

# Using Metrics in Bearing Condition Monitoring! <sup>1</sup>

## *MDA: Bearing Lifeguard™-A Next Generation Technology* <sup>1</sup>

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### Introduction:

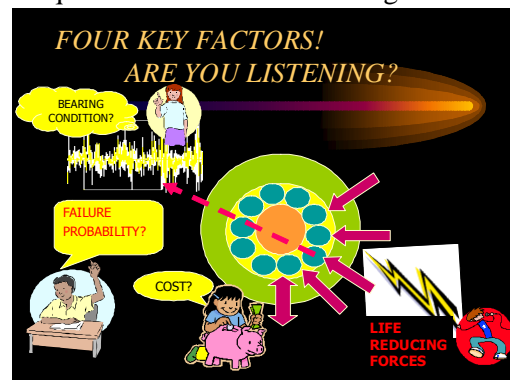
“There is a 40 % chance of showers today.”

Trying to accurately predict the time of a bearing failure is like trying to predict the weather. Like the weather, classic rolling element bearing failures are somewhat random in nature and are best predicted by statistical methods.

When trying to make replacement decisions on a suspect bearing, don't ask: When will it fail? Better to ask: What is the probability of failure before the next routine shutdown? The technology described in this article will answer that question.

But; Like a TV remote control, that requires little knowledge of video technology, the Bearing Lifeguard system with MDA removes the complexity and requires minimal understanding of the underlying vibration analysis technology.

The system applies proven diagnostic techniques to obtain statistical failure estimates. It measures and quantifies low frequency acceleration forces, surface roughness, defect impacts, ratios and envelope levels to provide meaningful estimates of the bearing condition and life expectancy. The technology is a Metrics based, next generation smart system that is a powerful, yet easy to use.



### WHY METRICS? – Saves Money with Clear Understandable Information:

- On bearing condition
- On remaining life
- On forces reducing life
- On near term failure
- On financial risk of inaction
- On total cost of failure
- Makes the mechanic's job easier!
- Reduced training cost.!
- Reduced consulting costs.!
- Conveys useful information.
- Easy to Benchmark
- Improves Decision making.

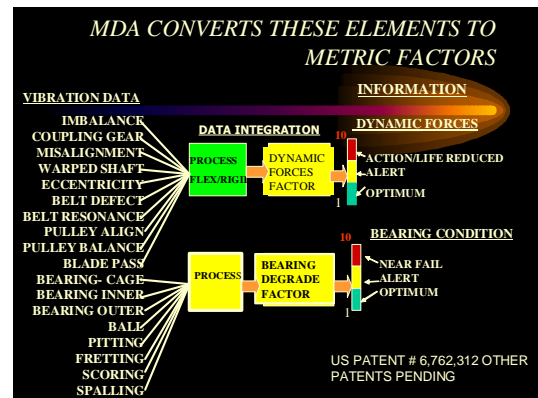
# What is MDA Technology?

MDA (Multiple Discriminant Analysis) is a patented <sup>1</sup> bearing condition assessment tool that provides information on four key factors affecting machinery maintenance costs:

## **Life reducing forces-Bearing Condition-Failure probability and Financial risk**

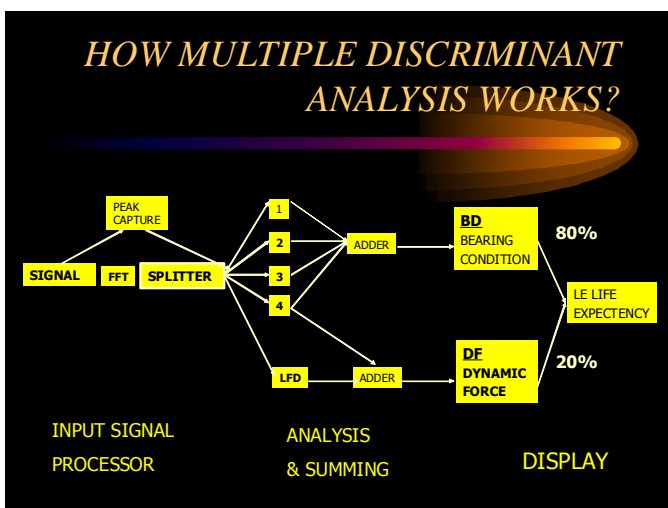
As its name implies, the system utilizes multiple analytical techniques designed to assess a rolling element bearing's condition and reduces each of the process outcomes to a 1-10 Metric called a DISCRIMINANT. A metric value of <1 indicates a near optimum condition and a value near 10 is set to indicate a worst case (Near failure.) condition.

When a bearing degrades, whether from lubrication film breakdown, or subsurface fatigue, a common pattern develops. Microscopic scoring or subsurface fatigue migration cracks begin to appear. A defined failure occurs when a surface defect reaches 10 mil inches square.<sup>2</sup> In this process, measurable acceleration impacts and high frequency energy with specific characteristics, begin to develop. The nature of these accelerations, carefully measured on the bearing housing, provides a useful indication of the ball/race interface surface condition and defect severity. While many diagnostic procedures have proven useful, none are without some element of uncertainty. To improve the diagnostic reliability the MDA system employs multiple procedures, (Six in the system described.) that are all quantified and reduced to the 1-10 Metric and the results are further combined to produce three final Metrics reflecting **Bearing Condition**, **Life Reduction forces** and resulting **Expected Life**. The latter is used to calculate failure probabilities.



## What is a DISCRIMINANT?

.....a diagnostic element that yields a quantifiable Metric related to a specific bearing condition.



1) **The LF (Low Frequency) Discriminant** captures the RMS (root mean square value) of all the low frequency accelerations including those caused by misalignment and rotational imbalance, up to approximately four times the rotational frequency. Accelerations measured near the bearing load zone most accurately reflect the bearing ball/race/housing interface contact forces. Level corrections are made for rigid or flexibly mounted systems. This value is converted to a 1-10 metric.

2) **The CF (Crest Ratio) Discriminant** measures the average ratio between the peak value of high frequency acceleration spikes and the RMS value of the acceleration energy. The character of this measurement is such that it is very sensitive to micro cracks in the bearing/race surfaces. It may be high on a new bearing and often declines after run in and increases to higher values in the latter stages of failure.

3) **The HF (High Frequency) Discriminant** is a measure of high frequency accelerations indicating general surface irregularities, roughness and surface degradation. Microscopic impacts do not contribute significantly to this level because of their short duration and low energy.

4) **The KF (Kurtosis) Discriminant** provides an exponential measure of both the short duration peak impacts and the HF RMS energy. It will respond strongly to a bearing with rough surface spalling and micro surface fatigue crack degradation. It is a highly reliable indicator of a near failure condition.

5) **The ED (Envelope) Discriminant** is sensitive to shock impact ringing in the measurement system caused by impact durations near the accelerometer resonant period. It converts the RMS to a 1-10 Metric which typically increases dramatically in a near failure condition...

6) **Peak accelerations** are also converted to a Metric which is factored into the BC calculation. The value of P is not displayed as a distinct Discriminant.



The Discriminants are all displayed in a time stamped bar graph form as shown above and may be examined as the last five, last fourteen, last 24 or all, for purposes of observing changes or trends over time. The system provides weighting coefficients that may adjusted for each measuring point by the supervisor. This allows for tailoring each assembly for optimizing system performance.

## What is a FACTOR?

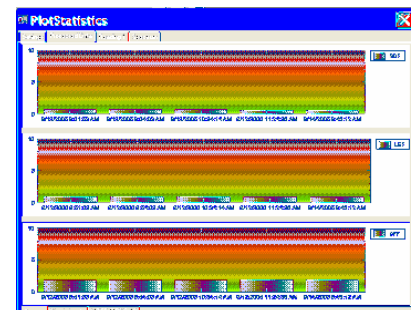
**.....a formulaic combination of Discriminants designed to provide informational Metrics on operational conditions such as dynamic forces, bearing condition, and life expectancy.**

The Discriminant values are weighted and combined to produce a **BC Bearing Condition Factor** in which each analysis technique votes on the bearing surface condition. A reading of 1 indicates a like new, near optimum operating condition and a 10 reflects diagnostic agreement that the bearing is near failure.

The final 1-10 **LE Life Expectancy Factor** reflects the life shortening influence of the **DF low frequency Dynamic Forces** alerts the user to reduced bearing life.

The uniform 1-10 metric system allows the user to quickly assess the system condition and puts all of the complex processing activity out of sight.

The final step converts the factors to numbers displayed on the information screen.



## The Bearing Information Screen

Since most maintenance supervisors are not interested in becoming vibration experts:

It all comes down to this!

Each measurement immediately provides all key bearing informational estimates based on MDA measurements:

- The bearing ID #-
- The Forecast period in days (45 to 270 Default 90)
- MTTF- Mean Time to Failure based on measured bearing condition data
- MTTF based on the influence of dynamic forces acting on the bearing\*
- POF-Probability of failure in the Forecast period
- POF short term (14 days)
- Risk Estimate -the financial risk of failure in the forecast period
- **COA**-the actual user defined cost of failure.

\* User defined - Default is 20% life reduction for DF= 10

ALERT MESSAGES:-

**POF > 50% -- -'BEARING SERVICE RECOMMENDED**

**DF >3--- CHECK BALANCE/ALIGNMENT**

At the end of the collection sequence the information and raw data are stored for review.

## SYSTEM CONFIGURATION

The system is implemented in a three level password protected configuration in either planned, unplanned collection, or review sequence. Assembly ID and location are verified by barcode.

**TECHNICIAN LEVEL (Moderately skilled personnel.)**is intended for data verification, collection and observational notes.

**ANALYST- (Engineer skilled in data analysis and evaluation.)** All of the data collected may be reviewed in the Review mode. It allows examination of Factors, Discriminants for level and trends, as well as signal time history and frequency spectra.

**SUPERVISOR**-this level will define the assemblies, the system parameters, collection sequences and password assignments in the Database Utility.

## TECHNICIAN LEVEL DATA COLLECTION

Following a planned or unplanned sequence the Technician selects a data point and mounts or connects to an existing industrial 100 mv/g accelerometer [Power supplied is 24 volt, 2 ma constant current.] If the sensitivity is not 100 mv/g the user may enter the correct value in the

Field	Value	Unit
Forecast period	90	Days
Estimated MTTF	2160	Hours
Estimated Life	1677	Hours
Probability of Failure in forecast period	63	%
Short term Probability (14 day)	6	%
Risk Estimate (Forecast Period)	\$6321	CoA
CoA	\$10000	

assembly point set up. If the sensor is not connected or is defective, a warning message is displayed.

A 'signal test' screen appears which displays the raw data signal for confirmation by the technician. When confirmed as "real" the collector selects "use this data" to initiate the collection process.

### **THE ANALYST LEVEL allows more detailed analysis when required.**

It is assumed that in a well run facility most equipment is running properly and requires only routine service and periodic checks. On occasion problems occur that require more detailed examination. This is especially true if extraordinary costs or safety issues are involved. The ANALYST LEVEL of BearingLifeguard provides additional information for the experienced practitioner. It allows access to all data FACTORS and DISCRIMINANTS used in the system calculations, as well as acceleration time, spectrum and envelope demodulation data.

### **THE SUPERVISORY LEVEL**

Provides access to all of the above plus control over schedule planning, defining the assembly details, rotational frequency, flexible or hard mounting, variable of fixed speed and locations as well as modifying system parameters and some processing coefficients. The Supervisor can also implement VFD noise and gear mesh rejection filters when required.

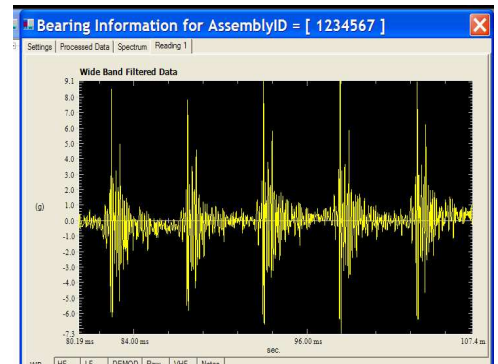
### **SOME MORE ANALYSIS DETAIL?**

It is important to note that the Metrics provided in the BearingLifeguard/MDA system are statistical estimates based on measured diagnostic data. When the decision to schedule a bearing replacement may be critical to a process, safety or involve substantial cost, it is prudent to carefully examine the actual data used in the analysis to validate the conclusions. While the stored data may be uploaded and examined independently, the system provides convenient Tab selected data displays for the user.

The Analyst Level may examine unfiltered or filtered Sonic and Ultra sonic acceleration data.

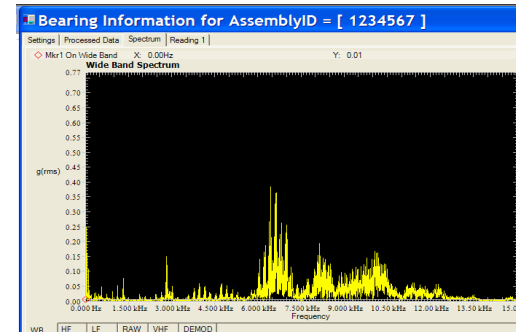
### **Time History Display-**

The acceleration versus time signal illustrated may be zoomed for close examination...



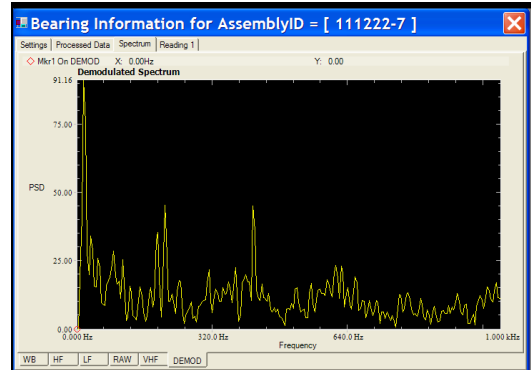
### **Frequency Spectrum Display**

The frequency spectrum may be Tab selected and displayed, zoomed and specific frequencies identified and amplitudes measured by the analyst.



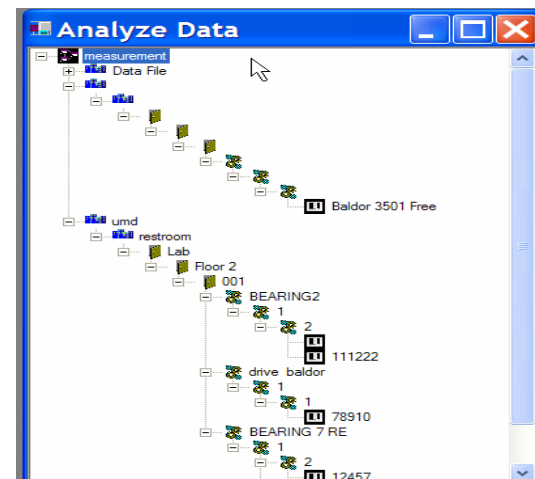
## Modulated spectrum display

The system allows Tab selected examination of low frequency impact envelopes. . The impact frequencies are sometimes useful in recognizing inner, outer or ball defects.



## PLANNED or UNPLANNED SEQUENCE TREE DISPLAYS

A conventional tree display of the facility, building, floor room, assembly and sensor point locations allows selection by mouse click or barcode scanner.



## CONCLUSION

The Bearing LifeGuard System's use of Metrics in rolling element bearing monitoring represents a new and unique approach. It is not meant to replace the need for analysis expertise, but rather to make the job of routine monitoring less complex and more useable by maintenance practitioners. It is designed to accommodate both the vibration novice and the expert. Good results with this system require a properly mounted conventional accelerometer, with a mounted resonance between 15 kHz and 24 kHz. The system may be used as a walk around data collector with a user's Windows XP™ laptop, or rugged tablet computer. The MDA 400 provides a compact handheld terminal that provides data collection, waveform and information screen allowing quick data collection and uploading to a central PC with the Bearing LifeGuard software. The Metric approach lends itself nicely to 4-20 ma systems conveying Factor or Discriminant information in the 1-10 format. This provides all the analytic benefits of high frequency, ultrasonic analysis not possible in a 4-20 ma signal. The system has been used effectively on belt driven, directly or flexibly coupled motors, pumps and compressors, at running speeds from 1750 to 7200 RPM with consistently good results. Provision is made to adjust the system for use with lower speed machines. A user may select a 90 day forecast period for 3600 RPM, or more aggressive or conservative 45, 60, 180, or 270 day period for any selected machine. Variable speed machines should be run at consistent speed when collecting data for best results. Caution must be observed in using the system on gear driven assemblies because of

extraneous gear mesh noise not related to the bearing condition. However, provision is made to reject selected gear mesh frequencies.

For additional information, readers may contact the author at [John@bearinglifeguard.com](mailto:John@bearinglifeguard.com), or [sales@bearinglifeguard.com](mailto:sales@bearinglifeguard.com)

1) Patent # 6 763 342 B1, Copyright © Dynamic Measurement Consultants, LLC. Other Patents applied for.

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2) Ref: Torrington Bearing Service Manual.