Volume Booster

YT-300 / 305 / 310 / 315 / 320 / 325 Series

SIL Safety Instruction.

Supplement to product manual

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Rotork YTC Limited

Ver 1.03

Table of contents

1 Introduction

1.1 Purpose of this document

This document contains information and safety instructions that the user will require when using the volume booster in safety-related systems.

This document is for system planners, constructors, service & maintenance engineers and personnel who will perform commissioning the device.

1.2 Field of Application

The application includes control valve with volume boosters boosting air flow up to SIL3 level in accordance with the safety engineering requirements of IEC61508.
Volume boosters are suitable for SIL2 at HFT=0 and for SIL3 at HFT=1

In the event of a pneumatic power failure, the air supply to signal port and supply port will be exhaust, and the pressurized air in actuator chamber will be exhausted to atmosphere through exhaust hole of volume booster due to the movement of actuator's return spring. As a result, the position of stroke will be moved to the predefined safe end position (either OPEN or CLOSED).

1.3 Required documentation

This document only defines YT-300/305/310/315/320/325 volume booster's safety functions.
This document only applies in conjunction with YT-300/305/310/315/320/325 Product Manual.

1.4 Further information

The contents of these instructions shall not become part of or modify any prior existing agreement, commitment or legal matter.

Any statements contained herein do not create new warranties or modify the existing warranty.

The content reflects the technical status at the time of printing.

YTC reserves the right to make technical changes in the course of further development.

2 Acronyms and abbreviations

Acronym	Full term in English	Description
HFT	Hardware Fault Tolerance	Hardware fault tolerance: Ability of a function unit (Hardware) to continue executing a required function in the presence of faults or deviations.
MTBF	Mean Time Between Failures	Average period between two failures
MTTR	Mean Time To Repair	Average period between the occurrence of a fault in a device or system and the repair
PFD	Probability of Failure on Demand	Probability of dangerous failures of a safety function on demand
PFDavg	Average Probability of Failure on Demand	Average probability of dangerous failures of a safety function on demand
SIL	Safety Integrity Level	The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL 1 to SIL 4). Each level corresponds to a range of probability for failure of a safety function. The higher the Safety Integrity Level of the safety-related system, the lower the probability that it will not execute the required safety functions.
SFF	Safe Failure Fraction	Proportion of safe failures: Proportion of failure without the potential to bring the safety-related system into a dangerous or non-permissible functional status.
FIT	Failure in Time	Frequency of failure Number of faults within 10^9 hours
TI	Test Interval	Testing interval of the protective function
λsd	Failure rate for all safe detected failures	Overall rate for all safe detected failures.
λsu	Failure rate for all safe undetected failures	Overall rate for all unsafe detected failures.
λdd	Failure rate for all dangerous detected failures	Overall rate for all dangerous detected failures
λdu	*Failure rate for all dangerous undetected failures*	*Overall rate for all dangerous undetected failures*

3 Relevant standards

Standard	English	German
IEC 61508, Part 1 to 7	Functional safety of electrical / electronic / programmable electronic safety-related systems (Target group: Manufacturers and Suppliers of Devices).	

4 Terms and definitions

Terms	Explanation
Dangerous failure	A failure that has the potential to place the safety-related system in a dangerous state or render the system inoperative.
Safety-related system	A safety-related system performs the safety functions that are required to achieve or maintain a safe condition, e.g., in a plant. Example: pressure meter, logics unit (e.g., limit signal generator) and valve form a safety-related system.
Safety function	A specified function that is performed by a safety-related system with the goal, under consideration of a defined hazardous incident, of achieving or maintaining a safe condition for the plant. Example: limit pressure monitoring

5 Defining the Safety Integrity Level (SIL)

The achievable Safety Integrity Level is defined by the following safety-related parameters:

- Average probability of hazardous failures for a safety function on demand (PFDavg)
- Hardware Fault Tolerance (HFT)
- Fraction of failures that do not have the potential to put the safety-related system in a hazardous or fail-to-function state (SFF)

The specific safety-related parameters for YT-300/305/310/315/320/325 volume boosters as part of a safety function are listed in the section "Safety-related parameters".

The following table shows the dependence of the safety Integrity Level (SIL) on the Average Probability of Failure on Demand (PFDavg).

The table applies the "low demand mode", i.e. the safety-related system is check at most once a year

Safety Integrity Level (SIL)	PFDavg (low demand mode)
4	$\geq 10^{-5}$ ... $< 10^{-4}$
3	$\geq 10^{-4}$ ... $< 10^{-3}$
2	$\geq 10^{-3}$ ... $< 10^{-2}$
1	$\geq 10^{-2}$ ... $< 10^{-1}$

6 Safety-related system

Sensor, logics unit and actuator (positioner, volume booter, pneumatic actuator and valve) form a safety-related system that performs a safety function.

The Average Probability of Failure on Demand (PFDavg) is usually divided between the sensor, logics unit and actuator sub-system.

Typical division of the Average Probability of Failure on Demand (PFDavg) into sub-system

Sensor (e.g., pressure meter)	Logics unit (e.g., PLC)	Actuator (e.g., valve)
$\leq 35\%$	$\leq 15\%$	$\leq 50\%$

Functional description

If the pneumatic power which is being supplied to the positioner and the volume booster is blocked, following safety function will be activated.

The pressurized air in actuator chamber will be exhausted to atmosphere through exhaust hole of volume booster due to the movement of actuator's return spring. As a result, the position of stroke will be moved to the predefined safe end position (either OPEN or CLOSED).

7 Information for the safety function

Important

Safety-related systems without a self-locking function must be monitored or set to an otherwise safe condition after performing the safety function within MTTR (8 hours).

The device lifecycle must be evaluated according to the specified MTBF.

8 Periodic checks

Safety checks

The Safety function for the entire safety loop must be checked regularly in accordance with IEC 61508.

The test intervals are determined when calculating the individual safety loops of a plant(PFDavg's).

On the YT-300/305/310/315/320/325 volume booster, the following specific checks should be carried out:

Connect the set value of 0 MPa.

- Check whether the valve moves to the appropriate safety position – "tight closing".

Functional checks

We recommend that the functioning of the volume booster is checked at regular intervals of one year.

Check at least the following:

1. Connect the set value of 0 MPa.
   - Check whether the valve moves to the appropriate end position.
   - Check the locally displayed internal, digitized values for the setpoint and position.
2. Connect the set value of the appropriate pneumatic pressure.
   - Check whether the valve moves to the appropriate end position.
   - Check the locally displayed internal, digitized values for the setpoint and position.

Repairs

When you send a defective device to the repair department, include information describing the error and, if possible, the cause.

Important

When ordering replacement devices always provide the lot number of the original device (on the name plate)

9 Safety engineering parameters

9.1 Prerequisites

- The compressed air supply is free of oil, water and dust in accordance with DIN/ ISO 8573-1.
- The repair period (MTTR) following a device fault is 8 hours.
- The mean temperature over a longer period of time is 40 ℃
- The volume booster is used only in applications with low request rates (low demand mode).

9.2 Specific safety-related parameters

Important

The PFDav values provided in the table are valid for YT-300/305/310/315/320/325 volume boosters.

Type	Category	SFF	PFD_{SPEC}		Λdu[1/h]	PFDavg[1]
YT-300/305/310/315/320/325	SIL3	75%	$5.035 * 10^{-6}$	Single Channel (HFT = 0)	$5.74 * 10^{-9}$	$2.52 * 10^{-5}$

10 Glossary

Dangerous failure

Failure with the potential to bring the safety-related system into a dangerous or non-functional status.

Safety function

Defined function executed by a safety-related system with the objective of achieving or maintaining a safe system status taking into account a defined dangerous occurrence.

Example:

Limit pressure monitoring

Safety Integrity Level

Safety-related system

A safety-related system executes the safety functions that are required to achieve or maintain a safe status in a system.

It consists of a sensor, logic unit/control system and final controlling element.

Example:

A safety-related system is made up of a pressure transmitter, a limit signal sensor and a control valve.

SIL

The international standard IEC 61508 defines four discrete Safety Integrity Level (SIL) from SIL 1 to SIL 4. Each level corresponds to the probability range for the failure of a safety function. The higher the SIL of the safety-related system, the higher probability that the required safety function will work.

11. Certificate

Certificate

No.: 968/V 356.06/19

Product tested	Volume Booster	**Certificate holder**	Rotork YTC Limited 81, Hwanggeum-ro 89 beon-gil Gimpo-si Gyeonggi-do, 10048 South Korea
Type designation	YT-300, YT-305, YT-310, YT-315, YT-320, YT-325		
Codes and standards	IEC 61508 Parts 1-2 and 4-7:2010 IEC 61511 Parts 1-3:2004		
Intended application	The volume boosters are suitable for use in a safety instrumented system up to SIL 2. Under consideration of the minimum required hardware fault tolerance the devices may be used in a redundant architecture (HFT=1) up to SIL 3.		
Specific requirements	The instructions of the associated Installation, Operating and Safety Manual have to be considered.		

Summary of test results see back side of this certificate.

Valid until 2021-02-22

The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/V 356.06/19 dated 2019-02-18.
This certificate is valid only for products which are identical with the product tested.

Köln, 2019-02-18

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Manufacturer	**Rotork YTC Limited** **81, Hwanggeum-ro 89 beon-gil,** **Yangchon-eup, Gimpo-si, Gyeonggi-do, 10048** **South Korea**
Product tested	**Volume Booster** **YT-300, YT-305, YT-310, YT-315, YT-320, YT-325**

Device-Specific Values

Probability of Dangerous Failure on Demand	PFD_{spec}	3,26 E-05
Confidence Level	1-α	95 %
Safe Failure Fraction (see note)	SFF	84 %
Hardware Fault Tolerance	HFT	0
Diagnostic Coverage	DC	0 %
Type of Sub System		Type A
Mode of Operation		Low Demand
Proof Test Coverage	PTC	82 %

Note

The Safe Failure Fraction (SFF) was estimated by an alternative method with a FMEA according to EN 161:2011/A3:2013.

Derived Values for 1oo1-Architecture

Assumed Demands per Year	n_{op}	1 / a	1,14 E-04 / h
Assumed Test Interval	T_i	8760 h	1 a
Total Failure Rate	$\lambda_S + \lambda_D$	2,32 E-08 / h	23 FIT
Lambda Dangerous	λ_D	3,72 E-09 / h	4 FIT
Lambda Safe	λ_S	1,95 E-08 / h	20 FIT
Mean Time To Failure	MTTF	4,30 E+07 h	4.911 a
Mean Time To Dangerous Failure	$MTTF_D$	2,69 E+08 h	30.694 a
Average Probability of Failure on Demand	**PFD_{avg}**	**1,63 E-05**	

Useful Lifetime

A time of usage of more than 5 years (+ 1.5 years of storage) can only be favored under responsibility of the operator, consideration of specific external conditions (securing of required quality of media, max. temperature, time of impact), and adequate test cycles.

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