GEMÜ R480 Victoria

Butterfly valve with bare shaft

EN

SIL Safety Manual

further information
webcode: GW-R480

Contents

1 General information

The safety manual contains information and safety notes which apply to the use of the butterfly valve in safety-related applications.

The safety manual only applies in connection with the respective installation, operating and maintenance instructions.

Designation	Item number
ba_R480_de_gb	88730584

1.1 Definition of terms

Automatic Diagnostics

Tests performed on line internally by the device or, if specified, externally by another device without manual intervention.

Device

A device is something that is part of an element; but, cannot perform an element safety function on its own.

Dynamic Applications

The movement interval of the final element device is less than 200 hours. Movement may be accomplished by PVST, full stroke proof testing or a demand on the system.

Element

A collection of devices that perform an element safety function such as a final element consisting of a logic solver interface, actuator and valve.

exida criteria

A conservative approach to arriving at failure rates suitable for use in hardware evaluations utilizing the 2_H Route in IEC 61508-2.

Fault tolerance

Ability of a functional unit to continue to perform a required function in the presence of faults or errors (IEC 61508-4, 3.6.3).

FIT

Failure in Time: Failure rate ($1x10^{-9}$ failures per hour)

FMEDA

Failure Modes, Effects and Diagnostic Analysis

HFT

Hardware Fault Tolerance

Low demand mode

Mode, where the demand interval for operation made on a safety-related system is greater than twice the proof test interval.

PFD_{AVG}

Average Probability of Failure on Demand

PVST

Partial Valve Stroke Test - It is assumed that Partial Valve Stroke Testing, when performed, is automatically performed at least an order of magnitude more frequently than the proof test; therefore, the test can be assumed an automatic diagnostic. Because of the automatic diagnostic assumption, the Partial Valve Stroke Testing also has an impact on the Safe Failure Fraction.

Random Capability

The SIL limit imposed by the Architectural Constraints for each element.

Severe Service

Condition that exists when material through the valve has abrasive particles, as opposed to Clean Service where these particles are absent.

SFF

Safe Failure Fraction, summarizes the fraction of failures which lead to a safe state plus the fraction of failures which will be detected by automatic diagnostic measures and lead to a defined safety action.

SIF

Safety Instrumented Function

SIL

Safety Integrity Level

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).

SSI

Site Safety Index

Static Applications

The movement interval of the final element device is greater than 200 hours. Movement may be accomplished by PVST, full stroke proof testing or a demand on the system.

Type A element

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

1.2 Abbreviations

DC

Diagnostic Coverage: Diagnostic coverage of dangerous failures (DC = λ_{dd} / (λ_{dd} + λ_{du}))

FIT

Failure in Time: Failure rate ($1x10^{-9}$ failures per hour)

FMEDA

Failure Modes, Effects and Diagnostic Analysis

HFT

Hardware Fault Tolerance

MTBF

Mean Time Between Failures

MTTR

Mean Time To Restoration

PFD $_{AVG}$

Average Probability of Failure on Demand

PVST

Partial Valve Stroke Test

SFF

Safe Failure Fraction

SIF

Safety Instrumented Function

SIL

Safety Integrity Level

TSO

Tight Shut-Off

T [Proof]

Proof Test Interval

2 Standards / Literature used

The services delivered by the testing organization exida were performed based on the following standards / literature:

IEC 61508-2:2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
Mechanical Component Reliability Handbook, 4th Edition, 2016	exida LLC, Electrical & Mechanical Component Reliability Handbook, Fourth Edition, 2016 (pending publication, not publicly available at the time of this report)
Safety Equipment Reliability Handbook, 4th Edition, 2015	exida LLC, Safety Equipment Reliability Handbook, Fourth Edition, 2015, ISBN 978-1-934977-13-2
Goble, W.M.,2010	Control Systems Safety Evaluation and Reliability, 3rd edition, ISA, ISBN 97B-1-934394-80-9. Reference on FMEDA methods
IEC 60654-1:1993-02, second edition	Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic conditions
O'Brien, C., Stewart, L., & Bredemeyer, L., 2018	Exida LLC., Final Elements in Safety Instrumented Systems IEC 61511 Compliant Systems and IEC 61508 Compliant Products, 2018, ISBN 978-1-934977-18-7
Scaling the Three Barriers, Recorded Web Seminar, June 2013	http://www.exida.com/Webinars/Recordings/SIF-Verification-Scaling-the-Three-Barriers
Meeting Architecture Constraints in SIF Design, Recorded Web Seminar, March 2013	http://www.exida.com/Webinars/Recordings/Meeting-Architecture-Constraints-in-SIF-Design
Random versus Systematic – Issues and Solutions, September 2016	https://www.exida.com/Resources/Whitepapers/random-versus-systematic-failures-issues-and-solutions
Bukowski, J.V. and Chastain-Knight, D., April 2016	Assessing Safety Culture via the Site Safety IndexTM, Proceedings of the AIChE 12th Global Congress on Process Safety, GCPS2016, TX: Houston
Bukowski, J.V. and Stewart, L.L., April 2016	Quantifying the Impacts of Human Factors on Functional Safety, Proceedings of the 12th Global Congress on Process Safety, AIChE 2016 Spring Meeting, NY: New York

Criteria for the Application of IEC 61508:2010 Route 2H, December 2016	Exida White Paper, Sellersville, PA www.exida.com
Goble, W.M. and Brombacher, A.C., November 1999, Vol. 66, No. 2	Using a Failure Modes, Effects and Diagnostic Analysis (FMEDA) to Measure Diagnostic Coverage in Programmable Electronic Systems, Reliability Engineering and System Safety, Vol. 66, No. 2, November 1999.

3 Functional description

GEMÜ R480 Victoria® is a soft seated butterfly valve. It is available in nominal sizes DN 25 to 600 and in various body versions such as Wafer, Lug and U section (flanged).

3.1 Safety function

The safety function of the Butterfly Valve is to open on trip, close on trip, or close with a tight shutoff on trip.

4 Failure categories description

In order to judge the failure behavior of the Butterfly Valve, the following definitions for the failureof the device were considered.

Fail-Safe State:

Valve, Full Stroke	State where the valve is closed.
Valve, Tight-Shut-Off	State where the valve is closed and sealed with leakage no greater than the defined leak rate; Tight shut-off requirements shall be specified according to the application, if shut-off requirements allow flow greater than ANSI class V, respectively ANSI class IV, then Full Stroke numbers may be used.
Valve, Open-To-Trip	State where the valve is open
Fail Safe	Failure that causes the device 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).
Valve	Failure that prevents the valve from moving to the defined fail-safe state within the normal time span.
Fail Dangerous Undetected	Failure that is dangerous and that is not being diagnosed by automatic diagnostics, such as Partial Valve Stroke Testing.
Fail Dangerous Detected	Failure that is dangerous but is detected by automatic diagnostics, such as Partial Valve Stroke Testing.
No Effect	Failure of a component that is part of the safety function but that has no effect on the safety function.
External Leakage	Failure that causes process fluids, gas, hydraulic fluids or operating media to leak outside of the valve or actuator; External Leakage is not considered part of the safety function and therefore this failure rate is not included in any of the numbers. External leakage failure rates should be reviewed for secondary safety and environmental issues.

The failure categories listed above expand on the categories listed in IEC 61508 in order to provide a complete set of data needed for design optimization.

5 Assumptions

- The worst-case assumption of a series system is made. Therefore, only a single component failure will fail the entire Butterfly Valve, and propagation of failures is not relevant.
- Failure rates are constant for the useful life period.
- Any product component that cannot influence the safety function (feedback immune) is excluded. All components that are part of the safety function including those needed for normal operation are included in the analysis.
- The stress levels are specified in the exida Profile used for the analys is limited by the manufacturer's published ratings.
- Materials are compatible with the environmental and process conditions.
- The device is installed and operated per the manufacturer's instructions.
- Valves are installed such that the controlled substance will flow through the valve in the direction indicated by the flow arrow, located on the valve body.
- In order to claim diagnostic coverage for Partial Valve Stroke Testing it is automatically performed at a rate at least ten times faster than the Demand frequency.
- Partial Valve Stroke Testing of the final element includes position detection from actuator mounted position sensors, typical of quarter turn installations.
- Worst-case internal fault detection time is the PVST test interval time.

6 SIL manufacturer's declaration GEMÜ R480 (Static Application)

SIL manufacturer's declaration

Functional safety in accordance with IEC 61508 and IEC 61511

We,

GEMÜ Gebr. Müller Apparatebau GmbH & Co. KG
Fritz-Müller-Straße 6-8
74653 Ingelfingen-Criesbach, Germany

declare that, for the product listed below, the failure rates outlined below were detected in safety-related applications in accordance with IEC 61508 and IEC 61511.

The failure rates were calculated by means of an FMEDA (Failure Modes, Effects and Diagnostic Analysis) in accordance with IEC 61508. The evaluation was performed by exida.com (report number: GEMÜ 13/08-046 R003).

Product description:	GEMÜ butterfly valve R480 Victoria®
Type of valve:	A
Safety function:	The safety function of the Butterfly Valve is to open on trip, close on trip, or close with a tight shutoff on trip.
HFT (Hardware Fault Tolerance):	0
MTTR (Mean Time To Restoration):	48 hours

The determined failure rates apply to the operating mode with low usage rate:

	Failure rates Clean Service* (in FIT**)					
	Without external test			With external test		
	Closed position		Open position	Closed position		Open position
	Full stroke	Tight-sealed		Full stroke	Tight-sealed	
Safety function:	901	76	901	901	76	901
External leak	436	436	436	436	436	436
SIL (Safety Integrity Level):	2	2	2	2	2	2
λ_{DU} (Dangerous undetected):	556	1381	381	389	1214	214
λ_{DD} (Dangerous detected):	0	0	0	167	167	167
λ_{SU} (Safe undetected):	0	0	174	0	0	2
λ_{SD} (Safe detected):	0	0	0	0	0	172
PTC (Proof Test Coverage):	45 %	18 %	66 %	22 %	7 %	39 %

The determined failure rates apply to the operating mode with low usage rate:

	Failure rates Severe Service*** (in FIT**)					
	Without external test			With external test		
	Closed position		Open position	Closed position		Open position
	Full stroke	Tight-sealed		Full stroke	Tight-sealed	
Safety function:	1727	76	1727	1727	76	1727
External leak	544	544	544	544	544	544
SIL (Safety Integrity Level):	2	2	2	2	2	2
λ_{DU} (Dangerous undetected):	953	2604	605	677	2328	329
λ_{DD} (Dangerous detected):	0	0	0	276	276	276
λ_{SU} (Safe undetected):	0	0	349	0	0	3
λ_{SD} (Safe detected):	0	0	0	0	0	346
PTC (Proof Test Coverage):	43 %	16 %	68 %	20 %	6 %	42 %

As the External Leak failure rates are a subset of the No Effect failure rates, the total No Effect failure rate is the sum of the listed No Effect and External Leak rates. External leakage failure ratesdo not directly contribute to the reliability of the devicebut should be reviewed for secondary safety and environmental issues.

* Clean Service = without abrasive particles

** FIT = Failure In Time ($1x10^{-9}$ failures per hour)

*** Severe Service = with abrasive particles

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7 SIL manufacturer's declaration GEMÜ R480 (Dynamic Application)

SIL manufacturer's declaration

Functional safety in accordance with IEC 61508 and IEC 61511

We,

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Fritz-Müller-Straße 6-8
74653 Ingelfingen-Criesbach, Germany

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The failure rates were calculated by means of an FMEDA (Failure Modes, Effects and Diagnostic Analysis) in accordance with IEC 61508. The evaluation was performed by exida.com (report number: GEMÜ 13/08-046 R003).

Product description:	GEMÜ butterfly valve R480 Victoria®
Type of valve:	A
Safety function:	The safety function of the Butterfly Valve is to open on trip, close on trip, or close with a tight shutoff on trip.
HFT (Hardware Fault Tolerance):	0
MTTR (Mean Time To Restoration):	48 hours

The determined failure rates apply to the operating mode with low usage rate:

	Failure rates Clean Service* (in FIT**)					
	Without external test			With external test		
	Closed position		Open position	Closed position		Open position
	Full stroke	Tight-sealed		Full stroke	Tight-sealed	
Safety function:	915	91	915	915	91	915
External leak	457	457	457	457	457	457
SIL (Safety Integrity Level):	2	2	2	2	2	2
λ $_{DU}$ (Dangerous undetected):	356	1179	181	309	1132	134
λ $_{DD}$ (Dangerous detected):	0	0	0	47	47	47
λ $_{SU}$ (Safe undetected):	0	0	175	0	0	2
λ $_{SD}$ (Safe detected):	0	0	0	0	0	173
PTC (Proof Test Coverage):	20 %	6 %	39 %	8 %	2 %	17 %

The determined failure rates apply to the operating mode with low usage rate:

	Failure rates Severe Service*** (in FIT**)					
	Without external test			With external test		
	Closed position		Open position	Closed position		Open position
	Full stroke	Tight-sealed		Full stroke	Tight-sealed	
Safety function:	1739	91	1739	1739	91	1739
External leak	579	579	579	579	579	579
SIL (Safety Integrity Level):	2	2	2	2	2	2
λ_{DU} (Dangerous undetected):	680	2327	331	601	2248	251
λ_{DD} (Dangerous detected):	0	0	0	79	79	80
λ_{SU} (Safe undetected):	0	0	350	0	0	3
λ_{SD} (Safe detected):	0	0	0	0	0	347
PTC (Proof Test Coverage):	18 %	5 %	36 %	7 %	2 %	16 %

As the External Leak failure rates are a subset of the No Effect failure rates, the total No Effect failure rate is the sum of the listed No Effect and External Leak rates. External leakage failure ratesdo not directly contribute to the reliability of the devicebut should be reviewed for secondary safety and environmental issues.

* Clean Service = without abrasive particles

** FIT = Failure In Time ($1x10^{-9}$ failures per hour)

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