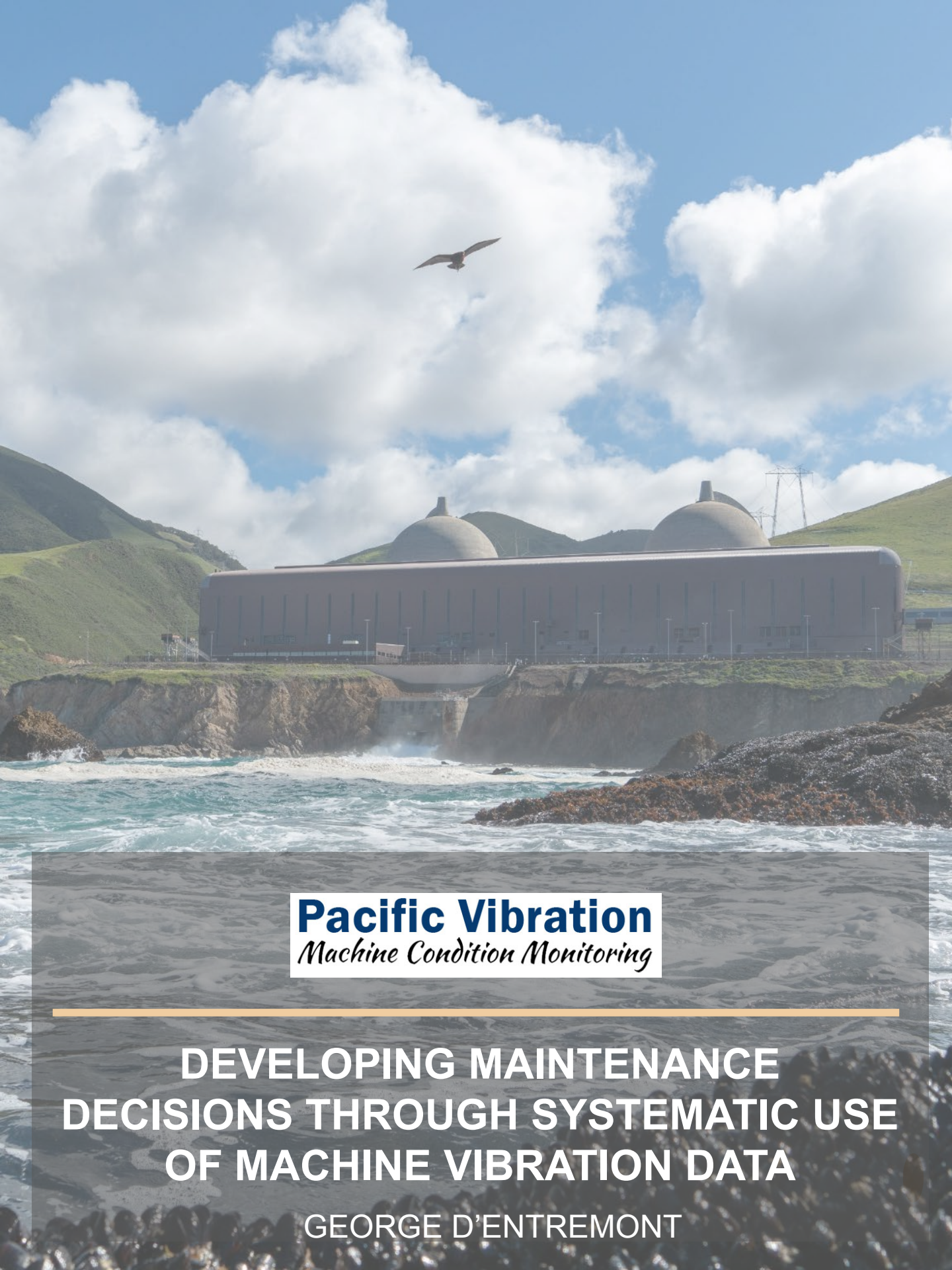




Pacific Vibration
Machine Condition Monitoring

**DEVELOPING MAINTENANCE
DECISIONS THROUGH SYSTEMATIC USE
OF MACHINE VIBRATION DATA**

GEORGE D'ENTREMONT

EXECUTIVE SUMMARY

This paper suggests systematic steps by which machine casing vibration data may be used to create maintenance decisions at a nuclear electric generating station. The paper is, in part, a response to discussions conducted in Japan, in 2013, between maintenance professionals from Japan and the United States. These discussions related to the use of systematic review and evaluation techniques that promote the most accurate maintenance decisions.

A machine vibration analyst, confronted with a large and expanding vibration database, may be overcome with questions of where he should concentrate his attention and what actions he should take to insure important data is not ignored. This paper presents a distilling technique, which reduces information from an existing vibration database in a manner that yields necessary maintenance decisions. It is offered as an example of one such approach taken at a US nuclear generating station; and which may, in turn, be used at other types of generation or production facilities.

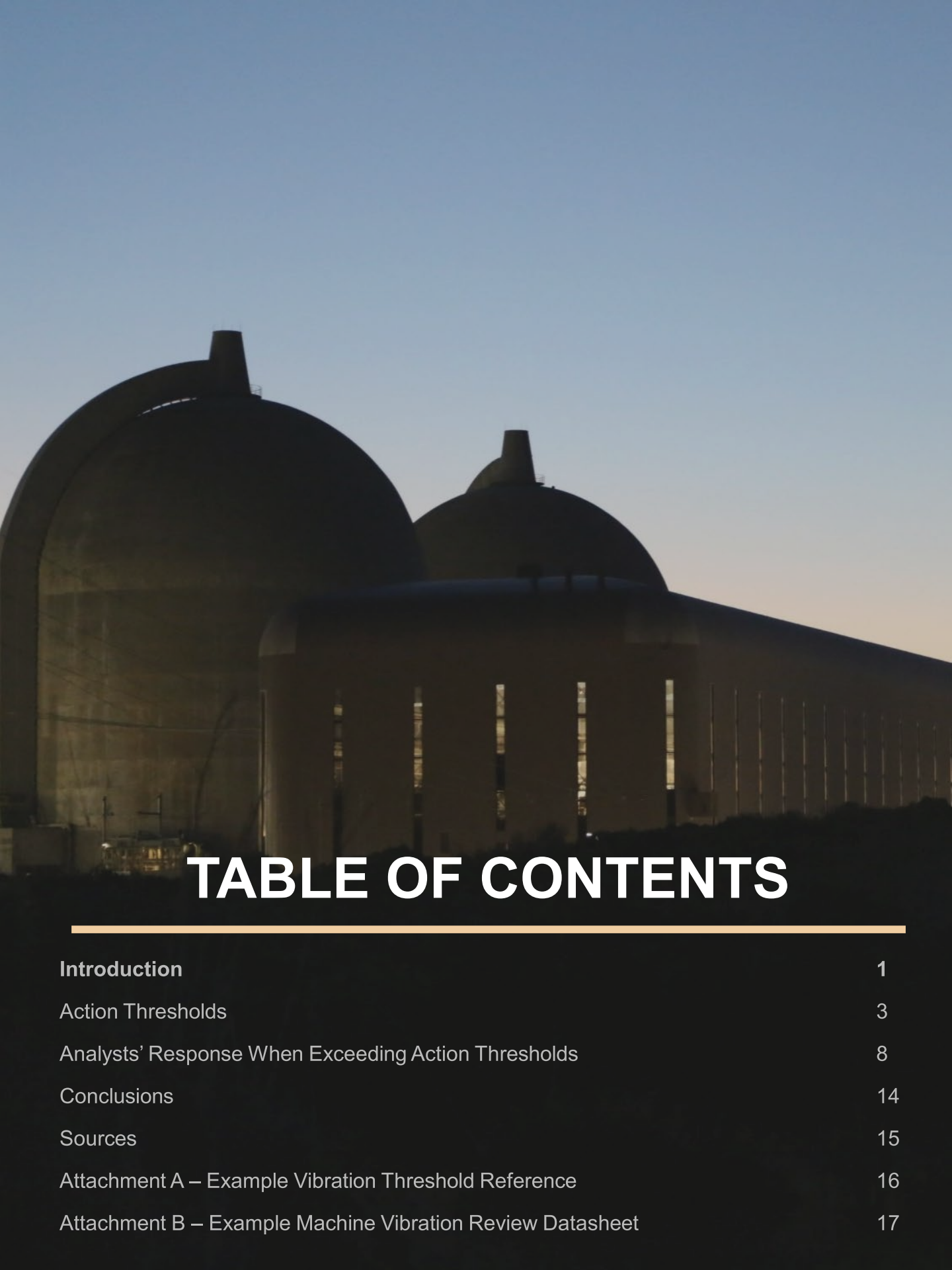


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INTRODUCTION

PURPOSE AND SCOPE

Once elements of Reliability-Centered Maintenance have been implemented at a nuclear station, many condition-directed maintenance tasks will be triggered by the results of machine vibration analysis. It becomes important, then, to understand the actions that should be taken by the vibration analyst in response to observed vibration data. Although a trained analyst may likely identify indications of early stage machine degradation through vibration data, his ability to confirm and communicate his observations in a manner that protects critical station functions warrants further attention. A vibration analyst, confronted with a large and expanding vibration database, may be overcome with questions of where he should concentrate his attention and what actions he should take to insure important data is not ignored. This paper presents a systematic distilling technique, which reduces information from an existing vibration database in a manner that yields necessary maintenance decisions.

The technique begins with the creation of action thresholds for vibration. These thresholds, once exceeded, prompt the analyst to take the following steps:

- Step 1: Confirm the vibration condition
- Step 2: Review vibration and other data
- Step 3: Evaluate the vibration condition against likely causes
- Step 4: Report evaluation results to the station organization
- Step 5: Inspect forensic results

DISCUSSION

In adopting principles of Reliability-Centered Maintenance, it is important for the vibration analyst to remain mindful that his inspections serve to protect critical functions that may no longer be protected by time-directed maintenance. His activities are not mere enhancements to scheduled maintenance. Recommendations resulting from his inspections may now be the single barrier against critical equipment failure.

Effective vibration analysis owes much to the ability of the individual analyst. This is an inescapable characteristic of the discipline. As a result, vibration evaluation may appear subjective... relying heavily on the intuition or whim of the individual analyst, and without scientific-like substance. It is important, then, to insure analysts receive sufficient training, opportunity for experience, and obtain suitable qualifications. It is also important, where possible, to follow systematic steps that support repeatable and accurate evaluations... resulting in effective maintenance recommendations. This paper presents a series of suggested systematic steps.

INTRODUCTION

PREREQUISITES

It is presumed that elements of Reliability-Centered Maintenance have already been implemented at the reader's station. These include:

- Identification of station critical functions, and condition-based inspections that protect these functions
- Use of trained vibration analysts and data-collectors
- Creation of a vibration database that:
 - Supports the examination of vibration amplitude trends and spectral content
 - Supports “alarming” functions for at least two levels of amplitude
 - Allows for identification of early stage degradation of rolling- element bearings
- Access to equipment operation and maintenance histories
- Access to station equipment design information such as:
 - Machine speeds
 - Power ratings
 - Types of bearings used
 - Etc.

KEY POINT

Effective vibration analysis owes much to the ability of the individual analyst. This is an inescapable characteristic of the discipline. As a result, vibration evaluation may appear subjective. It is important, where possible, to follow systematic steps that support repeatable and accurate evaluations that result in effective maintenance recommendations.

ACTION THRESHOLDS

DISCUSSION

It is not possible for the vibration analyst to individually inspect and resolve every subtle change in amplitude, or the significance of every spectral peak in his station's entire vibration database. For this purpose, Action Thresholds are used. These thresholds are those levels of machine vibration amplitude that, if exceeded, warrant additional investigation and evaluation by the analyst. It is common practice, then, that the majority of the vibration analyst's attention is directed towards thresholds that have been exceeded. If an action threshold has not been exceeded, the reviewing analyst may normally assume that the machine's vibration condition is acceptable for continued service.

These thresholds may alternately be referred to as "alert" or "danger" setpoints, acceptance criteria, or control criteria. Reference sources used to establish these thresholds may be obtained from several of the industry standards organizations, vendors of condition monitoring equipment, or the component manufacturer. Some analysts have found success in applying statistical deviations to established baselines as a means to establish thresholds. Safety related components, at US nuclear stations, probably have thresholds already specified by their operating license. It is not the intent of this paper to provide these threshold values, but instead to help the analyst use them once the station has adopted them.

Systematic steps suggested here include the use of three types of action thresholds. Each of the following thresholds warrants a different measure of attention by the analyst:

- Alert
- Danger
- Early Stage Rolling-Element Bearing Degradation

ALERT

"Alert" refers to that level of overall vibration that simply warrants additional evaluation by the analyst. It is commonly presented in units of overall velocity, and within a frequency range of approximately 10Hz to 1000Hz. Machine vibration exceeding the Alert value is treated as a symptom of a potential machine fault. Resultant evaluation is left to the skill of the analyst. The analyst will probably want to investigate machine and vibration characteristics other than amplitude prior to making a maintenance recommendation. It is not assumed that the vibration condition will necessarily reflect degradation nor warrant corrective maintenance.

Vibration analysts specifying Alert thresholds for safety related components at US nuclear stations will probably adopt the "Alert Range" threshold already mandated by their operating

ACTION THRESHOLDS

license (ref. ASME OM Code). As an additional resource, standards published by the International Organization for Standardization can be useful in establishing vibration Alert thresholds for rotating components beyond those covered by the ASME OM Code.

The following standards may be either adopted or modified according to station experience to establish Alert thresholds:

Pumps:

ISO 10816-7-2009 (preceded by ISO 10816-3-1998)

Alert Threshold is based on:

- Upper value of Zone B (Criterion I: Vibration magnitude) or
- Change in vibration magnitude exceeding 25% of the upper value of Zone B (Criterion II: Change in vibration magnitude)

Fans:

ISO 14694-2003

Alert Threshold is based on “Alarm” value (reference Table 5)

Motors:

ISO 10816-3-2009 (preceded by ISO 10816-3-1998)

Alert Threshold is based on:

- Upper value of Zone B (Criterion I: Vibration magnitude) or
- Change in vibration magnitude exceeding 25% of the upper value of Zone B (Criterion II: Change in vibration magnitude)

DANGER

“Danger” refers to that higher amplitude of overall vibration that is not just a symptom of degradation... but of such severity that it is the actual problem itself. In this case, vibration may cause damage to the machine. This is the last warning the vibration analyst is able to provide his station of pending machine failure. The threshold is commonly presented in units of overall velocity, and within a frequency range of approximately 10Hz to 1000Hz.

A condition of “Danger”, once reported to station management, commonly prompts the question “how long before it fails?” Vibration analysis, as a science, has yet to prove that the moment of a machine’s failure can be predicted with repeatable certainty. The importance of the “Danger” threshold remains, however, as that level beyond which the vibration analyst is no longer able to provide further warning of pending failure.

ACTION THRESHOLDS

Although a machine vibrating above the Danger threshold may survive a long period of time, it remains critical that the condition be communicated to station management. The maintenance strategy for the equipment under survey, adopted through principles of Reliability-Centered Maintenance, may rely exclusively on vibration monitoring to forewarn of some failure modes. With the highest vibration warning exhausted, supported system functions will be left unprotected unless corrective measures are implemented.

KEY POINT

A condition of “Danger”, once reported to station management, commonly prompts the question “how long before it fails?” Vibration analysis, as a science, has yet to prove that the moment of a machine’s failure can be predicted with repeatable certainty.

Vibration analysts specifying Danger thresholds for safety related components at US nuclear stations will probably adopt the “Required Action Range” threshold already mandated by their operating license (ref. ASME OM Code). As an additional resource, standards published by the International Organization for Standardization can be useful in establishing vibration Danger thresholds for rotating components beyond those covered by the ASME OM Code.

The following standards may be either adopted or modified according to station experience to establish Danger thresholds:

Pumps:

ISO 10816-7-2009 (preceded by ISO 10816-3-1998)

Danger Threshold is based on the upper value of Zone C (Criterion I: Vibration magnitude)

Fans:

ISO 14694-2003

Danger Threshold is based on the “Shutdown” value (reference Table 5)

Motors:

ISO 10816-3-2009 (preceded by ISO 10816-3-1998)

Danger Threshold is based on the upper value of Zone C (Criterion I: Vibration magnitude)

ACTION THRESHOLDS

EARLY STAGE ROLLING-ELEMENT BEARING DEGRADATION

The use of Alert and Danger Thresholds, as previously described, is insufficient to identify early stages of rolling-element bearing degradation. Damage to contact surfaces in these types of bearings may occur under the influence of load; or in the presence of inadequate lubrication, contamination, circulating currents, or background vibration. Early stages of rolling-element bearing degradation will be initially noticed in higher frequencies of vibration (i.e. > 1000 Hz), and be most clearly presented in units of acceleration. Later stages of bearing degradation will be evidenced in those lower frequencies monitored for the Alert and Danger thresholds (i.e. $10\text{Hz} - 1000\text{Hz}$), but at a severity of degradation possibly too late to plan corrective maintenance prior to failure.

Vibration analysts must select a method to identify early stages of rolling-element bearing degradation. Choices include High Frequency Detection (HFD), demodulation, auto-correlation, or simple banding around those higher frequencies showing early stages of degradation. Additional choices are offered by several of the vendors of vibration monitoring equipment. Some of these techniques are only specifically suited to the vibration monitoring equipment purchased for use by the station. There are such a wide variety of techniques used to monitor for the onset of rolling- element bearing degradation, no attempt will be made, here, to offer suggestions dealing with appropriate thresholds. Once a technique has been selected at a station, it will likely be necessary to consult with either peers using the same technique or the vendor of the station's monitoring equipment to establish suitable thresholds. It is not the intent of this paper to choose the method or threshold used by the analyst, but rather to suggest that some means must be selected and implemented.

Trending of these higher frequencies presents unique challenges. The common means of mounting vibration transducers used for route monitoring is through use of a magnet. This type of mounting may provide inconsistent results by attenuating some measure of those higher frequencies evidencing early stage rolling-element bearing degradation. Fluctuations in trended amplitude may occur due to small differences in how the transducer is mounted for each survey. Additional variations may occur due to the influence of the mounted resonance of the transducer. These variations may make selection of a specific threshold difficult. It may, then, become necessary to identify early stages of rolling-element bearing degradation by increases above established baselines.

ACTION THRESHOLDS

DOCUMENTING THRESHOLDS

Although industry standards may provide some initial bases, the most accurate thresholds will be those established uniquely for each component within a station's vibration monitoring program. Such component-specific thresholds are created with knowledge of the component's actual operating behavior and vibration characteristics observed over time. To maintain adequate control and document these bases, it is useful for each station to establish a Vibration Threshold Reference. Once this document is created, it should be tested against experience and modified when necessary. See "Attachment A – Example Vibration Threshold Reference" as a sample cover page and threshold information for the Alert and Danger thresholds of three components.

KEY POINT

Although industry standards may provide some initial bases, the most accurate Alert and Danger thresholds will be those established uniquely for each component within a station's vibration monitoring program.

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

DISCUSSION

Once an Action Threshold is exceeded, the vibration analyst uses his training and experience to determine the reason a machine's vibration condition has exceeded the threshold. The result of his investigation may lead to a maintenance recommendation. A "maintenance recommendation" will be that communication delivered to station management by the analyst that serves to protect equipment under the analyst's surveillance. The importance of creating an effective maintenance recommendation should not be understated, as it may be the single barrier against equipment failure and the resultant loss of those system functions it supports. This paper proposes that the analyst attack the issue by performing five sequential steps. These steps are merely a template or guide that can be used by the analyst to approach and solve the vibration condition systematically. These steps are not intended to replace the analyst's process of thinking or analyzing the problem. The steps are not proscriptive... that is, they do not force the analyst to abandon his training, experience, best judgment, or even intuition. The analyst may even determine that it is not necessary to perform all five steps, as the vibration condition may be dispositioned prior to their completion. The steps, instead, provide a loose framework within which the analyst performs his work. Their purpose is to help the analyst act in a systematic manner that promotes accurate and repeatable maintenance recommendations. The steps are:

- | | |
|--------|--|
| Step 1 | Confirm the vibration condition |
| Step 2 | Review vibration and other data |
| Step 3 | Evaluate the vibration condition against likely causes |
| Step 4 | Report evaluation results to the station organization |
| Step 5 | Inspect forensic results |

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

STEP 1: CONFIRM THE VIBRATION CONDITION

Given all the instances in which vibration data exceeds an action threshold, a significant number of the cases will be solved and possibly dismissed at this first step of confirming the vibration condition. The confirmation begins with, simply, re-collecting the data. This will minimize errors in the data collection, such as would occur if data was initially collected on the wrong point, with a loosely mounted probe, or with a loose transducer cable that generates unwanted noise in the data signal. Data re-collection will also reduce the likelihood that a momentary operational transient is the source of an unrepresentative vibration reading. The analyst may wish to have a second person obtain the re-collected data, possibly with a different vibration instrument to further minimize the chance of error.

The vibration analyst may choose to augment his confirmatory survey with a general walk-down of the area, and a careful visual inspection of the machine. While keeping vigilance for his own safety and his station's safety protocols, he might be able to identify obvious faults such as looseness at bolted or grouted interfaces. Additional tools, such as a strobe light or infrared spot radiometer, could aid this inspection.

An additional element of confirmation will be to review the station's Vibration Threshold Reference (see "Documenting Alert and Danger Thresholds" above) to confirm that the threshold is properly set. Recent maintenance, for example, may warrant that thresholds established by specifying a deviation in magnitude from a previous reference should be re-baselined to a new reference.

A final element of confirming the vibration condition is to conduct a preliminary review of the vibration reading. This may include a discussion with peers to identify whether they have observed similar conditions, or with contacts in the Operations or Maintenance departments to determine whether operational events or recent maintenance may be responsible for a change in observed vibration condition. If the analyst determines that the condition is immediately recognizable and solvable; he may choose to exercise his evaluation skills to have the condition either immediately dismissed, or continue its disposition by skipping subsequent steps of Review (Step #2) and Evaluate (Step #3).

STEP 2: REVIEW VIBRATION AND OTHER DATA

Once the vibration condition is confirmed, the analyst should review additional available data associated with the equipment under attention. While it may be a temptation to find the simplest conclusion based on the earliest evidence observed, a more exhaustive examination of all available evidence will give those planning maintenance the best chance to correct the condition. This more careful review will minimize the likelihood that the

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

condition is misdiagnosed. It will also give those planning maintenance an opportunity to inspect for multiple causes of the condition if they exist.

A suggested method of vibration data review is to collate the data on one or two pages in a matrix format. That is, as the vibration database is being reviewed page-by-page, critical notes are recorded on a summary sheet. This summary sheet will be referred to, from this point forward, as the Review Datasheet. It indicates vibration amplitudes, trends, dates of significant events, significant spectral peaks, etc. The value of this type of review is, first, to give the analyst some structured time to become intimate with all pertinent data. Secondly, it results in a detailed data matrix that summarizes information in a manner that can be more effectively evaluated later.

The data review is not confined to vibration data. Additional review of data from corroborating PdM technologies such as infrared thermography or oil analysis, if available, should be performed. Determination of various fault frequencies may be necessary to allow the vibration analyst to evaluate otherwise unknown spectral peaks. Most valuable, however, will be that of performing a review of maintenance and operational histories. These histories, once known, often clarify an otherwise elusive evaluation.

One simple technique is to create the Review Datasheet in a matrix format on simple lined paper. The analyst may use acronyms and shorthand to his liking. He may use arrows to indicate trends, and parenthetical information to identify previous baselines and significant dates. An additional area of the Review Datasheet, or a second page, may be used to list events from his review of maintenance and operational histories. Once the document is completed, he carefully looks it over... circling in red or highlighting those items that appear significant, thus warranting special attention during subsequent evaluation.

Attachment B "Example Machine Vibration Review Datasheet" is offered as a simple example of a Review Datasheet. Significant trends are highlighted. Machine history is recorded at the bottom of the page. Analysts may choose to create their own style of summarizing data in a manner that is most intuitive and easy to review later. The result will be a "Review Datasheet" that will be used in the next step of Evaluate.

STEP 3: EVALUATE THE VIBRATION CONDITION AGAINST LIKELY CAUSES

As stated in the introduction, effective vibration analysis owes much to the ability of the individual analyst. In the short history of machine vibration analysis, little has been done to replace his skills realized through experience, training, or intuition. Those uncomfortable

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

relying on an analyst's individual skills have proposed expert systems, or other systematic means to make decisions otherwise made by the analyst. The systematic steps proposed in this paper do not intend to replace the analyst's contribution, be it through his intuition or otherwise. These recommendations, instead, intend to surround the analyst with a loose systematic framework within which he makes his or her evaluations.

A "Machine Vibration Matrix", reflects an itemization of vibration related machine conditions and their commonly occurring symptoms. The example provided (reference "Pacific Vibration Matrix" at www.pacificvibration.net) was created at a particular station, and reflects knowledge obtained through training, research, and experience at that station. Analysts evaluating a vibration condition at their station may refer to such a document as an aid to consider all possible faults associated with observed vibration data. It may also be used to identify additional diagnostic techniques available to confirm possible faults. A Machine Vibration Matrix is not useful to someone untrained as an analyst. It offers no new information to the analyst, but only summarizes information he's already learned. It is useful as an aid to prompt the analyst to systematically employ evaluation tools he already knows.

An analyst performing an evaluation begins by comparing the Review Datasheet just completed in the previous step to his station's Machine Vibration Matrix. The evaluation performed here by the analyst is not one of rote repetition or tedious review, but instead involves higher-order skills of comprehension and evaluation. The Machine Vibration Matrix is not a decision tree. That is, it does not have a beginning and end. It is used, instead, in a free-form manner that allows the analyst to follow clues as he finds them. Its use may begin by comparing troublesome cases against the top row of vibration related machine conditions as presented on the matrix. Given time for review, the analyst will eventually identify one or more likely causes of the offending vibration, and possibly prompt additional testing or investigations. The eventual outcome represents the results of the analyst's evaluation, from which he can estimate the severity of the condition and provide recommendations to the station organization.

Readers wishing to adopt recommendations from this paper may elect to use the Pacific Vibration Matrix (pacificvibration.net) as a basis from which to create a Machine Vibration Matrix suitable for their own station. Readers may not agree with all of the diagnostic elements contained in the Pacific Vibration Matrix. They may, then, modify or incorporate diagnostic elements reflective of their own experience and equipment.

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

STEP 4: REPORT EVALUATION RESULTS TO THE STATION ORGANIZATION

Some may say the job of the vibration analyst is complete once the cause of a machine's offending vibration condition has been evaluated. This, however, discounts the ultimate charter of vibration analysis as it relates to Reliability-Center Maintenance... to preserve system function. The vibration evaluation, if it identifies a condition threatening a critical system function, must eventually yield a maintenance decision.

The vibration analyst's expertise serves to protect equipment. An analyst who identifies a vibration condition that threatens equipment must report such findings and recommendations to the plant Operations Department. This is the analyst's "maintenance recommendation". The analyst, however, does not keep the expertise, training, or day-to-day knowledge of the station's operation to understand how the equipment surveyed contributes to overall system function. This is the job of the station's Operations Department. Personnel from the Operations Department receive ongoing training and certification; and, in the case of nuclear generating stations, hold the legal obligation to operate the station in a manner that supports those critical system functions that protect generation, site personnel, and the public. "Maintenance decisions" are those maintenance activities directed by the Operations Department that serve to protect the station's critical system functions. They must balance risk levels and resources in a manner that best protects critical functions.

When an analyst delivers a maintenance recommendation to the plant Operations Department, it can be helpful to include representatives from the Maintenance Department as recipients of this report. While formal documentation is normally required, a face-to-face meeting between the vibration analyst and representatives from the Operations and Maintenance Departments serves to quickly track the response to the proper level of urgency. The analyst should keep himself available to respond to questions regarding the severity level of the condition, as well as his recommendations for repair. Representatives from the Operations Department will make the *maintenance decision*, hopefully with the counsel of the vibration analyst and Maintenance Department representative.

KEY POINT

The vibration evaluation, if it identifies a condition threatening a critical system function, must eventually yield a *maintenance decision*.

ANALYSTS' RESPONSE WHEN EXCEEDING ACTION THRESHOLDS

STEP 5: INSPECT FORENSIC RESULTS

Following maintenance to correct a vibration condition, a confirmatory vibration survey must be conducted to insure that maintenance was effective. Inspections should also be done to confirm the suspected cause. These may be done as a simple review of maintenance findings, or by more elaborate forensic examinations. Results of these inspections will serve to broaden the experience base of analysts at the station. They should also be used to modify, as necessary, two documents previously cited in this paper:

- Vibration Threshold Reference (see Attachment A)
- Machine Vibration Matrix (example at “pacificvibration.net”)

Future evaluations of machine vibration will, then, benefit from ongoing experience gained through each maintenance effort.

CONCLUSIONS

This paper proposes a more systematic, and probably exhaustive method of solving machine vibration issues at a nuclear station than one may initially suspect. The method is a distilling technique that reduces a large vibration database into necessary maintenance decisions. The method begins with the creation of three Action Thresholds:

- Alert
- Danger
- Early Stage Rolling-Element Bearing Degradation

If collected vibration data exceeds any of these thresholds, the following steps are taken to either solve or dismiss the condition as one that warrants a maintenance recommendation:

Step 1	Confirm the vibration condition
Step 2	Review vibration and other data
Step 3	Evaluate the vibration condition against likely causes
Step 4	Report evaluation results to the station organization
Step 5	Inspect forensic results

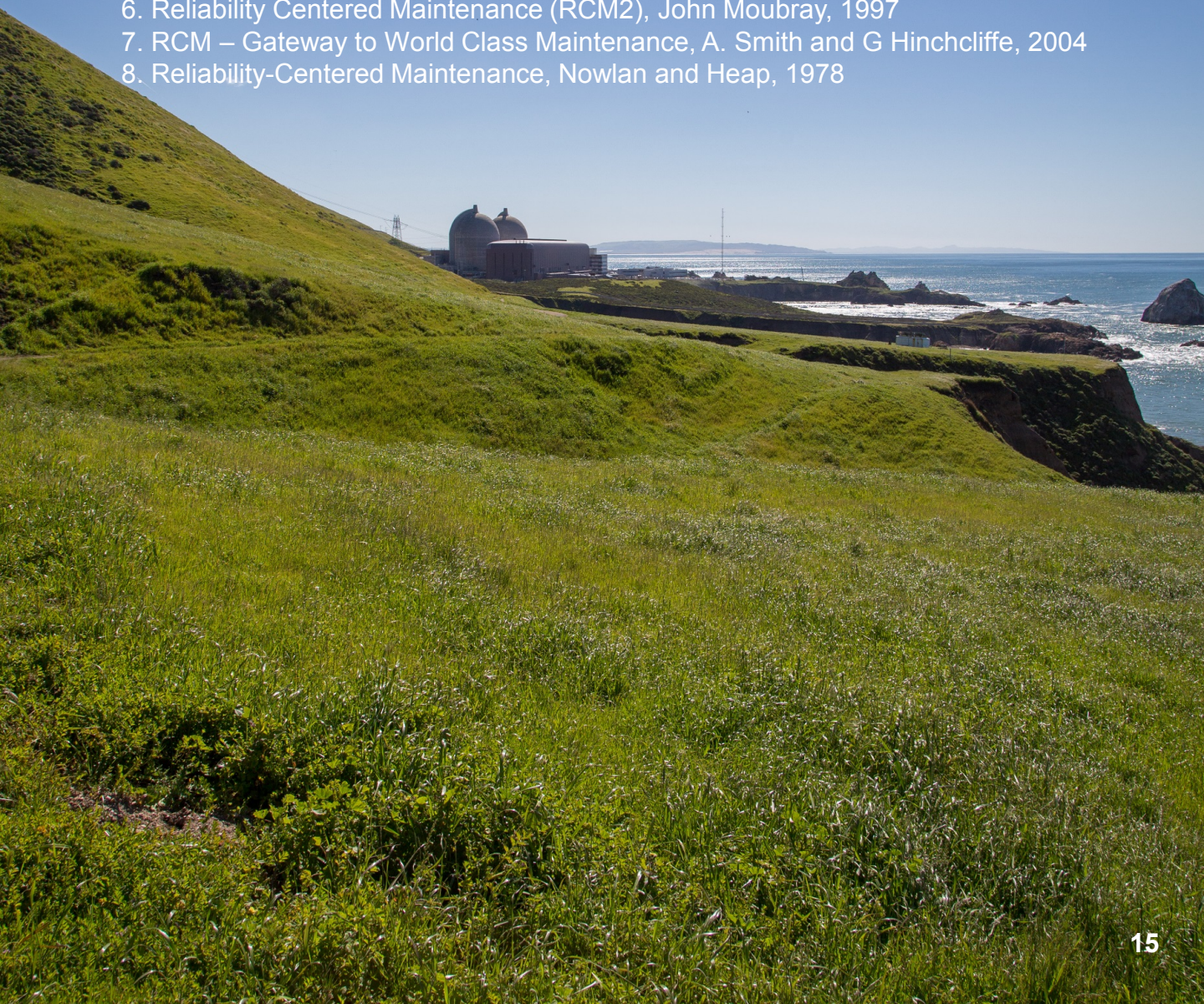
The use of a “Machine Review Datasheet” is suggested as a tool to help the analyst more thoroughly investigate vibration conditions (see Attachment B). The creation and use of two additional documents is also suggested to help the analyst deal with vibration conditions specific to his station, and capture experience to improve future evaluations:

- Vibration Threshold Reference (Attachment A)
- Machine Vibration Matrix (example at “pacificvibration.net”)

The suggestions presented here may not suit the needs of every analyst considering these recommendations. The author does not wish to discredit contrasting techniques already practiced and perfected by other analysts. Within his own experience, however, he has come to believe that a structured approach, such as the one described here, provides a basis for repeated success, and often yields solutions to otherwise elusive vibration problems.

SOURCES

1. ISO 10816-3-2009, Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15000 r/min when measured in situ, 2009
2. ISO 10816-7-2009, Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 7: Rotodynamic pumps for industrial applications, including measurements on rotating shafts, 2009
3. ISO 14694-2003, Industrial fans – Specifications for balance quality and vibration levels, 2003
4. ISO 15243-2004, Rolling bearings – Damage and failures – Terms, characteristics and causes, 2004
5. ASME OM Code-2001, Subsection ISTB, Inservice Testing of Pumps in Light-Water Reactor Nuclear Power Plants, 2001
6. Reliability Centered Maintenance (RCM2), John Moubray, 1997
7. RCM – Gateway to World Class Maintenance, A. Smith and G Hinchcliffe, 2004
8. Reliability-Centered Maintenance, Nowlan and Heap, 1978



Attachment A – Example Vibration Threshold Reference

Identification and Bases for Alert and Danger Vibration Thresholds for Three Components

The Vibration Specialist may use this guidance to establish Alert and Danger vibration thresholds for the specified components.

“Alert Threshold” Column: Identifies that magnitude of vibration, which warrants increased attention by the analyst to determine its cause. Two means of establishing this value are offered. The Vibration Specialist may use his discretion to select one of these choices:

- Choice #1 – “w/o Baseline”. This is an amplitude value, which may be used if there is no vibration baseline established following initial component installation or maintenance.
- Choice #2 – “Baseline Plus Mag Dev”. This is a magnitude deviation that may be added to a baseline vibration condition established during normal operating conditions. There is no minimum number of samples required to establish this baseline.

“Danger Threshold” Column: Identifies that magnitude of vibration, which, if exceeded, may cause damage to the affected equipment.

<u>Component</u>	<u>Threshold Bases</u>	<u>Alert Threshold</u> w/o Baseline Baseline Plus Mag Dev	<u>Danger Threshold</u>	<u>Drawing Reference</u>	<u>Applicable Vendor Threshold</u>
Air Side Seal Oil Pumps <u>Motors/Pumps</u> (50 HP)	ISO 10816-3- 1998 Table A.3	0.25 ips-p Baseline + 0.07 ips-p	0.40 ips-p	Utility Drawing #663282 Shts 48, 490 663280-1	None Applicable
CCW Pumps <u>Motors/Pumps</u> (400 HP)	ISO 10816-3- 1998 Table A.3	0.25 ips-p Baseline + 0.07 ips-p	0.40 ips-p	Utility Drawing #663213-27-7	Motor Unloaded 0.0025 in p-p
Electro-Hydraulic Pumps <u>Motors</u> (30 HP)	ISO 10816-3- 1998 Table A.4	0.16 ips-p Baseline + 0.04 ips-p	0.25 ips-p	Utility Drawing #663284 Shts 1,36, & 72	None Applicable

Attachment B – Example Machine Vibration Review Datasheet

Equipment: *Gland Exhauster 21*

Date: *3/8/10*

Survey Point	Overall Amplitude and Trend	Dominant Spectral Peaks and Trend
Motor OB-A	Vel 0.31 ips-p → HFD 0.80 g-p → Accel 1.2 g-p →	Vel: 1X @ 0.25 ips-p → 3X @ 0.06 ips-p → Demod: No peaks present
Motor OB-H	Vel 0.51 ips-p (0.28 on 7/09) HFD 0.85 g-p → Accel 0.9 g-p →	Vel: 1X @ 0.47 ips-p ↑ (0.23 on 7/09) 3X @ 0.06 ips-p ↑ (new on 11/09) Demod: No peaks present
Motor OB-V	Vel 0.46 ips-p ↑ (0.22 on 7/09) HFD 0.7 g-p → Accel 0.6 g-p →	Vel: 1X @ 0.42 ips-p ↑ (0.18 on 7/09) Demod: No peaks present
Motor IB-H	Vel 0.51 ips-p ↑ (0.27 on 7/09) HFD 0.9 g-p → Accel 0.95 g-p →	Vel: 1X @ 0.48 ips-p ↑ (0.23 on 7/09) Demod: No peaks present
Motor IB-V	Vel 0.61 ips-p ↑ (0.30 on 7/09) HFD 0.85 g-p → Accel 0.9 g-p →	Vel: 1X @ 0.58 ips-p ↑ (0.29 on 7/09) Demod: No peaks present

Notes:

" → " indicates trend direction

Parenthesis indicates value and month at which baseline was established

Machine History:

Motor overhauled and fan impeller replaced – 3/10/05

Recent Motor Relub – 3/19/07, 4/01/08, 4/15/09,

Report: "Unusual Noise During Start", Notif #50014531, 10/2/09

Report: "Noise and Thermal OL Trip During Start", Notif #50236900, 2/10/10