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MEGGITT

SAFETY MANUAL

vibro-meter®

TQxxx proximity measurement chains using an IQS900 signal conditioner

SIL Safety

This document contains important information about products that are intended for use in safety-related applications.

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PREFACE

About this manual

This manual provides reference information on the use of TQxxx proximity measurement chains using an IQS900 signal conditioner with diagnostics, from Meggitt's vibro-meter® product line, in safety-related applications (functional-safety contexts).

It is applicable to TQxxx proximity measurement chains consisting of a TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx), optional EAxxx extension cable (EA90x or EA40x) and an IQS900 signal conditioner with diagnostics, as typically used for machinery protection system (MPS) and/or condition monitoring system (CMS) applications.

About Meggitt and vibro-meter®

Meggitt PLC is a global engineering group, headquartered in the UK, specialising in the design and manufacture of high-performance components and systems for aerospace and energy markets.

The Meggitt facility in Fribourg, Switzerland, operates as the legal entity Meggitt SA (formerly Vibro-Meter SA). vibro-meter® is a product line of Meggitt that applies our core sensing and monitoring technologies to power generation, oil & gas and other industrial markets.

Meggitt SA produces a wide range of vibration, dynamic pressure, proximity, air-gap and other sensors capable of operation in extreme environments, electronic monitoring and protection systems, and innovative software for aerospace and land-based turbomachinery.

vibro-meter® products and solutions have been at the forefront of sensing and monitoring for more than 65 years and help keep machinery and equipment working safely, reliably and efficiently. This includes the TQxxx proximity measurement chains and IQS900 signal conditioner produced for the Meggitt vibro-meter® product line.

To learn more about Meggitt Switzerland, our proud tradition of innovation and excellence, and our solutions for energy markets and applications, visit the www.meggittsensing.com/energy website.

Who should use this manual?

This manual is written for personnel such as designers and operators of monitoring and/or protection systems in safety-related applications that use a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics as an input (sensor) to an external monitoring and/or protection system (safety instrumented system (SIS)) that performs a safety function.

The system designers and operators are assumed to have the necessary technical training in safety, reliability, electronics and/or mechanical engineering (professional certificate/diploma or equivalent) to enable them to design, install, configure, use and maintain such safety instrumented systems.

Structure of the manual

This section gives an overview of the structure of the document and the information contained within it. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The chapters are presented in a logical order. You should read those that are most relevant to your safety-related application and then keep the document at hand for future reference.

The structure of the document is as follows:

Chapter 1 Introduction

Explains the purpose and scope of this safety manual.
Introduces TQxxx proximity measurement chains and the IQS900 signal conditioner.

Chapter 2 System description

Explains the operation of TQxxx proximity measurement chains and the IQS900 signal conditioner.
Specifies the requirements for a valid TQxxx proximity measurement chain using an IQS900 signal conditioner such as sensor, cabling, signal conditioner, measurement chain and power supply considerations.

Chapter 3 How to use the system for safety

Explains how a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics is used in safety-related applications in terms of the various safety properties. And provides safety parameters and highlights safety considerations relevant to the design, installation, configuration, use and maintenance of these systems.

Chapter 4 Configuration

Provides configuration information for TQxxx proximity measurement chains.

Chapter 5 Installation and commissioning

Provides installation and commissioning information for TQxxx proximity measurement chains.

Chapter 6 Operation and maintenance

Provides proof test and other operation and maintenance information for TQxxx proximity measurement chains.

Chapter 7 Safety issues

Provides safety parameters and highlights safety considerations relevant to the design, installation, configuration, use and maintenance of TQxxx proximity measurement chains in safety-related applications.

Chapter 8 Service and support

Provides contact information for technical support.
Includes information regarding important SIL safety product information and the procedure to follow in order to opt in and receive such SIL product communications.
Includes information regarding product returns and the procedure to follow in order to report problems and return Meggitt vibro-meter® Energy products for repair.

Related publications and documentation

See 1.5 Related documentation and 1.6 Applicable functional safety standards.

Abbreviations

The following table defines some abbreviations useful to this safety manual and related documentation.

Abbreviation	Meaning
AC	alternating current
CCF	common cause failure
CMS	condition monitoring system
DC	diagnostic coverage
DC	direct current
EA40x	EA40x extension cable
EA90x	EA90x extension cable
EAxxx	used to refer to EA90x and EA40x extension cables
FMEDA	failure modes, effects and diagnostic analysis
HFT	hardware fault tolerance
IEC 13849	ISO standard “Safety of machinery – Safety-related parts of control systems”
IEC 61508	IEC standard “Functional safety of electrical/electronic/programmable electronic safety-related systems”
IQS45x	IQS450 or IQS452 signal conditioner
IQS900	IQS900 signal conditioner
MPS	machinery protection system
MRT	mean repair time Note: See also MTTR.
MTTFd	mean time to dangerous failure
MTTR	mean time to restoration Note: MTTR = MRT, where mean time to restoration (hour) = mean repair time (hour) as per IEC 61508-6 © IEC:2010 Table B.1
N/A	not applicable, not available
PFD	probability of failure on demand (low-demand system)
PFDavg	average probability of failure on demand
PFH	probability of failure per hour (high-demand system)
PL	performance level
PTC	proof test coverage
PST	process safety time

Abbreviation	Meaning
PTI	proof test interval
PNR	part number
SFF	safe failure fraction
SIF	safety instrumented function
SIL	safety integrity level
SIS	safety instrumented system
SRS	safety-related system
TQ4xx	TQ4xx proximity sensor
TQ9xx	TQ9xx proximity sensor
TQxxx	used to refer to TQ9xx and TQ4xx proximity sensors
TSL	total system length
TÜV	A technical inspection agency (from the German – Technischer Überwachungs-Verein)
VibroSmart®	VibroSmart® distributed monitoring system (DMS) based monitoring and protection systems from Meggitt's vibro-meter® product line
vibro-meter®	Meggitt product line
VM600	VM600 rack-based monitoring and protection systems from Meggitt's vibro-meter® product line

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 MIGHT RESULT IN INJURY TO THE OPERATOR AND/OR THIRD PARTIES, AND/OR RESULT IN DAMAGE TO EQUIPMENT.

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.

NOTE : The NOTE symbol. This draws the operator's attention to complementary information or advice relating to the subject being treated.

Important remarks on safety-related applications

USE OF A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS IN SAFETY-RELATED APPLICATIONS (FUNCTIONAL-SAFETY CONTEXTS) ASSUMES THAT THE INSTRUCTIONS AND RECOMMENDATIONS IN THIS SAFETY MANUAL ARE IMPLEMENTED AS APPROPRIATE BY THE END USER.

FAILURE TO FOLLOW THE INSTRUCTIONS AND IMPLEMENT THE RECOMMENDATIONS IN THIS SAFETY MANUAL MIGHT RESULT IN INJURY TO THE OPERATOR AND/OR THIRD PARTIES, AND/OR RESULT IN DAMAGE TO EQUIPMENT AND WILL INVALIDATE ANY WARRANTY.

Important remarks on safety

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

By doing this, you will be aware of the potential hazards and be able to work safely, ensuring your own protection and also that of the equipment.

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.

All personnel who are liable to operate the equipment described in this manual should be trained in the correct safety procedures.

Meggitt 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 Meggitt SA. Any modification, transformation or repair carried out on the equipment without written permission from Meggitt SA will invalidate any warranty.

Electrical safety and installation

WHEN INSTALLING A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER, OBSERVE ALL SAFETY (WARNING AND CAUTION) STATEMENTS IN THIS MANUAL AND IN THE *PROXIMITY MEASUREMENT CHAINS USING TQ9XX PROXIMITY SENSORS INSTALLATION MANUAL* OR *PROXIMITY MEASUREMENT CHAINS USING TQ4XX PROXIMITY SENSORS INSTALLATION MANUAL* AS APPROPRIATE, AND FOLLOW ALL NATIONAL AND LOCAL ELECTRICAL CODES.

ONLY TRAINED AND QUALIFIED PERSONNEL (SUCH AS A QUALIFIED/LICENSED ELECTRICIAN) SHOULD BE ALLOWED TO INSTALL OR REPLACE THIS EQUIPMENT. CHECKS TO ENSURE ELECTRICAL SAFETY SHOULD BE CARRIED OUT BY A COMPETENT PERSON.

FAILURE TO FOLLOW THESE INSTRUCTIONS CAN RESULT IN DEATH, SERIOUS INJURY, AND/OR EQUIPMENT DAMAGE.

Replacement parts and accessories

Use only approved replacement parts and accessories.

Do not connect with incompatible products or accessories.

Only use replacement parts and accessories intended for use with TQxxx proximity measurement chains and the IQS900 signal conditioner that have been approved by Meggitt SA.

Using incompatible replacement parts and accessories could be dangerous and may damage the equipment or result in injury.

For information on replacement parts and accessories:

- Visit the Meggitt vibro-meter® Energy website at www.meggittsensing.com/energy
- Contact your local Meggitt representative.

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1 INTRODUCTION

1.1 Purpose

This safety manual provides the specific information required to use a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics in safety-related applications (functional-safety contexts), in accordance with the IEC 61508 and ISO 13849 safety standards.

For example, an IQS900 signal conditioner with diagnostics can detect and indicate problems with the measurement chain including issues with the sensor, cabling and/or the signal conditioner itself (see 1.1.1 Diagnostic capability).

Refer to the *Proximity measurement chains using TQ9xx proximity sensors installation manual* for more general information on TQ9xx proximity sensors, EA90x extension cables and IQS900 signal conditioners, and for the information required to use a TQ9xx-based proximity measurement chain in standard (non-safety related) applications.

Refer to the *Proximity measurement chains using TQ4xx proximity sensors installation manual* for more general information on TQ4xx proximity sensors, EA40x extension cables and IQS45x signal conditioners, and for the information required to use a TQ4xx-based proximity measurement chain in standard (non-safety related) applications.

See 1.5 Related documentation.

1.1.1 Diagnostic capability

An IQS900 signal conditioner with diagnostics can detect and indicate the following sensor / measurement chain problems:

- Sensor missing (or disconnected)
- Sensor short-circuited
- Outputs short-circuited (TQxxx, EAxxx and/or IQS900)
- Incorrect IQS900 power supply
  (that is, outside of nominal input voltage range of
  −18 to −30 V_{DC} for a current output signal or −19 to −30 V_{DC} for a voltage output signal).

Upon detection of a problem, an IQS900 signal conditioner with diagnostics will drive/saturate the measurement/diagnostic component (DC) of its output signal to a value outside of the normal operating range to indicate that there is an issue.

In a safety-related application (functional-safety context), the output signal from an IQS900 signal conditioner with diagnostics can be used an input to an external monitoring and/or protection system that performs a safety function by taking this input, together with other safety-related signals and performing a system-level safety function, such as initiating the shutdown (trip) of a machine.

1.2 TQxxx proximity measurement chains

To use a TQxxx proximity measurement chain in a safety-related application requires a measurement chain consisting of the following components:

- TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx)
- Optional EAxxx extension cable (EA90x or EA40x)
- IQS900 signal conditioner with diagnostics.

The EA90x extension cable is optional as its use depends on the overall length of the measurement chain required by a particular application (known as the total system length (TSL)) and other application requirements such as the optimum location for the separation between the integral and extension cables or the need to eliminate the requirement for an extension cable altogether.

NOTE: The total system length (TSL) is the sum of the nominal lengths of the TQxxx proximity sensor's integral cable and the optional EAxxx extension cable. The supported TSLs for a TQxxx proximity measurement chain are obtained from different combinations of TQxxx proximity sensor integral cable and EAxxx extension cable.
Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* or *TQ4xx, EA40x and IQS45x proximity measurement chain data sheet* as appropriate, for further information.

The components of a TQxxx proximity measurement chain are shown in Figure 1-1.

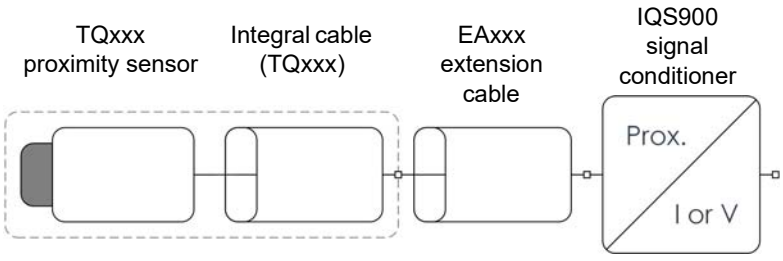

Figure 1-1: TQxxx proximity measurement chain

1.2.1 IQS900 compatible proximity sensors and extension cables

The TQ9xx proximity sensors are backward compatible replacements for all legacy TQ4xx sensors, the EA90x extension cables are backward compatible replacements for all legacy EA40x cables and the IQS900 signal conditioner is a backward compatible replacement for all legacy IQS45x signal conditioners.

For new applications, a TQ9xx proximity measurement chain consisting of a TQ9xx, an optional EA90x and an IQS900 is the recommended solution.

For existing applications using a TQ4xx proximity measurement chain consisting of a TQ4xx, an optional EA40x and an IQS45x, an appropriately configured IQS900 signal conditioner can be used as a replacement for the IQS45x signal conditioner, as follows:

- An IQS900 signal conditioner without diagnostics is a direct replacement for an IQS45x signal conditioner in most TQ4xx proximity measurement chains.
- An IQS900 signal conditioner with diagnostics is a replacement for an IQS45x signal conditioner that brings enhanced reliability and significant risk reduction, thereby making the “upgraded” TQ4xx proximity measurement chain suitable for use in safety-related systems, such as SIL 2 in accordance with IEC 61508 and Cat 1 PL c in accordance with ISO 13849.

1.2.2 IQS900 signal conditioner with diagnostics

The IQS900 signal conditioner contains a high-frequency modulator/demodulator that drives a TQxxx proximity sensor with an electromagnetic field used to measure the distance between the sensor tip and the target such as a rotating machine shaft, then converts the signal from the sensor into a current or voltage signal suitable for input to a machinery monitoring and/or protection system (such as a VM600 or VibroSmart®).

The IQS900 is a versatile and configurable device that supports optional diagnostics that runs health checks on the components of the TQxxx proximity measurement chain (TQ9xx or TQ4xx proximity sensor with integral cable, optional EA90x or EA40x extension cable and the IQS900 signal conditioner itself) and updates its output signal (DC measurement/diagnostic component) to indicate the integrity of the measurement chain.

The diagnostics / health checks are specified in 1.1.1 Diagnostic capability.

IN SAFETY-RELATED APPLICATIONS (FUNCTIONAL-SAFETY CONTEXTS), AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS SHOULD BE USED AND ANY REQUIRED SAFE STATE BEHAVIOUR, INCLUDING THE LATCHING OF ALARMS OR RELAYS, MUST BE IMPLEMENTED BY AN EXTERNAL MONITORING AND/OR PROTECTION SYSTEM AT THE SAFETY-SYSTEM LEVEL.

A TQxxx proximity measurement chain can be used as an input (sensor) to an external monitoring and/or protection system (safety instrumented system (SIS)) configured to perform a safety function (safety instrumented function (SIF)), as shown in Figure 1-2.

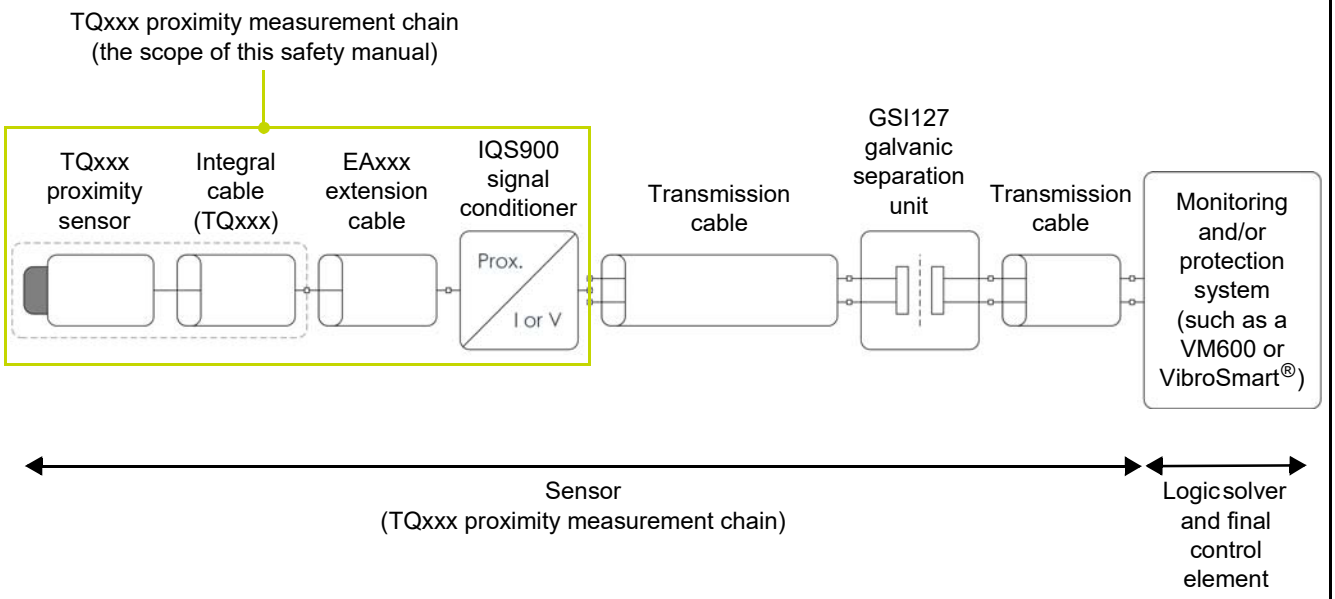

Figure 1-2: TQxxx proximity measurement chain as an input to a monitoring and/or protection system

In certain industries and applications, the monitoring and/or protection systems used are known by other names. For example, the terms “machinery protection system (MPS)” and “condition monitoring system (CMS)” are commonly used in the oil & gas industry.

1.3 Reference part numbers

The TQ9xx-based proximity measurement chain components (TQ9xx proximity sensors, EA90x extension cables and IQS900 signal conditioner) listed in Table 1-1 can be part of a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics in safety-related applications.

The TQ4xx-based proximity measurement chain components (TQ4xx proximity sensors and EA40x extension cables) listed in Table 1-2 can be part of a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics in safety-related applications.

Table 1-1: Reference part numbers for TQ9xx proximity measurement chain components (TQ9xx, EA90x and IQS900) suitable for safety-related applications

Component	Type / Description	Part number (PNR)
TQ901 (pending)	Standard-mount proximity sensor with a 2 mm measurement range, Ø5 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-901-000-01x
TQ902	Standard-mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-902-000-01x
TQ903 (pending)	Standard-mount proximity sensor with a 12 mm measurement range, Ø18 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-903-000-01x
TQ912	Reverse-mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-912-000-01x
TQ922 (pending)	Standard-mount proximity sensor with a 2 or 4 mm measurement range, Ø12.7 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-922-000-01x
TQ923 (pending)	Standard-mount proximity sensor with a 12 mm measurement range, Ø25 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-923-000-01x
TQ932 (pending)	Reverse-mount proximity sensor with a 2 or 4 mm measurement range, Ø12.7 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-932-000-01x
TQ942 (pending)	Right-angle (90°) mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-942-000-01x
EA901 (pending)	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ901 proximity sensor.	913-901-000-01x
EA902	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ9x2 proximity sensors.	913-902-000-01x
EA903 (pending)	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ9x3 proximity sensors.	913-903-000-01x

Table 1-1: Reference part numbers for TQ9xx proximity measurement chain components (TQ9xx, EA90x and IQS900) suitable for safety-related applications (continued)

Component	Type / Description	Part number (PNR)
IQS900	Signal conditioner with configurable measurement range and sensitivity (which also determines the type of output signal: current (µA/µm) or voltage (mV/µm)), optional diagnostics, IP20 protection rating and self-locking connector. Note: For use with TQxxx proximity sensors and EAxxx extension cables.	204-900-000-01x
Notes In the Part number (PNR) column, "-01x" represents the latest version of the product. Refer to the relevant *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* for further information.		

As shown in Table 1-1, one version of the IQS900 signal conditioner, developed in accordance with the IEC 61508 and ISO 13849 safety standards, is available.

As explained in 1.2.1 IQS900 compatible proximity sensors and extension cables, the IQS900 signal conditioner can be used with TQ9xx proximity measurement chains (Table 1-1) and TQ4xx proximity measurement chains (Table 1-2).

Table 1-2: Reference part numbers for TQ4xx proximity measurement chain components (TQ4xx and EA40x) suitable for safety-related applications

Component	Type / Description	Part number (PNR)
TQ401	Standard-mount proximity sensor with a 2 mm measurement range, Ø5 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-401-000-01x
TQ402	Standard-mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-402-000-01x
TQ403	Standard-mount proximity sensor with a 12 mm measurement range, Ø18 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-403-000-01x
TQ412	Reverse-mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-412-000-01x
TQ422	Standard-mount proximity sensor with a 2 or 4 mm measurement range, Ø12.7 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-422-000-01x
TQ423	Standard-mount proximity sensor with a 12 mm measurement range, Ø25 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-423-000-01x
TQ432	Reverse-mount proximity sensor with a 2 or 4 mm measurement range, Ø12.7 mm tip, 100 bar pressure rating (sensor tip), IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-432-000-01x
TQ442	Right-angle (90°) mount proximity sensor with a 2 or 4 mm measurement range, Ø8.2 mm tip, IP68 protection rating (sensor tip and integral cable), self-locking connector and optional cable protection	111-442-000-01x
EA401	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ901 proximity sensor.	913-401-000-01x
EA402	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ9x2 proximity sensors.	913-402-000-01x
EA403	Extension cable with a self-locking connector and optional cable protection. Note: For use with TQ9x3 proximity sensors.	913-403-000-01x
Notes In the Part number (PNR) column, “-01x” represents the latest version of the product. Refer to the relevant *TQ4xx, EA40x and IQS45x proximity measurement chain data sheet* for further information.		

1.3.1 Configurations

A TQxxx proximity measurement chain is highly-configurable. When ordering a TQxxx proximity measurement chain, the TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx), optional EAxxx extension cable (EA90x or EA40x) and IQS900 signal conditioner components have different part numbers (PNRs) and ordering option codes that are used to specify the complete configuration of the measurement chain.

For example, TQ9xx proximity sensors have order options such as environment, body thread, body length, unthreaded length, integral cable length, optional protection and total system length that are configurable.

NOTE: The components of a TQxxx proximity measurement chain are configured in the factory as part of the manufacturing process. During manufacture, the configuration is fixed and cannot be changed later.

NOTE: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* or *TQ4xx, EA40x and IQS45x proximity measurement chain data sheet* as appropriate, for further information on configurable product options.

1.3.2 IQS900 signal conditioner

The IQS900 signal conditioner is a configurable product. When ordering an IQS900, the part number (PNR) and ordering option codes are used to specify the complete configuration of the device. For example, a complete IQS900 signal conditioner ordering number, including part number (PNR) and ordering option codes, is:
204-900-000-01x-A*x*-B*xx*-C*x*-H*xx*-I*x*.

NOTE: IQS900 signal conditioners are configured in the factory as part of the manufacturing process. During manufacture, the configuration is fixed and cannot be changed later.

Importantly, when ordering an IQS900 signal conditioner, it can be configured as either “with diagnostics” or “without diagnostics”. The ordering option code **C*x*** is used to specify the configuration of an IQS900’s optional diagnostics as follows:

- Ordering number 204-900-000-01x-A*x*-B*xx*-**C2**-H*xx*-I*x*
  for an IQS900 **with diagnostics**.
- Ordering number 204-900-000-01x-A*x*-B*xx*-**C1**-H*xx*-I*x*
  for a IQS900 **without diagnostics**.

(In the IQS900 part number (PNR) 204-900-000-01x, “-01x” represents the latest version of the product. Refer to a TQ9xx, EA90x and IQS900 proximity measurement chain data sheet for further information.)

NOTE: Only an IQS900 signal conditioner with diagnostics (ordering option code **C2**) should be used in safety-related applications (functional-safety contexts).

The diagnostics / health checks are specified in 1.1.1 Diagnostic capability.

NOTE: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* for further information on configurable product options and ordering option codes.

1.3.3 Identifying an IQS900 signal conditioner

As shown in Figure 1-3, the product label on the top of an IQS900 signal conditioner shows the complete ordering number – including part number (PNR) and ordering option codes.

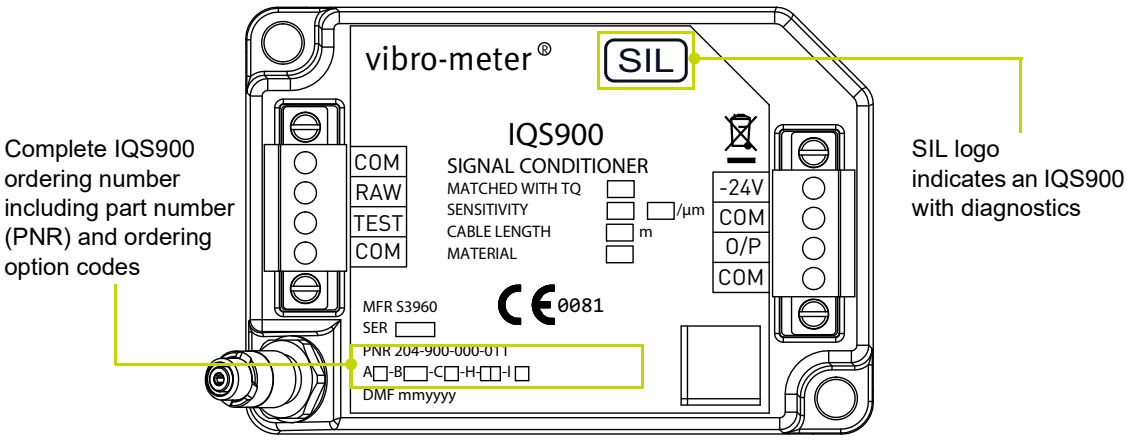

Figure 1-3: Top view of an IQS900 signal conditioner with a typical product label showing the complete ordering number

NOTE: An IQS900 signal conditioner with diagnostics, suitable for use in safety-related applications, is identified by the ordering option code **C2** and a **SIL** logo.

1.4 Use in safety-related applications

It is the end-user's responsibility to ensure that only an IQS900 signal conditioner with diagnostics is used in a safety-related application (functional-safety context), and that the recommendations in this safety manual are implemented as appropriate by the end user.

FAILURE TO FOLLOW THE INSTRUCTIONS AND IMPLEMENT THE RECOMMENDATIONS IN THIS SAFETY MANUAL MIGHT RESULT IN INJURY TO THE OPERATOR AND/OR THIRD PARTIES, AND/OR RESULT IN DAMAGE TO EQUIPMENT.

Always check the product label to ensure that the part number (PNR) and ordering option codes are correct before installing or replacing an IQS900 signal conditioner (see 1.3.1 Configurations and 1.3.3 Identifying an IQS900 signal conditioner).

1.5 Related documentation

This safety manual is limited to the information and actions that are required to ensure compliance with the relevant safety certifications and standards.

Table 1-3 lists other documentation, such as data sheets and manuals, that must be referred to for information outside the scope of this safety manual.

Table 1-3: Related documentation

Document name	Document reference
TQ9xx, EA90x and IQS900 proximity measurement chain data sheets	265-10x
TQ4xx, EA40x and IQS45x proximity measurement chain data sheets	265-06x
Proximity measurement chains using TQ9xx proximity sensors installation manual	MAPROX900/E
Proximity measurement chains using TQ4xx proximity sensors installation manual	MAPROX400/E

NOTE: Ensure that the latest version of related documentation is being used by obtaining the documents from the Meggitt vibro-meter® Energy website at www.meggittsensing.com/energy or by contacting your local Meggitt representative.

1.6 Applicable functional safety standards

Table 1-4: Applicable functional safety standards

Document name	Document reference
IEC 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems	Ed. 2 (2010)
ISO 13849-1: Safety of machinery – Safety-related parts of control systems – Part 1	Ed. 3 (2015)

2 SYSTEM DESCRIPTION

2.1 TQxxx proximity measurement chain overview

TQxxx proximity measurement chains allow the contactless measurement of the relative displacement of moving machine elements. Accordingly, these measurement chains are ideally suited for measuring the relative vibration and axial position of rotating machine shafts such as those found in steam, gas and hydraulic turbines, as well as in alternators, turbocompressors and pumps.

A TQxxx proximity measurement chain consists of a TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx), optional EAxxx extension cable (EA90x or EA40x) and an IQS900 signal conditioner. Together, these components form a calibrated proximity measurement chain in which each component is interchangeable. The measurement chain outputs a current or voltage signal proportional to the distance between the sensor tip and the target such as a rotating machine shaft.

2.2 Operation of a TQxxx proximity measurement chain

TQxxx proximity sensors use a non-contact measurement technique based on the eddy-current principle, which requires that the target material must, in all cases, be metallic. For example, the active part of a TQ9xx proximity sensor is a coil of wire moulded inside the tip of the sensor (made of PPS (polyphenylene sulfide), a high-performance thermoplastic), which is crimped to a stainless steel body (AISI 316L).

A TQxxx sensor has an integral cable, terminated with a self-locking miniature coaxial connector. The sensor is connected to an IQS900 signal conditioner either using the sensor's integral cable or using an EAxxx extension cable (see 1.2 TQxxx proximity measurement chains and Figure 1-1). Different EAxxx extension cables can be used to effectively lengthen the sensor/measurement chain front-end and various cable lengths (integral and extension) can be ordered. TQxxx proximity measurement chains are highly configurable (see 1.3.1 Configurations).

The IQS900 signal conditioner, made with high-quality, high-reliability components in a painted aluminium housing, contains a high-frequency modulator/demodulator that supplies a driving signal to a TQxxx sensor. When the TQxxx sensor coil is excited by the high-frequency signal from a IQS900 signal conditioner, a magnetic field is emitted by the coil. If an electrically conducting material is moved into this field, the characteristics of the magnetic circuit change, causing the amplitude of the high-frequency signal present in the coil to vary. This signal amplitude, related to the distance between the tip of the sensor and the target, is processed by the IQS900 signal conditioner in order to provide an output proportional to the distance between the sensor and target as either a current signal (µA/µm) suitable for transmission over longer distances or a voltage signal (mV/µm) suitable for transmission over shorter distances.

In addition, optional accessories such as IP172 interconnection protectors, JB118 junction boxes, ABA17x industrial housings, KS107 flexible conduits (protection tubes) and SG1xx cable feedthroughs are available for the mechanical and environmental protection of the connections and components in a TQxxx proximity measurement chain.

Finally, it is important to note that a TQxxx proximity measurement chain is typically powered (energised) using a limited-power, low-voltage power supply, such as a sensor power supply output provided by a VM600 or VibroSmart® monitoring and/or protection system, a GSI127 galvanic separation unit or other suitable power supply.

2.3 Operation of an IQS900 signal conditioner with diagnostics

As shown in Figure 2-1, the output from an IQS900 signal conditioner is an analogue signal consisting of a dynamic measurement component (AC) and a quasi-static measurement/diagnostic component (DC).

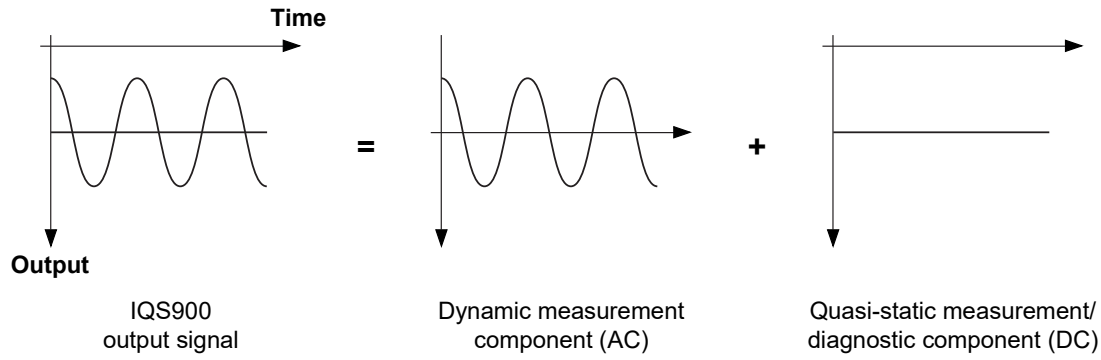

Figure 2-1: Output signal from an IQS900 signal conditioner

For the output signal from an IQS900 signal conditioner with diagnostics:

- The dynamic measurement component (AC) corresponds to the measured vibration.
- The quasi-static measurement/diagnostic component (DC) corresponds to either the gap (distance) to the target or the diagnostic status of the measurement chain.

For an IQS900 with diagnostics, internal electronic circuitry checks the integrity of the TQxxx proximity measurement chain (sensor, cabling and signal conditioner) and updates the nominal value of the quasi-static measurement/diagnostic component (DC) as follows:

- During normal operation of the measurement chain, the measurement/diagnostic component (DC) is a value within the normal operating range that corresponds to the gap (distance) to the target.
- When there is a problem with the measurement chain, the measurement/diagnostic component (DC) is driven/saturated to a value outside of the normal operating range to indicate a problem with the measurement chain or its power supply.

NOTE: For an IQS900 with diagnostics, any quasi-static measurement/diagnostic component (DC) value within the normal operating range of the IQS900 corresponds to normal operation of the TQxxx proximity measurement chain. All other values indicate a problem with the measurement chain (see Table 2-1).

Table 2-1 lists the permitted values for the quasi-static measurement/diagnostic component (DC) of the output signal from an IQS900 with diagnostics.

Table 2-1: Permitted values for the quasi-static measurement/diagnostic component (DC) of the output signal from an IQS900 with diagnostics

Measurement /diagnostic component (DC) value	Measurement chain OK?	Description
−15.5 to −20.5 mA_{DC} or −1.6 to −17.6 V_{DC} (within the normal operating range)	Yes	Normal operation. Both measurement components (AC and DC) of the output signal can be trusted.
>−15.5 or <−20.5 mA_{DC} or >−1.6 or <−17.6 V_{DC} (outside of the normal operating range)	No	Problem with the measurement chain (sensor, cabling and/or signal conditioner)
Notes The output signal from an IQS900 signal conditioner can be either a current (mA) or a voltage (V) signal, depending on the configured measurement range and sensitivity (which also determines the type of output signal).		

For reference, Table 2-2 lists the permitted values for the quasi-static measurement/diagnostic component (DC) of the output signal from an IQS900 without diagnostics.

Table 2-2: Permitted values for the quasi-static measurement/diagnostic component (DC) of the output signal from an IQS900 without diagnostics

Measurement /diagnostic component (DC) value	Description
−15.5 to −20.5 mA_{DC} or −1.6 to −17.6 V_{DC} (within the normal operating range)	Normal operation
Notes The output signal from an IQS900 signal conditioner can be either a current (mA) or a voltage (V) signal, depending on the configured measurement range and sensitivity (which also determines the type of output signal).	

NOTE: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* and the *Proximity measurement chains using TQ9xx proximity sensors installation manual* for further information.

2.4 TQxxx proximity measurement chain in safety-related applications

When a TQxxx proximity measurement chain is used in a safety-related application (functional-safety context), certain conditions/restrictions apply.

AS AN INPUT (SENSOR) TO AN EXTERNAL SAFETY INSTRUMENTED SYSTEM (SIS) PERFORMING A SAFETY INSTRUMENTED FUNCTION (SIF), A TQXXX PROXIMITY MEASUREMENT CHAIN MUST CONSIST OF A TQXXX PROXIMITY SENSOR WITH INTEGRAL CABLE (TQ9XX OR TQ4XX), OPTIONAL EAXXX EXTENSION CABLE (EA90X OR EA40X) AND AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS.

2.4.1 Valid TQxxx, EAxxx and IQS900 measurement chains

In order to support the correct operation of an IQS900 signal conditioner with diagnostics, a TQxxx proximity measurement chain must be “valid”, that is, consist of a TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx), optional EAxxx extension cable (EA90x or EA40x) and an IQS900 signal conditioner with diagnostics.

2.5 Power supply

Table 2-3 shows the power supply specifications for an IQS900 signal conditioner.

Table 2-3: IQS900 signal conditioner power supply specifications

Parameter	Value
Input voltage range (nominal) for a current output signal	−18 V_{DC} to −30 V_{DC}
Input voltage range monitoring for a current output signal	−17.28 ±0.45 V_{DC} to −30.25 ±0.80 V_{DC}
Input voltage range (nominal) for a voltage output signal	−19 V_{DC} to −30 V_{DC}
Input voltage range monitoring for a voltage output signal	−19.00 ±0.50 V_{DC} to −30.25 ±0.80 V_{DC}
Current consumption (with nominal 24 V_{DC} supply)	25 mA max.
Overvoltage protection (diode)	Protection starts between −31.4 and −34.7 V_{DC} at an ambient temperature of 23°C ±5°C (73°F ±9°F)
Power-up time	<30 s

NOTE: The power supply requirements are slightly different depending on whether an IQS900 signal conditioner is configured with a current output signal or a voltage output signal.
The power supply input to an IQS900 signal conditioner must meet the required specifications in order to ensure that the IQS900's diagnostics circuitry can drive/saturate the quasi-static measurement/diagnostic component (DC) of the output signal as required under all circumstances.

The IQS900 signal conditioner should be powered (energised) using a limited-power, low-voltage power supply such as a sensor power supply output provided by a VM600 or VibroSmart® monitoring and/or protection system, a GSI127 galvanic separation unit or other suitable power supply.

In safety-related applications, an IQS900 must be powered using a limited-power, low-voltage power supply with a safe limitation of −30 V_{DC} (nominal), even in the event of a single fault with the power supply.

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3 HOW TO USE THE SYSTEM FOR SAFETY

3.1 Safety function

A TQxxx proximity measurement chain provides an analogue output signal (current or voltage) consisting of a dynamic measurement component (AC) that corresponds to the measured vibration and a quasi-static measurement/diagnostic component (DC) that corresponds to the gap (distance) to the target such as a rotating machine shaft, within the safety accuracy, according to the configuration of the components of the measurement chain (see 2.4.1 Valid TQxxx, EAxxx and IQS900 measurement chains).

Importantly, for an IQS900 signal conditioner with diagnostics, the quasi-static measurement/diagnostic component (DC) is also used to indicate the diagnostic status of the TQxxx proximity measurement chain (TQ9xx or TQ4xx proximity sensor with integral cable, optional EA90x or EA40x extension cable and the IQS900 signal conditioner itself).

In a safety-related application (functional-safety context), the output signal from a TQxxx proximity measurement chain – more specifically, the output from a IQS900 signal conditioner with diagnostics – is an input (sensor) to an external monitoring and/or protection system (safety instrumented system (SIS)) that performs a safety function by taking this input together with other safety-related signals and performing a system-level safety function, such as initiating the shutdown (trip) of a machine.

NOTE: For the external monitoring and/or protection system performing a safety function:
- Any alarms corresponding to a safety function must be configured as latching.
- Any relays corresponding to a safety function must be configured as latching and normally energised (de-energised to trip).
- An analysis must be carried out at the safety-system level to ensure that no alarm can be missed or to identify all possible impacts and acceptability of residual risks in case of a missed alarm.

Table 3-1 lists the safety accuracy and other important safety properties for a TQxxx proximity measurement chain.

3.2 Safety output(s)

A TQxxx proximity measurement chain – more specifically, a IQS900 signal conditioner with diagnostics – has one safety-critical output: an analogue signal (current or voltage) consisting of a dynamic measurement component (AC) and a quasi-static measurement/diagnostic component (DC), as described in 2.2 Operation of a TQxxx proximity measurement chain.

In typical safety-related applications:

- During normal operation of the measurement chain, the measurement component (AC) and the measurement/diagnostic component (DC) are used to indicate whether the machinery being monitored is operating correctly or not.
- When there is a problem with the measurement chain, the measurement/diagnostic component (DC) is used to indicate that the measurement chain is not operating correctly, that is, to indicate a problem with the measurement chain or its power supply.

It is important to note that for a TQxxx proximity measurement chain, there is no safe state. Instead, dangerous-detected failures (λ_{DD}) in the measurement chain are indicated by driving/saturating the measurement/diagnostic component (DC) of the output signal to a value outside of the normal operating range. Accordingly, any required safe state behaviour, including the latching of alarms or relays, must be implemented by an external monitoring and/or protection system at the safety-system level.

A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS PROVIDES A SAFETY-CRITICAL OUTPUT BUT DOES NOT PROVIDE A SAFE STATE. ANY REQUIRED SAFE STATE BEHAVIOUR, INCLUDING THE LATCHING OF ALARMS OR RELAYS, MUST BE IMPLEMENTED BY AN EXTERNAL MONITORING AND/OR PROTECTION SYSTEM.

THE EXTERNAL MONITORING AND/OR PROTECTION SYSTEM MUST BE ABLE TO MEASURE THE SAFETY-CRITICAL OUTPUT WITH AN ACCURACY OF AT LEAST ±0.1 MA OR ±0.1 V.

See also 7.7 Configuring the external monitoring and/or protection system.

3.3 Safety properties(s)

Table 3-1 lists the other important safety properties for a TQ9xx-based proximity measurement chain.

Table 3-1: Other important safety properties for a TQ9xx-based proximity measurement chain

Safety property	Description / Value
SIL level (IEC 61508)	SIL 2
Systematic capability (IEC 61508)	2
Cat and PL levels (ISO 13849)	Cat 1 and PL c. Note: See also 3.5 ISO 13849-1 performance level.
Modes of operations	Low-demand mode or High-demand (continuous) mode
Type of subsystem	Type A
Hardware fault tolerance (HFT)	0
Dangerous-detected failures (λ_{DD})	173.5 failure rate (FIT). Note: For dangerous-detected failures (λ_{DD}), the output from an IQS900 signal conditioner with diagnostics is defined.
Dangerous-undetected failures (λ_{DU})	40.8 failure rate (FIT). Note: For dangerous-undetected failures (λ_{DU}), the output from an IQS900 signal conditioner with diagnostics is undefined, that is, “other” current or voltage values.
Safe-detected failures (λ_{SD}) and safe-undetected failures (λ_{SU})	λ_{SD} = 0.0 failure rate (FIT). λ_{SU} = 0.8 failure rate (FIT). Note: An IQS900 signal conditioner with diagnostics has neither safe-detected (λ_{SD}) nor safe-undetected (λ_{SU}) failures, that is, there is no latched safe state.
Safe failure fraction (SFF) for Type A subsystem	81% (calculated value). SIL 2 requires ≥60% for a Type A device with HFT = 0.
Process safety time (PST)	<25 ms in Low-demand mode. <500 ms in High-demand (continuous) mode. Note: This is the time required for an IQS900 signal conditioner with diagnostics to update the nominal value of the measurement/diagnostic component (DC) of its output signal.
Allocation of SIL budget	PFDavg <20% of the SIL 2 budget for a PTI ≤10 years (PTC of 90%). PFH <20% of the SIL 2 budget at 40.8 FIT. Note: For a TQ9xx-based proximity measurement chain (TQ9xx proximity sensor, EA90x extension cable and IQS900 signal conditioner with diagnostics). See also Table 3-2.
Safety accuracy	Sensitivity: ±10%. Note: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* for typical sensitivity values.
Notes Failure rate calculations and analysis were performed with a long-term ambient temperature of 40°C (104°F). For an IQS900 signal conditioner with diagnostics, output values are defined in Table 2-1 and 7.7.1 Defining the alarm levels.	

Additional failure modes, effects and diagnostic analysis (FMEDA) calculations, details and results can be made available on request. Contact your Meggitt SA for further information.

3.4 Design verification

Table 3-2 lists the important design verifications for a TQ9xx-based proximity measurement chain.

Table 3-2: Design verification for a TQ9xx-based proximity measurement chain

Design verification	Description / Value					
Probability of failure per hour (PFH)	4.08×10^{-8} (calculated value). Note: SIL 2 requires $<1 \times 10^{-6}$.					
Average probability of failure on demand (PFDavg)	Proof test interval (PTI)	1 year	2 years	3 years	5 years	10 years
	PFDavg by proof test years	3.41×10^{-4}	5.02×10^{-4}	6.62×10^{-4}	9.84×10^{-4}	1.79×10^{-3}
	Note: SIL 2 requires $<1 \times 10^{-2}$.					

Notes

With a proof test interval (PTI) of 10 years, the SIL 2 budget is maintained below 20% for the complete TQ9xx-based proximity measurement chain (TQ9xx proximity sensor, EA90x extension cable and IQS900 signal conditioner with diagnostics).
Failure rate calculations and analysis were performed for a long-term ambient temperature of 40°C (104°F).
For reference, the typical maintenance intervals for the types of machinery monitored by TQ9xx-based proximity measurement chains are 3 to 4 years.

3.5 ISO 13849-1 performance level

3.5.1 Single TQ9xx-based proximity measurement chain performance level

Table 3-3 shows the calculated results for a typical single TQ9xx-based proximity measurement chain (HFT = 0) consisting of a TQ9xx proximity sensor, EA90x extension cable and IQS900 signal conditioner with diagnostics in a category 1 system architecture, according to ISO 13849-1.

Table 3-3: Performance level (PL) for a typical TQ9xx-based proximity measurement chain according to ISO 13849-1

Component	MTTFd[1] (in years)	MTTFd category	Performance level (PL)
TQ9xx-based proximity measurement chain	532.8	High	c

Notes

1. Mean time to dangerous failure (MTTFd).
Additional mean time between failures (MTBF) and failure modes, effects and diagnostic analysis (FMEDA) calculations, details and results can be made available on request. Contact your local Meggitt representative for further information.

Accordingly, for a typical single TQ9xx-based proximity measurement chain, the maximum performance level (PL) achievable is Cat 1 PL c (as per Table K.1 of DIN ISO 13849-1).

NOTE: In safety-related applications, loss of the safety function is detected by the safety-critical output of the TQxxx proximity measurement chain (IQS900 signal conditioner with diagnostics) being checked and latched by the external monitoring and/or protection system.

3.6 Environmental and application limits

NOTE: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* or *TQ4xx, EA40x and IQS45x proximity measurement chain data sheet* as appropriate, for further information on environmental and application limits such as temperature, humidity, IP protection rating, vibration and shock.

3.7 Safety certificate(s)

The TQxxx proximity measurement chains/systems described in this safety manual are certified by TÜV® SÜD:

- SIL 2 in accordance with IEC 61508-1:2010 and IEC 61508-2:2010.
- Cat 1 PL c in accordance with ISO 13849-1:2015.

NOTE: The TÜV® SÜD safety certificates can be obtained from the Meggitt vibro-meter® Energy website at www.meggittsensing.com/energy or by contacting your local Meggitt representative.

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4 CONFIGURATION

4.1 Configuration

During manufacture, the components of a TQxxx proximity measurement chain (TQ9xx or TQ4xx proximity sensor with integral cable, optional EA90x or EA40x extension cable and the IQS900 signal conditioner) are configured in accordance with the individual part numbers (PNR) and ordering option codes defined by the customer at the time of ordering (see 1.3.1 Configurations).

NOTE: Refer to a *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* or *TQ4xx, EA40x and IQS45x proximity measurement chain data sheet* as appropriate, for further information on ordering option codes.

After manufacture, the configuration of a TQxxx proximity measurement chain cannot be changed.

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5 INSTALLATION AND COMMISSIONING

5.1 Installation

For general information on the installation of a TQxxx proximity measurement chain, refer to the *Proximity measurement chains using TQ9xx proximity sensors installation manual* or *Proximity measurement chains using TQ4xx proximity sensors installation manual* as appropriate.

5.2 Commissioning

USE OF A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS IN A SAFETY-RELATED APPLICATION (FUNCTIONAL-SAFETY CONTEXT) REQUIRES THAT THE MEASUREMENT CHAIN IS COMMISSIONED AS AN INTEGRAL PART OF THE OVERALL SAFETY-RELATED SYSTEM COMMISSIONING.

NOTE: Installation and commissioning should only be performed by competent and authorised personnel following the plant specific guidelines in force at the installation.

For the commissioning of a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics in a safety-related application, it is important to ensure that the correct components are used and that they are connected together correctly:

- An IQS900 signal conditioner with diagnostics must be used (see 1.2.2 IQS900 signal conditioner with diagnostics).
- The TQxxx proximity sensor with integral cable (TQ9xx or TQ4xx) and optional EAxxx extension cable (EA90x or EA40x) must be compatible with the IQS900 (see 2.4 TQxxx proximity measurement chain in safety-related applications and 2.4.1 Valid TQxxx, EAxxx and IQS900 measurement chains).
- The external power supply used to power the IQS900 signal conditioner must meet the requirements specified in 2.5 Power supply.
- Correct wiring must be verified.

See also 7.8 Commissioning.

NOTE: It is important to note that a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics is used as an input (sensor) to an external monitoring and/or protection system (safety instrumented system (SIS)) that performs a safety function, so it is the external system that provides the “intelligence” in the safety system.
Accordingly, any required safe state behaviour, including the latching of alarms or relays, must be implemented by an external monitoring and/or protection system at the safety-system level.

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6 OPERATION AND MAINTENANCE

6.1 Proof test

A proof test is required to detect dangerous faults which are undetected by the integrated diagnostics of a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics.

NOTE: The proof test should be performed in accordance with overall safety-system requirements.

The following proof test provides a proof test coverage (PTC) of 90%.

Equipment required

- Small screwdriver
- Multimeter such as a digital multimeter (DMM).

Procedure

1- For the measurement channel of the external monitoring and/or protection system using the TQxxx proximity measurement chain as an input, bypass the safety function and take appropriate action to ensure that a shutdown (“trip”) of the machinery is not accidentally initiated by the proof test.

2- Measure and record the value of the output signal on the IQS900 signal conditioner’s main output.

For example, a multimeter (DMM) could be used to measure the signal via the IQS900 signal conditioner’s output screw-terminal connector (as shown on the right of the image in Figure 1-3). Alternatively, the external monitoring system could be used to measure the signal.

NOTE: When measuring the output signal of the IQS900 signal conditioner, be sure to use the main output (not the “RAW” output).
For an IQS900 signal conditioner with a current-modulated output signal (that is, using current (2-wire) signal transmission), the main output uses the “−24V” and “COM” pins of the output screw-terminal connector and can be measured using a multimeter (DMM) as shown in Figure 6-1.
For an IQS900 signal conditioner with a voltage-modulated output signal (that is, using voltage (3-wire) signal transmission), the main output uses the “O/P” and “COM” pins of the output screw-terminal connector and can be measured using a multimeter (DMM) as shown in Figure 6-2.

NOTE: When measuring the output signal of the IQS900 signal conditioner, be sure to record both the dynamic measurement component (AC) and the quasi-static measurement/diagnostic component (DC) of the signal (see Figure 2-1).

3- Disconnect the coaxial sensor cable (TQxxx proximity sensor's integral cable or optional EAxxx extension cable) from the input of the IQS900 signal conditioner and check that the quasi-static measurement/diagnostic component (DC) of the output signal from the IQS900 indicates that there is a problem with the measurement chain.

For an IQS900 signal conditioner with diagnostics, a measurement/diagnostic component (DC) value of −15.5 to −20.5 mA_{DC} or −1.6 to −17.6 V_{DC} indicates normal operation, while other values indicate a problem (see 2.3 Operation of an IQS900 signal conditioner with diagnostics, Table 2-1 and Figure 7-1).

4- Reconnect the coaxial sensor cable (TQxxx proximity sensor's integral cable or optional EAxxx extension cable) to the input of the IQS900 signal conditioner (that is, reassemble the sensor/measurement chain) and check that the value of the output signal on the IQS900 signal conditioner's main output is equal to the AC and DC values recorded before the disconnection (see step 2).

5- For the measurement channel of the external monitoring and/or protection system using the TQxxx proximity measurement chain as an input, remove the bypass on the safety function and restore the system to normal operation.

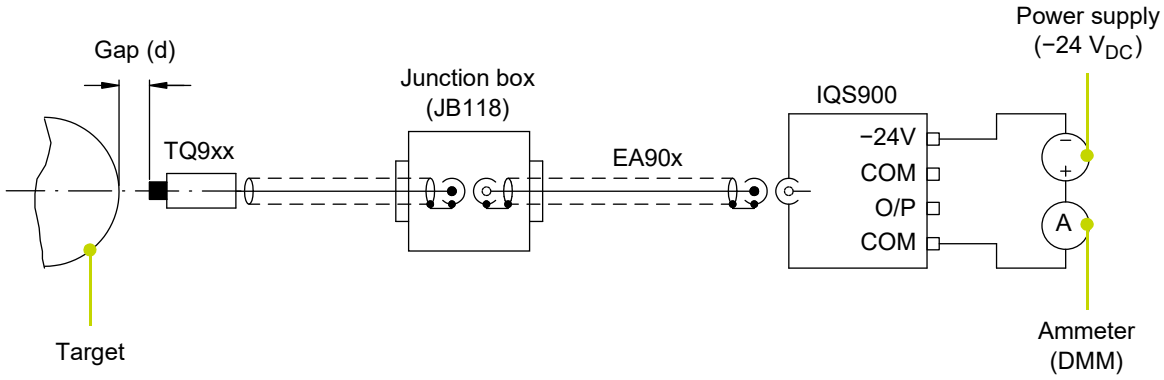


Figure 6-1: Characterisation for systems using current (2-wire) signal transmission

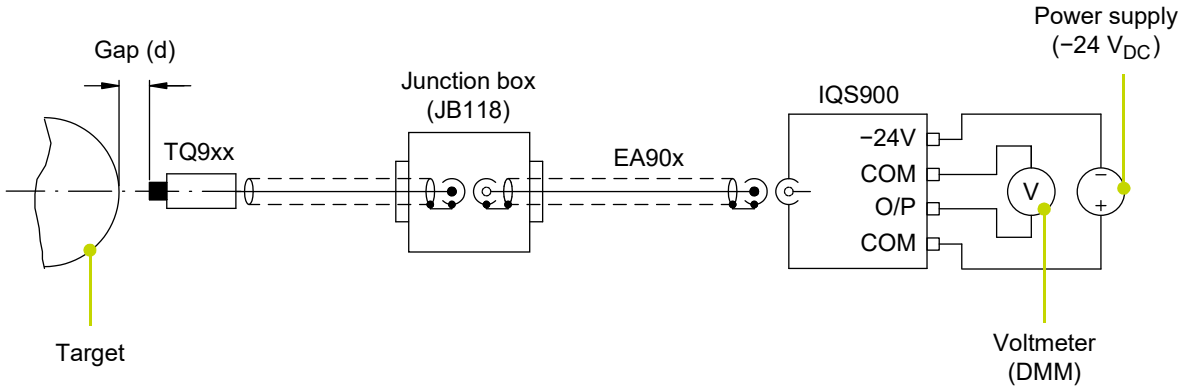


Figure 6-2: Characterisation for systems using voltage (3-wire) signal transmission

See also 6.2 Partial testing.

6.2 Partial testing

Partial testing is required to reach SIL 2, as it increases safety and detects possible “stuck-at” faults which may be undetected by the integrated diagnostics of a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics.

FOR A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS, PARTIAL TESTING IS REQUIRED FOR SIL 2 CHAINS/SYSTEMS IN ACCORDANCE WITH IEC 61508.

NOTE: Partial testing should be performed once per year but does not replace system requirements for a proof test (see 6.1 Proof test).

Equipment required

- Small screwdriver
- Signal generator
- Multimeter such as a digital multimeter (DMM) – optional.

Procedure

1- For the measurement channel of the external monitoring and/or protection system using the TQxxx proximity measurement chain as an input, bypass the safety function and take appropriate action to ensure that a shutdown (“trip”) of the machinery is not accidentally initiated by the proof test.

2- Use a signal generator to inject a known voltage signal on the IQS900 signal conditioner’s “TEST” input, via the screw-terminal connector (as shown on the left of the image in Figure 1-3).

NOTE: A test input signal (“TEST”/ and “COM”) allows an AC voltage input signal to be injected at the input to the IQS900 signal conditioner, effectively emulating the dynamic measurement component (AC) of an input signal from a TQ9xx (or TQ4xx) sensor.
Refer to section §9.4.2 Test input functionality of the *Proximity measurement chains using TQ9xx proximity sensors installation manual* for further information.

3- Check that the dynamic measurement component (AC) of output signal from the IQS900 (i) corresponds to the injected signal and (ii) changes to correspond to changes in the injected signal.

For example, the external monitoring system could be used to measure the signal. Alternatively, a multimeter (DMM) could be used to measure the signal via the IQS900 signal conditioner’s output screw-terminal connector (as described in step 2 of 6.1 Proof test).

4- Remove the voltage signal from the IQS900 signal conditioner’s TEST input.

5- For the measurement channel of the external monitoring and/or protection system using the TQxxx proximity measurement chain as an input, remove the bypass on the safety function and restore the system to normal operation.

See also 6.1 Proof test.

6.3 Maintenance and end-of-life product disposal

For general maintenance and end-of-life product disposal information, refer to the *Proximity measurement chains using TQ9xx proximity sensors installation manual* or *Proximity measurement chains using TQ4xx proximity sensors installation manual* as appropriate.

See also 7.10 Maintenance.

7 SAFETY ISSUES

7.1 Safety function

In practice, the output signal from a TQxxx proximity measurement chain – more specifically, the output from a IQS900 signal conditioner with diagnostics – is an input (sensor) to an external monitoring and/or protection system (external safety instrumented system (SIS) that performs a safety function by taking this input together with other safety-related signals and performing a system-level safety function, such as initiating the shutdown (trip) of a machine.

Accordingly, any required safe state behaviour, including the latching of alarms or relays, must be implemented by an external monitoring and/or protection system at the safety-system level.

See also 3.1 Safety function.

7.2 Safety output(s)

See Table 2-1.

7.3 Safety time

See process safety time (PST) in Table 3-1.

7.4 Power supply

See 2.5 Power supply.

7.5 Installation

Installation must be performed following the guidelines in the *Proximity measurement chains using TQ9xx proximity sensors installation manual* or *Proximity measurement chains using TQ4xx proximity sensors installation manual* as appropriate.

Environmental restrictions depend on the components of the TQxxx proximity measurement chain (TQ9xx or TQ4xx proximity sensor with integral cable, optional EA90x or EA40x extension cable and IQS900 signal conditioner).

NOTE: Refer to the relevant *TQ9xx, EA90x and IQS900 proximity measurement chain data sheet* for further information on environmental restrictions.

7.6 Configuring a TQxxx proximity measurement chain

A TQxxx proximity measurement chain is highly-configurable with ordering option codes that are used to specify the required configuration of the individual measurement chain components at the time of ordering (see 1.3.1 Configurations).

7.7 Configuring the external monitoring and/or protection system

For the external monitoring and/or protection system (safety instrumented system (SIS)) used with a TQxxx proximity measurement chain, it is important that the alarm levels/limits (alert and/or danger) configured for the proximity measurements (vibration and gap) are appropriate for the machinery/system under protection.

NOTE: Refer to the monitoring and/or protection system documentation for further information, such as a VM600 or VibroSmart®.

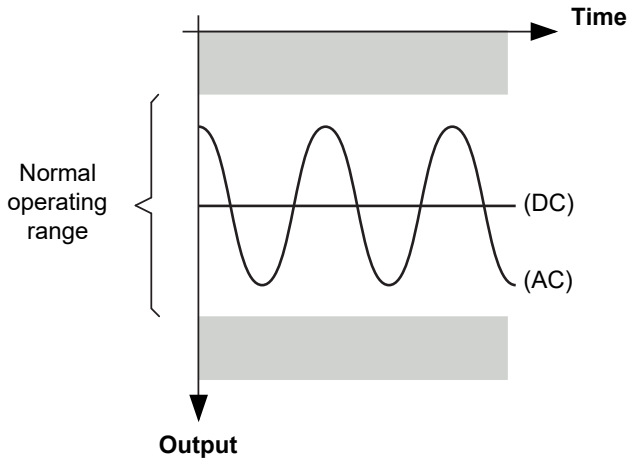
A TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics:

- Continuously updates the dynamic measurement component (AC) of the IQS900's output signal to correspond to the measured vibration and the quasi-static measurement/diagnostic component (DC) of the output signal to correspond to the gap (distance) to the target.
- Runs health checks on the components of the TQxxx proximity measurement chain (TQxxx proximity sensor, cabling and the IQS900 signal conditioner itself) and drives/saturates the quasi-static measurement/diagnostic component (DC) of the IQS900's output signal outside of its normal operating range to indicate a problem with the measurement chain.

In safety-related applications, the external monitoring and/or protection system used with a TQxxx proximity measurement chain must monitor the measurement/diagnostic component (DC) of the IQS900 signal conditioner's output signal for the values described in Table 2-1 and Figure 7-1.

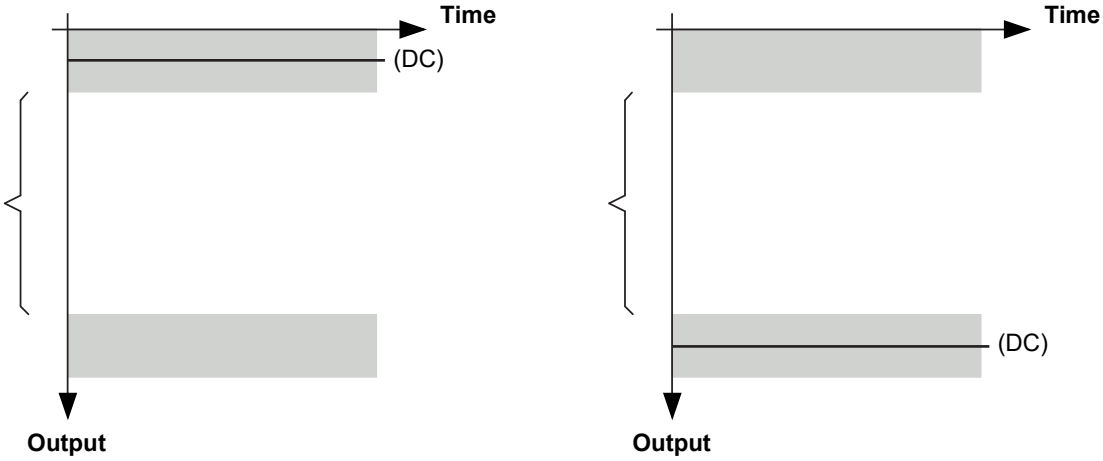
A TQXXX PROXIMITY MEASUREMENT CHAIN USING AN IQS900 SIGNAL CONDITIONER WITH DIAGNOSTICS PROVIDES A SAFETY-CRITICAL OUTPUT BUT DOES NOT PROVIDE A SAFE STATE. ANY REQUIRED SAFE STATE BEHAVIOUR, INCLUDING THE LATCHING OF ALARMS OR RELAYS, MUST BE IMPLEMENTED BY AN EXTERNAL MONITORING AND/OR PROTECTION SYSTEM.

THE EXTERNAL MONITORING AND/OR PROTECTION SYSTEM MUST BE ABLE TO MEASURE THE SAFETY-CRITICAL OUTPUT WITH AN ACCURACY OF AT LEAST ±0.1 MA OR ±0.1 V.



(a) Measurement/diagnostic component (DC) value = −15.5 to −20.5 mA_{DC}
or
−1.6 to −17.6 V_{DC}.

Note: The measurement/diagnostic component (DC) value is within the normal operating range, so the measurement chain is OK and both measurement components (AC and DC) of the output signal can be trusted.



(b) Measurement/diagnostic component (DC) value = >−15.5 or <−20.5 mA_{DC}
or
>−1.6 or <−17.6 V_{DC}.

Note: The measurement/diagnostic component (DC) value is outside of the normal operating range, so the measurement chain is not OK!

Note: In the (a) and (b) drawings above, the grey areas correspond to the recommended alarm levels/ranges to be configured for the external monitoring and/or protection system (safety instrumented system (SIS)).

Figure 7-1: Output signal from an IQS900 signal conditioner with diagnostics

7.7.1 Defining the alarm levels

As shown in Figure 7-1 (a), during normal operation, an IQS900 signal conditioner with diagnostics will update its output signal as follows:

- Quasi-static measurement/diagnostic component (DC) to a value within the normal operating range of −15.5 to −20.5 mA_{DC} or −1.6 to −17.6 V_{DC} that corresponds to the measured gap.
- Dynamic measurement component (AC) to a value within the normal operating range of −15.5 to −20.5 mA_{DC} or −1.6 to −17.6 V_{DC} that corresponds to the measured vibration (displacement).

NOTE: Proximity measurements (vibration and gap) depend on the measurement range and sensitivity configured for the IQS900 (see 1.3.1 Configurations).

As shown in Figure 7-1 (b), after the detection of a problem with the measurement chain (sensor, cabling and/or signal conditioner), an IQS900 signal conditioner with diagnostics will update its output signal as follows:

- Quasi-static measurement/diagnostic component (DC) to a value outside of the normal operating range, that is, >−15.5 or <−20.5 mA_{DC} or >−1.6 to <−17.6 V_{DC}.

See also 2.3 Operation of an IQS900 signal conditioner with diagnostics, including Table 2-1 and 3.2 Safety output(s).

Accordingly, in a safety-related application, the external monitoring and/or protection system using a TQxxx proximity measurement chain as an input must be capable of detecting and reporting the diagnostic status of the measurement chain as communicated by the measurement/diagnostic component (DC) of the IQS900 signal conditioner's output signal. More specifically, the corresponding sensor/measurement chain OK check/levels must be suitable (see Figure 7-1 and Table 2-1).

It is also important that the measurement channel / machinery monitoring system using a TQxxx proximity measurement chain as an input is configured to detect and report any problems with the measurement chain as quickly as possible, that is, corresponding delay times should be configured as zero (0).

For the measurement/diagnostic component (DC) of the output signal from an IQS900, the configuration of the safety function in the external monitoring and/or protection system must be made in consultation with the safety system engineer (or a similar authority).

For the measurement component (AC) and the measurement/diagnostic component (DC) of the output signal from an IQS900, the configuration of the alarm levels/limits in the external monitoring and/or protection system must be made in consultation with the site manager. It is the end user's responsibility to ensure that the alarm levels/limits are appropriate for the machinery/system under protection.

NOTE: Refer to the monitoring and/or protection system documentation for further information.

7.8 Commissioning

Installation and commissioning of a a TQxxx proximity measurement chain should only be performed by competent and authorised personnel following the plant specific guidelines in force at the installation.

Further, a TQxxx proximity measurement chain must be commissioned as an integral part of the overall safety-related system commissioning.

USE OF A TQXXX PROXIMITY MEASUREMENT CHAIN IN A SAFETY-RELATED APPLICATION (FUNCTIONAL-SAFETY CONTEXT) REQUIRES THAT THE MEASUREMENT CHAIN IS COMMISSIONED AS AN INTEGRAL PART OF THE OVERALL SAFETY-RELATED SYSTEM COMMISSIONING.

See also 5 Installation and commissioning.

7.8.1 Guidelines for commissioning

NOTE: Refer to the monitoring and/or protection system documentation for further information.

7.9 Product lifetime

In safety-related applications, a TQxxx proximity measurement chain has a product lifetime of 10 years after entry into service.

7.10 Maintenance

TQxxx proximity measurement chain proof testing should be performed in accordance with the overall maintenance plan for the external monitoring and/or protection system (safety instrumented system (SIS)). See 6.1 Proof test for the proof test procedure.

General maintenance should be performed following the guidelines in the latest version of the *Proximity measurement chains using TQ9xx proximity sensors installation manual* or *Proximity measurement chains using TQ4xx proximity sensors installation manual* as appropriate.

See 8.1 Contacting us for the contact details relevant to repairing defective hardware.

IF A TQXXX PROXIMITY MEASUREMENT CHAIN IS UNDER MAINTENANCE OR REPAIR, THEN THE ATTACHED SYSTEM AND EQUIPMENT MAY NO LONGER BE PROTECTED. THEREFORE, SUCH PROCEDURES SHOULD ONLY BE UNDERTAKEN BY AUTHORISED PERSONNEL RESPECTING THE OVERALL PLANT OPERATION PROCEDURES.

7.11 Mean time to repair

The mean time to repair/restoration (MTTR = MRT) for a TQxxx proximity measurement chain is considered to be 8 hours.

7.12 Assumptions

When a TQxxx proximity measurement chain using an IQS900 signal conditioner with diagnostics is used in safety-related applications (functional-safety contexts), certain characteristics of connected equipment such as a VM600 or VibroSmart® monitoring and/or protection system, or a GSI127 galvanic separation unit, and associated transmission cabling are assumed as follows:

#1

The power supply to an IQS900 signal conditioner is able to provide a minimum supply current of 25 mA_{DC}.

#2

The power supply to an IQS900 signal conditioner is able to ensure a supply voltage of
−17.28 to −30.25 V_{DC} for an IQS900 with a current output or
−19.00 to −30.25 V_{DC} for an IQS900 with a voltage output,
for the maximum current consumption of 25 mA_{DC}, at the input to the IQS900 on the **−24V** screw-terminal connector.

#3

For an IQS900 signal conditioner configured with a current output, the maximum input impedance for connected equipment is 600 Ω.

NOTE: This is in order to have an IQS900 output signal loss of 1% max.

#4

For an IQS900 signal conditioner configured with a voltage output, the minimum input impedance for connected equipment is 50 kΩ.

NOTE: This is in order to have an IQS900 output signal loss of 1% max.

#5

The external monitoring and/or protection system connected to the output of an IQS900 signal conditioner is capable of reading the quasi-static measurement/diagnostic component (DC) of the IQS900's output signal with an accuracy of at least ±0.1 mA or ±0.1 V.

NOTE: This is in order to be able to identify the diagnostic status of a TQxxx proximity measurement chain, that is, to distinguish between normal operation and a dangerous-detected failure.

8 SERVICE AND SUPPORT

8.1 Contacting us

Meggitt's worldwide customer support network offers a range of support, including 8.3 Technical support and 8.4 Sales and repairs support. For customer support, contact your local Meggitt representative. Alternatively, contact our main office:

Customer support department
Meggitt SA
Route de Moncor 4
Case postale
1701 Fribourg
Switzerland

Telephone: +41 26 407 11 11
Email: energysupport@ch.meggitt.com
Website: www.meggittsensing.com/energy

8.2 SIL safety product information

For products used in safety-related applications, it is important that:

- Meggitt's technical support team is able provide you and/or the end user with product-related safety information such as service bulletins and/or product recalls.

NOTE: Accordingly, the Energy SIL safety product communications procedure described on page 8-3 should be used in order to opt in and receive such SIL product communications.

- You and/or the end user provide Meggitt's technical support team with product-related applications information such as operating issues and/or failures.

NOTE: Accordingly, the Energy product return procedure described on page 8-5 should be used in order to report problems and return Meggitt vibro-meter® Energy products for repair.

8.3 Technical support

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

- General advice
- Technical advice
- Troubleshooting
- Site visits.

NOTE: For further information, contact Meggitt SA (see 8.1 Contacting us).

8.4 Sales and repairs support

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

- New products
- Spare parts
- Repairs.

NOTE: If a product has to be returned for repairs, then this should be done in accordance with the Energy product return procedure described on page 8-5.

8.5 Customer feedback

As part of our continuing commitment to improving customer service, we warmly welcome your opinions. To provide feedback, complete the Energy customer feedback form on page 8-10 and return it Meggitt SA's main office (see 8.1 Contacting us).

SIL SAFETY PRODUCT INFORMATION

Energy SIL safety product communications procedure

In order for important future information concerning the use of a Meggitt vibro-meter® Energy SIL safety product to be communicated to users, it is important that Meggitt SA has contact and product information for the users of SIL products.

Accordingly, in order to opt in and receive SIL safety product communications, please use the online SIL safety product communications procedure on the Meggitt vibro-meter® Energy website at:

www.meggittsensing.com/energy/service-and-support/silproductcommunications

As described on the website, the SIL safety product communications procedure is as follows:

1- Complete and submit online the **Energy SIL safety product communications form** that is available on the website (note: * indicates a required field).

For each type of Energy SIL safety product, a separate Energy SIL safety product communications form must be completed and submitted online.

2- An acknowledgement email will be sent by return to confirm that the form was received by Meggitt SA and that your contact and product information has been added to the Energy SIL safety product database managed by our Customer support department.

Accordingly, any important future information concerning the use of an Energy SIL safety product will be communicated to you, should this become necessary.

NOTE: For SIL products used in safety-related applications, Meggitt SA strongly recommends that you opt in and receive SIL product communications as this could include important future information concerning the safety of a product such as safety bulletins and/or product update/replacement information.
If you do not opt in to receive SIL product communications, you might not receive important future information concerning the safety of a product.

NOTE: The **Energy SIL safety product communications form** reproduced below is included to support the gathering of information required for completion and submission online.

Energy SIL safety product communications form

Customer contact information

First name:*

Last name:*

Job title:

Company:*

Address:*

Country:*

Email:*

Telephone:*

Fax:

SIL safety product information

Product type:*

Part number (PNR):*

Serial number (SER):

Enter “Unknown” if the serial number (SER) is not known.

Meggitt SA purchase order number:

Date of purchase (dd.mm.yyyy):

Site where installed:

End user:

SIL safety product communications

Do you want to opt in and receive important communications information concerning your SIL safety product?:*

☐ Yes

☐ No

Note: For SIL safety products used in safety-related applications, Meggitt SA strongly recommends that you opt in to receive SIL product communications as this could include important future information concerning the safety of a product such as safety bulletins and/or product update/replacement information.

REPAIRS AND RETURNS

Energy product return procedure

If a Meggitt vibro-meter® Energy product needs to be returned to Meggitt Switzerland, please use the online product return procedure on the Meggitt vibro-meter® Energy website at:

www.meggittsensing.com/energy/service-and-support/repair

As described on the website, the product return procedure is as follows:

1- Complete and submit online the **Energy product return form** that is available on the website (note: * indicates a required field).

For each Energy product to be returned, a separate Energy product return form must be completed and submitted online. It is possible to return multiple items of the same product type with the same form (same part number (PNR), multiple serial numbers (SNRs) – separated with a coma ",").
When an Energy product return form is submitted online, the website displays a message confirming that the form has been successfully sent.

2- When the Energy product return form has been processed by Meggitt Switzerland, a return merchandise authorisation (RMA) document with a unique RMA # reference number and containing a pre-filled end-user certificate (EUC) will be emailed by return.

Received forms are typically processed and the RMA document sent within 2 working days.

NOTE: Please do not return any products to Meggitt Switzerland without a supporting return merchandise authorisation (RMA) document.
Please use the RMA # reference number in all future communications regarding a product return.

3- Review, complete and sign the RMA document and also review, complete and sign the EUC that the RMA contains (separate signatures are required for each).

For each Energy product to be returned, an associated single-use end-user certificate (EUC) is required, unless your company has an annual end-user certificate (EUC) in place. Either end-user certificate can be used to cover multiple products.
Multiple items of the same product type (same part number (PNR), multiple serial numbers (SNRs)) are allowed for a single RMA and EUC.

4- Optionally, to support your internal processes, you may want to issue one purchase order (PO) per product (may include multiple items / serial numbers) and send it to Meggitt Switzerland.

5- Send the Energy product(s) together with printed and signed copies of the return merchandise authorisation (RMA) document (or documents) and the end-user certificate (or certificates) to Meggitt Switzerland at:

Meggitt SA, Energy repairs department, Route de Moncor 4, Case postale, 1701 Fribourg, Switzerland.

NOTE: The **Energy product return form** reproduced below is included to support the gathering of information required for completion and submission online.

Energy product return form

Contact information

First name:*

Last name:*

Job title:

Company:*

Address:*

Country:*

Email:*

Telephone:*

Fax:

Product information

Product type:*

Part number (PNR):*

Serial number (SER):

Note: Enter “Unknown” if the serial number (SER) is not known.

Ex product:

☐ Yes

☐ No

SIL product:*

☐ Yes

☐ No

Meggitt SA purchase order number:

Date of purchase (dd.mm.yyyy):

Product under warranty:

☐ Yes

☐ No

☐ Don’t know

Site where installed:

End user:

Return information

Reason for return:*

☐ Repair

☐ Calibration / recertification

☐ Out-of-box problem

☐ Return

If the reason for return is “Repair”, please answer the following questions:*

Type of failure:

☐ Continuous

☐ Intermittent

☐ Temperature dependent

How long was the operating time before failure?

Description of failure:

Please provide a detailed description in order to help with problem diagnosis.

If the reason for return is “Out-of-box failure”, please answer the following questions:*

Type of out-of-box failure:

☐ Product damaged

☐ Incorrect product configuration

☐ Incorrect product delivered

☐ Problem with documentation / labelling

☐ Product dead-on-arrival

Additional information:

Please provide as much information as possible in order to help with problem diagnosis.

Ex product information – additional information required for Ex products only

Is the product installed in a hazardous area (potentially explosive atmosphere)?:

☐ Yes

☐ No

If the product is installed in a hazardous area, please answer the following questions:

How long was the operating time before failure?:

Additional information:

SIL product information – additional information required for SIL products only*

Note: For SIL products used in functional-safety contexts/systems, this **SIL product information** section must be completed.

For a TQxxx-based proximity measurement chain using an IQS900 signal conditioner with diagnostics, when was it installed and first operated (dd.mm.yyyy)?:

For a TQxxx-based proximity measurement chain using an IQS900 signal conditioner with diagnostics, when was a proof test last executed (dd.mm.yyyy)?:

Is the product installed in a safety-related system?:*

☐ Yes

☐ No

If the product is installed in a safety-related system, please answer the following questions:*

Did the system fail** in a safe mode?:* (That is, the safety relay operated but the trip was spurious.)

☐ Yes

☐ No

☐ Not applicable

Did the system fail** in a dangerous state?:* (That is, the failure did not result in the safe state.)

☐ Yes

☐ No

☐ Not applicable

How long was the operating time before failure (in hours)?:*

Additional information:

** A faulty indicator LED is considered as a cosmetic failure.

FEEDBACK

Energy customer feedback form

Manual information

Title of manual:

TQxxx proximity measurement chains using an IQS900 signal conditioner safety manual

Reference:	MAIQS900-FS/E	Version:	Edition 1
Date of issue:	September 2021		

Customer contact information

First name:*

Last name:*

Job title:

Company:*

Address:*

Country:*

Email:*

Telephone:*

Fax:

Feedback – general

Please answer the following questions:

Is the document well organised?	☐ 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?	☐ Yes	☐ No

Please include any additional information in the “Feedback – additional” section below.

Feedback – additional

Additional information:

Please provide as much feedback as possible in order to help us improve our product documentation.
Continue on a separate sheet if necessary …

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