERCAWS version 1.0 is able to
run on standard 386 (or higher)
PCs with at least three
Megabytes of RAM, a 256 color
SuperVGA display, a mouse, a 60
Megabyte or larger hard drive,
DOS 5.0 or higher, and
MicroSoft Windows 3.1.

Supported Hardware Enhancements
Because of the way that
Microsoft Windows operates,
performance (especially speed
of graphics) can be
considerably enhanced by having
more RAM (more than 6 Megabytes
recommended) a math coprocessor
and a larger hard drive (more than 100 Megabytes if there is to be much more software on it) with plenty of empty space for windows to write temporary files to while running.

The release version supports 256 color graphics. While ERCAWS is able to be "operated" with a standard 16 color 640 X 480 VGA graphics card and display, the graphics are much better using a 256 (or higher) color graphics card (photo colors will be poorly rendered on a 16 color only display).

Printer support for printing out the photographs, diagrams, and texts in black and white or color for internal utility reports is incorporated into ERCAWS and uses available Windows printer drivers. Good results can be had with 300 dpi or higher Laser Printers or Ink Jet Printers. ERCAWS allows the user to designate the location of pictures on the page as well as horizontal and vertical size of the printed picture.

3) Maintain a high standard of root cause analysis
4) Training of engineering, maintenance, and operations personnel in equipment failure mechanisms correction and avoidance
5) Maintaining knowledge and experience over time as experienced personnel are lost by retirement or attrition.

Equipment and component failures can result in significant unplanned production losses, large amounts of lost revenue, and occasionally, degradation of safety margins. EPRI's ERCAWS can help utilities reduce the number, cost, and duration of such events, thus enhancing plant safety, reliability, availability, productivity, and profitability.

SUMMARY

EPRI's ERCAWS, developed by FPI International, puts state of the art root cause and multimedia technologies together to assist the power industry in solving equipment problems. This development fulfills the industry need for a software product that will be used in all types of power plants for systematic diagnosis and correction of equipment problems, resulting in enhanced plant safety, reliability, and availability.

For further information, contact EPRI Project Manager, Avtar Singh, at (415)-855-2384.