

# Advanced Machinery Fault Diagnosis and Signal Processing

## Course Details, Speakers and Agenda

A Practical Course on Advanced Vibration Analysis and Condition Monitoring taught by world recognized expert Professor Bob Randall, University of New South Wales, Australia  
Assisted by Dr Suri Ganeriwala, SpectraQuest, Inc

SpectraQuest offers a practical course on Machine Condition Monitoring and Diagnostics with an emphasis on signal processing techniques. The objective is to provide tools to prepare you to become an expert in analyzing machinery faults. Topics include overview of condition monitoring techniques, basic vibration theory, and advanced signal processing principles like FFT methods, Hilbert methods via FFT and related amplitude, phase and frequency demodulation, cepstrum, order tracking and time synchronous averaging. Rather than giving pure theory, it would be illustrated at all stages with diagnostic examples and demonstrations using SpectraQuest Machinery Fault Simulators. The concept of cyclostationarity with principal application to bearing diagnostics will be provided. The course would cover a range of techniques for bearing diagnostics, as well as for gear diagnostics. It could also cover IC engines by a number of techniques, including simple torsional vibration analysis by frequency demodulation of shaft encoder signals using SpectraQuest bearing wear and gearbox dynamics simulators.



The course will provide a hands-on approach, with theory/lectures followed by real life examples as well as demonstration of novel techniques for fault diagnosis. The approach involves a classroom with several workstations set up for carrying out controlled exercises. Each workstation consists of Machinery Fault Simulator with different machine fault kits, a multi-channel data acquisition system, simulation/training/diagnosis/analysis software, fully wired sensors, and necessary accessories such as tachometer, strobe, etc. All the PCs are connected to a client-server type network for free exchange of data and enhanced discussion.

**Date:** April 5-9, 2010

**Venue:** Holiday Inn, 3207 North Boulevard, Richmond, VA - mention 'SpectraQuest' when making your reservation to obtain the special reduced accommodation rate of only \$70 per night

**Who Should Attend?** This course covers advanced material which a Category III or IV Vibration Analyst will be able to understand. If you have any questions, please e-mail to [juli@spectraquest.com](mailto:juli@spectraquest.com) or call **804-261-3300**

**Cost:** \$1,695.00 if registering prior to 1 March, 2010  
\$1,895.00 after 1 March, 2010

The cost will cover all coffee breaks, lunches, and one dinner at a popular local restaurant. Attendees will receive a free copy of the 'Signal Processing Fundamentals and Simulation' software (\$495 value) along with class notes.

## Preliminary Course Agenda

Timings: Day1 - Day4: 8.30am – 5.00pm, Day5: 8.30am - 3:00pm

### Day 1 – AM

Overview of condition monitoring and vibration analysis – fault detection schemes and manifestation - typical diagnostics procedure – transducers and measurements

### Day 1 – PM

Signal processing – Fourier analysis - Hilbert transforms – practical FFT analysis – demodulation – cyclostationarity and spectral correlation– introduction to cepstrum analysis – time-frequency analysis, STFT, Wigner-Ville distribution, wavelets.

### Day 2 – AM

Rolling element bearing vibrations – fault diagnostics through envelope analysis – applications of cyclostationarity, local faults and extended faults – spectral kurtosis (SK) for determining optimum frequency band for demodulation– minimum entropy deconvolution (MED) to remove smearing effect of transmission path – combination for semi-automated process.

### Day 2 – PM

Exercises

### Day 3 – AM

Gear vibrations – separation of gear and bearing signals by self adaptive noise cancellation (SANC), discrete/random separation (DRS), linear prediction – order tracking (angular sampling) – synchronous averaging of individual gear signals – residual analysis – cepstrum analysis – amplitude and phase demodulation of gearmesh signal- transmission error (TE) measurement using shaft encoders.

### Day 3 – PM

Exercises

### Day 4 – AM

Reciprocating machine vibrations – time (crank angle) vs frequency representations – spectrogram comparison for detecting change – torsional vibration (angular velocity) measurement for irregular combustion – determination of angular velocity by phase demodulation of encoder signal followed by differentiation in the frequency domain (simultaneously removing irrelevant high and low frequency noise) – determination of angular velocity by encoder pulse timing with a high frequency clock – benefits of instantaneous (Wigner-Ville) spectrum after removal of periodic components – determination of cylinder pressure (or pressure torque) from external acceleration and/or torsional vibration measurements.

### Day 4 – PM

Exercises

### Day 5 – AM

Dynamic structural response – introduction to experimental modal analysis (EMA) and operational deflection shape (ODS) – simple structural response measurements with a single accelerometer, first used to measure and adjust force frequency range by changing impact pad, then responses at different locations – determination of excited frequency range from mass of hammer and stiffness of impact pad – ODS using a fixed and a roving accelerometer - exercises (time permitting).

### Day 5 – PM

Exercises and closure

## Previous Course Attendees Comments

"Excellent coverage of diagnostic tools with applications to important classes of machinery. Professor was knowledgeable and insightful." - Mitch Wlodawski, DSPcon Inc

"Excellent overview, wide palette of techniques and case studies" - Gianluca Nicchiotti, Vibro-Meter SA

"A very good advanced course. I would recommend this course to my colleagues" - Alberto Ordonez, Universidad Carlos III de Madrid

## Speakers

**Professor R. B. Randall**, University of New South Wales, Australia is a world-recognized expert on machinery fault diagnostics and prognostics, especially bearings and gearboxes. He has pioneered numerous signal processing techniques for analyzing complex machinery signals such as helicopter gearboxes, IC engines, reciprocating machines etc. He has published extensively on signal processing and diagnostics. Professor Randall is a frequent invited keynote speaker at conferences and symposia. He worked in industry for over 10 years in Australia, Canada, and Europe before becoming a senior fellow at Brüel & Kjær for 17 years. He has been teaching at the University of New South Wales, Australia for the last 20 years. Bob is well known all over the world for introducing innovative signal processing techniques for complex machinery fault diagnosis and prognosis.

**Dr. Suri Ganeriwala** is the founder and president of Spectra Quest, Inc. He has over 25 years' of industrial and academic experience in machinery vibration diagnostics and control, signal processing, and visco-elastic materials characterization. He has developed a unique method of instruction using the Spectra Quest Machinery Fault Simulator (MFS), which is his brainchild from concept to completion. He has authored over thirty papers and articles in journals, magazines, and books. He obtained a Ph.D. in Mechanical Engineering from the University of Texas at Austin.

