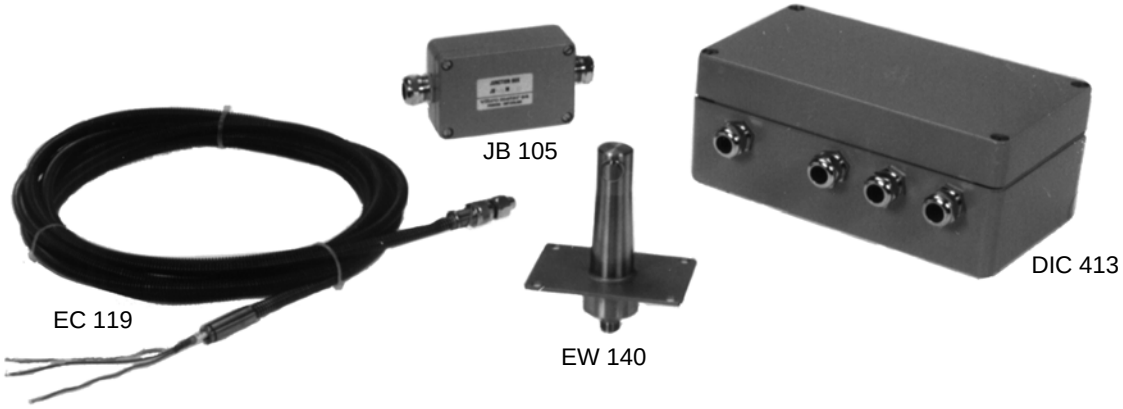
Vibro-Meter

Instruction Manual

GAS TURBINE
ICE DETECTION SYSTEM

EW 140 ICE SENSOR & DIC 413 DE-ICING CONTROLLER

MAEW-DIC/E



Ex

This document contains important information about products that are intended for use in potentially explosive atmospheres.

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PREFACE

About this manual

This manual provides information on gas turbine ice detection systems using Vibro-Meter's EW 140 ice sensor and matching DIC 413 de-icing controller. It describes the installation and general use of these systems.

Who should use this manual?

The manual is intended for use by qualified installation personnel (e.g. mechanical and electrical fitters).

NOTE : Personnel involved in the installation of Vibro-Meter equipment are assumed to have the necessary technical training in electronics and/or mechanical engineering (professional certificate/diploma, or equivalent) to enable them to install the equipment correctly and safely.

Respect the instructions!

The procedures described in this manual should be strictly adhered to in order to ensure the ice detection system is mounted correctly, and thus functions as intended.

Personnel involved in the installation of Vibro-Meter equipment must respect general safety procedures as well as general and specific machine constructor guidelines and instructions.

Related documentation

Further information on products can be found in their corresponding data sheets. These documents can be found on Vibro-Meter's web site or obtained from your local Vibro-Meter agent.

The following document contains further information on equipment that can be used in potentially explosive atmospheres (Ex applications):

- Safety instructions and ATEX certificates for products used in potentially explosive atmospheres (Ex applications) (ref. MA_ATEX_WARN).

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SAFETY

Symbols and styles used in this manual

The following symbols are used in this manual where appropriate :

The WARNING safety symbol

THIS INTRODUCES DIRECTIVES, PROCEDURES OR PRECAUTIONARY MEASURES WHICH MUST BE EXECUTED OR FOLLOWED. FAILURE TO OBEY A WARNING CAN RESULT IN INJURY TO THE OPERATOR OR THIRD PARTIES.

The CAUTION safety symbol

This draws the operator's attention to information, directives or procedures which must be executed or followed. Failure to obey a caution can result in damage to equipment.

The ELECTROSTATIC SENSITIVE DEVICE symbol

This indicates that the device or system being handled can be damaged by electrostatic discharges.
Refer to **Handling precautions for electrostatic sensitive devices on page xiii** **for further information.**

NOTE: This is an example of the NOTE paragraph style. This draws the operator's attention to complementary information or advice relating to the subject being treated.

Important remarks on safety

Read this manual carefully and observe the safety instructions before using the equipment described.

Additional remarks

Every effort has been made to include specific safety-related procedures in this manual using the symbols described above. However, operating personnel are expected to follow all generally accepted safety procedures.

Safety procedures should be communicated to all personnel who are liable to operate the equipment described in this manual.

Vibro-Meter does not accept any liability for injury or material damage caused by failure to obey any safety-related instructions or due to any modification, transformation or repair carried out on the equipment without written permission from Vibro-Meter. Any modification, transformation or repair carried out on the equipment without written permission from Vibro-Meter will invalidate any warranty.

Equipment used in potentially explosive atmospheres

THIS MANUAL COVERS EQUIPMENT THAT CAN BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES, AS WELL AS EQUIPMENT THAT CANNOT BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES.

TO ENSURE THAT THE EQUIPMENT CAN SAFELY BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES, IT IS ESSENTIAL TO:

- **VERIFY IT IS IDENTIFIED WITH SPECIAL MARKING DESCRIBED IN THE "EC TYPE EXAMINATION CERTIFICATE" FOR THE PRODUCT**
- **RESPECT THE CRITERIA MENTIONED IN THE SAME "EC TYPE EXAMINATION CERTIFICATE"**

AN "X" OR A "U" PLACED AFTER THE CERTIFICATE NUMBER INDICATES THAT THE EQUIPMENT IS SUBJECT TO SPECIAL CONDITIONS FOR SAFE USE. THESE CONDITIONS ARE MENTIONED IN THE "SCHEDULE" SECTION OF THE CERTIFICATE.

REFER TO THE SAFETY MANUAL (SEE RELATED DOCUMENTATION ON PAGE V FOR FURTHER INFORMATION).

General handling precautions

Vibro-Meter's transducers (sensors / probes) are rugged devices which can withstand a certain amount of careless handling. Nevertheless, certain precautions should be taken when handling.

Read the following recommendations carefully before handling transducers.

- Do not drop the transducer onto a hard surface or subject it to violent shocks.
- Protect the body/head of the transducer with plastic protective netting when it is being handled, stored or transported. Remove this protection only when mounting the transducer or when inspecting/testing it.
- Check for dents when inspecting the transducer as this is a sign that it could have suffered a physical shock by impact. This may have caused damage to components within the transducer.
- Do not excessively bend the transducer cable or associated cables. Respect the minimum bending radius quoted in the appropriate data sheet or mechanical drawing.
- When storing and using the equipment, respect the environmental specifications (temperature, humidity) quoted in the appropriate data sheet.
- Refer also to Handling precautions for electrostatic sensitive devices on page xiii.

Handling precautions for electrostatic sensitive devices

Certain devices used in electronic equipment can be damaged by electrostatic discharges resulting from built-up static electricity. Because of this, special precautions must be taken to minimize or eliminate the possibility of these electrostatic discharges occurring.

Read the following recommendations carefully before handling electronic circuits, printed circuit boards or modules containing electronic components.

- Before handling electronic circuits, discharge the static electricity from your body by touching and momentarily holding a grounded metal object (e.g. a pipe or cabinet).
- Avoid the build-up of static electricity on your body by not wearing synthetic clothing material, as these tend to generate and store static electric charges. Cotton or cotton blend materials are preferred because they do not store static electric charges.
- Do not handle electronic circuits unless it is absolutely necessary. Only hold modules by their front panel handles.
- Do not touch printed circuit boards, their connectors or their components with conductive devices or with your hands.
- Put the electronic circuit, printed circuit board or module containing electronic components into an antistatic protective bag immediately after removing it from the system rack.

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1 INTRODUCTION TO ICE DETECTION SYSTEMS

1.1 Reasons for using an Ice Detection System

Turbomachinery operating in an environment where intake air is moisture laden and the ambient temperature is below 0°C (+32°F) runs the risk of engine icing. Supercooled water droplets suspended in the intake air may freeze upon impact with engine parts such as the intake air filter, turbine bullet nose or stator vanes. The problem is worsened by the fact that the increase in air velocity in the intake ducting causes a temperature reduction, therefore engine icing is possible at ambient air temperatures above 0°C (+32°F).

Ice accretion on engine parts deteriorates engine efficiency due to disrupted airflow. If significant layers are allowed to build up, pieces of ingested ice are likely to cause damage to the turbine, leading to costly repair and down time. When engine anti-icing/de-icing is performed by injecting hot bleed air into the cold intake air, the efficiency of the engine also drops.

A reliable ice detection system is a cost effective solution to engine icing. Deicing may be used only when and as long as necessary, thereby increasing engine efficiency while protecting the turbine against damage due to ice ingestion.

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2 COMPONENTS DESCRIPTIONS

The ice detection system described in this manual is intended for aeroderivative and heavy-duty gas turbines. It consists of the items listed in Table 2-1.

1	EW 140 ice sensor
2	EC 119 cable assembly
3	JB 105 junction box
4	Field cable
5	DIC 413 de-icing controller

Table 2-1: Items constituing the ice detection system.

Figure 2-1 shows these items used in a typical application; the monitoring of ice formation on an LM 2500 gas turbine.

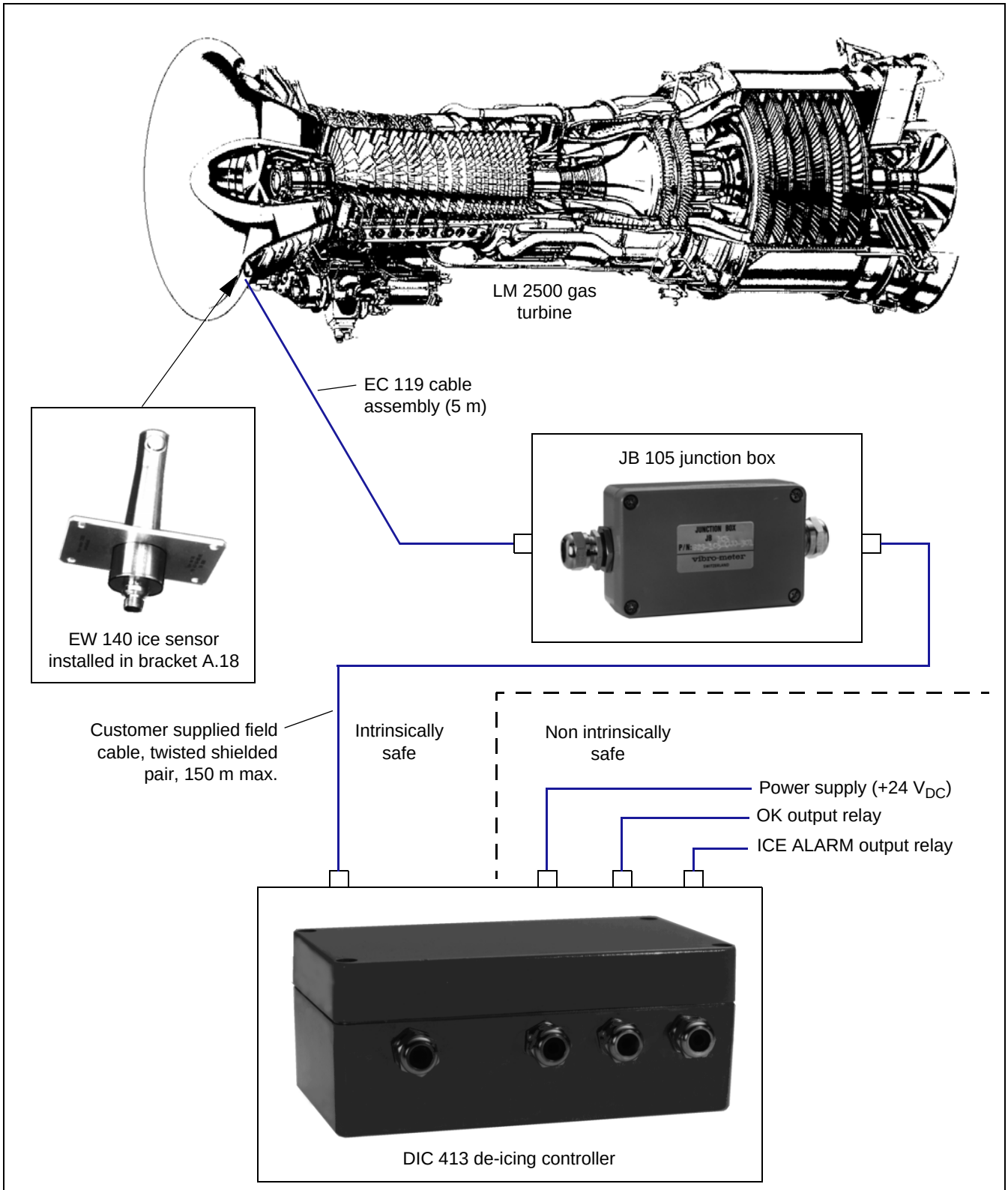

Figure 2-1: LM 2500 ice detection system overview

2.1 EW 140 Ice Sensor

The EW 140 is a probe type ice sensor, meaning that a small metal tube protrudes into the intake air flow (see Figure 2-2). The ice-sensitive element is a small vibrating metallic diaphragm, which sits at the extremity of this supporting tube and must face the intake airflow. Several versions of the sensor exist and these can be used with various types of gas turbines.

The ice thickness on the sensitive element of the sensor is continuously monitored. The presence of water (as opposed to ice) on the sensitive element produces the opposite effect on the sensor output. This allows the EW 140 to clearly discriminate between ice and water, ensuring that there are no false alarms due to water or any liquid contaminant on the sensing element.

The EW 140 is very sensitive. When it is used with the DIC 413 de-icing controller, the ice thickness alarm level can be set as low as 0.2 mm (8 mil).

The ice sensor was designed to meet the stringent environmental requirements of a gas generator : it is hermetically sealed, is very rugged and has good resistance to corrosion and abrasion. High reliability has been achieved thanks to (i) the relatively straightforward physical principle behind this type of ice sensor, which is inherently reliable, and (ii) the choice of high quality components.

The EW 140 is certified as being intrinsically safe and is suitable for use in potentially explosive atmospheres. It conforms to the EN 60079-0 and EN 60079-11 standards. It is ATEX certified and has protection type Ex ib IIB T5.

NOTE: Refer to Appendix A - EC Type Examination Certificates for further information.

The specifications of the product can be found in the EW 140 & DIC 413 data sheet.

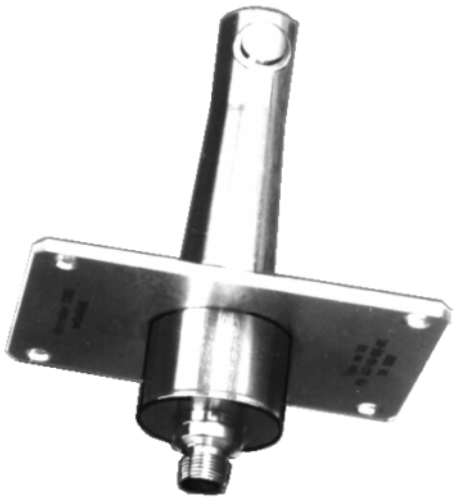

Figure 2-2: The EW 140 ice sensor

2.1.1 Versions

The EW 140 ice sensor is available in 3 different versions depending on the application. Table 2-2 shows these versions of the EW 140.

Version	Comments
-011	*Shortest version.* *Specifically designed to fit on bracket A-18 on the front frame of the LM 2500 gas generator, but can be used on any gas turbine (e.g. Siemens V94.2).*
-111	*Longer than Version 011.* *Used mainly for certain Alstom gas turbines (e.g. GT13).*
-121	*Longest version available.* *Intended for thick-walled, heavy-duty gas turbines where the wall thickness is between 3" and 4.5" (7.5 cm and 11 cm).* *Typically GE Frames 5, 6, 7 and 9 have these dimensions.* *Adaptation of the sensor to the particular installation is the responsibility of the purchaser.*

Table 2-2: Versions of the EW 140.

Refer to the corresponding data sheet for further information on dimensions.

2.1.2 Operation

2.1.2.1 Operating principle

The measuring principle is based on a continuously vibrating diaphragm, made of a corrosion resistant bronze-aluminium alloy. This diaphragm is forced into oscillation at its resonant or natural frequency by a piezoelectric material, which is driven by an electronic oscillator located in the ice sensor. The resonant frequency is ultrasonic (above 70 kHz) and the maximum oscillation amplitude very small (under 1 micrometer or 0.04 mil) so that effectively there are no moving parts.

Ice accretion on the diaphragm increases its stiffness, or rather increases the average stiffness of the ice-diaphragm system, causing the natural frequency and oscillator frequency to increase.

Water or liquid contaminants increase the diaphragm weight without increasing its stiffness, causing the natural frequency and oscillator frequency to drop. This gives a clear discrimination between ice and liquid.

2.1.2.2 Failure detection

Sensor failures, such as electronic failure, piezoelectric material damage, broken wire or mechanical damage will either stop the oscillator altogether or the oscillator frequency will move out of the normal measurement range.

This gives a simple, reliable, built-in means of self test; all that is needed is to check that the oscillator frequency in the normal measurement range.

If the output frequency of the sensor is not in the normal operating range, this is immediately detected and indicated by the DIC 413 de-icing controller.

2.1.2.3 Output signal

The output of the EW 140 ice sensor is a frequency modulated current with a DC component. This signal is read on the sensor oscillator circuit power supply lines.

1- Signal Amplitude :

DC component is 8 mA nominal (24 V_{DC})

AC component is 3 mA peak-peak (24 V_{DC})

2- Frequency Band :

The normal operating frequency band is 60 kHz to 100 kHz

2.2 EC 119 Cable Assembly

The EC 119 is a heavy-duty, environmentally resistant cable assembly that connects the EW 140 ice sensor to the JB 105 junction box. It is terminated at one end by a Vibro-Meter CG 505 connector (for connecting to the EW 140) and at the other end by a Ø11 mm adapter. See Figure 2-3 and the wiring diagram in Chapter 4 - Electrical Connections.

The cable assembly features a high quality Vibro-Meter MTLN 205A cable (MTLN = medium temperature, low noise). This is a two-core, shielded cable with PTFE insulation. It is contained within a galvanized steel flexible leaktight tube.

The cable assembly used in the ice detection system is 5 meters (16 ft 5 in) long. The maximum weight of this assembly is 650 grams (23 oz).

The operating temperature range of the EC 119 is -55°C to +200°C (-67°F to +392°F).

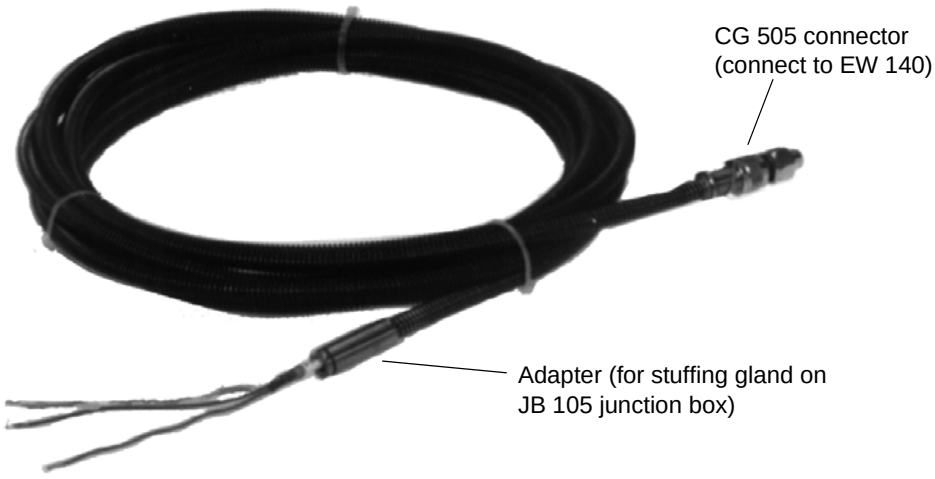

Figure 2-3: The EC 119 cable assembly

2.3 JB 105 Junction Box

The JB 105 junction box allows fast connection/disconnection between the heavy-duty EC 119 cable assembly and the field cable provided by the customer, which connects the junction box to the DIC 413 de-icing controller.

Refer to the JB 105 data sheet for further information.

Figure 2-4: The JB 105 junction box

2.4 Field cable supplied by customer

This cable connects the JB 105 junction box to the DIC 413 de-icing controller. It is usually supplied by the customer, but Vibro-Meter can offer a number of quality cables that are suitable for this application.

When the customer provides this cable, the minimum requirements outlined in 3.3 - Field Cable must be fulfilled. Basically a quality, twisted, shielded pair cable, maximum 150 meters (164 yards) long, will fulfil requirements.

2.5 DIC 413 De-Icing Controller

This signal processor is housed in a rugged die-cast aluminium box (see Figure 2-5) that withstands 100 % humidity and meets the splashproof requirements of NEMA 12.

The DIC 413 provides power to and reads the signal from one EW 140 ice sensor. When the ice thickness alarm level has been exceeded on the sensitive element of the ice sensor, this is immediately detected by the processor, which then activates the ICE ALARM output relay.

A continuous, built-in automatic test function is provided. Any failure in the system (due to the EW 140 ice sensor, the connecting cables or the DIC 413 de-icing controller itself) causes a change of state of the OK relay output. The DIC 413 can, therefore, be used as an actuator of a visible alarm and/or an automatic controller of the engine de-icing system.

The DIC 413 is certified as being intrinsically safe and is suitable for use in potentially explosive atmospheres. It conforms to the EN 60079-0 and EN 60079-11 standards. It is ATEX certified and has protection type [Ex ib] IIB.

NOTE: Refer to Appendix A - EC Type Examination Certificates for further information.

The specifications of the product can be found in the EW 140 & DIC 413 data sheet.

Figure 2-5: The DIC 413 de-icing controller

2.5.1 Operation

The DIC 413 de-icing controller provides power to and receives the current modulated signal from the EW 140 ice sensor. The frequency of this current modulated signal is measured by the controller. If it exceeds a pre-determined value, indicating that the ice thickness on the sensitive element of the EW 140 ice sensor is greater than a pre-determined thickness, the ICE ALARM OUTPUT relay (RE2) of the controller is activated.

The ice thickness alarm level is factory set at 0.2 mm (8 mils) but can be adjusted by changing jumper connections inside the controller box (see Table 2-3).

Jumper	Alarm Setting
J1	*Alarm level = 0.2 mm (8 mils) (factory-set value)*
J2	*Alarm level = 0.5 mm (20 mils)*
J3	*Alarm level = 1.0 mm (40 mils)*
J4 & J5	*These may be used to switch in resistors provided by the user to enable his own customized alarm levels to be set (in the range 0.2 to 2.0 mm)*

Table 2-3: Jumpers to set the alarm level.

The DIC 413 also has a continuous, built-in, automatic test feature that checks to see if the frequency output by the ice sensor is in the normal operating range. If this is not the case, the OK OUTPUT relay (RE1) of the controller is deactivated, indicating a failure. This test is simple but extensive because the complete measurement chain is continuously checked up to (but not including) the output relays of the controller.

An internal or external power supply failure is considered as a failure and will deactivate the OK OUTPUT relay.

The DIC 413 also outputs an analog signal on the F/U OUTPUT. This is a voltage varying between 0 V and 10 V which is proportional to the frequency of the current modulated signal received from the EW 140 ice sensor. This voltage corresponds to the situations listed in Table 2-4.

Voltage on F/U OUTPUT	Corresponding Situation
Between 0 and 1 V_{DC}	*System failure or measurement range exceeded, causing saturation*
Between 2 V_{DC} and 4.8 V_{DC}	*Liquid or contaminants on the ice sensor's sensitive surface*
5 V_{DC} ± 0.2 V_{DC}	*Clean sensor, no ice or liquid on the sensitive surface*
Between 5.2 V_{DC} and 10 V_{DC}	*Clean sensor, no ice or liquid on the sensitive surface. Refer to the graph of output voltage vs ice thickness that can be found on the data sheet (applicable for clear ice at -20°C).*

Table 2-4: Definition of voltage ranges for F/U OUTPUT.

2.5.2 Relay characteristics

2.5.2.1 OK OUTPUT (Relay RE1)

This output can be user-configured by opening/short-circuiting solder bridge points 1 and 2 on the DIC 413 board :

1- Solder point 1 closed with point 2 open (= the factory-set configuration) :

The OK OUTPUT is normally short-circuited, but becomes open-circuit when a problem is detected.

2- Solder point 1 open with point 2 closed :

The OK OUTPUT is normally open-circuit, but becomes short-circuited when a problem is detected.

2.5.2.2 ICE ALARM Output (Relay RE2)

This output can be user-configured by opening/short-circuiting solder bridge points 3 and 4 on the DIC 413 board :

1- Solder point 3 closed with point 4 open (= the factory-set configuration) :

The ICE ALARM output is normally open-circuit when no ice is detected, but becomes short-circuited when ice is present.

2- Solder point 3 open with point 4 closed :

The ICE ALARM output is normally short-circuited, but becomes open-circuit when ice is present.

Both relays have the same output characteristics as those used on the Vibro-Meter relay printed circuit board, type 204-010-550. Refer to the data sheet for this product for further information (see Related documentation on page v).

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3 INSTALLATION

3.1 Requirements for equipment used in potentially explosive atmospheres

TO ENSURE THAT THE EQUIPMENT CAN SAFELY BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES, IT IS ESSENTIAL TO RESPECT THE CRITERIA MENTIONED IN THE "EC TYPE EXAMINATION CERTIFICATE".

AN "X" OR A "U" PLACED AFTER THE CERTIFICATE NUMBER INDICATES THAT THE EQUIPMENT IS SUBJECT TO SPECIAL CONDITIONS FOR SAFE USE. THESE CONDITIONS ARE MENTIONED IN THE "SCHEDULE" SECTION OF THE CERTIFICATE.

REFER TO APPENDIX A - EC TYPE EXAMINATION CERTIFICATES FOR FURTHER INFORMATION.

3.2 EW 140 Ice Sensor

Refer to the corresponding data sheet for information on dimensions for mounting the sensor.

When mounting the EW 140, ensure that its casing makes good electrical contact with the turbine casing in order to assure correct earthing.

In the case of version -121, note that the mounting surface must be perpendicular to the hole through the turbine wall to ensure there is no shock vibration near the diaphragm.

3.3 Field Cable

The field cable that connects the JB 105 junction box to the DIC 413 de-icing controller is usually customer supplied. In order to fulfil operational and intrinsic safety requirements, this cable must meet the specifications given in Table 3-1.

Parameter	Value
Cable form	*2-core, twisted, shielded*
Max. cable length	*150 m*
Max. conductor resistance	*R < 50 Ω/km*
Max. capacitance between conductors	C_p *< 150 pF/m*
Max. capacitance between conductors and shield	C_f *< 150 pF/m*
Max. breakdown voltage	*1.5* kV_{RMS}

Table 3-1: Field cable specifications.

Vibro-Meter's K210 cable fulfils all the requirements given in Table 3-1. Refer to the K210 data sheet for further information.

3.4 DIC 413 De-Icing Controller

Refer to the wiring diagram in Chapter 4 for information on electrical connections to the unit.

4 ELECTRICAL CONNECTIONS

4.1 General precautions

THE LENGTHS OF THE CABLES (INTEGRAL CABLES AND CABLE ASSEMBLIES) INSTALLED IN POTENTIALLY EXPLOSIVE ATMOSPHERES MUST BE DETERMINED AS PER THE CRITERIA OUTLINED IN THE EC TYPE EXAMINATION CERTIFICATE FOR THE PRODUCT.

4.2 General wiring diagram

NOTE: Information on connecting the equipment to the electronic monitoring system can be found on the project-specific wiring diagram delivered with the system.

Additional information is given in the general wiring diagram listed in Table 4-1.

	Wiring diagram	Figure
Gas turbine ice detection system for use in potentially explosive atmospheres	047-140-000E011	Figure 4-1

Table 4-1: Index of general wiring diagram.

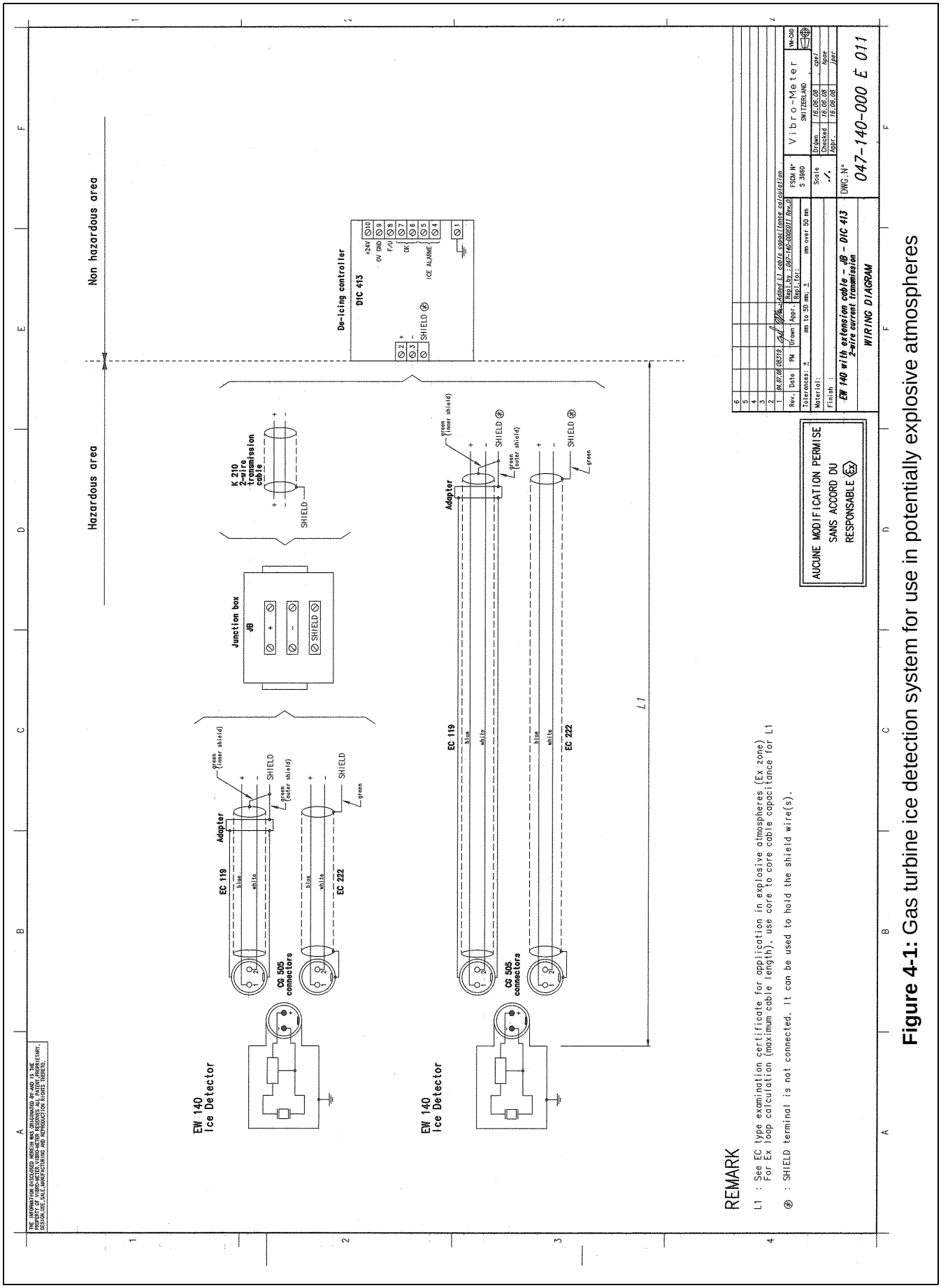

Figure 4-1: Gas turbine ice detection system for use in potentially explosive atmospheres

5 MAINTENANCE

5.1 Maintenance

5.1.1 General

No specific maintenance is required for the EW 140 ice sensor or DIC 413 de-icing controller, or any associated equipment described in this manual.

NOTE: Any attempt by unauthorized personnel to modify or repair equipment still under guarantee will invalidate the warranty.

Refer to 6 - Customer Support for contact details for repairing defective hardware.

5.1.2 Requirements for equipment used in potentially explosive atmospheres

ANY MAINTENANCE WORK PERFORMED ON VIBRO-METER EQUIPMENT THAT CAN BE USED IN POTENTIALLY EXPLOSIVE ATMOSPHERES MUST RESPECT THE CRITERIA MENTIONED IN THE "EC TYPE EXAMINATION CERTIFICATE".

REFER TO APPENDIX A - EC TYPE EXAMINATION CERTIFICATES FOR FURTHER INFORMATION.

DO NOT ATTEMPT TO MODIFY OR REPAIR THESE PRODUCTS.

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6 CUSTOMER SUPPORT

6.1 Contacting us

Vibro-Meter's worldwide customer support network offers a range of support including 6.2 - Technical support and 6.3 - Sales and repairs support. For customer support, please contact your local Vibro-Meter representative. Alternatively, contact our main office:

Customer support
Vibro-Meter SA
Route de Moncor 4
PO Box 1616
CH-1701 Fribourg
Switzerland

Tel.: +41 (0)26 407 11 11
e-mail: energysupport@ch.meggitt.com
web: www.vibro-meter.com

6.2 Technical support

Vibro-meter's technical support team provide both pre-sales and post-sales technical support, including:

1- General advice

2- Technical advice

3- Troubleshooting

4- Site visits

NOTE: For further information, please contact Vibro-Meter (see 6.1 - Contacting us).

6.3 Sales and repairs support

Vibro-Meter's sales team provide both pre-sales and post-sales support, including advice on:

1- New products

2- Spare parts

3- Repairs

NOTE: If a product has to be returned to Vibro-Meter for repairs, then it should be accompanied by a completed Failure report form on page 6-3.

6.4 Customer feedback

As part of our continuing commitment to improving customer service, we warmly welcome your opinions. To provide feedback, please complete the Customer feedback form on page 6-5 and return it Vibro-Meter's main office (see 6.1 - Contacting us).

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FAILURE REPORT FORM

If the product has to be returned to Vibro-Meter for repairs, then:

1- Complete this failure report form

2- Attach a photocopy of this report to the faulty unit and retain the original copy for your records

3- Send the product together with the attached failure report form to Vibro-Meter by registered post

NOTE: Please provide as much information as possible in order to assist fault diagnosis.

NOTE: A failure report MUST be sent with each faulty product.

Contact details:

Name _____ Job title _____

Company _____ Email _____

Address _____

Country _____ Post code _____

Telephone _____ Fax _____

Signature _____ Date _____

Product details:

Product type: _____

Serial number (S/N): _____ Part number (P/N): _____

Vibro-Meter order number: _____

Date of purchase: _____ Site where installed: _____

Is the failure (put an ☒ where appropriate):

☐ Continuous ? ☐ Intermittent ? ☐ Temperature dependent?

Description of failure:

_____

_____

_____

_____

_____

(Please continue overleaf)

(Continued)

(Please continue on a separate sheet if necessary)

CUSTOMER FEEDBACK FORM

Title of manual:

GAS TURBINE ICE DETECTION SYSTEM

Reference: MAEW-DIC/E **Version:** **Edition 3** **Date of issue:** April 21/09

Customer contact details:

Name _____ Job Title _____

Company _____ *Email* _____

Address _____

Signature _____ *Date* _____

General feedback:

Please answer the following questions:

• Is the document well organized?	**Yes**	**No**
• Is the information technically accurate?	**Yes**	**No**
• Is more technical detail required?	**Yes**	**No**
• Are the instructions clear and complete?	**Yes**	**No**
• Are the descriptions easy to understand?	**Yes**	**No**
• Are the examples and diagrams/photos helpful?	**Yes**	**No**
• Are there enough examples and diagrams/photos?	**Yes**	**No**
• Is the style/wording easy to read?	**Yes**	**No**
• Is any information not included? (please list in “comments” below)	**Yes**	**No**

Additional feedback:

_____

_____

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_____

(Please continue overleaf)

(Continued)

(Please continue on a separate sheet if necessary)

Appendices

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A EC TYPE EXAMINATION CERTIFICATES

Refer to Table A-1.

Product(s) covered	Certificate(s)
EW 140	*LCIE 02 ATEX 6096 X*
	CSA LR 62075-3
DIC 413	*LCIE 02 ATEX 6091 X*
	CSA LR 62075-3

Table A-1: Relevant “EC Type Examination Certificates”.

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Vibro-Meter

ATEX Certificate :

LCIE_02ATEX_6096_X

for EW 140

Although the certificate is available in the 3 languages (English, French and German), the liability of the notified body applies only on the text of the original copy of the certificate that it published.

EN

Bien que le certificat soit traduit dans les 3 langues (Anglais, Français et Allemand), seul le texte de la copie originale du certificat peut engager la responsabilité de l'organisme notifié qui l'a publié.

FR

Obwohl das Zertifikat in drei Sprachen (Englisch, Französisch und Deutsch) übersetzt ist, können nur die bescheinigten Behörden, die den Text auf der Originalausgabe des Zertifikates herausgegeben haben, zur rechtlichen Verantwortung gezogen werden.

DE

EX

Vibro-Meter S.A.
Route de Moncor 4
CH - 1701 Fribourg
Switzerland

www.vibro-meter.com

MEGGiTT

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CETTE PAGE EST LAISSÉE INTENTIONNELLEMENT VIDE
DIESE SEITE WURDE ABSICHTLICH LEER GELASSEN

1 **ATTESTATION D'EXAMEN CE DE TYPE**

2 Appareils et systèmes de protection destinés à être utilisés en atmosphères explosibles
Directive 94/9/CE

3 Numéro de l'attestation CE de type
LCIE 02 ATEX 6096 X

4 Appareil ou système de protection
Capteur de glace
Type : EW 140

5 Demandeur : VIBRO-METER S.A.

6 Adresse : BP 1071
1701 FRIBOURG - SUISSE

7 Cet appareil ou système de protection et ses variantes éventuelles acceptées est décrit dans l'annexe de la présente attestation et dans les documents descriptifs cités en annexe.

8 Le LCIE, organisme notifié sous la référence 0081 conformément à l'article 9 de la directive 94/9/CE du Parlement européen et du Conseil du 23 mars 1994, certifie que cet appareil ou système de protection est conforme aux exigences essentielles en ce qui concerne la sécurité et la santé pour la conception et la construction d'appareils et de systèmes de protection destinés à être utilisés en atmosphères explosibles, données dans l'annexe II de la directive. Les vérifications et épreuves figurent dans notre rapport confidentiel N° 41 031 010 R.

9 Le respect des exigences essentielles en ce qui concerne la sécurité et la santé est assuré par la conformité aux documents suivants :
- EN 50014 (1997) + amendements 1 et 2
- EN 50020 (1994)

10 Le signe X lorsqu'il est placé à la suite du numéro de l'attestation, indique que ce matériel ou système de protection est soumis aux conditions spéciales pour une utilisation sûre, mentionnées dans l'annexe de la présente attestation.

11 La présente attestation d'examen CE de type porte uniquement sur la conception, l'examen et l'essai de l'équipement ou du système de protection spécifié conformément à la directive 94/9/CE.
Toutes autres exigences de la Directive sont applicables au procédé de fabrication et de livraison de cet équipement ou système de protection. Ces derniers ne sont pas couverts par la présente attestation.

12 Le marquage de l'appareil ou du système de protection devra comporter, entre autres indications utiles, les mentions suivantes :

Ex II 2 G

EEx ib IIB T5 Tamb maxi = + 60 °C

1 **EC TYPE EXAMINATION CERTIFICATE**

2 Equipment or Protective System Intended for use in Potentially explosive atmospheres
Directive 94/9/EC

3 EC type Examination Certificate number
LCIE 02 ATEX 6096 X

4 Equipment or Protective system
Ice detection
Type : EW 140

5 Applicant : VIBRO-METER S.A.

6 Address : BP 1071
1701 FRIBOURG - SUISSE

7 This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein refered to.

8 LCIE, notified body number 0081 in accordance with article 9 of the directive 94/9/EC of the European Parliament and Council of 23 March 1994, certifies that this equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective system intended for use in potentially explosive atmospheres, given in Annex II to the directive.
The examination and test results are recorded in confidential report No 41 031 010 R.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with :

- EN 50014 (1997) + amendments 1 and 2
- EN 50020 (1994)

10 If the sign X is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate.

11 This EC Type examination certificate relates only to the design, examination and tests of the specified equipment or protective system in accordance to the directive 94/9/EC.

Further requirements of the Directive apply to the manufacturing process and supply of this equipment or protective system. These are not covered by this certificate.

12 The marking of the equipment or protective system shall include the following :

Ex II 2 G

EEx ib IIB T5 Tamb maxi = + 60 °C

Fontenay-aux-Roses, le 10 septembre 2002

Le Directeur de l'organisme certificateur
Manager of the certification body

Par délégation
Michel BRÉNON
Directeur adjoint
à la Certification

Timbre society seal

LABORATOIRE CENTRAL DES INDUSTRIES ELECTRIQUES
Société anonyme à Directoire et Conseil de surveillance au capital de 15 745 984 euros - RCS Nanterre B 408 363 174
33, avenue du Général Leclerc - BP n° 8 - F 92266 FONTENAY-AUX-ROSES CEDEX - Tél. : +33 1 40 95 60 60

(A1) **ANNEXE**

(A2) **ATTESTATION D'EXAMEN CE DE TYPE**
LCIE 02 ATEX 6096 X

(A3) Description de l'équipement ou du système de protection

Capteur de glace
Type : EW 140

Ce capteur permet la détection et la mesure d'une épaisseur de glace déposée sur sa membrane et de transmettre l'information vers une zone non dangereuse.

Le marquage sera le suivant :

VIBRO-METER S.A.
Adresse : ...
Type : EW 140
N° de fabrication : ...
Année de fabrication : ...
Ex II 2 G
EEx ib IIB T5 Tamb maxi = + 60 °C
LCIE 02 ATEX 6096 X

Le marquage CE est accompagné du numéro d'identification de l'organisme notifié responsable de la surveillance du système approuvé de qualité (0081 pour le LCIE).

Le matériel devra également comporter le marquage normalement prévu par les normes de construction du matériel électrique concerné.

Paramètres spécifiques du ou des modes protection concernés :

Ui ≤ 32 V	Ii ≤ 25 mA	Pi ≤ 0,8 W
Ri ≤ 0	Ci ≤ 0	Li = 0

(A4) Documents descriptifs

Dossier technique N° DT 1007, rév. 1 du 15 mars 2002.
Ce document comprend 9 rubriques (13 pages).

(A5) Conditions spéciales pour une utilisation sûre

L'appareil est un matériel à sécurité intrinsèque et peut être placé en atmosphères explosibles.

L'appareil ne pourra être associé qu'à un matériel de sécurité intrinsèque d'un type certifié et cette association devra être compatible du point de vue de la sécurité intrinsèque.

Les caractéristiques électriques de la source d'alimentation ne devront excéder les valeurs suivantes :

Uo ≤ 32 V ; Icco ≤ 25 mA ; Po ≤ 0,8 W

Classement en température : T5 à Ta = + 60 °C.

(A6) Exigences essentielles en ce qui concerne la sécurité et la santé

La conception du matériel satisfait aux normes européennes EN 50014 (1997 + amendements 1 et 2) et EN 50020 (1994).

(A1) **SCHEDULE**

(A2) **EC TYPE EXAMINATION CERTIFICATE**
LCIE 02 ATEX 6096 X

(A3) Description of Equipment or protective system

Ice detection
Type : EW 140

This equipment is able to detect and measure the ice strength on its diaphragm. The detector does data processing to a safe atmosphere.

The marking will be the following :

VIBRO-METER S.A.
Address : ...
Type : EW 140
Serial number : ...
Year of construction : ...
Ex II 2 G
EEx ib IIB T5 Tamb maxi = + 60 °C
LCIE 02 ATEX 6096 X

The CE marking shall be accompanied by the identification number of the notified body responsible for surveillance of the approved quality system (0081 for LCIE).

The equipment must also carry the usual marking required by the manufacturing standards applying to such equipments.

Specific parameters of the mode of protection concerned :

Ui ≤ 32 V	Ii ≤ 25 mA	Pi ≤ 0,8 W
Ri ≤ 0	Ci ≤ 0	Li = 0

(A4) Descriptive documents :

Technical file n° DT 1007, rev. 1 dated on March 15th, 2002.
This file includes 9 items (13 pages).

(A5) Special conditions for safe use

The apparatus is intrinsically safe and can be used in potentially explosive atmospheres.

The above mentioned apparatus must only be associated to a IS certified apparatus, and this combination must be compatible as regards intrinsic safety.

Electric specifications of supply system must not exceed the following values :

Uo ≤ 32 V ; Icco ≤ 25 mA ; Po ≤ 0,8 W

Temperature classification : T5 to Ta = + 60 °C.

(A6) Essential Health and Safety Requirements

The design of the equipment complies to european standards EN 50014 (1997 + amendments 1 and 2) and EN 50020 (1994).

05-a

L C I E

1 **AVENANT D'ATTESTATION D'EXAMEN CE DE TYPE**

2 **Appareil ou système de protection** destiné à être utilisé en atmosphères explosibles **(Directive 94/9/CE)**

3 Numéro de l'avenant :
LCIE 02 ATEX 6096 X / 01

4 Appareil ou système de protection :
Capteur de glace
Type : EW 140

5 Demandeur : VIBRO-METER S.A.

15 **DESCRIPTION DE L'AVENANT**

- Mise à jour normative selon les normes :
EN 60079-0 (2006) et EN 60079-11 (2007)
- Ajout de la plage de température ambiante dans les conditions spéciales d'utilisation sûres

Les résultats des vérifications et essais figurent dans le rapport confidentiel N° 60056381-557031 / 11

Paramètres spécifiques du ou des modes de protection concerné(s) :
Inchangés

Le marquage doit être :
Modifié comme suit:
EEx devient Ex

Ui ≤ 32 V	Ii ≤ 25 mA
Pi ≤ 0,8 W	Ri ≈ 0
Ci ≈ 0	Li ≈ 0

16 **DOCUMENTS DESCRIPTIFS**

Dossier de certification N° DT 1030 du 05/03/2007.
Ce dossier comprend 2 rubriques (7 pages).

17 **CONDITIONS SPECIALES POUR UNE UTILISATION SURE**
Température d'utilisation : -55°C à +60°C

18 **EXIGENCES ESSENTIELLES DE SECURITE ET DE SANTE**
Couvertes par les normes :
EN 60079-0 (2006) et EN 60079-11 (2007)

19 **VERIFICATIONS ET ESSAIS INDIVIDUELS**
Inchangés

Fontenay-aux-Roses, le 23 octobre 2007

1 **SUPPLEMENTARY EC TYPE EXAMINATION CERTIFICATE**

2 **Equipment or protective system** intended for use in potentially explosive atmospheres **(Directive 94/9/EC)**

3 Supplementary certificate number :
LCIE 02 ATEX 6096 X / 01

4 Equipment or protective system :
Ice detection
Type : EW 140

5 Applicant : VIBRO-METER S.A.

15 **DESCRIPTION OF THE SUPPLEMENTARY CERTIFICATE**
- Normative update according to standards' :
EN 60079-0 (2006) and EN 60079-11 (2007)
- Adding of operational temperature range in clause "special conditions for safe use

The examination and test results are recorded in confidential report N° 60056381-557031 / 11

Specific parameters of the mode(s) of protection concerned:

Unchanged

The marking shall be :
Modified as follows :
EEx becomes Ex

Ui ≤ 32 V	Ii ≤ 25 mA
Pi ≤ 0,8 W	Ri ≈ 0
Ci ≈ 0	Li ≈ 0

16 **DESCRIPTIVE DOCUMENTS**

Certification file N° DT 1030 dated 2007/03/05
This file includes 2 items (7 pages).

17 **SPECIAL CONDITIONS FOR SAFE USE**

Operational temperature : -55°C to +60°C

18 **ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**

Covered by standards:
EN 60079-0 (2006) and EN 60079-11 (2007)

19 **ROUTINE VERIFICATIONS AND TESTS**
Unchanged

Le responsable de certification ATEX
ATEX certification manager

Henri CERVELLO

NOTIFIED BODY 0081

LCIE — 33, av du Général Leclerc — Tél : +33 1 40 95 60 60 — Société Anonyme
Laboratoire Central — BP 8 — Fax : +33 1 40 95 86 56 — au capital de 15 745 984 €
des Industries Electriques — 92266 Fontenay-aux-Roses cedex — contact@lcie.fr — RCS Nanterre B 408 363 177
Une société de Bureau Veritas — France — www.lcie.fr

- Deutsche Übersetzung der originalen französischen Kopie der Seite -1 -

1 **EG-PRÜFZERTIFIKAT**

2 Geräte und Schutzsysteme zur Verwendung in explosionsgefährdeten Bereichen - **Richtlinie 94/9/EG**

3 EG-Zertifikatnummer:
LCIE 02 ATEX 6096 X

4 Gerät oder Schutzsystem
Vereisungsgeber, Typ:
EW 140

5 Hersteller : VIBRO-METER SA

6 Anschrift : BP 1071, CH-1701 FRIBOURG, SCHWEIZ

7 Dieses Gerät oder Schutzsystem und die möglichen, zulässigen Varianten sind im Anhang dieses Zertifikats und den darin aufgeführten Unterlagen beschrieben.

8 LCIE, eingetragen unter der Nummer 0081 gemäß Artikel 9 der Richtlinie 94/9/EG des Europaparlamentes und des Rates vom 23. März 1994, bestätigt, dass dieses Gerät oder Schutzsystem die wesentlichen Gesundheits- und Sicherheitsanforderungen in Bezug auf die Auslegung und die Bauart von Geräten und Schutzsystemen zur Verwendung in explosionsgefährdeten Bereichen nach Anhang II der Richtlinie erfüllt.
Die Prüf- und Testergebnisse sind im vertraulichen Bericht Nr. 41 031 010 R aufgezeichnet.

9 Die Einhaltung der wesentlichen Gesundheits- und Sicherheitsanforderungen wird durch die Übereinstimmung mit den den folgenden Dokumenten sichergestellt :
- EN 50014 (1997) + Änderungen 1 und 2
- EN 50020 (1994)

10 Ein "X" nach der Zertifikatnummer gibt an, dass für die sichere Verwendung des Gerätes oder Schutzsystemes besondere Bedingungen gemäß dem Anhang dieses Zertifikates gelten.

11 Dieses EG-Prüfzertifikat betrifft nur die Bauart und die Prüfungen und Tests des betreffenden Gerätes oder Schutzsystemes nach der Richtlinie 94/9/EG.
Zusätzliche Anforderungen dieser Richtlinie gelten für die Fertigung und Lieferung des Gerätes oder Schutzsystemes.

12 Die Kennzeichnung des Gerätes oder Schutzsystems muss unter anderem die folgenden Angaben enthalten:


II 2 G
EEx ib IIB T5 $T_{amb\ max}$ = + 60°C

Fontenay-aux-Roses, 10. September 2002

Leiter Zertifizierung
Trockenstempel

- Deutsche Übersetzung der originalen französischen Kopie der Seite -1 -

(A1) **ANHANG**

(A2) **EG-PRÜFZERTIFIKAT**
LCIE 02 ATEX 6096 X

(A3) Beschreibung des Gerätes oder Schutzsystems
Vereisungsgeber, Typ:
EW 140
Dieser Fühler dient zur Erkennung und Messung der Eisdicke auf seiner Membran und zur Übertragung der Information in einen ungefährlichen Bereich.
Die Kennzeichnung ist wie folgt :
VIBRO-METER S.A.
Adresse
Typ: EW 140
Herstellungsnummer
Herstellungsjahr

II 2 G
EEx ib IIB T5 $T_{amb\ max}$: + 60°C
LCIE 02 ATEX 6096 X
Die EG-Kennzeichnung wird von der Kennnummer der Stelle, die für die Überwachung des genehmigten Qualitätssystems zuständig ist (0081 für LCIE) begleitet.
Die Geräte müssen ebenfalls mit der Kennzeichnung versehen sein, die in den Herstellungsnormen der betreffenden elektrischen Geräte normalerweise vorgesehen sind.
Spezielle Parameter für die betreffende(n) Schutzart(en) :

$U_i \leq 32$ V, $I_i \leq 25$ mA, $P_i \leq 0.8$ W.

$R_i \leq 0$, $C_i \leq 0$, $L_i = 0$,

(A4) Beschreibende Unterlagen
Technische Unterlagen Nr. DT 1007, Änd. 1 vom 15. März 2002. Dieses Dokument beinhaltet 9 Teile (13 Seiten).

(A5) Spezielle Bedingungen für die sichere Verwendung
Das Gerät ist eigensicher und kann in explosionsgefährdeten Bereichen verwendet werden.
Das Gerät darf nur mit einem eigensicheren Gerät eines zertifizierten Typs verbunden werden und dieser Verbindung muss in Bezug auf die Eigensicherheit kompatibel sein.
Die elektrischen Eigenschaften der Versorgungsquelle dürfen die folgenden Werte nicht überschreiten:

$U_0 \leq 32$ V, $I_{cc0} \leq 25$ mA, $P_0 \leq 0.8$ W.

Temperatureinteilung: T5 bis Ta = + 60 °C.

(A6) Wesentliche Anforderungen in Bezug auf Sicherheit und Gesundheit
Die Bauart des Gerätes entspricht den europäischen Normen EN 50014 (1997 + Änderungen 1 und 2) und EN 50020 (1994).

- Deutsche Übersetzung der original französisch/englischen Kopie der Seite -2 -

1 **ERGÄNZUNG ZUR EG-BAUMUSTERPRÜFBESCHEINIGUNG**

2 **Betriebsmittel oder Schutzsystem** zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen – **Richtlinie 94/9/EG**

3 Nummer der Ergänzungsbescheinigung:
LCIE 02 ATEX 6096 X / 01

4 Betriebsmittel oder Schutzsystem:
Vereisungsdetektor
Typ: EW 140

5 Hersteller: VIBRO-METER S.A.

15 **BESCHREIBUNG DER ERGÄNZUNGSBESCHEINIGUNG**
– Normgerechte Überarbeitung entsprechend den Normen:
EN 60079-0 (2006) und EN 60079-11 (2007)
– Betriebstemperaturbereiche im Abschnitt „Besondere Bedingungen für die sichere Anwendung“ hinzugefügt
Die Ergebnisse der Prüfung sind im vertraulichen Prüfbericht Nr. 60056381-557031 / 11 festgehalten.
Spezifische Kenndaten der betroffenen Schutzarten:
Unverändert
Kennzeichnung:
Nur die folgenden Elemente werden wie folgt geändert:
EEx wird zu EX
$U_i \leq 32$ V $I_i \leq 25$ mA
$P_i \leq 0{,}8$ W $R_i \sim 0$
$C_i \sim 0$ $L_i \sim 0$

16 **BESCHREIBENDE DOKUMENTE**
Bescheinigung Nr. DT 1030 vom 05. März 2007.
Dieses Dokument besteht aus 2 Elementen (7 Seiten).

17 **BESONDERE BEDINGUNGEN FÜR DIE SICHERE ANWENDUNG**
Betriebstemperaturbereich: –55 °C bis +60 °C

18 **GRUNDLEGENDE GESUNDHEITS- UND SICHERHEITSANFORDERUNGEN**
Abgedeckt durch die Normen:
EN 60079-0 (2006) und EN 60079-11 (2007)

19 **ROUTINEMÄßIGE PRÜFUNGEN UND TESTS**
Unverändert
ATEX-Bescheinigungsbevollmächtigter
Die Haftung von LCIE beschränkt sich allein auf den französischen Originaltext. Dieses Dokument darf nur vollständig und ohne Veränderungen vervielfältigt werden.

Fontenay-aux-Roses, 23. Oktober 2007

Leiter Zertifizierung
Trockenstempel

LCIE haftet nur für den französischen Text.
Dieses Zertifikat darf nur vollständig und ohne Änderungen vervielfältigt werden.

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DIESE SEITE WURDE ABSICHTLICH LEER GELASSEN

Vibro-Meter

ATEX Certificate :

LCIE_02_ATEX_6091_X

for DIC 413

Although the certificate is available in the 3 languages (English, French and German), the liability of the notified body applies only on the text of the original copy of the certificate that it published.

EN

Bien que le certificat soit traduit dans les 3 langues (Anglais, Français et Allemand), seul le texte de la copie originale du certificat peut engager la responsabilité de l'organisme notifié qui l'a publié.

FR

Obwohl das Zertifikat in drei Sprachen (Englisch, Französisch und Deutsch) übersetzt ist, können nur die bescheinigten Behörden, die den Text auf der Originalausgabe des Zertifikates herausgegeben haben, zur rechtlichen Verantwortung gezogen werden.

DE

EX

Vibro-Meter S.A.
Route de Moncor 4
CH - 1701 Fribourg
Switzerland

www.vibro-meter.com

MEGGiTT

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DIESE SEITE WURDE ABSICHTLICH LEER GELASSEN

1 **ATTESTATION D'EXAMEN CE DE TYPE**

2 Appareils et systèmes de protection destinés à être utilisés en atmosphères explosibles
Directive 94/9/CE

3 Numéro de l'attestation CE de type
LCIE 02 ATEX 6091 X

4 Appareil ou système de protection
Processeur
Type : DIC 413

5 Demandeur : VIBRO-METER S.A.

6 Adresse : BP 1071
1701 FRIBOURG - SUISSE

7 Cet appareil ou système de protection et ses variantes éventuelles acceptées est décrit dans l'annexe de la présente attestation et dans les documents descriptifs cités en annexe.

8 Le LCIE, organisme notifié sous la référence 0081 conformément à l'article 9 de la directive 94/9/CE du Parlement européen et du Conseil du 23 mars 1994, certifie que cet appareil ou système de protection est conforme aux exigences essentielles en ce qui concerne la sécurité et la santé pour la conception et la construction d'appareils et de systèmes de protection destinés à être utilisés en atmosphères explosibles, données dans l'annexe II de la directive. Les vérifications et épreuves figurent dans notre rapport confidentiel N° 41 031 010 P.

9 Le respect des exigences essentielles en ce qui concerne la sécurité et la santé est assuré par la conformité aux documents suivants :
- EN 50014 (1997) + amendements 1 et 2
- EN 50020 (1994)

10 Le signe X lorsqu'il est placé à la suite du numéro de l'attestation, indique que ce matériel ou système de protection est soumis aux conditions spéciales pour une utilisation sûre, mentionnées dans l'annexe de la présente attestation.

11 La présente attestation d'examen CE de type porte uniquement sur la conception, l'examen et l'essai de l'équipement ou du système de protection spécifié conformément à la directive 94/9/CE.
Toutes autres exigences de la Directive sont applicables au procédé de fabrication et de livraison de cet équipement ou système de protection. Ces derniers ne sont pas couverts par la présente attestation.

12 Le marquage de l'appareil ou du système de protection devra comporter, entre autres indications utiles, les mentions suivantes :

Ex II (2) G

[EEx ib] IIB Tamb maxi = + 60 °C

1 **EC TYPE EXAMINATION CERTIFICATE**

2 Equipment or Protective System Intended for use in Potentially explosive atmospheres
Directive 94/9/EC

3 EC type Examination Certificate number
LCIE 02 ATEX 6091 X

4 Equipment or Protective system
Icing controller
Type : DIC 413

5 Applicant : VIBRO-METER S.A.

6 Address : BP 1071
1701 FRIBOURG - SUISSE

7 This equipment or protective system and any acceptable variation thereto is specified in the schedule to this certificate and the documents therein refered to.

8 LCIE, notified body number 0081 in accordance with article 9 of the directive 94/9/EC of the European Parliament and Council of 23 March 1994, certifies that this equipment or protective system has been found to comply with the Essential Health and Safety Requirements relating to the design and construction of equipment and protective system intended for use in potentially explosive atmospheres, given in Annex II to the directive.
The examination and test results are recorded in confidential report No 41 031 010 P.

9 Compliance with the Essential Health and Safety Requirements has been assured by compliance with :

- EN 50014 (1997) + amendments 1 and 2
- EN 50020 (1994)

10 If the sign X is placed after the certificate number, it indicates that the equipment or protective system is subject to special conditions for safe use specified in the schedule to this certificate.

11 This EC Type examination certificate relates only to the design, examination and tests of the specified equipment or protective system in accordance to the directive 94/9/EC.

Further requirements of the Directive apply to the manufacturing process and supply of this equipment or protective system. These are not covered by this certificate.

12 The marking of the equipment or protective system shall include the following :

Ex II (2) G

[EEx ib] IIB Tamb maxi = + 60 °C

Fontenay-aux-Roses, le 10 septembre 2002

Le Directeur de l'organisme certificateur
Manager of the certification body

Timbre sec/dry seal

Par délégation
Michel BRÉNON
Directeur adjoint
à la Certification

13-c

LABORATOIRE CENTRAL DES INDUSTRIES ELECTRIQUES
Société anonyme à Directoire et Conseil de surveillance au capital de 15 745 984 euros - RCS Nanterre B 408 363 174
33, avenue du Général Leclerc - BP n° 8 - F 92266 FONTENAY-AUX-ROSES CEDEX - Tél. : +33 1 40 95 60 60

(A1) **ANNEXE**

(A2) **ATTESTATION D'EXAMEN CE DE TYPE**
LCIE 02 ATEX 6091 X

(A3) Description de l'équipement ou du système de protection

Processeur
Type : DIC 413

Le processeur DIC 413 sert à l'alimentation d'un capteur de mesure d'épaisseur de glace et au traitement du signal fourni par ce dernier.

Le marquage sera le suivant :

VIBRO-METER S.A.
Adresse : ...
Type : DIC 413
N° de fabrication : ...
Année de fabrication : ...
Ex II (2) G
[EEx ib] IIB Tamb maxi = + 60 °C
LCIE 02 ATEX 6091 X

Le marquage CE est accompagné du numéro d'identification de l'organisme notifié responsable de la surveillance du système approuvé de qualité (0081 pour le LCIE).

Le matériel devra également comporter le marquage normalement prévu par les normes de construction du matériel électrique concerné.

Paramètres spécifiques du ou des modes de protection concernés :

Uo ≤ 32 V, Icco ≤ 20 mA, Po ≤ 0,64 W

(A4) Documents descriptifs

Dossier technique N° DT 1006, rév. 1 du 15 mars 2002.
Ce document comprend 21 rubriques (29 pages).

(A1) **SCHEDULE**

(A2) **EC TYPE EXAMINATION CERTIFICATE**
LCIE 02 ATEX 6091 X

(A3) Description of Equipment or protective system

Icing controller
Type : DIC 413

Icing controller DIC 413 is used as supply for a sensor which measured ice thickness and as data processing given by this sensor.

The marking will be the following :

VIBRO-METER S.A.
Address : ...
Type : DIC 413
Serial number : ...
Year of construction : ...
Ex II (2) G
[EEx ib] IIB Tamb maxi = + 60 °C
LCIE 02 ATEX 6091 X

The CE marking shall be accompanied by the identification number of the notified body responsible for surveillance of the approved quality system (0081 for LCIE).

The equipment must also carry the usual marking required by the manufacturing standards applying to such equipments.

Specific parameters of the mode of protection concerned :

Uo ≤ 32 V, Icco ≤ 20 mA, Po ≤ 0,64 W

(A4) Descriptive documents :

Technical file n° DT 1006, rev. 1 dated on March 15th, 2002.
This file includes 21 items (29 pages).

05-a

(A1) **ANNEXE**

(A2) **ATTESTATION D'EXAMEN CE DE TYPE**
LCIE 02 ATEX 6091 X (suite)

(A5) Conditions spéciales pour une utilisation sûre

Ce type d'appareil est un matériel associé de sécurité intrinsèque. Il ne peut être placé en atmosphère explosible.

Il ne pourra être associé (bornes capteur N° 2-3) qu'à un matériel de sécurité intrinsèque d'un type certifié (par exemple, l'appareil EW140) et cette association devra être compatible du point de vue de la sécurité intrinsèque.

Pour un coefficient de sécurité de 1,5 ; les paramètres électriques sur la ligne raccordant le circuit à sécurité intrinsèque aux bornes du capteur (N° 2-3) doivent rester conformes aux valeurs suivantes :

Co ≤ 0,5 µF ; Lo ≤ 200 mH

Température maximale d'utilisation : + 60 °C

(A6) Exigences essentielles en ce qui concerne la sécurité et la santé

La conception du matériel satisfait aux normes européennes EN 50014 (1997 + amendements 1 et 2) et EN 50020 (1994).

Vérifications et épreuves individuelles :

Essai de rigidité diélectrique du transformateur pendant une minute sous une tension sinusoïdale de 50 Hz, d'une valeur efficace égale à 1500 V entre les enroulements primaire et secondaire.

(A1) **SCHEDULE**

(A2) **EC TYPE EXAMINATION CERTIFICATE**
LCIE 02 ATEX 6091 X (continued)

(A5) Special conditions for safe use

This equipment is "intrinsically safe associated electrical apparatus" and must not be installed in potentially explosive atmospheres.

This equipment must only be associated (sensor terminals No 2-3) to certified IS apparatus (for example, EW140 equipment) and this combination must be compatible as regards intrinsic safety.

For a 1,5 safety factor, electric parameters of terminals which are linked to certified IS apparatus and sensor terminals (N° 2-3) must not exceed following values :

Co ≤ 0,5 µF ; Lo ≤ 200 mH

Maximum operating temperature : + 60 °C

(A6) Essential Health and Safety Requirements

The design of the equipment complies to european standards EN 50014 (1997 + amendments 1 and 2) and EN 50020 (1994).

Individual examinations and tests :

Dielectric strength test of transformer during one minute, with a sine-shaped voltage at 50 Hz of 1500 V r.m.s. between the primary windings and the secondary windings which are interconnected to each other.

1 **AVENANT D'ATTESTATION D'EXAMEN CE DE TYPE**

2 **Appareil ou système de protection** destiné à être utilisé en atmosphères explosibles **(Directive 94/9/CE)**

3 Numéro de l'avenant :
LCIE 02 ATEX 6091 X / 01

4 Appareil ou système de protection :
Processeur
Type : DIC 413

5 Demandeur : VIBRO-METER S.A.

15 **DESCRIPTION DE L'AVENANT**

Mise à jour normative selon les normes :
EN 60079-0 (2006) et EN 60079-11 (2007)

Les résultats des vérifications et essais figurent dans le rapport confidentiel N° 60056381-557031 / 07

Paramètres spécifiques du ou des modes de protection concerné(s) :
Inchangés

Le marquage doit être :
Modifié comme suit:
EEx devient Ex

Um : 32V	Io : 20mA
Uo : 32V	Po : 0,64W
Co : 0,5 µF	Lo : 200mH

16 **DOCUMENTS DESCRIPTIFS**

Dossier de certification N° DT 1030 du 05/03/2007.
Ce dossier comprend 2 rubriques (7 pages).

17 **CONDITIONS SPECIALES POUR UNE UTILISATION SURE**
Inchangées

18 **EXIGENCES ESSENTIELLES DE SECURITE ET DE SANTE**
Couvertes par les normes :
EN 60079-0 (2006) et EN 60079-11 (2007)

19 **VERIFICATIONS ET ESSAIS INDIVIDUELS**
Inchangés

Fontenay-aux-Roses, le 22 octobre 2007

Le responsable de certification ATEX
ATEX certification manager

Henri CERVELLO

1 **SUPPLEMENTARY EC TYPE EXAMINATION CERTIFICATE**

2 **Equipment or protective system** intended for use in potentially explosive atmospheres **(Directive 94/9/EC)**

3 Supplementary certificate number :
LCIE 02 ATEX 6091 X / 01

4 Equipment or protective system :
Icing controller
Type : DIC 413

5 Applicant : VIBRO-METER S.A.

15 **DESCRIPTION OF THE SUPPLEMENTARY CERTIFICATE**
Normative update according to standards' :
EN 60079-0 (2006) and EN 60079-11 (2007)

The examination and test results are recorded in confidential report N° 60056381-557031 / 07

Specific parameters of the mode(s) of protection concerned:

Unchanged

The marking shall be :
Modified as follows :
EEx becomes Ex

Um : 32V	Io : 20mA
Uo : 32V	Po : 0,64W
Co : 0,5 µF	Lo : 200mH

16 **DESCRIPTIVE DOCUMENTS**

Certification file N° DT 1030 dated 2007/03/05
This file includes 2 items (7 pages).

17 **SPECIAL CONDITIONS FOR SAFE USE**

Unchanged

18 **ESSENTIAL HEALTH AND SAFETY REQUIREMENTS**

Covered by standards:
EN 60079-0 (2006) and EN 60079-11 (2007)

19 **ROUTINE VERIFICATIONS AND TESTS**
Unchanged

LCIE — 33, av du Général Leclerc — Tél : +33 1 40 95 60 60 — Société Anonyme
Laboratoire Central des Industries Electriques — BP 8 — 92260 Fontenay-aux-Roses cedex — Fax : +33 1 40 95 86 56 — au capital de 15 745 984 €
Une société de Bureau Veritas — France — contact@lcie.fr — RCS Nanterre B 408 363 174
www.lcie.fr

- Deutsche Übersetzung der originalen französischen Kopie der Seite -1 -

1 **EG-PRÜFZERTIFIKAT**

2 Geräte und Schutzsysteme zur Verwendung in explosionsgefährdeten Bereichen - **Richtlinie 94/9/EG**

3 EG-Zertifikatnummer
LCIE 02 ATEX 6091 X

4 Gerät oder Schutzsystem
Prozessor
Typ:DIC 413

5 Hersteller : VIBRO-METER SA

6 Adresse : BP 1071, CH-1701 FRIBOURG, SCHWEIZ

7 Dieses Gerät oder Schutzsystem und die möglichen, zulässigen Varianten sind im Anhang dieses Zertifikats und den darin aufgeführten Unterlagen beschrieben.

8 LCIE, eingetragen unter der Nummer 0081 gemäß Artikel 9 der Richtlinie 94/9/EG des Europaparlamentes und des Rates vom 23. März 1994, bestätigt, dass dieses Gerät oder Schutzsystem die wesentlichen Gesundheits- und Sicherheitsanforderungen in Bezug auf die Auslegung und die Bauart von Geräten und Schutzsystemen zur Verwendung in explosionsgefährdeten Bereichen nach Anhang II der Richtlinie erfüllt.
Die Prüf- und Testergebnisse sind im vertraulichen Bericht Nr. 41 031 010 P aufgezeichnet.

9 Die Einhaltung der wesentlichen Gesundheits- und Sicherheitsanforderungen wird durch die Übereinstimmung mit den den folgenden Dokumenten sichergestellt :
- EN 50014 (1997) + Änderungen 1 und 2
- EN 50020 (1994)

10 Ein "X" nach der Zertifikatnummer gibt an, dass für die sichere Verwendung des Gerätes oder Schutzsystemes besondere Bedingungen gemäß dem Anhang dieses Zertifikates gelten.

11 Dieses EG-Prüfzertifikat betrifft nur die Bauart und die Prüfungen und Tests des betreffenden Gerätes oder Schutzsystemes nach der Richtlinie 94/9/EG.
Zusätzliche Anforderungen dieser Richtlinie gelten für die Fertigung und Lieferung des Gerätes oder Schutzsystemes.

12 Die Kennzeichnung des Gerätes oder Schutzsystems muss unter anderem die folgenden Angaben enthalten:
Ex II (2) G
[EEx ib] IIB $T_{amb\ max}$ = +60°C

Fontenay-aux-Roses, 10. September 2002

Leiter Zertifizierung
Trockenstempel

LCIE haftet nur für den französischen Text.
Dieses Zertifikat darf nur vollständig und ohne Änderungen vervielfältigt werden.

- Deutsche Übersetzung der originalen französischen Kopie der Seite -1 -

(A1) **ANHANG**

(A2) **EG-PRÜFZERTIFIKAT**
LCIE 02 ATEX 6091 X

(A3) Beschreibung des Gerätes oder Schutzsystems
Prozessor
Typ:DIC 413
Der Prozessor DIC 413 dient zur Versorgung eines Messgebers für die Eisdicke und zur Verarbeitung des vom Messgeber gelieferten Signals.
Kennzeichung :
VIBRO-METER S.A.
Adresse :...
Typ: DIC413
Herstellungsnummer: ...
Herstellungsjahr : ...
Ex II (2) G
[EEx ib] IIB Tamb max = + 60 °C
LCIE 02 ATEX 6091 X
Die EG-Kennzeichnung wird von der Kennnummer der Stelle begleitet, die für die Überwachung des genehmigten Qualitätssystems verantwortlich ist (0081 für LCIE).
Die Geräte müssen ebenfalls mit der Kennzeichnung versehen sein, die in den Herstellungsnormen der betreffenden elektrischen Geräte normalerweise vorgesehen sind.
Spezielle Parameter der betreffenden Schutzart(en) :
$U_0 \leq \pm 32$ V; $I_{cc0} \leq 20$ mA; $P_0 \leq 0.64$ W.

Beschreibende Unterlagen
Technische Unterlagen Nr DT 1006, Änd. 1 vom 15. März 2002. Dieses Dokument umfasst 21 Teile (29 Seiten).

- Deutsche Übersetzung der originalen französischen Kopie der Seite -2 -

(A1) **ANHANG**

(A2) **EG-PRÜFZERTIFIKAT**
LCIE 02 ATEX 6091 X (Fortsetzung)

(A5) Spezielle Bedingungen für eine sichere Verwendung:
Dieser Gerätetyp ist ein dazugehöriges, eigensicheres Gerät. Es kann nicht in explosionsgefährdeten Bereichen verwendet werden.
Es kann nur (Klemmen Geber Nr. 2-3) an ein eigensicheres Gerät eines zertifizierten Typs (z.B. Gerät EW 140) angeschlossen werden und diese Verbindung muss in Bezug auf die Eigensicherheit kompatibel sein.
Bei einem Sicherheitskoeffizienten von 1,5 müssen die elektrischen Parameter der Leitung, die den eigensicheren Kreis mit den Geberklemmen (Nr. 2-3) verbindet, den folgenden Werten entsprechen :
$C_0 \leq 0{,}5\ \mu F$; $L_0 \leq 200$ mH
Maximale Verwendungstemperatur: + 60°C

(A6) Wesentliche Anforderungen in Bezug auf Sicherheit und Gesundheit:
Die Bauart des Gerätes entspricht den europäischen Normen EN 50014 (1997 + Änderungen 1 und 2) und EN 50020 (1994).
Einzeltests und -prüfungen :
Prüfung der dielektrischen Festigkeit des Transformators unter Sinusspannung 50 Hz mit einem Effektivwert von 1.500 V zwischen der primären und der sekundären Wicklung.

Seite 3/3

- Deutsche Übersetzung der original französisch/englischen Kopie der Seite -2 -

1 **ERGÄNZUNG ZUR EG-BAUMUSTERPRÜFBESCHEINIGUNG**

2 **Betriebsmittel oder Schutzsystem** zur bestimmungsgemäßen Verwendung in explosionsgefährdeten Bereichen – **Richtlinie 94/9/EG**

3 Nummer der Ergänzungsbescheinigung:
LCIE 02 ATEX 6091 X / 01

4 Betriebsmittel oder Schutzsystem:
Vereisungsüberwachung
Typ: DIC 413

5 Hersteller: VIBRO-METER S.A.

15 **BESCHREIBUNG DER ERGÄNZUNGSBESCHEINIGUNG**
Normgerechte Überarbeitung entsprechend den Normen:
EN 60079-0 (2006) und EN 60079-11 (2007)
Die Ergebnisse der Prüfung sind im vertraulichen Prüfbericht Nr. 60056381-557031 / 07 festgehalten.
Spezifische Kenndaten der betroffenen Schutzarten:
Unverändert
Kennzeichnung:
Änderung wie folgt:
EEx wird zu Ex
Um: 32 V Io: 20 mA
Uo: 32 V Po: 0,64 W
Co: 0,5 µF Lo: 200 mH

16 **BESCHREIBENDE DOKUMENTE**
Bescheinigung Nr. DT 1030 vom 05. März 2007.
Dieses Dokument besteht aus 2 Elementen (7 Seiten).

17 **BESONDERE BEDINGUNGEN FÜR DIE SICHERE ANWENDUNG**
Unverändert

18 **GRUNDLEGENDE GESUNDHEITS- UND SICHERHEITSANFORDERUNGEN**
Abgedeckt durch die Normen:
EN 60079-0 (2006) und EN 60079-11 (2007)

19 **ROUTINEMÄßIGE PRÜFUNGEN UND TESTS**
Unverändert
ATEX-Bescheinigungsbevollmächtigter
Die Haftung von LCIE beschränkt sich allein auf den französischen Originaltext. Dieses Dokument darf nur vollständig und ohne Veränderungen vervielfältigt werden.

Fontenay-aux-Roses, 22. Oktober 2007

Leiter Zertifizierung
Trockenstempel

Seite 1/1

LCIE haftet nur für den französischen Text.
Dieses Zertifikat darf nur vollständig und ohne Änderungen vervielfältigt werden.

Vibro-Meter

EN

CSA Certificate :

LR 62075-3

for EW 140 & DIC 413

EX

Vibro-Meter S.A.
Route de Moncor 4
CH - 1701 Fribourg
Switzerland

www.vibro-meter.com

MEGGiTT

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Certificate of Compliance

Certificate Number: LR 62075-3

Revision: LR 62075-4

Date Issued: February 25, 1997

Issued to: **VIBRO-METER S.A.**
Moncor 4
Boite Postale 1071
CH-1701 Fribourg
Switzerland
Attention: Mr. Martin Wyss

The products listed below are eligible to bear the CSA Mark

Issued by: Doug Lippert
Toronto, ON Canada

Signature:

CLASS

2258 03 - PROCESS CONTROL EQUIPMENT - Intrinsically Safe and Non-Incendive Systems - For Hazardous Locations

PRODUCTS

Class I, Groups C and D

Ice detection system: Model DIC 413 Control Unit (located in non-hazardous location) rated 24Vdc, 80mA; signal output contacts rated 250V, 5A (resistive) ; providing intrinsically safe circuits to Model EW 140 Transducer.

APPLICABLE STANDARDS

CSA Std C22.2 No. 142-M1987 - Process Control Equipment
CAN/CSA-C22.2 No. 157-92 - Intrinsically Safe and Non-Incendive Equipment for Use in Hazardous Locations

Supplement to Certificate of Compliance

Certificate Number: LR 62075-3

Issued to: **VIBRO-METER S.A.**
Moncor 4
Boite Postale 1071
CH-1701 Fribourg
Switzerland
Mr. Martin Wyss

The products listed, including the latest revision described below, are eligible to be marked in accordance with the referenced Certificate.

Issued By: Doug Lippert
Toronto, ON Canada

Signature

Product Certification History

Revision	Date	Description
-4	Feb. 25/97	Update to include new Model DIC 413 'F1', 'F2' fuses.

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B ASME PAPER ON ICE DETECTION

This appendix contains a paper reprinted from the American Society of Mechanical Engineers (ASME) journal "IGTI-Vol. ASME Cogen Turbo Power". This paper was presented at ASME Cogen Turbo Power '94 (Portland, Oregon, Oct. 25-27 1994).

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The American Society of Mechanical Engineers

Reprinted From
IGTI–Vol. ASME Cogen Turbo Power
Editors: H. A. Kidd, D. H. Cooke,
T. H. Fransson, and E. M. Greitzer
Book No. I00376 – 1994

AN INDUSTRIAL SENSOR FOR RELIABLE ICE DETECTION IN GAS TURBINES

J. W. Freestone and M. Weber
Department of Machinery Monitoring and Diagnostics
Vibro-Meter SA
Fribourg, Switzerland

ABSTRACT

Ice formation in the intake duct and compressor blading is a constant risk on gas turbines operating in regions where there are unfavourable ambient conditions. If allowed to continue there is a clear danger that pieces of ice will be ingested by the machine causing substantial damage. To protect the machine from possible damage, if ice is suspected by the operator the de-icing system is activated, injecting hot bleed air from the last compressor stages into the cold inlet air, naturally causing a decrease in power and efficiency . There exists a requirement for an ice detection system which will reliably detect the presence of ice and therefore optimise the use of bleed air for de-icing and reduce unnecessary power and efficiency losses.

This paper discusses the necessary conditions for icing and describes a robust industrial sensor for reliable ice detection. The system, which is suitable for ground based gas turbines, has been installed on a 130MW gas turbine in Holland for the last three years and some of the results are presented here together with the economic advantages to be gained from installing such a system.

THE PROBLEM OF ICE FORMATION IN GAS TURBINES

Ice build up on gas turbines in power generation is a well known problem for utilities operating in regions where air is moisture laden and the ambient temperature below 0°C. Even above 0°C, turbine icing is possible because of the temperature reduction of the air caused by the increase in velocity in the inlet ducting. Ice build-up leads to decreased efficiency, and if allowed to continue, there is a clear danger that pieces of ice will be ingested by the engine causing damage. It is normal practice when ice is suspected to carry out de-icing by injecting hot bleed air into the cold intake air which naturally causes considerable loss in power and efficiency.

Type of Icing	Appearance	Particular atmospheric conditions
Frost	Rough, white, low density	Night radiational cooling, surface temperature below freezing
Rime ice	Opaque, milky, air bubbles	Supercooled water droplets present in the atmosphere
Clear ice	Transparent, solid	Freezing rain
Glaze ice	Smooth surface, white solid, irregular structure	Temperatures around freezing and supercooled water droplets present

TABLE 1 TYPES OF ICING

The accretion of ice on a surface is a complex thermodynamic process, depending on air temperature and velocity, water content and droplet size, and surface conditions of the body in the air flow. Also, the type of ice formation varies considerably according to the thermodynamic conditions. See table 1 above.

Types of ice formation

In general there are two main types of ice formation which are encountered on ground based gas turbines: rime and glaze. Rime ice is found at low temperatures, typically below -8°C, and low liquid water content where there is a rapid freezing process. The supercooled water droplets freeze on impact, trapping air bubbles, resulting in a milky white colour.

Glaze ice forms at total temperatures near freezing, where there is usually a high liquid water content. In this case, the freezing process is more gradual and the resulting ice formation is generally clear and smooth, sometimes containing air pockets. Often the droplets flow or runback on the surface some distance before freezing. Since the air speed is usually high enough to prevent accretion on leading edges, the water will freeze further back on the object. This runback of water can lead to particular ice formations such as the classical double horned shape as shown in fig 1.

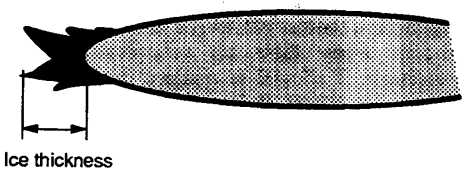


FIG 1 DOUBLE-HORNED ICE FORMATION

Critical areas for ice formation

Since the physics of ice formation are particularly complex, it is difficult to predict precisely where ice will build up at first in the turbine. However it is known that icing severity generally increases with airspeed because the water droplets have less time to flow around an object. Secondly, it is also known that the size and shape of the body affect its ability to accumulate ice. Sharp leading edges have a greater collection efficiency than thick leading edges.

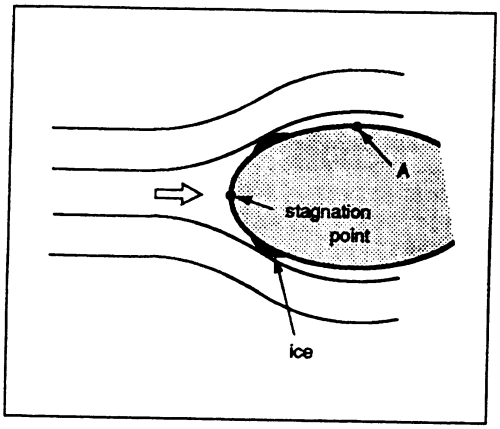


FIG 2 INITIAL FORMATION OF ICE

Referring to figure 2, theory tells us that at the stagnation point the air temperature is at its highest (Total Air Temperature). Around the body the (static) air temperature is less, in function of the air velocity. For a suitably low (total) air temperature, the point where freezing takes place will be between the stagnation point and the major diameter (point A in the figure). The droplets only impinge on a surface which faces the direction of airflow.

Taking these factors into account it can be presumed that the critical areas are in the region of the smallest cross-section of the turbine, where the air speed increases according to the laws of fluid dynamics, but before any compression takes place.

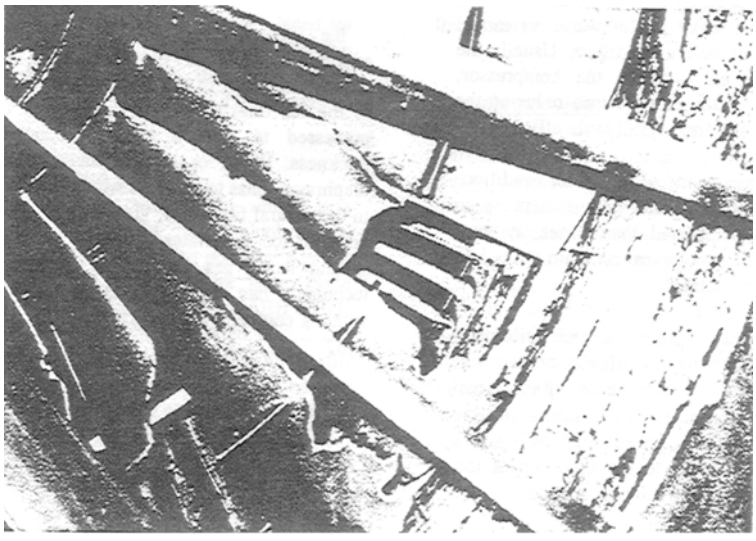
It would also follow that the first row of stator vanes or supporting struts near the inlet will be the most susceptible to ice accretion. As a practical consideration, leaking plenum doors can also cause icicle formation and subsequent ingestion damage.

Equally to be considered, since the humidity level is slightly higher before the filter (the filter can act like a sponge), it can be expected that ice will build up at the air filter. However this is more related to the initial air temperature since the change in velocity across the filter is small. Clearly since the local conditions and geometry are different from installation to installation it is difficult to be precise where ice will initially form. Each installation must be judged on its own merit. One or two examples for different types of turbine are given later.

Consequences of ice formation

For ground based gas turbines, ice formation can cause performance losses. This may result from blockage of the intake filter, or as a result of ice accretion on early stationary compressor stages. In either case there is a reduction in air mass flow, hence power and efficiency. Under some conditions, the distortion of the airflow can setup vibratory excitations and lead to blade failure. Severe blockage can lead to a stall condition or flameout. Perhaps most serious is the possibility of structural damage caused by ice shedding, leading to foreign object damage of the compressor stages, as illustrated in fig 3, resulting in costly repairs and loss of production. It is obviously imperative to prevent the occurence of the latter situation.

FIG 3 FOREIGN OBJECT DAMAGE OF BLADING



CURRENT PRACTICE FOR DETECTING AND REMOVING ICE

Since no reliable means of ice detection has been available up to now, the commonly used method is to establish the likelihood that ice could soon form, i.e. the conditions are approaching a dangerous limit.

The most widespread technique in this respect for establishing the *probability* of the presence of ice is through a calculation from a measurement of relative humidity and temperature. Manufacturers of turbines typically recommend that gas turbines are fitted with an anti-icing system to ensure that the humidity of the air is less than that shown in figure 4 at temperatures less than 7°C.

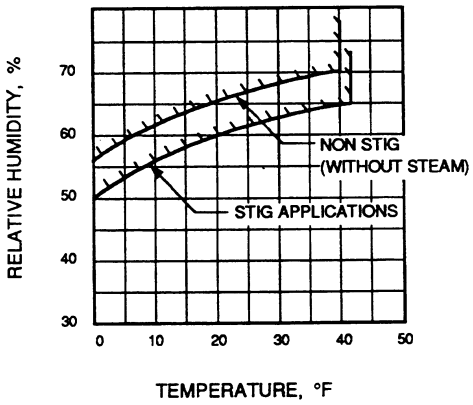


FIG 4 ICING CONDITIONS

Preventing ice accretion

Anti-icing systems make use of warm air mixed with the cold inlet air before the filters. Usually the source of this hot air is from the compressor, extracted from the last stages, obviously reducing the available turbine power and overall cycle efficiency.

Because of the uncertainty of the actual conditions when ice will occur, the anti-icing system is in operation for a longer period than necessary even though no ice is present. A typical estimate of the loss in power output is given later.

It is clearly desirable to prevent any ice build up at the same time minimising the efficiency penalties caused by the use of compressor air or other thermal sources. Ideally to minimise these losses a reliable system of ice detection is required which will give a more accurate indication as to the initiation of ice. Such a system is proposed in the next section.

DESCRIPTION OF THE ICE DETECTION SYSTEM

Principle of operation

The principle of operation adopted is that the resonant (or natural) frequency of a solid body will change with a change in mass or stiffness. As illustrated in fig 5,

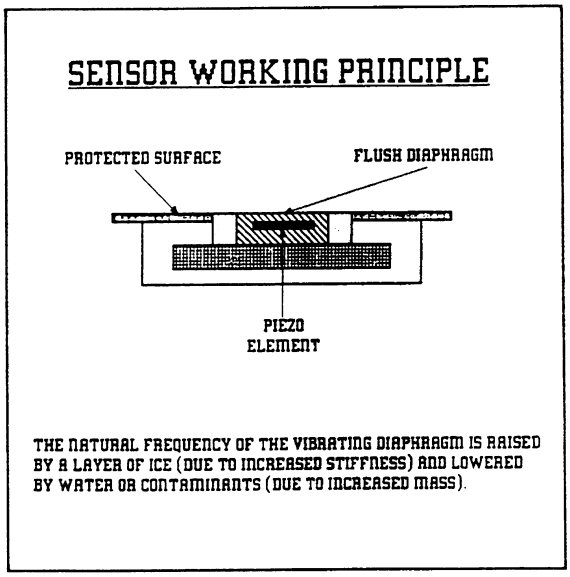


FIG 5 PRINCIPLE OF OPERATION

the ice sensor has a vibrating diaphragm which is forced into oscillation by a piezoelectric material at an ultrasonic frequency.

Ice accretion on the diaphragm increases the average stiffness of the diaphragm, causing the natural frequency of the system to increase according to the ice thickness. The variation in frequency is processed to give a signal proportional to ice thickness. Water or liquid contaminants cause the diaphragm mass to increase which leads to a decrease in the natural frequency, giving a clear discrimination between ice and water. Although the application to ground based gas turbines is relatively new, the technique has been successfully applied by the author's company for detecting ice on aircraft since 1987.

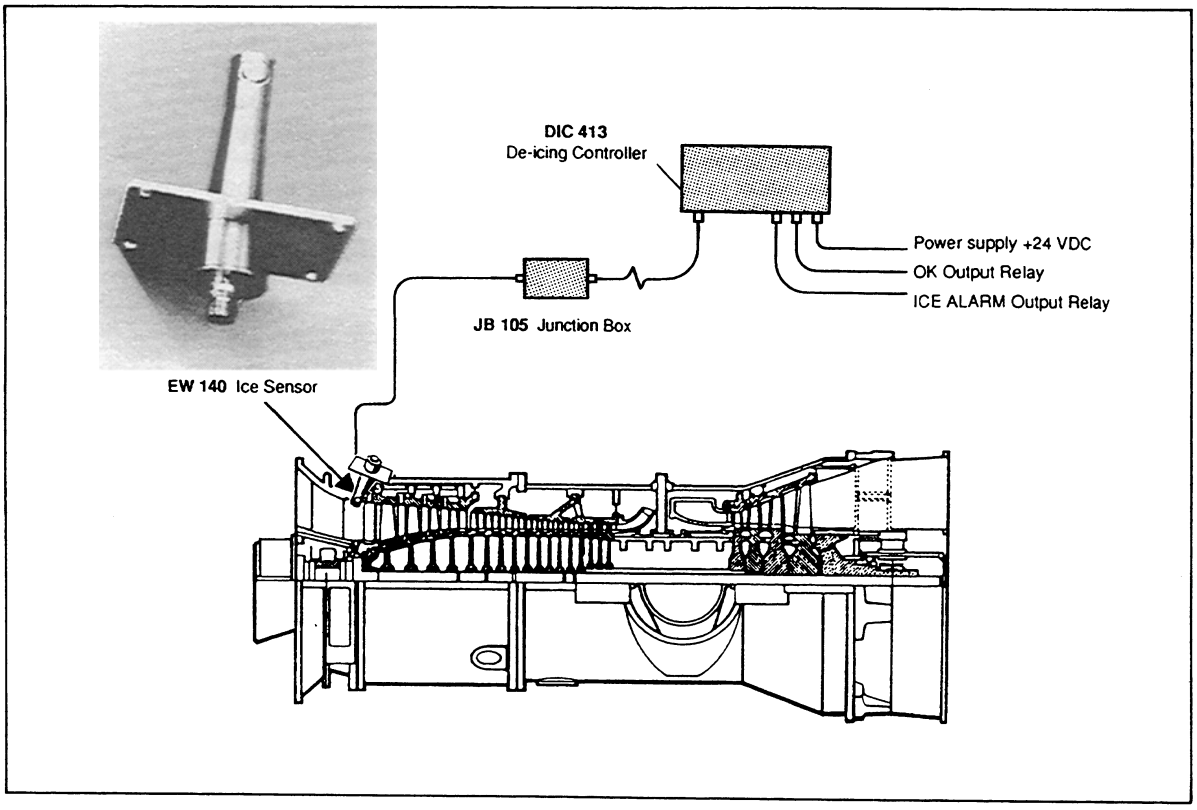


FIG 6 GENERAL LAYOUT

Parts and layout

Fig 6 shows the components of the system. The ice sensor which is placed at a critical position (or positions) in the intake air flow, a junction box and the conditioning electronics which may be placed up to 150m away from the turbine. The electronic conditioner is equipped with an ice alarm output which may be used to activate the anti-icing system.

Sensor position in the turbine

It seems that the positioning of the sensor is a fairly controversial subject. A number of manufacturers find that that the best position is in the bell mouth at the entry to the compressor, for example on the GE LM 2500, Siemens V94.2 and ABB GT13. For the Rolls Royce Avon, the preferred position is before the air filter. At the time of writing this is still no definite conclusion except to say the positioning of the sensor appears to be turbine specific.

If it is not clear at which of the two positions ice is expected to form initially for a particular site condition, it may be prudent to install a sensor at both the locations.

Signals provided

There are two different signals provided as standard - an OK signal and an ICE alarm. The OK signal indicates that the system is functioning normally and that no ice is present.

The ice alarm is activated when a pre-selected ice thickness has been attained. At present during installation, one of five different thicknesses of ice may be selected to generate the alarm signal. Subsequently the signal may be used to activate the anti-icing system automatically or as an indication to the operator to take action.

Response curves

The following graphs (see fig 7) show the transfer function of the ice detection system. In the case of water on the element the effective mass of the active sensor element will increase giving a decrease in the resonant frequency. When the ice layer begins to form, it results in a stiffenening of the element (with a slight increase in mass) and therefore an increase in the resonant frequency.

Calibration and maintenance

There is practically no calibration to be made with this sensor because it is the construction of the membrane which decides the resonant frequency. This remains the same after fabrication, unless the membrane is damaged by an external influence. Over time there could be build up of deposits on the sensor, just as may be found on the compressor blades. A suitable washing procedure will return the sensor to its original condition.

Advantages over other techniques

Another vibratory method which has been used to detect ice makes use of a vibrating reed. The disadvantage of the reed is that it cannot discriminate between ice and water, since both add to the mass and decrease the resonant frequency.

RESULTS TO DATE

Such an ice detection system as described has been in operation on a Siemens V94.2 gas turbine at the Eemscentrale of EPON in the north of Holland over the last three winters. The sensor has only been removed for cleaning during the annual outage, the electronics are as installed. The ice sensor is placed in the air intake of the turbine upstream of the inlet guide vanes as shown in fig 8, in the upper casing about 20° above the horizontal. The increase in resonant frequency caused by the ice layer is processed by the conditioning electronics to give a signal proportional to ice thickness. During these tests the operator activated the hot de-icing air which was admitted into the air intake for a period until the ice was removed.

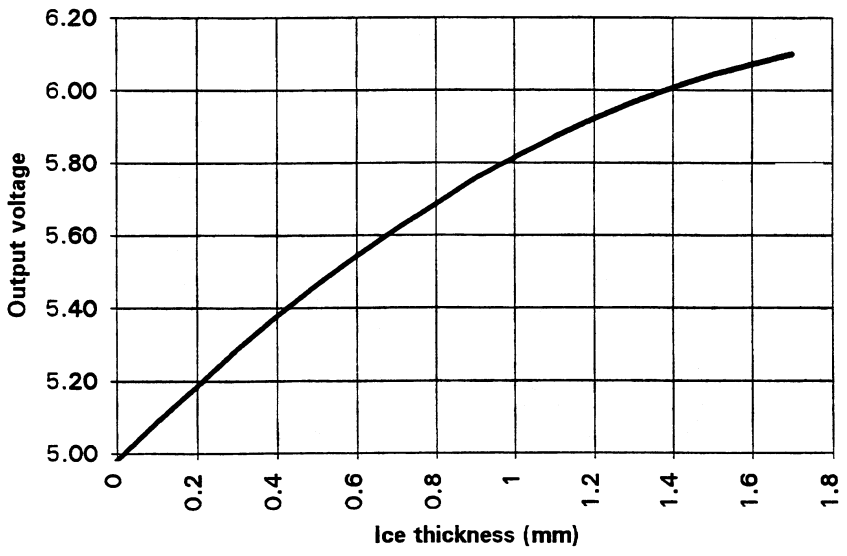


FIG 7 ICE DETECTION SYSTEM RESPONSE

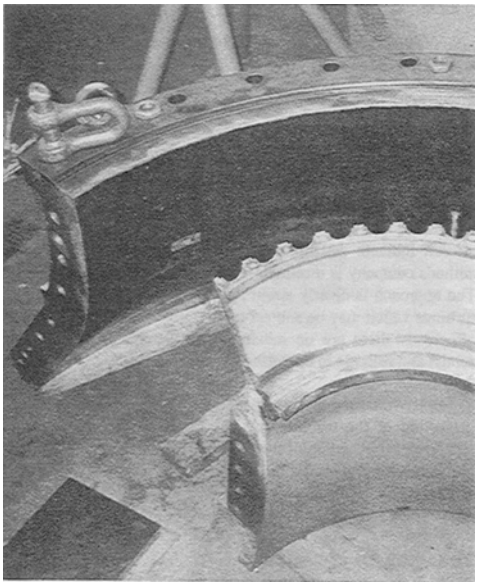
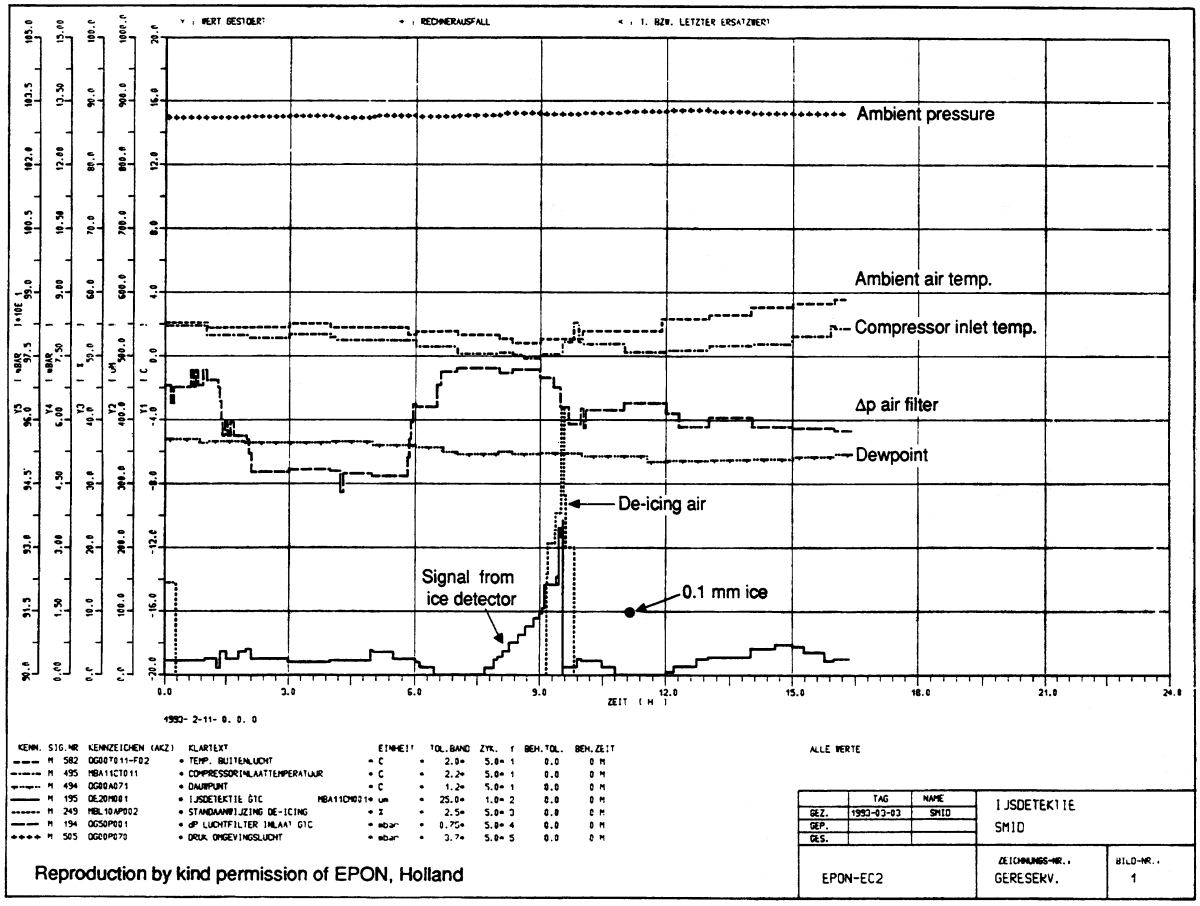


FIG 8 UPPER CASING SHOWING SENSOR POSITION

Typical curves in operation

Typical curves of the operation can be seen in fig 9 recorded by Eemscentrale on Feb 11th 1993. For test purposes the voltage output (solid line) from the de-icing controller was recorded indicating a layer of ice building up around 9am. At 0.1mm ice thickness, the de-icing system was switched on (shown by the dashed line), injecting hot bleed air into the intake for about 30 minutes after which time the ice layer was removed. The other parameters, shown in the figure, such as inlet air temperature do not give a clear indication of the formation of ice.

FIG 9 TYPICAL OPERATIONAL CURVES



ESTIMATED SAVINGS AND BENEFITS

As well as performing the primary task of protecting the machine from ice damage, the ice detection system can optimise the efficiency of the gas turbine by limiting the use of the bleed air to that which is necessary. Currently, the bleed air quantity that is injected to prevent ice is switched off when the operator believes (by experience) that the ice has gone. With the ice detection system, which allows the operator to know exactly whether ice or water is present, it gives him the possibility to shut down the bleed air as soon as possible, hence increasing output and raising the efficiency.

Increased MWh and revenue

At Eemscentrale in Holland, where the system is installed on a 135MW gas turbine, the following information has been obtained.

On average, in a winter (Nov.-Feb) the de-icing system is switched on for 200 hours; 50 hours for ice detection and 150 hours for maximum pressure difference across the air filter (due to high humidity). During de-icing the recirculated air causes a loss of 9MW. The potential saving is about 50 hours per year, or expressed in energy terms this represents 9 x 50 = 450MWh per year.

Not only is protection of the machine assured, but there is a fast return on investment for the system even using a conservative figure for the cost of electricity. Through the use of a sensor with effectively no moving parts, the reliability is high and hence the operating costs are minimal.

The utility now rely on the ice detection system instead of the relative humidity and dewpoint measurement used previously. EPON are performing further tests with the amount of de-icing air admitted to remove the ice as quickly and efficiently as possible.

CONCLUSIONS

The experience gained to date with the ice detection sensor as described above and on other gas turbines (LM2500s and Rolls-Royce Avons) in the North Sea as well as considerable experience on aircraft indicate that the principle developed by the author's company is a reliable means of ice detection. The approach is clearly applicable to all types of gas turbines which may be subject to ice formation. Since effectively there are no moving parts the system is robust and reliable in operation.

Implementation of this system not only ensures protection of the turbine from ice damage but also allows an optimisation of the control loop for de-icing and hence minimises the impact on power output and efficiency.

ACKNOWLEDGEMENTS

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