Failure Modes, Effects and Diagnostic Analysis

Project:

Primary Elements

Company:

Rosemount Inc.

(an Emerson Process Management company)

Chanhassen, MN

USA

Contract Number: Q13/04-008

Report No.: ROS 13/04-008 R001

Version V1, Revision R0, June 16, 2013

Ted Stewart

Management Summary

This report summarizes the results of the hardware assessment in the form of a Failure Modes, Effects, and Diagnostic Analysis (FMEDA) of the Rosemount Primary Element(s). A Failure Modes, Effects, and Diagnostic Analysis is one of the steps to be taken to achieve functional safety certification per IEC 61508 of a device. From the FMEDA, failure rates are determined. The FMEDA that is described in this report concerns only the hardware of the Primary Element. For full functional safety certification purposes all requirements of IEC 61508 must be considered.

A Flowmeter consists of a Primary Element that is attached to one of the following devices: Rosemount 3051, Rosemount 3051S, Rosemount 3051S Multivariable, Rosemount 2051, and Rosemount 3095 differential pressure transmitters. The specific Primary Elements that were considered are the 485 Annubar Primary Element, the 405 Compact Primary Element, and the 1195 Integral Orifice Plate.

Table 1 gives an overview of the different versions that were considered in the FMEDA of the Primary Element.

Table 1 Version Overview

Primary Element	Flowmeter – High Trip, Normal Service
Primary Element	Flowmeter – Low Trip, Normal Service

The Primary Element is classified as a Type A[1] element according to IEC 61508, having a hardware fault tolerance of 0.

The failure rates for the Primary Element are listed in Table 2. This data was done using the Predictive Analytics technique developed by *exida*. For this device, data from several field failure studies totaling over three billion unit hours was compiled. This data was analyzed using a 90% confidence interval per Route 2_H requirements of IEC 61508. Given the considerable quantity of data and the quality of the data collection system, this data meets Route 2_H requirements.

Table 2 Failure rates - Primary Element incremental, Route 2_H compliant

Failure Category	Failure Rate (FIT)	
	Flowmeter	
	High Trip	Low Trip
Fail Safe Undetected	8	10
Fail Dangerous Undetected	11	9
Residual	51	51
External Leak	93	93

[1] Type A element: "Non-Complex" element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2, ed2, 2010. / Type B element: "Complex" element (using micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2, ed2, 2010.

These failure rates are the incremental rates to be added to the pressure transmitter to obtain totals for the sub-system. The incremental failure rates account for stress reduction on the transmitter when a Primary Element is used. These failure rates are valid for the useful lifetime of the product, see Appendix A.

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 4.2.2.

Table 3 lists the failure rates for the Primary Element according to IEC 61508, ed2, 2010.

Table 3 Failure rates - Primary Element incremental, Route 2_H, according to IEC 61508 in FIT

Device	λ_{SD}	λ_{SU}[2]	λ_{DD}	λ_{DU}
Flowmeter – High Trip (Normal conditions)	0	8	0	11
Flowmeter – Low Trip (Normal conditions)	0	10	0	9

A user of the Primary Element can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates is presented in section 4.4 along with all assumptions.

[2] It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.

Table of Contents

1 Purpose and Scope

This document shall describe the results of the hardware assessment in the form of the Failure Modes, Effects and Diagnostic Analysis carried out on the Primary Element. From this, failure rates, and example PFD_{AVG} values are calculated.

The information in this report can be used to evaluate whether a Primary Element meets the average Probability of Failure on Demand (PFD_{AVG}) requirements. As this data meets Route 2_H requirements, architectural constraints per Route 2_H may be used.

2 Project Management

2.1 *exida*

exida is one of the world's leading accredited Certification Bodies and knowledge companies specializing in automation system safety and availability with over 300 years of cumulative experience in functional safety. Founded by several of the world's top reliability and safety experts from assessment organizations and manufacturers, *exida* is a global company with offices around the world. *exida* offers training, coaching, project oriented system consulting services, safety lifecycle engineering tools, detailed product assurance, cyber-security and functional safety certification and a collection of on-line safety and reliability resources. *exida* maintains the largest process equipment database of failure rates and failure modes with over 60 billion unit operating hours.

2.2 Roles of the parties involved

Rosemount Inc.	Manufacturer of the Primary Element
exida	Performed the FMEDA hardware assessment

Rosemount Inc. contracted *exida* in March 2013 with the hardware assessment of the above-mentioned device.

2.3 Standards and Literature used

The services delivered by *exida* were performed based on the following standards / literature.

[N1]	IEC 61508-2: ed2, 2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
[N2]	Electrical & Mechanical Component Reliability Handbook, 2nd Edition, 2008	*exida* LLC, Electrical & Mechanical Component Reliability Handbook, Second Edition, 2008, ISBN 978-0-9727234-6-6
[N3]	EMCR Handbook, 2011 Update	*exida* LLC, Electrical & Mechanical Component Reliability Handbook, 2011 Update
[N4]	Safety Equipment Reliability Handbook, 3rd Edition, 2007	*exida* LLC, Safety Equipment Reliability Handbook, Third Edition, 2007, ISBN 978-0-9727234-9-7
[N5]	Goble, W.M. 1998	Control Systems Safety Evaluation and Reliability, ISA, ISBN 1-55617-636-8. Reference on FMEDA methods
[N6]	IEC 60654-1:1993-02, second edition	Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic condition
[N7]	O'Brien, C. & Bredemeyer, L., 2009	*exida* LLC., Final Elements & the IEC 61508 and IEC Functional Safety Standards, 2009, ISBN 978-1-9934977-01-9

2.4 Reference documents

2.4.1 Documentation provided by Rosemount Inc.

[D1]	May 2013	Product Data Sheet; 00813-0100-4485, Rev EB
[D2]	March 2012	Annubar Reference Manual; 00809-0100-4809, Rev CB
[D3]	April 2006	Integral Orifice Flowmeter Series; 00809-0100-4686; Rev HA

2.4.2 Documentation generated by *exida*

[R1]	ROS 1304008 R001 Primary Elements FMEDA Report	FMEDA report, Primary Element (this report)

3 Product Description

A Flowmeter consists of a Primary Element that is attached to one of the following devices: Rosemount 3051, Rosemount 3051S, Rosemount 3051S Multivariable, Rosemount 2051, and Rosemount 3095 differential pressure transmitters. The purpose of this report is to consider the additional failure rates between these elements when attached to a pressure transmitter.

These elements have the ability to attach onto numerous devices such as a Rosemount 2051, Rosemount 3051, Rosemount 3051S, etc. A user may visit the supplier's website for the technical specifications. A flowmeter measures flow and comes in numerous ways.

- Rosemount 4-20mA Flowmeter

  A Rosemount Pressure Transmitter can be combined with primary elements to offer fully assembled flowmeters. The direct mount flowmeter capability eliminates troublesome impulse lines associated with traditional installations. With multiple primary element technologies available, Rosemount flowmeters offer a flexible solution to meet the performance, reliability, and installation needs of nearly any flow measurement application.

3.1 Rosemount Flowmeter Series

Rosemount Flowmeters combine the proven pressure transmitter and the latest primary element technology: Annubar Averaging, Compact Conditioning Orifice Plate, and Integral Orifice Plate. Flowmeters are factory configured to meet your application needs. Direct or remote mount configurations are available, but only the Direct mount configurations have been included in this analysis.The direct mount flowmeter capability eliminates troublesome impulse lines associated with traditional installations. With multiple primary element technologies available, Rosemount flowmeters offer a flexible solution to meet the performance, reliability, and installation needs of nearly any flow measurement application.

3.1.1 Annubar Flowmeter

Annubar flowmeters reduce permanent pressure loss by creating less blockage in the pipe. They are ideal for large line size installations when cost, size, and weight of the flowmeter are concerns. This analysis includes the Rosemount Model 485 Sensor and a 3-way Valve Manifold. Not included in this analysis are the 'Flo-tap' models that can be installed and removed from service while the process is running.

3.1.2 Compact Flowmeter

Compact Conditioning flowmeters reduce straight piping requirements to 2D upstream and 2D downstream from a flow disturbance. These models feature simple installation of the Compact Flowmeter between any existing raised-face flanges. This analysis includes the Rosemount Model 405 Conditioning / Orifice Plate and a 3-way Valve Manifold.

3.1.3 Integral Orifice Flowmeter

These feature precision honed pipe sections for increased accuracy in small line sizes, and self-centering plate design prevents alignment errors that magnify measurement inaccuracies in small line sizes. This analysis includes the Rosemount Model 1195 Sensor and a 3-way Valve Manifold

Table 4 gives an overview of the different versions that were considered in the FMEDA of the Primary Element.

Table 4 Version Overview

Primary Element	Flowmeter – High Trip, Normal Service
Primary Element	Flowmeter – Low Trip, Normal Service

The Primary Element is classified as a Type A[3] element according to IEC 61508, having a hardware fault tolerance of 0.

[3] Type A element: "Non-Complex" element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2, ed2, 2010. / Type B element: "Complex" element (using micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2, ed2, 2010.

4 Failure Modes, Effects, and Diagnostic Analysis

The Failure Modes, Effects, and Diagnostic Analysis as performed based on the documentation obtained from Rosemount Inc. and is documented in [D1, D2, D3, D4].

4.1 Failure categories description

In order to judge the failure behavior of the Primary Element, the following definitions for the failure of the device were considered.

Fail-Safe State	State where the output exceeds the user defined threshold.
Fail Safe	Failure that causes the device to go to the defined fail-safe state without a demand from the process.
Fail Detected	Failure that causes the transmitter output signal to go to the predefined alarm state.
Fail Dangerous	Failure that deviates the measured input state or the actual output by more than 2% of span and that leaves the output within active scale.
Fail Dangerous Detected	Failure that is dangerous but is detected by automatic diagnostics.
Fail Dangerous Undetected	Failure that is dangerous and that is not being diagnosed by automatic diagnostics.
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 to leak outside of the valve; External Leakage is not considered part of the safety function and therefore this failure rate is not included in the Safe Failure Fraction calculation.

The failure categories listed above expand on the categories listed in IEC 61508 which are only safe and dangerous, both detected and undetected.

External leakage failure rates do not directly contribute to the reliability of a component but should be reviewed for secondary safety and environmental issues.

4.2 Methodology – FMEDA, Failure Rates

4.2.1 FMEDA

A Failure Modes and Effects Analysis (FMEA) is a systematic way to identify and evaluate the effects of different component failure modes, to determine what could eliminate or reduce the chance of failure, and to document the system in consideration.

A FMEDA (Failure Mode Effect and Diagnostic Analysis) is an FMEA extension developed by *exida*. It combines standard FMEA techniques with the extension to identify online diagnostics techniques and the failure modes relevant to safety instrumented system design. It is a technique recommended to generate failure rates for each important category (safe detected, safe undetected, dangerous detected, dangerous undetected, fail high, fail low, etc.) in the safety models. The format for the FMEDA developed by *exida* is an extension of the standard FMEA format from MIL STD 1629A, Failure Modes and Effects Analysis.

Predictive Analytics is a technique developed by *exida* where the design information of the FMEDA is combined with field failure studies to utilize all known information to predict failure rates.

4.2.2 Failure Rates

The failure rate data used by *exida* in this FMEDA is from the Electrical and Mechanical Component Reliability Handbook [N2] which was derived using a database of over sixty billion unit operating hours of field failure data from multiple sources analyzed at a confidence interval of 90% per IEC 61508, Route 2H. The rates were chosen in a way that is appropriate for safety integrity level verification calculations. The rates were chosen to match *exida* environmental profile 4 for process wetted parts and profile 3 for all others, see Appendix C. It is expected that the actual number of field failures due to random events will be less than the number predicted by these failure rates.

For hardware assessment according to IEC 61508 only random equipment failures are of interest. It is assumed that the equipment has been properly selected for the application and is adequately commissioned such that early life failures (infant mortality) may be excluded from the analysis.

Failures caused by external events however should be considered as random failures. Examples of such failures are environmental stress outside of ratings, loss of power, physical abuse, or accidental damage

The assumption is also made that the equipment is maintained per the requirements of IEC 61508 or IEC 61511 and therefore a preventative maintenance program is in place to replace equipment before the end of its “useful life”. Corrosion, erosion, coil burnout etc. are considered age related (late life) or systematic failures, provided that materials and technologies applied are indeed suitable for the application, in all modes of operation.

The user of these numbers is responsible for determining their applicability to any particular environment. Accurate plant specific data may be used for this purpose. If a user has data collected from a good proof test reporting system that indicates higher failure rates, the higher numbers shall be used. Some industrial plant sites have high levels of stress. Under those conditions the failure rate data is adjusted to a higher value to account for the specific conditions of the plant.

4.3 Assumptions

The following assumptions have been made during the Failure Modes, Effects, and Diagnostic Analysis of the Primary Element.

- Only a single component failure will fail the entire Primary Element.
- Failure rates are constant, wear-out mechanisms are not included.
- Propagation of failures is not relevant.
- All components that are not part of the safety function and cannot influence the safety function (feedback immune) are excluded.
- The stress levels are average for an industrial environment and can be compared to the *exida* Profile 4 with temperature limits within the manufacturer’s rating. Other environmental characteristics are assumed to be within manufacturer’s rating.
- Materials are compatible with process conditions.
- The device is installed per manufacturer’s instructions.

4.4 Results

Using Predictive Analytic reliability data per IEC 61508 Route 2_H extracted from the *exida* Electrical and Mechanical Component Reliability Database the following failure rates resulted from the Primary Element FMEDA.

Table 5 Failure rates Primary Element incremental

Failure Category	Failure Rate (FIT)	
	Flowmeter	
	High Trip	Low Trip
Fail Safe Undetected	8	10
Fail Dangerous Undetected	11	9
Residual	51	51
External Leak	93	93

Incremental failure rates should be used when adding failure rates to a transmitter FMEDA. This table accounts for duplicate mechanical components that are already included in the transmitter FMEDA failure rates.

External leakage failure rates do not directly contribute to the reliability of the Primary Element but should be reviewed for secondary safety and environmental issues.

These failure rates are valid for the useful lifetime of the product, see Appendix A.

Table 6 lists the failure rates for the Primary Element according to IEC 61508.

Table 6 Incremental Failure rates according to IEC 61508 in FIT

Device	λ_{SD}	λ_{SU}[5]	λ_{DD}	λ_{DU}
Flowmeter – High Trip (Normal conditions)	0	8	0	11
Flowmeter – Low Trip (Normal conditions)	0	10	0	9

The hardware fault tolerance of the device is 0. The SIS designer is responsible for using this data to verify the SIL design and meet other requirements of applicable standards for any given SIL as well.

[5] It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.

5 Using the FMEDA Results

5.1 SIL Verification

Three constraints must be checked to fully verify that a design meets a target SIL level. These are:
1. PFH / PFDavg - the probability of dangerous failure must be less than the target number for a set of equipment used in a safety instrumented function. The PFDavg calculation is based on a number of variables but the primary product attribute is the "dangerous undetected" failure rate.

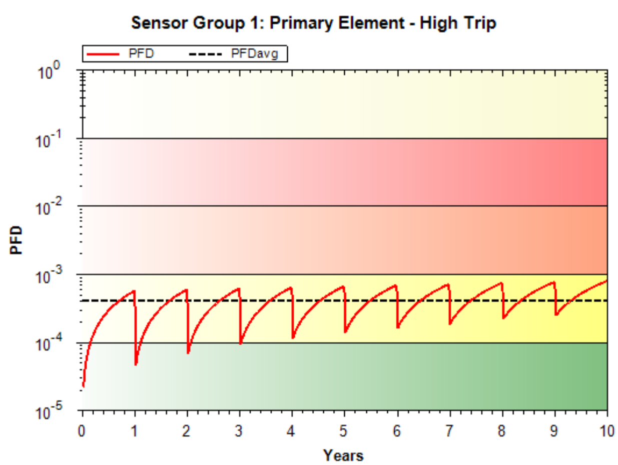
2. Systematic Capability - all products used in a safety instrumented function must meet systematic capability for the target SIL level. This is normally achieved by purchasing a product with IEC 61508 certification for the given SIL level (or better). It may also be done with a prior use justification.

3. Architecture Constraints - For each element in a safety instrumented function, minimum architecture constraints must be met. For this product the constraints in IEC 61508:2010 Route 2_H are recommended as the product meets Route 2_H requirements.

FMEDA reports contain information useful for constraint 1 and constraint 3. It is the responsibility of the Safety Instrumented Function designer to do verification for the entire SIF. *exida* recommends the accurate Markov based exSILentia® tool for this purpose.

5.2 SIF Verification Example

A Rosemount transmitter is combined with a Rosemount Primary Element, High Trip. Failure rates from the Rosemount pressure transmitter are added to the incremental failure rates for a high trip Primary Element.



These numbers were obtained from the exSILentia™ SIL verification tool which accurately calculates PFDavg (Table 7) using discrete time Markov models.

Table 7 Example SIF Verification Results

Constraint	Result		SIL 2 Requirement	SIL Achieved
Sensor sub-system PFDavg	4.24-04		PFDavg max. = 0.01	2
Sensor sub-system SIL Capability	Systematic Capability = SC3	*exida* IEC 61508 Certified	SC2	3
Sensor sub-system Architecture Constraints	HFT=0	Route 2_H Table	HFT=0	2

Sensor sub-system MTTFS: 650.37 years

In order to perform the PFDavg calculation part of the Safety Integrity Level verification, the following assumptions have been made.

Mission Time: 10 years

Startup time: 24 hours

The SIF operates in Low demand mode.

Equipment Leg (each): Clean Service (Sys. Cap.: N/A)

Primary Element - High Trip (Sys. Cap.: N/A) (My Own)

High trip

β–factor: - [%]

MTTR: 24 hours

Proof Test Interval: 12 months

Proof Test Coverage: 95.5 [%]

It is the responsibility of the Safety Instrumented Function designer to do calculations for the entire SIF. *exida* recommends the accurate Markov based exSILentia® tool for this purpose.

6 Terms and Definitions

FIT	Failure In Time (1x10-9 failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
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
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).
Type A element	"Non-Complex" element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2
Type B element	"Complex" element (using complex components such as micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2
Severe service	Condition that exists when the process material is corrosive or abrasive, as opposed to Clean Service where these conditions are absent.

7 Status of the Document

7.1 Liability

exida prepares FMEDA reports based on methods advocated in International standards. Failure rates are obtained from a collection of industrial databases. *exida* accepts no liability whatsoever for the use of these numbers or for the correctness of the standards on which the general calculation methods are based.

Due to future potential changes in the standards, best available information and best practices, the current FMEDA results presented in this report may not be fully consistent with results that would be presented for the identical product at some future time. As a leader in the functional safety market place, *exida* is actively involved in evolving best practices prior to official release of updated standards so that our reports effectively anticipate any known changes. In addition, most changes are anticipated to be incremental in nature and results reported within the previous three year period should be sufficient for current usage without significant question.

Most products also tend to undergo incremental changes over time. If an *exida* FMEDA has not been updated within the last three years and the exact results are critical to the SIL verification you may wish to contact the product vendor to verify the current validity of the results.

7.2 Releases

Version:	V1	
Revision:	R0	
Version History:	V1, R0:	Incorporated Rosemount comments; 6/16/13, Ted Stewart
	V0, R2:	Removed Level per customer request. Only doing Flowmeter
	V0, R1:	Draft; FMEDA for Flowmeter and Level per customer request.
Author(s):	Greg Sauk, William M Goble	
Review:	V0, R1:	William M Goble
Release Status:	RELEASED	

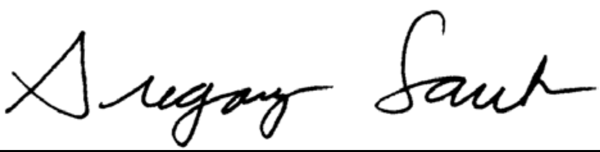
7.3 Future Enhancements

At request of client.

7.4 Release Signatures

Dr. William M. Goble, Principal Partner

Ted Stewart, Safety Engineer



Gregory Sauk, CFSE, Safety Engineer

Appendix A Lifetime of Critical Components

According to section 7.4.9.5 of IEC 61508-2, a useful lifetime, based on experience, should be assumed.

Although a constant failure rate is assumed by the probabilistic estimation method (see section 4.2.2) this only applies provided that the useful lifetime[6] of components is not exceeded. Beyond their useful lifetime the result of the probabilistic calculation method is therefore meaningless, as the probability of failure significantly increases with time. The useful lifetime is highly dependent on the subsystem itself and its operating conditions.

This assumption of a constant failure rate is based on the bathtub curve. Therefore it is obvious that the PFD_{AVG} calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is the responsibility of the end user to maintain and operate the Primary Element per manufacturer's instructions. Furthermore regular inspection should show that all components are clean and free from damage.

Based on field failure data a useful life period of approximately 10 years is expected for the Primary Element in normal service. When plant experience indicates a shorter useful lifetime for normal service than indicated in this appendix, the number based on plant experience should be used.

A useful life period for Primary Elements in severe service should be based on plant specific failure data. The *exida's* SILStat™ software from *exida* is recommended for this data collection.

[6] Useful lifetime is a reliability engineering term that describes the operational time interval where the failure rate of a device is relatively constant. It is not a term which covers product obsolescence, warranty, or other commercial issues.

Appendix B Proof tests to reveal dangerous undetected faults

According to section 7.4.5.2 f) of IEC 61508-2 proof tests shall be undertaken to reveal dangerous faults which are undetected by diagnostic tests. This means that it is necessary to specify how dangerous undetected faults which have been noted during the Failure Modes, Effects, and Diagnostic Analysis can be detected during proof testing.

B.1 Suggested Proof Test

The primary failure mode in a Primary Element is fill leakage. The suggested proof test described in Table 8 will detect 98% of possible DU failures high trip normal service application of the Primary Element.

Table 8 Suggested Proof Test – Actuator / Valve

Step	Action
1.	Inspect the Primary Element for signs of leakage.
2.	Compare the pressure (or differential pressure) reading with another instrument.

Appendix C *exida* Environmental Profiles

Table 7 *exida* Environmental Profiles

exida Profile	1	2	3	4	5	6
Description (Electrical)	Cabinet mounted/ Climate Controlled	Low Power Field Mounted no self-heating	General Field Mounted self-heating	Subsea	Offshore	N/A
Description (Mechanical)	Cabinet mounted/ Climate Controlled	General Field Mounted	General Field Mounted	Subsea	Offshore	Process Wetted
IEC 60654-1 Profile	B2	C3 also applicable for D1	C3 also applicable for D1	N/A	C3 also applicable for D1	N/A
Average Ambient Temperature	30 C	25 C	25 C	5 C	25 C	25 C
Average Internal Temperature	60 C	30 C	45 C	5 C	45 C	Process Fluid Temp.
Daily Temperature Excursion (pk-pk)	5 C	25 C	25 C	0 C	25 C	N/A
Seasonal Temperature Excursion (winter average vs. summer average)	5 C	40 C	40 C	2 C	40 C	N/A
Exposed to Elements / Weather Conditions	No	Yes	Yes	Yes	Yes	Yes
Humidity[7]	0-95% Non-Condensing	0-100% Condensing	0-100% Condensing	0-100% Condensing	0-100% Condensing	N/A
Shock[8]	10 g	15 g	15 g	15 g	15 g	N/A
Vibration[9]	2 g	3 g	3 g	3 g	3 g	N/A
Chemical Corrosion[10]	G2	G3	G3	G3	G3	Compatible Material
Surge[11]						
Line-Line	0.5 kV	0.5 kV	0.5 kV	0.5 kV	0.5 kV	N/A
Line-Ground	1 kV	1 kV	1 kV	1 kV	1 kV	
EMI Susceptibility[12]						
80 MHz to 1.4 GHz	10 V/m	10 V/m	10 V/m	10 V/m	10 V/m	N/A
1.4 GHz to 2.0 GHz	3 V/m	3 V/m	3 V/m	3 V/m	3 V/m	
2.0Ghz to 2.7 GHz	1 V/m	1 V/m	1 V/m	1 V/m	1 V/m	
ESD (Air)[13]	6 kV	6 kV	6 kV	6 kV	6 kV	N/A

[7] Humidity rating per IEC 60068-2-3
[8] Shock rating per IEC 60068-2-6
[9] Vibration rating per IEC 60770-1
[10] Chemical Corrosion rating per ISA 71.04
[11] Surge rating per IEC 61000-4-5
[12] EMI Susceptibility rating per IEC 6100-4-3
[13] ESD (Air) rating per IEC 61000-4-2