Panametrics

Safety Manual

XMTCpro SIL

Thermal Conductivity Binary Gas Analyzer

panametrics.com

PANA078C71 EN A

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Safety Manual

PANA078C71 Rev. A

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panametrics.com

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Services

Panametrics provides customers with an experienced staff of customer support personnel ready to respond to technical inquiries, as well as other remote and on-site support needs. To complement our broad portfolio of industry-leading solutions, we offer several types of flexible and scalable support services including: Training, Product Repairs, Service Agreements and more.

Please visit https://panametrics.com/services for more details.

Typographical Conventions

Note: *These paragraphs provide information that provides a deeper understanding of the situation, but is not essential to the proper completion of the instructions.*

IMPORTANT: These paragraphs provide information that emphasizes instructions that are essential to proper setup of the equipment. Failure to follow these instructions carefully may cause unreliable performance.

CAUTION! This symbol indicates a risk of minor personal injury and/or damage to the equipment unless these instructions are followed carefully.

WARNING! This symbol indicates a risk of serious personal injury unless these instructions are followed carefully.

Safety Issues

WARNING! It is the responsibility of the user to follow all site rules and applicable regulatory requirements.

IMPORTANT Any instructions on grounding and cable termination in this manual are necessary for compliance with global EMC / RFI standards. Such compliance may be required by National EMC / RFI legislation.

Local Safety Standards

The user shall ensure that he operates the equipment in accordance with the applicable local codes, standards, regulations, or laws.

Qualification of Personnel

Ensure that all personnel have applicable training to use the equipment.

Personal Safety Equipment

Ensure that operators and maintenance personnel have all safety equipment applicable.

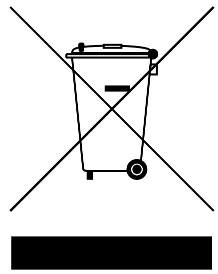
Unauthorized Operation

Ensure that unauthorized personnel cannot gain access to the operation of the equipment.

Environmental Compliance

Waste Electrical and Electronic Equipment

This apparatus required the extraction and use of natural resources for its production. It may contain hazardous substances that could impact health and the environment. To avoid the dispersal of these substances into our environment and to reduce the pressure on natural resources, we encourage you to use an appropriate "take-back" resource recovery scheme. These schemes will reuse or recycle most of the materials of your end-of-life equipment in an environmentally responsible way. The crossed-out wheeled bin symbol marked on the product invites you to use such a scheme.



If you need more information on the collection, reuse and recycling systems, please contact your local waste management administration.

As part of its commitment to the environment and the EU's WEEE Directive 2012/19/EU, Panametrics participates in a take-back scheme.

Please visit https://panametrics.com/health-safety-and-environment-hse for take-back instructions and more information about this initiative.

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Chapter 1. Introduction

1.1 Purpose

The purpose of the Safety Manual is to define the Functional Safety aspects of the XMTCpro-SIL Process Analyzer. For general installation and operational matters, refer to XMTCpro User's Manual, Doc. # PANA078C11 (*See Section 1.5, "References"*).

Table 1: XMTCpro Component Versions

	Part No. Revision	Software Revision	Bootloader Revision
Main Board PCB	703-2020-01 Rev C	N/A	N/A
IO PCB	703-2021-00 Rev A	N/A	N/A
HMI PCB	703-2022-00 Rev A	N/A	N/A
Cell + Boards	Rev C	N/A	N/A
Firmware	721-801-00 Rev C	2.0.6	2.0.6

1.2 Terms and Abbreviations

Basic Safety - The equipment must be designed and manufactured such that it protects against risk of damage to persons by electrical shock and other hazards and against the risk of creating fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition.

E/E/PE - The electrical and/or electronic and/or programmable electronic elements of an SIF. In short, these elements are the Functional Safety electronics.

Fault Detected State – The state of the SIL 4-20 mA output when the instrument has detected a fault. The output will be outside the 4 mA to 20 mA range to indicate an error. Some faults will set this state to 3.6 mA, some to 21 mA. For a hardware fault, the output will go to 0 mA.

FMEDA - Failure Modes, Effects and Diagnostic Analysis

Functional Safety - The ability of a system to carry out the actions necessary to achieve or to maintain a defined safe state for the equipment/machinery/plant/apparatus under control of the system.

HART - Highway Addressable Remote Transducer.

PFD_{AVG} - Average Probability of Failure On Demand.

Safety - Freedom from unacceptable risk of harm.

Safety Assessment - The investigation to arrive at a judgment – based on evidence – of the safety achieved by safety-related systems.

SIF – Safety Instrumented Function, a specific single set of actions and the corresponding equipment needed to identify a single hazard and act to return a system to a safe state. A Safety Instrumented System (SIS) is comprised of several individual SIF's.

SIL - Safety Integrity Level, discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest.

SIS - Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).

Note: *Further definitions of terms used for safety techniques and measures and the description of safety related systems are given in IEC 61508-4.*

1.3 Intended Audience and Reading Suggestions

This manual is intended for the Safety Engineer at the customer site. This document only applies in conjunction with the XMTCpro User Manual. Users are assumed to be qualified to operate a safety critical product and to respect all limits and follow the procedures outline within exactly as written.

For users who are unfamiliar with Functional Safety terminology and concepts, we recommend starting with the Glossary at the end of this manual. Once familiar with Functional Safety concepts, the user may want to refer to the section of the manual that is appropriate for the life cycle phase of the Process Analyzer. The main sections are: Installation and Commissioning, Maintenance, and Decommissioning.

1.4 Scope

This manual covers the following aspects of Functional Safety for the XMTCpro-SIL:

- Functional Safety Specifications of XMTCpro-SIL
- Installation and commissioning
- Maintenance, proof testing, service, and repair
- Decommissioning
- Contact information

1.5 References

The following documents are referenced in this manual:

- Functional Safety Standard IEC-61508
- XMTCpro User's Manual, Panametrics Doc. #PANA078C11 (available on the Panametrics Literature Library website: https://panametrics.com/services)
- FMEDA, XMO2-XMTC O2 / Thermal Conductivity Sensor; exida Report No. PAN 21-06-170 R006, V1, R1, exida 80 N. Main St, Sellersville, PA 18960

1.6 XMTCpro-SIL Functional Safety Characteristics

Table 2: Failure rates for XMTCpro with Good Maintenance Assumptions in FIT @ SSI=2

Failure Category	Failure Rate (FIT)
Fail Safe Detected	29.3
Fail Safe Undetected	50.5
Fail Dangerous Detected	1286.3
Fail Dangerous Undetected	131
No Effect	67.9

Table 3: Failure rates for XMTCpro Sensor with Good Maintenance Assumptions in FIT @ SSI=2

Failure Category	Failure Rate (FIT)
Fail Safe Detected	9.3
Fail Safe Undetected	1
Fail Dangerous Detected	9.3
Fail Dangerous Undetected	1
Low	45.6
No Effect	0

Table 4: Failure rates for XMTCpro IO Board with Good Maintenance Assumptions in FIT @ SSI=2

Failure Category	Failure Rate (FIT)
Fail Safe Detected	0.9
Fail Safe Undetected	73.1
Fail Dangerous Detected	206.3
Fail Dangerous Undetected	11.4
No Effect	143.2

Table 5: Failure rates for XMTCpro HMI Board with Good Maintenance Assumptions in FIT @ SSI=2

Failure Category	Failure Rate (FIT)
Fail Safe Detected	50.7
Fail Safe Undetected	33.8
Fail Dangerous Detected	0
Fail Dangerous Undetected	0.1
No Effect	122

Table 6 below is assumed to reflect a typical Safety Instrumented System (SIS).

Table 6: Design Criteria

Systematic Capability	2	Product Lifetime	10 years
HFT Hardware Fault Tolerance	0	Proof Test Interval	6 months
Type of Safety Related elements	Type B	Safety function reaction time[1]	1 Hour
		Diagnostic Test Interval[2]	60 seconds

Notes:

1. **Safety Function Reaction Time** from a cold start can be up to 1 hour, due to the time required to bring the measurement chamber to stable temperature. The reaction time to a fault while in homeostatic run mode is less than 60 seconds.
2. **Diagnostic Test Interval** worst case is 60 seconds. This is the period of time it takes to complete all internal automatic diagnostics while making measurements.

Table 7: Failure rates for Static Applications with Good Maintenance Assumptions in FIT @ SSI=2 according to IEC 61508

Application/Device/Configuration	λ_{SD}	λ_{SU}[3]	λ_{DD}	λ_{DU}	#	Low	DC
XMTCpro + Sensor + IO + HMI	90.2	158.4	1921.3	190.1	45.6	333.1	91

Where:

λ_{SD} = Fail Safe Detected

λ_{SU} = Fail Safe Undetected

λ_{DD} = Fail Dangerous Detected

λ_{DU} = Fail Dangerous Undetected

= No Effects Failures

DC = Diagnostic Coverage

These failure rates are valid for the useful lifetime of the product.

On these terms, the architectural constraints of an element must be determined. This can be done by following the 1H approach, or the approach according to IEC 61511:2016 which is based on 2H.

- The 1H approach involves calculating the Safe Failure Fraction for the entire element.
- The 2H approach involves assessment of the reliability data for the entire element.

The failure rate data used for this analysis meet the exida FMEDA criteria for Route 2H. Therefore, the XMTCpro meets the hardware architectural constraints for up to SIL 2 at HFT=0 when the listed failure rates are used. The architectural constraint type for the XMTCpro is B. The hardware fault tolerance of the device is 0. The SIS designer is responsible for meeting other requirements of applicable standards for any given SIL.

The digital communication protocol is only used for setup, calibration, and diagnostics purposes, not for safety critical operation.

The application program in the logic solver is constructed in such a way that Fail High and Fail Low failures are detected regardless of the effect, safe or dangerous, on the safety function.

Worst-case internal fault detection time is 1 hour.

As shown in *Table 6*, safety calculations are based on a useful product lifetime of 10 years.

1.6.1 System Description

The Functional Safety Chain of the XMTCpro consists of the sensor, signal conditioning, digital processing, 4-20mA analog output and alarm relays. The safety function of the device is the hydrogen measurement via the SIL 4-20mA output.

When measuring properly, the SIL output (pins 3 and 4 on analog input/output terminal –TB4) will be kept in 4-20 mA range to indicate to the SIS that there is a valid measurement.

IMPORTANT: 4-20mA output 1 is the functional safety output, both the modbus output and 4-20mA output 2 should not be used as part of an SIF design.

The Safety Accuracy of the device is 4%. Therefore, the SIL 4-20 mA measurement value could drift by 4% of range in either direction and still be considered a safe reading. This is not the same as measurement accuracy. Safety Accuracy is a tolerance that allows naturally occurring output drift without triggering a Safety Function fault.

A Functional Safety failure is indicated if the instrument could calculate an incorrect gas measurement and system faults. The instrument will react to a failure by setting the SIL Output (Pins 3 and 4 on TB4) to the Fault Detected state and setting an error message on the front screen and in the Modbus status register. These actions will alert the SIS that the instrument may not make a reliable measurement. The instrument will take these actions within one minute of detecting a failure plus one hour for initial warm up time. The Dangerous Detected state can be set to either 3.6 mA (LL) or 21.0 mA (HH) by the user. This is selectable in the program menu map. To clear the Fault Detected state, see *Section 4.1* for instructions.

The SIL function of the XMTCpro is valid only when the instrument is operated within the environmental limits listed in XMTCpro User's Manual, Doc. # PANA078C11, Chapter 8, Specifications.

1.6.2 Functional Safety Specifications

Safety accuracy has been defined as 4x the measurement accuracy. This means that if the instrument detects an error condition that could lead to an inaccuracy greater than the safety accuracy limit, the SIL output will go to the Dangerous Detected state.

- Diagnostic Response Time - The instrument shall respond to a fault condition within 60 seconds.
- Startup (warm up) Time - The instrument shall start making measurements within 30 minutes of applying power.
- Reliability Data and Lifetime Limit - The instrument is designed for a 10 year lifetime.

1.6.3 Prevention from Unauthorized Modification

During installation and commissioning, unauthorized personnel shall not be able to modify some parts of the system. These modifications could possibly result in a dangerous fault of the system. For this reason, an 'Admin and SIL' password is required to access these parameters. This password shall be safeguarded against unwarranted dissemination.

1.7 Product Safety Officer

Any failures that are detected and that compromise functional safety should be reported to the Product Safety Officer within Panametrics. Please contact *Panametrics Customer Service* or *Panametrics Technical Support*. Contact information is provided on the back cover of this manual.

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Chapter 2. Communication Tools

2.1 Measurement and Configuration

See the User Manual for instructions on installing and applying power to the meter. Upon applying power, the meter will go through a power-on self test and warm-up phase, then start to make measurements. This is the "online" state. When the meter is online, measurement data is being produced.

Logging in takes the meter offline and allows configuration and calibrations to be made. No measurement data is produced whilst in configuration and calibration mode. You must log out of the configuration state to return to online and resume measurements.

Note: *Before logging in to change configurations, be sure to contact the control room to take the meter offline from the Safety Instrumented System. This will prevent a false alarm in the safety system.*

Measurement data can be collected from the XMTCpro-SIL, and Configuration data can be programmed into the XMTCpro-SIL, using the following communication tools:

- The HMI
- Modbus
- Proprietary PC software, such as PanaView Plus

Prior to putting in operation, the XMTCpro must be installed and configured per Chapters 4 "Programming with HMI" and 5 "Programming with Modbus" of the User Manual.

2.2 Proof Testing

The proof test instructions in this manual are designed for use with Modbus Client or using the LCD/Keypad on the meter. Refer to *section 4.5 "Proof Tests"*.

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Chapter 3. Installing and Commissioning

Before using the process analyzer as part of an SIS, the XMTCpro must be installed and provided with initial programming. These Installation and Commissioning activities must be performed by trained Service personnel, or by an Authorized User who has received installation and commissioning training from Panametrics.

Panametrics Service Engineers and Channel Partners receive the following training for installation of the SIL-rated XMTCpro:

- Familiarity with the product and associated sample systems
- Familiarity with programming menu
- Familiarity with IEC61508
- How to conduct proof tests
- Interpreting diagnostic messages
- How to troubleshoot test results
- How to perform calibrations
- Responsibility of end user to verify calibration gases are linked to correct relays during a calibration

An end customer who wishes to commission the installation themselves, without using a trained Panametrics installer, takes full responsibility for performing these critical tasks correctly. A failure of any of these tasks can result in the product not meeting its SIL rating.

3.1 Introduction

Installation refers to the physical installation of the XMTCpro into a process, and physical connection to the SIS. Users must refer to the product user manual to complete installation. Chapter 2 "Installation" contains specific information related to this step. Commissioning is accomplished by:

- Installing the XMTCpro analyzer in the sample system (if you purchased your sample system from Panametrics, this step has already been done for you).

Note: *There are specific requirements/considerations for the sample system design please refer to the user manual for further details.*

- Test and Trim of the 4-20mA output
- Field calibrating the XMTCpro
- The XMTCpro is calibrated in the factory prior to shipping, creating the Factory Data Set. On receipt and after the field calibration has been completed, the operator will save the data to become the Active Data set, which is used by the device to make measurements. Any changes to programmed values after the date of commissioning (e.g. future field calibrations) will be made to the Active Data Set, leaving the Factory Data Set unchanged. After a field calibration is overwritten, it is still retained as Restore Previous Data Set, so the user can Restore Previous required.
- If at any point there is an error in the Active Data Set, the Authorized User may revert the Active Data Set to the Factory or Restore Previous Data Set, which will put the device into a known working condition. Similarly, the Service Person may overwrite the Active Data Set with the Factory Data Set if there is an issue during Commissioning. Since the integrity of the SIL Output is so critical, the device maintains all three data sets in memory as a backup, in case of error.

WARNING! **Customers should only connect a host computer to the XMTCpro with a direct wired connection. Use of any USB to TCP/IP conversion software or devices to connect through Internet is NOT recommended.**

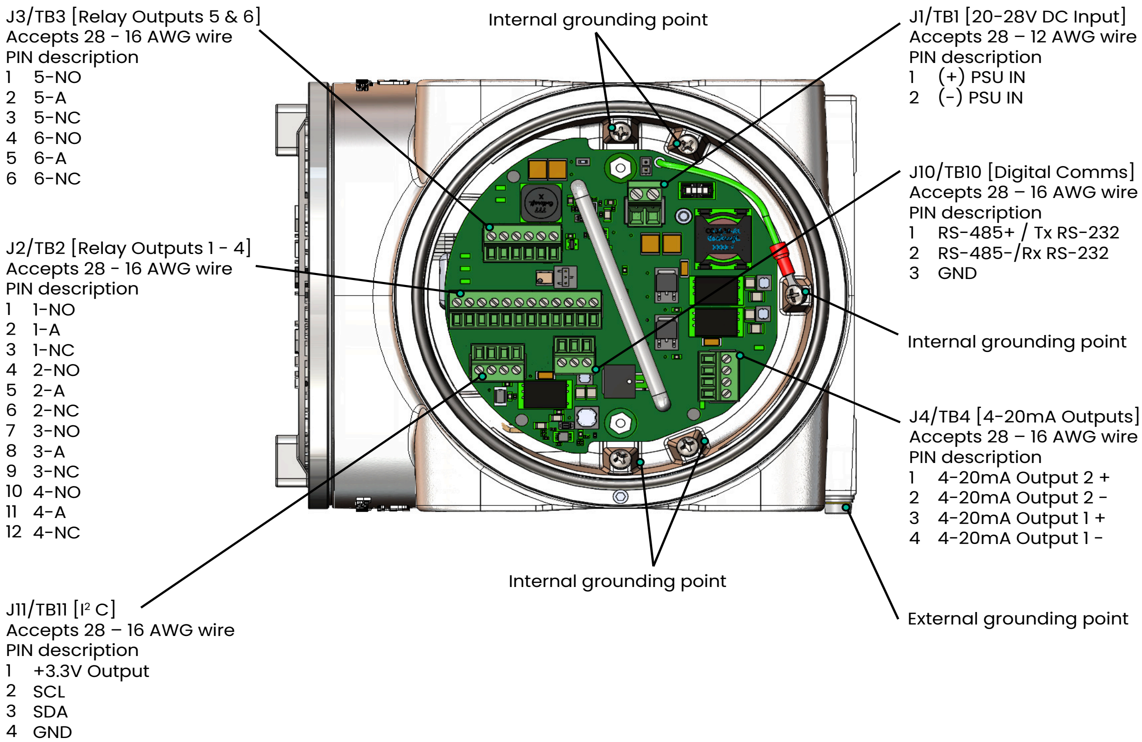

Figure 1: XMTCpro SIL Wiring Diagram

3.1.1 Role of Authorized User

The Authorized User is responsible for protecting the safety of the SIS parts that are outside the scope of the XMTCpro. The Authorized User shall be allowed to take the XMTCpro out of the DD state, and it shall be his responsibility to prevent the SIS from misinterpreting that reading. Panametrics shall ensure the instrument acts in a predictable, controlled way. To clear the Dangerous Detected state, see *Section 4.1, "Fault Modes"* for instructions.

IMPORTANT: The user is required to verify the calibration after field calibration. The user must repeat the calibration until the check verifies the data or restores previous calibration data.

IMPORTANT: In the event of set point changes or field calibrations the user should verify the changes have taken effect in the device.

3.1.2 Operating Modes: Measurement (Safe) and Configuration (Non-Safe)

The XMTCpro has two operating modes: Measurement and Configuration. The default mode is Measurement, during which the measurement unit inside the XMTCpro electronics will make measurements based on the response of the sensor in the application. The second mode, Configuration Mode, is intended only for changing programmed parameters, and is a temporary condition.

Measurement Mode is the safe operating mode. In this mode, the XMTCpro will make measurements and drive a SIL Output value. If the calculation passes all internal tests and has been verified, the SIL output will reflect the measurement. If the XMTCpro detects a chance that the measurement might not meet the requirements, the SIL output will go to the Dangerous Detected state so the SIS does not use the potentially erroneous measurement value. The instrument will remain in the Dangerous Detected state until an Authorized User intervenes. For troubleshooting tips, the Authorized User should refer to *Appendix B, Troubleshooting*.

Configuration Mode is non-safe, since the instrument is not outputting a signal when in this mode, and since a change of parameters could produce a non-accurate measurement. An Authorized User can put the instrument into Configuration Mode by entering the program menu with a password. When entering this mode, the SIL Output will go to the Dangerous Detected state as a precaution. A change in programmed parameters could affect the accuracy of the SIL Output, so the output goes to the Dangerous Detected state, notifying the SIS that it is not providing a Functionally Safe measurement. The error line on the LCD will indicate this.

3.2 Hydrogen Cooled Generator (H2G) Installations

Hydrogen cooled generator (H2G) applications must provide an external independent means of verifying the atmospheric composition during the purge process. Never mix hydrogen with oxygen and never expose personnel to potentially toxic environments without first verifying safety.

3.3 Hazard and Risk Analysis to be Performed by the Customer

The impact of commissioning on adjacent operating units and facilities or other field services shall be evaluated prior to completion of commissioning. Customer safety procedures shall dictate the method for this evaluation.

WARNING! **The user is required to check the gas in the chamber prior to entry. This check must be independent of the of the software in the XMTCpro.**

WARNING! **Switching to the H2/CO2 curve is not allowed until a 100% CO2 measurement is taken independent of the XMTCpro indication prior to the introduction of air.**

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Chapter 4. Maintenance

4.1 Fault Modes

The Fault Detected state is set due to measurement errors or system faults. Measurement errors can be caused by temporary distortions in the signal. If a Fault Detected State occurs due to measurement errors, the device will put the SIL Output in the Fault Detected state. The instrument will recover from measurement error without user intervention, when the conditions recover. Also, a Fault Detected State occurs due to system faults. In this case the device will put the SIL Output in Fault Detected state and it will remain that way until an Authorized User Intervenes.

To recover from a system fault, the authorized user will need to follow troubleshooting steps which may include logging into the device to perform checks, tests to verify, validate functionality and resolve issues. For details refer to troubleshooting tips in *Appendix B, Troubleshooting*.

IMPORTANT: Only Authorized Personnel shall be allowed to execute a reset, per the local Safety Plan at the customer site.

IMPORTANT: Please contact our *Customer Service* or *Technical Support* areas listed on the back cover to report any failures to Panametrics.

4.2 Repair and Replacement

There are no user-replaceable components on printed circuit assemblies, and the only replaceable component for the overall product is the battery.

The sensor cell includes an O-ring seal, which is never exposed to a harsh environment when the sensor is used according to the user manual. There is no need for periodic replacement of any O-ring seals except when a unit is returned to the factory for service.

Any failures that are detected and that compromise functional safety should be reported to the Product Safety Officer within Panametrics. The user is responsible for maintaining adequate risk reduction for the Safety Instrumented Function during repair and replacement.

Repair and replacement activities must be performed by trained Service personnel, or by Authorized Customers who have Service training. This ensures functional safety compliance and keeps the Panametrics traceability database up to date.

The XMTCpro requires periodic Zero and Span calibrations in the field to compensate for normal drift. Both the zero point and the span point of the XMTCpro will drift by ±0.5% of span per month, so calibration is required every 2 months to stay within the ±2% of span accuracy. Calibration can be run remotely via Modbus if the customer has Zero and Span gas cylinders permanently connected to the XMTCpro sample system. It is the customer's responsibility to verify that the zero and span gas cylinders contain the correct calibration gases and that they are properly connected to the sample system. The system can not automatically detect if a calibration cylinder is incorrectly connected.

Note: *Field calibration should only be completed by trained personnel and as described in the product user manual.*

4.3 Modifications and Traceability

4.3.1 Purpose

The modification process involves changes to hardware or software for installed systems.

Any modification at the system shall be documented by the Authorized User with the consequences of the modification to the system.

4.3.2 Traceable Components

Hardware Modifications must be performed by trained service personnel, or by authorized customers who have service training. Any hardware or firmware change to an installed system must be reflected in the traceability database at Panametrics. That is, if hardware is changed, the serial number and version of the new hardware component must be noted in the database. If firmware is changed, the new firmware version must be noted in the database. It is vital to keep the database up to date in the event that a repair or replacement action comes up as noted in "User Restrictions".

Please contact our *Customer Service* or *Technical Support* areas listed on the back cover to send updates to the traceability database.

4.4 Firmware Update

In case firmware updates are required, they shall be performed at the factory or by a Panametrics certified service technician. The user will not be required to perform any firmware updates.

4.5 Proof Tests

The objective of proof testing is to detect failures within the meter that are not detected by the routine diagnostics of the instrument. The main concern is undetected failures that could prevent the Safe Output from performing its intended function. The person(s) performing the proof test of the meter should be trained in SIS operations, including bypass procedures, analyzer maintenance and company Management of Change procedures. Tests can be executed via the LCD/keypad or Modbus Client.

The results of the proof test shall be documented and this documentation shall be part of a plant safety management system. Any failures that are detected and that compromise functional safety should be reported to the Product Safety Officer within Panametrics. *Table 8* below describes the proof test options.

Note: *Proof Test Coverage: Per FMEDA, XMO2-XMTC O2 / Thermal Conductivity Sensor; exida Report No.* PAN 21-06-170 R006, V1, R1 *execution of this suite of proof tests will detect 80% of possible DU failures in the XMTCpro.*

Table 8: Proof Test Options

Proof Test #1	Tests Solenoids
Proof Test #2	Tests Relays
Proof Test #3	Tests NAMUR
Proof Test #4	Tests Alarms
Proof Test #5	Tests CH1
Proof Test #6	Tests CH2

Note: *Except as noted in the tables on the following pages, the Operator must log in at the SIL User access level to execute these tests. Refer to the user manual on how to login as SIL User via LCD or Modbus.*

4.5.1 Proof Test #1 - Solenoids

Step	Action
1	Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.
2	Execute the test for the first solenoid, second or both using the LCD/Keypad or via Modbus.
3	**Using LCD/Keypad:** • Navigate to Diagnose -> Proof Tests -> Proof Test Mode. • Ensure Proof Test Mode is enabled. • Then under Proof Tests -> Test Solenoids. • Select SOL 1/SOL2/SOL BOTH. **Using Modbus:** • Ensure the PROOF_TEST register has a value of 1 (Enabled). • Then write to the register TEST_SOLENOIDS that will verify the operation of calibration relays. • Value of 1/2/3 will test SOL 1/SOL 2/SOL BOTH.
4	Restore the loop to full operation.

Step	Action
5	Ensure that no alarms or warnings are present in the meter. **Using LCD/Keypad:** • Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped. **Using Modbus:** • Observe the register CTX_STATUS for any alarm trips.
6	Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.

4.5.2 Proof Test #2 - Relays

Step	Action
1	Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.
2	Execute the test for each relay: Low-Low (LL), Low (L), High (H) and High-High (HH) using the LCD/Keypad or via Modbus.

3	**Using LCD/Keypad:**
	• Navigate to Diagnose -> Proof Tests -> Proof Test Mode.
	• Ensure Proof Test Mode is enabled.
	• Then under Proof Tests -> Test Relays:
	• Select Relay LL /Relay L /Relay H/ Relay HH.
	Using Modbus:
	• Ensure the PROOF_TEST register has a value of 1 (Enabled).
	• Then write to the register TEST_RELAYS that will verify the operation of alarm relays.
	  • LL - 1
	  • L - 2
	  • H - 4
	  • HH - 8

4	Restore the loop to full operation.
5	Ensure that no alarms or warnings are present in the meter. **Using LCD/Keypad:** • Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped. **Using Modbus:** • Observe the register CTX_STATUS for any alarm trips.
6	Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.

4.5.3 Proof Test #3 - NAMUR

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>1</td><td>Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.</td></tr>
<tr><td>2</td><td>Set the NAMUR to test the analog NAMUR levels.</td></tr>
<tr><td>3</td><td>Using LCD/Keypad:

Navigate to Diagnose -> Proof Tests Mode.
Ensure Proof Test Mode is enabled.
Then, under Proof Tests -> Test NAMUR.
Select NAMUR LL, NAMUR L, NAMUR H, NAMUR HH.

Using Modbus:

Write values from 0-4 to the register TEST_NAMUR and observe the CH1 and CH2 values.
The following table indicates the expected values:

<table>
<tr><td>TEST_NAMUR</td><td>CH1 (mA)</td><td>CH2 (mA)</td></tr>
<tr><td>0</td><td>NORMAL</td><td>NORMAL</td></tr>
<tr><td>1</td><td>3.6</td><td>3.6</td></tr>
<tr><td>2</td><td>3.8</td><td>3.8</td></tr>
<tr><td>3</td><td>20.5</td><td>20.5</td></tr>
<tr><td>4</td><td>21</td><td>21</td></tr>
</table></td></tr>
<tr><td>4</td><td>Restore the loop to full operation.</td></tr>
<tr><td>5</td><td>Ensure that no alarms or warnings are present in the meter.
Using LCD/Keypad:

Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped.

Using Modbus:

Observe the register CTX_STATUS for any trips.
</td></tr>
<tr><td>6</td><td>Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.</td></tr>
</table>

4.5.4 Proof Test #4 - Alarms

Step	Action
1	Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.
2	Execute each alarm individually and test and the 4-20 mA output and alarm relays to verify.
3	**Using LCD/Keypad:** • Navigate to Diagnose -> Proof Tests -> Proof Test Mode. • Ensure Proof Test Mode is enabled. • Under Proof Test -> Test Alarms. • Select each alarm and then enable it. • After enabling, validate that the 4-20 mA corresponds to the enabled alarm. **Using Modbus:** • Ensure the PROOF_TEST register has a value of 1 (Enabled). • Write to the register TEST_ALARMS. The XMTCpro has 15 alarms. Enter values from 1-15 to observe each alarm. • After enabling, validate that the 4-20 mA corresponds to the enabled alarm.
4	Observe the 4-20 mA output signaling NAMUR levels. Observer the alarm relays toggle. Observe the backlight and the feedback LEDs blinking. The Red LED on the meter should blink out the 3-digit error code entered.
5	Restore the loop to full operation.
6	Ensure that no alarms or warnings are present in the meter. **Using LCD/Keypad:** • Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped. **Using Modbus:** • Observe the register CTX_STATUS for any alarm trips.
7	Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.

4.5.5 Proof Test #5 - CH1

Step	Action
1	Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.
2	Set a CH1 output level and test the analog output using a multimeter.
3	**Using LCD/Keypad:** • Navigate to Diagnose -> Proof Tests -> Proof Test Mode. • Ensure Proof Test Mode is enabled. • Under Proof Test -> Test CH1. • Set CH1 as 4.0 mA and press Enter. **Using Modbus:** • Ensure the PROOF_TEST register has a value of 1 (Enabled). • Write to the register TEST_CH1 a value of 4.0.
4	Measure the primary output with the multimeter and observe the value of ADC2_MV changing (Over Modbus Only).

Step	Action
5	Ensure that no alarms or warnings are present in the meter. **Using LCD/Keypad:** • Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped. **Using Modbus:** • Observe the registers ALARM_01_MA to ALARM_16_MA for any trips.
6	Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.

4.5.6 Proof Test #6 - CH2

Step	Action
1	Power cycle the unit and electrically bypass the safety PLC by using a maintenance override function or take other appropriate action to avoid a false trip, following Management of Change procedures.
2	Set a CH2 output level and test the analog output using a multimeter.
3	**Using LCD/Keypad:** • Navigate to Diagnose -> Proof Tests -> Proof Test Mode. • Ensure Proof Test Mode is enabled. • Under Proof Test -> Test CH2. • Set CH2 as 4.0 mA and press Enter. **Using Modbus:** • Ensure the PROOF_TEST register has a value of 1 (Enabled). • Write to the register TEST_CH2 a value of 4.0.
4	Measure the secondary output with the multimeter.
5	Ensure that no alarms or warnings are present in the meter. **Using LCD/Keypad:** • Navigate to Diagnose -> Faults and Alarms to check if any alarms have been tripped. **Using Modbus:** • Observe the register CTX_STATUS for any alarm trips.
6	Remove the bypass from the safety PLC or otherwise restore normal operation. Ensure you disable Proof Test Mode.

Chapter 5. Decommissioning Phase

Upon completion of service, the analyzer shall be decommissioned (removed from service) by an authorized user.

5.1 Objective

Before decommissioning any safety system from active service, be sure a proper review is conducted and obtain any required authorization. Also, maintain appropriate safety functions during decommissioning activities.

Management of change procedures shall be implemented for all decommissioning activities.

5.2 Hazard and Risk Analysis to be Performed by the Customer

The impact of decommissioning on adjacent operating units and facilities or other field services shall be evaluated prior to decommissioning.

5.3 Disposal

Disposal shall comply with the *Waste Electrical and Electronic Equipment Directive* (WEEE Directive) at the following link: http://ec.europa.eu/environment/waste/weee/index_en.htm.

Please contact our *Customer Support Service* listed on the back cover to report a decommissioned product.

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Appendix A. Glossary

Access Levels: There are three access levels in the analyzer: User, Admin and SIL User. Each Data Set has parameters that include all three Access Levels.

Authorized User: An operator of a SIL Instrument that has been properly trained in Functional Safety and is therefore authorized to operate and maintain the SIL instrument. Access that is restricted to Authorized Users only may be controlled by password protection or other security means.

Life Cycle: A Functional Safety product has three basic Life Cycle stages: Commissioning, Maintenance, and Decommissioning. Each stage has Functional Safety concerns and actions that are described in this manual.

Proof Testing: The analyzer has many self-tests that it performs continuously to ensure the integrity of the Safe Output value. But there are some functions that can not be tested routinely because they would cause an alarm condition, instrument reset, etc. These functions must be tested periodically through a process called Proof Testing. This consists of taking the analyzer offline by disconnecting it from the SIS or otherwise preventing the SIS from using its SIL Output in safety calculations. The Authorized User then performs certain tests and records the results per the Customer Safety Plan (outside the scope of this manual). Finally, the Authorized User brings the analyzer back on line by reconnecting it with the SIS.

SIL Output: Only the SIL Analog Output is SIL rated and may be used as an input to the SIS.

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Appendix B. Troubleshooting

Code	Error/Warning	Possible cause	Possible solution
112	NMI_FAULT	MCU has hard faulted	Reboot system via power cycle
113	BUS_FAULT	MCU has hard faulted	Reboot system via power cycle
114	SIF_TIMEOUT	Safety function did not respond in the required time	Reboot system via power cycle
115	NO_TRIM_CH1	No valid trim data available	Perform a test & trim
116	IOX_LOST	Hardware fault	Contact factory
117	TEMPMV_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
118	NOT_FOUND	Missing data	Contact factory
121	HARD_FAULT	MCU has hard faulted	Reboot system via power cycle
122	USAGE_FAULT	MCU has hard faulted	Reboot system via power cycle
123	NO_WDG	Safety function did not respond in the required time	Reboot system via power cycle
124	NO_TRIM_CH2	No valid trim data available	Perform a test & trim
125	LCD_LOST	Hardware fault	Contact factory
126	TEMPMV_OVER_RANGE	Heater is over the target temperature	Verify ambient temp. is within limits
127	INVALID_ARG	Configuration is invalid	Contact factory
131	SVC_FAULT	MCU has hard faulted	Reboot system via power cycle
132	SIF_LOST	Safety function did not respond in the required time	Reboot system via power cycle
133	NO_H2G	H2G configuration is invalid	Contact factory
134	ECC_ERROR	Data corrupted	Contact factory
135	BOARDMV_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
136	CRC_ERROR	Data corrupted	Contact factory
141	NO_TEMP_CONTROL	Heater has not reached temperature	Contact factory
142	BROWNOUT	Power supply not providing enough power	Verify power supply meets requirements
143	ADC_CRC_ERROR	ADC readout is corrupted	Contact factory
144	BOARDMV_OVER_RANGE	Ambient Temperature too high	Verify ambient temp. is within limits
145	ACCESS_DENIED	Attempt to configure without first logging in	Log in
146	NO_CLOCK	Time date not set	Set time and date
149	CRC_ERROR	Data corrupted - Not safety related	Repeat action or Contact factory
151	PRESSURE	Pressure sensor not calibrated	Contact factory
152	ALARM_LOST	Error occurred while raising an alarm	Contact factory
153	TEMPC_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
154	TYPE_MISMATCH	Invalid configuration	Contact factory
155	PIN_RESET	System has rebooted	Should only be active during power up, if not contact factory
158	NO_MODBUS	Modbus connection cannot be established	Contact factory

Code	Error/Warning	Possible cause	Possible solution
162	TEMPC_OVER_RANGE	Heater has not reached temperature	Verify ambient temp. is within limits
163	UNDER_RANGE	Attempt to write configuration to an invalid value	Repeat action
164	SW_RESET	System has rebooted	Should only be active during power up, if not contact factory
167	MODBUS_NOREG	Attempted to read non-existing modbus register	Try different parameters
171	BRDC_UNDER_RANGE	Heater has not reached temperature	Should only be active during power up, if not contact factory
172	OVER_RANGE	Attempt to write configuration to an invalid value	Repeat action
173	LPWR_RESET	System has rebooted	Should only be active during power up, if not contact factory
176	MODBUS_NOCMD	Modbus request cannot be satisfied	Try different parameters
182	CPU_RESET1	System has rebooted	Should only be active during power up, if not contact factory
185	MODBUS_IDLE	Modbus timed out due to no activity	Try different parameters
191	CPU_RESET2	System has rebooted	Should only be active during power up, if not contact factory
194	MODBUS_TYPE_ERR	Modbus request cannot be satisfied	Try different parameters
211	MEM_FAULT	MCU has hard faulted	Reboot system via power cycle
212	DBGMON_FAULT	MCU has hard faulted	Reboot system via power cycle
213	NO_COMP	Configuration is invalid or the sensor is damaged	Contact factory
216	BRDC_OVER_RANGE	Heater has not reached temperature	Contact factory
217	INCOMPLETE	Configuration is invalid	Contact factory
221	OS_FAULT	MCU has hard faulted	Reboot system via power cycle
222	NO_BKCOMP	Configuration is invalid or the sensor is damaged	Contact factory
223	MCU_LOST	MCU has hard faulted	Contact factory
225	PRESS_UNDER_RANGE	Pressure too low	Contact factory
231	NO_PRCOMP	Configuration is invalid or the sensor is damaged	Contact factory
232	UART_LOST	Modbus connection cannot be established	Contact factory
234	PRESS_OVER_RANGE	Pressure too high	Contact factory
241	RAM_LOST	Hardware fault	Contact factory
243	TIMEOUT	Required action has not completed within required time frame	Repeat action
245	BUSY	Busy processing earlier requests	Repeat action
261	NOCOMP_BAD_GAS_CAL	Configuration is invalid or the sensor is damaged	Contact factory
311	NO_INIT	Configuration is invalid	Contact factory
312	NO_PRBKCOMP	Configuration is invalid or the sensor is damaged	Contact factory
313	ROM_LOST	Hardware fault	Contact factory
315	NOT_YET_SAVED	Configuration is invalid	Contact factory

Code	Error/Warning	Possible cause	Possible solution
321	NO_FASTRESP	Configuration is invalid or the sensor is damaged	Contact factory
322	MPU_LOST	Hardware fault	Contact factory
324	WARMUP	Heater has not reached temperature	Should only be active during power up, if not contact factory
331	DAC_LOST	Hardware fault	Try placing a load on the CH1 output
332	GASMV_UNDER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
333	CAL_REMINDER	Calibration is due	Perform field calibration
341	GASMV_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
342	ERR_EARLY_UNDER	Gas is beyond user configurable trip point	1. Verify configurable trip points 2. Verify Process 3. Contact factory if process is correct
343	OFFLINE	User has logged in	Log out to resume measurements
351	ERR_EARLY_OVER	Gas is beyond user configurable trip point	1. Verify configurable trip points 2. Verify Process 3. Contact factory if process is correct
411	NO_DRIFTCOMP	Calibration data is missing	Perform a Field calibration
412	ADC_LOST	Hardware fault	Contact factory
413	GAS_UNDER_RANGE	Gas provided is outside of calibrated range	Perform a Field calibration
421	PWM_LOST	Hardware fault	Contact factory
422	GAS_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
431	BKMV_UNDER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
511	FLASH_LOST	Hardware fault	Contact factory
512	BKMV_OVER_RANGE	Gas provided is outside of calibrated range	1. Verify Process 2. Contact factory if process is correct
521	PMV_UNDER_RANGE	Pressure too high	Contact Factory
611	PMV_OVER_RANGE	Pressure too low	Contact Factory

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