BETA
PRESSURE & TEMPERATURE SWITCHES
Info to design, install, verify and maintain a SIF

SIL Safety Manual .: SP 065 rev B	
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1 Introduction

This Safety Manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the BETA Pressure and Temperature Switches.
This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 functional safety standards

§1.1 Terms and Abbreviations

Safety	Freedom from unacceptable risk of harm
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
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 resulting fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition
Safety Assessment	The investigation to arrive at a judgment - based on evidence - of the safety achieved by safety-related systems
Fail-Safe State	**State where the micro switch is de-energized and spring is extended. (The switch could be de- or pressurized.)**
Fail Safe	**Failure that causes the switch to go to the defined fail-safe state without a demand from the process.**
Fail Dangerous	Failure that does not respond to a demand from the process (i.e. being unable to go to the defined fail-safe state).
Fail Dangerous Undetected	Failure that is dangerous and that is not being diagnosed by automatic testing.
Fail Annunciation Undetected	Failure that does not cause a false trip or prevent the safety function but does cause loss of an automatic diagnostic and is not detected by another diagnostic.
Fail Annunciation Detected	Failure that does not cause a false trip or prevent the safety function but does cause loss of an automatic diagnostic or false diagnostic indication.
Fail No Effect	Failure of a component that is part of the safety function but that has no effect on the safety function.
Low demand mode	Mode, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.

§1.2 Acronyms

FMEDA	Failure Modes, Effects and Diagnostic Analysis
HFT	Hardware Fault Tolerance
MOC	Management of Change. These are specific procedures often done when performing any work activities in compliance with government regulatory authorities.
PFDavg	Average Probability of Failure on Demand
SFF	Safe Failure Fraction, the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault.
SIF	Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop).
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).

§1.3 Product Support

Product support can be obtained from:

BETA B.V.
P.O. Box 1227
NL-2280 CE Rijswijk
The Netherlands

§1.4 Related Literature

Hardware Documents:

- BETA Pressure and Temperature Switches Installation, Operation and Maintenance Instructions SP 001
- Safety Integrity Level Selection – Systematic Methods Including Layer of Protection Analysis, ISBN 1-55617-777-1, ISA
- Control System Safety Evaluation and Reliability, 2nd Edition, ISBN 1-55617-638-8, ISA
- Safety Instrumented Systems Verification, Practical Probabilistic Calculations, ISBN 1-55617-909-9, ISA

§1.5 Reference Standards

Functional Safety

- IEC 61508: 2000 Functional safety of electrical/electronic/ programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety – Safety Instrumented Systems for the Process Industry Sector

2 Device Description

The core of a BETA Pressure and Temperature Switch is a high quality, self-aligning diaphragm/piston/spring sensor.
The limited piston travel translates pressure at the diaphragm directly to actuation of the micro switch or air-relay, with no intervening linkages or mechanisms and with full protection against very high over range pressure.
The piston sensor is isolated from the process fluid by a diaphragm and static O-ring seal, retained by a process connection port.
These three are the only process wetted parts and are available in an extensive range of materials and sizes.

3 Designing a SIF using a BETA Pressure and Temperature Switch.

§3.1 Safety Function

The safety function of the switches is that the micro switch will de-energize when the input pressure, or temperature, rises above, or falls below, the set-point within the stated safety accuracy
The BETA Pressure and Temperature Switches is intended to be part of final element subsystem as defined per IEC 61508 and the achieved SIL level of the designed function must be verified by the designer

§3.2 Environmental limits

The designer of a SIF must check that the product is rated for use within the expected environmental limits. Refer to the BETA BV BETA Pressure and Temperature Switches IO manual for environmental limits

§3.3 Application limits

The materials of construction of a BETA Pressure and Temperature Switches are specified in the BETA BV General Bulletin SP.210. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the BETA Pressure, Temperature and Vacuum Switches are used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

§3.4 Design verification

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from BETA BV. This report details all failure rates and failure modes as well as the expected lifetime. This is also listed in the Assessment report.

The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer via a calculation of PFD_{AVG} considering architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and the specific failure rates of all products included in the SIF. Each subsystem must be checked to assure compliance with minimum hardware fault tolerance (HFT) requirements. The exida exSILentia® tool is recommended for this purpose as it contains accurate models for the BETA Pressure and Temperature Switches and their failure rates.

When using BETA Pressure and Temperature Switches in a redundant configuration, a common cause factor of at least 5% should be included in safety integrity calculations.

The failure rate data listed the FMEDA report is only valid for the useful life time of a BETA Pressure and Temperature Switches. The failure rates will increase sometime after this time period. Reliability calculations based on the data listed in the FMEDA report for mission times beyond the lifetime may yield results that are too optimistic, i.e. the calculated Safety Integrity Level will not be achieved.

§3.5 SIL Capability

3.5.1 Systematic Integrity

The product has met manufacturer design process requirements of Safety Integrity Level (SIL) 2. These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer. A Safety Instrumented Function (SIF) designed with this product must not be used at a SIL level higher than the statement without “prior use” justification by end user or diverse technology redundancy in the design.

3.5.2 Random Integrity

The BETA Pressure and Temperature Switches is a Type **A Device**. Therefore based on the SFF between 60% and 90%, when the BETA Pressure and Temperature Switches is used as the only component in a final element subassembly, a design can meet SIL 2 @ HFT=0.

When the final element assembly consists of many components (BETA Pressure and Temperature Switches, SIS logic solver(s), final element(s) etc.) the SIL must be verified for the entire assembly using failure rates from all components. This analysis must account for any hardware fault tolerance and architecture constraints.

3.5.3 Safety Parameters

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the BETA Pressure and Temperature Switches.

§3.6 Connection of the Beta Pressure and Temperature Switches to the SIS Logic-solver.

The BETA Pressure and Temperature Switches are connected to the safety rated logic solver which is actively performing the safety function.

§3.7 General Requirements

The system's response time shall be less than process safety time. The BETA Pressure and Temperature Switches will move to its safe state in less than 3 sec. under specified conditions.

All SIS components including the BETA Pressure and Temperature Switches must be operational before process start-up.

User shall verify that the BETA Pressure and Temperature Switches are suitable for use in safety applications by confirming the nameplates are properly marked.

Personnel performing maintenance and testing on the BETA Pressure and Temperature Switches shall be competent to do so.

Results from the proof tests shall be recorded and reviewed periodically.

The useful life of the BETA Pressure and Temperature Switches is discussed in the Failure Modes, Effects and Diagnostic Analysis, Report No.: BETA 08/04-32C R001 of Exida.

4 Installation and Commissioning

§4.1 Installation

The BETA Pressure and Temperature Switches must be installed per standard practices outlined in the Installation and Operation Manual SP 001.

The environment must be checked to verify that environmental conditions do not exceed the ratings.

The BETA Pressure and Temperature Switches must be accessible for physical inspection.

§4.2 Physical Location and Placement

The BETA Pressure and Temperature Switches shall be accessible with sufficient room for process connections and shall allow manual proof testing.

Process piping to the Switch shall be kept as short and straight as possible to minimize the restrictions and potential clogging. Long or kinked (pneumatic) tubes may also increase the switch reaction time.

The BETA Pressure and Temperature Switches shall be mounted in a low vibration environment. If excessive vibration can be expected special precautions shall be taken to ensure the integrity of process connectors or the vibration should be reduced using appropriate damping mounts.

§4.3 Connection to the Process

The process connection of the BETA Pressure and Temperature Switches may be held with a wrench, but never use on the sensor body or the enclosure.

Ensure that the process connection and the pipe to which it is to be connected are properly aligned. Proper alignment prevents excessive pressures being exerted on the switch.

Check the size and type of the process connection. Connect the switch to the pipe or tube

Pay attention for the position of the two process connections of the differential sensor. Process connection are marked ‘High’ and ‘Low’.

5 Operation and Maintenance

§5.1 Proof test procedure

The objective of proof testing is to detect failures within a BETA switch that are not detected by any automatic diagnostics of the system. Of main concern are undetected failures that prevent the safety instrumented function from performing its intended function.

The frequency of proof testing, or the proof test interval, is to be determined in reliability calculations for the safety instrumented functions for which a BETA switch is applied. The proof tests must be performed more frequently than or as frequently as specified in the calculation in order to maintain the required safety integrity of the safety instrumented function.

The following proof test is recommended. The results of the proof test should be recorded and any failures that are detected and that compromise functional safety should be reported to BETA BV.

Step	Action
1	Take appropriate action to avoid a false trip.
2	Inspect the device for any visible damage, corrosion or contamination.
3	Increase the pressure to reach the increasing “set point” value and verify that the electric signal goes into the safe state.
4	Lower the pressure to reach the decreasing “set point” value and verify that the electric signal remains in the normal state.
5	Repeat steps 3 and 4 twice or more and evaluate average set point value and repeatability.
6	Restore the connection to full operation.
7	Restore normal operation

Table1: Recommended Proof Test

This test will detect approximately 90% of possible DU failures in the BETA Pressure and Temperature Switches.

The person(s) performing the proof test of a BETA Pressure and Temperature Switches should be trained in SIS operations, including bypass procedures, switch maintenance and company Management of Change procedures. No special tools are required.

§5.2 Repair and replacement

Repair procedures on the BETA Pressure and Temperature and Switches will be on separate Specification Manuals and are with the recommended spare parts.

§5.3 Useful Life

The useful life of the BETA Pressure and Temperature Switches is 10 to 15 years, or 10,000 cycles

§5.4 BETA BV Notification

Any failures that are detected and that compromise functional safety should be reported to BETA BV.

Please contact BETA BV customer service:

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The Netherlands
www.beta-b.nl

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