Plant Diagnosis Service

Plant Diagnosis Service List

Fuji Electric

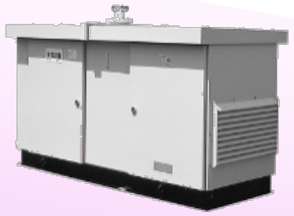
Other Diagnosis Service

Power generating facilities

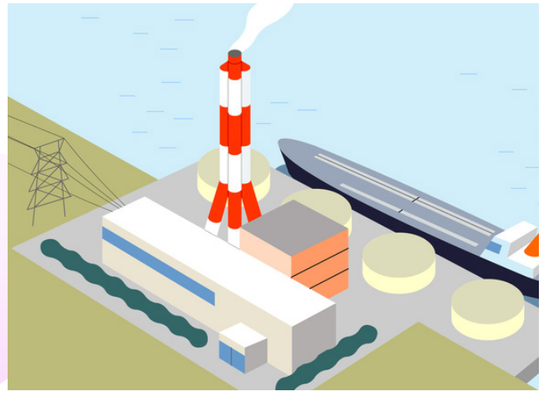
Power generating facility

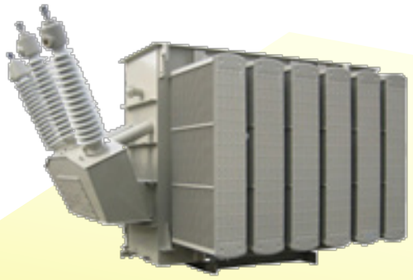
High-speed Breaking Facility

Emergency power generators

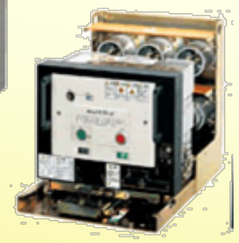


High-voltage Circuit Breaker





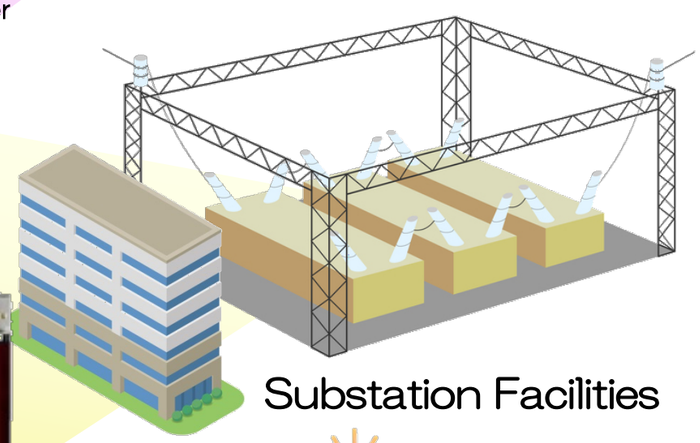
Oil-filled Transformers



Breaker

Medium-voltage Distribution Panels

Molded Transformers



Substation Facilities

Rotary Machines

Drive Control Facility

UPS(Uninterruptible Power Supply)

Plant Pipe

DCS(Distributed Control System)

PLC(Programmable Logic Controller)

Industrial Instruments

Analyzer

Waterworks Facility

Drainage Facility

Steam Facility

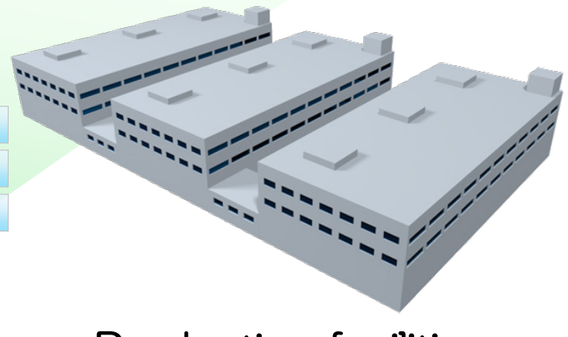
Lighting facility

applied electric motive power Facility

Supervisory control Facility

Instrumentation Facility

Utility facilities



Production facilities

Plant Diagnosis Service

to Photo

Fuji Electric

A-1-1 ○ ■	Environmental diagnosis and deterioration diagnostic services
A-1-2 ○ ■	Installation environment diagnosis services for electrical facility equipment
A-2-1 ○ ■★	Deterioration diagnosis services using infrared thermography
A-2-2 ○ ■	Live diagnostic services for in-service electrical equipment using infrared thermography
A-3 ○	Remaining life time diagnosis services for power distribution panel control wiring

B-4-1○ ■	High-precision remaining life assessment services for oil-filled transformers
B-4-2○ ■	Dissolved gas analysis(DGA) for oil-filled transformers and testing of insulation oil properties
B-4-3○	Torque diagnosis services for on-load tap changers

B-3 ○	Deterioration diagnosis service for substation switchgear CB-MEC

B-2-1 ○ ■★	Simplified partial discharge diagnosis services for distribution panels
B-2-2 ○ ■	Partial discharge diagnosis services for power distribution panels(COPAS)
B-8 ○	Deterioration diagnosis services for auxiliary relays AR-MEC

B-5-1 ○	MOLMOS Optical diagnosis services for deterioration of molded transformers
B-5-2 □ ○	Partial discharge diagnosis device for preventive maintenance of molded transformers MOL-MEC

C-1 ● ★	Diagnostic services for adjustable speed drive systems
C-2-1 ● ★	Remaining service life assessment system for limited life parts of general-purpose inverters
C-2-2 ○	Deterioration diagnosis system for environmental factors of general-purpose inverters

C-3-3 ○	Remaining life assessment services for High-voltage electric motors
C-3-1 ● ★	★Reliability assessment for medium-voltage motors.
C-3-2 ○ ■	Insulation diagnosis for medium-voltage rotating machines
C-3-4 ○ ■	ROPAS Online partial discharge diagnosis services for medium-voltage rotating machines
C-3-5 ●	Physico-chemical diagnosis services for thermal deterioration of insulation
C-4 ○ ■	Wireless Diagnostic System for Rotating Machine Vibration (Wiserot)
C-5 ○ ■	ProHealth

E-3	Diagnosis services for printed circuit boards by a sampling method.
E-2	電源ユニットの劣化診断
E-4-1	プリント基板の劣化診断
E-4-2	プリント基板洗浄
E-4-3	プリント基板コーティング

E-1 ○ ★	Equipment diagnosis services for information processing controllers

D-1 ○ ■	Battery instant discharge diagnosis device(BSC)

F-3 ○ ■	To find air leaks into condenser 「Leak Buster」

B-1 ○ ■ ★	Deterioration diagnosis services for substation equipment
B-7-1 ○ ■	Diagnosis services for 3.6kV cables
B-7-2 ○ ■	電力ケーブルの劣化診断

F-1-1 ■	Radiation transmission type pipe diagnostic equipment
F-1-2 ■	Radiation transmission type pipe thickness measurement equipment
F-2 ● ■	ファーマーナイト コンポジットリペアサービス

G-1	Controllability diagnosis services for industrial plants
G-2 ● ■	Optimal Energy Operation System FeTOP
G-3 ● ■	Analysis support system for process line and assembly line
G-4 ○	f(S)NISDAS-x

Power generating facility

Emergency power generators

High-voltage Circuit Breaker

High-speed Breaking Facility

Oil-filled Transformers

Breaker

Medium-voltage Distribution Panels

Molded Transformers

Rotary Machines

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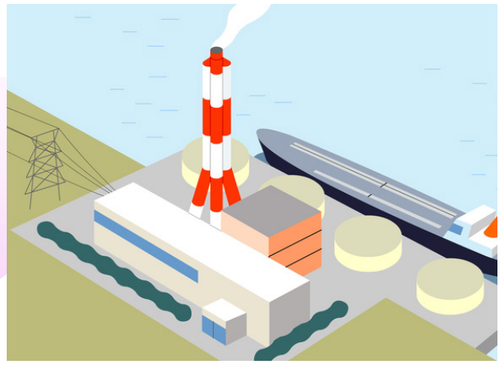
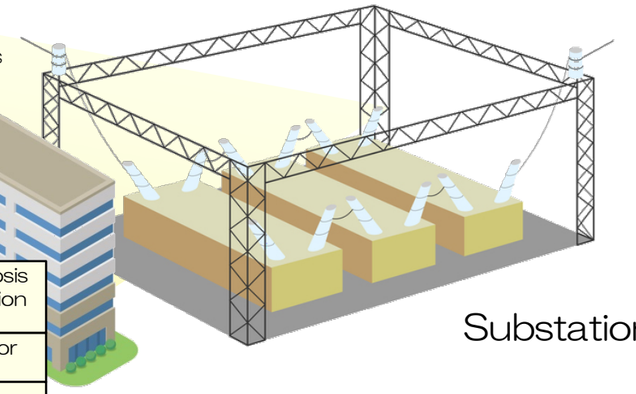
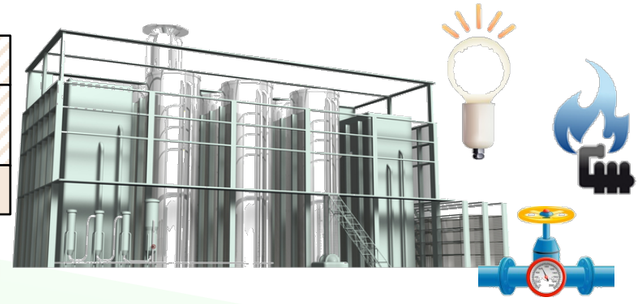


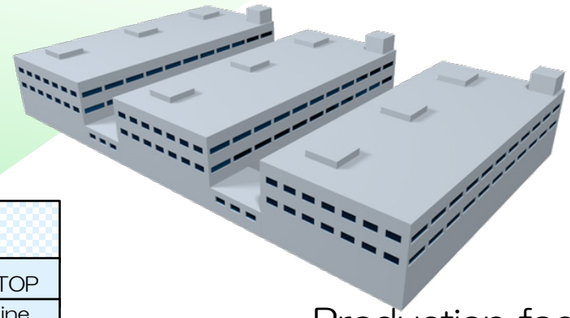
Power generating facilities



Substation Facilities



Utility facilities



Production facilities

- ● :with oversea
- ○ :with oversea (with condition)
- ■ : Other maker products are covered
- □ :Other maker products are covered with conditions
- ★ (Asterisk) : Simple Diagnosis

No Asterisk: secondary Diagnosis

Fuji Electric

Innovating Energy Technology

Environmental diagnosis and deterioration diagnostic services

to Photo

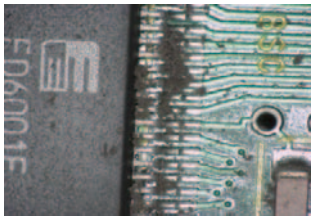
Overview

Without exaggeration, the installation environment has a huge impact on the reliability and service life of information processing devices and control equipment. As the stresses of a variety of environmental factors on the equipment continue to accumulate, symptoms will begin appearing, such as degraded performance of electronic components and corrosive deterioration of printed circuit boards.
In our environment diagnosis services, we take precise measurements of the environment that do not rely on human sensory evaluations, and examine the environmental factors that affect the reliability and service life of information processing equipment and control equipment. In our deterioration diagnosis services, we assess the equipment' s state of deterioration and estimate the remaining service life from the characteristic deterioration of the electronic components. Then we propose the best method of renewing the equipment and recommend the appropriate timing for preventive replacements.

1. Effects of the installation environment

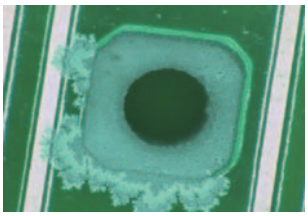
Various environmental factors have an impact including temperature, humidity, dust, and corrosive gas. For example, it is said that when equipment that can be used in an operating temperature range of 5 to 40°C is operated at 35°C compared to 25°C, the failure rate would nearly double. (This is the rule of doubling for every 10°C of change.) Intermittent failures can be caused by condensation induced by temperature changes in high humidity. Also, the build-up of dust and dirt deposits may clog air filters causing the equipment' s internal temperatures to rise, and these deposits may absorb moisture and cause the insulation to deteriorate. The presence of corrosive gases may further have a compound effect with the humidity and cause the corrosion of the basic materials used in electronic components such copper, silver, and gold.

●Example of nonconforming part caused by dust



●Example of nonconforming part caused by corrosive gas

Corrosion of the printed circuit patterns



Whisker generation on IC leads

2. Environment diagnosis

●Measurement items and time periods

Temperature and humidity: Measured continuously for 1 month using a digital thermo-hygrometer

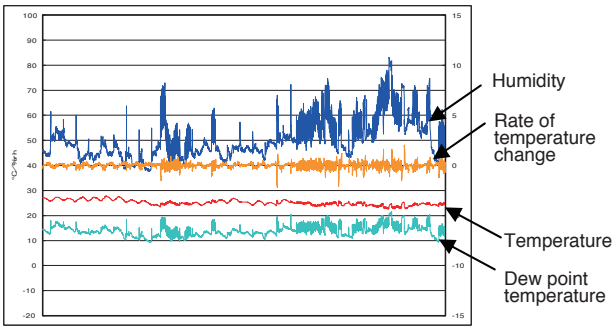
Corrosive gas: Exposure of test pieces to measure concentration and corrosion for 1 month in the gas environment

Dust deposits: Component analysis is performed on dust samples taken from the ceiling and interior of the cabinet

Airborne dust: During the examination period, 1 to 3 measurements are taken using a laser particle meter.

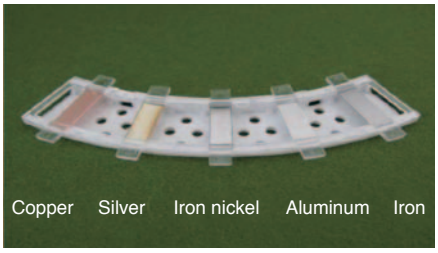
Installation conditions: The conditions, such as the state of dust deposits and presence or absence of corrosion, are observed and photographs are taken

●Example of temperature and humidity measurement

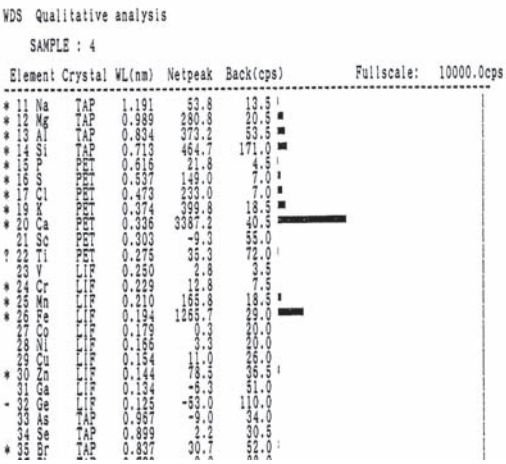


●Example of corrosive gas analysis results

(1) Sulfur dioxide: 0 to 5 ppb (guideline concentration)
(2) Hydrogen sulfide gas: 1 to 7 ppb (guideline concentration)
(3) Chlorine gas: 0 to 5 ppb (guideline concentration)



●Example of dust deposit component analysis results



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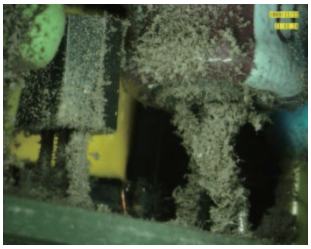
3. Deterioration diagnosis

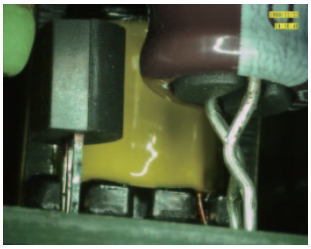
●On-site diagnosis

Timed with the customer's periodic equipment maintenance or other schedule, we will sample the printed circuit boards and use a microscope to examine the state of dust deposits and corrosion, and also clean the equipment to remove dust.

Before cleaning



After cleaning



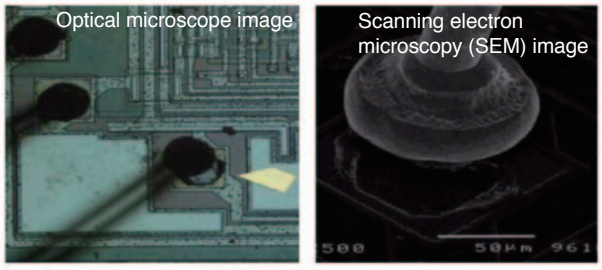
●Removal for off-site diagnosis

We will select and remove a printed circuit board that has conspicuous contamination and corrosion and examine it at our factory.

Contents of examination

(1) State of dust deposits and attachment, presence or absence of corrosion on printed circuit boards
(2) Formation of substances (whiskers) or mold, presence or absence of corrosion on IC terminal parts
(3) Component analysis of dust deposits and corrosive products on printed circuit boards
(4) Dissipation factor (tan-delta) and capacitance measurements of aluminum electrolytic capacitors
(5) Resistance change characteristics and state of internal grease solidification of variable resistors
(6) Characteristics inspection and opening examination of ICs

●Example of IC opening examination



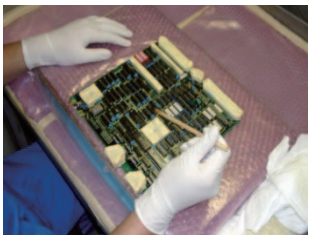
4. Printed circuit board cleaning by washing and coating

●Steps in cleaning (Overview)

(1) Acceptance testing
(2) Air blow cleaning
(3) Masking before washing
(4) Washing and drying
(5) Masking before coating
(6) Coating and drying
(7) Shipping

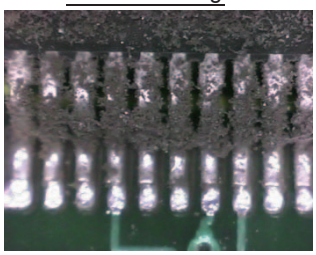
Example of PCB washing

Example of PCB coating

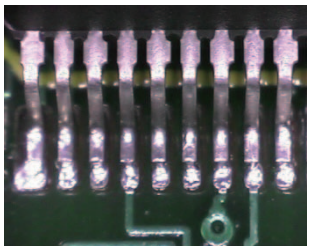


●Examples comparing before and after washing

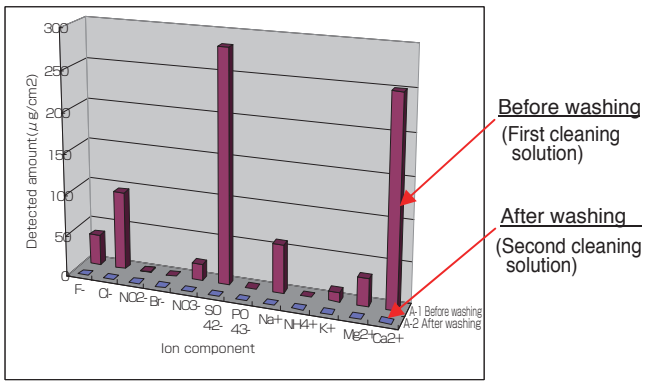
Before washing



After washing

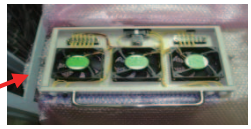


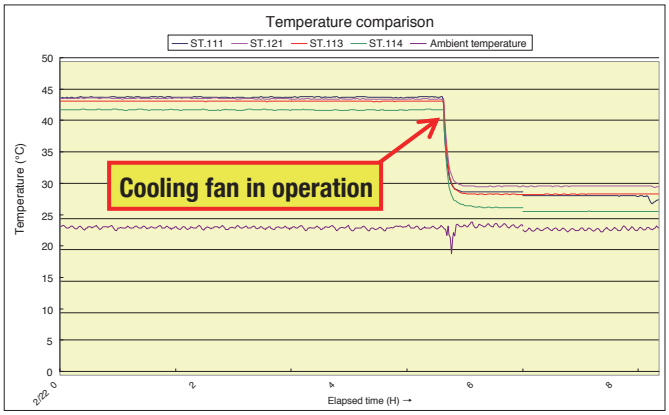
●Ion component analysis of the cleaning solution



5. Using cooling fans to improve the cabinet internal temperature environment

Cooling fan unit





⚠ Safety precautions

Note: Before using this product, in order to use it correctly, be sure to carefully read the Instruction Manual and Specifications, or contact our company or your dealer for information as necessary.
Note: This product is intended to be handled by persons with specialized technical knowledge.

Fuji Electric Co., Ltd.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Installation environment diagnosis services for electrical facility equipment

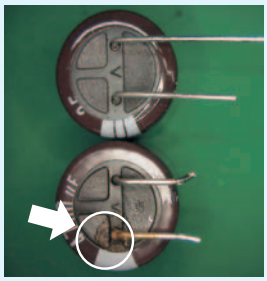
to Photo

The reliability and service life of industrial information processing devices and control equipment in a substation are said to be dependent on the installation environment. In recent years, the digitization of protection relays has been progressing, and substation equipment is seeing increasing use of electronic components and printed circuit boards. Due to environmental factors, concerns for such equipment include performance losses of electronic components, corrosion of printed circuit boards, and silver sulfide corrosion of control equipment and conductors. We will provide various proposals after performing a diagnosis on the installation environment to access the current state of the substation.

Effects of the installation environment

Various environmental factors have an impact including temperature, humidity, dust, and corrosive gas. For example, it is said that when equipment that can be used in an operating temperature range of 5 to 40°C is operated at 35°C, the service life of its electrolytic capacitors is halved compared to that at 25°C. Intermittent failures can be caused by condensation induced by temperature changes in high humidity.
Also dust and dirt deposits may absorb moisture and cause the insulation to deteriorate. The presence of corrosive gases may further have a compound effect with the humidity and cause the corrosion of the basic materials used in electronic components such copper, silver, and gold.

Examples of nonconforming part caused by temperature and humidity:
Electrolytic capacitor leakage



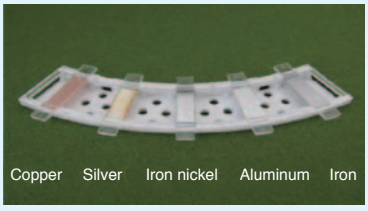
Examples of nonconforming part caused by corrosive gas:
Corrosion of contact part

Environment diagnosis

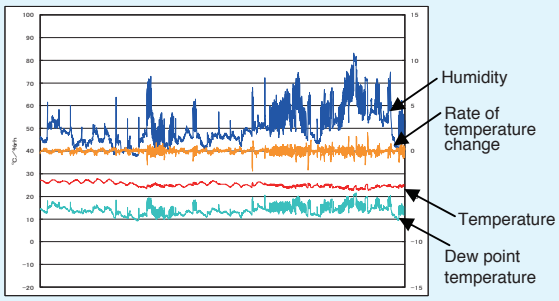
In order to prevent nonconformities due to environmental factors, rather than relying on human sensory examinations, it is necessary to perform accurate measurements of the environment and take preventive action.

Analysis results

(1) Sulfur dioxide: 0 to 5 ppb (guideline concentration)
(2) Hydrogen sulfide gas: 220 to 280 ppb (guideline concentratio
(3) Chlorine gas: 0 to 5 ppb (guideline concentration)



Example of temperature and humidity measurements



Temperature and humidity	Measured continuously for 1 month using a digital thermo-hygrometer
Corrosive gas	Exposure of concentration test pieces for 1 month in a measuring object gas (hydrogen sulfide gas, sulfur dioxide, chlorine gas) environment
Degree of corrosion	Exposure in an environment for 1 month using an oxygen-free copper strip
Degree of contamination	Dust samples taken from a reference area inside the panel are tested in a laboratory and the equivalent weight of chlorine is measured from the electrical conductivity

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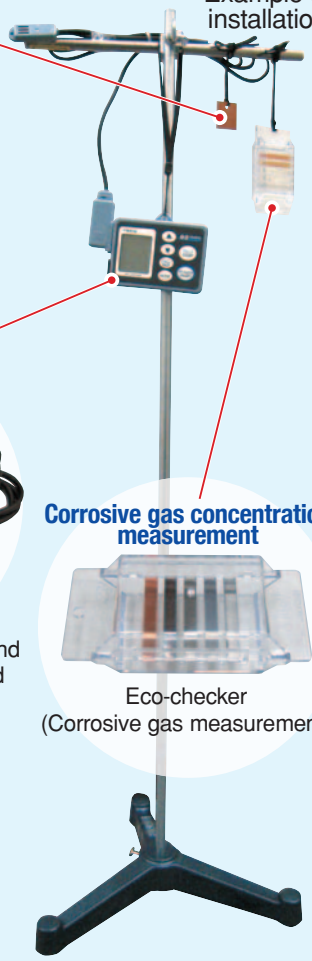
Measurement method and equipment

Example of installation



Corrosion measurement

Oxygen-free copper strip (Degree of corrosion measurement)

Temperature and humidity measurement

Recorder for temperature and humidity(Temperature and humidity measurement)

Corrosive gas concentration measurement

Eco-checker (Corrosive gas measurement)

Contamination measurement

Dust inside the panel is collected using a clean gauze and analyzed in a laboratory

Set up in the measurement location and left exposed for 1 month

Evaluation method

Classification of environment

Temperature, humidity, corrosive gas, and level of contamination are evaluated in compliance with JEITA IT-1004 and the environment is divided into the following classes.

Class A	Good environment that does not adversely affect the equipment.
Class B	General level of environment.
Class S	Harsh environment for equipment. When subdivided further into Class S1 to S4, the higher the number, the harsher the environment.

The degree of corrosion is evaluated in compliance with ISA S71-1985.04 and divided into the following classes.

Class G1	Mild	Environment which is sufficiently controlled so that corrosion is not a factor affecting the reliability of the device.
Class G2	Moderate	Environment in which the effects of corrosion cannot be ignored. The environment may be a determining factor in the reliability of the device.
Class G3	Harsh	Environment in which the possibility of corrosion occurring is high. Since this level requires a more rigorous and immediate evaluation, it is necessary to install environment controls or a specially designed package device.
Class GX	Severe	Environment in which long-term use of electronic and electrical equipment cannot be possible.

Example of environment diagnosis proposal

Substation with air conditioners

- Installation of dehumidifiers
- Review of the air conditioner placement, review of air conditioning power
- Extraction of vulnerable parts of the building proper and review its structure

Substation without air conditioners

- Installation of air conditioners
- Installation of dehumidifiers
- Repair of entrance door seals
- Extraction of vulnerable parts of the building proper and review its structure
- Application of dustproof coating

Substation with high concentration of corrosive gas

- Filtration of outside air intake using filters
- Review of the sealing of the substation (Pressurized structure)
- Repair of door seals

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⚠ Safety precautions

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

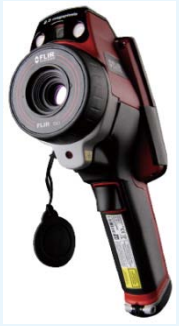
Deterioration diagnosis services using infrared thermography

Overheating state of equipment can safely and quickly investigate using infrared thermography in operation.

Overview

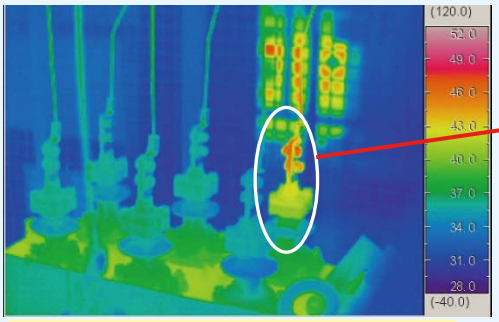
- **Non-contact and remote temperature measurement.**
  (Maintenance) Inspection of target equipment can be performed from a safe distance while the equipment is running.
- **Deformation spots can be determined visually.**
  Defects can be spotted at a glance.
- **Total cost reductions are possible.**
  Checking the equipment while it is in operation makes it possible to reduce equipment downtime.

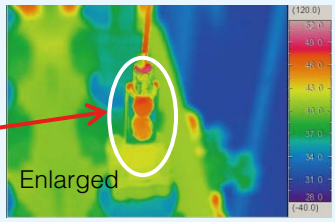
Infrared thermography



* Infrared thermographic reference photograph

Detection example 1





The circled portion shows an example of a defect, which causes high temperature.

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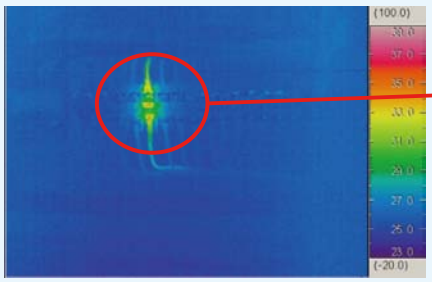
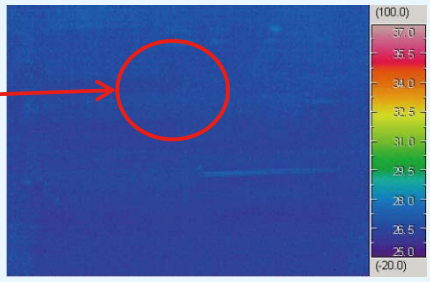
Detection example 2

Detection example of a loose screw on a connected part



Increased temperature at the loose spot



Hot spot disappears after tightening the loose screw

Diagnosis steps

Preparation 1
(1) Is it possible to direct-viewing at measurement sites?
(2) Can any obstructions be removed?

Preparation 2
(1) A safety check of the measurement location

Measurements
(1) Specify the monitoring sites
(2) Measurement ⇒ recording

Based on the measurement results, we will propose methods for maintaining the equipment in the future.

Analysis

Prepare reports

Proposal of condition-based maintenance (CBM)

- **Prevention of failure accidents**
- **Optimal maintenance plan**
- **Optimal replacements timing**

Attention in the application

- To enable direct access to the equipment, please remove the cover or door at the location you wish to be checked for overheating.
- Errors may occur during the measurement.

⚠ Safety precautions

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Note: This product is intended to be handled by persons with specialized technical knowledge.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Live diagnostic services for in-service electrical equipment using infrared thermography

We will efficiently and safely diagnose the condition of your machinery and electrical equipment while they remain in operation.

to Photo

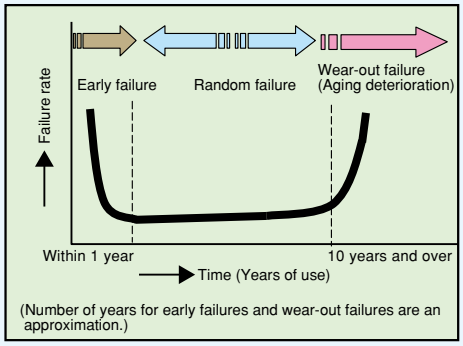
Benefits

- **Diagnostic work is non-contact and safe**
- **No time restrictions such as power shut-downs**
- **Small teams for efficient response**
- **Rapid and precise visualization of equipment surface temperatures**
- **Management of trend data on aging deterioration**

Infrared Thermography Level II certification

Certified by the American Society for Nondestructive Testing, Inc. (ASNT)

Failure rate curve (Bathtub curve)



(Number of years for early failures and wear-out failures are an approximation.)

Prior confirmation 1

(1) Is the location to be measured directly accessible? (Space, distance, angle)
(2) Can any obstacles be removed? (Protective cover)
(3) Are there any factors that could have thermal influences in the surrounding area? (Sunlight, peripheral equipment)

Prior confirmation 2

(1) What is the voltage of the circuits? (Very high voltage, high voltage, low voltage)
(2) What are the safety conditions of the workplace? (Spacing distances, obstacles, differences in level)

Measurement work

(1) Details of deformation areas (Hot spots)
(2) Measurement ⇒ Record (Name, temperature and humidity, load)

Analysis

Preparation of report on diagnosis results

Based on the measurement results, we will propose methods for future repairs and maintenance.

Proposal of condition-based maintenance (CBM)

- **Prevention of failure-related accidents**
- **Optimal maintenance plan**
- **Optimal timing for replacements**

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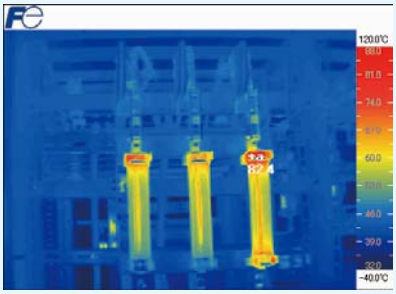
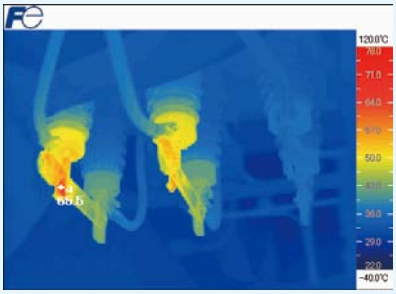
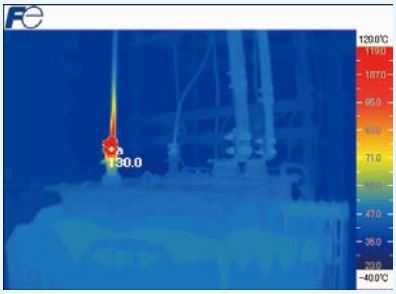
Examples of equipment deterioration



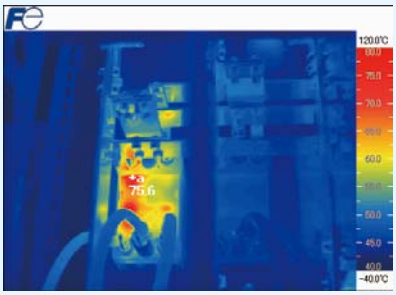
Air-insulated load switchgear



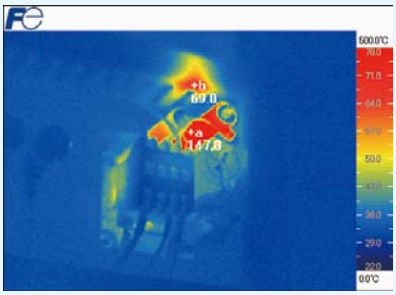
Disconnect switch



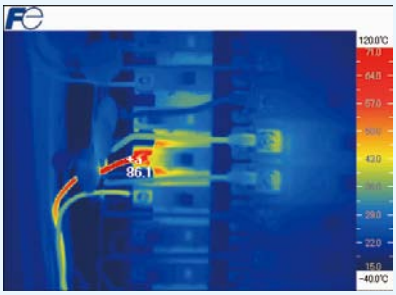
Oil-filled transformer



Molded case circuit breaker



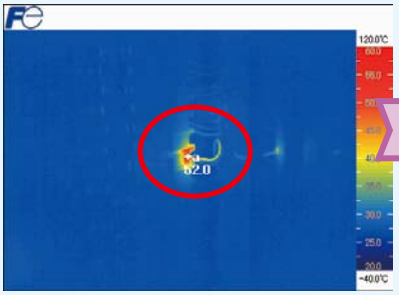
Electromagnetic contactor



Disconnect terminal

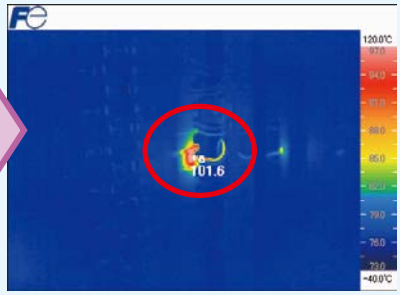
Examples of worsening deterioration

2010 (Bad condition)



Left as is

2011 (Worsening condition)



Condition: 50°C increase in temperature over 1 year (52°C ⇒ 102°C)
Carbonized coating and patina formation on electrical wiring due to high temperatures.

to menu

to Photo

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2013-9(I13/I13)T1FOLS

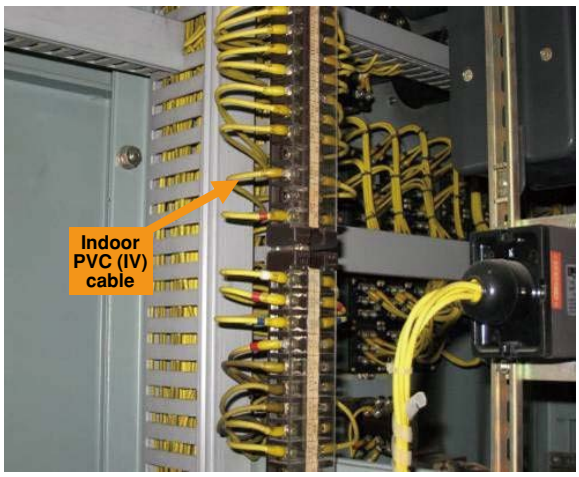
Fuji Electric

Innovating Energy Technology

Remaining life time diagnosis services for power distribution panel control wiring

to Photo

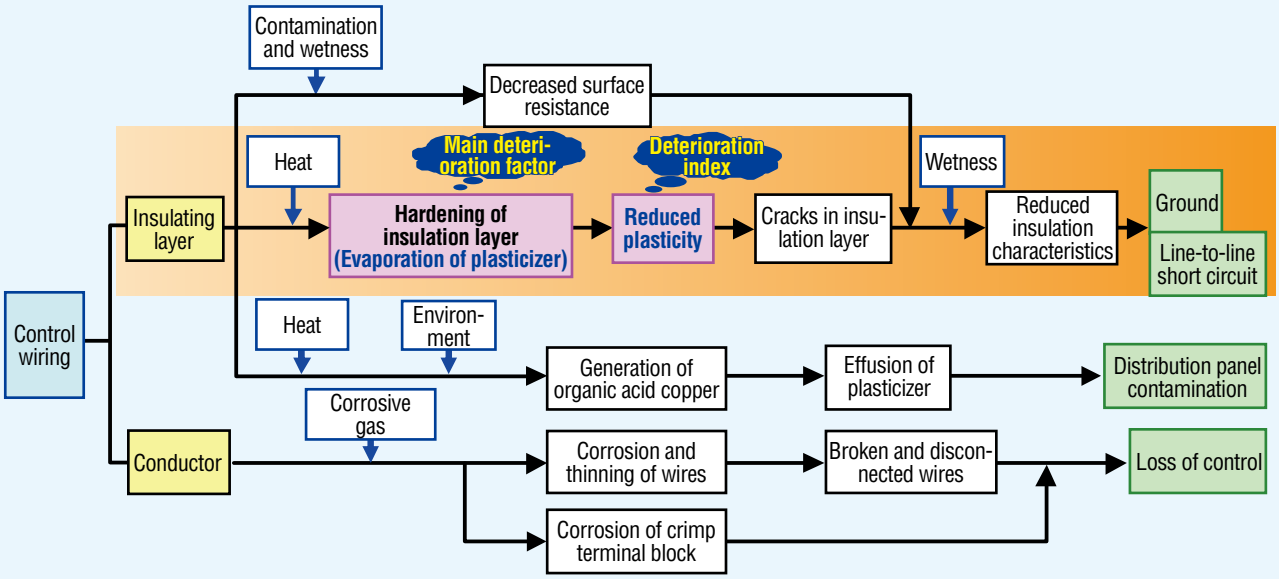
Remaining life of 600 V PVC insulated cable used in power distribution panels is assessed.



Overview

Remaining life time was diagnosed by measuring the insulation resistance and elongation at break using sampled IV cables

Deterioration process, mode, and measuring devices



Insulation resistance measurement equipment

Elongation-at-break test equipment

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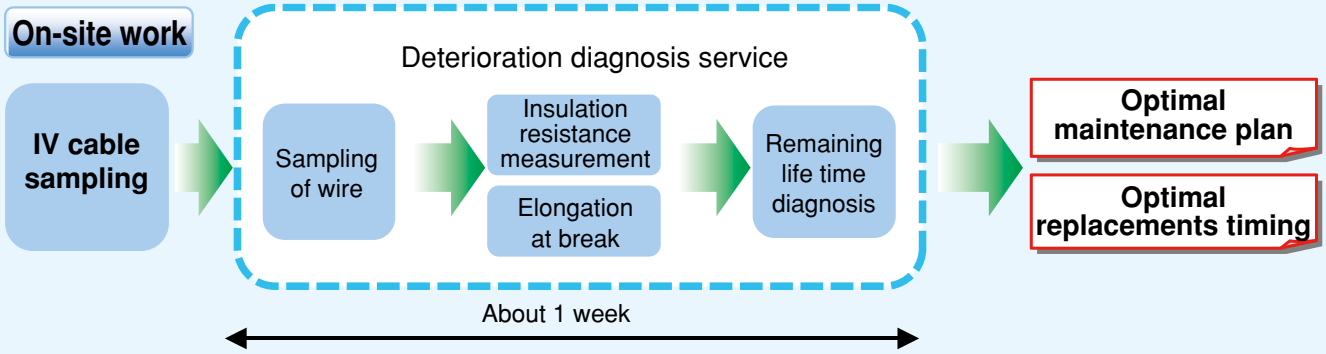
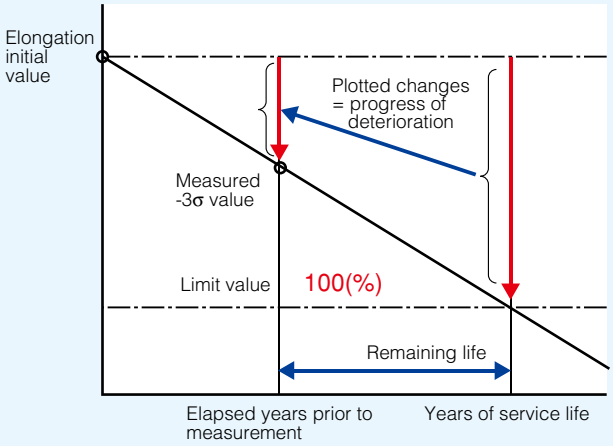
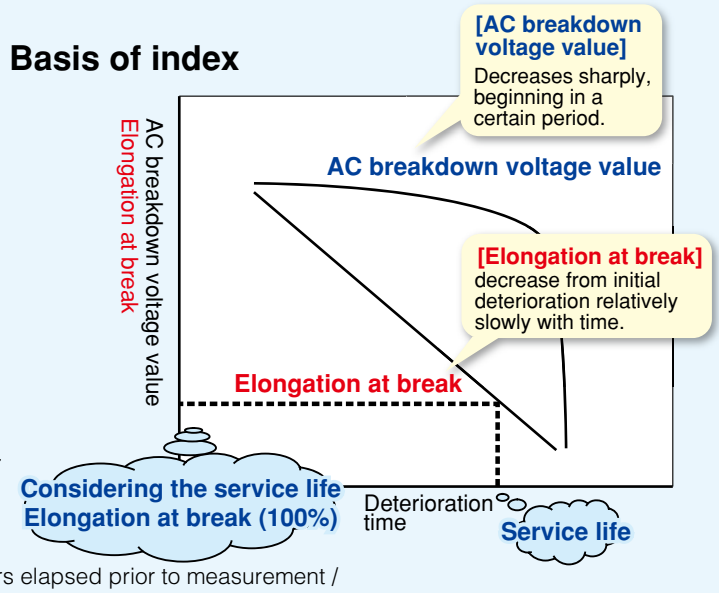
Flow of deterioration diagnosis



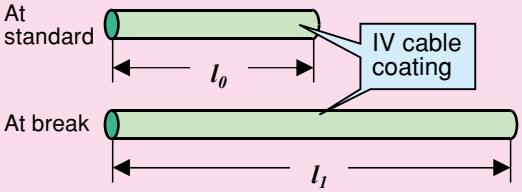
Calculation of service life



Basis of index



(Eq.) Years of service life = (Initial value −100) × No. of years elapsed prior to measurement / (Initial value − Measured value − 3σ)



$$\varepsilon = \frac{l_1 - l_0}{l_0} \times 100(\%)$$

ε: Elongation at break (%)
l_1: Length of test piece at break (mm)
l_0: Length of test piece at standard time (mm)

For example, if Length of test piece at standard time l_0=150(mm), and Length of test piece at break l_1=300(mm) ... Broken at twice of standard length the length at standard time, then ⇒ Elongation at break ε=(300−150)/150×100=100(%)

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Deterioration diagnosis services for substation equipment

to menu

to Photo

Among all the equipment in a substation facility, the percentage of aging and deteriorating equipment will continue to increase. To maintain, improve, and ensure the reliability of the power supply, it is important to be able to identify and understand the state of aging equipment and the precise locations of problem areas.
Fuji Electric's diagnosis specialists have a wealth of experience in diagnosing substation equipment. We will perform deterioration diagnosis services tailored to customer objectives and provide information that enables customers to create their maintenance plans.

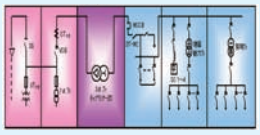
1. Primary diagnosis (Visual and other diagnosis)

Based on the past inspection records and maintenance history, we will evaluate the state of deterioration by checking the operating condition of each equipment and doing sensory examinations, such as visual observations.Then based on the results of these examinations and using a medium-term maintenance plan, we will provide a proposal that includes the timing of the next inspection, equipment replacements, etc.

2. Secondary diagnosis (Detailed inspection)

When based on the results of the primary diagnosis the necessity for a detailed diagnosis (requiring power to be shut off) is indicated, we will provide a proposal with such specifics and quantitatively evaluate the extent of the deterioration.Then based on the evaluation results, we will propose a concrete timetable for equipment replacements and an optimal maintenance plan to follow up to the replacement timing.

Total diagnosis for substation equipment









Epoxy molded transformer

Flow of diagnosis

We will seize and report the overview of equipment deterioration by performing the primary evaluation(visual diagnosis) without interrupting the customer's operations, get an overview of the deterioration of the equipment, and report on our findings.Based on the results of the primary evaluation, we will propose plans for future maintenance, equipment replacements, as well as the need for a secondary diagnosis.

to Photo

Key points of diagnosis

Primary diagnosis

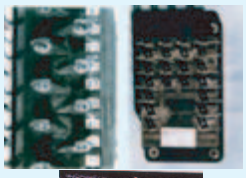
- Confirmation of the deterioration status of the equipment
- Examination of the years of operation and the status of maintenance inspections
- Examination of trouble details and repair history
- Examination of technical issues
- Extraction of problems from maintenance inspection system
- Examination of when equipment manufacturing ended

Secondary diagnosis

- Partial discharge diagnosis and localized overheating diagnosis
- Molded transformer deterioration diagnosis
- Circuit breaker and switchgear deterioration diagnosis Etc.

Examples of equipment deterioration

Protection relays



Silver migration phenomenon

Deterioration of internal parts of protective relays

Insulation supporter

Grounding caused by contamination and deterioration

Extraction of old technology parts

Extraction of older equipment for which maintenance services have ended

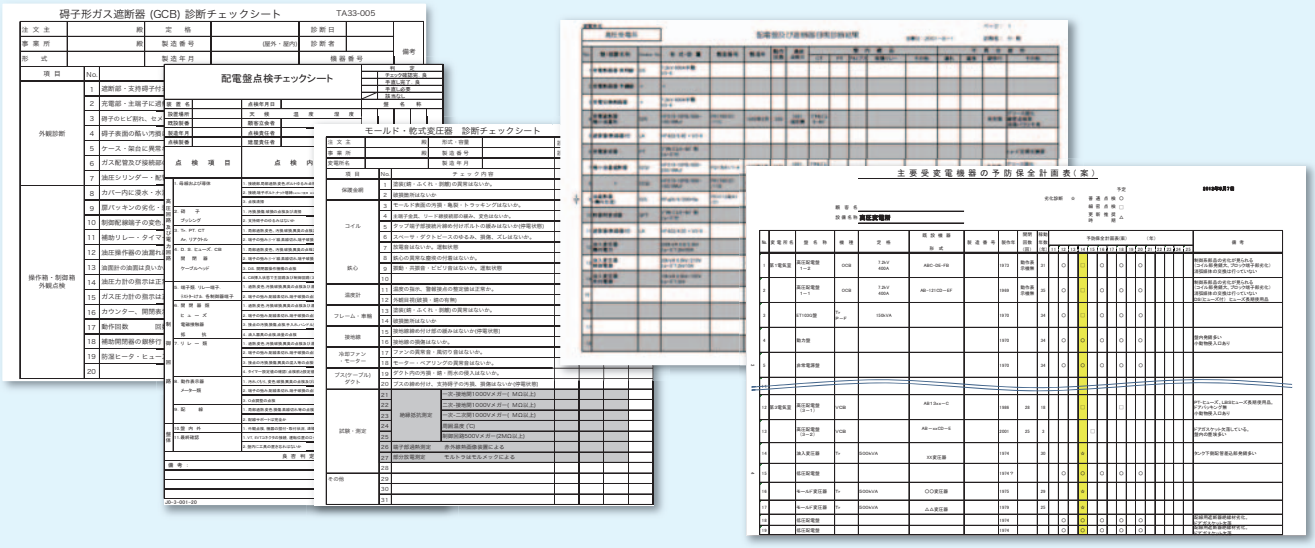
Early detection of abnormalities

Prevention of malfunctions

Prevention of accidents

Prevention of equipment shutdowns due to aging deterioration

Report Samples



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2013-9(I13/I13)T1FOLS

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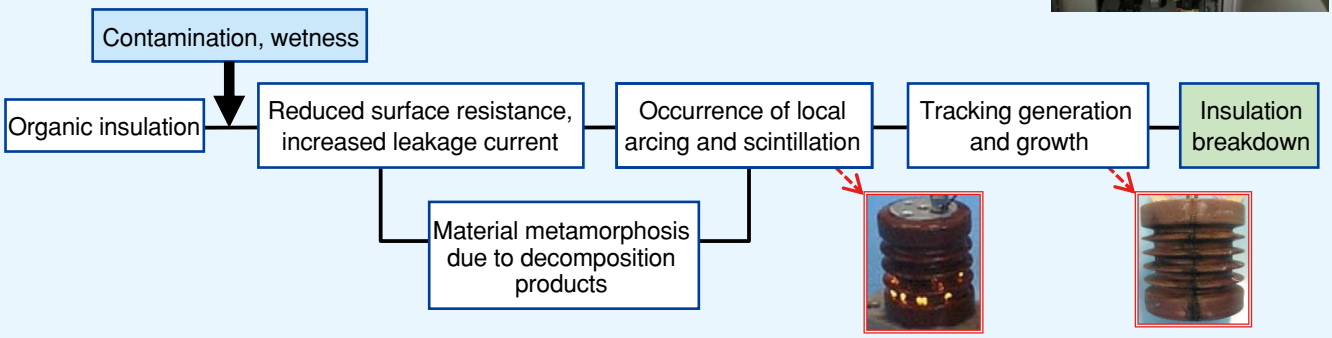
Simplified partial discharge diagnosis services for distribution panels

to Photo

Partial discharge of power distribution panels is measured to diagnose deterioration of the insulation in the distribution panels.

When the insulation in a power distribution panel has deteriorated, there is a possibility that partial discharge may be occurring in environments with contamination and due to aging deterioration. If the deterioration is allowed to progress as is, this may lead to accidents.

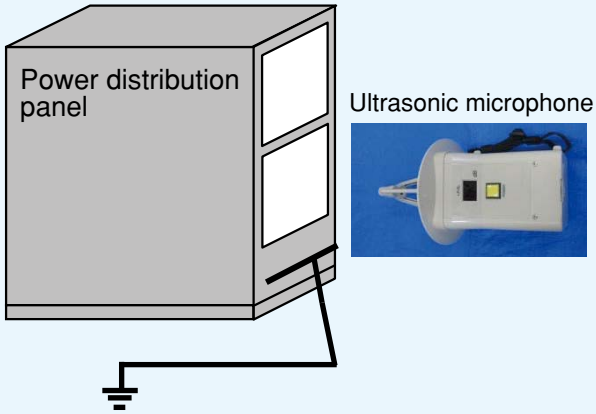
Process of deterioration



Overview

- Intended for very-medium- and medium-voltage power distribution panels with aging insulation.
- An ultrasonic microphone is used to check for partial discharge sound arising from the surface deterioration of the insulation.

System configuration



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to Photo

Flow of deterioration diagnosis

Preliminary examination and preparation

1. Check the information on the rating plate
(Rated voltage, year of manufacture)

Deterioration diagnosis services

Measurement → Prompt report → Diagnostic results report

Same day / 1 week

Optimization of maintenance plan

Based on the measurement results, we will evaluate the state of deterioration of the power distribution panel and propose methods for maintaining the equipment as well as a replacements plan for the future.

Important notes about this service

- The door of the target distribution panel will need to be opened to mount the ultrasonic microphone.
- When partial discharge is detected, an additional visual inspection will be required, conducted separately from the diagnosis services, to identify the location of the partial discharge. This visual inspection will require the power to be turned off and the equipment to be shut down. And as necessary, we will perform an analysis of any deposited matter.

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Fuji Electric

Innovating Energy Technology

Partial discharge diagnosis services for power distribution panels

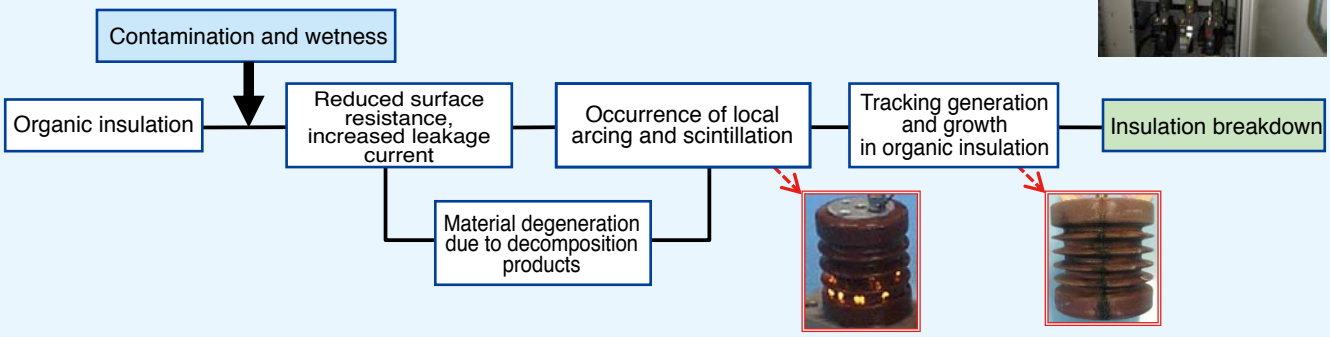
COPAS (Cubicle Online PD Acquisition System)

Partial discharge of power distribution panels is measured to diagnose deterioration of the insulation in the distribution panels.

Photo

When the insulation in a power distribution panel has deteriorated, there is a possibility that partial discharge may be occurring in environments with high humidity (85% or more) at dawn. If the deterioration is allowed to progress as is, this may lead to accidents.

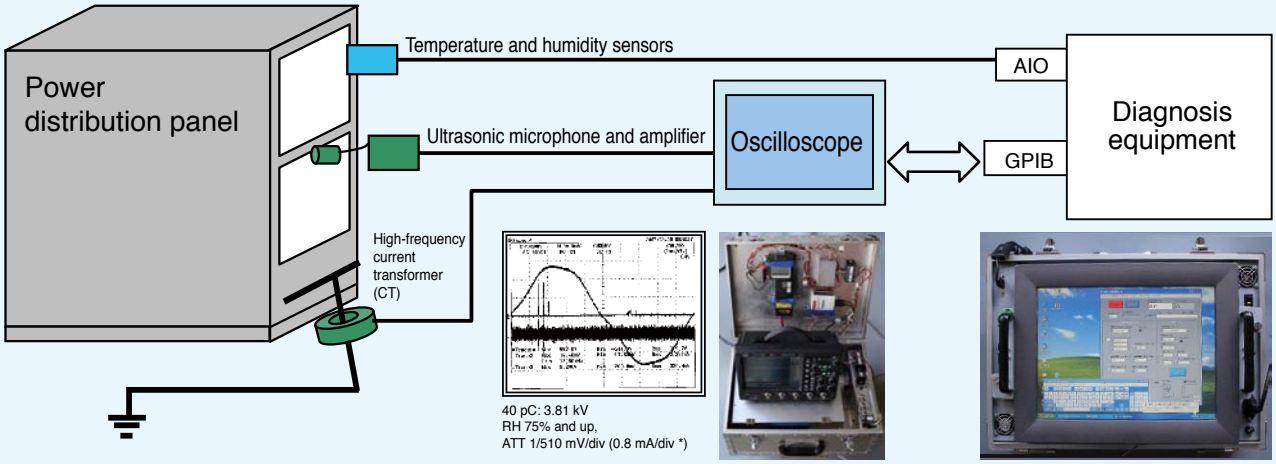
Process of deterioration



Overview

- Intended for power distribution panels up to 30 kV with aging insulation.
- Electric charge of partial discharge generated from the surface deterioration of the insulation is measured.
- Changes in the electric charge of discharge caused by humidity variations are measured using continuous monitoring throughout the day.

System configuration



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Flow of deterioration diagnosis

Preliminary examination and preparation

1. Check the information on the rating plate (Rated voltage, year of manufacture)
2. Select the places to attach the sensors

Deterioration diagnosis services

Attachment of sensors Calibration → Measurement → Preliminary report → Evaluation of deterioration

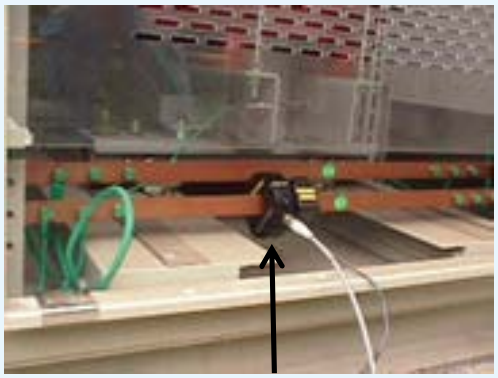
15H～24H | 1 to 2 days | 1 week

→ Optimization of maintenance plan

Target power distribution panels and measurement method

- Distribution panels used in high-humidity environments and panels for which there are concerns about degraded insulation.
- Measurement is performed automatically by a device that is installed for about 12 to 24 hours, including the hours around dawn.

Ultrasonic microphone



Ground-wire current transformer (CT)

Based on the measurement results, we will evaluate the state of deterioration of the power distribution panel and propose methods for maintaining the equipment as well as a replacement plan for the future.

Important notes about this service

- The measurement equipment requires access to a 100 V power outlet.
- The door of the target distribution panel will need to be opened to mount the ultrasonic microphone. (The door will be closed after the sensor is installed.)
- When partial discharge is detected, an additional visual inspection will be required, conducted separately from the diagnosis services, to identify the location of the partial discharge. This visual inspection will require the power to be turned off and the equipment to be shut down. And as necessary, we will perform an analysis of any deposited matter.

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2013-10(J13a/I13)T0.5FOLS

Fuji Electric

Innovating Energy Technology

Deterioration diagnosis services for substation switchgear CB-MEC

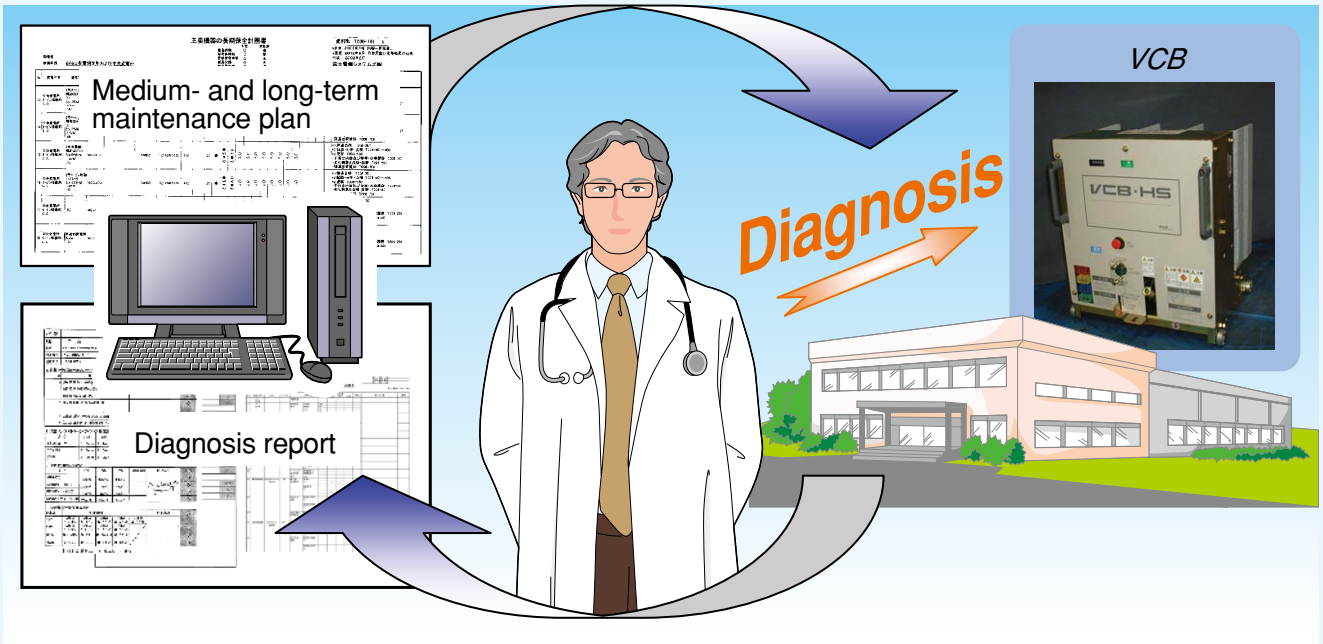
About 15 to 20 years after being newly installed, circuit breakers and contactors will have certain problems apparently due to aging deterioration.
We use our CB-MEC, deterioration diagnosis device, to quantitatively diagnose the state of switchgear deterioration to prevent equipment accidents.

to Photo

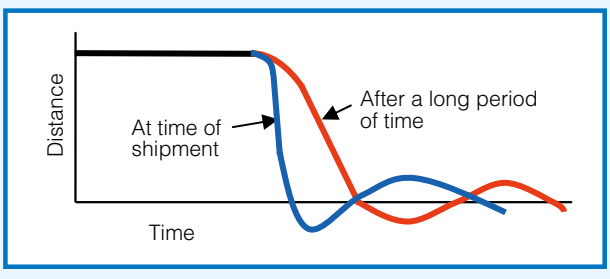
We promise to improve our customers' facilities management by:

(1) Proposing appropriate inspection cycles and replacements timing
(2) Managing deterioration trends based on accumulated data
(3) Implementing a major reduction of total diagnosis time (50% decrease)

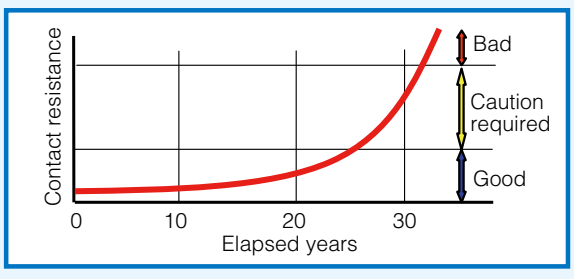
Overview of deterioration diagnosis



VCB operating speed trend management



Trend management of characteristics



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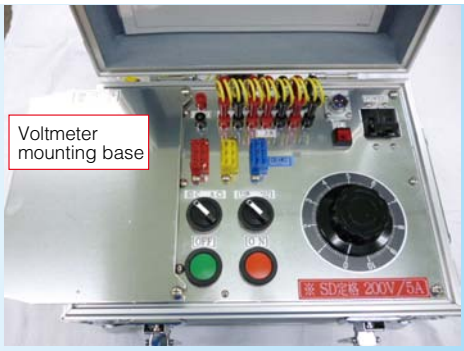
Deterioration diagnosis application examples

- **Substation equipment (CB-MEC)**
  - Circuit breakers
  - Electromagnetic contactors

Operation test equipment

Features of deterioration diagnosis

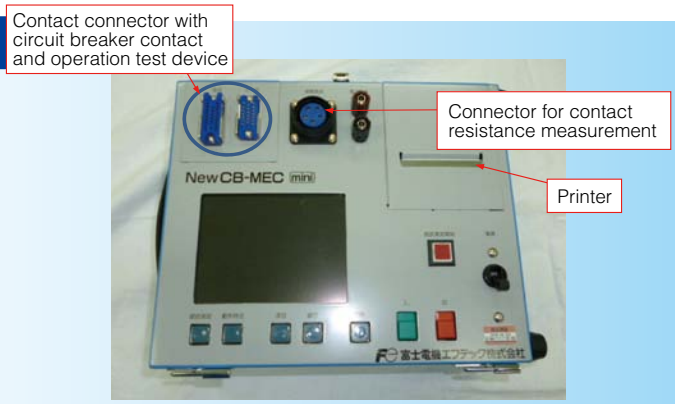
- Automatic determination using analysis technology based on advanced measurement technology and integrated data for a long terms
- Various measurements, automatic determination, recording and output of each device is available in a short time (Waveform management and numerical management are also possible.)
- By recording the trend data in time series, it is possible to also monitor the trends in characteristic changes.



Operation test device

Introduction effects of deterioration diagnosis device

- Automated diagnostic data measurement enables significant time-savings, requiring only one-third to one-half of conventional diagnostic time
- Quantitative judgment on deterioration enables setting of appropriate inspection cycles and decisions on replacements



CB-MEC
External appearance of diagnostic equipment

Main items of diagnosis

- **CB-MEC (Deterioration diagnosis of circuit breakers and switchgear)**
  1) Switching operation characteristics
  2) Insulation resistance
  3) Main circuit contact resistance
  4) Switching speed characteristics
  5) Trend management of characteristic changes

to Photo

⚠ Safety precautions

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

High-precision remaining life assessment services for oil-filled transformers

Winner of PM Excellent Product Award (Development Award) from Japan Institute of Plant Maintenance
Winner of Technical Achievement Award (Development Award) from Japan Electrical Manufacturers' Association

Do you have any transformers in use for more than 25 years?
The service life expectancy of a transformer is 30 years.

"The damage from accidents caused by aging deterioration is huge."
"If it's still usable, that's already a sign of danger."

At Fuji Electric
"We can very precisely predict the remaining service life using our own structured neural networks."

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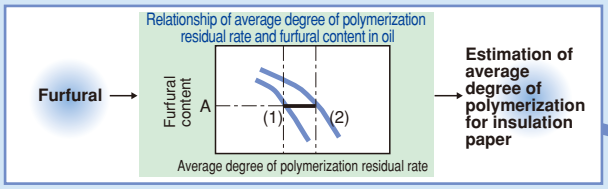
Structured neural networks

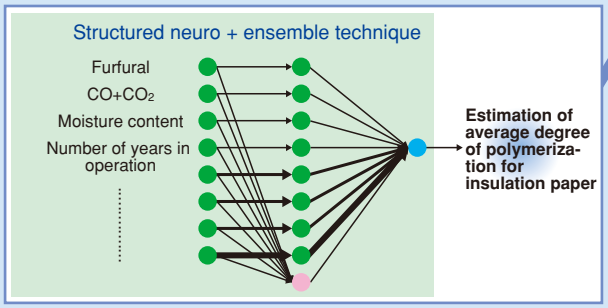
Fuji Electric' s proprietary prediction and diagnosis technology was developed to be more highly precise and uses a modified neural network technique capable of learning complex multivariate relationships and automatically tuning the structure of the model.
We have a proven track record that includes forecasting electricity demand and optimizing energy plant operations.

Predicting remaining service life using structured neural networks

Conventional method (Furfural method)

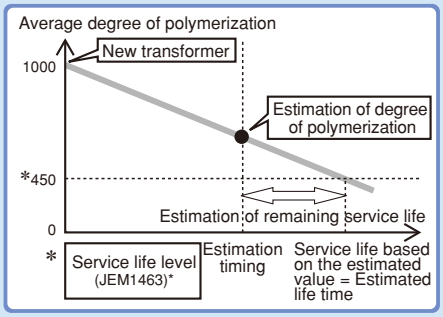


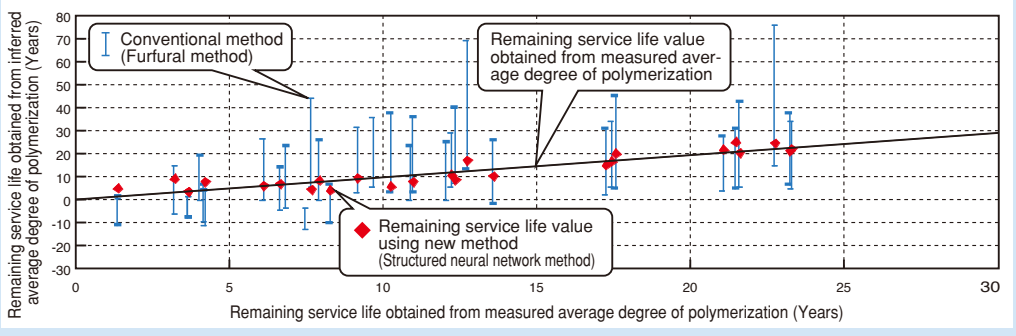
Method using structured neural networks



Problem:
The estimation range of the average degree of polymerization residual rate corresponding to the amount of furfural A is wide [(1) to (2)].

Remaining service life prediction





*JEM1463 is the evaluation criteria for the average degree of polymerization for transformer insulation paper.
(Evaluation criteria for the average degree of polymerization of the insulation paper used for the coil of an oil-filled transformer over 1,000 kVA.)

Conventional method (Average prediction range)	**15 years**
Structured neural network method (Average prediction range)	**3 years**

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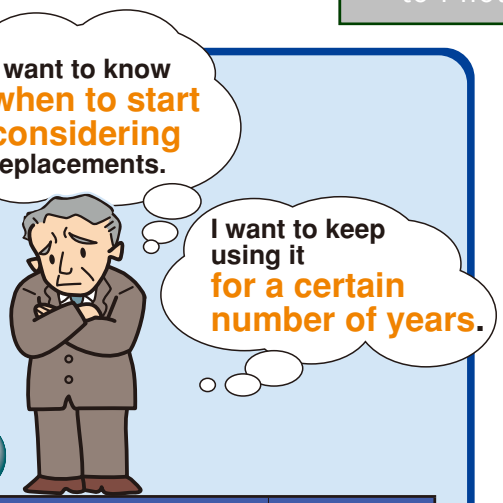
Flow of remaining service life assessment

Intended mainly for transformers with more than 15 years of operation.

- Extraction of 1 liter of oil from transformer
- Oil analysis
  - 1. Analysis of gas in oil
  - 2. Examination of oil characteristics
  - 3. Furfural analysis
- Estimation of average degree of polymerization using structured neural networks
- Remaining service life prediction



Inspection cycle and replacements timing

Classification	Part	Inspection cycle and replacements timing	Considerations
Parts in oil	Inside main unit	Consider an internal inspection depending on the results of an oil gas analysis performed once every 1 to 2 years.	There is a service life expectancy of 30 years.
Oil sealed units	Gasket Seal section	Total replacements of gaskets about every 15 years.	Since transformers are generally said to have a service life of 30 years, during that time parts are replaced one time.
Air accessories	Protection relay type parts	Replacements in 15 years.	
Mechanical wear parts	Cooling devices Oil pumps Cooling fans	Total replacements when bearings are worn.	Regularly maintained against wear.
	Load tap changers (LTCs)	Inspect at every switching frequency of 30,000 to 70,000 times. Replace at: switching frequency of 200,000 times (electrical) switching frequency of 800,000 times (mechanical)	

Optimal replacements timing

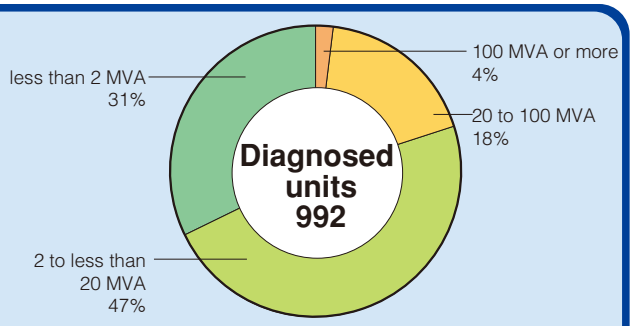
Optimal maintenance plan

We will respond promptly.

Typical schedule: Oil extraction, oil analysis: 5 days
Remaining service life prediction: 2 days

Our diagnosis experience

As of the end of March 2013 we have diagnosed 992 transformers (of which 30% were competitors' products). As a result, the diagnosis results helped our customers to make replacements plans or to review maintenance plans and we won a reputation for our diagnosis services that can be utilized effectively to create optimal maintenance and replacements plans.



Fuji Electric has presented on its structured neural networks and high-precision remaining service life assessment for oil-filled transformers at at various academic conferences.

"Method for optimizing the learning of a neural network" (JP Patent 2008-4226754)
"Deterioration diagnosis method for oil-filled electrical equipment" *
"Remaining service life estimation method for oil-filled electrical equipment" *

*: Patent pending

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Dissolved gas analysis (DGA) for oil-filled transformers and testing of insulating oil properties

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The percentage of aging and deteriorated devices among all the equipment in substations continues to increase. It is important to be able to understand the degree of deterioration of such aging equipment and the proper treatment for trouble spots in order to maintain, secure, and improve the reliability of the power supply.

Internal faults and the degree of aging deterioration of oil-filled transformers can be determined by analyzing their insulating oil.

1. Dissolved gas analysis

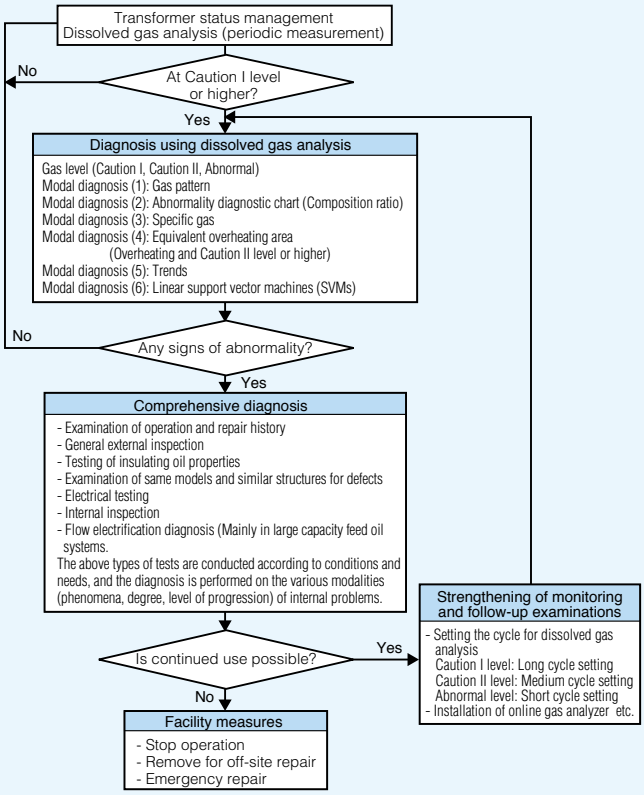
Inside an oil-filled transformer, localized overheating and discharge causes thermal breakdown of the insulating oil and insulation materials, and the decomposed gas that is generated gets dissolved into the insulating oil. Dissolved gas analysis is a method of diagnosing the presence or absence of internal faults in the transformer by sampling and analyzing the concentrations of the gases dissolved in the insulating oil.

Dissolved gas analysis

Dissolved gas volume and criteria for determining deterioration

	Total combustible gas TCG	Hydrogen H_2	Methane CH_4	Ethane C_2H_6	Ethylene C_2H_4	Acetylene C_2H_2	Carbon monoxide CO
Caution I level	500	400	100	150	10	0.5	300
Caution II level	(1) $C_2H_2 \geq 0.5$ (2) With $C_2H_4 \geq 10$, TCG ≥ 500						
Abnormal level	(1) $C_2H_2 \geq 5$ (2) With $C_2H_4 \geq 100$, TCG ≥ 700 (3) With $C_2H_4 \geq 100$, TCG rate of increase$\geq$ 70 per month						

Diagnosis flow chart of maintenance management using dissolved gas analysis

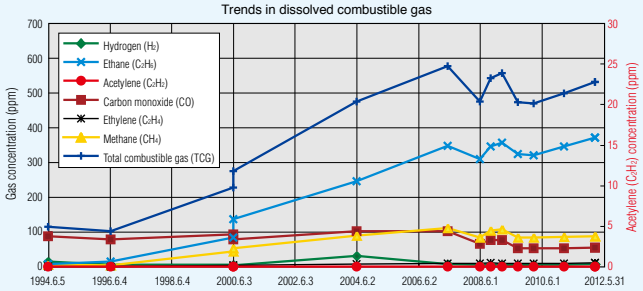


Examples of report details

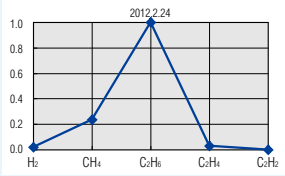
1. Trends in dissolved gas

(Note: n, nd = below the detection limit)

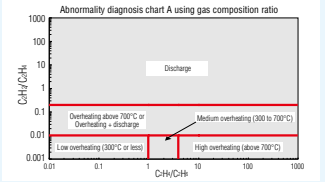
Sampling date (Year, month, day)	Oxygen (O_2)	Nitrogen (N_2)	Hydrogen (H_2)	Carbon monoxide (CO)	Carbon dioxide (CO_2)	Methane (CH_4)	Ethane (C_2H_6)	Ethylene (C_2H_4)	Acetylene (C_2H_2)	Total combustible gas (TCG)	TCG rate of increase per month (ppm)
1994.6.5	1321	8801	14	88	144	5	7	n	nd	114	
1996.6.16	2163	14540	6	78	145	4	14	t	nd	102	0
2000.6.4	1709	66031	6	92	239	43	83	4	n	228	3
2000.6.4	1053	62953	(3)	79	128	53	136	4	n	275	0
2004.5.30	1120	76332	31	102	412	89	245	8	n	475	4
2007.5.17	712	74592	8	102	469	110	348	9	n	577	3
2008.5.31	484	77131	5	66	625	84	310	9	n	474	-8
2008.10.1	1322	87451	5	76	521	104	345	11	n	541	17
2009.2.16	1659	87212	6	77	345	107	356	10	n	556	3
2009.8.25	911	74437	(4)	53	405	83	324	9	n	473	-13
2010.2.22	1259	82253	5	53	331	83	320	9	n	470	0
2011.2.21	921	88712	5	53	444	85	346	10	n	499	2
2012.2.24	665	77104	7	55	428	88	370	11	n	531	3
2012.2.24	665	77104	7	55	428	88	370	11	n	531	3
Determination criteria											
Caution I level			400	300		100	150	10	0.5	500	
Caution II level	(1) $C_2H_2 \geq 0.5$ ppm (2) $C_2H_4 \geq 10$ ppm and TCG ≥ 500 ppm										
Abnormal level	(1) $C_2H_2 \geq 5$ ppm (2) $C_2H_4 \geq 100$ ppm and TCG ≥ 700 ppm (3) $C_2H_4 \geq 100$ ppm and TCG rate of increase ≥ 70 per month										



2. Gas pattern

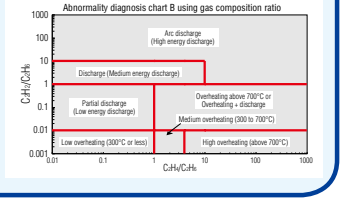


3. Abnormality diagnosis chart (Composition ratio)



4. Specific gas

IEC-60599 (1999)	If $CO_2/CO < 3$, cellulose is degraded.
IEEE Std.C57.104-1991	If $CO_2/CO > 7$, normal.
International Council on Large Electric Systems (CIGRE) materials 15/21/33-19 (TF15.01.01) (1996)	If $CO_2/CO > 10$, cellulose is overheated. If $CO_2/CO < 3$, cellulose is degraded by electrical abnormalities.



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2. Insulating oil property testing services

This is a method for diagnosing the health of insulation properties achieved by managing the moisture content, insulation breakdown voltage, total acid number, and volume resistivity in order to determine the deterioration level of insulating oil during operation.

Insulating oil property testing

Measurement items and determination criteria

Item \ Voltage kV	Standard value			
	6.6 or less	11 to 77	110 to 275	≥500
Moisture (ppm)	<40	<40	<30	<20
Dielectric breakdown voltage (kV)	>30	>30	>40	>50
Volume resistivity ($\times 10^{12}$ Ω·cm 80°C)	>1.0	>1.0	>1.0	>5.0
Total acid number (mg KOH/g)	<0.3	<0.2	<0.1	<0.1

(1): Normal value, (2): Caution value, (3): Abnormal value

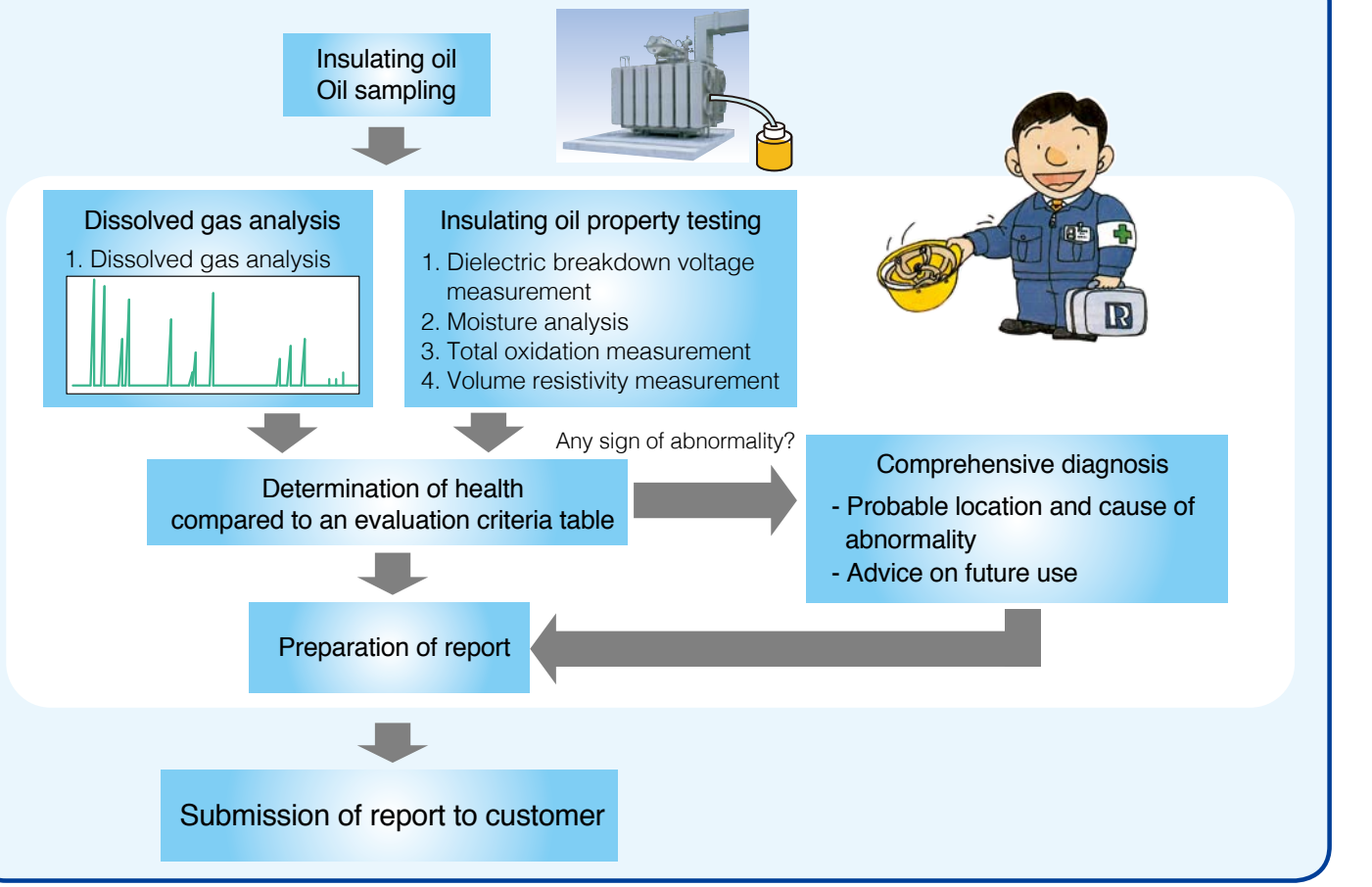
Examples of report details

Insulating oil property testing

Item		Control value	This time	Last time	Time before last
		Oil sampling date	September 14, 2012	August 31, 2012	February 24, 2012
		Analysis date	September 19, 2012	September 10, 2012	February 28, 2012
		Oil sampling temperature	38°C	40°C	74°C
Dielectric breakdown test	kV/2.5mm	over 40	85	40	74
Moisture	ppm	Less than 30	5	41	6
Total acid number	mg KOH/g	Less than 0.1	0.005	0.005	0.005
Volume resistivity	Ohm-cm (80°C)	over 0.01	–	–	–
Determination			Good	Abnormal	Good

Sample: 154/3.45 kV, 15 MVA unit

Flow of insulating oil diagnosis for oil-filled transformers



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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Torque diagnosis services for on-load tap changers

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In power transformers equipped with on-load tap changers, since failure of the on-load tap changer can not only stop the power supply from the transformer but could also lead to serious malfunction of the transformer itself, it is important to perform regular inspections and diagnosis.

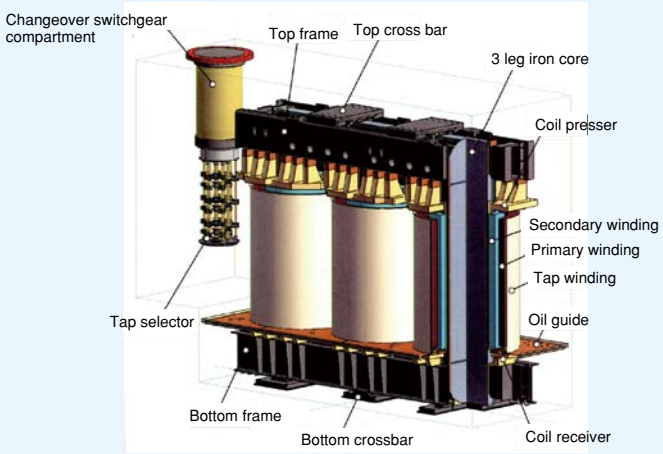
Fuji Electric's torque diagnosis services for on-load tap changers measure and analyze the tap changing torque without needing to bleed the insulating oil from the transformer. Our diagnosis identifies any signs of abnormality in the tap selector drive mechanism, and we provide information that helps customers prepare their equipment maintenance plans and renewal plans.

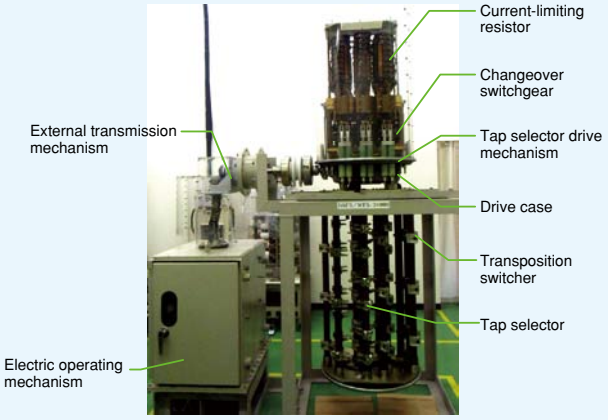
An on-load tap changer may have an in-tank configuration with the tap selector, transposition switcher and tap selector drive mechanism built into an oil-filled tank, or it might be in a compartment (changeover switchgear compartment) separate from the tank and comprising the changeover switchgear, electric operating mechanism, and external transmission mechanism.

The electric operating mechanism and external transmission mechanism can be checked during routine inspection patrols, and the changeover switchgear can be inspected during regular inspections. However, the tap selector drive mechanism is installed in a drive case in the bottom of the changeover switchgear compartment, so it is usually not possible to check it without a large-scale inspection that involves bleeding the insulating oil from the transformer body.

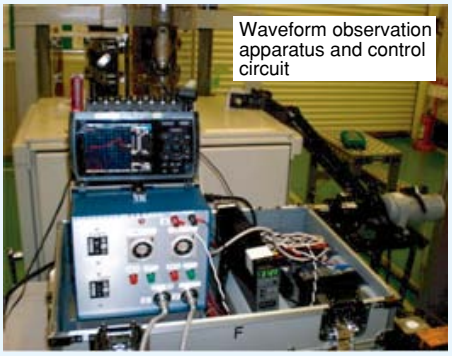
Fuji Electric's torque diagnosis services for on-load tap changers externally measure and graph the torque time variations during switching. By comparing the torque waveforms with normal switching torque waveforms and switching sequence timing, we can not only identify whether or not there are any signs of abnormality, we can narrow down the location of the defect and provide information on appropriate timing for equipment maintenance and renewals.

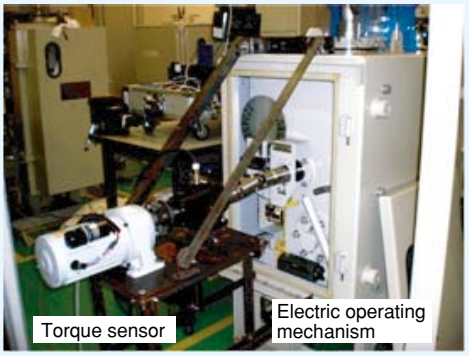
On-load tap changer configuration





Torque diagnosis device configuration





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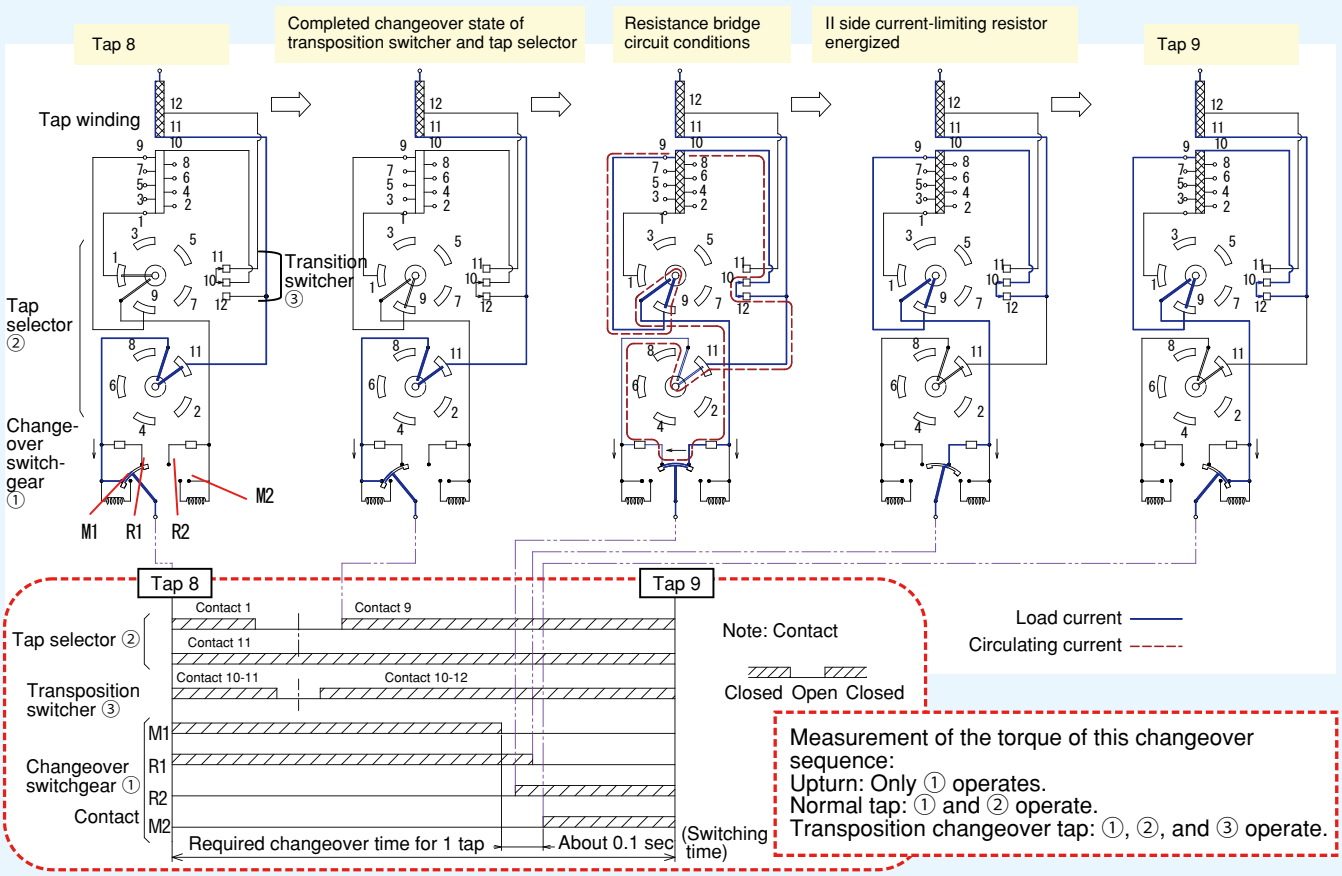
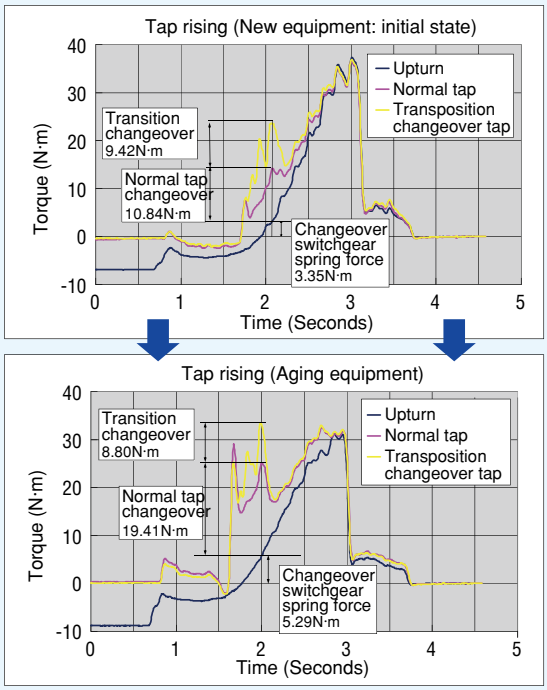
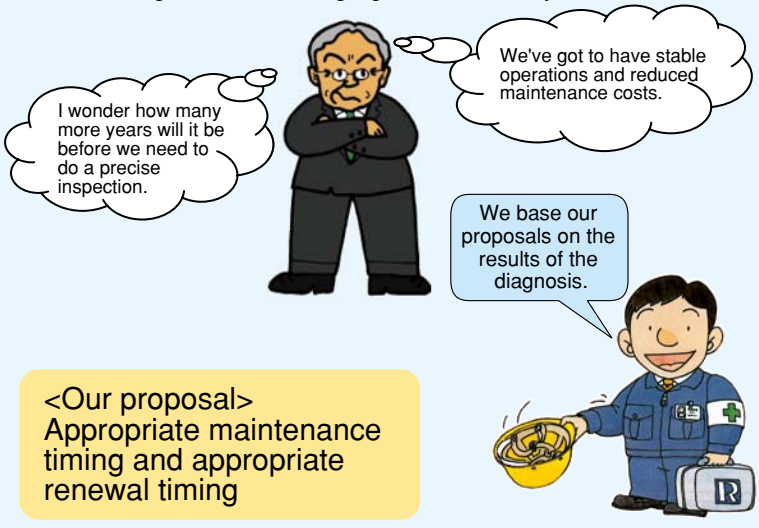
Example of diagnosis



Measurement of the torque of this changeover sequence:
Upturn: Only ① operates.
Normal tap: ① and ② operate.
Transposition changeover tap: ①, ②, and ③ operate.



In the case at the bottom for the aging equipment, the maximum value of the switching torque is 33.5 N·m which is equivalent to 33.6 N·m for new equipment of the same type. However, while this on-load tap changer is below the determination criteria (70 N·m), it requires twice as much torque as new equipment for the changeover of the tap selector, so it was diagnosed as showing signs of abnormality.



<Our proposal>
Appropriate maintenance timing and appropriate renewal timing

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

MOLMOS

Optical diagnosis services for deterioration of molded transformers

Features

- The degree of deterioration of the resin in molded transformers can be easily measured using optical reflectance characteristics.

Introduction effects

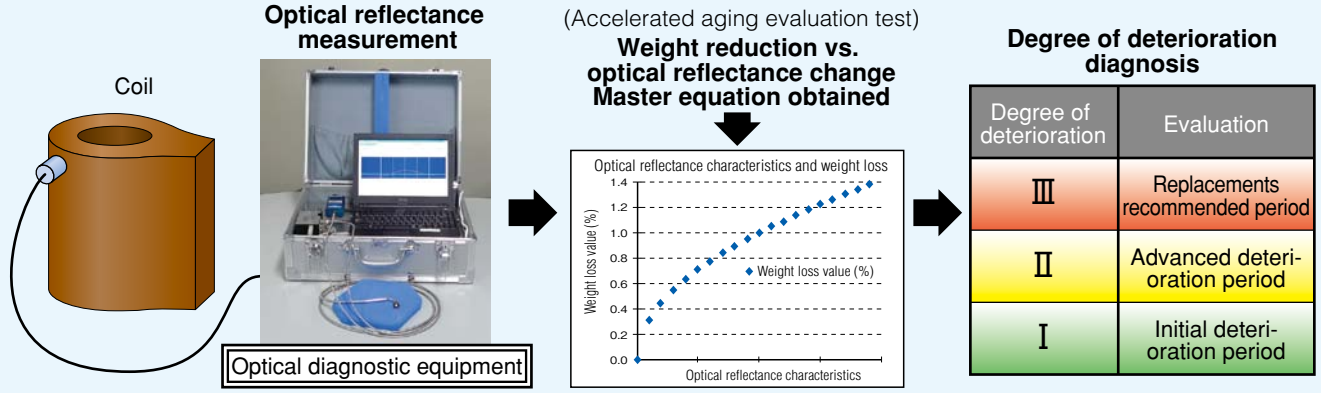
to Photo

- The degree of deterioration can be assessed quantitatively from numerical data.
- Assessment of the degree of deterioration enables the creation of optimal maintenance plans.
- Assessment of the degree of deterioration enables the determination of the optimal replacements priority.

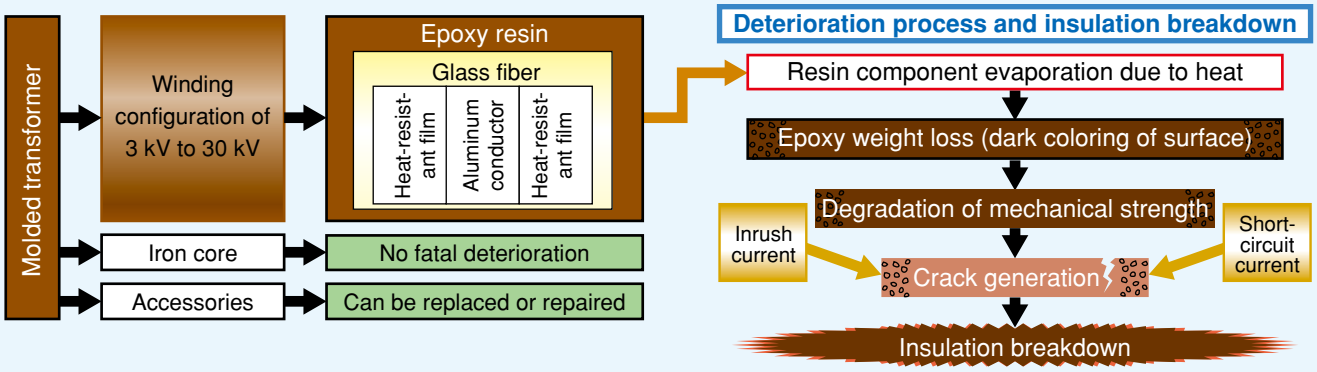
Diagnosis using optical reflectance characteristics

- The life time of molded transformers depends on the thermal deterioration of the epoxy resin of insulation.
- Thermal deterioration darkens the color and reduces the weight of the epoxy resin.
- There is a correlation between the weight loss and dark coloring of the epoxy resin, so we diagnose the degree of deterioration by measuring the optical reflectance.

Deterioration diagnosis using optical reflectance characteristics



Molded transformers and deterioration process



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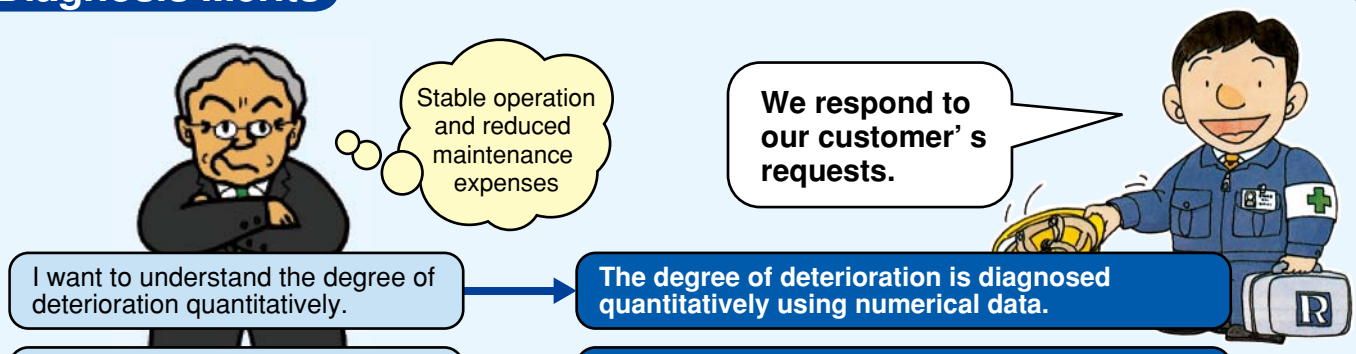
Diagnosis Merits



I want to understand the degree of deterioration quantitatively.	**The degree of deterioration is diagnosed quantitatively using numerical data.**
I want to create an optimal maintenance plan.	**You can create an optimal maintenance plan by understanding the degree of deterioration.**
I want to know the best timing for replacements.	**By understanding the degree of deterioration, you can determine replacements priorities.**

Diagnosis conditions the diagnosis services

- Target: 3 kV to 30 kV molded transformers manufactured by Fuji Electric.
- External appearance: No discoloration due to ultraviolet, chemicals, corrosive gas, and No significant accumulation of dirt and dust or repainting.
- Power shutdown: Power to the transformer needs to be shut off for measurement.

Diagnosis flow

Pre-confirmation
1. Information on nameplate
2. Visual appearance
3. Operating condition

→

Optical reflectance measurement
1. Optical reflectance measurement
2. Up-down measurements for each phase

→

Degree of deterioration diagnosis
1. Average value calculation
2. Weight loss estimation
3. Degree of deterioration diagnosis

Diagnosis cases

As of March 2013, we have performed diagnosis on 153 molded transformers.
Although day-to-day visual observations and insulation resistance measurements taken at periodic inspections were unable to find abnormalities, by using optical diagnosis of the resin we were able to find equipment for which the weight reduction had progressed up to the recommended replacements time.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Partial discharge diagnosis device for preventive maintenance of molded transformers

MOL-MEC

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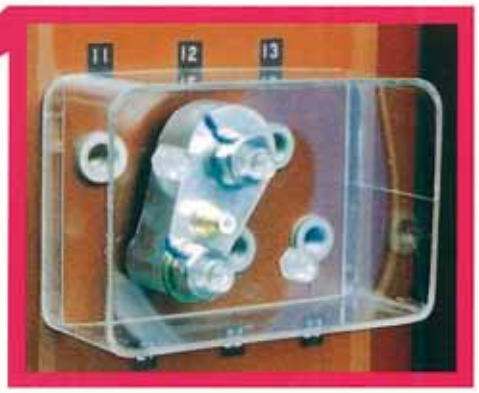
This device is a portable on-site deterioration diagnosis device used to diagnose the deterioration of molded transformers installed in substation facilities by detecting the presence or absence of partial discharge.
During periodic inspections, this preventive maintenance diagnosis device for molded transformers enables the presence or absence of partial discharge to be easily diagnosed on-site by connecting the detection unit (PM tester) to the non-voltage tap changer terminal (PM terminal) on the molded transformer, which also serves as the partial discharge detection terminal.

External appearance of molded transformer with deterioration diagnosis prediction function



PM terminal section

Features

- The device is portable so on-site diagnosis of partial discharge can be performed in a short period of time.
- Use of the PM terminal minimizes the impact of various noises at the site enabling reliable detection of partial discharge.
- The PM tester connects to the PM terminal by optical fiber to ensure safety during detection.

PM terminal

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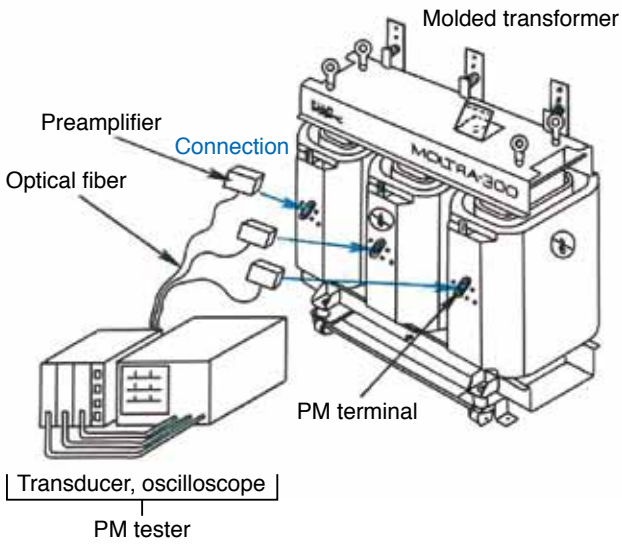
Configuration

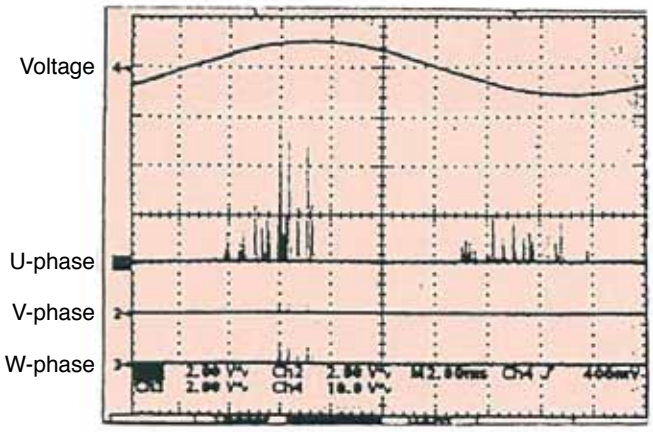


Preamplifier and PM tester (transducer, oscilloscope)

Diagnosis procedure

The diagnosis is performed by a diagnostic technician with the following steps.

- Turn off power so there is no voltage at the molded transformer.
- Connect the PM tester to the PM terminal.
- Calibrate the electric charge of discharge.
- Turn on power so the molded transformer is in a receiving state.
- Detect the partial discharge. (diagnosis)
- Turn off power so there is no voltage at the molded transformer.
- Disconnect the PM tester.
- Restore power so the molded transformer is in a receiving state again.



Example of detected waveform

Please contact us for information about applying this device to existing molded transformers from our company.

⚠ Safety precautions

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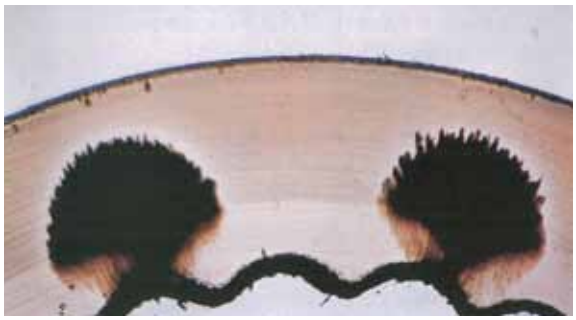
2013-9(I13/I13)T1FOLS

Diagnosis services for 3.6 kV cables

to Photo

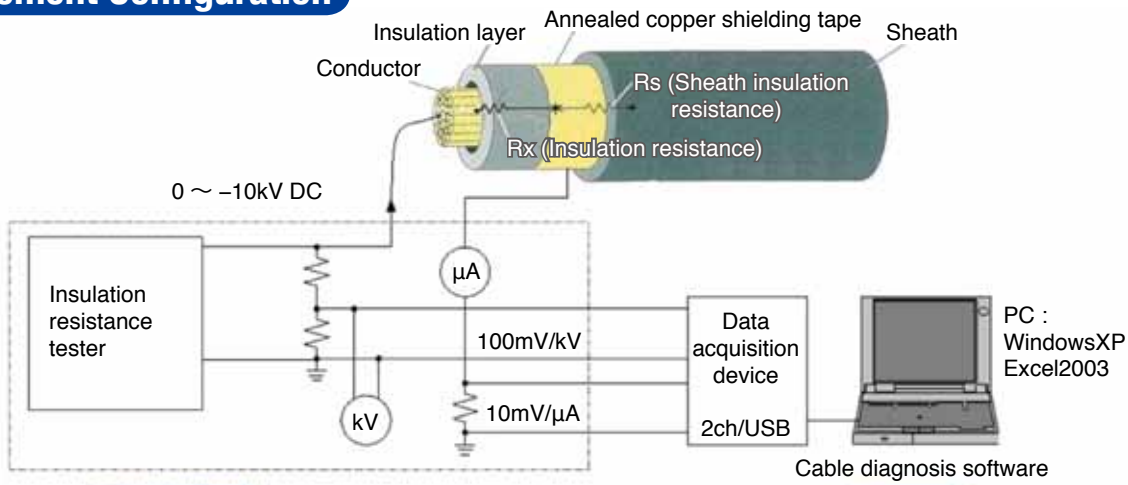
Performing the periodic inspections of substation equipment, we recommend to diagnose for 3.6 kV cables as well as equipment.

In order to prevent accidents and damage due to the aging deterioration of diagnosis services 3.6 kV cables, we have developed a diagnostic device for diagnosis services for 3.6 kV cables that measures the DC leakage current.

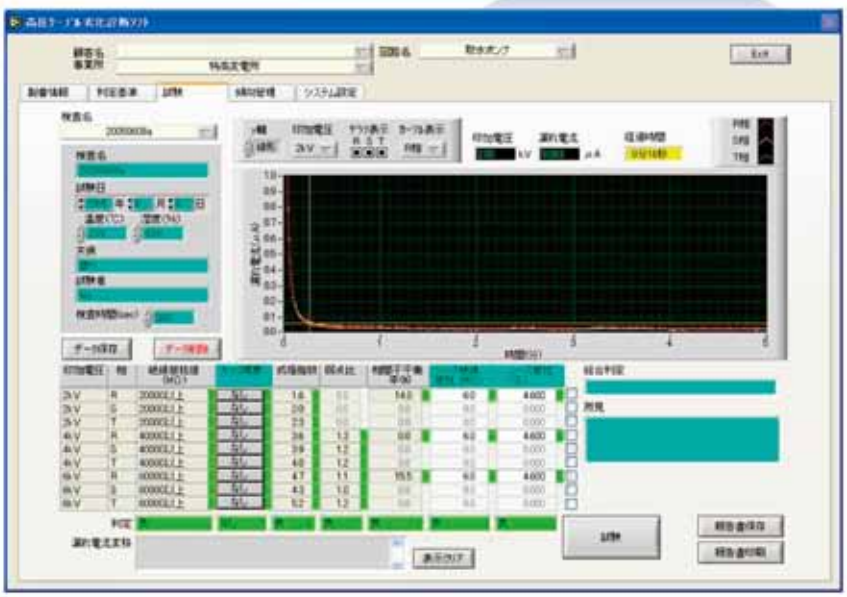


Source: High-voltage CV cable maintenance and inspection guidelines, Technical Data No. 116 A

Measurement Configuration



Insulation resistance tester (High-Bit Mega), Musashi Co., Ltd.



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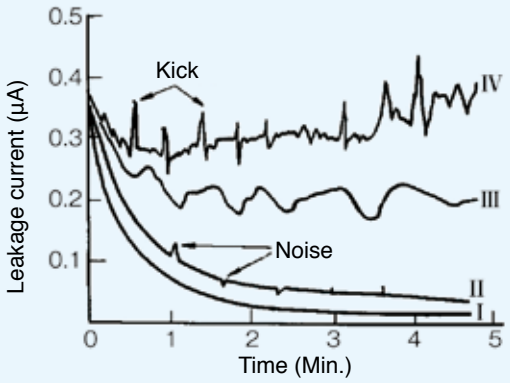
Features of cable diagnostic equipment

- Automatic calculation functions of cable diagnosis index
  1) Insulation resistance value
  2) Polarization index
  3) Vulnerability ratio
  4) Three core unbalanced rate
- Automatic quality determination using judgment criteria
- Trend management functions using measurement data history ⟶ to propose scheduled equipment investments
- Test results creation function ⟶ to submit the report of diagnosis results in that day

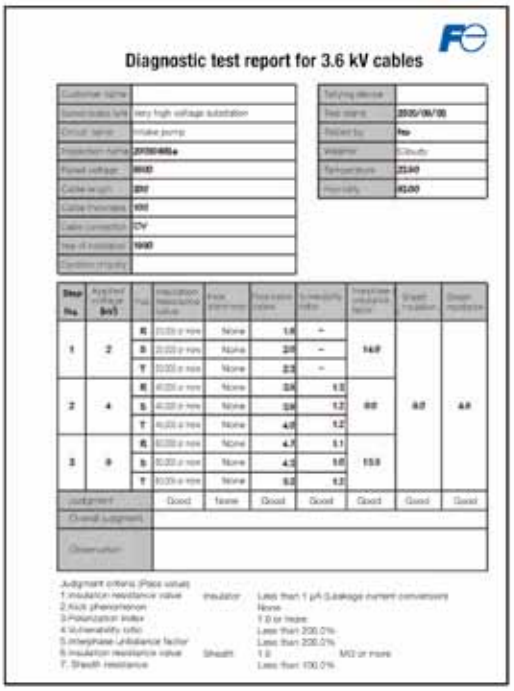
Example chart of leakage current versus time characteristic, and state of cable

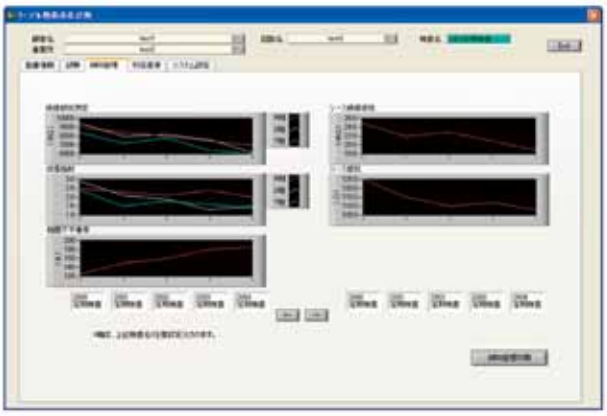


I : Normal cable
II : Normal cable with noise in the measurement
III : Deteriorated cable with large absolute value of leakage current
IV : Deteriorated cable can be seen the kick phenomenons and leak-current's upward trend

Source: The Institute of Electrical Engineers of Japan, Technical Report (No. 182)

Output (Diagnostic test report and trend management)


Diagnostic test report for 3.6 kV cables



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2013-9(I13/I13)T1FOLS

Fuji Electric

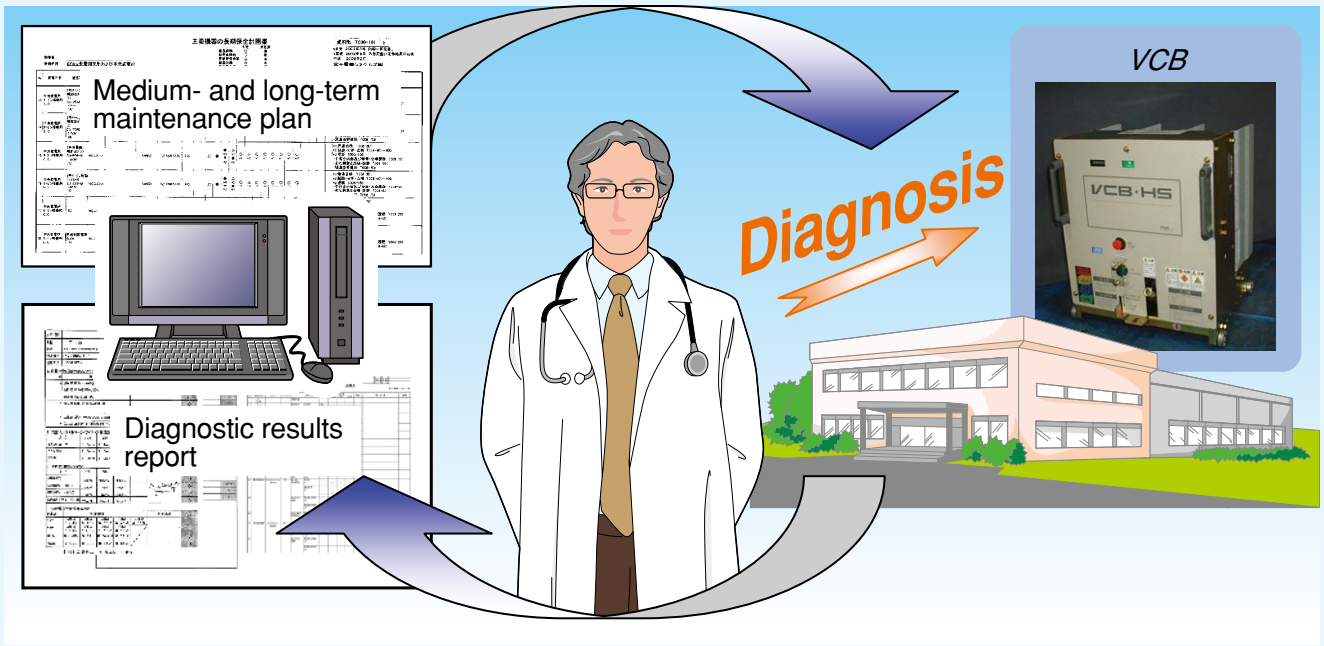
Innovating Energy Technology

Deterioration diagnosis services for auxiliary relays

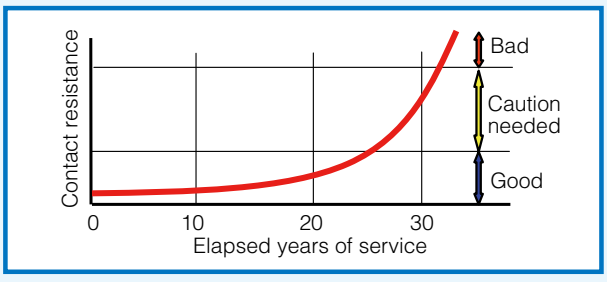
AR-MEC（Measuring Equipment of Characteristics for Aux Reray）

Auxiliary relays are often used to configure the control logic in power distribution panels.
In elapsed years from 15 to 20 years after delivery, the resistance of the contacts increases due to aging deterioration of the auxiliary relays which causes conduction failures, and ultimately equipment malfunctions will become apparent.
To prevent equipment accidents, we use deterioration diagnosis equipment, AR-MEC, to quantitatively diagnose the deterioration state of the auxiliary relays.

Overview of deterioration diagnosis



Contact resistance trends of auxiliary relays



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Target equipment for deterioration diagnosis

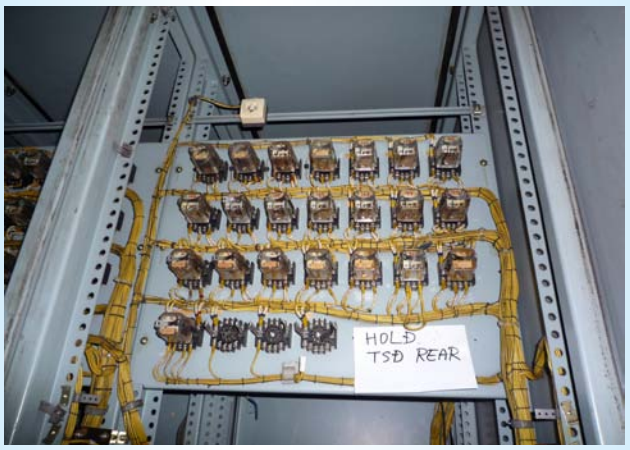
- **Deterioration diagnosis equipment (AR-MEC)**

  - Auxiliary relay models

    HH52P HH54P

    HH22P HH23P

  - Voltage: DC 24 V, DC 100/110 V, AC 100 V



Features of deterioration diagnosis

- Automatic determination using analysis technology based on state-of-the-art measurement technology and years of accumulated data.
- Various measurements of each device, automatic determination, recording, and output are all possible in a short period of time (numerical control).

Benefit of using the deterioration diagnosis equipment

- Can prevent the failure by quantitative deteriotation decision.

<Appearance of diagnosis equipment>

Main items of diagnosis

(1) Coil resistance

(2) Contact resistance

to Photo

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Diagnostic services for adjustable speed drive systems

to Photo

Do you have any long-running adjustable speed drives in operation?

Just how bad is the condition?

Can the broken equipment be fixed?

How much time is needed for repairs?

Will an inspection be possible?

Is an overhaul going to be doable?

When is the best timing for a replacements?

M400

C type

Let's learn the status of the equipment's deterioration and service by performing a diagnosis.

Diagnosis benefits

1. Examination of current state and deterioration factors
2. Proposals on maintenance planning and service life-prolonging measures
3. Proposals on optimal replacements planning

Diagnosis features

1. Visual examination performed without power shutdown while equipment is in operation
2. Examination performed from various aspects by a specialist technician
3. Maintenance provided based on status of equipment and service

Diagnosis target equipment

Fuji Electric brand variable speed drives

TRANSIDYN speed controllers (A to D, U2)

LEONIC, FRENIC

Diagnosis checkpoints

1. Installation environment
2. Physical deterioration, service life related to needs
3. Spare parts, maintenance history

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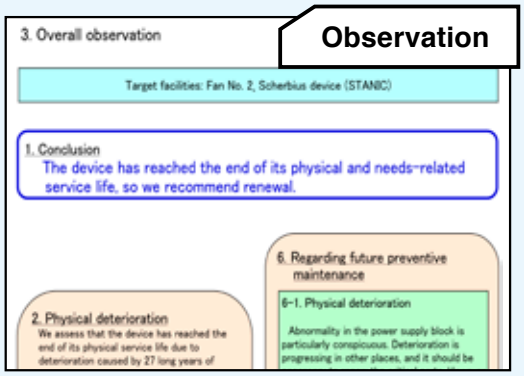
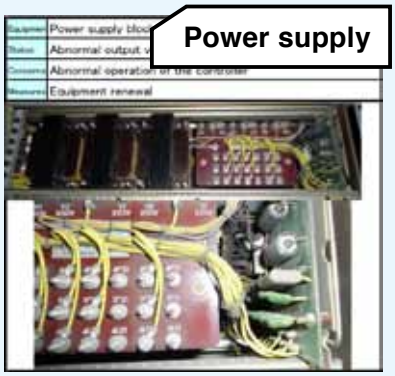
Examples of diagnostic reports

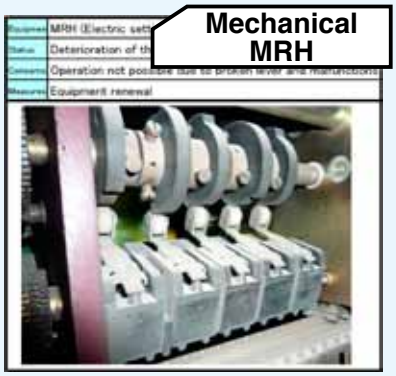
Observation



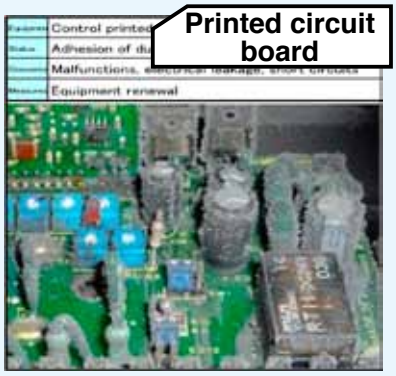
Power supply



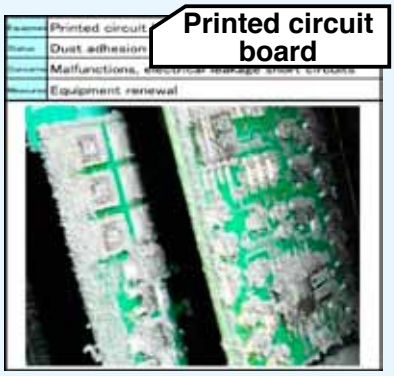
Mechanical MRH



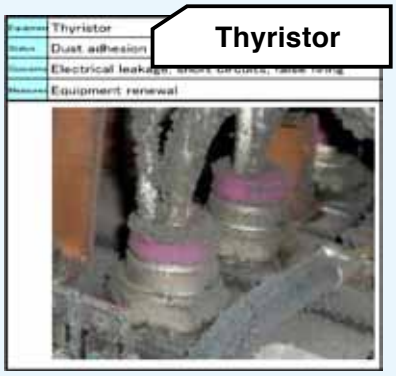
Printed circuit board



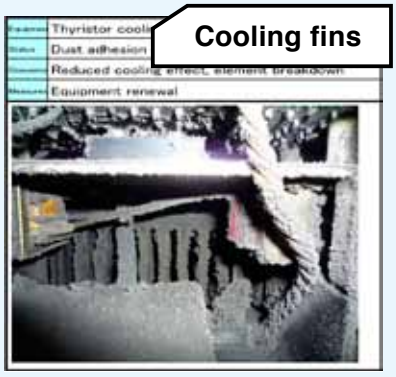
Printed circuit board



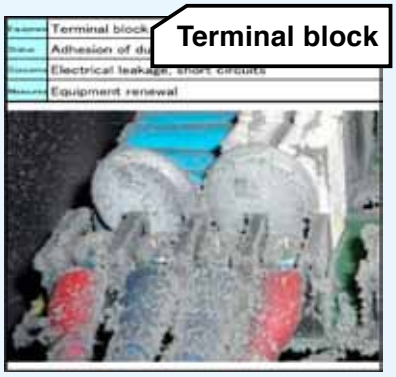
Thyristor



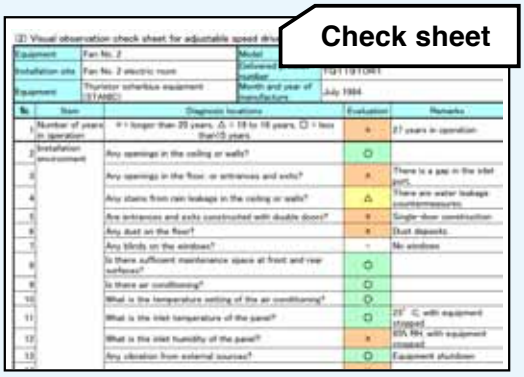
Cooling fins



Terminal block



Check sheet



Long-term stable operation and reduced maintenance costs achieved through diagnosis

Service life of the equipment varies depending on what is done in maintenance.

Proper preventive maintenance prolongs the service life of the equipment.

Proper preventive maintenance reduces maintenance costs.

Let's perform preventive maintenance through diagnosis.

Diagnosis requirements

- About 3 hours are needed.
- Necessary to open and take photos of panels.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Remaining service life assessment system for limited life parts of general-purpose inverters

to Photo

We perform rapid on-site remaining service life assessment while the equipment is in operation.

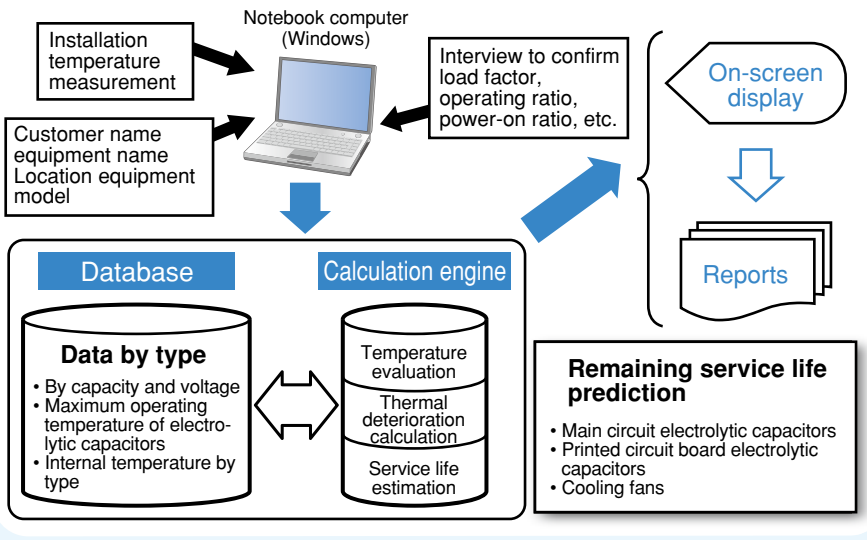
Compared with the traditional style of replacing when broken, we have achieved optimized preventive maintenance that enables you to use the equipment reliably for as long as possible.

Overview of the diagnostic system

Remaining life time diagnosis system of limited life parts diagnoses is (the system) for fans and capacitors etc. Your operating environment and conditions are reflected in the diagnosis.

1. Target limited life parts: Main circuit electrolytic capacitors, printed circuit board electrolytic capacitors, cooling fans.
2. Target models: Fuji Electric general-purpose inverters (30 kW and above) manufactured from 1994 to 2009; FRENIC 5000 G9S/P9S, VG5S, G11S/P11S, VG7S, RHC-A, RHC-B, RHC-C.
3. Diagnostic results: Recommended replacements timing is calculated, printable reports in Excel sheets are viewable on-screen.

Fuji Electric's customer engineers (CEs) will visit your location and perform the diagnosis on site.



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Features and benefits of the diagnostic system

Features

1. Diagnosis can be performed while equipment is in operation.
2. Diagnostic results are quickly available on site.
3. Diagnosis can be performed tailored to temperature and operating conditions.

Benefits

1. Specified replacements timing for limited life parts reflects the usage status.
2. Failures can be prevented before they occur.
3. Optimized maintenance plans can be achieved
4. Optimized equipment investment plans can be achieved.

Parts replacements timing from JEMA

Part name	Standard replacement cycles	Replacements method, other details
Cooling fans	2 to 3 years	Replace with new part
Aluminum electrolytic capacitors for smoothing on main circuit	5 years	Replace with new part
Aluminum electrolytic capacitors on printed circuit boards	5 years	Replace with new board

Source: General-purpose inverter periodic inspection recommendations, Oct. 2001, Japan Electrical Manufacturers' Association (JEMA)

- **Optimized preventive maintenance is achieved.**
- **We will propose an optimal maintenance plan (parts replacements or renewal).**

Sample output from the diagnostic system

Output on Excel sheets.

Calculation results and recommended replacements timings are listed.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Deterioration diagnosis system for environmental factors of general-purpose inverters

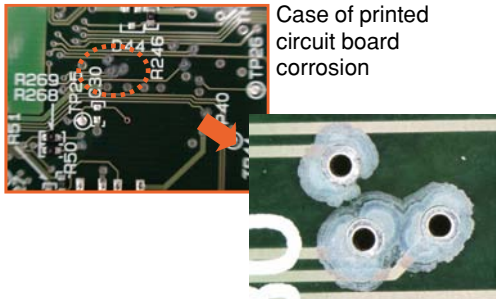
to Photo

How is the installation environment of your inverters?

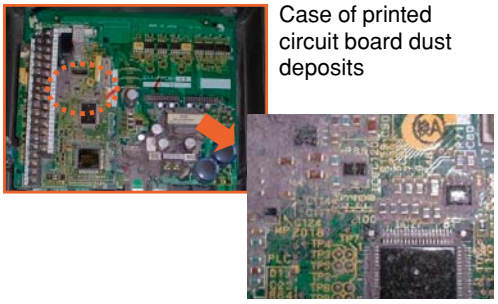
Printed circuit boards inside inverters are degraded by environmental factors

Printed circuit board deterioration by environmental factors are:

Disconnections due to corrosive thinning of the wiring pattern (copper foil) caused by corrosive gas, and **short circuits at insulation parts between the wiring patterns caused by dust deposits**.



Case of printed circuit board corrosion



Case of printed circuit board dust deposits

The deterioration and the remaining life time diagnose using environmental factors of the printed circuit boards.

Corrosive gas and deterioration diagnosis

- We quantitatively diagnose the timing of malfunctions due to corrosive thinning of the wiring patterns (copper foil) of the printed circuit board.
- We perform the diagnosis based on corrosive gas (H_2S and Cl_2) concentrations, and temperature and humidity data.
- Diagnosis is possible without having to shut down the inverter.

Dust deposits and deterioration diagnosis

- We quantitatively diagnose the timing of malfunctions due to dust deposits at insulation parts between the wiring patterns of the PCB.
- We perform the diagnosis by collecting dust deposit samples (for calculating the amount of chloride ions in the collected dust deposits) and based on the temperature and humidity data.

Diagnostic results

1. With the installation environmental factors reflected in the results, the degree of deterioration and remaining service life of the printed circuit boards can be understood.
2. Failures can be prevented before they occur.
3. Optimized equipment investment planning and environment improvements can be achieved.

to menu

52A9-E-0026

Corrosive gas deterioration diagnosis

Environmental measurements taken using the environmental measurement kit

- Exposure for 1 month in the measurement location
- Corrosive gas concentration measurement
  Hydrogen sulfide gas (H_2S)
  Chlorine gas (Cl_2)
- Thermo-hygrometer

Items input and output in the diagnosis

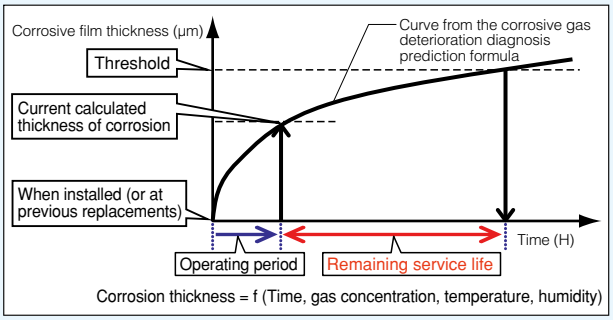
Input of equipment data and related information

- Equipment type, installation date, diagnosis date
- Ambient temperature and humidity: Environmental measurements and continuous measurement for 1 month
- Corrosive gas concentration (Hydrogen sulfide gas, chlorine gas): Environmental measurements and continuous measurements for 1 month

Output

- Expected amount of corrosion on current printed circuit board
- Remaining service life due to corrosive deterioration

Corrosive gas diagnostic curve and threshold



Diagnosis flow

Environmental measurement (About 1 month)
↓
Data analysis (About 1 month)
↓
Diagnosis using analysis software (About 1 day)
↓
Preparation of report (About 1 week)

Dust deposit deterioration diagnosis

Dust collection method

- Dust is collected from the printed circuit board itself or in a specified amount from within the panel that enables an estimation of the dust on the printed circuit board.

Items input and output in the diagnosis

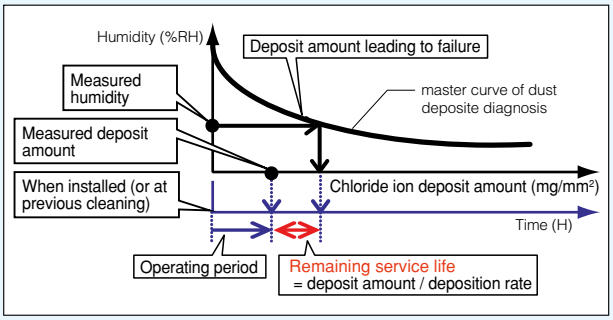
Input of equipment data and related information

- Equipment type, installation date, diagnosis date
- Ambient temperature and humidity: Environmental measurements and continuous measurement for 1 month
- Amount of dust deposits: Dust deposits are collected and the amount of chloride ions in the collected dust is calculated

Output

- Remaining service life due to the dust deposits

Dust deposit master curve



Diagnosis flow

Environmental measurement (About 1 month) + Dust collection (About 1 day))
↓
Data analysis (About 2 weeks)
↓
Diagnosis using analysis software (About 1 day)
↓
Preparation of report (About 1 week)

to Photo

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Reliability assessment for medium-voltage* motors

to Photo

* 3 kV to 13 kV

We would like to be able to diagnose a large number of medium-voltage* motors.

Fuji Electric provides diagnosis services for customers of our medium-voltage* motors that enable assessment of the degree of aging deterioration of those motors using desktop calculations based upon operational data that we receive from the customers. Please consider using our services as your primary diagnosis for a large number of motors.

Operating system for reliability assessment for medium-voltage* motors

Customer

Selection of target motors

Examination of nameplate

- Facility name (Item No.)
- Motor machine number
- Output
- RPMs
- Voltage
- Insulation class
- Current
- Year of manufacture

Operating performance examination of the target motors

- Years of operation
- Number of start-ups per day
- Ambient temperature
- (● Installed location)
- Load current (load factor)
- Start-up time
- Presence or absence of water cooling
- (● Years of installation)

Calculation of degree of deterioration based on operating performance data and specifications of individual motor parts

- Insulation method
- Presence or absence of cooling water
- Operation time
- Load factor
- Start-up frequency (No. of times)
- Wedge
- Pressboard (PB) presence or absence
- Cumulative operation time
- Temperature of stator (ST) windings
- Start-up time
- Cable
- Room temperature (RT)

Fuji Electric

Reliability assessment of target motors

- Comprehensive assessment and evaluation points for each part
  - A (100 to 75)
  - B (74 to 50)
  - C (49 or less) as well as Insulation assessment (25 or less)
- Calculation of service life expectancy in years (as a reference)

Precision diagnosis

Select and reassess based on the evaluation points while taking the importance of the equipment into account

Electrical diagnosis of insulation and Remaining service life assessment (F-resin/S)

Proposal of medium- and long-term maintenance plans

Inspection and maintenance or Full replacements of motors or Coil rewinding insulation replacements

to menu

Reliability assessment method based on the operating performance of medium-voltage* motors

It is not economical to waste expenses on a large number of machines like medium-voltage* motors only for the sake of determining their condition. Fuji Electric's original diagnostic method is a reliability assessment method based on the equipment's operating performance that evaluates not only the temperature level of stator wiring but the reliability reduction level of moter's whole parts the motor's reduced reliability using calculations performed on the desktop.

● Gather operating performance data

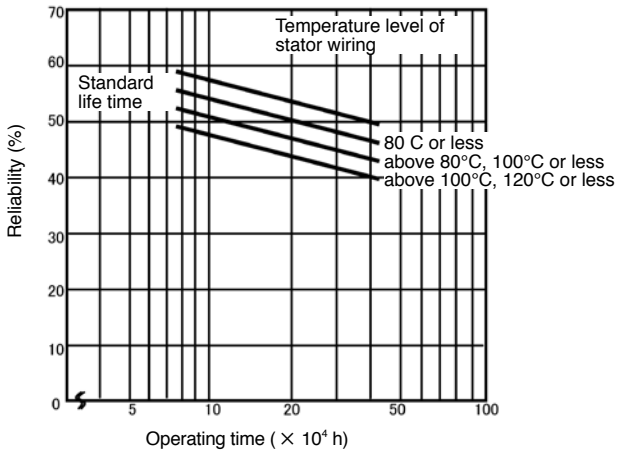
- Operation time
- Cumulative operation time
- Load factor or current value
- Start-up frequency
- Start-up time

Assign a grade to each component of the electric motor, using historical data such as operating time, and evaluate the reliability of each component aiming at a comprehensive assessment.

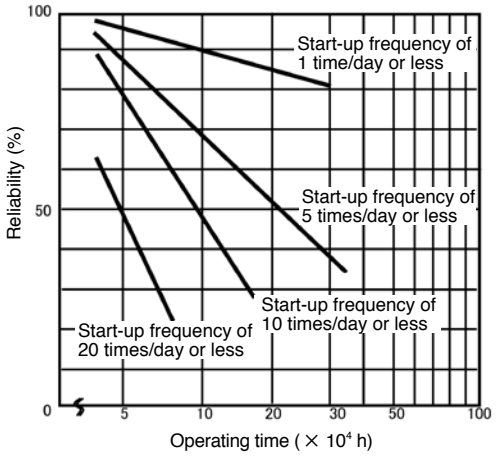
● Evaluate each component of the motor

Part	Grade		Reliability		Evaluation score
Insulation	(50)	×	X1	=	Y1
Wedge	(15)	×	X2	=	Y2
Squirrel-cage rotor	(15)	×	X3	=	Y3
Air cooler	(10)	×	X4	=	Y4
Pressboard (PB)	(5)	×	X5	=	Y5
Mechanical structure parts	(5)	×	X6	=	Y6
Xn : Obtained from the reliability curve of each component					∑ Y

Reliability of shellac insulation



Reliability of squirrel-cage rotor



● Comprehensively evaluate the degree of deterioration using the total of the evaluation points and the evaluation points for the insulation.

Class	Total evaluation score	Evaluation
A	100 ～ 75	No particular problems
B	74 ～ 50	Periodic reassessment recommended
C	49 or less, or insulation 25 or less	Substitution replacement recommended

★ 3 kV to 13 kV

⚠ Safety precautions

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Note: This product is intended to be handled by persons with specialized technical knowledge.

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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

Insulation diagnosis for medium-voltage* rotating machines

to Photo

* 3 kV to 13 kV

Insulation is an organic living thing.

For medium-voltage* rotating machines, the insulation of the windings is the most important thing affecting their service life. This is why, as manufacturers, we are constantly searching for the very best materials and processing methods to use in our research and development in order to provide products that in every aspect make full use of the best technology possible. However, since the principal materials used for insulation, which include shellac mica, Bakelite, synthetic resin film, and epoxy resin, all in fact include organic matter, during the many years the equipment is in use the quality of this insulation material will begin changing and likewise degrading the insulation properties. As a result, the insulation withers and shrinks, causing air pockets inside the insulation material which in turn cause an increase in harmful partial discharge and the insulation structure to break down. This may ultimately lead to unexpected breakdowns of the rotating machine itself.

To prevent sudden breakdowns of rotating machines

To keep on living a healthy life, it is essential for us to do things to take care of our health every day. One might say that among these, we have placed an emphasis on getting regular health checkups, and they have become a part of our lives.
For medium-voltage* rotating machines as well, to prevent sudden breakdowns it is necessary to always check the condition of the insulation and know precisely how the aging is progressing. Particularly for rotating machines that are over 10 years old, we recommend regular diagnostic testing of the insulation, which is not unlike the checkups adults receive to prevent health disorders as they get older.
Based on our lifecycle service system, and according to the manufacturing specifications of the winding, Fuji Electric will perform an appropriate diagnosis of the deterioration and make recommendations for managing the remaining service life, such as continued use while monitoring reliability, overhauls, and replacements.

How insulation diagnosis is performed

Using our accumulated expertise, we precisely evaluate the diagnostic data to accurately determine the deterioration trends and reliability of the insulation.

Direct current (DC) test
(Ohmmeter test and polarization index measurement)

Dielectric dissipation factor test
(Tan-delta measurement)

Partial discharge test
(Corona characteristics)

Alternating current (AC) test
(V-I characteristics)

Visual and other inspections
(Disassembly during maintenance)

In order to be able to perform this diagnostic work smoothly on site, we have configured diagnosis vehicles that are equipped with special measurement devices.

to menu

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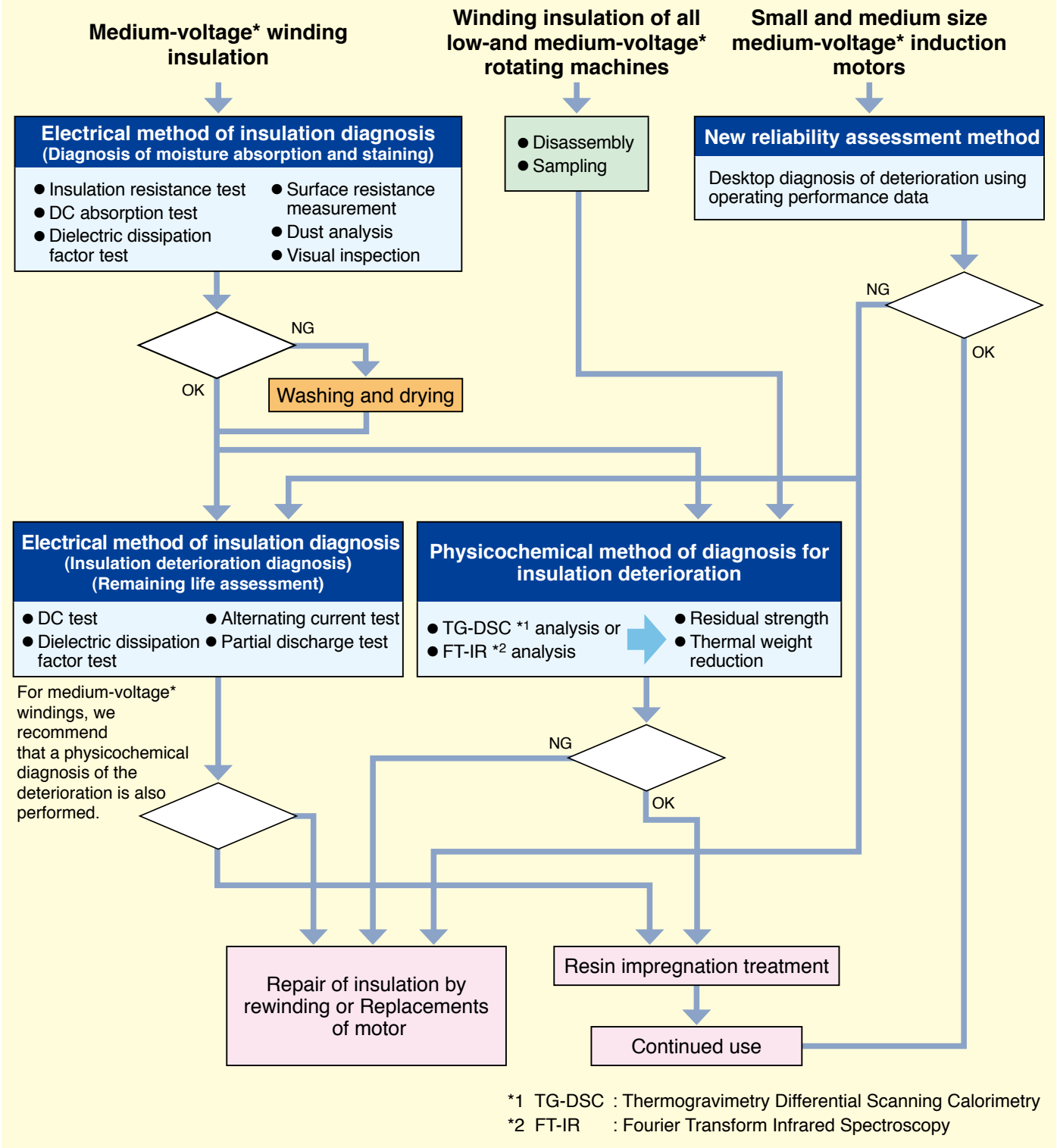
Fuji Electric has established three methods for diagnosing the insulation of rotating machines. We will select and use the most suitable method of diagnosis and propose appropriate measures to be taken based on the diagnostic results.

Application and procedures of the diagnosis method



⚠ Safety precautions

* 3 kV to 13 kV

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Remaining life assessment services for high-voltage* electric motors

*: 3.6kV

to Photo

We predict the remaining service life by diagnosing the insulation electrically.

Features

- **Rewinding and replacements timing will become clear.**
- **Maintenance costs can be managed systematically.**
- **Reduction of opportunity losses will be achieved.**

Application example

- **Stator windings of medium-voltage* rotating machines**
  - F-resin/S (resin rich) insulation
  - F-resin/F (single coil vacuum impregnating) insulation

Remaining service life prediction method

Electrical diagnosis of the insulation is performed

Electrical diagnosis of the insulation of target rotating machines is performed

(1) DC absorption test

(2) AC test

(3) Dissipation factor test (Tan-delta test)

(4) Partial discharge test (Corona test)

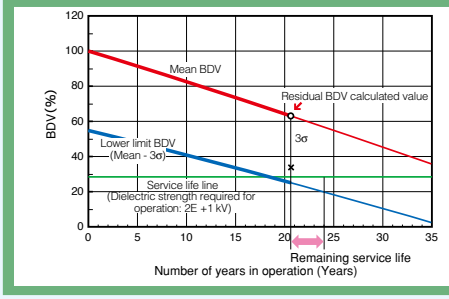
Calculation of residual breakdown voltage (BDV)

Data used for calculation

- Number of years in operation
- ΔI_{12}
- $\Delta \tan\delta_{12}$
- $Qmax_{12}$

Calculation of residual breakdown voltage and deterioration curve using multiple regression equations

Remaining service life calculated by extending the deterioration curve

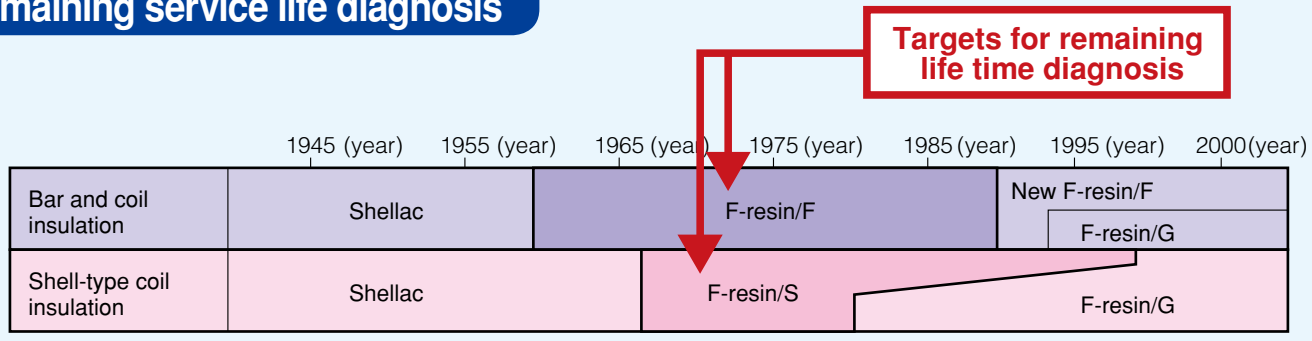


Measurement locations	Western calendar	Number of years in operation (Years)	Measured value: Data Classification	Measured value: ΔI 12 (%)	Measured value: Δtanδ12 (%)	Measured value: qmax12 (pC)	Predicted value: Mean level	Predicted value: Below lower level BDVm3σ(%)	Dielectric strength required for operation 2E+1kV(%)
Batch	Sept 1982	0.0	Initial				98.40	61.50	21.28
	Sept 2003	21.0	Actual measurement	0.00	0.00	0.00	60.61	33.38	21.28
	Sept 2004	22.0	Forecast	--	--	--	53.08	26.64	21.28
	Sept 2005	23.0	Forecast	--	--	--	49.53	23.37	21.28
	Sept 2006	24.0	Service life	--	--	--	47.29	21.28	21.28
	Sept 2007	25.0	Forecast	--	--	--	45.83	19.90	21.28
	Sept 2008	26.0	Forecast	--	--	--	41.96	16.19	21.28
	--	--	--	--	--	--	--	--	--

Output example of remaining service life prediction ▶

This diagnostic system predicts the remaining service life by calculating the residual breakdown voltage using multiple regression equations.

Transition of insulation in Fuji Electric medium-voltage* rotating machines and remaining service life diagnosis



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Building Procedure for Prediction system of Remaining Lifetime

Actual rotating machines that used F-resin/F or R-resin/S insulation with operational track records are used as samples at the time of its rewinding or disposal.

Integrating non-destructive tested data

Electrical diagnosis of insulation

Integrating destructive tested data

Destructive testing of actual machines

Seek the correlation between non-destructive diagnostic data and residual breakdown voltage (BDV) by means of multivariate analysis

Derive multiple regression equations

Establish the deterioration master curve of the sample

Fuji Electric's insulation diagnosis system

Fuji Electric has established a system that can respond quickly to customer requests by deploying our insulation diagnosis vehicle anywhere and anytime from three locations in Japan (Kawasaki district, Suzuka district, and Shunan district).

Remaining service life assessment begins with insulation diagnosis.

Diagnosis devices

Insulation diagnosis vehicle

⚠ Safety precautions

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ROPAS (Rotating machine Online Partial Discharge Acquisition System)

Online partial discharge diagnosis services for medium-voltage* rotating machines

*: 2kV to 13kV

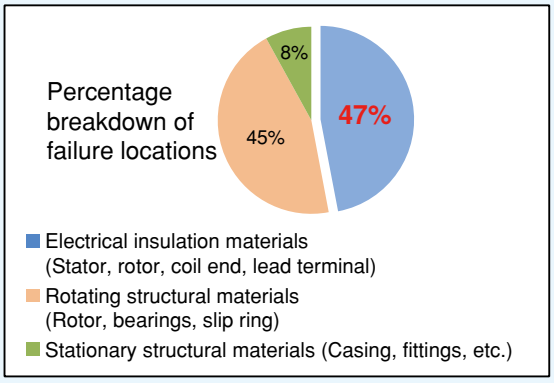
To diagnose deterioration of the winding insulation, partial discharge of the stator coil of medium-voltage* rotating machines is measured under on-line while the machines are online.

Overview

- Target equipment for diagnosis: Medium-voltage* rotating machines, 2 to 13kV
- While the rotating machines are in operation, various sensors are used to detect partial discharge caused by deterioration of the insulation.
- Identifies generation of slot discharge, interphase discharge, and spark discharge which cannot be detected when using offline diagnosis.
- The partial discharge detection level (IEEE standard 1434-2000) enables signs of insulation deterioration to be discovered early.

Deterioration factors

- Electrical
- Mechanical
- Thermal
- Environmental



(Source: The Institute of Electrical Engineers of Japan, Technical Report No. 230, Section II)

Online measurement of partial discharge

↓

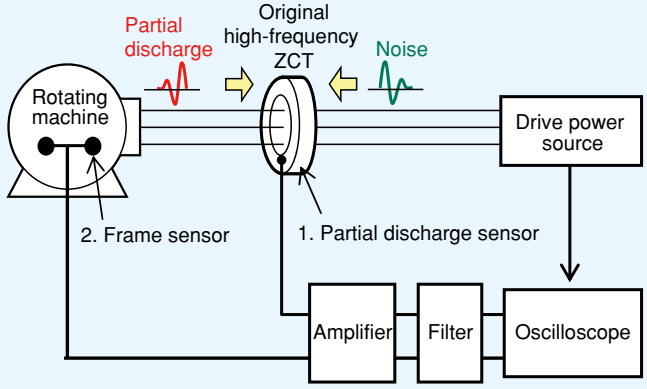
Trend monitoring of discharge conditions

↓

Detection of signs of insulation deterioration (Insulation diagnosis)

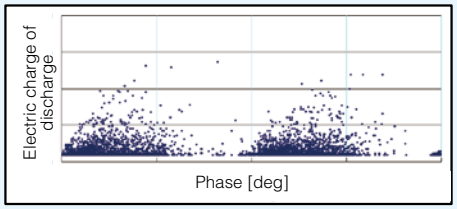
System configuration

Two types of sensors can be selected for diagnosis.

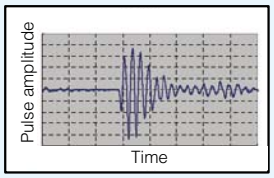


Partial discharge analysis and evaluation

- Measurement of discharge amount
- Analysis of discharge pattern (q-ϕt characteristics)



Pulse characterization



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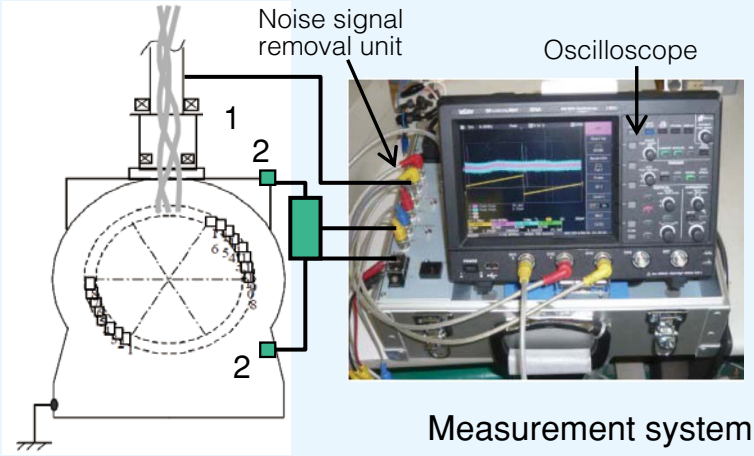
Measurement device

Target equipment for diagnosis
(Rotating machines and motors)

On-site photo



Measurement system

1. Partial discharge sensor

The three-phase cables are clamped together by the sensor.

2. Frame sensor

The paint coating on the outer frame of the rotating machine is removed in two places and the sensors are attached by suction.

Insulation diagnosis steps

Preparations

1. Select a rotating machine for diagnosis
2. Check the information on its rating plate (Rated voltage and capacity, wiring connections, year of manufacture)

Estimate

Measurement

1. Attachment of sensors
2. Waveform acquisition

Analysis

Proposal of condition-based maintenance (CBM)

- **Prevention of failure accidents**
- **Optimal maintenance plan**
- **Optimal replacements timing**

Important notes about this service

- The measurement equipment requires access to a 100 V power outlet.
- To use the frame sensors, the paint coating must be removed where the sensors will be attached.

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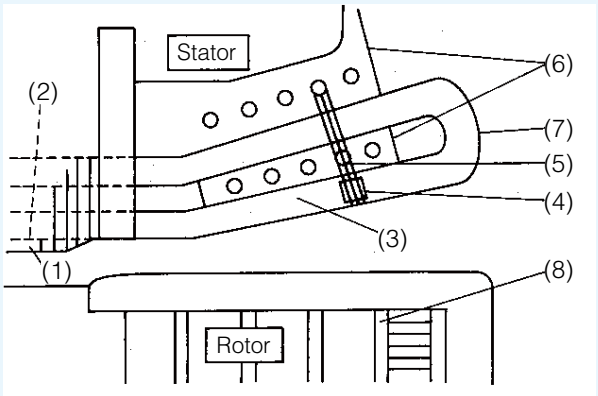
Physico-chemical diagnosis services for thermal deterioration of insulation

to Photo

We can understand the deterioration degree of the insulation material by performing thermal analysis on trace samples collected from the insulating parts of the rotating machines diagnosis target.

Sample collection and repairs

Samples are collected mainly from the insulating parts shown in the figure below.

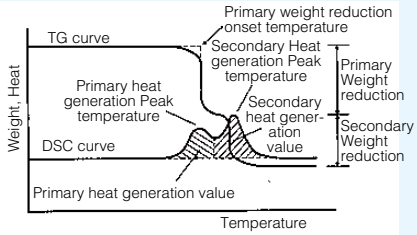


1. Wedge
2. Under wedge
3. Coil end insulation layer
4. Spacer between coil end
5. Restraining cord
6. Coil end supporter
7. Varnish
8. Spacer between coil end

Analysis

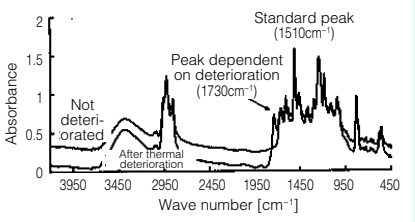
The collected samples are taken to a laboratory where they are powdered to prepare them for performing thermal analysis or infrared spectroscopic analysis.

Thermal analysis (TG-DSC)



Results of TG-DSC analysis

Infrared spectroscopic analysis (FT-IR)



Results of IR analysis

Flow of diagnosis

Sample collection and repairs → Adjustment of the test pieces → Analysis and Explanation → Evaluation → Determination

1 to 3 days

1 month

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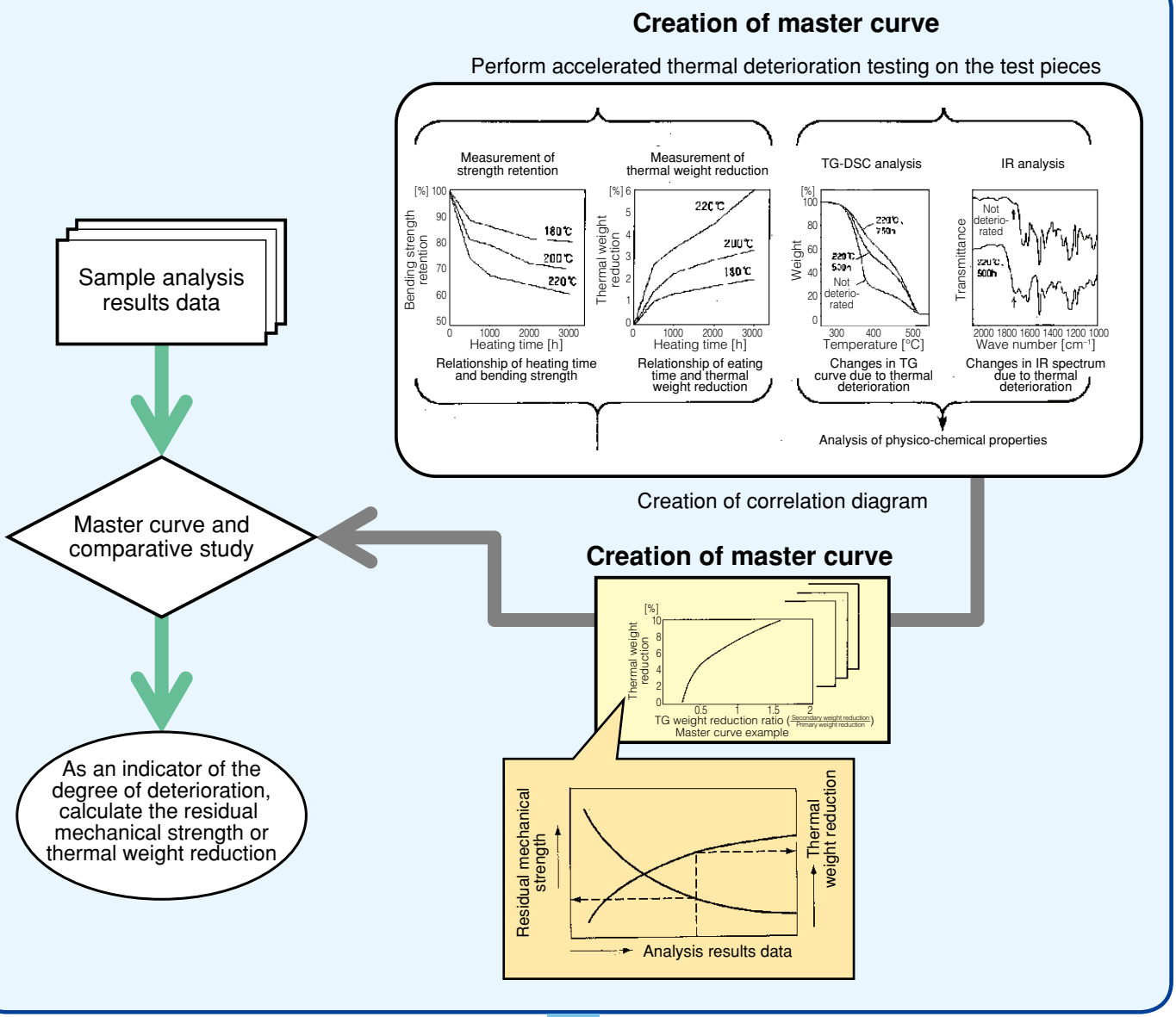
to Photo

Evaluation



Determination criteria

Degree of deterioration	Residual mechanical strength (Laminate)	Thermal weight reduction		Remarks
		Resin	Varnish	
Small	75% or more	less than 2.5%	less than 10%	No problems with operation
Medium	50 to 75%	2.5 to 5%	10 to 20%	Operation possible, but caution required
Large	less than 50%	5% or more	over 20%	Replacements is necessary

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Wireless Diagnostic System for Rotating Machine Vibration [Wiserot]

[reference]

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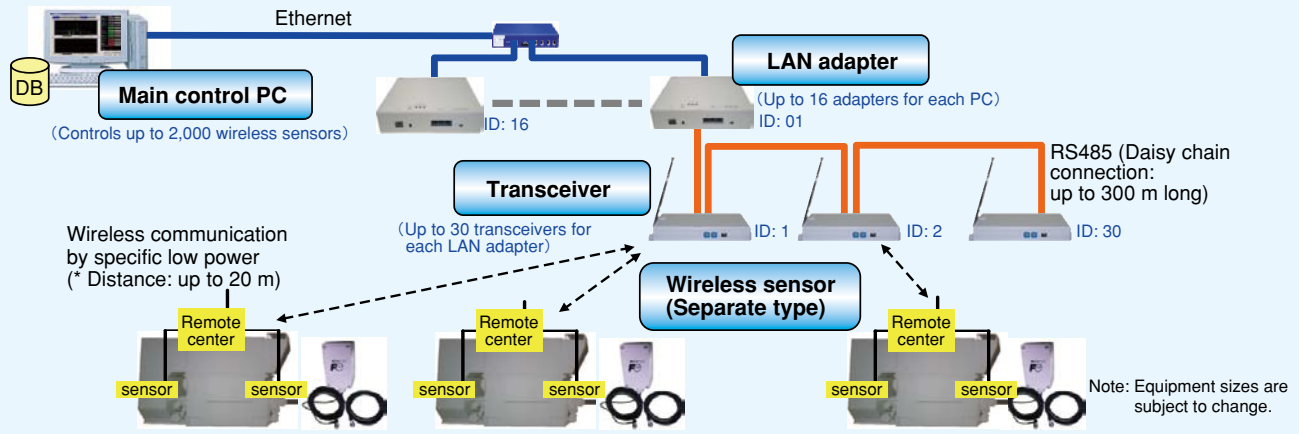
An industry-first ideal solution for simple diagnosis of rotating machine vibration using a specific low-power wireless sensor.
This is the best solution for simple diagnostic of rotating machine vibration.

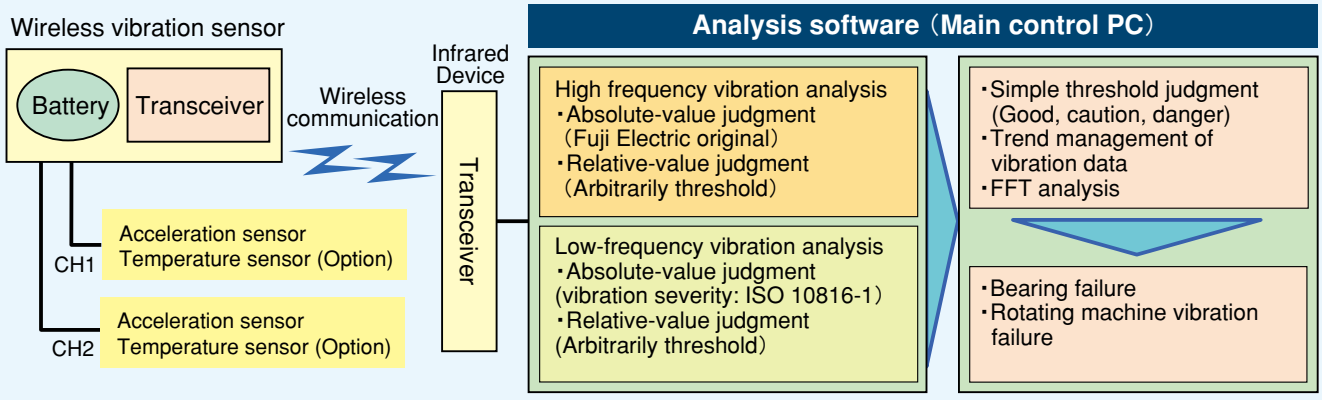
Overview

- Target rotation range is 600 rpm to 3,600 rpm for general rotating machines.
- Measures trends of mechanical vibration and bearing vibration and temperature (option).
- No need for hard wiring makes this system easy to install for existing equipment and in adverse environments.
- Measures an extensive range of frequency vibrations to diagnose using only one wireless sensor.
- Analyze trends of vibration and fast Fourier transform (FFT) spectrum on the main control PC.

System structure



Simple diagnostic functions



※ Wiserot is the brand name for Fuji Electric's Wireless Simple Diagnostic System for Rotating Machine Vibration

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Diagnosis target equipment

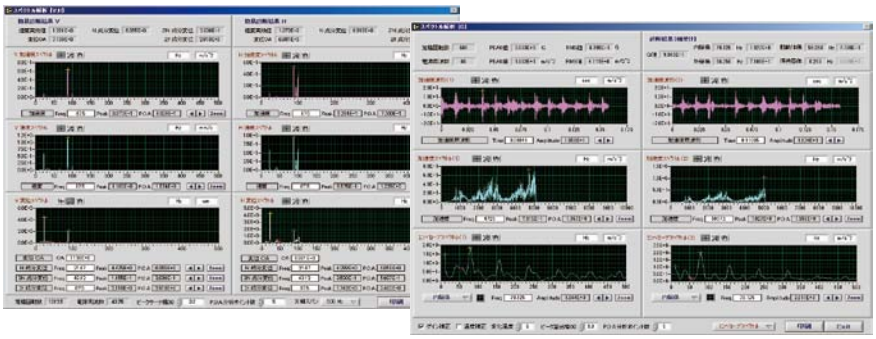
Diagnose item	Frequency	Vibration measurement	Judgment item	Judgment reference
Rotating machine vibration	Low frequency (10 to 250Hz)	VEL (Velocity)	Root mean square (RMS) value (amplitude of vibration)	Absolute-value judgment in reference to ISO 10816-1 vibration evaluation standard
		DSP (Displacement)	Peak over all (O/A) value	Trend management (relative judgment)
			Vibration revolution (N/2N) element	Trend management (relative judgment)
			Vibration electromagnetic (2f) element	Trend management (relative judgment)
Bearing vibration	High frequency (1k to10kHz)	ACC (Acceleration)	Root mean square (RMS) value (amplitude of vibration)	Trend management (relative judgment)
			Bearing diagnosis evaluation (Q) value	Rolling bearing absolute-value judgment using Fuji Electric's original standard

System specifications

No.	Item	Wireless sensor (Separate type)
1	Applicable scope of diagnosis	General rotating machines (600 rpm to 3600 rpm) Measurement performed during constant speed rotation. Rolling bearings are target of bearing diagnosis.
2	Communication distance	About 20 m (Distance may vary depending on the installation environment.) (Remote sensors can be set for communication in closed structures.)
3	Frequency	433 MHz (Specific low power)
4	Measuring target	Low frequency (One direction), high frequency (Displacement of measured object: over 1 μm)
5	Low frequency	10 Hz to 250 Hz, 4096 sampling points
6	High frequency	1 kHz to 10 kHz, 4096 sampling points
7	Dustproof, waterproof construction	Conforms to IP64 standard.
8	Operating temperature	Remote center: 0 to 60°C Sensor: 0 to 120°C
9	Sensor size	About ϕ16 mm x 25 mm
10	Attachment	Screw-mounted type (M6 threaded hole is necessary in rotating machine for mounting.) Magnetic type
11	Measuring cycle	Once per week, or once per day (in general usage)
12	Battery life	About 2 years (When battery is used at a sampling frequency of once per week.) (Uses special button battery.)

≪trend monitoring graph≫

≪FFT spectrum analysis graph≫



Note: This diagnosis system is currently available only in Japan. In order to be used outside of Japan, it is necessary to comply with the communication standards of the country of use. If you are interested in this system, please do not hesitate to contact us at any time.

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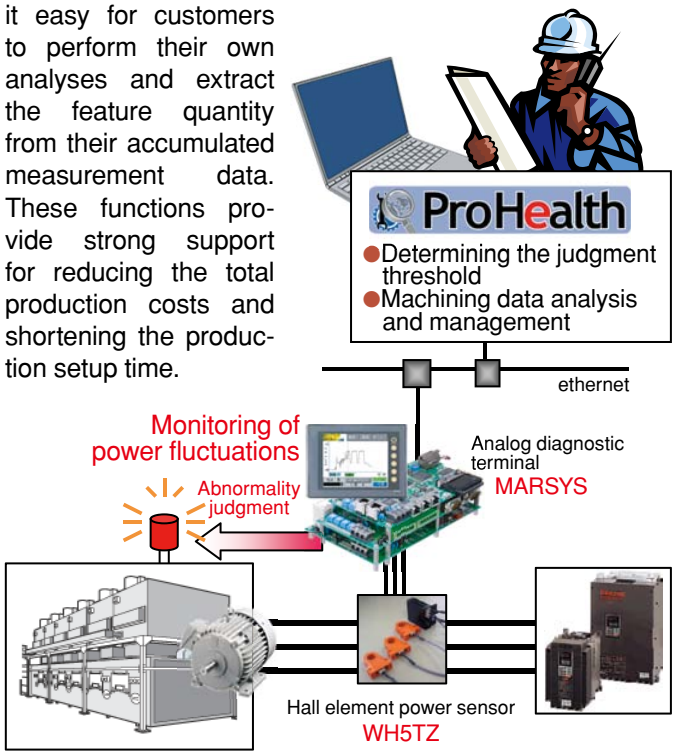
ProHealth

Supporting the stable operation and improved operating cost of machining equipment

to Photo

ガスタービンテクノロジー2003
PM
2003PM優秀製品賞
開発賞
PM Awards

ProHealth is an online diagnostic system that supports the stable operation and improved operating costs of machining equipment. By using a variety of methods to analyze and diagnose various sensor information (such as current, voltage, and temperature) obtained from analog diagnostic terminals, this system enables an accurate understanding of the state of the moving parts and tools in machining equipment. In addition, to grasp the condition of the equipment, different optimal algorithms and thresholds are used for each target equipment and workpiece. For this purpose, we offer a variety of analysis functions to make it easy for customers to perform their own analyses and extract the feature quantity from their accumulated measurement data. These functions provide strong support for reducing the total production costs and shortening the production setup time.



The role of machining equipment is to provide cutting energy to the blades of the tools. That is to say, while cutting tools play the most important part in producing product quality, they are also the most short-lived parts of the machining equipment. For this reason, to achieve a machining equipment line that is capable of continuous automated and unattended operation, information on cutting edge changes during machining becomes a critical target for measurement and monitoring.

A general method for measuring the load on a motor is to measure the load current. However, changes in the load current and mechanical fluctuations of the load do not necessarily match. This is because the power factor is involved, and active power becomes the power source for the motor. For this reason, in order to diagnose the service life of the cutting tools, it is essential to have technology capable of following the machining activities and measuring the active power at high speed.

Also, another critical achievement factor is determining the monitoring areas (timing, monitoring thresholds) by analyzing large amounts of collected data.

■ Analog diagnostic terminals (MARSYS)

Traditionally, general-purpose measuring instruments have been used to reliably measure analog signals that are changing at high speed. However, such instrumentation is expensive, and there are other issues such as the instruments not being suitable for permanent installation in some systems. To solve these problems, we offer analog diagnostic terminals with high-speed, versatile program functions that comprise technology cultivated in the development of integrated controllers and utilize a wide lineup of peripheral equipment. These terminals are capable of collecting various analog signals such as those from current, voltage, and temperature sensors, and by monitoring the upper and lower limits of signal levels, they can output alarms.

- Maximum of 2 analog channels can be recorded and displayed at the same time.
- Collection cycle data can be divided into a maximum of 8 areas, and for each area, the upper and lower limit, as well as the top upper limit and the bottom lower limit, can be monitored and alarms can be output.

■ Hall element power sensors (WH5TZ)

We have sensors available that can measure the secondary side power value of an inverter or servo. In recent years, inverters have been widely used for machining equipment. Because the output voltage of the inverter is controlled by a pulse-width modulation (PWM)

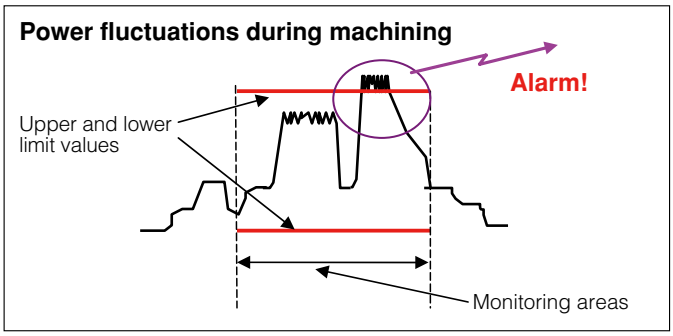
to menu

control circuit, accurate monitoring is difficult with power value calculation done by measuring the current using a current transformer (CT). For this reason, we provide Hall element power sensors to enable secondary side power measurements of the inverter.

- With a response rate of 30 msec, power measurement is possible even when the operating frequency of the inverter changes.
- Accuracy is ±10% when the operating frequency of the inverter is in the region of 30 Hz or less, and ±1.5% when the frequency is in the region of 45 Hz or more.

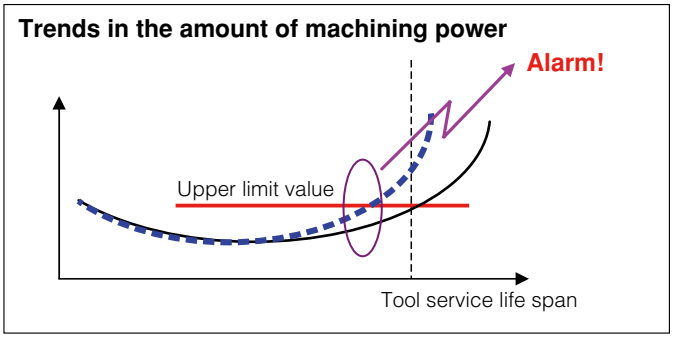
■ Extensive analysis tools

- Diagnostic functions using envelope curves



The data collected for each cycle is displayed along a time axis, and the envelope curves for diagnosis are calculated with an overlay of the data for a certain period of time. When trends are diagnosed by monitoring thresholds, a rule of thumb is used to judge abnormalities, and the threshold values are determined. For this reason, it is necessary to use trial and error in order to obtain accurate threshold values. However, with envelope curve diagnosis, it is possible to automatically generate highly accurate judgment threshold values in order to generate a judgment pattern based on the fluctuations of data at normal times.

- Integral power analysis functions

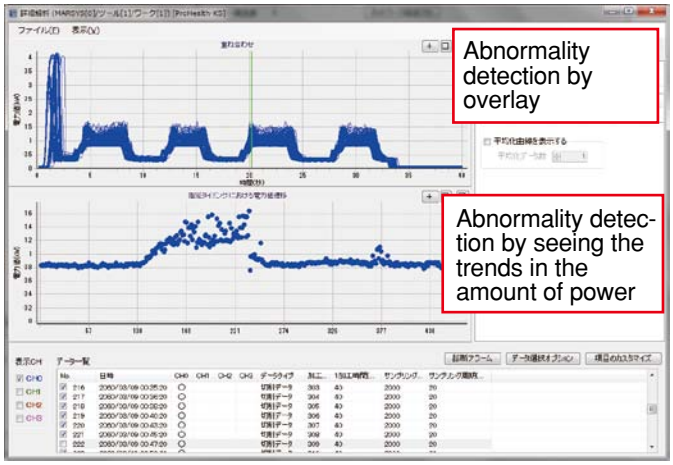


The integral power consumption of each cycle can be calculated, and this enables diagnosis of the trends in the electric power consumption by machining unit.

Also, the integral power consumption of a specified range within a cycle can be calculated. For this reason, even if a power value increase at a specific timing is small and difficult to detect, changes in the machining state can be detected with the accumulation of changes in very small power values within a specified range.

to Photo

[Example of display screen]



■ Database (Tool and workpiece change compatible) functions

Besides searching by date and machine number, the collected data can also be searched by tool and workpiece. For this reason, data on the same machining conditions can be easily analyzed from a large amount of collected data.

■ Benefits

Tool service life diagnosis can eradicate processing defects caused by damage during processing, such as by chipping, and improve processing quality. Also, by optimizing the tool service life span from the collected data, it is possible to reduce costs such as those involved in tool purchases, replacements time, re-grinding costs, and labor for pickup and delivery tasks and management. In addition, by developing for a relational database that associates such information as equipment details and machining conditions with tool service life spans and cutting tool performance track records, this information can be used to select processing conditions during the production setup stage which will make it possible to shorten the startup time of the line.

- Substitution of cutting tool breakage detection sensor
  - Optimization of processing cycle time
- Visualization of processing conditions
  - Judgment of chipped and broken cutting tools is possible
- Trend analysis
  - Optimizations such as cutting tool replacements timing, cycle time

⚠ Safety precautions

Note: Before using this product, in order to use it correctly, be sure to carefully read the Instruction Manual and Specifications, or contact our company or your dealer for information as necessary.
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Fuji Electric

Innovating Energy Technology

Diagnosis is performed in a short time while batteries are charging!

Battery instant discharge diagnosis device

(BSC: Battery Super Checker)

to Photo

The uninterruptible power supplies (UPS) and DC power supplies that protect the stable operation of the IT infrastructure from a blackout are premised on the batteries that they use being healthy.
Battery instant discharge diagnosis device (BSC) checks the health of batteries by performing discharge tests in a short time on a cell-by-cell basis while they are in operation.

Features

(1) The diagnosis is performed while the customer's facilities are in operation.

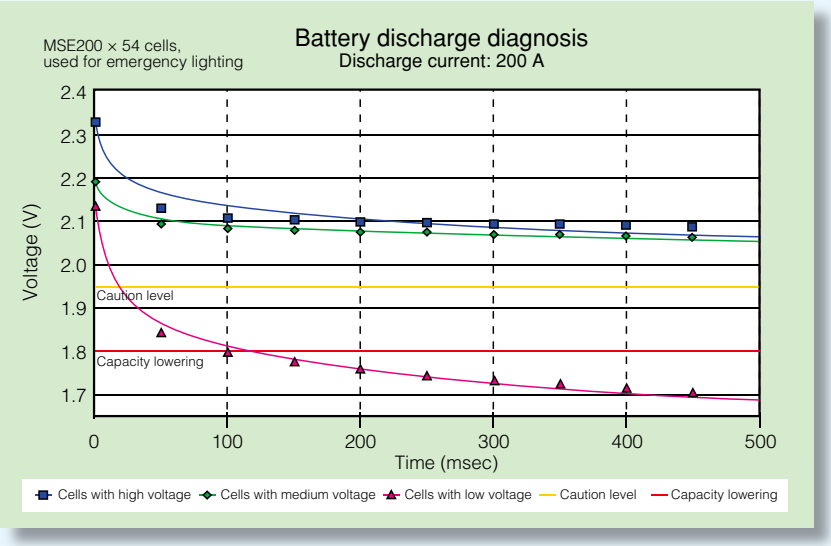
(2) Since the rapid discharge characteristics (0.5 to 1.5 seconds / 1 to 3C discharge rate) are diagnosed for each cell:
- Deterioration and failures can be identified individually even when multiple batteries are connected.
- About 400 batteries can be diagnosed per day.
- Since diagnosis and verification are done by direct discharge, tests can be performed even during a blackout.
- Only less than 0.1% is discharged for the diagnosis so there is no concern about depleting the capacity of the batteries.

(3) Our technician will submit the diagnostic results with overall findings on the spot.

(4) The diagnosis is safe and reliable because it is performed by qualified battery maintenance personnel.

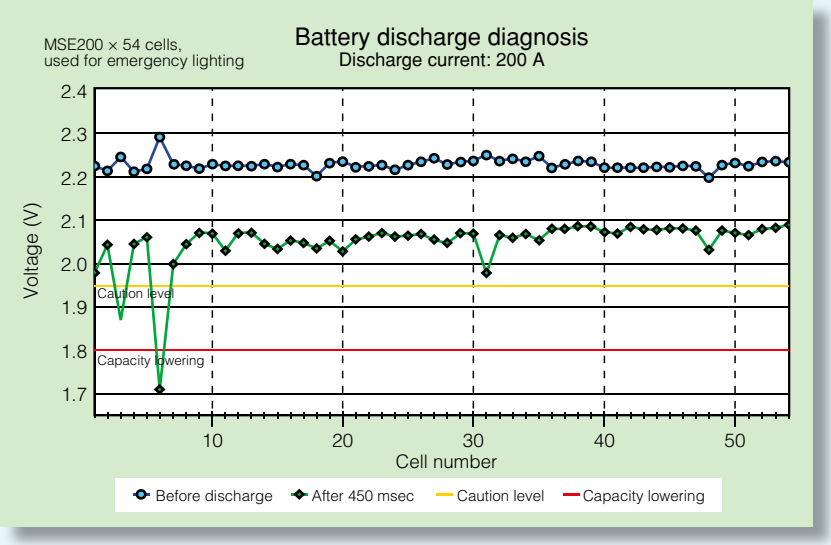
Example of diagnostic data

Discharge characteristics



Discharge tests are performed on all cells, and cells with the largest voltage drops, average cells, and cells with the smallest voltage drops can be confirmed on a discharge graph.
(Cells with capacity lowering have severe voltage drops.)

Voltage graph of all cells



The graph contains caution level and capacity lowering level lines determined from the BSC measurement data versus the capacity tests which enables the voltage distribution of all the cells to be confirmed.

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Paradigm of diagnostic results

- As materials for determining the replacements timing for the battery service life
- As basic data for sorting good cells for life-prolonging treatment
- As a tool for identifying premature aging and bad cells
- As tool for periodic inspection of battery facilities

Target batteries for diagnosis

Liquid-filled lead-acid batteries, alkaline batteries, sealed lead-acid batteries
Battery capacity: 20 AH to 3,000 AH
(The 5000 series is compatible with batteries 600 AH and less.)
Batteries from any manufacturer can be diagnosed.
Small batteries used in mini-UPS and dry cell batteries cannot be diagnosed.

Diagnostic technicians

Diagnosis is performed by technicians who are Storage Battery Facility Maintenance Qualified Personnel certified by the Battery Association of Japan.

BSC main specifications

Item	Specification
Battery voltage	1, 2, 4, 6, 8, 12 V
Discharge current	20 to 3,000 A, arbitrary setting in one-ampere increments
Data file	250 cells per file
Memory card	Compact flash, 1 card
Communication	RS-232C, 1 port
Display	40 digits × 4 lines, backlit LCD
Measurement precision	Each range full scale ± 1%
Internal resistance measurement	Possible
Operating voltage	DC 12 V (battery-powered)
Operating time	More than 2 hours (after 15 min. full charge)
Temperature and humidity	0 to 35°C, 20% to 80%
Weight	4.0 kg (for BSC 5000 model)

Note: Patent acquired

Example of diagnosis being performed

BSC external appearance

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2013-9(I13/K07)T1FOLS

Fuji Electric

Innovating Energy Technology

We perform the diagnosis without shutting down your equipment.

Equipment diagnosis services for information processing controllers

to Photo

Target equipment for diagnosis

When about 10 years have passed since delivery, we perform diagnostic tests on information processing control devices as part of the overall system configuration.

- Electrical enclosures for DCS, PLC, PIO, HCI equipment
- PC-related peripherals, network-related equipment, monitoring systems

- MICREX HDC, PMS, ICS, SAS, ACS, ASA series
- MICREX F series, SX series
- Factory automation PCs, general-purpose PCs, various PODs
- Printers, hardcopy, loaders
- Hubs, routers, modems, optical converters
- FAISES monitors, scheme monitors, FORS, NISDAS








Equipment diagnosis objectives and key points

Objectives of equipment diagnosis

- Based on the equipment diagnosis results, we will offer various proposals aimed at ensuring the stable operation of the equipment and minimizing maintenance costs.

Key points of equipment diagnosis

1) Evaluation of the deterioration conditions
2) Evaluation of the installation environment and maintenance conditions
3) Presence or absence of failure history and failed parts
4) Evaluation of presence or absence of accelerated deterioration factors
5) Presence or absence of replacement parts and scope of applicable evaluation

Equipment diagnosis

- **Equipment diagnosis performed using a visual observation checksheet —Submission of a proposal and estimate**

(In compliance with and under the supervision of the Deputy Vice Minister, Government Buildings Department of the Ministry of Land, Infrastructure, Transport and Tourism (as enacted in 1994))

Submission of proposal

- Preventative maintenance proposal (Consumable parts, service life-limited components, environmental protection)
- Service life-prolonging treatment proposal (Overhaul, cleaning)
- Partial replacement
- Replacement proposal

Detailed diagnosis required

Detailed equipment diagnosis

- Sampling survey
- Power supply deterioration diagnosis
- Installation environment diagnosis

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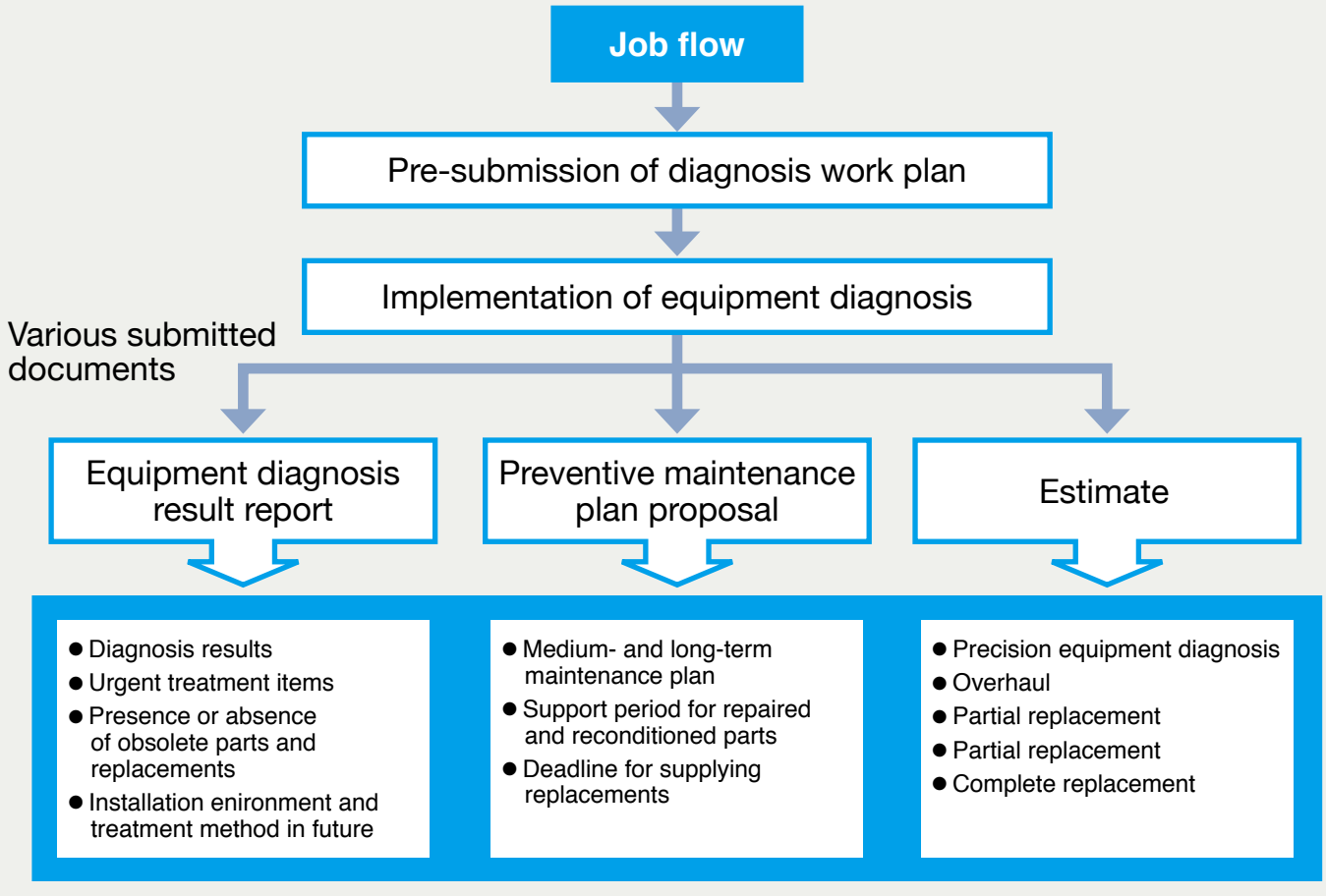
Content of equipment diagnosis

Equipment diagnosis

- Checklist-based equipment diagnosis
- Installation environment (temperature and humidity measurements) diagnosis
- Evaluating of the presence and absence and the conditons of deterioration acceleration factors
- Recording of conditions using a digital camera
- Component analysis to identify collected dust deposits (Optional charged service)
- Determination of necessity for precision equipment diagnosis (Optional charged service)

Temperature and humidity recorder

Flow of equipment diagnosis



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2013-9(I13/I13)T1FOLS

Fuji Electric

Innovating Energy Technology

We propose optimal service life-prolonging measures in a short time.

Diagnosis services for printed circuit boards by a sampling method

Overview

This diagnosis service investigates the condition of printed circuit boards by sampling them during operation to propose optimal service life-prolonging measures.

to Photo

Contents of investigation

- Magnified observation of corrosion state and dirt on printed circuit boards
- Component analysis of deposits on printed circuit boards
- Cleaning of printed circuit boards to confirm removal of corrosion products
- Ion component analysis of the printed circuit board cleaning solution

In about one month after the printed circuit boards are sampled, we will submit a report on the investigation results and propose optimal service life-prolonging measures.

Contents of proposal

- Overhaul of power supply units
- Replacements of deteriorated parts
- Cleaning of printed circuit boards (Cleaning only to the extent required)
- Coating of printed circuit boards (Coating recommended for cases of minor corrosion)

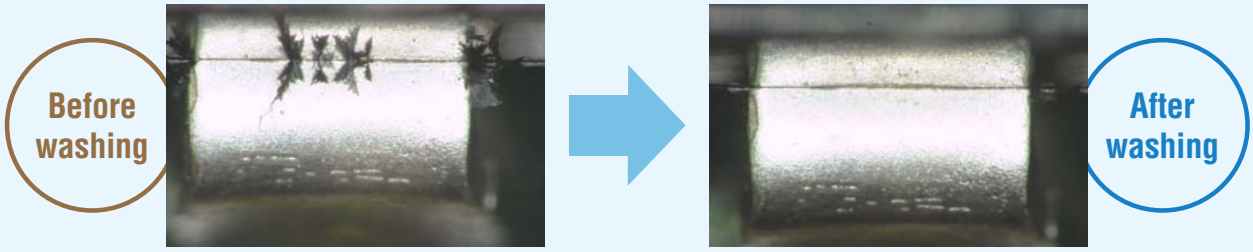
Contents of sampling diagnosis report (Example)

- State of contamination (Magnified observation)

  In addition to checking the state of corrosion and dirt, and whether it can be removed by an air cleaning air, we also check for the presence or absence of oil mist.

- Removal of corrosion products

  In addition to removing dirt and dust by washing, we also remove the products of corrosion.



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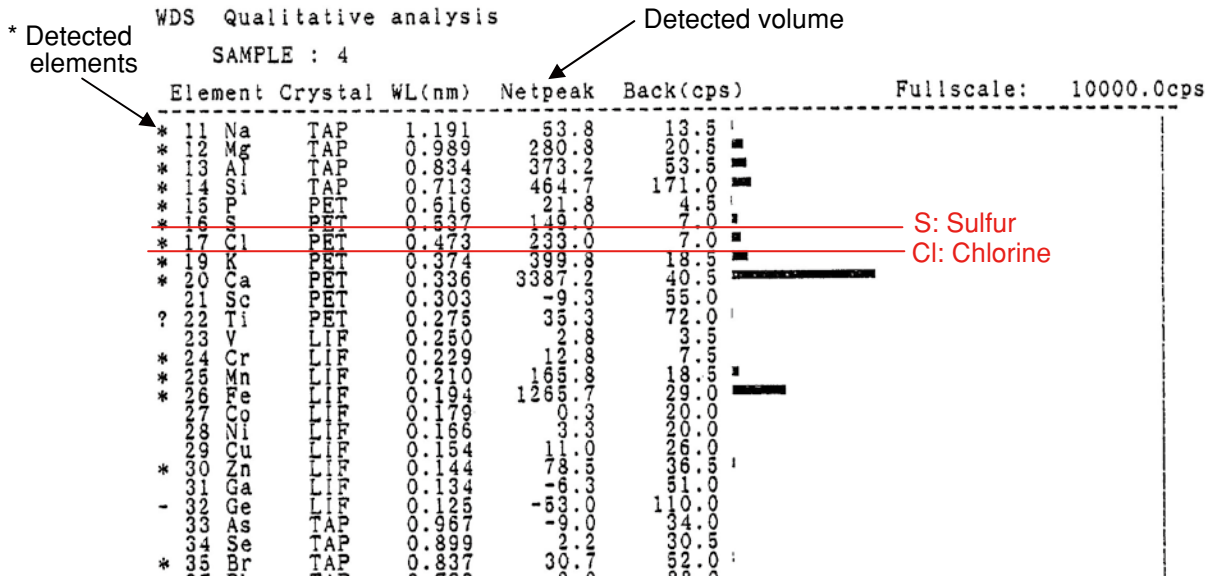
Component analysis of deposits on printed circuit board

This analysis focuses on the corrosive components of sulfur (S) and chlorine (Cl) contained in the deposits.



WDS Qualitative analysis

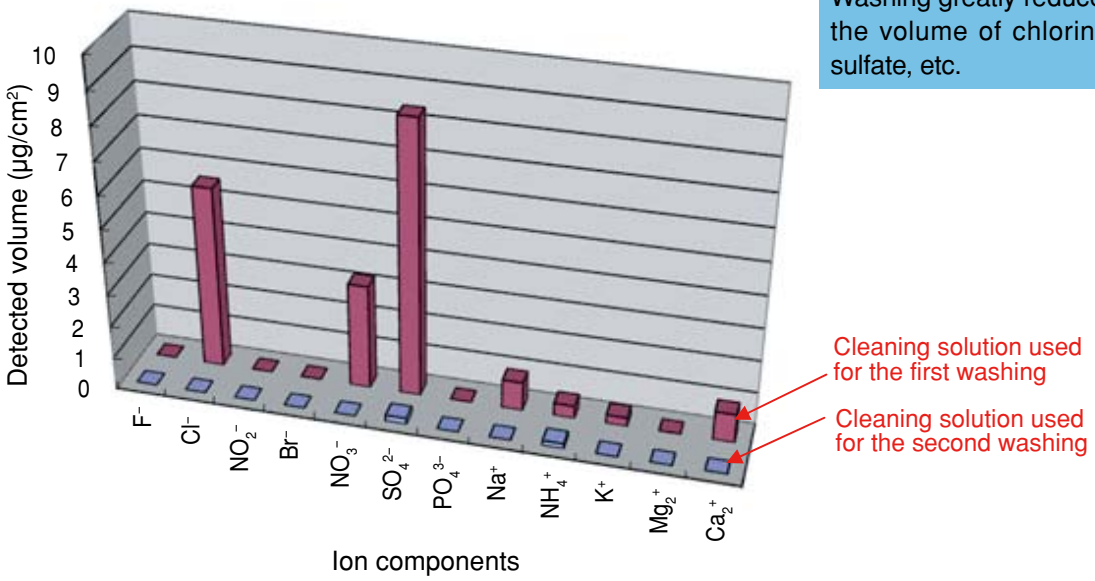
SAMPLE : 4

	Element	Crystal	WL(nm)	Netpeak	Back(cps)	Fullscale: 10000.0cps
*	11 Na	TAP	1.191	53.8	13.5	
*	12 Mg	TAP	0.989	280.8	20.5	
*	13 Al	TAP	0.834	373.2	53.5	
*	14 Si	TAP	0.713	464.7	171.0	
*	15 P	PET	0.616	21.8	4.5	
*	16 S	PET	0.537	149.0	7.0	
*	17 Cl	PET	0.473	233.0	7.0	
*	19 K	PET	0.374	399.8	18.5	
*	20 Ca	PET	0.336	3387.2	40.5	
	21 Sc	PET	0.303	-9.3	55.0	
?	22 Ti	PET	0.275	35.3	72.0	
	23 V	LIF	0.250	2.8	3.5	
*	24 Cr	LIF	0.229	12.8	7.5	
*	25 Mn	LIF	0.210	165.8	18.5	
*	26 Fe	LIF	0.194	1265.7	29.0	
	27 Co	LIF	0.179	0.3	20.0	
	28 Ni	LIF	0.166	3.3	20.0	
	29 Cu	LIF	0.154	11.0	26.0	
*	30 Zn	LIF	0.144	78.5	36.5	
	31 Ga	LIF	0.134	-6.3	51.0	
-	32 Ge	LIF	0.125	-53.0	110.0	
	33 As	TAP	0.967	-9.0	34.0	
	34 Se	TAP	0.899	2.2	30.5	
*	35 Br	TAP	0.837	30.7	52.0	

Ion component analysis of the printed circuit board cleaning solution

Besides improving the appearance of the printed circuit boards by washing, we also conduct an ion component analysis of the cleaning solution to evaluate the cleaning effect scientifically.

Washing greatly reduces the volume of chlorine, sulfate, etc.



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2013-9(I13/I13)T1FOLS

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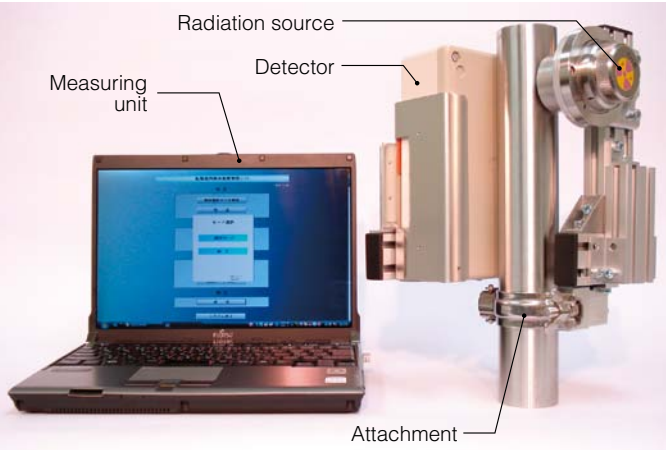
Innovating Energy Technology

Radiation transmission type pipe diagnostic equipment

to Photo

This equipment can diagnose a variety of pipe conditions by means of non-contact, non-destructive tests.



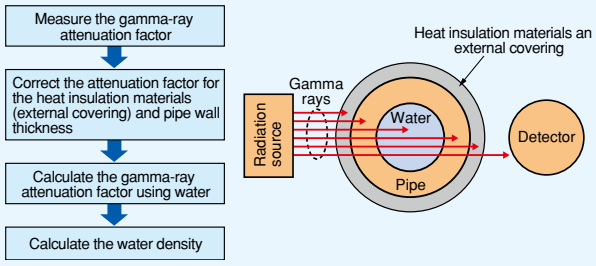
- This equipment makes use of the attenuation of the radiation transmitted through the pipe to diagnose the pipe's condition through a non-contact, non-destructive mode of testing, and can be applied to piping of various sizes from small to large diameters. The equipment can be used to monitor pipe conditions in a wide range of locations including indoor and outdoor installations, and can be used while plants remain in operation.
- Bluetooth is used for data communication between the detector and Measuring unit (PC) of the equipment for wireless connectivity.

Features

- Since tests are performed by transmitting radiation into the pipe, measurements can be taken even through existing thermal insulation materials.
  - Thermal insulation related work is kept to a minimum.
  - The equipment can be used while the plant is in operation.
- The equipment is certified and marked as such, so setting up a controlled area or obtaining special permission for use is not required.
  - The only requirement for use is submitting a notice that certified radiation-emitting equipment is being used.
- Using Bluetooth for wireless connectivity, attachment and rotation on pipes can be done quickly and easily.
  - This can be easily installed in high or confined locations.

Measurement principle: Example of measuring the density of fluid in the pipe

Using the attenuation factor of the radiation (gamma rays), the density of the fluid in the pipe can be calculated by presetting values for the heat insulation materials, external covering, and pipe wall thickness.



Adaptation example

Measurement of the density and level of fluid in the pipe

- Density measurement of cooling water
- Density measurement of sludge water
- Density measurement of slurry
- Density measurement of black liquor
- Void fraction measurement of two-phase fluids
- Level position measurement of fluid

Measurement of pipe wall thickness on both sides

- Screening of thinning trends
- Detection of rust inside the pipe
- Detection of deposits inside the pipe
- Detection of foreign matter inside the pipe

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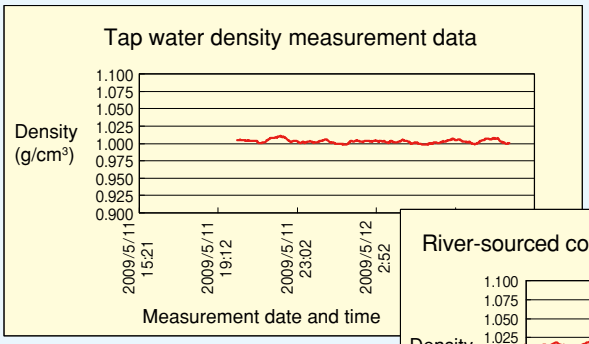
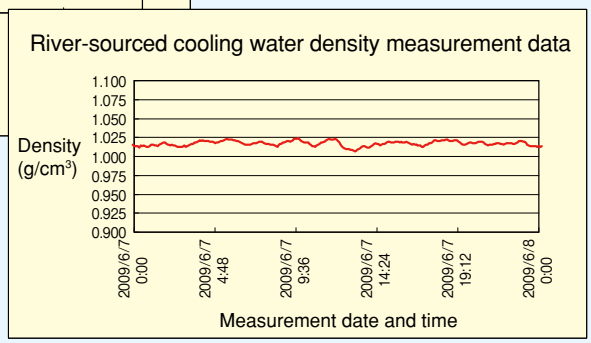
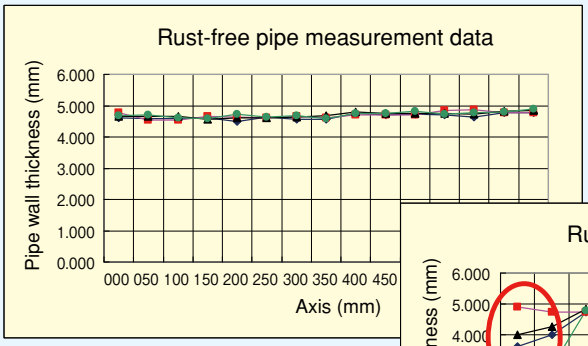
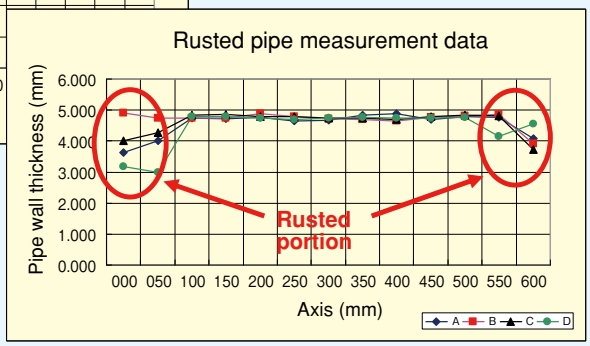
Examples of typical density measurements





Example of rust detection





to Photo

Product specifications

Item		Specification		Remarks
Applicable pipes	Material	Carbon steel, low alloy steel, stainless steel, etc.		
	External dimension Wall thickness	Size	External dimension: 25 A to 200 A Wall thickness: 25 mm or less	Water-filled pipe: External diameter 25 A to 200 A Wall thickness: 15 mm or less
Heat insulation material	Material	Calcium silicate		Applicable for use with other materials (Option)
	Thickness	50 mm or less		
Instruction fluctuation errors		Within ±2% of the nominal wall thickness, or within ±0.2 mm, whichever is greater.		Detection value is the total of pipe wall measurements taken on both sides (Not including error for thermal insulation material thickness) For density measurements: ±0.02 g/cm³
Calibration accuracy		Within ±0.5% of the calibration prototype wall thickness, or within ±0.2 mm, whichever is greater.		
Radiation source used		^{137}Cs, 10 MBq or less		Certified radiation-emitting device
Operating temperature and humidity		0 to 40°C, 80% RH or less		
Weight (Part mounted on pipe)		4 kg for pipes 65 A or less, 8 kg for pipes 80 A or less		

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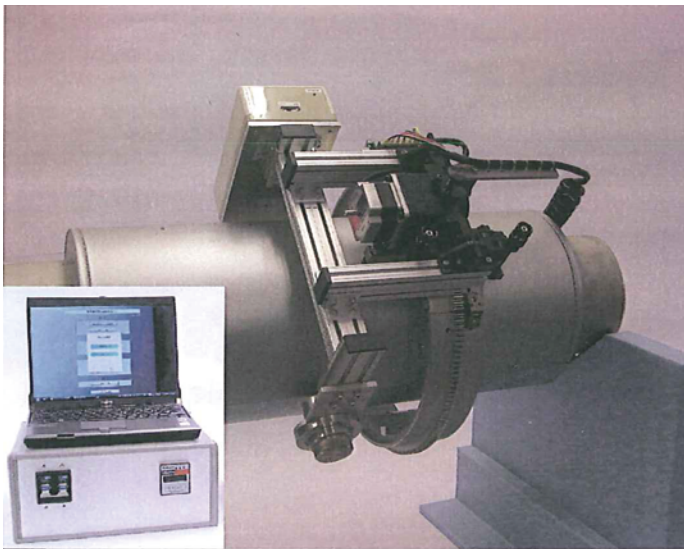
2013-9(I13/I13)T1FOLS

Radiation transmission type pipe thickness measurement equipment

Using a three-beam calculation method, we have achieved absolute value measurement of piping thickness.

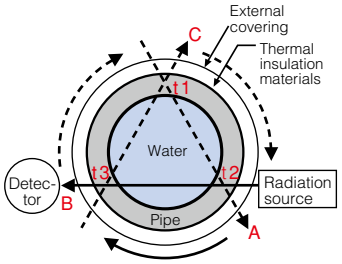
to Photo



Measurement principle

Using the attenuation factor of the radiation (gamma rays), the wall thickness of the pipe can be calculated by presetting values for the thermal insulation materials, external covering materials, thickness, and density.

1. Measure the attenuation factor of the gamma rays
2. Correct the attenuation factor for the thermal insulation materials (external covering materials) and water
3. Calculate the attenuation factor of the gamma rays for the piping
4. Calculate the pipe wall thickness at A, B, and C
5. Calculate the piping specimen thickness at t1, t2, t3



A=t1+t2 B=t2+t3 C=t3+t1	t1=(A+C-B)/2 t2=(A+B-C)/2 t3=(B+C-A)/2

Features

- Detection by radiation transmittance
  - Non-contact
  - Transmittance values for the thermal insulation materials and water can be corrected using design values or other data.
  - Can be used even when thermal insulation materials and water are present.
  - Measurement and examination can be performed during operation and without needing to remove and restore the thermal insulation materials.
- Uses a low-level radiation source.
  - Radiation source shielding wall is lightweight.
    - Can be manually transported and set up.
      - Can be used in high and confined locations.
  - Safety during use is ensured.
    - Certified radiation-emitting equipment
      - Setting up a controlled area, stationing a radiation protection supervisor, and obtaining special permission for use are not required.

Benefits

- **Measurements can be taken while the plant is in operation**

  For long-lead piping items, the existing pipes can be examined for wall thinning before conducting periodic inspections, and arrangements involving the piping can also be made in advance.

- **Wall thinning measurement expenses can be significantly reduced**

  Thinning measurements can be taken through the thermal insulation materials, so the costs for removing and restoring the thermal insulation materials can be drastically reduced.

Application examples

Pipe wall thinning measurement by measuring the absolute value of the pipe thickness
Profile measurement of the piping cross-section
Examination of aging changes in the pipe wall thickness

Application fields

Power plants, in-house power generation facilities, facility maintenance departments of petrochemical and steel industries, maintenance companies

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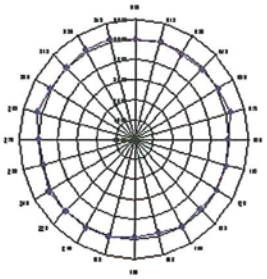
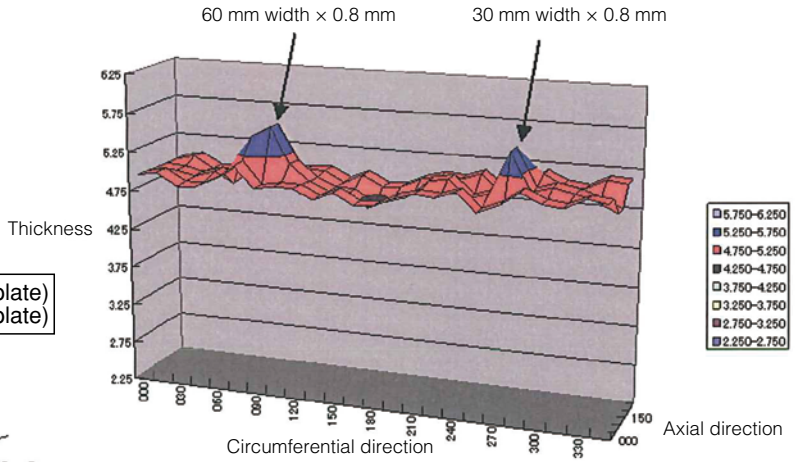
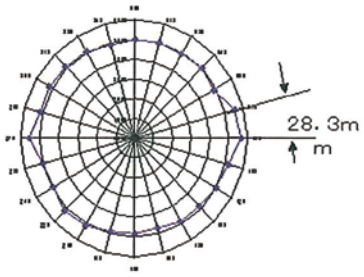
Profile measurement examples

Measured pipe: 200 A, Thickness:
5 mm, Thermal insulation material: 30 mm

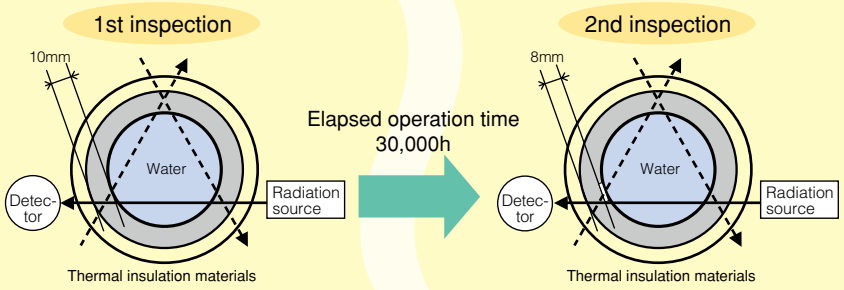




090 at 60 mm width × 0.8 mm (SUS plate)
270 at 30 mm width × 0.8 mm (SUS plate)



Example of remaining life calculation



(1) Determination of when the measured wall thickness value is less than the minimum required wall thickness
(2) When the measured wall thickness value is less than the minimum nominal wall thickness
Calculation of the per-unit thinning ratio and remaining service life

Calculation example
(in the case of the required minimum wall thickness is 4 mm)

Wall thinning ratio at per-unit representative sites
= (10–8) / 30,000 h = 0.66 mm / 10,000 Hr

Remaining life time
(8–4) / 0.66 = 60,000 Hr

Product specifications

Item		Specification		Remarks
Target pipe	Material	Carbon steel, stainless		
	Position	Straight pipe		
	External diameter	Empty pipe	External diameter: 80 A to 500 A, Thickness: 30 mm or less	
	Wall Thickness	Water-filled pipe	External diameter: 80 A to 300 A, Thickness: 20 mm or less	
Thermal insulation material	Material	Calcium silicate		Applicable for use with other materials (Option)
	Thickness	50 mm or less		
Instruction fluctuation errors		Within ±2% of nominal wall thickness (1.645σ)		Statistical fluctuation error (Not including error for thermal insulation material thickness etc.)
Calibration accuracy		Within ±0.5% of the calibration reference prototype thickness, or within ±0.2 mm, whichever is greater.		
Radiation source used		^{137}Cs, ^{60}Co (10 MBq or less)		Certified radiation-emitting device
Measurement time for 1 point		Within 300 s when external diameter is 200 A or less, and wall thickness is 10 mm or less.		Conditions: Radiation source intensity: 10 MBq, Thermal insulation thickness: 50 mm, Empty pipe
		Within 400 s when external diameter is 500 A or less, and wall thickness is 30 mm or less.		
Operating temperature and humidity		0 to 40°C, at RH of 80% or less		

⚠ Safety precautions

Note: Before using this product, in order to use it correctly, be sure to carefully read the Instruction Manual and Specifications, or contact our company or your dealer for information as necessary.
Note: This product is intended to be handled by persons with specialized technical knowledge.

Fuji Electric Co., Ltd.

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- **Contact Information**
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Inquiry items

Please inform us of the following information when you inquire about Leak Buster:

1. Company name

2. Plant name

3. Plant output kW

4. Address

5. Contact
   TEL :
   FAX :
   E-mail :

6. Name of person in charge

7. Plant operation situation
   1) Air leak amount when normal kg/h
   2) Present air leak amount kg/h
   3) Decrease in vacuum ☐ Yes (mmHg deteriorated) ☐ No
   4) Type of air ejector ☐ Vacuum pump ☐ Ejector system
   5) When air leak has increased ☐ Unknown ☐ From month: , year:
   6) Other

Printed on recycled paper

Fuji Electric Systems Co., Ltd.
Gate City Ohsaki, East Tower, 11-2, Osaki 1-chome, Shinagawa-ku, Tokyo 141-0032, Japan
Phone : (03)5435-7114

Internet address : http://www.fesys.co.jp

2008-12(L2008/L2008)DE-K/CTP2Ok Printed in Japan

e-Front runners

Detection technology of air leak into condenser

Leak Buster

Fuji Electric Systems Co., Ltd.

PEC 201

We promise the safe operation of equipment thanks to our detection technology to find air leaks into the condenser.

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Effect of air leaks into the air system

At an electric power plant within a condensing plant, a condenser is installed to make optimal use of steam energy, and the pressure in this equipment is a vacuum.
If an external air leak increases in these areas of vacuum, this will result in increased fuel costs due to a decline in performance and corrosion of the equipment. To ensure safe operation of the plant, it is vital to discover abnormal air leaks early and take appropriate measures for the same.

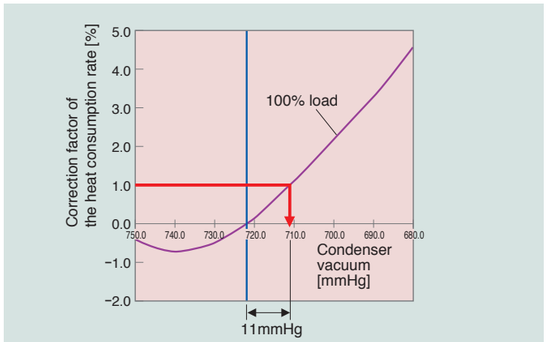
Evaluation of economy due to decreased vacuum of condenser

Economic loss when the heat consumption rate deteriorates by 1%
We calculated an increase in fuel cost on a trial basis due to a decreased vacuum in terms of the economy. Assuming a plant using coal of the 600MW class, the fuel cost of about 100 million yen per year will increase if the heat consumption rate deteriorates 1% (about 11mmHg for vacuum deterioration).

Deterioration of the coal fuel cost:
(1,830×0.01×600,000×24×365×0.95×1)/1,000 ≒ 91,380,000yen

Power increase of vacuum pump:
75×24×365×0.95×9≒ 5,600,000yen

Overall loss:
91,380,000 + 5,600,000= 96,980,000yen



Condition for trial calculation (coal power of 600MW)
Heat consumption rate: 1,830kcal/kwh
Coal price : 1yen/1,000kcal
Electric charge : 9yen/kW
Operation rate : 95%, load 600MW
When the vacuum deteriorates: vacuum pump operation (75kW)×2 units

What is the Leak Buster?

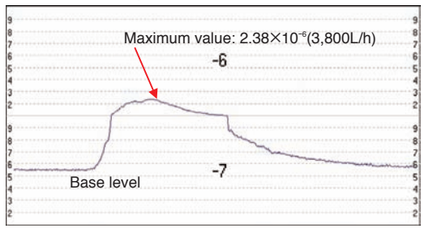
Technology to identify the point of air leakage into the vacuum system and measure the amount of air leakage from the identified point. It uses helium as the detection gas and the detection accuracy of the air leak volume is very high, 100 to 1,000 times in comparison with the conventional CFC.

For this reason, air leak points as yet undiscovered can be located. Furthermore, “the air leak volume” is measured with our original detection technology (patent pending).


Spraying the heat insulation portion


Spraying in a high position (extension rod used)

Condenser expansion portion:
Example of air leak detection



Air leak volume: equivalent to 5.0kg/h

Features

1) **Air leak points of the vacuum portion can be accurately detected during operation.**
2) **The air leak volume can be measured.**
3) **The measurement can be made without dismantling the heat insulation.**
(A hole of about 10mm in diameter is required for inserting the helium gun)
4) **Measuring work is completed in a few days.**
5) **No major setup is required.**


Helium reaction monitor

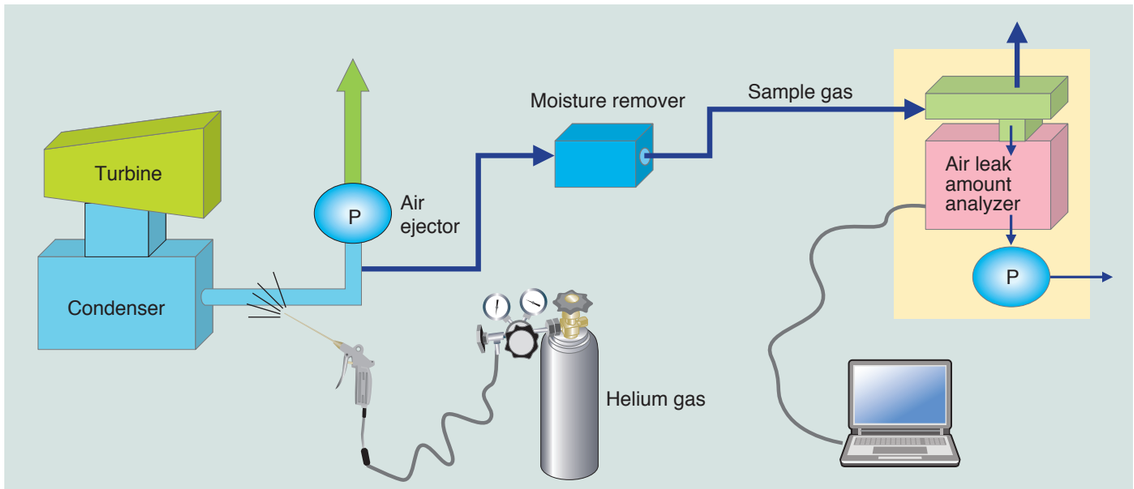

Helium gas cylinder (10L)

to Photo

Size of the leak point?

In case of a power plant, the allowable air leak volume is generally about 20kg/h. If the air leak escaping into a vacuum system is 20kg/h, the area of that portion is equivalent to one hole 6mm in diameter.

System configuration



Implementation Example of Leak Buster

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Actual installation of Leak Buster (thermal power plant: 1,000MW plant)

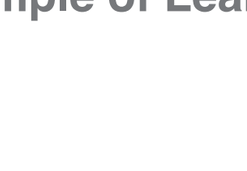
Plant situation

Air leak amount increased 40kg/h in comparison with the time of operation start
Air leak volume at the operation start: 15kg/h
Present air leak amount: 55kg/h

No backup because the spare vacuum pump is also operated.

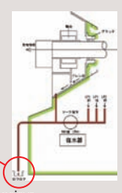
Implementation example of Leak Buster

Measurement was made at the vacuum portion of 200 to 300 points, and two remarkable air leak points were identified.



Identified air leak points

Drain piping around turbine bearing →	about 35kg/h
Low-pressure turbine gland portion →	about 4kg/h
Estimated air leak volume:	about 35kg/h



Drain piping around the turbine bearing
Draining portion


Low-pressure turbine gland

Air amount after permanent measures

Contents of permanent measures

- Replacement of drain piping around the turbine bearing
- Repair of the low-pressure turbine gland portion

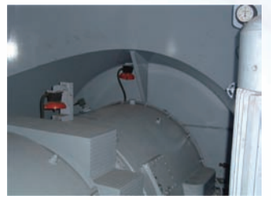
Improved

Air leak amount decreased to 15kg/h, same amount at the start of operation

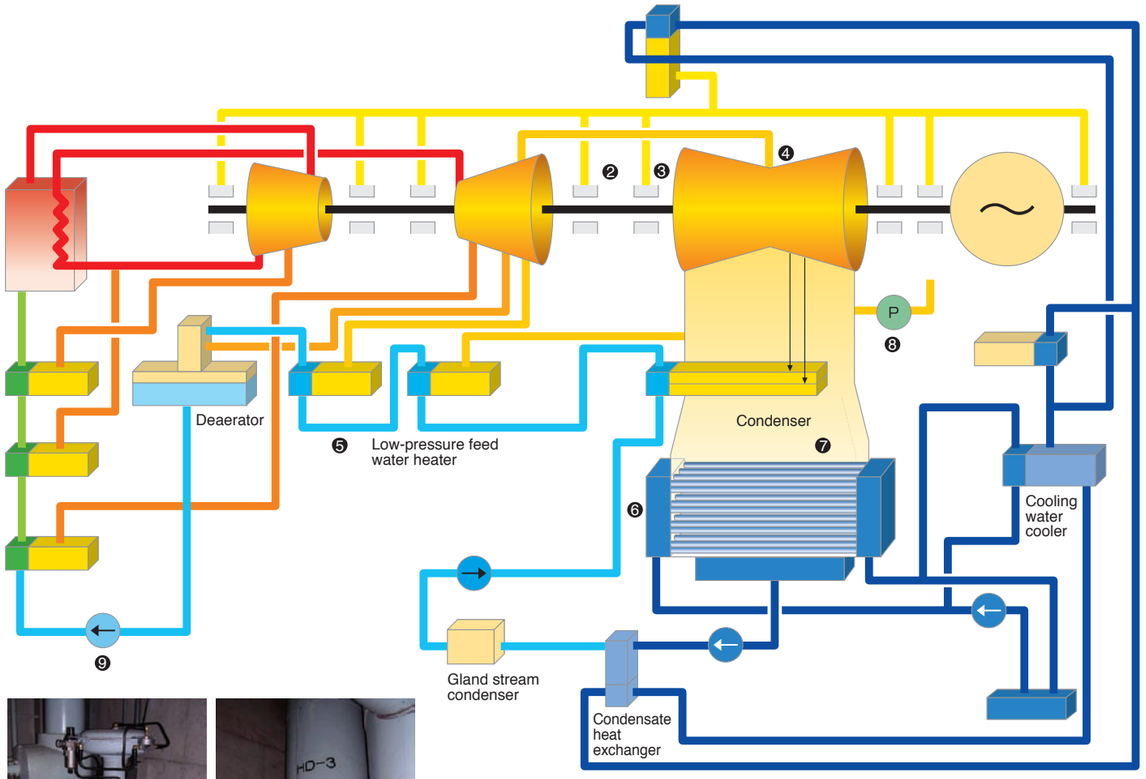
Air leak points/portions at the thermal power plant


❶ SAH drain pipe


❷ Turbine gland portion

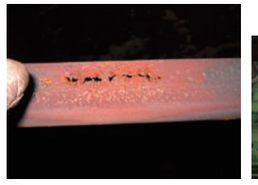

❸ Turbine gland portion


❹ Low-pressure turbine inlet




❺ Low-pressure feed water heater
Drain control valve

❻ Flash chamber


❼ Drain piping around the turbine bearing (passing through the condenser)


❽ Vacuum pump


❾ BFPT

Accuracy verification of estimated air leak volume

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Verification of estimated air leak volume

In order to compare the air leak volume estimated with the Leak Buster with the actual air leak volume, we temporarily repaired the portions (shown below) that can be repaired during operation and measured the actually reduced air amount.

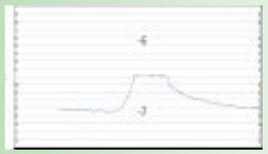
Consequently, an air leak amount estimated as 9.4kg/h was confirmed as a reduction of 8kg/h by actual measurement, proving the high measuring accuracy for each point.

Before temporary repair

After temporary repair

Detection point 1

BFPT flange portion



Maximum value: 1.24×10^{-6}(350L/h)
Air leak amount: **0.5kg/h**

Sealed with tape.
No air suction

Air leak amount: **0kg/h**

Detection point 2

BFPT flange portion

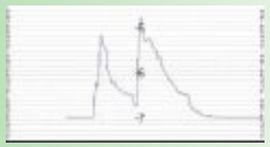
Maximum value: 9.53×10^{-6}(4,700L/h)
Air leak amount: **5.5kg/h**

Sealed with tape.
Some amount of air sucked from the bolt portion.

Maximum value: 8.24×10^{-7} (4,700L/h)
Air leak amount: **0.2kg/h**

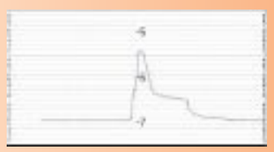
Detection point 3

Vacuum pump suction piping flange portion



Maximum value: 7.65×10^{-5}(4,000L/h)
Air leak amount: **5.0kg/h**

Sealed with tape.
Air sucked from flange of opposite portion



Maximum value: 1.99×10^{-6} (1,050L/h)
Air leak amount: **1.4kg/h**

Estimated air leak amount (before temporary repair): 11.0kg/h

Predicted reduced air amount: 9.4kg/h (11.0−1.6=9.4)

Measured reduced air amount: 8kg/h (50−42=8)

Estimated air leak amount (after temporary repair): 1.6kg/h

Air leak amount can be estimated highly accurately.

Results of Leak Buster

Results	Result 1	Result 2	Result 3	Result 4	Result 5
Turbine maker	Other company	Other company	Fuji Electric Systems Co., Ltd.	Other company	Fuji Electric Systems Co., Ltd.
Output [MW]	1000	1000	600	600	27
State before implementation	Operation of two spare vacuum pumps	Operation of two spare vacuum pumps	Operation of two spare vacuum pumps	Operation of two spare vacuum pumps	
	Vacuum deterioration 25mmHg	No vacuum deterioration	No vacuum deterioration	No vacuum deterioration	Vacuum deterioration 10mmHg
Design air amount	20kg/h	15kg/h	20kg/h	20kg/h	12kg/h
Air amount measurement	120kg/h or more (over range)	55kg/h	46kg/h	50kg/h	33kg/h
Increased air amount	100kg/h or more	40kg/h	26kg/h	30kg/h	21kg/h
Detecting air leak amount	131kg/h	39kg/h	28kg/h	29kg/h	19kg/h
Leak point	・LP turbine steam inlet pipe: 124kg/h ・Condenser expansion joint: 4kg/h ・Vacuum pump: 2kg/h ・LP turbine gland: 1kg/h	・Drain piping around turbine bearing: 35kg/h ・LP turbine: 4kg/h	・LP turbine: 13kg/h ・Around condenser: 13kg/h ・Around BFPT: 1.5kg/h ・Vacuum pump: 0.6kg/h	・LP turbine: 5kg/h ・Around condenser: 13kg/h ・Around BFPT: 6kg/h ・Vacuum pump: 5kg/h	・LP turbine: 4kg/h ・Around condenser: 13kg/h ・Around BFPT: 1kg/h ・Vacuum pump: 1kg/h
Repair content	LP turbine inlet temporary repair	Piping replaced	LP turbine inlet temporary repair	BFPT, vacuum pump temporary repair	Condenser flange portion temporary repair
Air amount after temporary repair	Result: 60kg/h Prediction: unknown because outside the range		Result: 36kg/h Prediction: 33kg/h (=46−13)	Result: 40kg/h Prediction: 39kg/h (=50−11)	Result: checking when starting next time Prediction: 20kg/h (=33−13)
Air amount after permanent measures		15kg/h (Same level as at operation start)			
Main leak portions or repair situation	・LP turbine inlet steam bellows portion	・Drain piping through condenser (drain piping around turbine bearing)	・LP turbine gland portion taping done	・BFPT flange portion	・Condenser connecting flange portion
					

Fuji Electric

Innovating Energy Technology

Improving the reliability and productivity of plants

Controllability diagnosis services for industrial plants

Optimal control tailored to the aging of your plant

to Photo

Is the performance of your equipment maximized to the utmost?

Focus on useless alarms and PID control!

Features

Controllability diagnosis and improvement

Develop your plant's performance without investing money, and achieve cost reductions and productivity improvements.

- It is said that 60% of PID control is not optimized. Stabilize your controllability and reduce the burden of inputting setting values overfrequently.
- Product service life can also be prolonged. You can expect cost down by reducing the use of chemicals and other materials.

Alarm message diagnosis and improvement

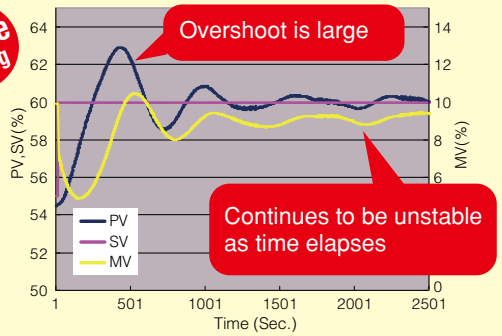
Reduce the burden on operators exposed to a flood of alarms. And this helps improve safety and profits.

- Reduce the unnecessary messages by analyzing and diagnosing the indicator messages issued by DCS plant control systems.
- We will propose program improvements such as automation of software using the correlation of such data as alarm and operation history.

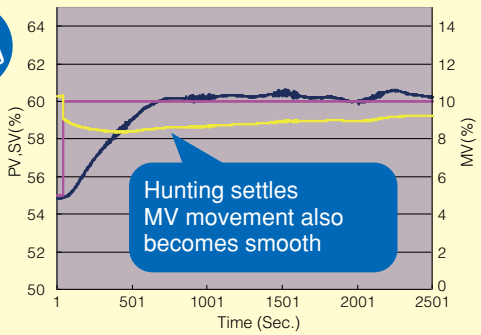
Example of controllability improvement

Case1 Temperature regulate

Before tuning



After tuning

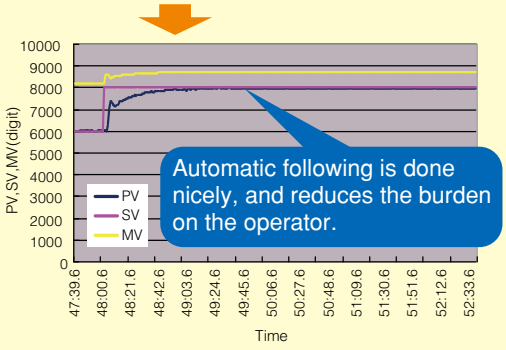


Case2 Lift pump control

Before tuning

Hunting goes on and automatic control is lost.
Manual operation by an operator was required.

After tuning



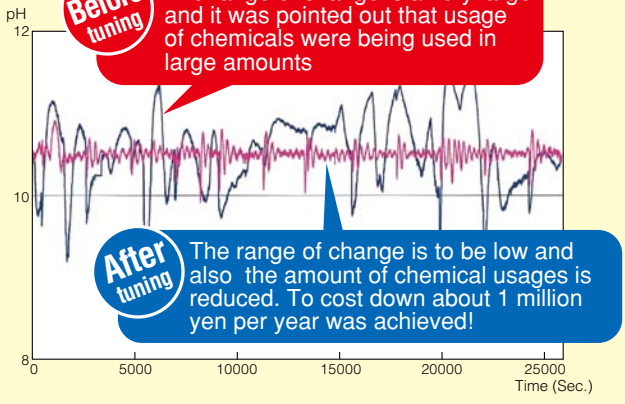
Case3 pH control

Before tuning

The range of change is a very large and it was pointed out that usage of chemicals were being used in large amounts

After tuning

The range of change is to be low and also the amount of chemical usages is reduced. To cost down about 1 million yen per year was achieved!



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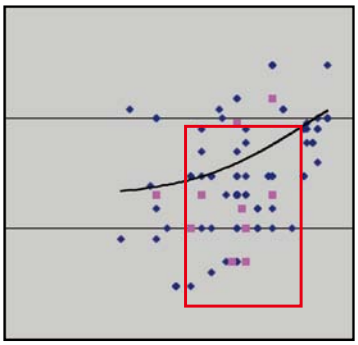
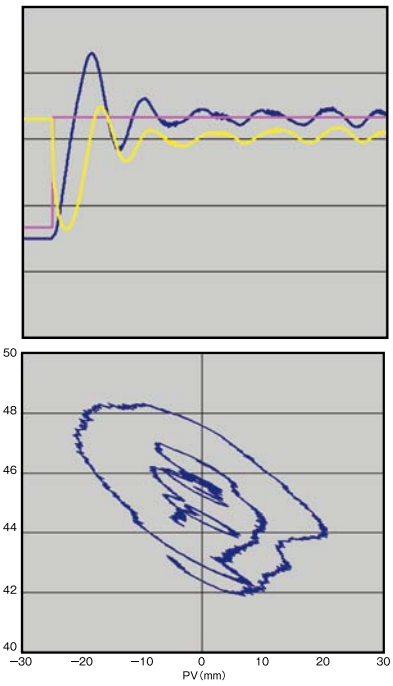
Controllability diagnosis and improvement

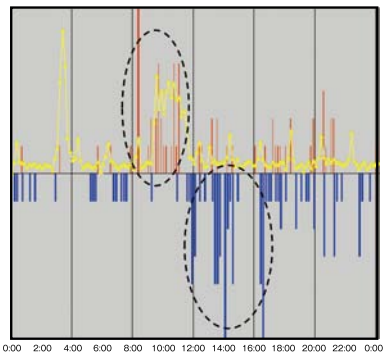
- Reduce unnecessary energy consumption caused by safety measures such as air-rich control*
  *Somewhat larger (increased) energy settings with an allowance for safety.
- Prevent wasteful consumption of energy due to setting for excessive overshooting
- Suppresses the spread of control malfunctions throughout the entire process caused by partial malfunctions
- Reduce the wasteful energy consumption caused by unnecessary switching
- Achieve the expected performance

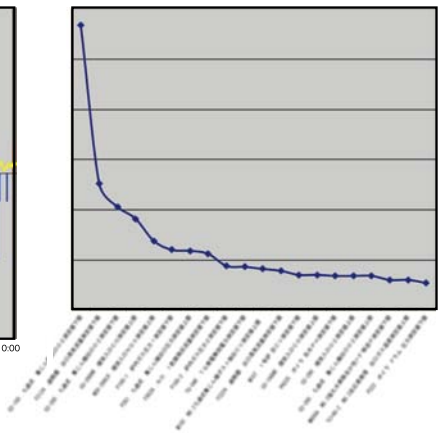




Alarm message diagnosis and improvement

- Use statistical methods to make messages and alarms that are indicators and visualized
- Start improvements by point screening and alarm management
- When many work processes are required, reconsider settings being studied for automation
- Reduce misses caused by incessant alarms
- Look closely at irregularities in the control operations





Target effects and results **Intelligently**

- Improve productivity first by improving combustion efficiency and reducing chemicals
- Save energy, by reduction energy source units, save money
- Significantly reduce loss cost management by making less investment and using fewer resources
- Gain a foothold toward ISO50001 energy-saving management and advanced control structure

In addition, great results can be achieved when combined with Fuji electric Total Optimization system for energy management system (Fe-TOP) and other energy management systems (EMS). Ideal for MICREX power users.

⚠ Safety precautions

Note: Before using this product, in order to use it correctly, be sure to carefully read the Instruction Manual and Specifications, or contact our company or your dealer for information as necessary.
Note: This product is intended to be handled by persons with specialized technical knowledge.

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e-Front runners

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Supporting package software for data acquisition and analysis.

f(s)NISDAS-x

Using Open-Network & I.T., based on SX, Diagnosis and Analysis System

Solution Service

Fuji Electric Systems Co., Ltd.

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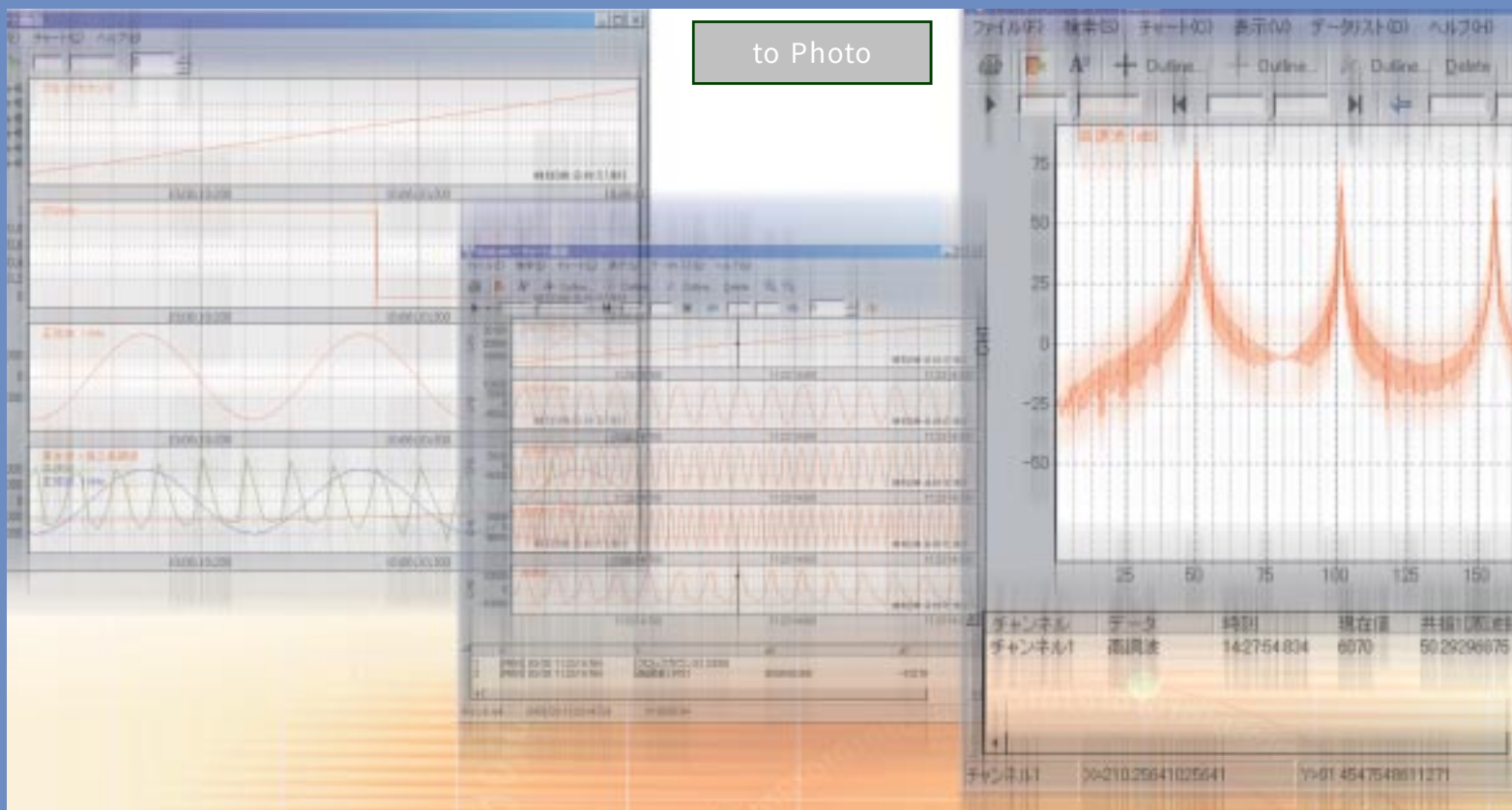
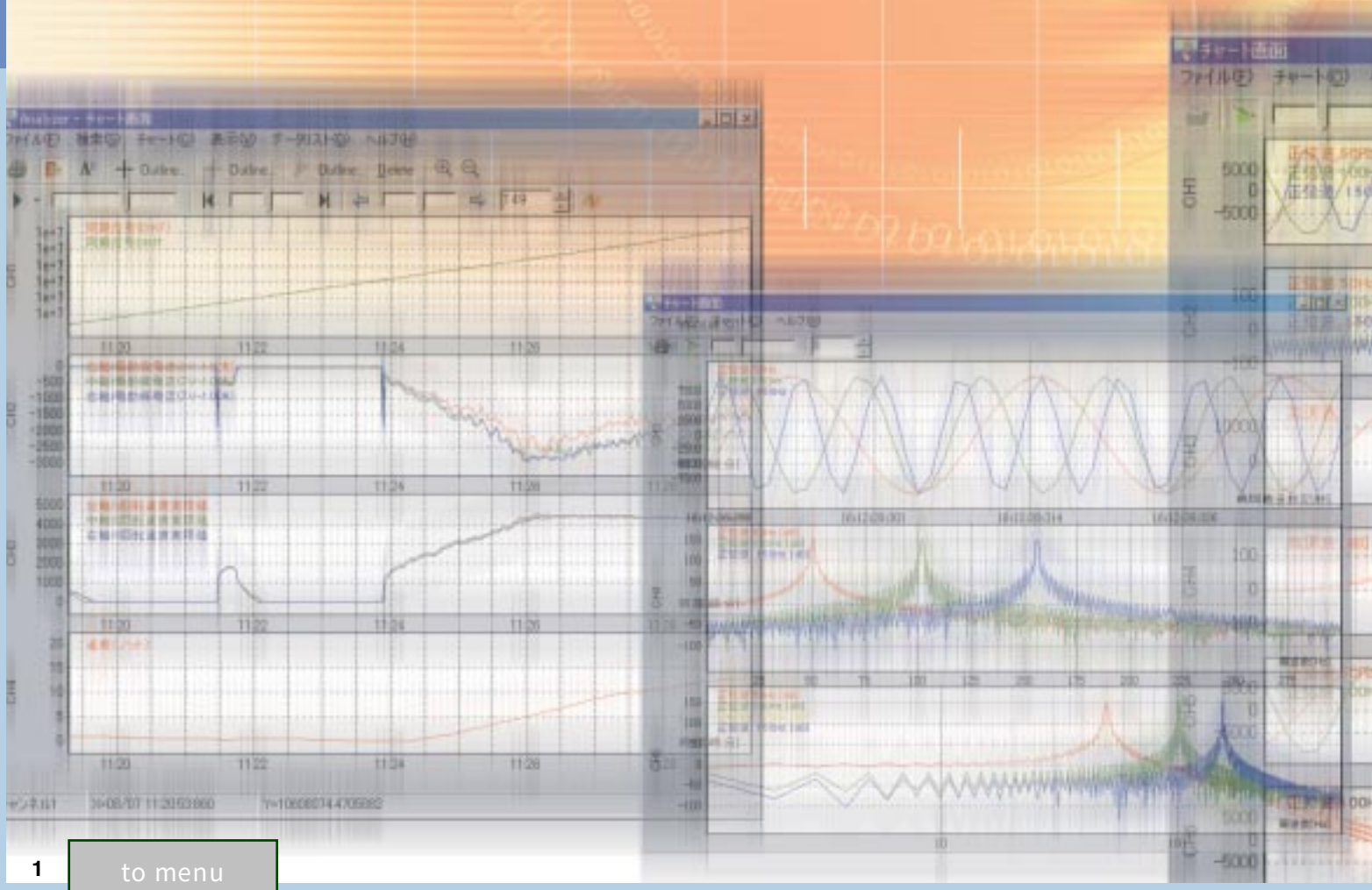


f(s)NISDAS-x



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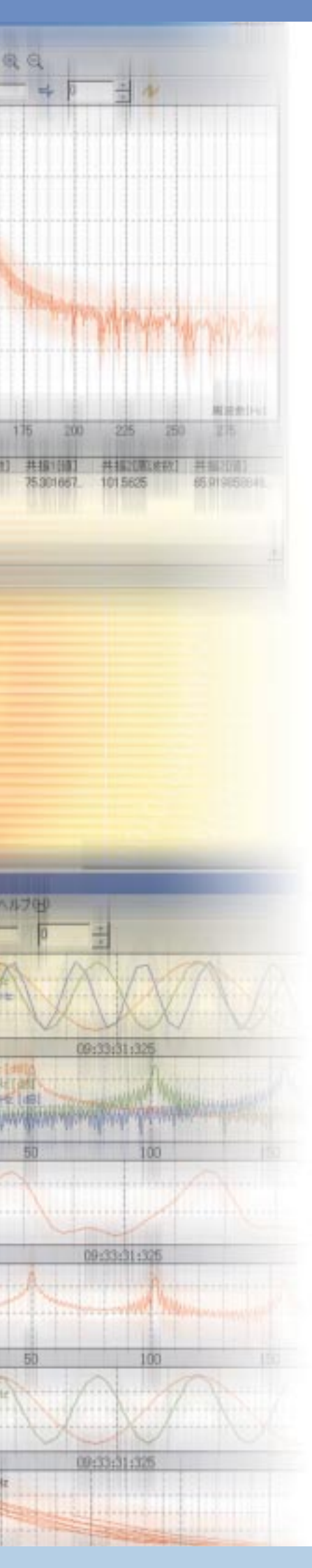

Package software f(s)NISDAS−x, the ideal solution for diverse uses such as startup, operation monitoring, and maintenance of production equipment

f(s)NISDAS−x is a software package which runs on a personal computer, and acquires and analyzes the data of a programmable controller (PLC), inverter, etc.

5 Key Features

1 Sophisticated system monitoring
~quick, simultaneous and voluminous~

- Rapid data acquisition with a sampling time of only 1ms
- Recording of consecutive data for up to 1 month or longer
- Data acquisition from multiple PLC units with a single personal computer
- Time axis matching of the data acquired from multiple PLC units in steps of 1ms due to unique synchronization technique (patent pending)

2 Enriched system analysis ~efficient utilization~

- Data analyzed simultaneously with data acquisition
- Data can also be analyzed after acquisition

3 Simplified operation ~easier to use~

- Simple operation method

4 Simple installation and high extendibility
~more simplification~

- Connectable to open network
- Easily installable in an existing system
- Monitoring of MICREX series PLC. Data monitoring of other companies' PLC units now under development.
- Conversion to a file format compatible with commercially available software

5 Support and service ~timely provided~

- We provide remote support using commercially available remote control software.

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Data Gathering

~Quick, simultaneous and large voluminous~

Quick data acquisition

$f_{(s)}$NISDAS–x can collect PLC data as quickly as 1ms. The acquired data is immediately saved to hard disk and displayed in real time in the chart window.

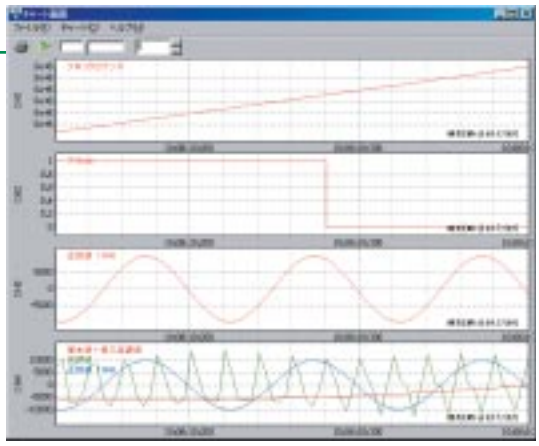
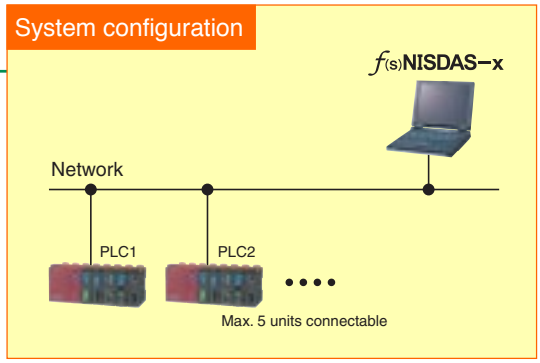


Chart window

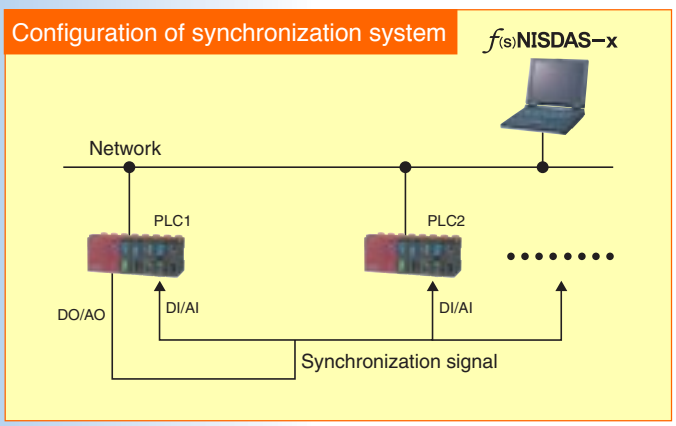
Simultaneous data acquisition from multiple PLC units

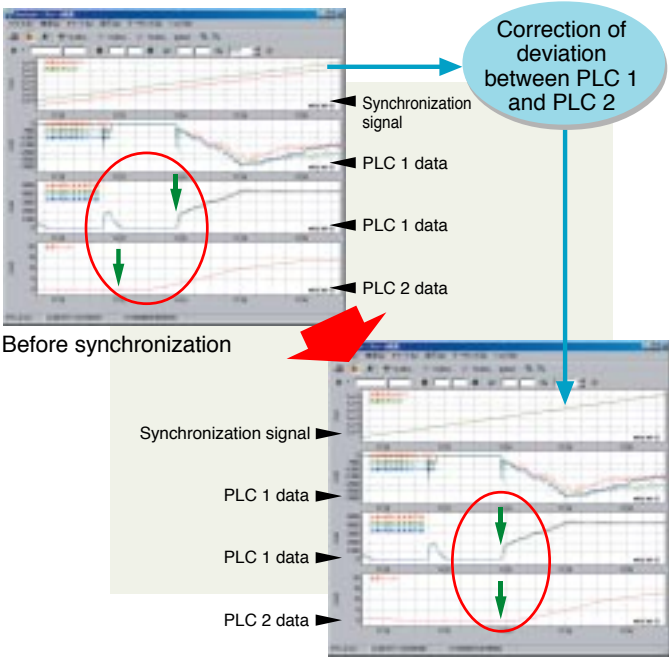
$f_{(s)}$NISDAS–x can connect up to 5 PLC units, allowing data of equipment controlled by multiple PLC units to be centrally managed.



• Synchronization of data (patent pending) • • •

Data input separately to multiple PLC units can be matched in the time axis and displayed on the same window. $f_{(s)}$NISDAS–x detects a deviation between the synchronization signals in PLC 1 and PLC 2 and matches the time axis to synchronize data. Synchronization –accuracy is 1ms at minimum.





Before synchronization

After synchronization

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Trace-back data acquisition

By setting a threshold value for the data to be acquired or a desired ON/OFF signal (trigger), the data across the trace-back point which satisfies such a setting can be traced back. For example, by setting an abnormal value as a threshold, you can trace back the data across the abnormal value.

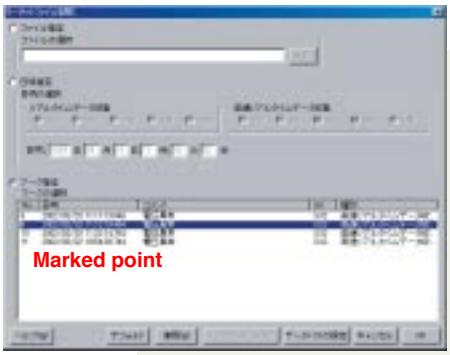
Trigger setting window

• Marked point

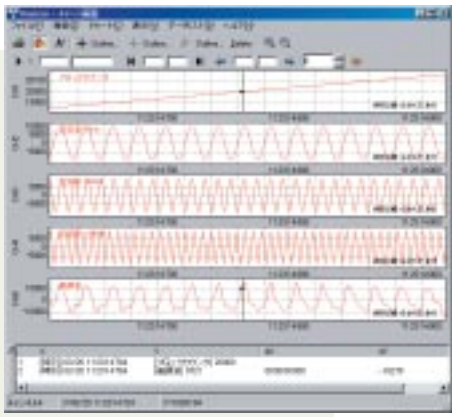
A time point which meets the set threshold value or condition can be automatically marked. And of course, marking can be set manually at a desired point.

• Callout of trace-back and marked points

Trace-back and marked points can be freely and easily called out later.



Callout of marked point



Marked point callout window

Recording of large-volume consecutive data

Since f(s)NISDAS–x saves data to the hard disk of a personal computer, consecutive data of more than ten gigabytes can be stored.

For instance, if a 40 GB hard disk is used for consecutive 8-word storage of data sampled every 1ms, data for 2 months or even longer can be stored *1.

*1) Assumes the standard data compression function is used.

Data Analyzing

to Photo

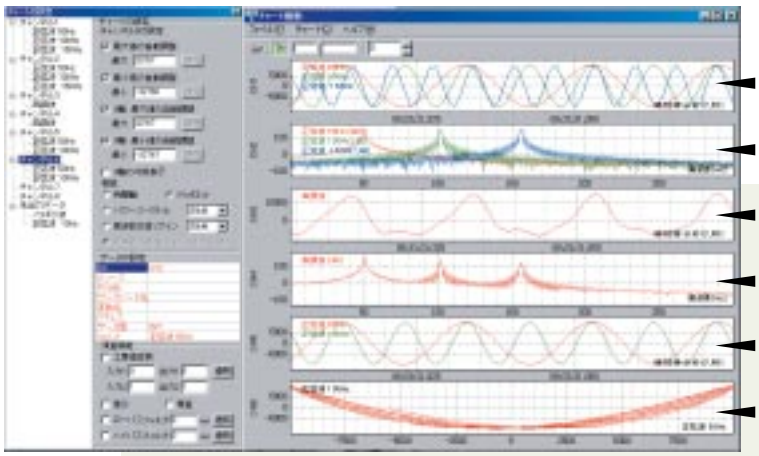
~Efficient utilization~

Data can be analyzed at the same time as acquisition.
Data can also be analyzed as you like after acquisition.

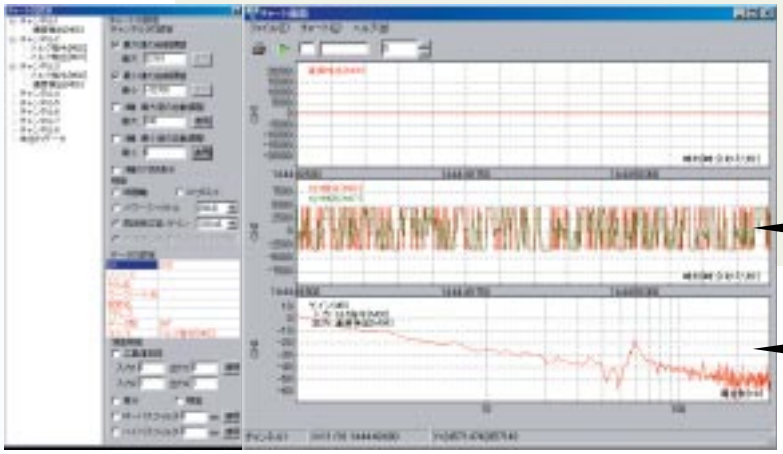
Various analyses

• Examples of analysis window display

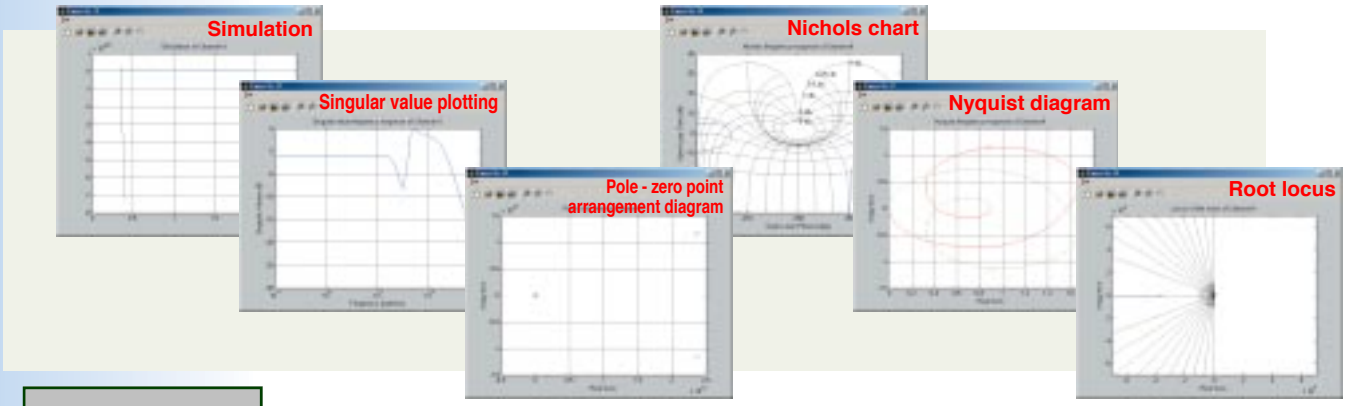
- Fast Fourier transform (FFT) power spectrum
- XY plotting
- Frequency response
  - Non-parametric identification
    - Gain diagram
    - Phase diagram
  - Parametric identification with ARX model
    - Gain diagram
    - Phase diagram
    - Step response
    - Simulation
    - Singular value plotting
    - Nichols chart
    - Nyquist diagram
    - Pole - zero point arrangement diagram
    - Root locus
- Differential calculation
- Integral calculation
- Filtering



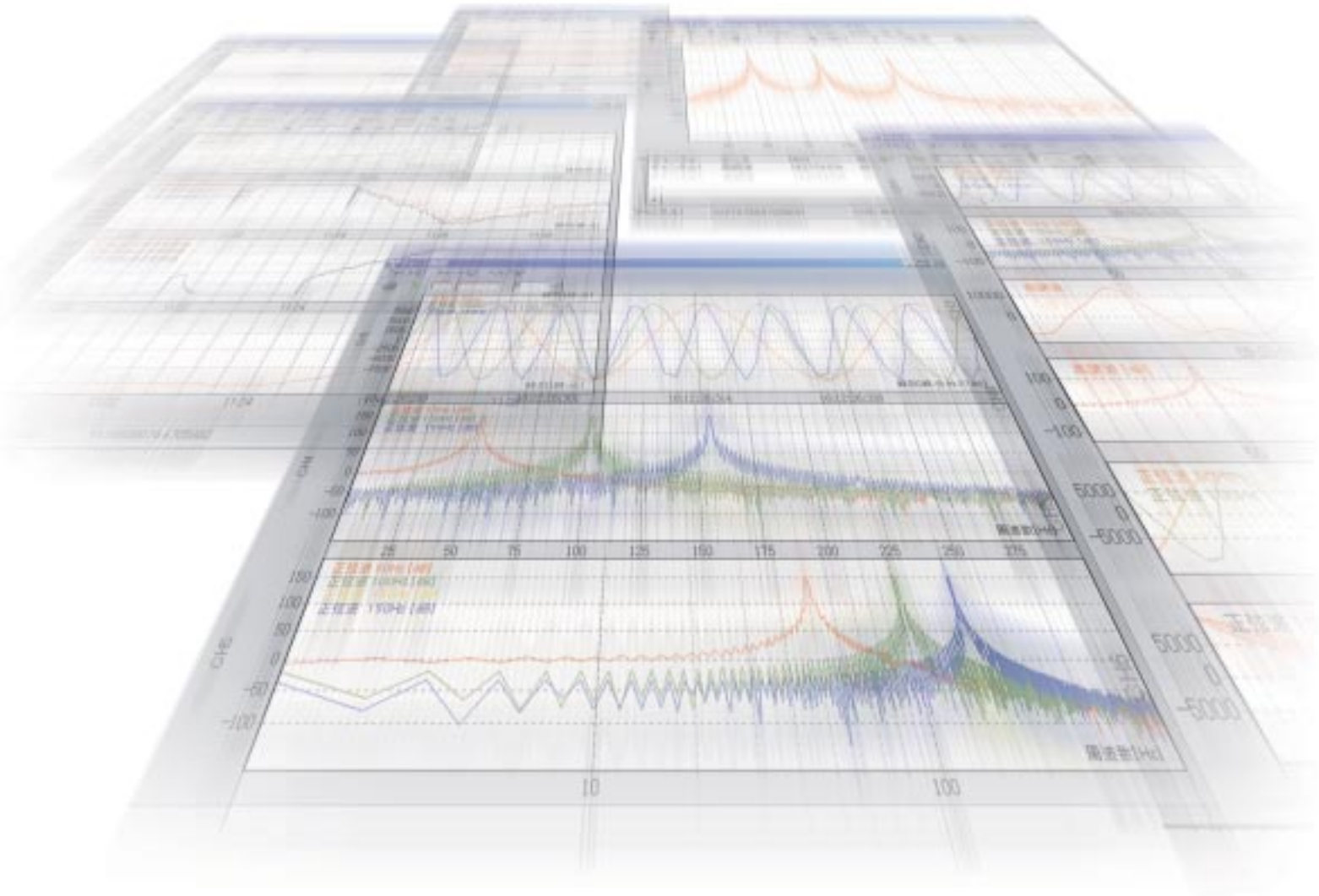
Time axis waveform
↓
Frequency axis waveform (power spectrum)
Time axis waveform
↓
Frequency axis waveform (power spectrum)
Time axis waveform display
↓ (XY plotting)
Lissajous waveform



Time axis waveform
↓ (Frequency response)
Frequency axis waveform (gain diagram)

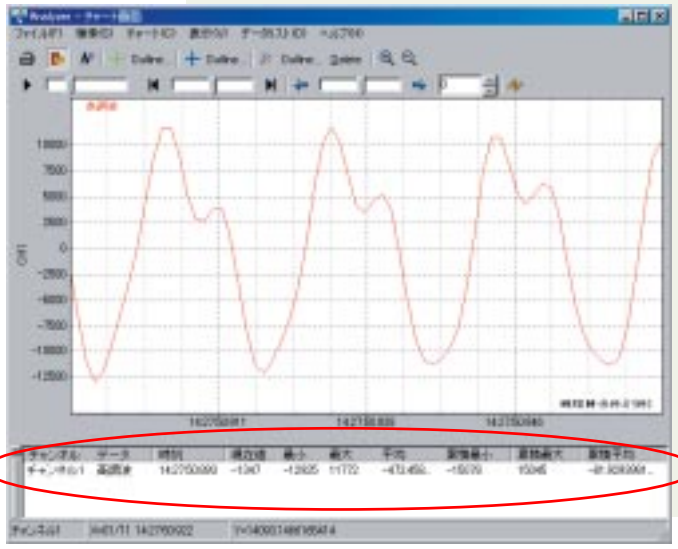


to menu

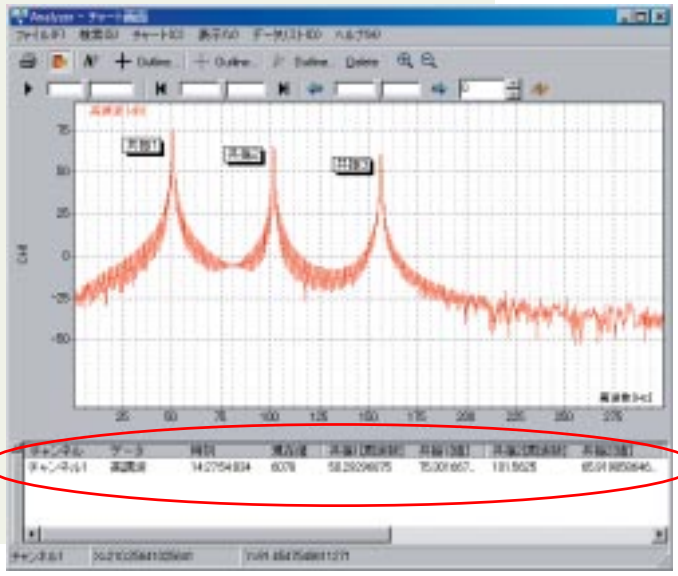


• Digital display of data in chart

The maximum, minimum and mean values of the data indicated in the chart window can be displayed digitally, as well as the cumulative maximum and minimum values and the analytical results such as resonance point.



Digital display of maximum, minimum and mean values



Digital display of resonance frequency

Usability

to Photo

~Easier to use~

Data callout

From the monitoring window, data for chart display can be selected by simple mouse operation.

Display of thinned-out data

Data is thinned out for display, so data display covers a longer period of time.

Conversion of data type

For example, data received as a Word file can be converted into bit data for chart display.

Zoom-in and zoom-out

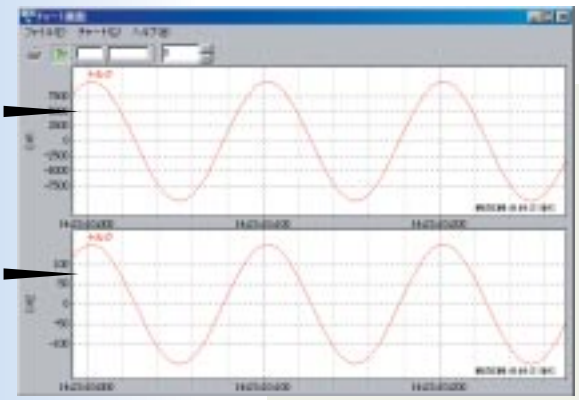
Chart display can be zoomed in or out in each channel. This is convenient for checking data in more detail and grasping the general trend.

Chart display

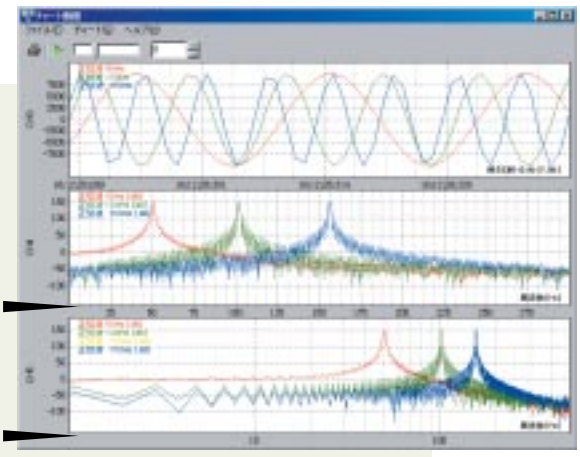
- Each window can contain chart display for up to 8 channels.
- On one channel, charts can be overlaid (up to 16 charts).

Setting of chart scale

- Scale conversion (conversion into engineering units)
- Linear scale/logarithmic scale changeover



Ordinate scale conversion



Abscissa scale changeover

to menu

Point cursor

A point can be set (checked) on a chart by clicking it with the mouse. The value at the checked point will be digitally displayed.

Cross-hair cursor

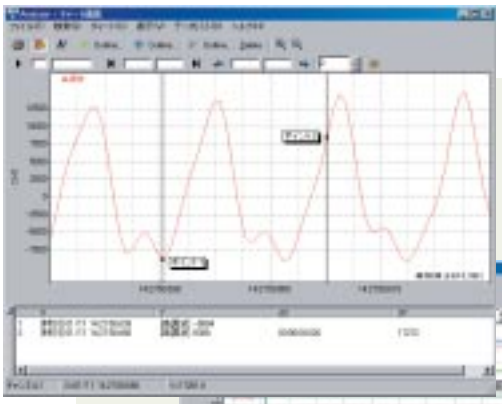
A cross-hair cursor can be displayed over channels. Multiple data values at the same time point and differences in data between 2 points can be known instantly.

Chart comment

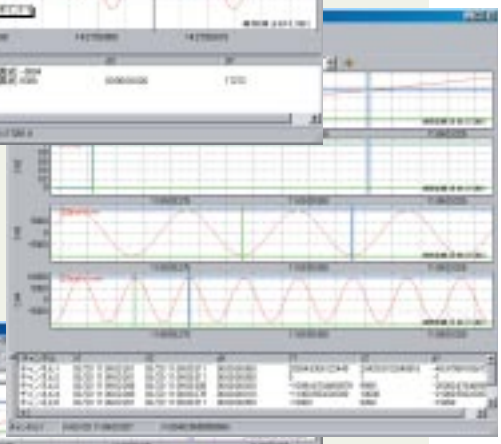
Comments and lines can be freely inserted in a chart. There is no need for tedious work such as manual entry or cutting/pasting of comments after chart printout.

Search for desired point in acquired data

On the presently displayed chart, a search can be made up to the set search value while scrolling the chart. Upon detection of the value, the point cursor is automatically generated and scrolling stops.



Point cursor



Cross-hair cursor

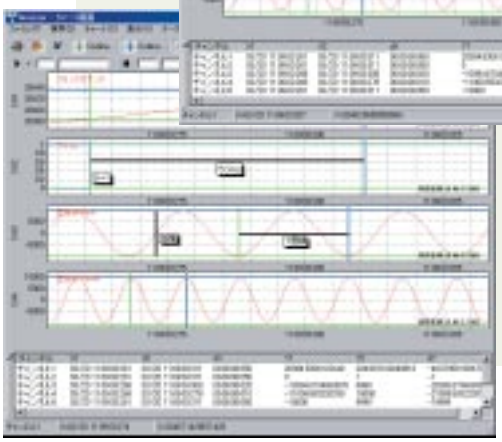
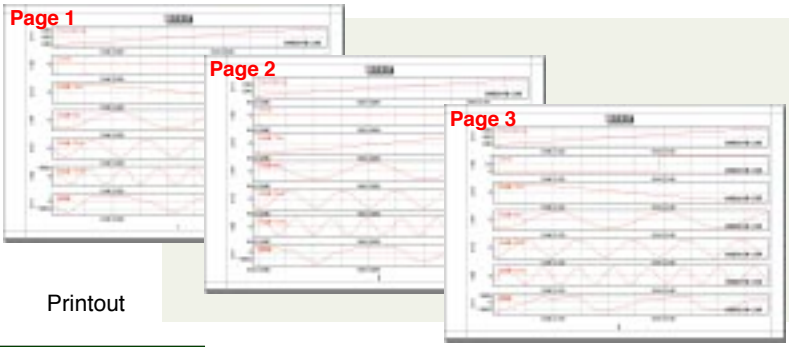


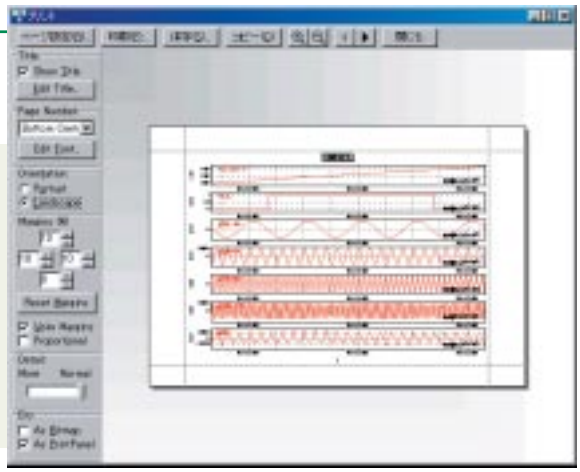
Chart comment

Printing

The object of chart display can be printed. Even with a page printer, printing continues with no omission caused by form feed.



Printout



Printout setting window

to menu

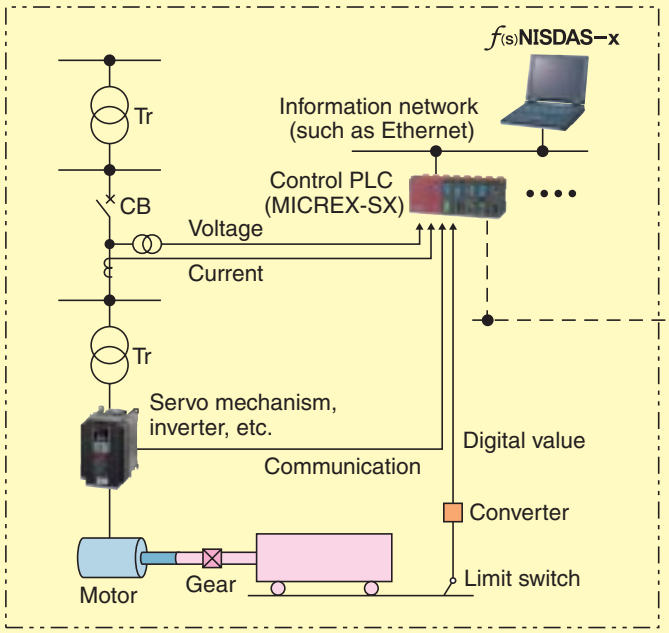
Flexibility and Extendibility

~More simplification~

to Photo

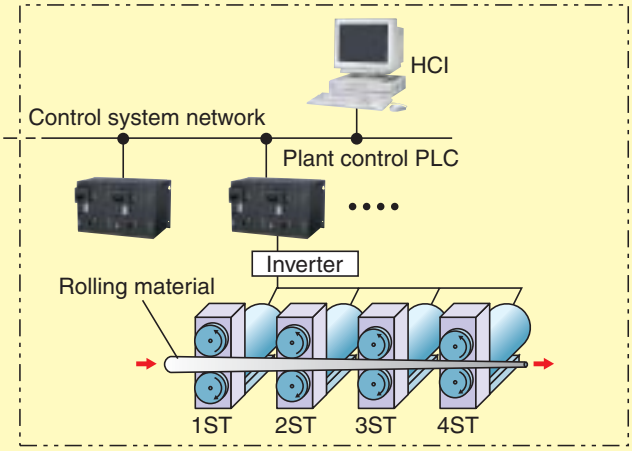
Connectable to multiple networks

Communication systems such as Ethernet, RS-232C (RS-485), USB and FL-net compatible with personal computers can be used. Communication via the CC-Link is under development.



Example of system configuration

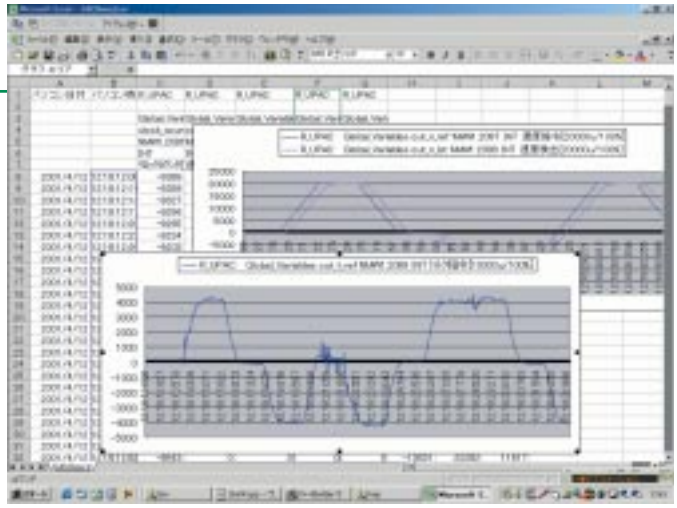
Shown here is an example of the system configuration where **ƒ(s)NISDAS–x** is incorporated in a bar steel rolling plant system*2.
The system configured with a control PLC (MICREX-SX) is connected to a personal computer, in which **ƒ(s)NISDAS–x** is installed, via an information network (such as Ethernet).
Each control PLC has a number of data which represents the status of the plant. Therefore, by acquiring this data, the customer can monitor and analyze the plant system.



*2) Bar steel rolling plant
In this facility, the steel to be rolled from a blast furnace or electric furnace is crushed gradually from the upstream side using multiple successive rolling stands (ST) so that bar steel such as steel frame or reinforcing steel is finally produced.

Outputting acquired data in CSV format

Because the acquired data saved in binary format can be converted into text (CSV) format, data can be easily read into commercially available software such as Excel (shown on the right).



Processing of acquired data with Excel

to menu

Support & Service

to Photo

~Timely provided~

Setup support (fee-based)

For customers using $f_{(S)}$NISDAS–x support on setting up the personal computer and using this product can be provided.

Remote support *3 (fee-based)

Usage of $f_{(S)}$NISDAS–x, data analysis, etc. can be better supported by sharing the personal computer monitor with the customer through remote control of $f_{(S)}$NISDAS–x from our company. (within Japan only)

Home page service (free)

The latest information will be provided through the Internet.

Website of $f_{(S)}$NISDAS–x
URL : http://www.fesys.co.jp/fsnisdas-x

Website of $f_{(S)}$NISDAS–x

Software download service

• Download of trial version (free)

When you register as a user for the trial version from the website of $f_{(S)}$NISDAS–x, this version can be download immediately. The trial version will show you just how useful $f_{(S)}$NISDAS–x is.

• Download of product version (fee-based)

By entering the license No. and download No. which are issued upon purchasing the product version, the product-version $f_{(S)}$NISDAS–x can be downloaded.

• Updating of product version (free)

By entering the license No. and download No. issued upon purchasing the product version as for downloading, the product-version $f_{(S)}$NISDAS–x in your computer can be updated.

■ Code Symbols

FSNIS 01 – □ □ □

Specifiable items

Basic type

Basic package

Code	Function
D	Data acquisition and analysis
A	Data analysis only

Option

Code	Function
1	Extended analysis and calculation
0	Unnecessary

Option

Code	Function
2	Data synchronization
0	Unnecessary

● Notes on purchase and type selection
- The package for analysis only (FSNIS01-A**) does not contain a data acquisition function.
- When using $f_{(S)}$NISDAS–x for the first time, be sure to purchase the data acquisition and analysis package (FSNIS01-D**).
- If you already have the data acquisition and analysis package (FSNIS01-D**) and want to purchase only the analysis function additionally, select the data analysis-only package (FSNIS01-A**).

*3) Due to security concerns, our company uses not the Internet but NTT's public telephone network ISDN, etc. Therefore, a contract needs to be made to connect to NTT's network (ISDN) and an ISDN modem (TA + DSU) must be prepared. Also, the host version of remote control software (Symantec pcAnywhere) is necessary. (within Japan only)

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■ Specifications

Data acquisition	**Sampling time**	■ High speed: 1ms minimum (max. 32 words) ■ Standard: 20ms (maximum 8192 words) Note) May vary slightly depending on the operating environment.
	Recordable volume	Varies with the hard disk capacity of the personal computer. Example) With a 40 GB hard disk: Recordable for 2 months or longer in 8-word data acquisition at 1-ms sampling interval and 243-word data acquisition at 30-ms sampling interval.
Trace-back		■ Trace-back through threshold judgment: Measurement time across the trigger point can be freely settable. ■ Automatic setting of marked point through threshold judgment
Chart operation and display		■ Number of channels: Max. 8 channels (max. 16 charts/8 channels) ■ Overlaying of charts (max. 16 charts/1 channel) ■ Abscissa linear scale/logarithmic scale changeover ■ Ordinate scale conversion (conversion into engineering units) ■ Data type conversion ■ Digital display of maximum, minimum and mean values, cumulative maximum, minimum and mean values, resonance frequency, etc. ■ Point cursor display (display of difference between cursor points) ■ Cross-hair cursor display (display of difference between cursor lines) ■ Frame feed, rewinding, automatic feed, automatic rewinding ■ Adjustment of data quantity on one screen and data thinned-out display ■ Zoom-in and zoom-out ■ Manual setting of marked point ■ Data search by comparing values
Printing	**Chart (analog) printing**	■ Header/page No. insertion ■ Uninterrupted printing of consecutive data
	Numeric (digital) printing	■ Printing of values indicated on chart ■ Printing of analytical result
File callout		■ Callout by file name specification ■ Callout by time specification ■ Callout by marked point
Basic analysis and calculation		■ FFT (power spectrum) ■ XY plotting (Lissajous waveform) ■ Low-pass filter and high-pass filter ■ Difference and Integration ■ Frequency response: Non-parametric identification • Gain diagram, • Phase diagram
Extended analysis and calculation (option)		■ Frequency response: Parametric identification with ARX model • Gain diagram • Phase diagram • Step response • Simulation display • Nichols chart • Nyquist diagram • Singular value plot display • Pole - zero point arrangement diagram • Root locus ■ Digital filter: Moving average, digitizing of continuous system filter, band-pass filter, notch filter ■ Multivariate analysis: Principal component analysis, Maharanobis' distance, etc. (under development) ■ Probability density distribution and frequency distribution analysis (under development)
Data synchronization (option)		■ Synchronization of data acquired with multiple PLC units: Correction of time axis deviation in the data acquired from multiple PLC units (may involve addition of a control PLC application)
Data recording format		Binary
Data link		Format conversion from binary to CSV
Monitored objects		Connectable units: Max. 5 units
Compatible network		■ Ethernet/RS-232C (RS-485)/USB/FL-net ■ CC-Link (under development)
Main hardware	**Personal computer**	■ Intel Pentium3 750 MHz or more recommended ■ Microsoft Windows 2000 Professional, Windows XP Professional
	Sources of data acquisition	■ Fuji Electric's PLC of MICREX-SX series ■ Fuji Electric's PLC of MICREX-AX/IX/HDC/F series (under development) ■ Fuji Electric's inverter FRENIC 5000-VG7 series UPAC option ■ Mitsubishi Electric's PLC of MELSEC series and other companies' PLCs (under development)

Trademark and Registered Trademarks

Fuji Electric Systems Co., Ltd. / Slogan symbol

Solution Service

The slogan symbol is based on Fuji Electric Systems' Solution & Service motto, and "S" that symbolizes them.

Fuji Electric Systems Co., Ltd.

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A-1-1 ○ ■	Environmental diagnosis and deterioration diagnostic services
A-1-2 ○ ■	Installation environment diagnosis services for electrical facility equipment
A-2-1 ○ ■★	Deterioration diagnosis services using infrared thermography
A-2-2 ○ ■	Live diagnostic services for in-service electrical equipment using infrared thermography
A-3 ○	Remaining life time diagnosis services for power distribution panel control wiring

Plant Diagnosis Service List

B-1 ● ■ ★	Deterioration diagnosis services for substation equipment
B-7-1 ○ ■	Diagnosis services for 3.6kV cables
B-7-2 ○ ■	電力ケーブルの劣化診断

B-2-1 ○ ■ ★	Simplified partial discharge diagnosis services for distribution panels
B-2-2 ○ ■	Partial discharge diagnosis services for power distribution panels(COPAS)
B-8 ○	Deterioration diagnosis services for auxiliary relays AR-MEC

B-3 ○	Deterioration diagnosis service for substation switchgear CB-MEC

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B-4-1 ○ ■	High-precision remaining life assessment services for oil-filled transformers
B-4-2 ○ ■	Dissolved gas analysis(DGA) for oil-filled transformers and testing of insulation oil properties
B-4-3 ○	Torque diagnosis services for on-load tap changers

B-5-1 ○	MOLMOS Optical diagnosis services for deterioration of molded transformers
B-5-2 □ ○	Partial discharge diagnosis device for preventive maintenance of molded transformers MOL-MEC

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C-1 ● ★	Diagnostic services for adjustable speed drive systems
C-2-1 ● ★	Remaining service life assessment system for limited life parts of general-purpose inverters
C-2-2 ○	Deterioration diagnosis system for environmental factors of general-purpose inverters

Plant Diagnosis Service List

Plant Diagnosis Service List

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C-3-3 ○	Remaining life assessment services for High-voltage electric motors
C-3-1 ● ★	★Reliability assessment for medium-voltage motors
C-3-2 ○ ■	Insulation diagnosis for medium-voltage rotating machines
C-3-4 ○ ■	ROPAS Online partial discharge diagnosis services for medium-voltage rotating machines
C-3-5 ●	Physico-chemical diagnosis services for thermal deterioration of insulation
C-4 ○ ■	Wireless Diagnostic System for Rotating Machine Vibration(Wiserot)
C-5 ○ ■	ProHealth

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D-1

Battery instant discharge diagnosis device(BSC)

Plant Diagnosis Service List

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E-1

quipment diagnosis services for information processing controllers

Plant Diagnosis Service List

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E-3	Diagnosis services for printed circuit boards by a sampling method

E-2	電源ユニットの劣化診断
E-4-1	プリント基板の劣化診断
E-4-2	プリント基板洗浄
E-4-3	プリント基板コーティング

Plant Diagnosis Service List

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F-1-1 ■	Radiation transmission type pipe diagnostic equipment
F-1-2 ■	Radiation transmission type pipe thickness measurement equipment
F-2 ● ■	ファーマーナイト コンポジットリペアサービス

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F-3 ○ ■	Detection technology of air leak into condenser 「Leak Buster」

Plant Diagnosis Service List

G-1	Controllability diagnosis services for industrial plants
G-2 ● ■	Optimal Energy Operation System FeTOP
G-3 ● ■	Analysis support system for process line and assembly line
G-4 ○	f(S)NISDAS-x