THE VIBRATION ANALYSIS AND PREDICTIVE MAINTENANCE PROGRAM AT FLORIDA POWER & LIGHT COMPANY'S ST. LUCIE NUCLEAR UNITS NO. 1 & 2

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The subject of this presentation is the vibration analysis and predictive maintenance program being formulated and implemented at Florida Power & Light Company's St. Lucie Nuclear Plant (Units 1 & 2).

To begin, let's look at some past methods of scheduling maintenance activities. First, there is the "as-fail" maintenance approach. This is sometimes an acceptable method, but usually causes lengthy, unscheduled unit downtimes, due to unavailability of maintenance personnel and spare parts.

The second most familiar method is the preventive maintenance approach. A preventive maintenance program uses the clock to schedule equipment inspections, overhauls or repairs. This time-based maintenance approach is certainly more effective than the previous "as-fail" program. I am sure you are all acquainted with the phrase "If it ain't broke, don't fix it". How many times have you seen a machine performing perfectly, disassembled because it was in the "master schedule", only to have the equipment return to service with hot bearings, leaking seals and excessive vibration?

The solution to implementing an effective maintenance program is somewhat a combination of the two previous approaches. By continuously and/or periodically gathering vibration data on critical or load limiting rotating equipment, (i.e. turbine-generators, motors, pumps, fans, M-G sets, etc) and carefully trending and analyzing this data, abnormalities or impending failures can be identified and maintenance scheduled in a timely fashion.

The main areas that require attention, in order to implement such a program are:

1. Trained personnel
2. Adequate vibration monitoring and analysis equipment
3. Data storage and trending capability
4. Management support when data indicated corrective action is warranted
5. Specific machine oriented alarm limits.

Most of these concerns are addressed by our Power Resources Procedure Number 3005 and 3005.1, but over the past several years vibration analysis equipment and computer hardware/software capabilities have taken huge steps forward. The equipment is much more sophisticated, and in my opinion, requires the skills of a small group of specialists to adequately set up, operate, trend data, and assist in machinery diagnosis and repair. Many times in the past, vast quantities of vibration data were taken and filed away. Data that is taken and not analyzed sufficiently is a waste of manpower and does nothing more than fill the plant file system with paper. Have you ever tried to manually trend the vibration data from just one piece of rotating machinery five (5) data points? Let me tell you, it's a lot of work!!! It requires approximately one manhour per machine, for each set of data. Now, try looking at data from 100 pieces of rotating equipment. Keep in mind that the person who has this task for the plant probably has other areas of responsibility and only deals in vibration analysis part-time.

In St. Lucie's efforts to organize an efficient and effective vibration analysis program with predictive capability, we are addressing all five previously identified ares.

In the area of trained personnel, we are providing vendor, and in-house vibration data-taking training down to the journeyman electrician level. The journeymen are being given in-house training on how to use portable, hand-held, tunable vibration meters, our "first line of defense" against undetected machinery failure. In addition to this effort, the journeymen mechanics are being trained on how to correctly align rotating equipment, (reverse-dial indicator method). This training will help in eliminating one of the most common contributing causes of excessive vibration, misalignment. An engineering technician has been trained in basic vibration data taking and analysis, in addition to the department engineer, with the intent of providing the technician with additional advanced training in the near future. An additional technician, is viewed as something that will be necessary down the road, as the vibration program expands.

The area of vibration analysis equipment has been thoroughly planned and budgeted, and the appropriate equipment purchased. The following is a list of what I would consider a very well-equipped vibration analyst's tool box.

The items are numbered in the order of our acquisition.

1. portable, hand-held tunable vibration meter (Bently Nevada TK-80)
2. digital vector filter (Bently Nevada DVF II)
2. velocity seismoprobes
2. proximity probes with proximitor
3. spectrum analyzer (Hewlett Packard H.P. 3582A)
4. oscilloscope: X-Y capability (Nicolet #2090)
5. X-Y-Y plotter (Hewlett Packard H.P. 9872C)
6. pre-amplifiers
6. 8-channel FM tape recorder (Hewlett Packard H.P. 3968A)

We acquired this equipment over a seven (7) year period, which spread out the total cost and made it bearable. This gradual method of equipment procurement is one I would strongly recommend. It also permits personnel time to become proficient with one piece of instrumentation, before another item is given to them.

To cover the third area of concern, a Hewlett Packard color computer (HP 9836C) was purchased, with suitable software to crunch, format and track data. Bently Nevada "ADRE" software will assist in the diagnosis of machinery malfunctions and greatly enhance our capability to store and trend vibration data. This is an absolute must when large numbers of machines are monitored.

The fourth area to address did not present very big problems at St. Lucie. The gradual, effective program of diagnosing and correcting vibration problems has demonstrated our capabilities to upper management, and made them receptive to our recommendations.

The last area of concern is currently being phased into our data base. Past vibration limit guidelines have been chosen based on Florida Power & Light's procedures, NEMA standards, vendor recommendations and such references as the "Rathbone Chart". While these are excellent foundations from which to select alarm limits, the best approach is to look at each machine, record present vibration levels (displacement and/or velocity) and then set 125% to 150% of this value as the alarm level. In my opinion, this should insure that any vibration magnitude increases are identified early enough to trend and diagnose the failure mode.

Our program is one of gradual implementation. First, each machine is identified on a master data-taking route. Probe locations on motors, pumps, and fans are selected for placement of velocity seismoprobes. Where possible, holes are drilled and tapped for acceptance of a stainless steel bolt, for solid probe attachment. Where this method is not possible, magnetic bases hold probes during data taking to insure reliable, repeatable data. Vertical, horizontal, and axial vibration planes are measured and recorded. A trained technician previews vibration magnitudes on Bently Nevada's Snapshot II LCD display, the heart of data recording system, and decides whether static or dynamic data storage is required.

An optical pickup is used to monitor shaft RPM and provide the reference for vibration phase angle.

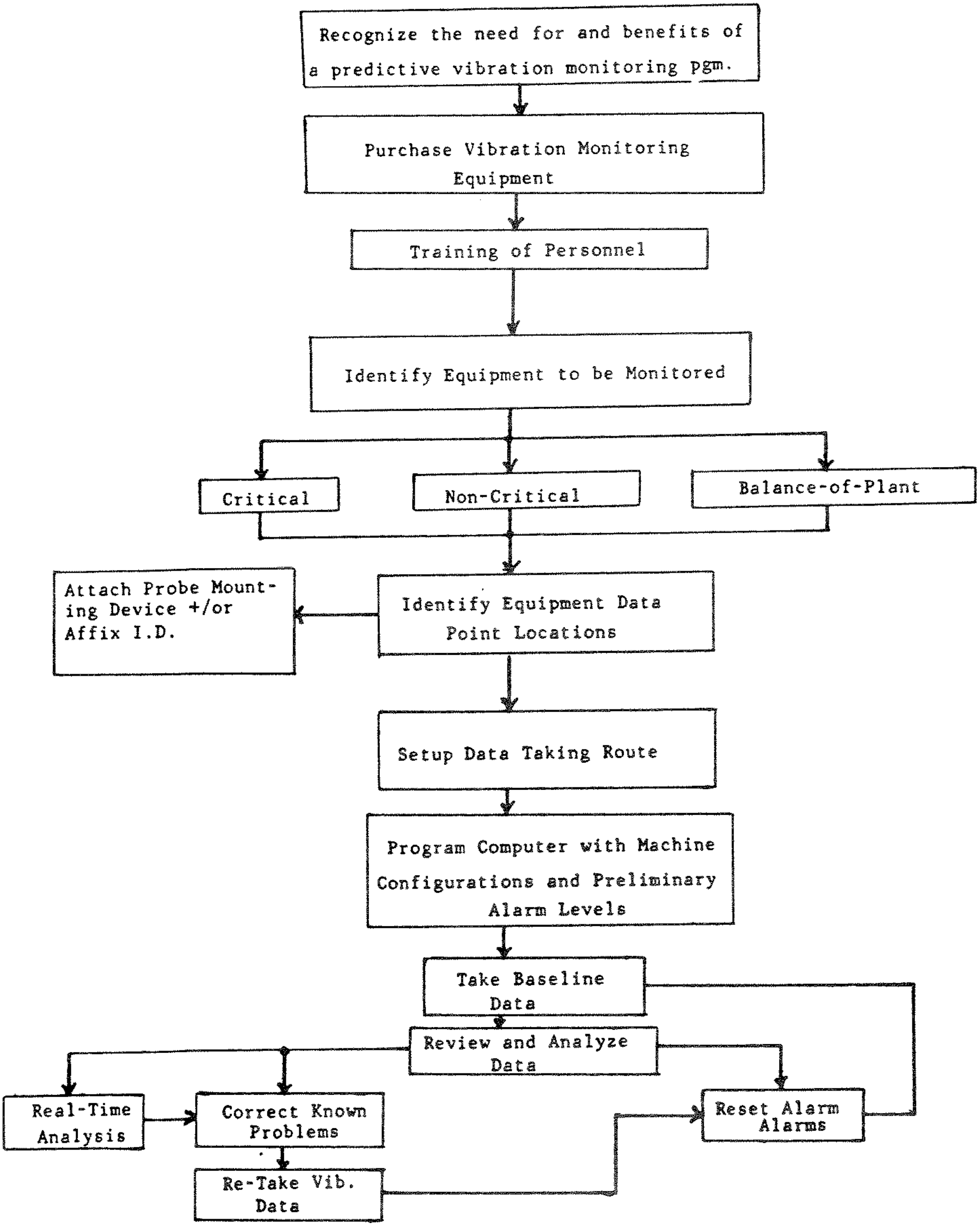
After approximately ten (10) complete machine trains (motor and pump combinations) are monitored, the Snapshot II data is down-loaded into the H.P. 9836C computer. The H.P. 9836C stores and manipulates this data, using the "Snap PM" software program, developed by Bently Nevada Corporation. A Vibration Exception list is printed after the recorded data is matched to machine configurations, and any preset alarm levels are exceeded. Data for any points in alarm can be retrieved at this time and displayed in selected formats such as spectrum (magnitude vs. frequency), time base (magnitude vs. time), orbit (X vs. Y), bode' (phase vs. magnitude), cascade, and/or trend plots.

Once this data is processed and stored, the Snapshot II memory can be cleared and loaded with the next set of machinery configurations and the vibration data route continued. If any of this data indicates increasing vibration levels, the frequency of monitoring could be increased or real-time analysis could be performed, using a spectrum analyzer and a digital vector filter.

The benefits of a predictive or "on-condition" vibration monitoring program have been well demonstrated over the past several years in the petroleum industry, as well as, at other electric utilities. Some of the benefits we at St. Lucie hope to achieve are a reduction in forced outages, advanced warning of equipment degradation permitting better scheduling of maintenance and allocation of repair parts, more efficient equipment operation, and a closer coordination effort between mechanical and electrical maintenance departments in identifying and correcting rotating equipment malfunctions.

St. Lucie Plant

Predictive Vibration Monitoring Program



NECESSARY VIBRATION ANALYSIS EQUIPMENT

1). Portable, Hand-Held, Tunable Vibration Meter

2). Digital Vector Filter

3). Velocity Seismoprobes / Accelerometers

4). Proximity Probes with Proximitor

5). Spectrum Analyzer

6). Oscilloscope (X-Y Capability)

7). X-Y-Y Plotter

8). Pre - Amplifiers

9). 8 - Channel FM Tape Recorder

MAIN AREAS THAT REQUIRE ATTENTION IN ORDER TO HAVE AN EFFECTIVE VIBRATION ANALYSIS AND PREDICTIVE MAINTENANCE PROGRAM

1). Trained Personnel

2). Adequate Vibration Analysis and Monitoring Equipment

3). Data Storage and Trending Capability

4) Management support when data indicates corrective action is warranted.

5). Specific machine oriented alarm levels

BENEFITS OF AN EFFECTIVE VIBRATION ANALYSIS AND PREDICTIVE MAINTENANCE PROGRAM

1). Reduction in forced outages

2). Advanced warning of equipment malfunctions providing better outage scheduling.

3). Better control of spare parts

4). More efficient equipment operation

5). Longer bearing life

6). Closer coordination efforts between Electrical and Mechanical Maintenance.

7). Immediate feedback on work that is well done.

FLORIDA POWER & LIGHT CO. ______ PLOT ______

ST. LUCIE PLANT ______ B. P. ______

UNIT # ______ DATE ______

MACHINE ______ RPM ______

MANUFACTURER ______ ROTN: ______

MODEL ______ LOCATION ______

ROTOR WEIGHT ______

TRANSDUCER TYPE ______

	NO LOAD	LOAD
PHASE LAG		
SENSITIVITY		

T.W. (______) X B.R. (______) = (______)
g/ozs/lbs inch

S.R. = ______ @ ______
INIT.= ______ @ ______
CW = ______ @ ______
RvCw = ______ @ ______
CW = ______ @ ______
RvCw = ______ @ ______
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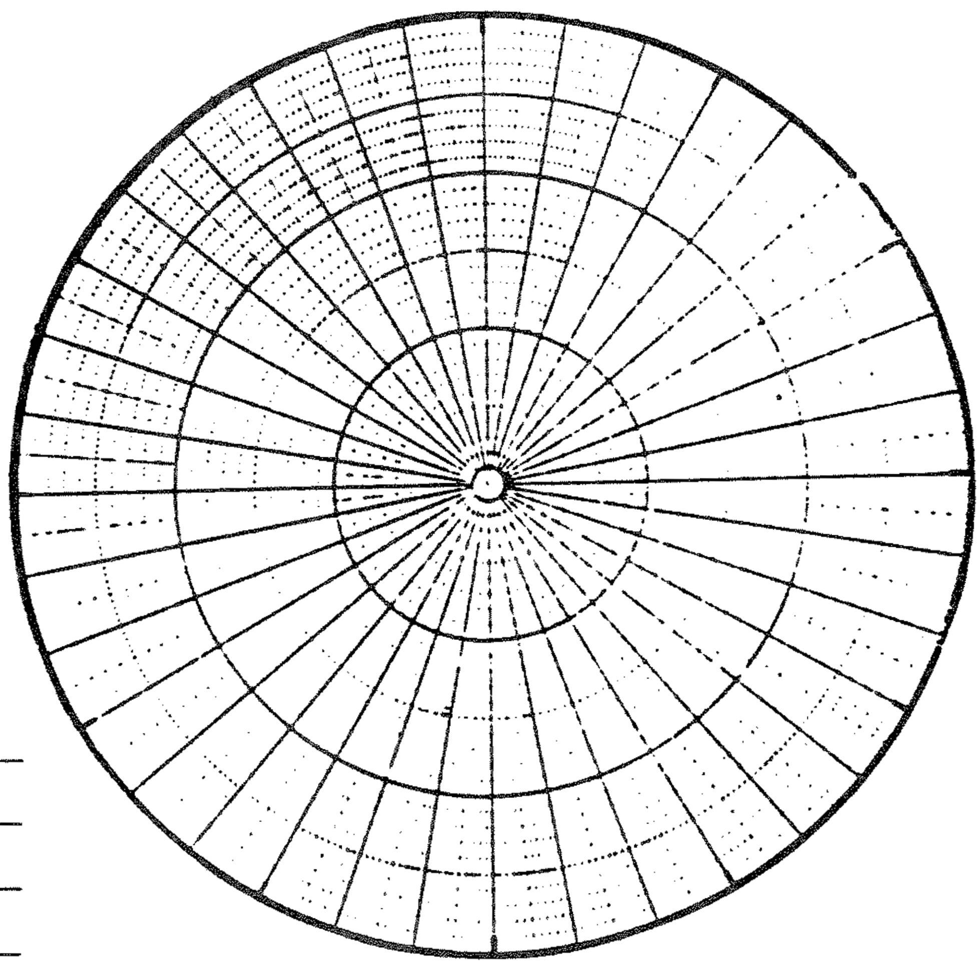

COMMENTS: ______