



Failure Modes, Effects and Diagnostic Analysis

Project:

Pressure switches D.T, D.X, B.T, B.X, X1T, 8000, 9671x, 9681x, 9692x
series

Customer:

Barksdale GmbH
Reichelsheim
Germany

Contract No.: Barksdale 11/05-020

Report No.: Barksdale 11/05-020 R001

Version V1, Revision R1, December 2011

Jan Hettenbach

Management summary

This report summarizes the results of the hardware assessment carried out on the pressure switches D.T, D.X, B.T, B.X, X1T, 8000, 9671x, 9681x, 9692x series. Table 1 gives an overview of the different versions that belong to the considered pressure switches.

The mechanical assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Version overview¹

Type	Comment
9681x, 9692x	Piston pressure switch, for hazardous areas, Ex i approval
9671x	Diaphragm seal piston sensor, for vacuum measurement, Ex i approval
B.T / B.X	Bourdon tube pressure switches with direct-acting pressure sensor and the snap-acting micro switch, Ex i approval, B.X types additional with Ex d approval
D.T / D.X	Mechanical pressure switch with metal diaphragm, Ex i approval, D.X types additional with Ex d approval
S8000/X1T	Mechanical pressure switches in diaphragm or piston design, Ex i approval
DP.T	Mechanical single/dual pressure switch, Ex i approval

For safety applications only the described versions of the pressure switches have been considered. All other possible variants and configurations are not covered by this report.

Barksdale GmbH and *exida* together did a quantitative analysis of the pressure switches D.T, D.X, B.T, B.X, X1T, 8000, 9671x, 9681x, 9692x to calculate the failure rates using *exida*'s experienced-based data compilation for the different mechanical components.

The pressure switches D.T, D.X, B.T, B.X, X1T, 8000, 9671x, 9681x, 9692x are classified as Type A² elements according to IEC 61508, having a hardware fault tolerance of 0.

All types can be used as monitoring devices which are switching at increasing pressure (max) or decreasing pressure (min).

The failure rates listed in this report do not include failures due to wear-out of any components. They reflect random failures and include failures due to external events, such as unexpected use, see section 4.2.3.

The failure rates according to IEC 61508:2010 2nd edition for the pressure switches D.T, D.X, B.T, B.X, X1T, 8000, 9671x, 9681x, 9692x series are listed in the following tables.

¹ All versions are available in several pressure ranges and switching contact materials (gold or silver). The listed versions are representative for the type series.

² Type A element: "Non-complex" element (all failure modes are well defined); for details see 7.4.4.1.2 of IEC 61508-2.



Table 2: Summary – IEC 61508:2010 failure rates³ for increasing pressure detection

Redundant (red.) design with two switches is specified in the following table separately. All types are with Ex i approval, B.X and D.X additional with explosion proof housing and Ex d approval.

Failure rates (in FIT) according to <i>exida</i> Profile 2											
Failure category	9681x, 9692x	9681x, 9692x (red.)	9671x	9671x (red.)	B.T / B.X	B.T / B.X (red.)	D.T / D.X	D.T / D.X (red.)	DP.T	DP.T (red.)	S8000 / X1T
Fail Safe Detected (λ_{SD})	0	0	0	0	0	0	0	0	0	0	0
Fail Safe Undetected (λ_{SU})	132	252	140	260	128	252	127	253	187	313	130
Fail Dangerous Detected (λ_{DD}) ⁴	0	27	0	27	0	32	0	29	0	29	0
Fail Dangerous Undetected (λ_{DU})	82	55	72	45	65	32	57	27	119	89	86
Fail Annunciation Undetected (λ_{AU}) ⁵	0	30	0	30	0	36	0	33	0	33	0
No effect	128	128	81	81	63	72	26	35	138	147	236
No part	0	0	0	0	0	0	0	0	0	0	29
Total failure rate (safety function)	214	334	212	332	193	316	184	309	306	431	216
SFF	61%	83%	66%	86%	66%	89%	69%	91%	61%	79%	60%
SIL AC ⁶	SIL2	SIL2	SIL2	SIL2	SIL2	SIL2	SIL2	SIL3	SIL2	SIL2	SIL2

³ It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

⁴ The device does not contain any internal diagnostics. The DD failures result from the fact that the redundant switch is considered to be a safety measure for the primary switch providing a DC of 90% by considering a common cause factor of 10%.

⁵ The AU failures result from the fact that the redundant switch is considered to be a safety measure and therefore is contributing to the "annunciation" failure category.

⁶ SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 3: Summary – IEC 61508:2010 failure rates⁷ for decreasing pressure detection

Redundant (red.) design with two switches is specified in the following table separately. All types are with Ex i approval, B.X and D.X additional with explosion proof housing and Ex d approval.

Failure rates (in FIT) according to <i>exida</i> Profile 2											
Failure category	9681x, 9692x	9681x, 9692x (red.)	9671x	9671x (red.)	B.T / B.X	B.T / B.X (red.)	D.T / D.X	D.T / D.X (red.)	DP.T	DP.T (red.)	S8000 / X1T
Fail Safe Detected (λ_{SD})	0	0	0	0	0	0	0	0	0	0	0
Fail Safe Undetected (λ_{SU})	145	265	144	264	140	266	137	260	197	320	145
Fail Dangerous Detected (λ_{DD}) ⁸	0	27	0	27	0	29	0	32	0	32	0
Fail Dangerous Undetected (λ_{DU})	69	42	68	41	53	23	47	14	109	77	71
Fail Annunciation Undetected (λ_{AU}) ⁹	0	30	0	30	0	33	0	36	0	36	0
No effect	128	128	81	81	63	72	26	35	138	147	236
No part	0	0	0	0	0	0	0	0	0	0	29
Total failure rate (safety function)	214	334	212	332	193	318	184	306	306	429	216
SFF	67%	87%	67%	87%	72%	92%	74%	95%	64%	82%	67%
SIL AC ¹⁰	SIL2	SIL2	SIL2	SIL2	SIL2	SIL3	SIL2	SIL3	SIL2	SIL2	SIL2

⁷ It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

⁸ The device does not contain any internal diagnostics. The DD failures result from the fact that the redundant switch is considered to be a safety measure for the primary switch providing a DC of 90% by considering a common cause factor of 10%.

⁹ The AU failures result from the fact that the redundant switch is considered to be a safety measure and therefore is contributing to the "annunciation" failure category.

¹⁰ SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL. For full assessment purposes all requirements of IEC 61508 must be considered.