Technical Reference

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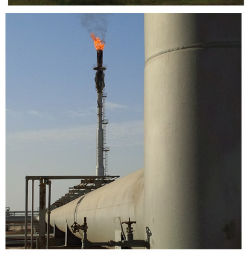
B-Series Flow Meter
SIL Safety Manual








SIL 1 FS APPROVED SAFETY INTEGRITY LEVEL - IEC 61508

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Overview

This manual provides information necessary to meet the compliance requirements of the IEC 61508 and/or IEC 61511 functional safety standards when incorporating a Kurz B-Series thermal mass flow meter into a safety-related system or subsystem.

- IEC 61508: Functional safety of electrical/electronic/programmable electronic safety related systems
- IEC 61511: Functional safety-Safety Instrumented Systems for the process industry sector

Kurz B-Series flow meters are used to measure the mass flow rate of gases. The Kurz B-Series includes the 454FTB, 454FTB-WGF, 534FTB, 504FTB, K-BAR 2000B, and K-BAR 2000B-WGF. For additional information, including environmental and maintenance requirements, refer to the following literature:

- Document # 367551, Technical Specification for Series 454FTB
- Document # 367533, Technical Specification for Series 454FTB-WGF
- Document # 367543, Technical Specification for Series 534FTB
- Document # 367547, Technical Specification for Series 504FTB
- Document # 367542, Technical Specification for Series K-BAR 2000B
- Document # 367540, Technical Specification for Series K-BAR 2000B-WGF
- Document # 368041, Kurz B-Series Hardware Guide
- Document # 368042, Kurz B-Series Operations Guide

Terms & Definitions

Dangerous failure	Failure with the potential to bring the safety instrumented system into a dangerous or non-functional state.
FMEDA	Failure Modes Effects and Diagnostic Analysis
HFT	Hardware Fault Tolerance, ability of a hardware to continue to perform a required function in the presence of faults or errors.
MTBF	Mean Time Between Failures
PFD	Probability of Failure on Demand, Probability of hazardous failures for a safety function on demand.
Safety function	The ability of a system to carry out actions necessary to maintain a defined safe state for a process, equipment, or a plant.
Safety-related system	A safety-related system performs the safety functions that are required to maintain a safe condition (for example, a flow meter, a burner, and a PLC).
SFF	Safe Failure Fraction, percentage of failures that do not have the potential to put the safety-related system in a hazardous state.
SIL	Safety Integrity Level, IEC 61508 defines four Safety Integrity Levels (SIL1 through SIL4). Each level corresponds to a level of probability for the failure of a safety function.
SIS	Safety Instrumented System, implementation of one or more safety instrumented functions.

Safety Function

Kurz B-Series thermal mass flow meters are intended to be part of a SIS subsystem, as defined per IEC 61508. The achieved SIL level of the designed function must be verified by the designer.

The B-Series flow meters generate a current output proportional to the mass flow rate of a process gas. All safety functions refer only to this analog output (AO) signal.

During normal operation, the flow meter output is between 3.8 mA and 20.5 mA. Faults are indicated less than 3.6 mA (the default LOW ALARM setting) or greater than 21 mA, depending on the configuration of the NE-43 alarm. The default LOW ALARM setting is recommended when the flow meter is used in a Safety Instrumented System. The flow meter enters an NE-43 alarm state during flow meter boot-up and sensor warm-up, indicating a detected failure to function for approximately 30 seconds. In the event there is a loss of power to the flow meter, the output will indicate less than 3.6 mA regardless of the NE-43 alarm configuration.

Configuration

The configuration of the device can be performed by entering input at the local keypad on the device or using the PC Application KzComm. Configuration changes should be verified after each programming or configuration procedure. The verification can be performed by downloading the configuration data from the device to confirm that the correct parameters or values were loaded or entered and saved into the device.

The PLC receiving the input from the Kurz B-Series flow meter should be configured to detect over range (>21 mA) and under range (<3.6 mA) failure of the Kurz B-Series flow meter and should recognize these as internal failure of the device and not cause a spurious trip.

The PLC should provide a signal to the Kurz B-Series flow meter through the flow meter digital input connection at TB6 to periodically initiate a zero-mid-span test cycle. This diagnostic test is used to detect the reliability of the analog output signal.

After commissioning, the Kurz B-Series flow meter access codes should be changed so that the device is protected against unwanted and unauthorized changes or operation.

Fault Conditions

Continual internal diagnostics are present within B-Series flow meters. The diagnostic features which only operate on start-up are not considered part of the safety function. Table 1 lists fault conditions that are detected and can be programmed to result in an output less than 3.6 mA or greater than 21 mA.

Table 1. Fault Conditions

Error Code	Fault Condition
0x0001	**RP resistance above high limit.** The velocity sensor resistance (RP) is above the normal range for the configured sensor type. Possible causes: Open circuit on the sensor wiring. Defective sensor or sensor control board.
0x0002	**RP resistance below low limit.** The velocity sensor resistance (RP) is below the normal range for the sensor type configured. Possible causes: Short in the sensor wiring. Defective sensor or sensor control board.
0x0004	**RTC resistance above high limit.** The process temperature sensor resistance (RTC) is above the normal range for the sensor type configured. Possible causes: Open circuit on the sensor wiring. Defective sensor or sensor control board.

Table 1. Fault Conditions (continued)

Error Code	Fault Condition
0x0008	**RTC resistance below low limit.** The process temperature sensor resistance is below the normal range for the sensor type configured. Possible causes: Short circuit on the sensor wiring. Defective sensor or sensor control board.
0x0010	**Wire loop resistance above high limit.** The sensor wire resistance from the sensor to its electronics board is above limit (> 5.0 ohms). Possible causes: Wire is too long for the gage being used. Loose wire joint connection (but not too loose, see code 20). Defective sensor or sensor control board.
0x0020	**Sensor RPs lead open circuit.** The sensor wire RPs is open circuit or not connected. Possible causes: Open circuit on the RPs wire, pin 1 of TB1. Open on the RP lead will also set this, Pin 3, TB1. Defective sensor or sensor control board.
0x0040	**High sensor or wire leakage.** The sensor or wiring is showing too much leakage current to ground. The trip point of this error is the equivalent of 100 kOhms leakage resistance. Possible causes: Wet or contaminated wiring or junction box. Water in the backend of a sensor. Corroded front side to a sensor. Sensor above temperature limit. Defective sensor control board.
0x0080	**Flow rate above design limits.** Under high heat flow conditions (very high flow rates), the demand to heat the sensor may exceed the drive limits of the sensor control board. The reported flow readings at this point are compressed and lower than the true flow readings.
0x0400	**ADC failed to convert measurement.** The circuits on the sensor control board which measures the input signals are not working properly. Possible causes: The sensor control board is defective and needs to be replaced.
0x0800	**Sensor control drive stopped responding.** The sensor drive voltage to heat the velocity sensor is not matching the set point. Possible causes: Short or miss-wiring of the sensor. Defective sensor control board needs replacing.

Table 1. Fault Conditions (continued)

Error Code	Fault Condition
0x1000	**Sensor over-voltage crowbar engaged.** The sensor drive voltage was not matching the set point and would not fall to low drive on command. The crowbar SCR was engaged to clamp the sensor drive voltage to zero. Possible causes: Sensor field wiring short to a DC power supply (4-20 mA) or 24 V supply. Defective sensor control board needs replacing.
0x2000	**Sensor type does not match configuration.** The sensor resistance ratio RTC/RP exceeds 10% of the normal value of the sensor for which the meter was configured. Possible causes: Wrong sensor is connected to the electronics. Confirm the serial number matches. Upset to the process temperature causing the two sensors (RP and RTC) to not match in temperatures. Defective sensor or sensor control board.
0x4000	**Abnormal sensor node voltages.** This fault is often a redundant error to the sensor and wiring errors. It looks only at the sensor wire voltages, not the resistance values. Possible causes: Incorrectly wired sensor. Short or open circuit. Defective sensor or sensor control board.
0x8000	**Unable to write config file to EEPROM.** The sensor and meter configuration data can not be verified after a memory write. Possible causes: Defective sensor control board. Any EEPROM read/write fault.
0x1+++++	**Flash memory segment error.** Program memory has changed; flash memory fault. Possible causes: Bit flip in invariable memory may be caused by cosmic rays, electromagnetic leakage.
0x2+++++	**RAM config data error.** Configuration data has changed unintentionally; variable memory fault. Possible causes: Bit flip in variable memory. Program code overwriting memory unintentionally.
0x4+++++	**Costate tasks timeout error.** A critical task has stopped executing; program sequence fault. Possible causes: Task stuck in an loop or long wait state.

SIL Capability

Kurz B-Series flow meters have met design process requirements according to IEC 61508 for Safety Integrity Level (SIL) 1.

- Kurz B-Series flow meters are considered to be a Type B element with a Hardware Fault Tolerance (HFT) of 0.
- The Safe Failure Fraction is calculated to be 79%.

A detailed FMEDA report is available by contacting Kurz Instruments Customer Services. The report details the failure modes and failure rates of the critical components in the flow meter. FMEDA assumptions are listed within the FMEDA report. The FMEDA was carried out by TUV Rheinland and the results are summarized in Table 2.

Table 2. FMEDA Report Summary

Description	Parameter
HFT – Hardware Fault Tolerance	0
Device Type	B
Failure Mode λ Total λs Safe Failures λd Dangerous Failures λdd Dangerous Detected λdu Dangerous Undetected	 299 FIT 150 FIT 149 FIT 87 FIT 62 FIT
SFF Safe Failure Fraction	79%
For High Demand or Continuous Mode PFH	62 FIT
For Low Demand PFDavg PTI 10 years PTI 5 years PTI 2 years PTI 1 year	 27.3E-04 13.6E-04 5.45E-04 2.72E-04
Diagnostic time interval	Zero-mid-span test cycle controlled by the PLC Note: Zero-mid-span test cycle shall be 100x the demand rate of the safety function.

Proof Test

The objective of the proof test is to detect failures that are not detected by automatic system diagnostics. The frequency of a proof test is determined by the reliability calculations of the SIS functions where the B-Series flow meter is installed. The frequency of proof testing should be adjusted to maintain the required integrity of the SIS function.

The following proof test is recommended:

1. Prior to beginning the proof test, bypass the safety function or take other appropriate action to avoid a false trip.
2. Generate or simulate an alarm condition to force the B-Series flow meter to indicate an alarm current output <= 3.6 mA and verify that the analog current reaches that value. See Table 1 for events that generate an alarm.
3. Remove the alarm condition and verify that the analog current recovers to the normal range.
4. Remove power from the flow meter.
5. Verify that the analog current at the PLC or safety DCS indicates <= 3.6 mA.
6. Restore power to the flow meter and verify that the analog current recovers to the normal range.
7. Perform a low-point and high-point calibration check by comparing the flow meter display readings and the AO current level values at each calibration point to known reference measurements.
8. If the calibration is within tolerance at both calibration points, the proof test is complete. Proceed to step 12.
9. If the calibration check is out of tolerance by more than 5%, remove the flow meter probe from the process and inspect the probe for dirt buildup. Clean the probe if necessary.
10. Repeat the low-point and high-point calibration checks specified in Step 7.
11. If the calibration is still out of tolerance, contact Kurz Instruments Technical Support for assistance.
12. After completing the proof test, remove the bypass from the safety function or otherwise restore normal operation.
13. The results of the proof test must be accurately recorded and archived.

Returning Equipment

If you believe your instrumentation is working improperly or needs to be recalibrated, contact Kurz Customer Service:

(831) 646-5911

service@kurzinstruments.com

Before you can receive your return material authorization (RMA) number, make sure you:

- Complete the Defective Unit information
- Understand RMA requirements
- Read the cleaning and shipping requirements

Have the following information readily available for your Customer Service Representative:

Defective / Recalibration Unit Information

Model number	
Serial number	
Application (industry)	
Environment of installation	
Gas type	
Flow range	
Standard conditions for recalibration	
Special QA requirements (such as nuclear, military, oxygen, calibration, or certification)	
Technical contact name	
Technical contact phone number	
Technical contact email	
Billing contact name	
Billing contact phone number	
Complete shipping address	
Complete billing address	

Cleaning Equipment Before It Is Returned

Thoroughly clean all equipment you are returning to Kurz. Kurz is unable to assume the risk of receiving contaminated equipment from our customers. In the event uncleaned equipment are received, you will be contacted so arrangements can be made, at your expense, for the equipment to be picked up and cleaned before Kurz personnel handle the equipment.

Receiving an RMA Number

You will be issued an RMA number when you contact Kurz Customer Service and provide the Defective Unit information.

Important ***Kurz personnel will not accept return material shipments if an RMA number is not clearly visible on the outside of the shipping container.***

Shipping Equipment

Securely package the cleaned equipment in a sturdy container. The packing slip must reference the RMA number, model number, and serial number. ***The return address and RMA number must be clearly marked on the outside of the container.***

Ship the container prepaid to Kurz Customer Service:

Kurz Instruments, Inc.
Customer Service Dept.
2411 Garden Road
Monterey, CA 93940-5394
USA