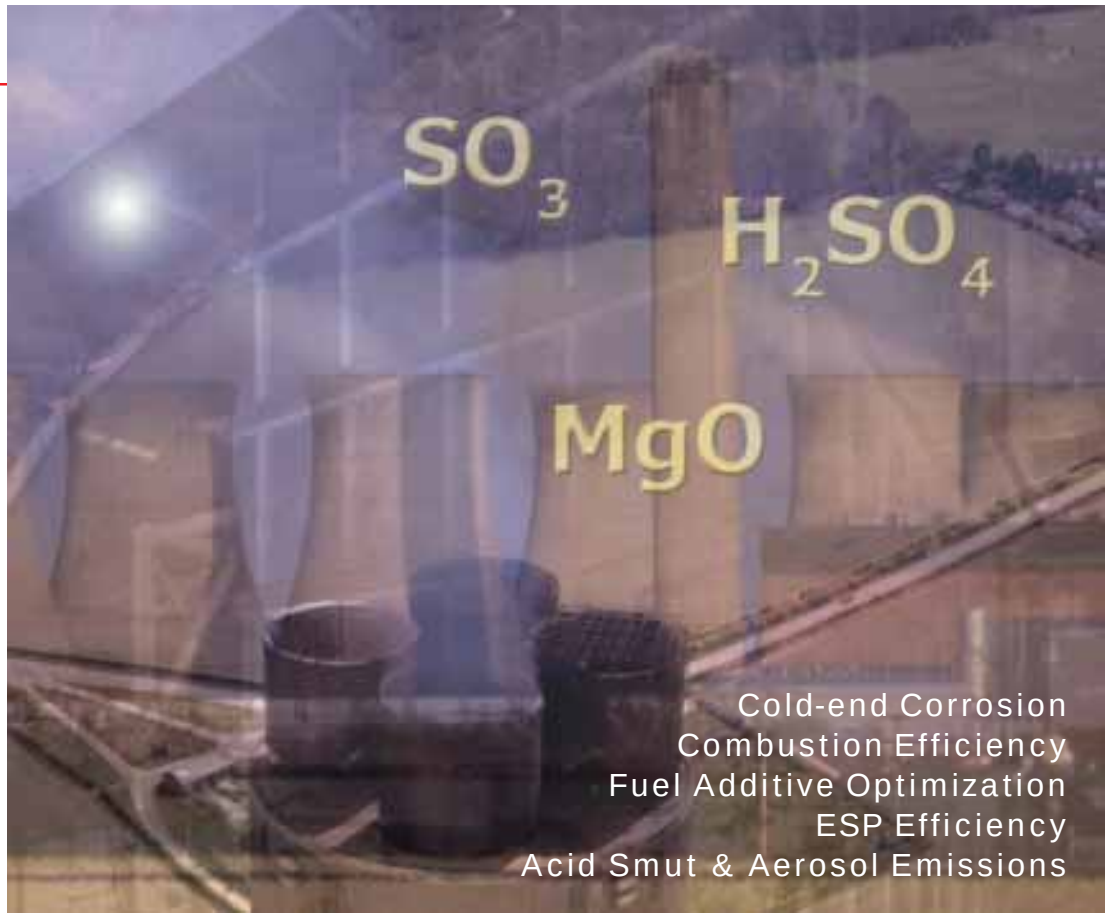
Benefits of sulphuric acid dewpoint temperature monitoring



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Combustion & Environmental Monitoring

Applications of Sulphuric Acid De

When Sulphur bearing fuel is burned in any combustion process, the sulphur oxidises to form SO_2. A small amount of SO_2 further oxidizes to form SO_3, which combines with the process gas moisture to form sulphuric acid (H_2SO_4). Predicting where acid may condense is difficult - measuring the acid dewpoint temperature is the most practical option.

Benefits of sulphuric acid dewpoint temperature (ADT) monitoring

Direct measurement, giving accurate and reliable monitoring of the sulphuric acid dewpoint temperature will assist with on-line control of flue gas temperatures, minimising maintenance costs and improving the total efficiency of the process. There are 3 main areas where acid dewpoint temperature measurement can have major benefit.

Process Control

- Manage the use of high cost fuel additives such as MgO
- Monitor SO_3 slip within an ESP to improve ash collection efficiency whilst minimising acid aerosol emissions

Thermal Efficiency

- Maximise overall boiler efficiency
- Reduce maintenance caused by cold-end corrosion in maintaining the exit gas above the dewpoint temperature

Emissions Control

- Monitor acid aerosol emissions (condensables)
- Monitor and reduce acid smut emissions

When compromising combustion efficiency is not an option, the Acid Dewpoint Temperature becomes a vital measurement and process control parameter.

Who should consider Sulphuric Acid Dewpoint Temperature Monitoring ?

Most plants firing fuels containing sulphur (in varying quantities) should consider the benefits of sulphuric acid dewpoint temperature monitoring. The plants or processes which would benefit most include those burning:

- **Fuel Oil**
- **Coal**
- **Diesel Fuel Oil**
- **Petcoke**
- **Oremulsion**

In addition, plants using fuel additives or SO_3 injection into ESPs can see significant benefit from acid dewpoint temperature monitoring.

H_2SO_4

Using SCR technology increases the conversion of SO_2 to SO_3

ewpoint Temperature Monitoring

Process Control

Treatments using fuel additives or injection processes can drastically affect the process gas make-up, enhancing the need to monitor the sulphuric acid dewpoint temperature for process control and optimization purposes.

Acid Dewpoint monitoring is the only efficient method of controlling the expensive use of fuel additives.

Manage the use of high cost Fuel Additives

Injecting Magnesium Oxide (MgO) to minimise corrosion and improve efficiency

Magnesium-based fuel additives limits SO_3 production by reducing catalytic formation of SO_3 from SO_2. They also help to neutralize acid formed at the cold end. Too little of these additives will allow higher levels of SO_2 forming free SO_3, which will increase the Acid Dewpoint temperature, reducing efficiency and allowing for the emission of pollutants into the atmosphere. Too much additive is unnecessary and expensive - and is ultimately emitted as a pollutant.

The acid dewpoint temperature is a primary measurement to control the use of these expensive fuel additives.

Fuel additives yield less acid formation - but in low sulphur fuel applications can increase pollutant emissions due to increased resistivity of the fly ash and poorer collection by the ESP.

MgO

SO_3

Improve Ash Collection / Reduce Emissions

Monitor SO_3 slip in an ESP to improve ash collection efficiency

This particular problem is mainly an issue where the fuel has a lower sulphur content (and high fly ash resistivity). The injection of SO_3 into flue gas immediately prior to the precipitator lowers the resistivity of the fly ash, allowing better collection by the ESP.

Any fly ash that is not collected using this method can be clearly termed '**Acid Smut Emissions**'.

It is also possible to over-saturate the gas stream with injected SO_3 - which will produce higher levels of free SO_3 and subsequent sulphuric acid formation - with the downstream problems of cold-end corrosion, visibility etc.

The concentration of SO_3 in the gas stream can be accurately determined from the acid dewpoint temperature measurement. ADT monitors display the SO_3 concentration as standard.

Importance of Acid Dewpoint Monitoring

Acid dewpoint monitoring has been used in processes where the resistivity of the fly ash must be changed to ensure that the precipitator operates at optimum performance.

A constant check of excess SO_3 and subsequent Sulphuric acid formation are possible with an acid dewpoint monitor.

Thermal Efficiency

Maximize combustion efficiency - Minimize cold end corrosion

Operating below the acid dewpoint temperature

Identifying the lowest metal temperature required to minimize or eliminate corrosion, allows the operator to reduce the flue gas temperature, which minimizes heat loss and improves overall efficiency.

Additionally, the pre-heating of the combustion air to increase efficiency will drop the exit gas temperature often below the acid dewpoint temperature.

Minimise cold-end corrosion by maintaining the exit gas above the dewpoint temperature

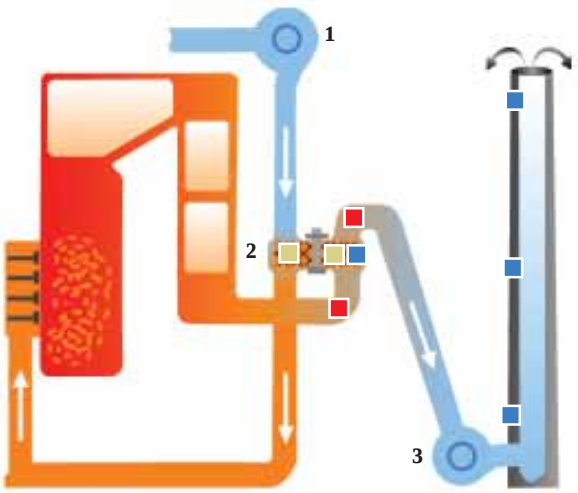
Sulphuric acid will condense on any surface below the dewpoint temperature. These surfaces, typically include economizers, air pre-heaters, ID fans and stack walls. The corrosion of process equipment such as these can involve complete process shut down and involve costly repair.

The economic costs of failing to take proactive steps against the formation of acid can be high.

Acid Dewpoint Temperature Determination

Load, oxygen levels, sulphur in fuel and boiler dirtiness are many of the parameters which will affect the acid dewpoint temperature. Direct measurement of the acid dewpoint temperature will assist with the on-line control of the process, minimize costs and improve total efficiency.

Typical Acid Corrosion and Fouling locations, and points for ADT measurement



Key

- Air Heater Fouling
- Acid Corrosion
- ADT Measurement Point

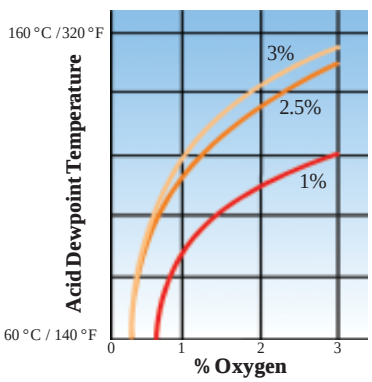
1 Forced Draught Fan
2 Air Heater
3 Induced Draft Fan

Known effects of varying excess air levels

The sulphur level in the specific fuel type has a direct influence on the acid dewpoint temperature. The most important factor in the formation of SO_3 is the level of excess air in the combustion process. The dewpoint temperature is reduced significantly where oxygen levels fall.

Graph - shows how excess oxygen can effect the dewpoint temperature, with fuels of varying sulphur levels (1, 2.5 and 3 %).

Continuous acid dewpoint monitoring is a proven method to ensure efficiency is optimised.



Emissions Control

Monitor and reduce acid smut emissions

Acid smut agglomerates can cause local corrosion to surrounding metalwork. Penetration of painted metallic surfaces is possible with high levels of acid present in the smuts.

Where acid smut is emitted into the atmosphere and lands on metal surfaces, it can create a point of corrosion. Additionally, on non-metallic surfaces it may cause a reddish brown stain. Some acid smuts will corrode even non-metallic materials such as fiberglass and plastics.

Such emissions will degrade the environmental quality in areas surrounding the process plant. The monitoring and control of the acid dewpoint temperature will assist with the reduction of such emissions.

To minimise the acid smut emissions from an oil-fired boiler it is necessary to:

- **Minimize the production of carbon** - *by monitoring carbon monoxide levels*
- **Minimize the formation of sulphuric acid** - *by monitoring the ADT*
- **Maintain the flue gas temperature above the dewpoint temperature until the gases reach the top of the stack.**

Common treatments for acid smut emissions on heavy fuel oil boiler systems are by fuel additives such as fine particle Magnesium Oxide. **Acid dewpoint monitoring helps to control the effect and use of these expensive additives.**

At temperatures below 180 °C or 350 °F, free SO_3 becomes H_2SO_4 in the presence of water concentrations greater than 8 %.

Monitor Acid Aerosol Emissions (Condensables)

Blue and white smoke is evidence of SO_3 present in the stack gas as condensed sulphuric acid. Monitoring of opacity (whilst useful) will not reveal the underlying problem.

SO_3 and Toxic Release Inventory (TRI)

Many countries are beginning to quantify Acid Aerosol Emissions. These are normally defined as sulphuric acid emissions in a vapor or liquid state, since the acid absorbed in the fly ash is assumed to be removed by the dust collectors. US EPA SARA Rule 313, Toxic Release Inventory (TRI), defines emissions as the qualitative or quantitative amount of sulphuric acid mist emitted from coal fired boilers over a one-year period.

The emission of blue and white smoke is the best indicator of the presence of SO_3 as fine droplets of sulphuric acid. This type of smoke carries over great airborne distances, creating increased pollution problems. This could cause public and legislative actions or restrictions in operation.

The concentration of SO_3 in the gas stream can be accurately determined from the acid dewpoint temperature measurement. ADT monitors display the SO_3 concentration as standard.

Black smoke indicates incomplete combustion - but blue & white smoke means the presence of SO_3 as condensed sulphuric acid - potentially a bigger problem to resolve.

How the measurement is made

The Conductive Cell technique

An acid film, such as sulphuric acid, is a good conductor of electricity. If a surface bearing two electrodes is introduced into a gas containing sulphuric acid vapour, any condensate forming on the surface would soon be detected by a current flowing between the electrodes.

A dewpoint temperature monitor comprises a stainless steel probe (to withstand acid corrosion) with a conductive cell (detector) mounted at the tip. The detector contains two electrodes which detect any acid deposition. The temperature of the detector is controlled by a flow of cooling air directed onto its inner surface, by a tube running up the inside of the probe.

The flow of air is either controlled manually (in a portable instrument) or automatically (in a continuous system). When the probe is inserted in the gas stream and the cooling air applied, the detector temperature falls until a point is reached where a thin film of sulphuric acid begins to condense on its surface. The condensed acid causes a current to flow across the electrodes which is monitored. The flow of cooling air is then adjusted, either manually or electronically to maintain a steady current across the electrodes.

Acid Dewpoint Temperature

When the current flow is constant, the rate of condensation is equal to the rate of evaporation. The temperature at which this occurs is the acid dewpoint temperature (ADT), which is a direct measurement - requiring no calibration or reference. The precise temperature is measured by the probe thermocouple, integrated into the conductive cell surface.

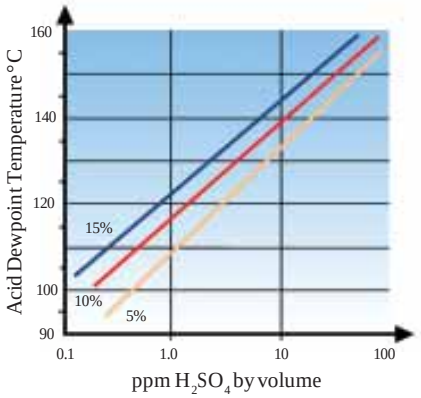
Understanding the corrosive potential of flue gas

The corrosive potential of flue gas can be assessed by measuring the **rate of acid build-up** (RBU) at temperatures below the acid dewpoint temperature. A graphical analysis of RBU vs temperature can identify the peak rate of acid condensation at a particular temperature.

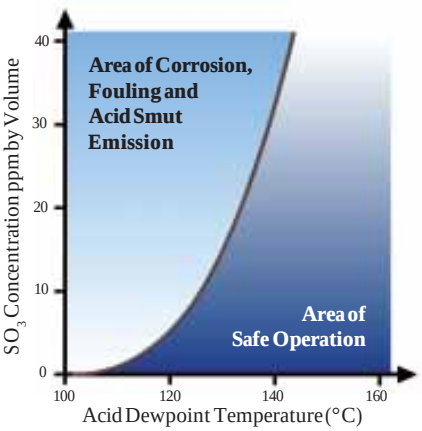
Sulphuric acid is formed from free SO_3 in the flue gas stream. The **concentration of SO_3** can provide a similar indication of corrosive potential. The direct relationship between an increase in ADT with an increase in sulphuric acid can similarly be applied to SO_3 concentration.

Additionally, the dewpoint monitor can calculate (with plant defined temperature parameters) a **minimum metal temperature** (MMT) to indicate the lowest temperature that flue gases can be exposed to metalwork without any corrosive effect.

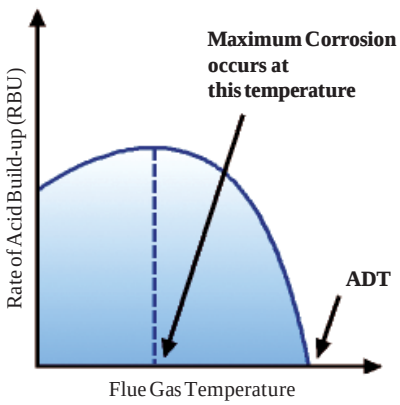
The relationship between H_2SO_4 and Acid Dewpoint Temperature with varying moisture contents



The relationship between SO_3 and Acid Dewpoint Temperature



The relationship between the Rate of Acid Build-up and Flue Gas Temperature



Measurement Solutions

Measurement of sulphuric acid dewpoint temperatures can be made using either a portable or a continuous monitoring device. Their key measurement characteristics are very similar, the operating principles are the same.

The portable analyser (Model 220) is ideally suited to periodic measurements, the continuous analyser (Model 440) provides on-line measurements ensuring that optimium operating conditions are constantly maintained.

Model 220

- Fully Portable System
- Measures Flue Gas Temperature
- Manual Operation
- Hand-held control unit
- Lightweight

It features a stainless steel probe and a compact, hand-held electronic control unit. Straightforward air and electronic connections ensure rapid assembly for immediate use.
Single press function keys invoke instant readings for SO_3, Efficiency, MMT and RBU.

Common Features

Acid Dewpoint Temperature

Rate of Acid Build-up

Calculation of the Minimum Metal Temperature (MMT)

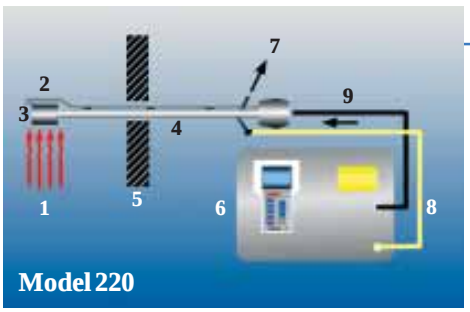
Calculation of SO_3 for Toxic Release Inventory

Model 440

- Continuous, fixed system
- Fully automatic operation
- Automatic Detector Cleaning
- Simple to operate
- Current loop outputs

It features a stainless steel probe, mounting tube, an electronic control unit (ECU) and an air control unit (ACU). The ACU houses the rest of the detector cleaning system plus the Motorized Air Flow Regulator (MAFR) which controls the flow of cooling air to the detector (driven by signals from the ECU). Air and water are supplied directly to the ACU.

The ECU processes the electrode and thermocouple signals from the detector to provide a readout of the ADT. The ECU also controls the operation of both the MAFR and detector cleaning system.

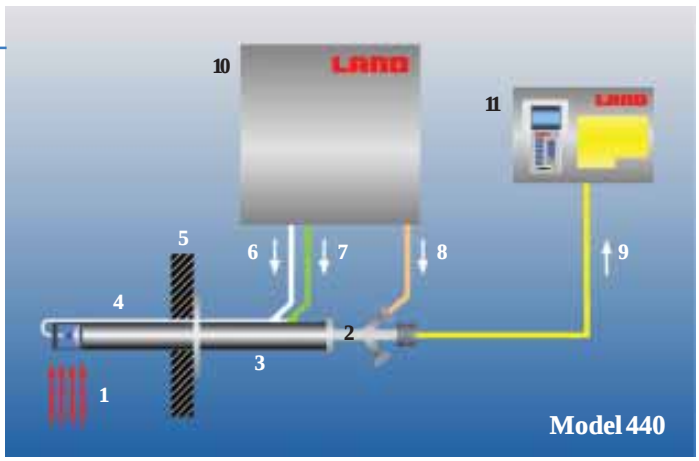


Model 220

1 Flue Gas Stream
2 External Thermocouple
3 Dewpoint Detector
4 Probe
5 Boiler Wall
6 Control Unit
7 Exhaust Air
8 Cooling Air to Probe
9 Signal connection Probe to Control Unit

Model 440

1 Flue Gas Stream
2 Probe
3 Mounting Tube
4 Cleaning Tube
5 Boiler Wall
6 Cooling Air / Water Mist
7 Cleaning Air / Water Mist
8 Cooling Air to Probe
9 Signal connection Probe to Control Unit
10 Air / Water Control Unit (ACU)
11 Electronic Control Unit (ECU)



Further Information

U.K.
Land Instruments International
Dronfield, Derbyshire
S18 1DJ
Telephone: +44 (0) 1246 417691
Facsimile: +44 (0) 1246 410585
E-Mail: combustion.info@landinst.com
Web: www.landinst.com

U.S.A.
Land Instruments International
10 Friends Lane
Newtown, PA 18940-1804
Telephone: +1 215 504 8000
Toll Free: (in USA) 800 523 8989
Facsimile: +1 215 504 0879
E-Mail: combsales@landinstruments.net
Web: www.landinstruments.net

Italy
Land Instruments International
Via dell'Industria, 2
20037 Paderno Dugnano, Milano
Telephone: +39 02 91 08 0020
Facsimile: +39 02 99 04 0418
E-Mail: info@landinst.it
Web: www.landinst.it

France
Land Instruments International
7 Parc des Fontenelles
78870 Bailly
Telephone: +33 (0)1 30 80 89 20
Facsimile: +33 (0)1 30 80 89 21
E-Mail: combustion@landinst.fr
Web: www.landinst.fr

Poland
Land Instruments International
ul. Michałowskiego 5/2
31-126 Krakow
Telephone: +48 12 632 82 62
Facsimile: +48 12 632 24 74
E-Mail: land@land.com.pl
Web: www.land.com.pl

Mexico
Land Instruments International
Av. Horacio 1132 Planta Baja "B"
Col. Polanco, D.F. 11550
Telephone: +52 (0) 55 5281 1165
Facsimile: +52 (0) 55 5281 5364
E-Mail: ventas@landinstruments.net

Specifications

Model 220 Portable Sulphuric Acid Dewpoint Monitor

Probe

Material:	Stainless steel
Detector:	Pyrex glass with platinum electrodes
Flue Gas Temperature:	0 to 400 °C/32 to 750 °F
Length:	1.2 m/4 ft standard
Weight:	2.0 kg/4.4 lb
Probe Access Port:	Minimum requirement 80 mm / 3 inches dia.

Control Unit

Design:	Portable, hand-held electronics
Multi-scale Display:	Acid Dewpoint Temperature, RBU, Ambient Temperature, Current, SO_3, Efficiency and MMT
Accuracy:	±2 °C / ±4 °F
Operating Temperature:	0 to 50°C / 32 to 120 °F
Input Air Supply:	5 cfm
Mains Power Supply:	110/240 V a.c. 50/60 Hz
Dimensions:	470 x 355 x 120 mm / 18.5 x 14 x 4.75 inches
Weight:	5.7 kg / 12.5 lb

Model 440 Continuous Sulphuric Acid Dewpoint Monitor

Probe

Material:	Stainless steel
Detector:	Pyrex glass with platinum electrodes
Flue Gas Temperature:	0 to 400 °C/32 to 750 °F*
Length:	1.2 m/4 ft standard
Weight (Probe):	2.4 kg/5.3 lb
Weight (M'ting Tube):	3.9 kg/8.6 lb
Mounting Flange:	LAND supplied

**Application Dependent*

Electronic Control Unit

Selectable Display:	Acid Dewpoint Temperature, RBU, MMT, SO_3
Output:	2 current loops 4-20mA (0 to 260 °C, 0 to 500 °F)
Accuracy:	±2 °C / ±4 °F
Operating Temperature:	0 to 50 °C / 32 to 120 °F
Input Air Supply:	3 litres/sec / 6 cfm
Mains Power Supply:	110/240 V a.c. 50/60 Hz
Alarms/Relays:	Maintenance / Fault; One common relay
Enclosure:	IP65/NEMA4
Weight:	18 kg / 38 lb
Dimensions (HxWxD):	380 x 600 x 210 mm / 15 x 23.6 x 8.3 inches

Air Flow Regulator and Detector Cleaning System

Enclosure:	IP65/NEMA4
Air Flow Rate:	3 litres/sec / 6 cfm
Air Pressure:	60 to 100 psi / 4 to 7 bar
Operating Temperature:	0 to 65 °C / 32 to 160 °F
Water Flow Rate:	4 litres/day maximum usage
Water Pressure:	20 psi/1.4 bar
Dimensions (HxWxD):	600 x 600 x 210mm / 23.6 x 23.6 x 8.6inches
Weight:	29.5 kg / 65 lb

Continuous product development may make it necessary to change these details without notice

Product Range

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

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