

DON STEVENS

DIAGNOSTIC DEVELOPMENT GROUP

RESEARCH AND DEVELOPMENT DIVISION

BABCOCK & WILCOX COMPANY

8011070/48

"DEVELOPMENT OF A REACTOR COOLANT PUMP  
MONITORING AND DIAGNOSTIC SYSTEM"

SPONSORED BY: DEPARTMENT OF ENERGY

PRIME CONTRACTOR: TOLEDO EDISON COMPANY

SUBCONTRACTOR: BABCOCK & WILCOX COMPANY  
{ NUCLEAR POWER GENERATION DIVISION }  
{ RESEARCH AND DEVELOPMENT DIVISION }

## PROGRAM OBJECTIVES

- I. DEVELOP AND DEMONSTRATE A PUMP MONITORING AND DIAGNOSTIC SYSTEM THAT WOULD:
  1. ALERT OPERATORS OF IMPENDING PUMP SEAL FAILURES
  2. PERFORM PUMP AND MOTOR PERFORMANCE MONITORING
  3. EXAMINE POTENTIAL RELATIONSHIPS BETWEEN PERFORMANCE AND SEAL PROBLEMS
  4. PROVIDE RELIABLE AND CONSISTENT PERFORMANCE RECORDS
  
- II. THESE OBJECTIVES ARE AIMED AT A REDUCTION IN PERSONNEL RADIATION EXPOSURE ATTRIBUTABLE TO FREQUENT MAINTENANCE.

PROJECT SCHEDULE

1. PROJECT START DATE - OCTOBER 1, 1980
2. INSTALLATION OF SYSTEM AT  
TECO'S DAVIS-BESSE UNIT 1 ~ SEPT. 1, 1981
3. DATA ACQUISITION FOR AT LEAST 1 FUEL CYCLE
4. TOTAL PROJECT DURATION - 40 MONTHS

# Reactor coolant pump monitoring and diagnostic system block diagram

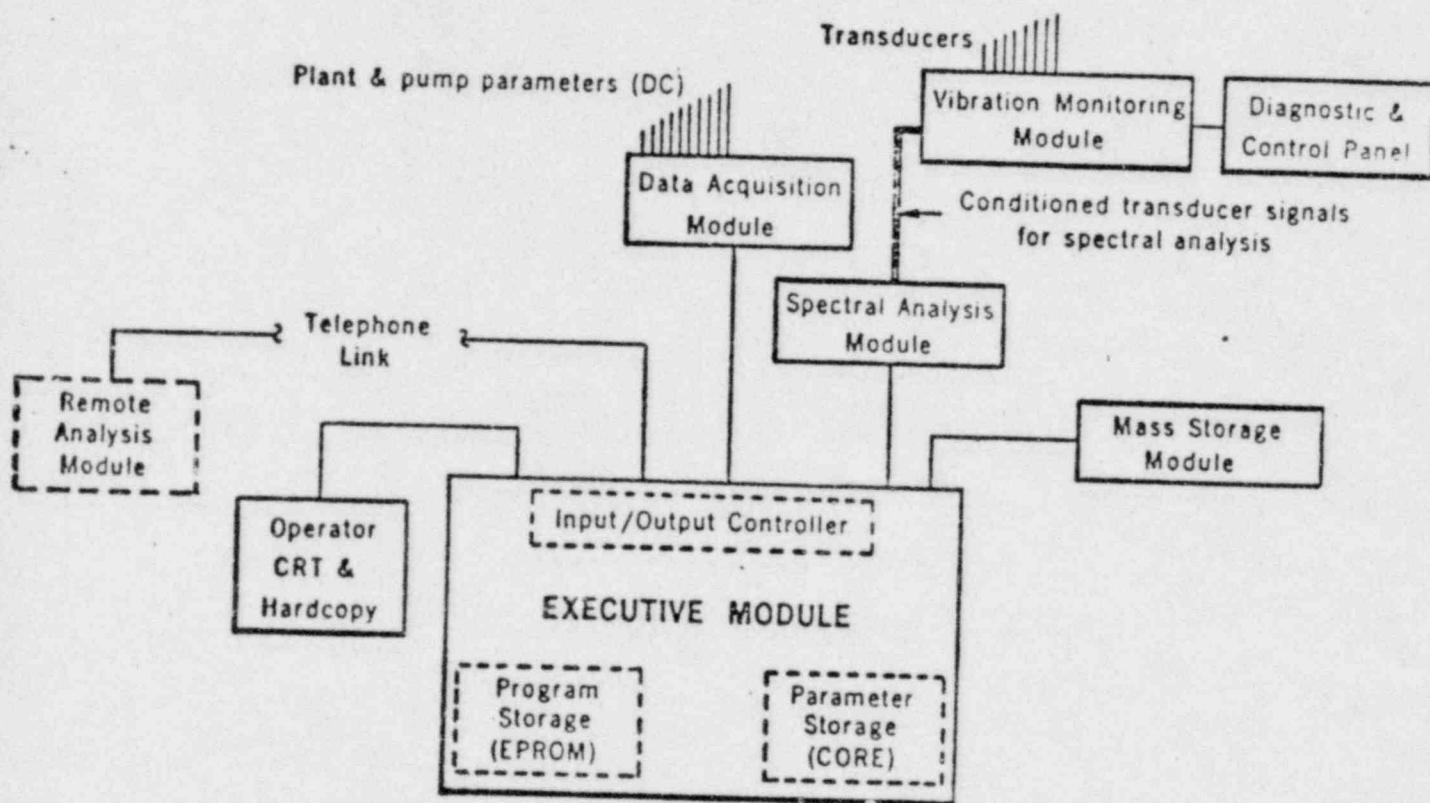


Figure 3.1

## DATA ACQUISITION MODULE INPUTS

- UPPER SEAL LEAKAGE - 4 CHANNELS
- 3RD SEAL CAVITY PRESSURE - 4 CHANNELS
- 2ND SEAL CAVITY PRESSURE - 4 CHANNELS
- SEAL RETURN ~~OUTLET~~ TEMPERATURE - 4 CHANNELS
- SEAL INJECTION FLOW - 4 CHANNELS
- ONE OTHER PUMP TEMPERATURE (NOT YET SELECTED) - 4 CHANNELS
- WIDE RANGE RCS PRESSURE - 1 CHANNEL
- CONTROLLED BLEED-OFF VALVE POSITION - 4 CHANNELS
- PUMP MOTOR BREAKER STATUS CONTACT - 4 CHANNELS
- PUMP NOT ZERO SPEED CONTACT - 4 CHANNELS
- RCS COLD LEG TEMPERATURE - 1 CHANNEL
- REACTOR POWER (% THERMAL) - 1 CHANNEL
- PLANT PARAMETERS

## TYPICAL SEQUENCE OF OPERATION

- REQUEST AND OBTAIN SEAL PERFORMANCE DATA FROM THE DATA ACQUISITION MODULE AND THE SPECTRAL ANALYSIS MODULE.
- DETERMINE THE PRESSURE DROP ACROSS EACH OF THE THREE PRESSURE REDUCING DEVICES (STAGING COILS) FOR ALL FOUR PUMPS.
- CALCULATE THE FLOW RATE THROUGH EACH PRESSURE REDUCING DEVICE.
- DETERMINE TOTAL SEAL LEAKAGE (CONTROLLED BLEED-OFF FLOW PLUS UPPER SEAL LEAKAGE) FOR EACH PUMP.
- CALCULATE THE LEAKAGE THROUGH THE FIRST AND SECOND SEAL STAGES FOR EACH PUMP.
- EVALUATE THE VALIDITY OF PUMP PARAMETERS TO DETERMINE IF AN INSTRUMENT MALFUNCTION EXISTS.
- DETERMINE IF A TRANSIENT IS IN PROGRESS.
- DETERMINE IF AN ALARM CONDITION EXISTS.
- CALCULATE THE POTENTIAL OF IMPENDING SEAL PROBLEMS.
- ANALYZE ALL OF THE CALCULATED INFORMATION AND PROVIDE THE PLANT OPERATOR WITH A CRT DISPLAY OF THE MOST IMPORTANT INFORMATION AT ALL TIMES, DEPENDING ON SYSTEM CONDITIONS.
- PROVIDE HARD COPY OF INFORMATION ON REQUEST AND/OR PERIODIC BASIS.
- PROVIDE DATA TO THE MASS STORAGE MODULE PERIODICALLY AS DEEMED NECESSARY UNDER CURRENT PUMP CONDITIONS.

## SYSTEM FEATURES

1. PERFORMS ANALYTICAL CALCULATIONS TO PROJECT EXPECTED PUMP PERFORMANCE
2. WHERE POSSIBLE, INPUT SENSOR VALIDATION IS INCLUDED BY THE USE OF ANALYTICAL REDUNDANCY
3. SYSTEM HAS SELF-DIAGNOSTICS
4. REMOTE ANALYSIS MODULE TO ALLOW:
  - A) DATA TRANSFER TO HOME OFFICE
  - B) REMOTE OPERATOR INTERACTION
5. FOURIER ANALYSIS OF DYNAMIC SIGNALS - BASED ON IN-HOUSE STUDIES OF ROTATING MACHINERY



## SYSTEM FEATURES

- I. OPERATOR MAY DEFINE MULTIPLE SPECTRAL RANGES FOR EACH SENSOR.
  - RANGE MAY BE IN THE REGION OF 0-25 kHz
  - SPECTRA MAY HAVE WIDTH OF 5 Hz-25 kHz
  - TOTAL OF ~300 SPECTRA MAY BE DEFINED
- II. SYSTEM WILL AUTOMATICALLY SCAN ALL SENSORS IN SPECTRAL RANGES DEFINED BY OPERATOR.
  - SPECTRA CAN BE STORED FOR TRENDING
  - SPECTRA WILL BE COMPARED TO BASELINE DATA AND TO ALERT LEVELS DEFINED BY OPERATOR
- III. SYSTEM HAS THE MATHEMATICAL CAPABILITY TO NORMALIZE AND CONVERT TO ENGINEERING UNITS AND TO DEFINE AND COMPARE PORTIONS OF SPECTRA

## CASA

### - COMPUTER ASSISTED SPECTRAL ANALYSIS -

DEVELOPED AND FIELD-TESTED BY THE BABCOCK & WILCOX COMPANY

CASA PROVIDES ON-LINE SCANNING OF PLANT PARAMETERS AND SPECTRA OF SENSORS MEASURING THE DYNAMICS OF AN NSS.

THE MICROCOMPUTER BASED SYSTEM CONSISTS OF:

- AN INPUT MULTIPLEXER FOR CHANNEL SWITCHING
- TWO DIGITAL MASS STORAGE UNITS FOR DATA STORAGE
- CRT AND KEYBOARD FOR OPERATOR INTERACTION
- FFT SPECTRUM ANALYZER
- TIME OF YEAR CLOCK FOR TIMED OUTPUT AND DOCUMENTATION

## CASA

### RESULTS OF FIELD TEST

THE SPECIAL PRODUCTS SECTION OF THE BABCOCK AND WILCOX COMPANY HAS FIELD TESTED A PROTOTYPE CASA SYSTEM AT THE PRAIRIE ISLAND PLANT OF NORTHERN STATES POWER COMPANY.

#### CONCLUSIONS:

- ALERT LEVELS BASED ON SELECTED FREQUENCIES RELEVANT TO THE MACHINE BEING MONITORED ARE MORE EFFECTIVE THAN BROAD BAND ALARMS
- CASA DETECTED CAVITATION WHILE INSTALLED BROAD BAND VIBRATION MONITOR DID NOT BECAUSE:
  1. THE CAVITATION CAUSED AN INCREASE OF A FACTOR OF 4 TO 100 AT THE KEY PUMP FREQUENCIES BEING MONITORED BY CASA
  2. THE CAVITATION CAUSED ONLY A 17% OVERALL INCREASE IN THE BROAD BAND LEVELS