RISKNOWLOGY®

Technical Report
Proven In Use – Series 2000

Client: Klay Instruments B.V.
Nijverheidsweg 5
7991 CZ Dwingeloo, The Netherlands
Products: Series 2000 and Hydrobar I, Pressure and Level Transmitter
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Author(s): W. Velten-Philipp

Risknowlogy Germany GmbH
Unterreut 6
76135 Karlsruhe
Germany
www.risknowlogy.com

Revisions

Revision	Date	Who	Description
0	2013-09-16	WVP	draft
1	2013-09-19	WVP	release

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Terms and Definitions

Term	Definition
Dangerous failure	An internal failure that prevents the product from carrying out its safety function upon demand. See also safe failure
Detected failure	An internal failure that is detected by built-in diagnostics. Because of the diagnostics the product can act upon the failure. See also undetected failure
FMEDA	Failure mode, effects and diagnostics analysis
Functional safety	A product is functionally safe if random, systematic and common cause failures do not lead to malfunctioning of the system and do not result in injury or death of humans, spills to the environment, or loss of equipment or production
Hardware fault tolerance	Hardware fault tolerance indicates the number of failures the product or subsystem can withstand without losing the safety function
HFT	See hardware fault tolerance
PFD	The probability that the safety function has failed upon demand
PFS	The probability that the safety function causes a spurious trip of the process
Safe failure	An internal failure where a product carries out its safety function without a demand from the process. This failure can lead to a spurious trip. See also dangerous failure
Safety function	Function implemented in the product required to achieve a safe state of the process
SFF	Safe failure fraction
SIL	Safety Integrity Level
STL	Spurious Trip Level®
Type	The complexity of a product is designated by Type A or Type B. See IEC 61508, part 2, clause 7.4.3.1.2 and 7.4.3.1.3
Undetected failure	An internal failure that is not detected by built-in diagnostics. See also detected failure

1 Introduction

1.1 Objective

The objective of this report is to document the proven in use study carried out for the Klay Series 2000 pressure and level transmitter. The purpose of the proven in use study is to demonstrate that the device is suitable to be used in safety instrumented functions up to SIL 2 according to IEC 61511 and SIL 1 according to IEC 61508 [1,2].

1.2 About Klay Instruments

Klay Instruments is a Dutch manufacturer of Process Instrumentation. Founded in 1978 Klay has build up a long history in development and production of process instrumentation.
Klay produces a wide range of pressure and level transmitters in stainless steel design.

1.3 About Risknowlogy

Risknowlogy is an international operating company that offers services, consulting, certification and training in the field of risk, reliability and safety. Risknowlogy was established in 2002 and has offices in Switzerland, Argentinia, Columbia, Germany, The Netherlands and United Arab Emirates. We consider the world as our work area and each location has obliged to maintain the same quality standards, rules, and business practices.

The headquarters of the Risknowlogy Corporation is located in Switzerland. Here we perform certification, business development, market our products and services, create new products and services, train our employees and service any country in the world that is not serviced by a local organization.

2 Product Description

2.1 Introduction

The product subject to the proven in use analysis is the Klay series 2000 and Hydrobar 'I' pressure transmitters.
This series of transmitters is available in many different process connections.
Examples from the product are shown in Figure 1.

Figure 1 – Series 2000 and Hydrobar I, Pressure and Level Transmitter

The functional safety properties according to IEC 61508 are:

- Safety function:
  Measurement of absolute relative pressure or level within the specified safety accuracy of 0.1 % from full span.
- The safety function response time is 100ms.
- This is a type B device with hardware fault tolerance 0.
- The operation mode is low demand mode.

The conditions of use and constraints are described by the safety manual [8].

The end user is responsible for the validation of the safety function.

The following tables shows the suitable Series 2000 types:

Type	Type-Number
Series 2000	2000-range-xx-xx
Series 2000-SAN	2000-SAN-range-xx-xx
Series CER-2000	CER-2000-range-xx-xx
Series 2000-Hydrobar Cable	Hydrobar-I-Cable(..m)-xx
Series Hydrobar-I	2000-Hydrobar-Cable(..m)-xx

Software Version 9.17

Series 2000 Serial from 4309036

Hydrobar I Serieal from 7309014

3 Proven In Use Demonstration

3.1 Restricted Functionality

The purpose of the transmitter is to measure the pressure and to transmit this pressure as a 4-20 mA signal. The functionality is restricted to pressure and hydrostatic level related measurements.
Possible configurations are related to process parameters. Access to the configuration is protected.

3.2 Conditions Of Use

The instrument considered for proven in use have been used in widely in the process industry in different operating environments [5]. These include more than 10 typical industrial process environments [4].

3.3 Field Data

Klay Instruments collected field data for the Series 2000 since production start. For the proven in use demonstration the field feedback since 2007 is taken into account [5]. From the operating hours of each instrument 6 month have been taken into account to exclude non-operating hours (e.g. from storage times, non-operation, etc). The typical operating time in the process industry is assumed 24 hours per day.
Klay Instruments has compiled customer feedback and repair data [5] into data bases. The summarised data demonstrates that during the time under consideration 15 random failures occurred which were classified as dangerous failures due to the lag of further information (see Table 1).

Table 1 – Operating hours and failures

Type	Operating hours	Safe Failures	Dangerous Failures
Series 2000	258038940 h	-	15

Note: IEC 61508 requires for route 2_H a diagnostic coverage of 60%. The DC derived from the FMEDA is not sufficient. Therefore compliance to route 2_H cannot be confirmed. The purpose of this proven in use demonstration is to allow later use of the instrument within the scope of IEC 61511 and to confirm the systematic capability.

3.4 Software and Modifications

During the time span used for the proven in use demonstration the products were not subject to modifications.

3.5 Reliability analysis (FMEDA)

The reliability study consists of a failure modes and effects analyses (FMEDA) [6] and the estimation of the average probability of failure on demand of the safety function. The FMEDA was carried out in line with the requirements of the IEC 61508 [1] standard. Table 2 presents a summary of the reliability data derived from the FMEDA and the failure rates calculated from the field data taking a confidence interval of 90% into account.

Figure 2 shows the PFD and PFDavg curve (20 years).

The FMEDA analysis, which represents design expectations, corresponds with the data from the proven in use data, which represents operational experience.

Table 2 – Functional safety data for Series 2000

Properties	FMEDA	Proven In Use	90% Confidence (upper limit)
Type	B		
Safe failure rate	137.4	---	---
Safe detected failure rate	0	n.a.	n.a
Safe undetected failure rate	137.4	n.a.	n.a
Dangerous failure rate	47.7	58	89.5
Dangerous detected failure rate	2.35	n.a.	n.a
Dangerous undetected failure rate	45.4	n.a.	n.a
DC	4.9%	n.a.	n.a
Safe failure fraction	75.5%	n.a.	n.a

Notes:

- Failure rates in FIT [10^{-9} 1/h]
- Confidence interval according to IEC 61508 route 2_H

Table 3 – PFDavg calculation results (1oo1)

T1[a]	**1**	**2**	**5**	**10**	**15**	**20**
PFDG	2,02E-04	4,01E-04	9,97E-04	1,99E-03	2,98E-03	3,98E-03
%SIL2	2,02%	4,01%	9,97%	19,90%	29,84%	39,78%

MTTR 72h

PFSavg is 5.98E-4.

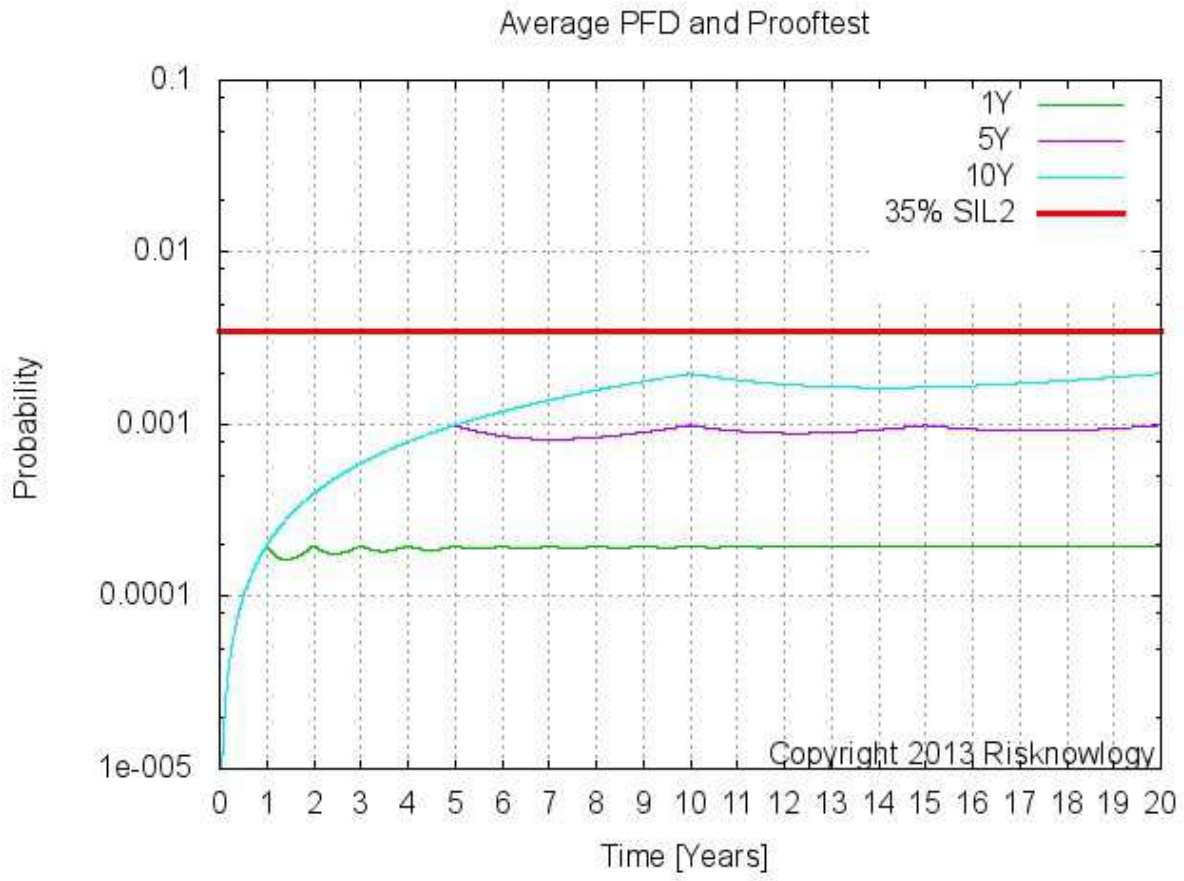

Figure 2 – PFDavg results

3.6 EMC, Basic safety and environmental testing

The product complies [9] to

- EMC directive 2004/108/EC
- ATEX directive 94/9/EC

4 User Documentation

The safety manual [8] provided by Klay Instruments provides all necessary information for use of the product. The manual was reviewed without any objections.

5 Conclusions

The proven in use analysis demonstrates that the specified safety function of the Series 2000 pressure transmitters are suitable for SIL1 according to IEC 61508 (FMEDA, route 1_H) and SIL 2 safety properties according to IEC 61511.

6 References

The following references have been used during the project:

1. IEC 61508: 2010
   Functional Safety of Electrical, Electronic, Programmable Electronic Safety Related Systems
2. IEC 61511: 2003
   Functional safety: Safety instrumented systems for the process industry sector
3. SN 29000, Failure Rates of Components, 2004
4. Applications 2000 series SIL
5. SIL-Repair-2007
   SIL-Repair-2008
   SIL-Repair-2009
   SIL-Repair-2010
   SIL-Repair-2011
   Fieldfeddb_2000.xls
6. FMEA-Klay_2000_WVP_2013-09-11
7. Schematics, Drawings
   04009.docx
   TR2000-1
   TR2000-2
   TR2000-3
   TR2000-4
   Q1242A
8. Manual, Safetymanual: SM-EN-2000/09-13/01
9. EMC, Environmental and basic safety
   ATEX DEKRA (KEMA) Certificate 03ATEX1219X
   Bureau Veritas Certificate 09165/C0 BV
   DNV Certificate A-13344
   EMC-Series-Hydrobar-cable-VM v1-1
   EMC-test-Series CER-2000-D-N v1-1
   EMC-test-Series-2000-SAN V1