LIST OF REVIEWS

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1. INTRODUCTION

1.1. Scope

This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 functional safety standards and information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) using Butterfly valves from Técnicas Transformaciones y Ventas S.A. (TTV hereafter).

1.2. Terms and Abbreviations

Describe basic terms of functional safety: what is functional safety, safety function, safe state, fail safe, fail dangerous, low demand mode, etc.

Typical abbreviations:

- **FMEDA:** Failure Modes, Effects and Diagnostic Analysis
- **HFT:** Hardware Fault Tolerance
- **PFDAVG:** Average Probability of Failure on Demand
- **SFF:** Safe Failure Fraction, the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault.
- **SIF:** Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop), Safety instrumented control/protection function.
- **SIL:** Safety Integrity Level, discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest.
- **SIS:** Safety Instrumented System — Implementation system of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).
- **DC:** Diagnostic Coverage Factor (if diagnostic measures exist)
- **PTC:** Proof Test Coverage Factor
- **PFH:** Probability of dangerous failure per hour
- **PFD:** Probability of dangerous failure per demand

1.3. Reference Documents

- TTV Product Data Sheet (Available on request to TTV).
- TTV Maintenance and installation instructions (Available on request to TTV).

1.4. Related Standards

- **IEC 61508** Parts 1-2 & 4-7 Functional safety of electrical/electronic/ programmable electronic safety-related systems
- **IEC 61511** Parts 1-3 Functional safety. Instrumented safety systems for the process industries sector.

2. PRODUCT DESCRIPTION

- The butterfly valves of this manual can be symmetric (concentric) or asymmetric (double- and triple-eccentric):

Concentric design:

The concentric valves are spherically machined, the disc is centered in the body and the shaft is centered in relation to the interior of disc. The knurled shaft or keyway generate the transmission of movement. The body of the standard concentric valves is covered by an elastomeric/PTFE liner that makes the closure of the valve and constitutes the gasket when installing the valves in the piping. The concentric valves are bi-directional and the torques are similar in both operations of opening & closing.

(Note: The high temperature metal concentric valves have only regulation purposes)

Eccentric design:

In the eccentric design, the disc is not centred in the body and the shaft is not centred in relation to the interior of disc. The keyway/pins generate the transmission of movement. In this kind of valves, the disc/seat ring makes the closure against the body of the valve. The eccentric valves have a preferential direction of closing.

- The opening and closing of the butterfly valves are achieved by 90º turn; counter-clockwise for opening and clockwise for closing. The valves can be equipped with a variety of operating mechanisms such as lever, handwheel, gearbox, electric actuator, hydraulic actuator or pneumatic actuator, with limit switches and controlled from a control panel. Any actuator mounted on a TTV valve has a position indicator for indicating if the valve is open or closed. This position indicator depends on the actuator type; it can be a digital or a mechanical indicator. Motorized valves are supplied by TTV with the actuators assembled and torque & position limits correctly adjusted; the instructions of the actuator's manufacturer must be followed. All valves are furnished with special purpose yokes designed for the motor operating unit to be used, following ISO 5211.

Moreover units can be supplied with all necessary contacts for local or remote indication. For hazardous locations, electric control units can also be furnished, on request, with flameproof or explosion proof enclosures, depending on specifications followed by the customer.

- TTV butterfly valves are fixed to the pipe through a system of bolted flanges. These flanges are standard and our drilling dimensions and tolerance are guaranteed on all valves.

- All valves are painted with polyamide 11-Rilsan blue RAL 5012 or EPOXY blue RAL 5024 as the standard of TTV. Other special coatings can be applied depending on the customer's needs.

Concentric Butterfly Valves Variants:

Design	Name	Types	Size	Pressure rating	Temp (Cº)
Butterfly Valve	Concentric soft seated	Wafer, Lug, Flanged, Double flanged, Grooved	DN32 to DN3000	PN6, PN10, PN16, PN25, PN40, class 150 lbs, class 300 lbs, API605	minus 50 ºC to +230 ºC Depending of the elastomer
Butterfly Valve	Concentric PTFE	Wafer, Lug	DN32 to DN600	PN6, PN10, PN16, PN25,PN40, class 150 lbs, class 300 lbs, API605	minus25 ºC to 200 ºC
Butterfly Valve	High temperature metal concentric	Wafer, Lug, Flanged	DN32 to DN2000	PN6, PN10, PN16, PN25,PN40, class 150 lbs, class 300 lbs, API605	minus190 ºC to 850 ºC

Eccentric Butterfly Valves Variants:

Design	Name	Types	Size	Pressure rating	Temp (Cº)
Butterfly Valve	Colossus: Metal/PTFE Double and triple eccentric high performance design.	Wafer, Lug, Flanged	DN32 to DN1600	PN6, PN10, PN16, PN25,PN40, class 150 lbs, class 300 lbs	Soft seat: R-PTFE: minus 50 ºC to +230 ºC Depending of the elastomer Hard seat: Meta l-Metal: minus 100ºC to +360ºC Special design for 500ºC
Butterfly Valve	Double eccentric , soft seat	Double flanged	DN32 to DN1600	PN6, PN10, PN16, PN25,PN40, class 150 lbs, class 300 lbs	minus 50 ºC to +230 ºC Depending of the elastomer

3. FUNCTIONAL SAFETY RELEVANT SPECIFICATIONS

3.1. Safety Function

The TTV Valves are typically used in ON/OFF services, so **the safety function of a valve is to close or to open the fluid pass** through it. In an emergency situation the valve must be able to close without leakage as fast as the equipment that operates the valve can do it.

3.2. Environmental Limits

- Temperatures below or above the limits of use for the butterfly valves may generate the loss of the safety function.

- Using the butterfly valves above the pressure limits may cause the loose of the safety function.

- Flame: most of the valves are Fire Safe certified that means that the continuous contact with flame or a fire will block the valve in the closed position assuring a controlled leakage.

3.3. Application Limits

The materials of construction of TTV butterfly valves are specified in the TTV datasheets and in the main literature. It is especially important that the designer of the SIF checks for the material compatibility considering on-site chemical contaminants and fluid conditions. If the TTV Valves are used outside the application limits or with incompatible materials or environment, the reliability data and predicted SIL capability becomes invalid.

3.4. Design Verification

A detailed Failure Modes, Effects and Diagnostics Analysis (FMEDA) report is available from TTV Valves for this product. This report details all failure rates and failure modes as well as expected lifetime of the product. The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer via calculation of PFD_{AVG} considering the architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and the specific failures rates of all equipment included in the SIF. Each subsystem must be checked to assure compliance with minimum Hardware Fault Tolerance (HFT) requirements.

The failure rate data listed in the FMEDA report is only valid for the useful lifetime of the TTV Valves. The failure rates will increase after this useful lifetime period has expired.

3.5. SIL Capability

The valves meet the requirements of IEC 61508:2010 and are suitable for use in a safety instrumented system up to SIL 2 (low demand mode).

Under consideration of the minimum required hardware fault tolerance HFT = 1 the valves may be used in a redundant structure up to SIL 3.

Product tested: **Butterfly Valves Concentric: Concentric soft seated, Concentric PTFE, High temperature metal concentric.**

Butterfly Valves Eccentric: Colossus, Double eccentric.

Results of Assessment

Route of Assessment		2_H / 1_S	
Type of Sub-system		Type A	
Mode of Operation		Low Demand Mode	
Hardware Fault Tolerance	HFT	0	
Lambda Dangerous confidence level of calculation 1-α = 95 %	λ_D	2,69 E-07 / h	269 FIT
Lambda Dangerous Undetected assumed Diagnostic Coverage DC = 0 %	λ_{DU}	2,69 E-07 / h	269 FIT
Mean Time To Dangerous Failure	$MTTF_D$	3,72 E+06 h	424 a
Average Probability of Failure on Demand 1oo1 assumed Proof Test Interval T_1 = 1 year	**$PFD_{avg}(T_1)$**	**1,18 E-03**	
Average Probability of Failure on Demand 1oo2 assumed Proof Test Interval T_1 = 1 year assumed β_{1oo2} = 10 %	**$PFD_{avg}(T_1)$**	**1,19 E-04**	

3.6. General Requirements

The TTV Valves will be moved to its defined safe state (closed or opened) in relation to the specific hazard scenario. All SIS components must be operational before process start-up. The user shall verify that the TTV Valves are suitable for use in safety applications by confirming the TTV Valves nameplate and model number is properly marked. Personnel performing maintenance and testing on the TTV Valves shall first be assessed as being competent to do so. Result from periodic proof tests shall be recorded and periodically reviewed. The TTV Valves shall not be operated beyond the useful lifetime.

Maintenance:

A complete maintenance and overhauling should be performed with a frequency that will depend on the working conditions of the valve. Within this procedure, aged and worn components should be changed. The procedure to carry out the maintenance is described in the TTV Maintenance and installation instructions.

4. INSTALLATION AND COMMISSIONING

4.1. Safety installation and storage

- The handling of valves, both whilst they are still inside the packaging and when they have been removed from it, is to be undertaken in accordance with the Assembly & Maintenance Manual.
- Check the packaging is fully secure in the event that it is to be moved.
- Always use endorsed chains and mooring straps of sufficient strength for moving the valve or the crates. Make sure they are in good condition.
- Hold the boxes by the marked mooring points.
- Never pass a valve or a crate through the air over a person.
- Storing valves must be carried out according the Assembly & Maintenance Manual.
- When opening the crates, be careful with packing nails. Never leave the point of a nail sticking out, remove the nail completely from the crate if necessary. Do not handle crates with bare hands, there could be splinters.
- When the valve is installed at a height above the ground, follow local safety regulations on working at heights.
- When the valve is welded on to the line, use suitable protection and safety equipment.