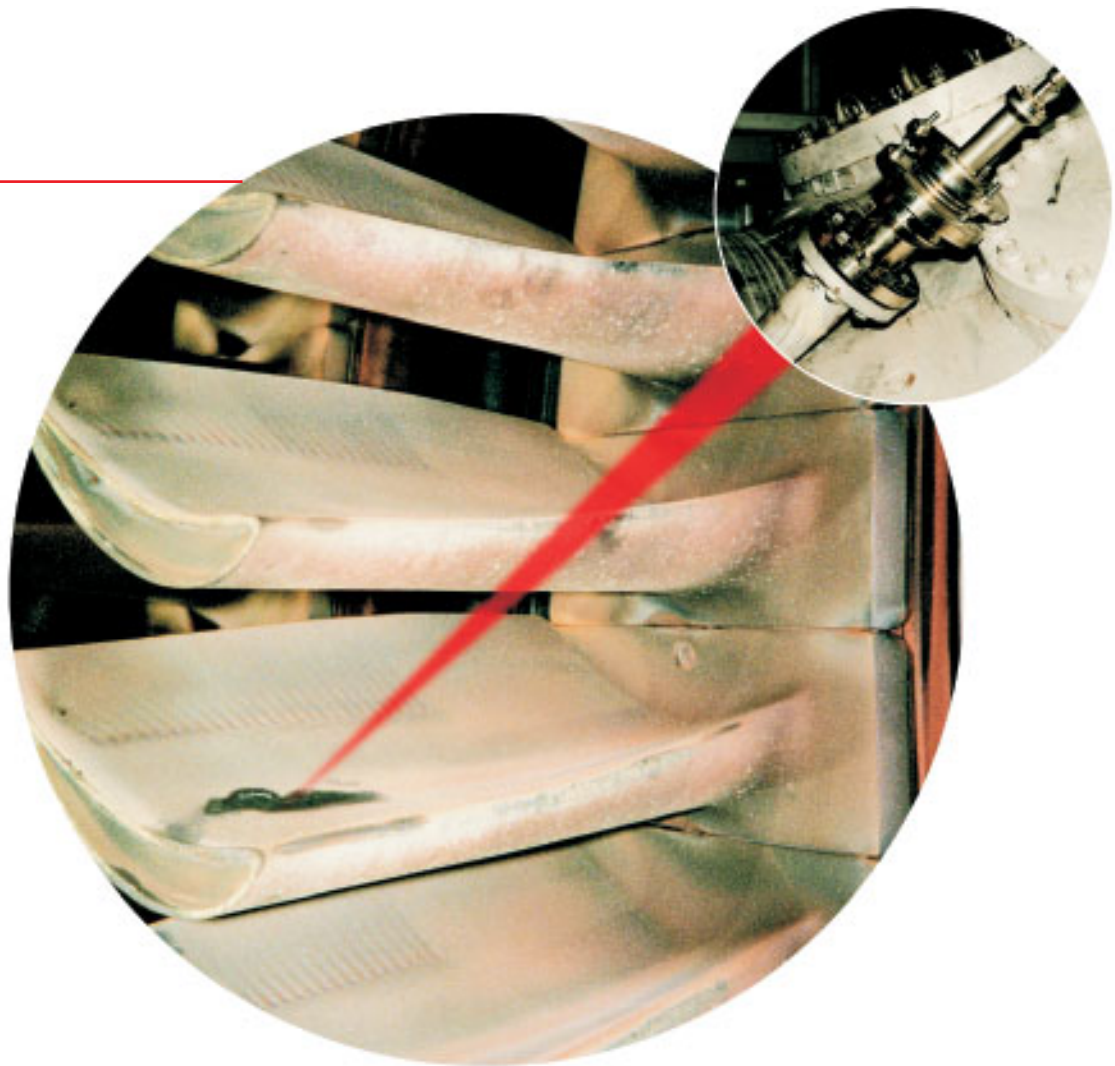
combustion turbine blade temperature analysis

Turbine Sentry
TBTMS



LAND

Combustion & Environmental Monitoring

An AMETEK® Company

improved operating effici
and blade failures in utilit

Accurate, high speed, non contact blade temperature monitoring on utility gas turbines

Real Benefits

- Continuous on-line measurement of individual blade condition
- Increased efficiency through improved engine firing rate
- Detection of blocked cooling channels
- Reliable, accurate blade row temperature
- Early warning of potential blade failure caused by over-temperature operation
- Continuous monitoring of blade coating condition

Key Features

Turbine Sentry gives you accurate, high speed analysis of gas turbine temperature data when and where you need it most - in your control room. The powerful, PC based **Data Sentry** provides all the tools necessary to obtain a complete picture of how efficiently your plant is running, as well as identifying potential problems at an early stage.

- Modular Design - *subsystems design simplify installation and maintenance*
- Rotor Sentry - *single data processing unit, field-expandable to handle up to 32 turbines*
- Performance - *30 readings per blade for high resolution blade temperature profiles*
- Reliability - *electronics separated from harsh engine environment by fiber optic link*
- Ease of Use - *menu structured PC control, running under Windows NT®, for automatic or manual operation*
- Compatibility - *exported tabular data can be used in any spreadsheet program accepting ASCII file format*
- Certified - *Pyrometer manufactured to ATEX directive 94/9/EC (CE Ex II 3 G T6)*

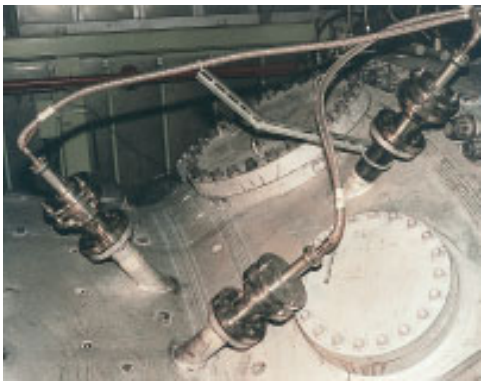


Photo: Typical Blade Sentry Installation

Optical Pyrometry

In utility turbines it has been accepted practice to obtain turbine blade temperature by back-calculation from exhaust gas temperature readings.

This method gives only a prediction of average blade row temperature, and uncertainties associated with this approach require the turbine to be operated below it's optimum efficiency.

Turbine Sentry uses optical pyrometers to measure blade temperatures, giving significantly better accuracy than traditional methods and showing individual blades clearly.

Improved Engine Firing Rate

Using the close coupling between blade and inlet gas temperature, **Turbine Sentry** allows greater control of engine firing rate through accurate rotor temperature measurement.

- Elimination of uncertainty of rotor temperature allows increased firing temperature and rate, hence greater efficiency

Each 0.1% increase in efficiency equates to an annual saving of approximately $20-40k.

ency - prevent premature damage
ty combustion turbines

Prevention of Blade Failure

Cooling integrity is critical - stress creep life has a strong correlation with blade temperature. Operation at over-temperature conditions can lead to damage or even catastrophic failure in the multi-million dollar range.

Turbine Sentry provides early indication of conditions that could ultimately lead to blade failure. Detection of individual overheated blades gives early warning of potential failure, enabling corrective action to prevent costly engine damage and downtime.

Turbine Sentry detected an incorrectly cooled blade running on a large utility turbine: potential failure was avoided, saving an estimated $2M in repair and production costs

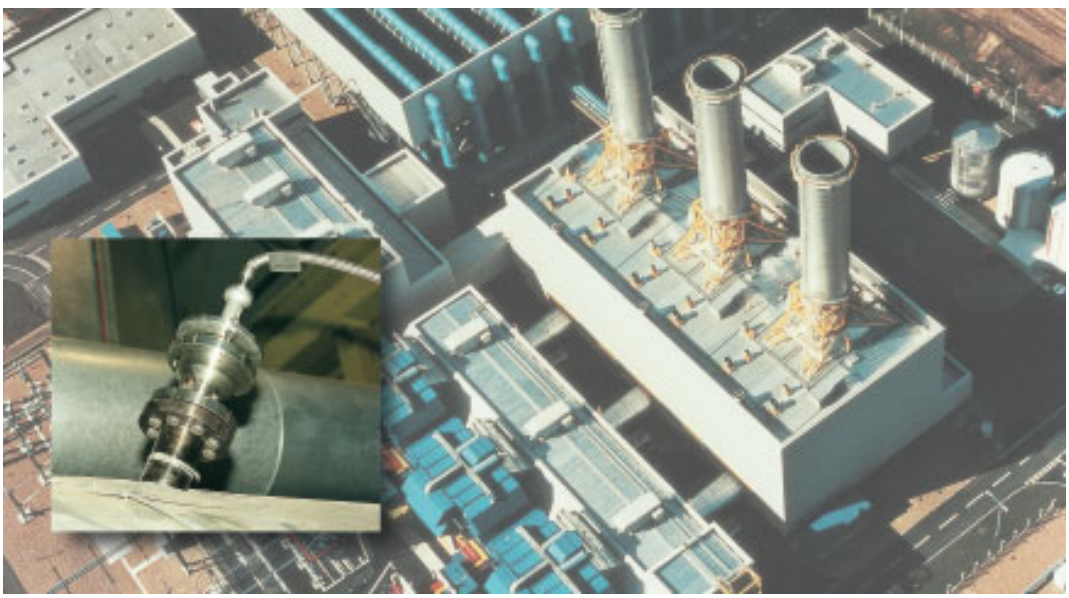
(Source EPRI literature ref. IN-101150)

Predictive Maintenance

All gas turbine blades are coated, usually with an anti-corrosion coating. **Turbine Sentry** can detect coating erosion, hence allowing the user improved planned maintenance. In modern turbine blade designs, increasing use is being made of thermal barrier coatings (TBCs). The relationship between blade temperature and the condition of the thermal barrier coating provides early warning of breakdown and subsequent loss of coating integrity.

- **Blade Life Management** - ***By direct monitoring of individual blades, it is possible to refine blade life predictions and improve 'hot section' maintenance scheduling.***

Extending the period between replacing a row of blades by one year could save over $100,000: avoiding replacement could save far more.



Detecting of over-temperature blades

Modern turbine designs improve efficiency through higher inlet gas temperatures. The blades are exposed to temperatures well above their operating limit, made possible by the introduction of blade cooling. Unimpaired cooling of individual blades is critical for their protection. Traditional, generalized temperature monitoring cannot indicate localized blockages.

Turbine Sentry has shown that temperature can vary significantly from blade to blade. Detection of cooling channel blockages (e.g. by oxidation) are not detectable by traditional methods.

The **Turbine Sentry** provides detailed non-contact temperature monitoring of combustion turbine blades for the purposes of engine operation and maintenance. A typical system comprises:

- **Blade Sentry** - Optical Pyrometer, Mounting Kit and KP/PSU
- **Rotor Sentry** - Data Acquisition System
- **Data Sentry** - Analysis Software for Windows NT®

Blade Sentry — Optical Pyrometer

The pyrometers are engine mounted to view the rotating blades directly through a pressure-proof sight glass assembly (mounting kit).

The optical signal collected by the pyrometer is transmitted through a rugged, flexible, fiber optic lightguide to a remote electronic signal conditioner.

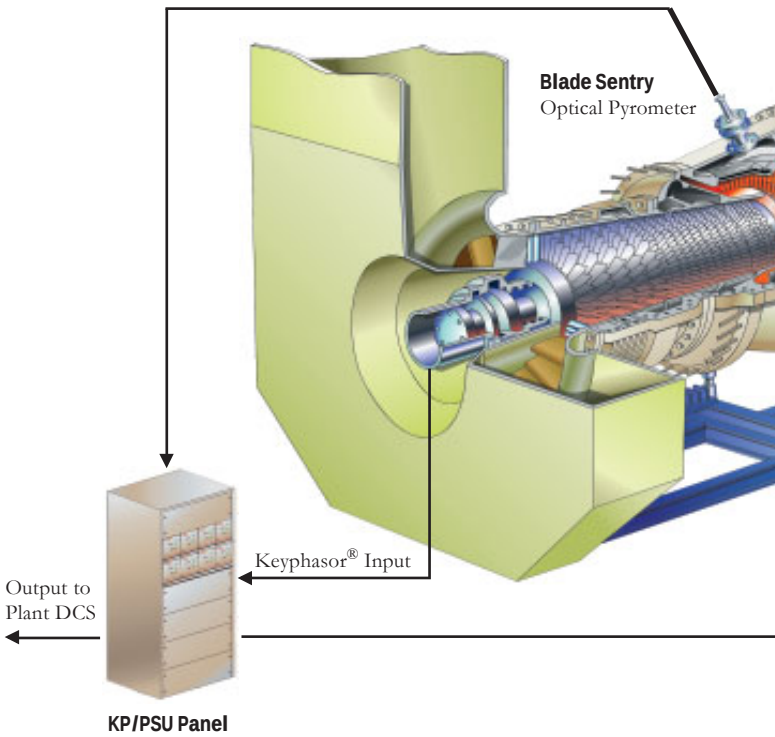
The signal conditioner provides the following linear 4 to 20mA outputs:

- ***Profile*** - a high speed signal sent to the DAS for data logging
- ***Peak*** - the highest temperature on the blade array
- ***Average*** - the average temperature of the blade array
- ***Average Peak*** - the average of the highest temperature of each of the blades

Photo: Blade Sentry Optical Pyrometer and Mounting Kit

The KP/PSU module provides power for each pyrometer and converts the Keyphasor® pulse (once per revolution) for use with **Rotor Sentry**. The KP/PSU also provides user connections to peak rotor temperature, average rotor temperature and average peak rotor temperature outputs from the pyrometer.

Keyphasor® is a trademark of Bently Nevada Corporation

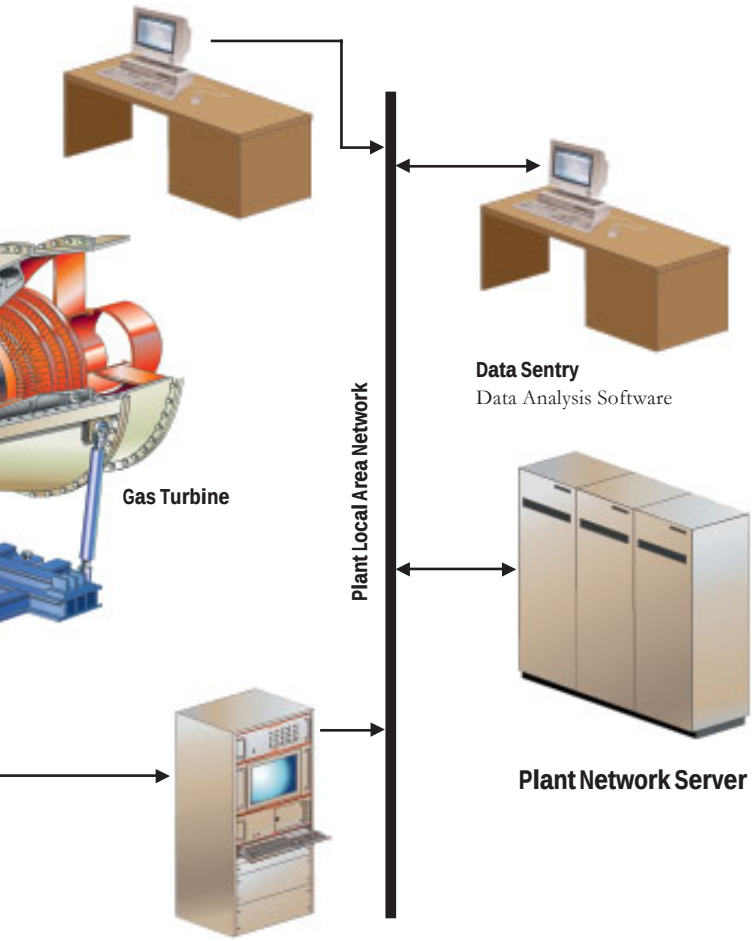


Rotor Sentry — Data Acquisition System

Rotor Sentry Data Acquisition Software system controls the capture of the blade 'thermal fingerprints'.

Features include

- Fully automatic operation
- Logging of other plant parameters for data correlation
- User definable data storage rate with comprehensive data historian functions
- Redundant data storage with optional rolling deletion
- Alarms
- Automatic data storage rate change on alarm
- On screen trending of temperature
- Hot particle rejection for oil fired gas turbines
- User selectable displays including 24 Hour Rolling Trend, Multi-channel and Single Channel.

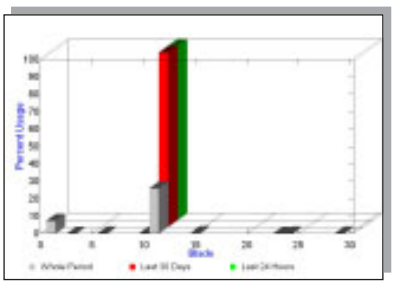


Analysis Software

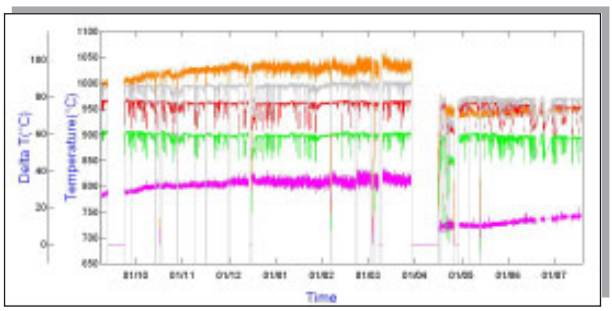
Data Sentry for Windows NT™ features:

- ***Export*** - data conversion routines to other industry standard software such as Excel™ and Lotus 123™
- ***Print*** - printout of selected data
  Display - single or multiple thermal fingerprints
- ***Comparison*** - up to 10 thermal fingerprints can be overlaid at different times
- ***Trend*** - allows selectable parameters to be trended
- ***Filtering*** - data can be filtered according to a range of operating conditions
- ***Statistical*** - on line analysis can indicate potential problem areas.
- ***Pan and Zoom***

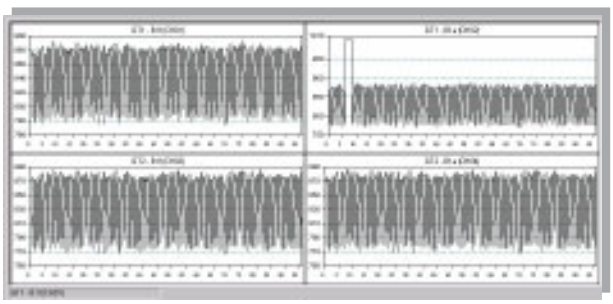
The **Data Sentry** analysis software can run alongside the acquisition software on the system PC or on a separate desktop PC under the Microsoft Windows NT™ environment.



Data Sentry - *Hottest Blade*



Data Sentry - *Rotor Trend display*



Rotor Sentry - *Multi-channel display*

Rotor Sentry DAS can accommodate up to 32 pyrometers in any combination on multiple turbines. The software captures and displays one revolution of temperature data (thermal fingerprint) comprising approximately 3000 temperature readings equally spaced around the blade array.

One complete fingerprint from each pyrometer is sampled every few seconds and stored to disk, at user-definable rates. The software can also monitor additional plant parameters such as:

- Gas Turbine Output Power
- Fuel Type
- Turbine Inlet Temperature
- Exhaust Gas Temperature

. . . a world of knowledge built on a generation of experience. . .

When you specify Turbine Sentry, you have the guarantee of quality, accuracy and reliability that only Land's four decades of experience can give you.

Wealth of Expertise

Turbine Sentry is based on 30 years experience in turbine blade pyrometer technology. Applications cover a wide spectrum, from small aircraft engines to large utility power plants, from basic research projects to in-flight deployment on production fighter aircraft. Some of Land's accomplishments include:

- 30 years as a supplier to all major ground-based and aero turbine manufacturers for engine development and pass-out testing.
- The world's first turbine blade pyrometer used on an operational fighter aircraft - more than 11000 pyrometers manufactured, in excess of 5 million flight hours.
- The world's first optical pyrometer specified for operational use on a civil aircraft engine - the General Electric GE90.

Turbine Sentry can be used on turbines made by all leading manufacturers. Satisfied customers include major utilities in the USA and Europe, along with many independent power producers worldwide.

The Turbine Sentry package gives you peace of mind before, during and after installation.

Complete Service and Maintenance

Land has a team dedicated solely to the installation, commissioning and maintenance of **Turbine Sentry** throughout the world. Typically, a system incorporating five pyrometers can be installed on a turbine in one day.

The majority of gas turbine manufacturers are able to produce turbines with integral turbine blade viewing ports. Pyrometers can then be installed at any time, usually during initial commissioning.

Custom Design

Land recognizes that, in the field of utility turbine blade pyrometry, each application has specific, often unique, requirements.

Flexibility is a key feature of **Turbine Sentry**. Each system is designed to meet the customer's exact needs. Features such as smaller target size, faster response speed and extended measurement span have all been implemented in **Turbine Sentry** measurement systems.

In addition to the externally mounted **Turbine Sentry** sensor, Land produces small probes designed to mount inside a gas turbine - ideal for use in turbine development programs, or locations where only limited access to the turbine is available.

Product Development

Land's commitment to continuous product improvement ensures that the most recent advances in both software and hardware design are incorporated into all components of the **Turbine Sentry** system.

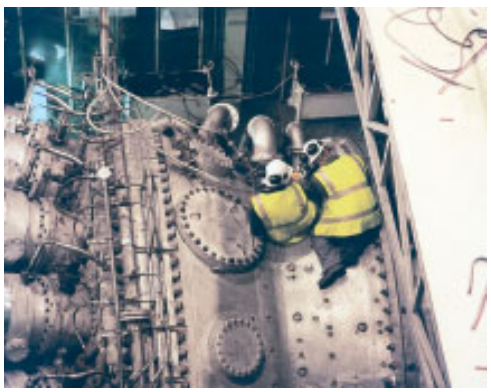


Photo: System Installation and Commissioning

Product Specifications

Blade Sentry

Mounting Kit

Pressure Rating:	20.4 bar / 300 psi or 40.8 bar / 600 psi
Temperature Rating:	371 °C / 700 °F
Weight:	19 kg / 42 lb or 20 kg / 44 lb
Material:	Stainless Steel

Optical Pyrometer

Temperature range:	650 to 1100 °C or 1200 to 2000 °F (other ranges available)
Outputs:	Linear 4 to 20mA outputs over temperature range
Field of view:	Optimized for particular gas turbine location
Rise time:	Down to 1.5 µs
Accuracy:	±2 °C/±4 °F*
Resolution:	Better than ±0.2 °C above 800 °C/±0.4 °F above 1470 °F
Ambient temperature:	Optic Head: Up to 350 °C/660 °F Fibre Optics: Up to 350 °C/660 °F Signal Conditioner : -30 to 70 °C/-22 to 158 °F (Operating)
Power supply voltage limits:	±18 to 30 V d.c. at 175 mA (max.) 50/60 Hz
Spectral response:	1 µm (nominal)
Sealing:	IP65
Certification:	Manufactured to ATEX directive 94/9/EC (CE Ex II 3 G T6)

**over electronics ambient temperature range 0 to 50 °C / 32 to 122 °F*

KP/PSU Module

Inputs:	Optical Pyrometer Unconditioned once per revolution (Keyphasor™) pulse
Outputs:	±24V d.c. pyrometer power supply Conditioned Keyphasor® pulse (or scan valid signal) User connection to DAS User connection to pyrometer outputs
Ambient temperature limits:	Operating 0 to 40 °C/32 to 104 °F Storage -10 to 70 °C/14 to 158 °F
Power supply voltage limits:	160 to 260 V a.c. or 80 to 120 V a.c. 50/60 Hz

Rotor Sentry

Inputs:	Up to 32, 4 to 20 mA Pyrometer Up to 32 TTL scan valid signals
Outputs:	Screen display ASCII Data stored to disk/network
Data Capture Rate:	Up to 600 kHz
Power supply:	90 to 260 V a.c., 50/60 Hz (switchable)
Ambient temperature limits:	Operating 0 to 40 °C/32 to 104 °F; Storage 0 to 75 °C/32 to 158 °F
PC Specification (minimum)	IBM PC-AT compatible Pentium or higher running at 200 MHz 64 Megabyte RAM; 1 Gigabyte Hard Disk Drive 1.44 Megabyte 3.5 in floppy disk drive; Standard VGA color graphics Standard AT-style keyboard; Mouse (or trackball) Windows NT Version 4.0 (or better)

Data Sentry for Windows NT™ features:

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Print - printout of selected data
Display - single or multiple thermal fingerprints
Comparison - up to 10 thermal fingerprints can be overlaid at different times
Trend - allows selectable parameters to be trended
Filtering - data can be filtered according to a range of operating conditions
Statistical - on line analysis can indicate potential problem areas.
Pan and Zoom

Further Information

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Product Range

- Gas Turbine Exhaust Emissions Monitoring
- Zirconia Oxygen Probes
- Carbon Monoxide Monitors
- Acid Dewpoint Monitors
- Dust & Opacity Monitors
- Portable Gas Analyzers
- Coal Mill Fire Detection
- Turbine Blade Temperature Monitoring
- Data Acquisition Systems

For futher details on any LAND product - visit our website

Quality Assurance

LAND's Factory Quality Management System is ISO9001 Certified for both Sales and Service.

Approval applies to products designed and manufactured in the UK

Approvalapplies in the USA

ATEX Approval

Blade Sentry pyrometer meets ATEX Directive 94/9/EC; coding CE Ex II 3 G T6

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