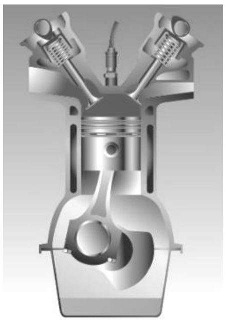
NUREN -'Hot'/'Cold' Engine Testing

OVERVIEW



- Adds intelligent **noise/vibration signature analysis** to engine testing (cold-crank and 'hot' [fired])
- Designed specifically for measuring noise/vibration ("NVH") signatures of **engines** to assess whether those engines contain **manufacturing faults**
- Uses high update rate 1/3-octave spectrum analysis to provide **joint time-frequency analysis** applicable to the engine work cycle
- Provides an automated data capture and processing environment in addition to in-depth interactive graphing / reporting
- Installs on top of a standard **PLATO** NVH test system platform

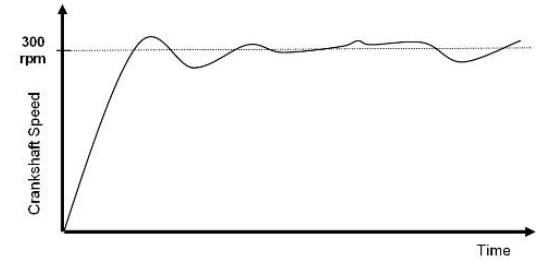
WHAT DOES NUREN MEASURE?

- Engine noise and/or engine **vibration**
- Engine **work-cycle marker signal** (typically obtained from camshaft sensor, cylinder pressure or ignition)

Data capture typically lasts for 32 complete engine work-cycles. Any variation in engine speed is accommodated by the **NUREN** cycle-locking process. The result is a fixed number of spectra per engine cycle that allows cycle-averaging of the data to take place.

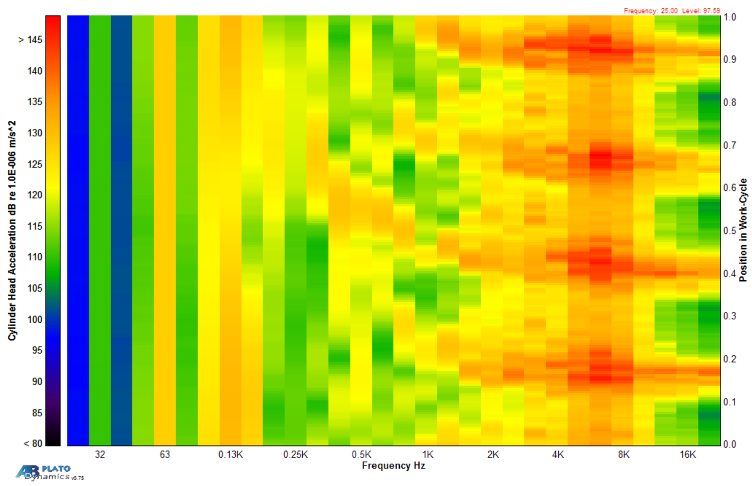
Crank Speed (rpm)	4-Stroke Engine	2-Stroke Engine
600	6.4	3.2
1200	3.2	1.6
2400	1.6	0.8
4800	0.8	0.4

Time (seconds) for 32 engine work-cycles



Cycle-locking process accommodates any variation in crank speed

THE BASIC NOISE/VIBRATION WORK-CYCLE 'MAP'



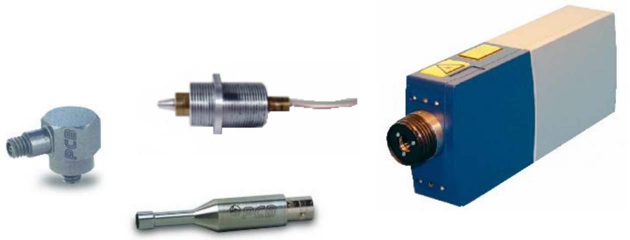
This example engine work-cycle map (for cylinder head vibration) shows a typically distinctive pattern for a 4-cylinder, 4-stroke, diesel engine. The plot is in terms of absolute vibration level. When faulty engines are tested, changes occur in these maps. For example, in the event of a missing exhaust valve rocker on cylinder 2, changes occur in the noise/vibration spectra corresponding to the difference in exhaust gas flow at that cylinder. When NUREN detects such differences, it can automatically fail the engine.

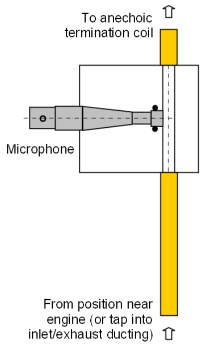
SPECTRAL PROCESSING

1/3rd-octave band frequency analysis based on continuous digital filtering to IEC615 Class 1 is used. The continuous nature of the analysis allows high spectrum updates rates to be used, providing the required resolution in the time (angle) domain.

SENSORS

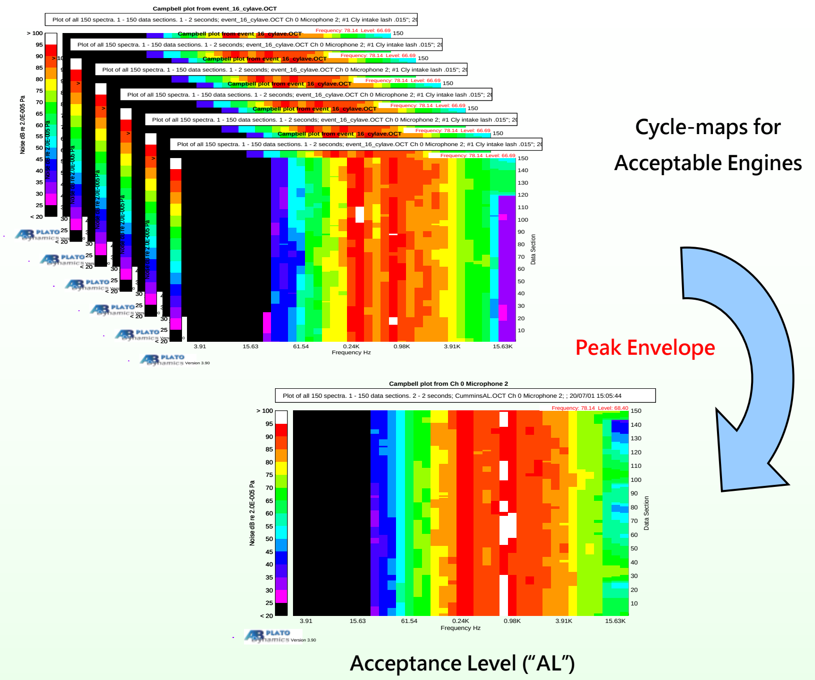
- Noise/Vibration
- Contacting / non-contacting
- You supply / we supply
- Your choice (with our guidance)





Specially designed **probe microphones** can be deployed, which allow noise measurements to be made close to hot engine surfaces or, if manifolds are not fitted at the time of testing, close to the intake/exhaust openings.

ACCEPTANCE LEVEL MAPS



In keeping with core **PLATO** methodology, a peak-envelope noise/vibration 'map' (**Acceptance Level**) is typically constructed from the results of normal [fault-free] engines. This process is automated during the system commissioning period for each engine type. Once the acceptance level has been learnt the system operates in **difference mode** forming '**difference maps**' for analysis. If noise/vibration energy is seen on the difference map that rises above user-set threshold and tolerance levels, **NUREN** will automatically fail the engine.

GET IN TOUCH

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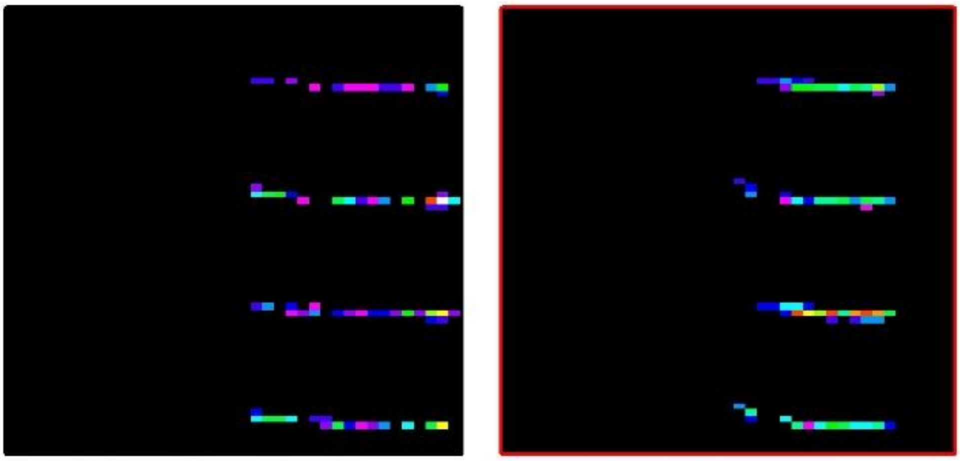
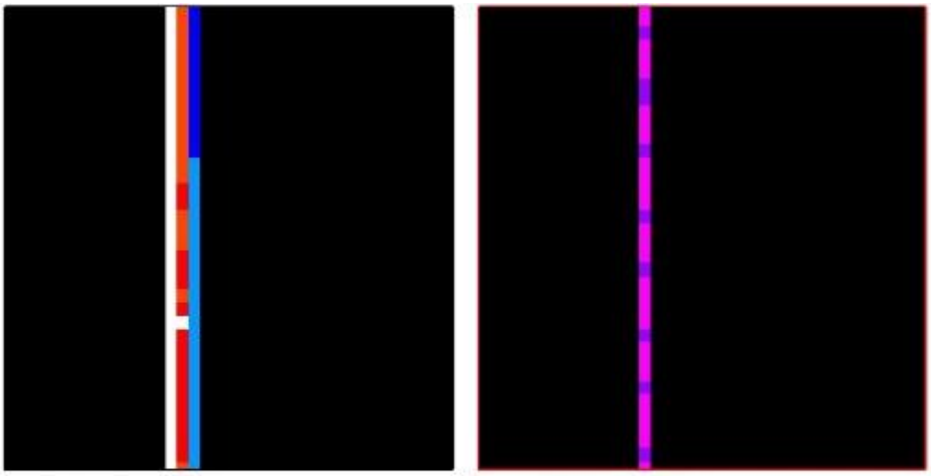
The example difference map shown here is from a 4-cylinder, 4-stroke, gasoline engine with a **timing-belt fault**. The left-hand graphic is derived from an accelerometer attached to a hydraulic clamp (used to hold the engine to the test stand during testing), whereas the right-hand graphic shows engine block surface vibration. The black zones on difference maps represent areas where the result data does not protrude above the acceptance level plus pre-set tolerance. The repetitive, impulsive nature of the fault can easily be seen.



Timing-Belt Fault Signature

By contrast, the further example shown here (from the same type of 4-cylinder, 4-stroke, gasoline engine, using the same sensors) is from an engine with a **balancer-shaft timing fault**. This fault shows relatively constant levels of excessive vibration energy throughout the complete engine cycle – as would be expected from the out-of-balance forces being generated.



Balancer-Shaft Timing Fault Signature

PRODUCTION LINE INTEGRATION

PLATO-NUREN systems are designed to integrate easily and effectively with your cold and hot engine test machines (new project or retro-fit). A fully-automatic test regime can be set-up which receives engine details and selects the relevant test protocol and acceptance levels etc. using either OPC-server (software based), hardware (e.g. 24V logic circuits) or CAN-bus (serial) communications. Once trained, the **NUREN** system operates rapidly to distinguish acceptable engines from unacceptable.

FAULTS DETECTABLE

Experience to-date indicates that **PLATO-NUREN** systems can detect the following faults:

- Valve lifter noises
- Valve backlash errors
- Balancer-shaft timing errors
- Hydraulic tappets that fail to pump-up or which are slow to pump-up
- Missing valve rockers on multi-valve engines
- Missing bearing shells
- Timing errors / timing-belt errors
- Piston "slap"
- Noisy ancillary equipment

ADDING AUTOMATIC FAULT CLASSIFICATION

A further **PLATO** sub-product called **FOCUS** can also be deployed to carry out intelligent **fault signature pattern-matching**. In brief, the pattern of difference map protrusions, which effectively define characterising frequencies and positions within the engine cycle, is examined and matched to a library of previously seen patterns. If a reasonable degree of "match" is determined the fault is classified and reported e.g. **missing valve rocker - cylinder 2** for example. See separate **FOCUS** brochure for more details, including details on how the fault definitions evolve, what happens when lower levels of match are detected and what happens when the fault pattern is a result of more than one discrete fault.

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