



IEC 61508 Functional Safety Assessment

Project:

Series MTD, GTD, FSD, and TOD Valves

Customer:

Korea Unicom Valve Co., Ltd.
Incheon,
Korea

Contract No.: Q13/03-082

Report No.: UNI 10/01-13 R001

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Management summary

This report summarizes the results of the functional safety assessment according to IEC 61508 carried out on the:

Korea Unicom Series MTD, GTD, FSD, and TOD Valves

The functional safety assessment performed by exida consisted of the following activities:

- *exida* Certification assessed the development process used by Korea Unicom Valve by an on-site audit and creation of a detailed safety case against the requirements of IEC 61508.
- *exida* Certification performed a detailed Failure Modes, Effects, and Diagnostic Analysis (FMEDA) of the devices to document the hardware architecture and failure behavior.
- *exida* Certification reviewed the manufacturing quality system in use at Korea Unicom Valve.

The functional safety assessment was performed to the requirements of IEC 61508, SIL 3 for mechanical components. A full IEC 61508 Safety Case was prepared, using the *exida* SafetyCaseDB™ tool, and used as the primary audit tool. Hardware process requirements and all associated documentation were reviewed. Environmental test reports were reviewed. Also the user documentation (Safety Manual and Installation Operation and Maintenance Manual) were reviewed.

The results of the Functional Safety Assessment can be summarized as:

The Korea Unicom Valve Series MTD, GTD, and FSD Valves in sizes ranging from 2 to 60 inches and the Series TOD Valves in sizes 3 to 60 inches were found to meet the requirements of IEC 61508 for up to SIL 3 (SIL 3 Capable); Type A, Route 2_H Device.

The manufacturer will be entitled to use the Functional Safety Logo.





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1 Purpose and Scope

This document shall describe the results of the IEC 61508 functional safety assessment of the Series MTD, GTD, FSD, and TOD Valves by *exida* according to the requirements of IEC 61508: ed1, 2010.

The results of this provides the safety instrumentation engineer with the required failure data as per IEC 61508 / IEC 61511 and confidence that sufficient attention has been given to systematic failures during the development process of the device.



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 a comprehensive failure rate and failure mode database on process equipment.

2.2 Roles of the parties involved

Korea Unicom Valve	Manufacturer of the Series MTD, GTD, FSD, and TOD Valves
<i>exida</i> Consulting	Performed the hardware assessment according to Option 1 (see section 1)
<i>exida</i> Certification	Performed the IEC 61508 Functional Safety Assessment according to Option 3 (see section 1)

Korea Unicom Valve contracted *exida* in January 2010 with the IEC 61508 Functional Safety Assessment of the above mentioned devices.

2.3 Standards / Literature used

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

[N1]	IEC 61508 (Parts 1 - 7): 2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
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2.4 Reference documents

2.4.1 Documentation provided by Korea Unicom Valve

[D1]	Catalogue (GTD-MTD-FSD-TOD).pdf	Product Catalogue for Unicom Butterfly Valve Line Up
[D2]	UH-102, Rev 0 May 2002	High-Seal Valves Designation of Parts GTD/MTD/FSD
[D3]	UH-01-001, Rev 0 May 2002	High-Seal Valves Type GTD/MTD/FSD
[D4]	UH-FSD-001, Rev 0 May 2006	High-Seal Valves Parts List Type FSD and MTD
[D5]	U1002-Q05-001 to 012, Rev 0, 2010/02/11	Valve Assembly Drawings for Min and Max sizes of GTD, MTD, and FSD valves
[D6]	U0803-P02-003 (Rev 1) 09.01.15	18in Valve Assembly Drawing
[D7]	WTOD-501, Rev 0, 2009/02/12	Designation of parts Triple Offset Valves

[D8]	U1002-P04-001, Rev 0, 2010/02/11	Triple Offset Butterfly Valves Assembly Drawing
[D9]	U1002-P04-003, Rev 0, 2010/02/11	Triple Offset Butterfly Valves – ASME Class 150 3-60 inch
[D10]	U1002-P04-004, Rev 0, 2010/02/11	Triple Offset Butterfly Valves – ASME Class 900 4-24 inch
[D11]	Register No. 0153 BV Certificate BV Certificate 271446-1 LCIE 04 AR 037 FTC 040219 CE-PED-H-KUV 001-08-KOR GF 1.1(K) TA 05 0001	Certification (examples) ISO 9001:2008 (API) ISO 9001:2008 / KS Q 9001:2009 ISO 14001:2004 / KS Q ISO 14001:2004 ATEX (BV) Fire Safety (Velosi) CE (BV) Packing System (TUV Rheinland)
[D12]	P-12866 13699/A1 BV SE524503-X	Type Approval (examples) D.N.V B.V. A.B.S.
[D13]	MQM Rev varies by section, most recent 2010/06/17	Quality Management System Manual– Sections 1 to 6
[D14]	UQM-J-1000, 2009/04/30	Regulation of the design activity
[D15]	UQM-J-1100, 2009/04/30	Regulation of the development new product
[D16]	UQM-J-1200, 2009/04/30	Regulation of the design verification activity
[D17]	UQM-J-1300, 2010/06/18	Regulation of the changing design
[D18]	UQM-J-2000, 2009/07/13	Regulation of the transferring design
[D19]	UQM-J-2100, 2009/07/13	Regulation of the drawing control
[D20]	PTDP-2A-02	Design & Development Plan (example)
[D21]	EB-9A-02, 2009/06/16	Design & Development Plan (example)
[D22]	PTDI-2A-01	Design Input Data Sheet (example)
[D23]	File name in Korean ¹	Customer Requirement Specification (example)
[D24]	Design Sheet.pdf, 2009/03/20	Calculation Sheets (example for HP Class 300-10”)
[D25]	File name in Korean ¹	Alternative Calculation Sheets (example)
[D26]	File name in Korean ¹	Design Checklist (example)
[D27]	File name in Korean ¹	Design Review Meeting Minutes (example)
[D28]	File name in Korean ¹	Data Sheets (example)

¹ Many of the documents sighted were written in Korean with no equivalent English translation. The contents of these documents were verbally translated during the audit by Dr. Woojune Yi, CEO of KoRTS, acting as independent translator subcontracted by *exida* Asia Pacific. This provided an adequate method of tracing and tracking activities and information.

[D29]	File name in Korean ¹	Design Drawings (examples)
[D30]	File name in Korean ¹	Documents stamped and signed by customer (examples)
[D31]	Life Cycle Test.pdf, 2010/04/23	Valve Life Cycle Test Report
[D32]	Cryogenic Test Report.pdf, 2010/03/25	TOD Valve Cryogenic Test Report
[D33]	DCR-UP10-0113, 2010/01/05	Requirement Report for a Design Change - Example
[D34]	UQM-B-7200, 2004/08/16	Material Acceptance Test Procedure
[D35]	UQM-K-1000, Rev 7, 2010/06/17	Regulation of the Purchasing Procedure ¹
[D36]	UQM-L-1000, Rev 0, 2009/04/15	Regulation of the product control
[D37]	UNI-B-5100, Rev A	Inspection and Test Plan - Form A4002-1(A)
[D38]	UNI-B-5100-Sample, Rev 0, 2010/04/19	ITP Example for projet STC BTX
[D39]	File name in Korean ¹	Test Results – Dimension Check (example)
[D40]	File name in Korean ¹	Test Results – Hydro Pressure (example)
[D41]	File name in Korean ¹	Test Results – Radiographic (example)
[D42]	Test Certificate-Sample, 2010/03/26	Final Inspection Report (example)
[D43]	IOM(High-Seal).pdf	Installation, Operation and Maintenance Manual GTD/MTD/FSD
[D44]	IOM(High-Seal).pdf, December 2006	Installation, Operation and Maintenance – TOD Manual
[D45]	Functional Safety Manuals R4.docx, V2R4, 2010/06/22	Safety Manual for Series MTD, GTD, FSD and TOD Valves
[D46]	File name in Korean ¹	Audit Plan (internal) – including QMS Design Process
[D47]	UQE-B-2000	Corrective Action Procedure
[D48]	H3000-1-Sample, 2009/10/20	Completed Customer Service Sheet and Corrective Action report ¹
[D49]	2009 Order List.xls	Unicom Shipment Data for 2009
[D50]	Form KCR-2023-1 - Calibration Certificate.pdf, 2010/01/26	Sample Calibration Certificate/Report
[D51]	Management Review - Customer Complaints.pdf	Management Review Meeting - Sample Meeting Minutes
[D52]	File name in Korean ¹	Audit Results (internal) – including QMS Design Process
[D53]	File name in Korean ¹	Audit Plan (external) – ISO 9001



[D54]	File name in Korean ¹	Audit Results (external) – ISO 9001
[D55]	Form B5600- ¹ , 2009/12/21	Formal training requirements checklist (example)
[D56]	Form F5100-2, 2008/07/23	Individual Training Record extract (example)
[D57]	UNI-9000 (Rev 2)	TOD Butterfly Valve product brochure

2.4.2 Documentation generated by *exida*

[R1]	Q13-03-082_UNI 06-06-21 R001 V4 R1 FMEDA MTD FSD.doc, 6/19/2013	FMEDA report, Unicom High-Seal Series FSD and MTD Valves
[R2]	Q13-03-082_UNI 06-06-21 R002 V3 R1 FMEDA GTD.doc, 6/19/2013	FMEDA report, Unicom High-Seal series GTD valves
[R3]	Q13-03-082_UNI_09-01-15_R001_V2R1_TOD_FMEDA.doc, 6/19/2013	FMEDA report, Unicom TOD Butterfly Valve
[R4]	IEC 61508 Audit Checklist Unicom Valves.docx, 05/25/2010	IEC 61508 Site Audit and Gap Analysis report (internal document)
[R5]	Unicom Valve SafetyCaseDB IEC 61508.esc, June 2010	IEC 61508 SafetyCaseDB for Series MTD, GTD, FSD, and TOD Valves
[R6]	Q13-03-082 UNI R001 V1 R2 Assesment.doc, 6/25/2013	IEC 61508 Functional Safety Assessment, Series MTD, GTD, FSD, and TOD Valves (this report)



3 Product Description

3.1 Korea Unicom Valve Series MTD, GTD, FSD, and TOD Valves

Korea Unicom Valve specializes in the manufacture of butterfly valves. This report covers four series of butterfly valves manufactured by Unicom: MTD, GTD, FSD and TOD. Brief details of each series are given below. The MTD, GTD, and FSD valves are available in nominal sizes from 2" to 72" in three different pressure classes 150, 300 and 600. The TOD series of valves are available in sizes from 3" to 48" however the FMEDA and certification only covers the 4 to 18 inch sizes, class 300. All of these series of valves are classified as Type A² devices according to IEC 61508, having a hardware fault tolerance of 0.

3.1.1 MTD

The MTD has precious metal seats and is applicable to high temperature as well as nominal pressure and temperature. The eccentric sealing system assures a low operating torque and positive sealing. A wide selection of valve materials ensures efficient performance in various industries. Sizes covered in this assessment and FMEDA are 2-60 inch for ANSI pressure Class 150, 3-24 inch for Class 300, and 3-28 inch for Class 600.

3.1.2 GTD

The GTD valve is designed for critical requirements and has proven its reliability and efficiency in a wide range of application for more than 15 years. The mechanism, which uses an eccentric structure, minimizes on-off torque at high pressure. This mechanism also provides tight shut-off. Carbon steel and stainless steel are standard materials for body and trim. This valve uses a teflon seat. Other special materials or particular treatment on trim and body are available as per the application and service. Sizes covered in this assessment and FMEDA are 2-60 inch for ANSI pressure Class 150, 3-24 inch for Class 300, and 3-28 inch for Class 600.

3.1.3 FSD

Having a combined function of GTD and MTD, the FSD gives a tight shut-off at nominal pressure and temperature rating. The FSD sealing system consists of reinforced teflon in combination with a metal seat. Although the FSD has a double seat structure, it requires relatively low operating torque. The FSD valve works with the metal seat when the teflon seat has been burned out. The FSD butterfly valve provides more reliability in applications with steam and hot air line. Sizes covered in this assessment and FMEDA are 2-60 inch for ANSI pressure Class 150, 3-24 inch for Class 300, and 3-28 inch for Class 600.

3.1.4 TOD

The TOD valve is a high performance butterfly valve that utilizes a Triple Offset Design. This design features a sealing mechanism that consists of contacts of an inclined and conical disc with a laminated seat. In result, the friction and abrasion between sealing elements (disk and seat) are minimized. The most unique feature of this design is that it can provide low torque, broad sealing width and bi-directional tight shut-off. Sizes covered in this assessment and FMEDA are 3 inch to 60 inch for ANSI pressure Class 150 and 4 inch to 24 inch for Class 900.

² Type A element: "Non-Complex" element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2, ed2, 2010

4 IEC 61508 Functional Safety Assessment

The IEC 61508 Functional Safety Assessment was performed based on the information received from Korea Unicom Valve and is documented in the SafetyCase [R5].

4.1 Methodology

The full functional safety assessment includes an assessment of all fault avoidance and fault control measures during hardware development and demonstrates full compliance with IEC 61508 to the end-user. The assessment considers all requirements of IEC 61508. Any requirements that have been deemed not applicable have been marked as such in the SafetyCase report, e.g. software development requirements for a product with no software. The assessment also includes a review of existing manufacturing quality procedures to ensure compliance to the quality requirements of IEC 61508.

As part of the IEC 61508 functional safety assessment the following aspects have been reviewed:

- Development process, including:
 - Functional Safety Management, including training and competence recording, FSM planning, and configuration management
 - Specification process, techniques and documentation
 - Design process, techniques and documentation, including tools used
 - Validation activities, including development test procedures, test plans and reports, production test procedures and documentation
 - Verification activities and documentation
 - Modification process and documentation
 - Installation, operation, and maintenance requirements, including user documentation
- Product design
 - Hardware architecture and failure behavior, documented in a FMEDA

The review of the development procedures is described in section 5.2. The review of the product design is described in section 5.3.

4.2 Assessment level

The Series MTD, GTD, FSD, and TOD Valves have been assessed per IEC 61508 to the following levels:

- SIL 3 capability

The development procedures will be assessed as suitable for use in applications with a maximum Safety Integrity Level of 3 (SIL 3) according to IEC 61508.



5 Results of the IEC 61508 Functional Safety Assessment

exida assessed the development process used by Korea Unicom Valve for these products against the objectives of IEC 61508 parts 1 and 2. The assessment was done on on-site at the Incheon, Korea facility on May 6-7 2010 and documented in the SafetyCase [R5].

5.1 Lifecycle Activities and Fault Avoidance Measures

Korea Unicom Valve has a defined product lifecycle process in place. This is documented in their Quality Management System Manual Section 5.3 [D13]. The manual includes a flowchart that details the process of Design and Development, and clearly shows the linkage between activities in the process. Every customer job goes through the complete design process. A documented modification process is also covered in the Quality Manual. No software is part of the design and therefore any requirements specific from IEC 61508 to software and software development do not apply.

This functional safety assessment has shown that the process sufficiently meets the requirements of IEC 61508, SIL 3. The assessment investigated the compliance with IEC 61508 of the processes, procedures and techniques as implemented for the Korea Unicom Valve MTD, GTD, FSD, and TOD development. The investigation was executed using subsets of the IEC 61508 requirements tailored to the SIL 3 work scope of the development team. The result of the assessment can be summarized by the following observations:

The audited Korea Unicom Valve design and development process complies with the relevant managerial requirements of IEC 61508 SIL 3.

5.1.1 Functional Safety Management

The valves manufactured by Korea Unicom Valve are not built for inventory. These valves are built-to-order. The basic designs are standardized, but each order can have trim and materials variations or specific customer requested proof tests. Due to the specialized nature of each valve, documentation that defines all of the requirements is generated for every order as part of the process.

FSM Planning

Korea Unicom Valve has a gated process in place for product development with specific deliverables, reviews and approvals at each gate. This is documented in their Quality Management System Manual Section 5.3 [D13]. The same process also addresses the development of modifications to existing products. This process and procedures referenced herein fulfill the requirements of IEC 61508 with respect to functional safety management.

Version Control

All documents as called out for in UQM-J-2100 [D19] are under version control. The Design drawings and documents are included in this section and are under version control. Use of this to control revisions was evident during the audit.

Training, Competency recording

Personnel training records are kept per standard quality procedures. Formal training requirements are tracked via a checklist [D55]. Additional completed required training is documented with a training certificate. A sample certificate was provided and reviewed [D56]. Korea Unicom Valve hired *exida* Consulting to be the independent assessor per IEC 61508 and to provide specific IEC 61508 knowledge.



5.1.2 Safety Requirements Specification and Architecture Design

For Korea Unicom Valve Butterfly Valves, the simple primary functionality of the valve is the same as the safety functionality of the product (Valve changes position, Close / Open). Therefore no special Safety Requirements Specification was needed. The normal functional requirements were sufficient. As the Butterfly Valve designs are simple and are based upon standard designs with extensive field history, no semi-formal methods are needed. General design and testing methodology is documented and required as part of the design process.

The first step for any new development is the creation of a Design Input Data Sheet [D22] from the Customer Requirements. Once this has been reviewed and the project accepted, engineering will develop the project and create the Design and Development Plan [D20]. This captures in detail all the requirements for the devices, such as critical functions, performance targets etc. *exida* reviewed the content of the specification for completeness per the requirements of IEC 61508. This meets SIL 3.

5.1.3 Hardware Design

The hardware design process consists of two distinct phases: concept verification, and design and development. During the concept verification, solutions to the customer requirements are reviewed by all relevant departments and the review is documented. Design and Alternative Design Calculation Sheets are completed. In the design and development phase, the design is further detailed. Per MQM Section 5.3 [D13], a design review is conducted and documented. During this phase the Test and Inspection Plan is developed (equal to validation plan per IEC 61508). Korea Unicom Valve has standards for documentation with specified output documents.

Korea Unicom Valve uses AutoCad and Solid Edge (3D modeling) as design tools. Old versions of these tools are kept. Previous drawings are not updated unless they are the basis for a new design.

Items from **IEC 61508-2, Table B.2** include observance of guidelines and standards, project management, documentation (design outputs are documented per MQM Section 5.3 [D13] and other quality guidelines), structured design, modularization, use of well-tried components / materials, and computer-aided design tools. This meets SIL 3.

5.1.4 Validation

Validation Testing is done via a documented plan, the Test and Inspection Plan [D37], written per the MQM Section 5.3 [D13] after the design validation confirmation meeting. The Test and Inspection Plan includes both standard product tests and any specific customer requirements. As the MTD, GTD, FSD, and TOD Valves are purely mechanical devices with a simple safety function, there is no separate integration testing necessary. However, the valves do undergo several separate tests before the valves are integrated with other vendor's valve actuators. The MTD, GTD, FSD, and TOD Valves perform only 1 safety function, which is extensively tested under various conditions during the validation testing.

Procedures are in place for corrective actions to be taken when tests fail. Test results are documented in the Final Inspection Report [D42] and reviewed.

Items from **IEC 61508-2, Table B.3** include functional testing, project management, documentation, and black-box testing (for the considered devices this is similar to functional testing). Field experience and statistical testing via regression testing are not applicable. This meets SIL 3.



Items from IEC **61508-2, Table B.5** included functional testing and functional testing under environmental conditions, project management, documentation, failure analysis (analysis on products that failed), expanded functional testing, black-box testing, and fault insertion testing (results included in the Final Inspection Report). This meets SIL 3.

5.1.5 Verification

The development and verification activities are defined in their Design and Development of New Product Procedure, MQM Section 5.3. For each phase the objectives are stated, required input and output documents and review activities. Review meetings are held per the Design and Development procedure and the results are documented in the meetings minutes. Per MQM Section 5.3, the following verification steps are defined: product idea review, concept definition review, feasibility review, design and development review, pilot run review, and introduction review. All verification activities are documented. This meets SIL 3.

5.1.6 Modifications

Modifications are done per their Quality Management System MQM-5 Section 5.7 [D13]. The process requires the changes to be identified and recorded; with changes reviewed and analyzed for impact, verified, validated and approved before implementation.

The review includes the potential impact on other components, and the impact on manufacturing and production.

Previously supplied products must be considered.

Customer approval required for internal changes.

The design and development changed must be performed by the designer who was the originator.

Design outputs must be distributed again if affected by the changes.

Records of the results of the review of changes must be maintained.

This meets SIL 3.

5.1.7 User documentation

Korea Unicom Valve creates the following user documentation: Installation/Operation/Maintenance Manuals [D43] and [D44] and product catalogs [D1] and [D57]. Additionally, Korea Unicom publishes a Safety Manual for the MTD, GTD, FSD, and TOD Series of valves [D45]. This Safety Manual was authored by *exida* and is distributed by Korea Unicom Valve. The released version of this manual is considered to be in compliance with the requirements of IEC 61508. The document includes all required operations, maintenance, and proof test procedures.

Items from IEC **61508-2, Table B.4** include operation and maintenance instructions, user friendliness, maintenance friendliness, project management, documentation, limited operation possibilities, and operation only by skilled operators (operators familiar with type of valve, although this is partly the responsibility of the end-user). This meets SIL 3.

5.2 Hardware Assessment

To evaluate the hardware design of the Series MTD, GTD, FSD and TOD Valves a Failure Modes, Effects, and Diagnostic Analysis was performed by *exida*. This is documented in [R1] for the FSD and MTD valve lines, [R2] for the GTD valve line, and [R3] for the TOD valve line.



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. An FMEDA (Failure Mode Effect and Diagnostic Analysis) is an FMEA extension. It combines standard FMEA techniques with extension to identify online diagnostics techniques and the failure modes relevant to safety instrumented system design.

The failure rate data used for this analysis meets the exida criteria for Route 2_H.

From the FMEDA failure rates are derived for each important failure category. The following tables summarize these failure rates according to IEC 61508. The FMEDA reports [R1] to [R3] can be consulted for all additional details as well as all assumptions. The failure rates listed are valid for the useful life of the devices. Based on Korea Unicom Valve endurance test data and general field failure data a useful life period of approximately 10 years is expected for the Series MTD, GTD, FSD, and TOD Valves as listed in the FMEDA reports.

Table 1 Failure rates in FITs for Unicom High-Seal series FSD and MTD valves according to IEC 61508

Application	λ_{SD}	λ_{SU}^3	λ_{DD}	λ_{DU}
Full Stroke, Clean Service	0	648	0	646
Tight Shut-Off, Clean Service	0	0	0	1337
Open on Trip, Clean Service	0	779	0	502
Full Stroke with PVST, Clean Service	0	648	178	468
Tight Shut-Off with PVST, Clean Service	0	0	178	1159
Open on Trip with PVST, Clean Service	121	658	178	324

Table 2 Failure rates in FIT for Unicom High-Seal series GTD valves according to IEC 61508

Application	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
Full Stroke, Clean Service	0	960	0	724
Tight Shut-Off, Clean Service	0	0	0	1727
Open on Trip, Clean Service	0	1169	0	502
Full Stroke with PVST, Clean Service	0	960	178	546
Tight Shut-Off with PVST, Clean Service	0	0	178	1549

³ 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



Open on Trip with PVST, Clean Service	199	970	178	324
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Table 3 Failure rates in FIT for TOD Butterfly Valves according to IEC 61508

Application	λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}
Full Stroke, Clean Service	0	662	0	622
Tight Shut-Off, Clean Service	0	0	0	1283
Open on Trip, Clean Service	0	784	0	500
Full Stroke with PVST, Clean Service	0	662	178	443
Tight Shut-Off with PVST, Clean Service	0	0	178	1105
Open on Trip with PVST, Clean Service	121	663	178	321

Note, as the Series MTD, GTD, FSD, and TOD Valves are only one part of a (sub)system, the SFF should be calculated for the entire final element combination. These results must be considered in combination with PFD_{AVG} values of other devices of a Safety Instrumented Function (SIF) in order to determine suitability for a specific Safety Integrity Level (SIL). The architectural constraints requirements of IEC 61508-2, Table 2 also need to be evaluated for each final element application. It is the end users responsibility to confirm this for each particular application and to include all components of the final element in the calculations.

The analysis shows that the design of the Korea Unicom Valve MTD, GTD, FSD, and TOD Valves can meet the hardware requirements of IEC 61508 SIL 3, depending on the complete final element design. The Hardware Fault Tolerance, PFD_{AVG} , and Safe Failure Fraction requirements of IEC 61508 must be verified for each specific design



6 Terms and Definitions

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 (1×10^{-9} failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
HFT	Hardware Fault Tolerance
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.
PFD_{AVG}	Average Probability of Failure on Demand
PVST	Partial Valve Stroke Test It is assumed that the Partial Stroke Testing, when performed, is automatically performed at least an order of magnitude more frequent 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.
SFF	Safe Failure Fraction summarizes the fraction of failures, which lead to a safe state and the fraction of failures which will be detected by 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).
Type A component	“Non-Complex” component (using discrete elements); for details see 7.4.4.1.2 of IEC 61508-2
Type B component	“Complex” component (using micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2



7 Status of the document

7.1 Liability

exida prepares reports based on methods advocated in International standards. *exida* accepts no liability whatsoever for the use of this report or for the correctness of the standards on which the general calculation methods are based.

7.2 Releases

This report replaces the following reports; all versions / revisions of these are now obsolete:

UNI 06/06-21 R003

Version: V2

Revision: R1

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V1, R1: Released to Korea Unicom Valve; July 16, 2010

V0, R1: Draft; July 13, 2010

Authors: Gregory Sauk

Review: V2, R1: William Goble; June, 25, 2013

V0, R1: Steven Close; July, 16, 2010

Release status: Released

7.3 Future Enhancements

At request of client.

7.4 Release Signatures

A handwritten signature in black ink that reads "Gregory Sauk".

Gregory Sauk, CFSE Senior Safety Engineer

A handwritten signature in black ink that reads "William M. Goble".

Dr. William M. Goble, Principal Partner