

**Report No. V 467.01/15 – Rev. 01**

**Examination of Suitability**

**Solenoid Valves of Types 52, 54 and 67 as  
Redundant Supply and Exhaust Assemblies**

**for Use in Defined**

**Performance Level  
acc. EN ISO 13849-1:2008  
and**

**Safe Integrity Level  
acc. IEC 61508:2010 and IEC 61511:2004**

**MAC Valves Europe INC.**

**Loncin, Belgium  
2015**

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**Publication of page 2-3 is permitted.**

**The test results presented in this report refer solely to the test object stated as described on page 2. The report does not represent a general statement about the serial production of the test object and gives not an authorization for use of a TÜV Rheinland test- / certification mark.**

## Examination of the suitability of quick exhaust valves for usage in defined safety integrity levels according to IEC 61508:2010 and IEC 61511:2004 and Performance levels according to EN ISO 13849:2008

<b>Manufacturer / contractor:</b>	MAC Valves Europe Inc. Rue Marie Curie 12 B-4431 Loncin Belgium	MAC Valves Inc. 30569 Beck Rd. Wixom, Mi 48393 U.S.A.	MAC Valves Asia Inc. No.45 Dongyuan Rd. Taoyuan County Taiwan 320-63
<b>Product, test item:</b>	<b>3/2 solenoid valve Redundant Supply &amp; Exhaust Assemblies</b>		
Type designation:	Series 52	Series 54	Series 67
Port size:	1/8 " – 1/4 "	G3/8" - G1/2" – G3/4"	G3/4" - G1"
Max. flow:	1200 NI/min	5100 NI/min	20000 NI/min
Pressure range (main valve)			
Internal pilot:	2.1 – 8.5 bar	2.1 – 8.0 bar	2.1 – 8.0 bar
External pilot:	Vacuum to 8,5 bar	Vacuum to 8.0 bar	Vacuum to 8.0 bar
Temperature range:		0 °C to + 50 °C	

### Test results:

**The valves are suitable for operation in safety-related systems with a Safety Integrity Level (SIL) of up to SIL 3 acc. to IEC 61508 and IEC 61511 due to its internal redundancy. Constraints of the calculated probability of dangerous failures according to the frequency of demand have to be considered.**

**The valves are suitable for operation in safety-related systems with a Performance Level (PL) d acc. To EN ISO 13849-1 due to its internal redundancy. If they are used in a redundant configuration (HFT = 1), the sub-system is usable up to PL e according EN ISO 13849-1.**

**A sufficient diagnostics has to be implemented. Constraints of the calculated Mean Time to Dangerous Failure acc. to the frequency of demand have to be considered.**

The test results refer only to the test object. The test results do not represent any statement with regard to the safety integrity level (SIL) and performance level (PL) of a specific system. The suitability for certain applications can only be realised through the evaluation of the respective safety-related overall system, including all safety-related components, in accordance with IEC 61508 / IEC 61511 and EN ISO 13849.

The test statement is bound to the implementation of a suitable quality management system.

The test statement is valid for new actuators for a period of time of 5 years after commissioning plus 1.5 year storage time. The maximum cycle lifetime is limited to the B<sub>10d</sub> value of the test item. The test statement presupposes that during this period of time the actuators are maintained and operated in accordance with the manufacturer's specifications.

**The Test Centre does not assume any further liability for application of the values determined.**

**The validity of the test report is limited to the period of time until January 2020.**

Dated in Cologne, 2016-10-14  
Inspector

Test Centre for Energy Appliances  
Reviewer

M. Eng. C. Li

Dr.-Ing. Jan Schumacher

## Summary of technical safety characteristics

**Table 1: Device specific values of series 52, 54 and 67**

Series			52 / 54	67
B <sub>10d</sub> value	B <sub>10d</sub>	[ - ]	10 500 000	5 500 000
Internal Hardware Fault Tolerance	HFT <sub>int</sub>	[ - ]	1	
Safe Failure Fraction per internal channel	SFF	[%]	60 - < 90	
Diagnostic Coverage	DC	[ - ]	0	
Common Cause Factor	β <sub>int</sub> <sup>(1)</sup>	[%]	10	
Type of Subsystem Acc. IEC 61508-2, 7.4.4.1.3		[ - ]	Type A	
Mode of Operation Acc. IEC 61508-4, 3.5.16		[ - ]	High and Low Demand Mode	
Dangerous Failure Rate	λ <sub>D</sub>	[1/h]	See below	
Low Demand Mode				
Probability of Dangerous Failure on Demand	PFD <sub>avg</sub>	[ - ]	4.65 E-05	
Assumed Test Interval	T <sub>i</sub>	[y]	1	
Assumed demand frequency	n <sub>op</sub>	[1/y]	1	
High Demand Mode				
Probability of Dangerous Failure per hour	PFH <sub>D</sub>	[1/h]	See below	
Mean Time to Dangerous Failure	MTTF <sub>D</sub>	[h]	See below	

(1): The Common Cause Factor is always to be examined taking into consideration the safety-related overall system with regard to the certain application.

$$PFH_D = \lambda_D = \frac{1}{MTTF_d} = \frac{0,1}{B_{10d}} \times n_{op}$$

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## **1. Task definition, reasons for testing**

Within the framework of the inspection the solenoid valve of the company MAC Valves Europe INC. were subjected to an examination of suitability with regard to deployment in safety-related systems in accordance with IEC 61508, IEC 61511 and EN ISO 13849.

The test items inspected are deployed in safety-related systems as part of the control of an actuator and are used to ensure redundancy of inlet pressure and exhaust. The safety function of the test item consists of failsafe closing (function-to-vent) by spring force with supply isolated.

The solenoid valve itself, used as a single device, can be delivered as normally open (NO) or normally closed (NC) type.

The test item is usually used as a safety-related component in an operation mode with a high rate of demand.

Testing refers solely to the test item. Additional components which are required for the operation of the test item such as, for example pressure switches, have not been taken into consideration.

The evaluation of the test items was carried out on the basis of

- a Failure Mode and Effect Analysis (FMEA),
- an endurance test to determine the probability of failure and
- the suitable and verified quality management system of the manufacturer.

The precise classification of a safety integrity level (SIL) in accordance with IEC 61508 / IEC 61511 and in a Performance Level (PL) in accordance with EN ISO 13849 can only be effected on the basis of the overall system in which the test item is used. The allocation to a maximum SIL / PL undertaken within the framework of the testing of the actuators is to be understood as the highest possible safety integrity level to which a system, in which the actuators examined are utilised, can be classified.

The test statement is bound to the verified implementation of a safety-related quality management system by the manufacturer. Amongst other things this quality management system has to ensure that the products produced, the production and the in-process testing of the products correspond to the documentation used for this examination.

### **Revision 1**

The minimum pressure of the internal pilot has been increase from 1.3 bar to 2.1 bar.

## 2. Test basis

The following standards are used as the basis for testing.

**Table 1:** Reference standards

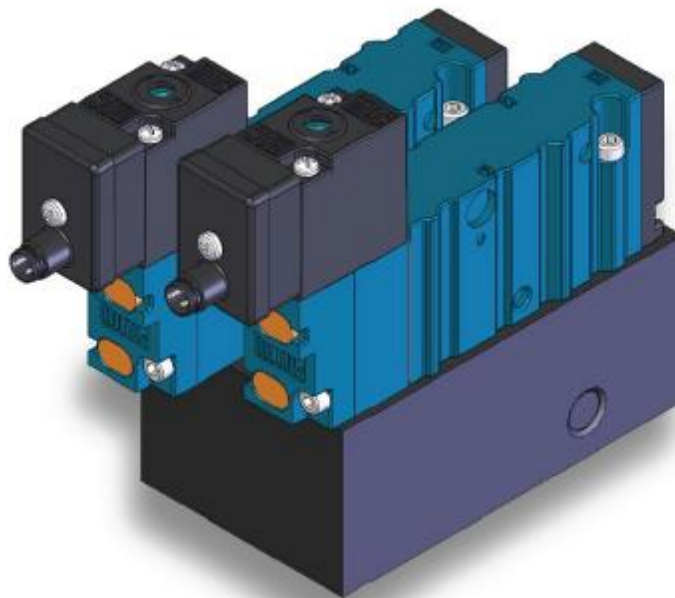
Standard	Reference in this document
IEC 61508-1:2010	IEC 61508-1
IEC 61508-2:2010	IEC 61508-2
IEC 61508-4:2010	IEC 61508-4
IEC 61508-7:2010	IEC 61508-7
IEC 61511-1:2004	IEC 61511-1
EN ISO 13849-1:2008	EN ISO 13849
EN 13611:2011	EN 13611

## 3. Description of the test item

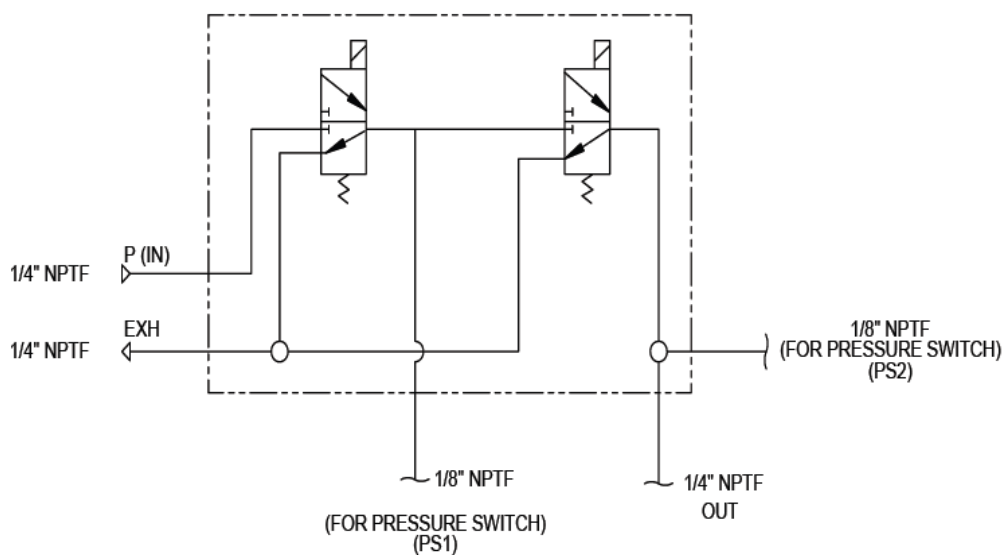
The purpose of the inspected 3/2 way solenoid valves of type 52, 54 and 67 is to ensure inlet pressure and exhaust when de-energized. The safety function of a single device consists of failsafe closing (NC) or failsafe opening (NO) by spring force.

Assembled on a manifold, the test items operate as redundant a valve packages (see Figure 1). The integrated porting (PS1 and PS2) allows connection of pressure switch for pressure detection (see Figure 2). The safety function of the redundant system consists of failsafe closing (function-to-vent) by spring force with supply isolated.

The test item can be used as a single device and also as a redundant manifold assembly.



**Figure 1:** Redundant manifold assembly



**Figure 2:** Port configuration

**Table 2:** Technical data

Product, test item:	<b>3/2 solenoid valve</b>		
Type designation:	Series 52	Series 54	Series 67
Port size:	1/8" – 1/4"	G3/8" – G1/2" – G3/4"	G3/4" – G1"
Operating medium:		Compressed air	
Max. flow:	1200 NI/min	5100 NI/min	20000 NI/min
Pressure range (main valve)			
Internal pilot:	2.1 – 8.5 bar	2.1 – 8.0 bar	2.1 – 8.0 bar
External pilot:	Vacuum to 8.5 bar	Vacuum to 8.0 bar	Vacuum to 8.0 bar
Temperature range:		0 °C to + 50 °C	

## 4. Testing

A part of the assessment of the inspected test items bases on results of an endurance test, which has been performed in the laboratory of the Test Centre.

### 4.1. Scope and test program

The aim of the test is to proof that the failure probability of the test item is below a certain failure probability  $\lambda_D$  according to IEC 61508-1, Table 3 and EN ISO 13849-1, Table 3. The appraisal of the failure probability bases on the  $B_{10d}$  values of the test items.

Therefore, a test program has been designed to determine the  $B_{10d}$  according the requirements of EN 13611, Annex K and to show, that the product designs can withstand the operating stresses in field, especially in regard to temperature and pressure. 11 samples of each type have been selected to perform 11,000,000 series for 52, 54 series and 6,000,000 cycles for 67 series (single devices, not as redundant assembly). The cycling test has been performed at high temperature (60 °C), low temperature (0 °C) and ambient temperature (20 °C) and with a pilot pressure of 8 bar.

### 4.2. Test results

The following tables summarized the result of the endurance testing. No negative effects to the safety function have been identified during the whole testing.

**Table 3:** Test result 52 and 54 series

Test samples	Total cycles	Results
1	11,067,500	No failure
2	11,067,500	No failure
3	11,067,500	No failure
4	11,067,500	No failure
5	11,067,500	No failure
6	11,067,500	No failure
7	11,067,500	No failure
8	11,067,500	No failure
9	11,067,500	No failure
10	11,067,500	No failure
11	11,067,500	No failure

**Table 2:** Test result 67 series

Test sample	Total cycles	Results
1	6,003,500	No failure
2	6,003,500	No failure
3	6,003,500	No failure
4	6,003,500	No failure
5	6,003,500	No failure
6	6,003,500	No failure
7	6,003,500	No failure
8	6,003,500	No failure
9	6,003,500	No failure
10	6,003,500	No failure
11	6,003,500	No failure

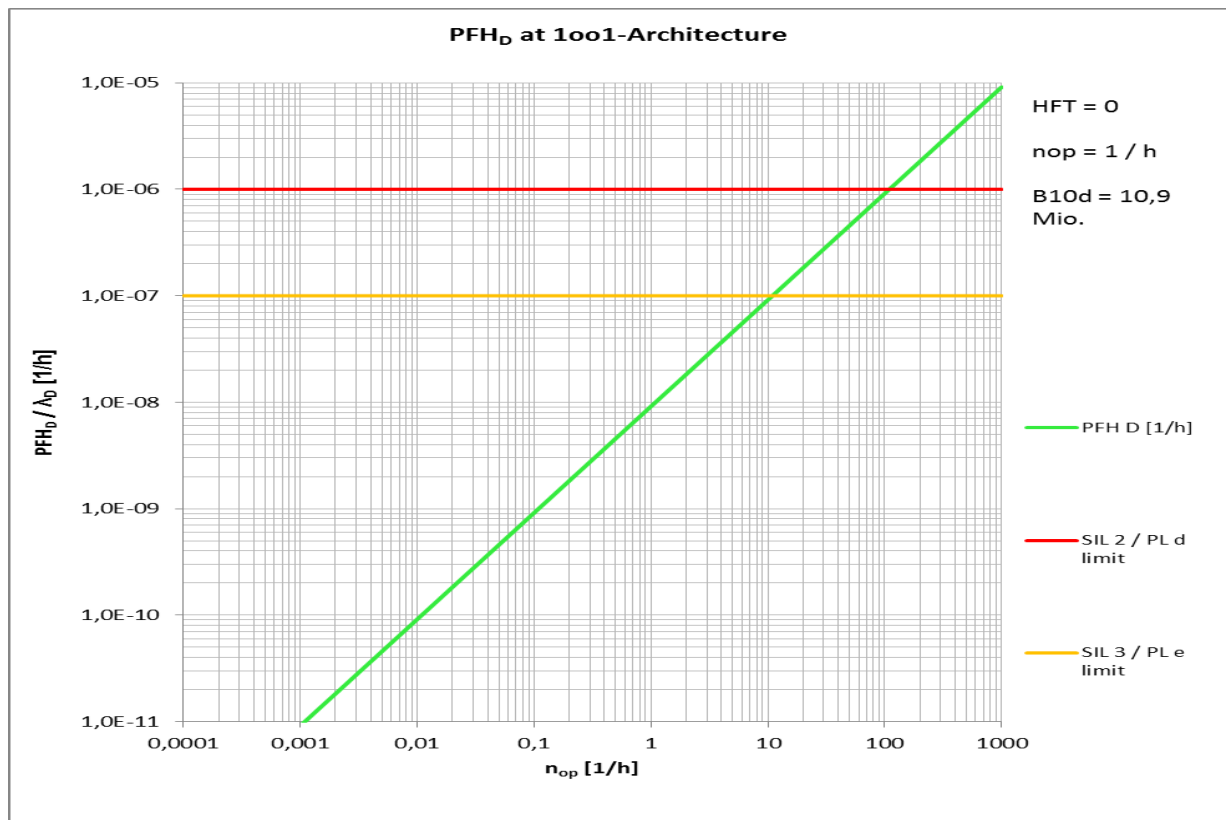
### 4.3. Calculation of $B_{10d}$ values

According EN 13611, Annex K.4.6, the following  $B_{10d}$  results.

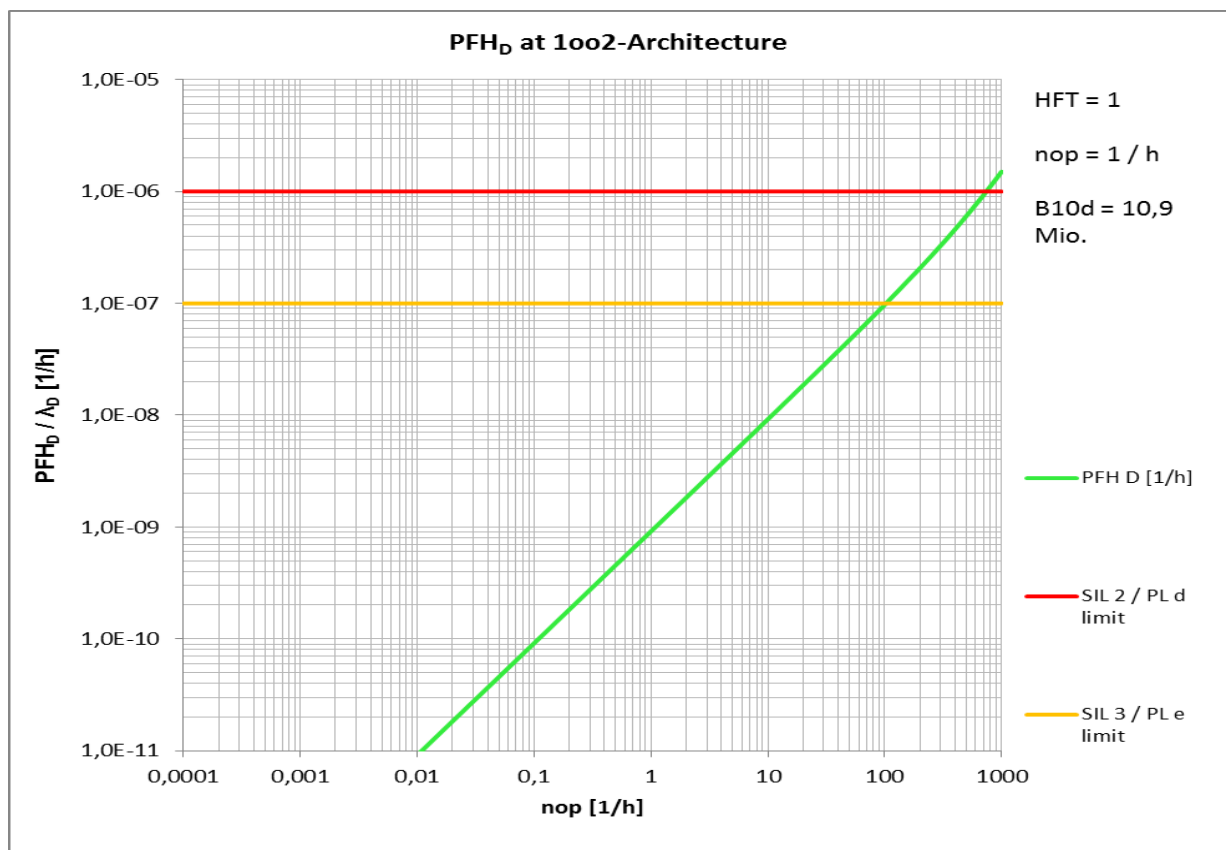
**Table 4:**  $B_{10d}$  value

	52 series	54 series	67 series
$\log_{x50\%}$	7,047		6,780
$S_{\log}$	0.006		0.006
b	87.184		87.184
T	11 209 355		6 070 247
<b><math>B_{10d}</math></b>	<b>10 500 000</b>		<b>5 500 000</b>

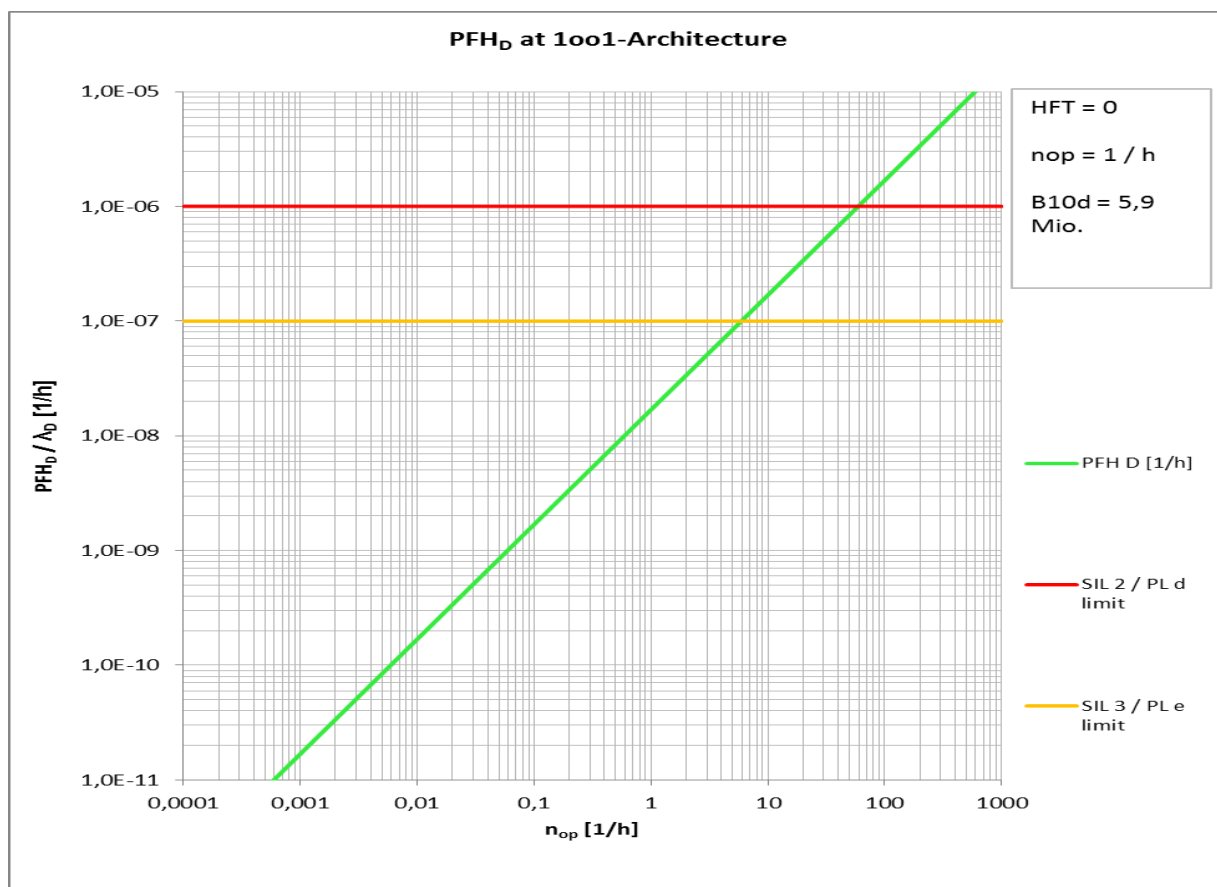




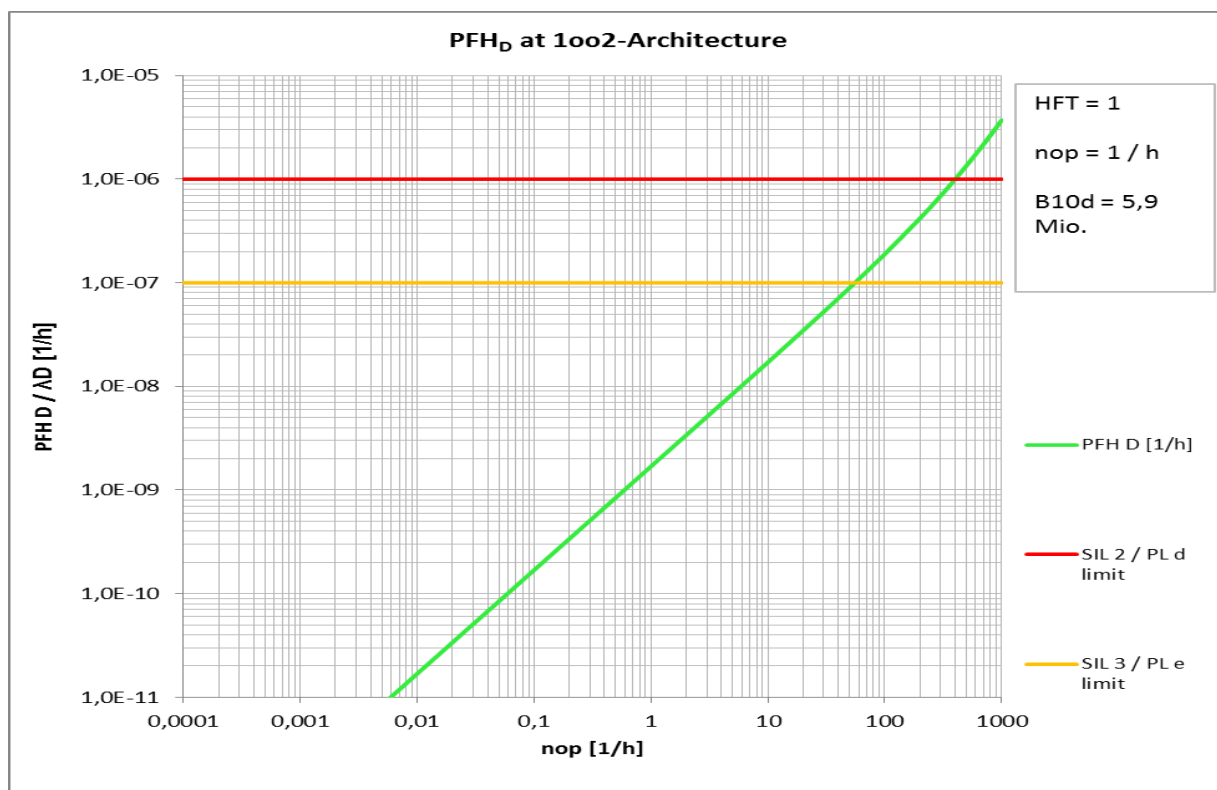
**Figure 3:** Failure probability on 1oo1 architecture for 52, 54 series



**Figure 4:** Failure probability on 1oo2 architecture for 52, 54 series



**Figure 5:** Failure probability on 1oo1 architecture for 67 series



**Figure 6:** Failure probability on 1oo2 architecture for 67 series

#### 4.4. Calculation of $PFD_{avg}$

For usage in low demand mode applications the failure rates and  $PFD_{avg}$  cannot be calculated out of the PFH value. Due to the high amount of successful tests the result would not be in a realistic range.

Therefore the first 300 test cycles of each test item have been evaluated to calculate the specific probability of failure on demand to:

$$PFD_{spec} = 9.07 \text{ E-04}$$

With an assumed Test interval of  $T_i = 1$  year and an assumed number of operation of  $n_{op} = 1$  per year the dangerous failure rate is:

$$\lambda_{DU} = 1.04 \text{ E-07}$$

The average probability of failure for the implemented 1oo2 architecture is:

$$PFD_{avg} = 4.65 \text{ E-05}$$

This value equates to 5 % of the range of probability of failure for a complete SIL 3 system.

## Inspection according EN ISO 13849

The inspection of the suitability for usage in safety-related systems according EN ISO 13849-1 bases on mean time to dangerous failure  $MTTF_d$  value and the presence of basic and well-tried safety principles.

### 4.5. Basic and well-tried safety principles

The FMEA conducted during this assessment and the measures documented in the FMEA for the design are a suitable proof that the design process of the test item is sufficient to fulfil the requirements for basic and well-tried safety principles.

Together with the quality control methods documented in the FMEA (especially the factory acceptance test), the manufacturing process of the test item is in the opinion of the Test Centre sufficient to produce components suitable for safety related systems of category B, 1-4 in accordance with EN ISO 13849-1.

### 4.6. Mean time to dangerous failure

The achievable Performance Level depends on  $MTTF_d$  of the test item and its architecture.

#### 4.6.1. Single Device

According EN 13611, Annex K.4, the  $MTTF_d$  value can be calculated with the  $B_{10d}$  value, which results from the endurance test.

$$MTTF_d = \frac{B_{10d}}{0,1 \times n_{op}}$$

The invers value of  $MTTF_d$  is the dangerous failure rate  $\lambda_D$  of the test item.

$$\frac{1}{MTTF_d} = \lambda_D = \frac{0,1}{B_{10d}} \times n_{op}$$

$MTTF_d$  also depends on the demand frequency of the test item. With the assumption of a demand frequency of one per hour  $n_{op} = 1/h = 8760 /a$ , Figure 3 and 5 and the following table result.

**Table 5:**  $MTTF_d$  for single device

	52, 54 Series	67 series
$MTTF_d [a]$	12,470	6,752
$\lambda_D [1/h]$	$9.15 \cdot 10^{-9}$	$1.69 \cdot 10^{-8}$

The failure rates in table 5 can be considered as the specific value for a single device of type 52, 54 and 67.

#### 4.6.2. Redundant Assembly

The failure probability of a redundant system can be calculated according EN 13611-1, Annex K4.8.

$$PFH_{DS} = \lambda_{DS} = (1 - \beta)^2 \cdot \lambda_{DV1} \cdot \lambda_{DV2} \cdot T + \beta \cdot (\lambda_{DV1} + \lambda_{DV2}) / 2$$

with     T:     proof test interval;  
          β:     common cause factor;  
          λ<sub>DV1</sub>: dangerous failure rate per hour for valve 1;  
          λ<sub>DV2</sub>: dangerous failure rate per hour for valve 2;

With β = 10 % and T = 1 a, Figure 4 and 6 and Table 6 result.

**Table 6:** MTTF<sub>d</sub> for redundant assembly

	52, 54 Series	67 series
MTTF <sub>d</sub> [a]	124,623	67,547
λ <sub>D</sub> [1/h]	9.16 · 10 <sup>-10</sup>	1.69 · 10 <sup>-9</sup>

The above mentioned failure rates refers only to a redundant system like the redundant supply and exhaust assemblies of the test items.

#### 4.7. Assessment

Under the consideration of basic and well-tried safety principles of the design and the documentation in regard of operating conditions the test items are suitable for usage in all categories (B, 1-4).

Under the assumption of a demand frequency of  $n_{op} = 1/h = 8760/a$ , the dangerous failure probability lies sufficient below the limit for PL e (see Figure 3-6). This means also, that the MTTF<sub>d</sub> can be considered as “high”, which meets the requirements for PL e according EN ISO 13849-1, Table 7. Furthermore, architecture of category 3 or 4 is mandatory for usage in PL e according EN ISO 13849-1, Figure 5. This requires a sufficient diagnostics. (For example pressure sensors should check if both valves work in the same way or if there is a failure.)

In the opinion of the Test Centre, the test items are suitable for usage up to PL e if used as a redundant assembly. As single devices, the test items are suitable for usage up to PL d.

The suitability for certain applications can only be realised through the evaluation of the respective safety-related overall system, including all safety-related components, in accordance with EN ISO 13849-1.

## 5. Inspection according IEC 61508 / 61511

### 5.1. Classification

#### 5.1.1. Determination of the mode of operation

In the opinion of the Test Centre the operation mode of the test item can be classified as an operation mode with a low and a high rate of demand (**low and high demand mode**) in accordance with IEC 61508-4, 3.5.16.

#### 5.1.2. Determination of the type of subsystem

The FMEA of the test items performed as part of the inspection has shown that the failure behaviour of all components deployed is sufficiently defined. There is still no systematic field data available for the test item for verification of the probability of failure.

Based on the documentation and analysis of the test items failure modes in the FMEA and the test results of the device, the system is at present classified as **Type A** in accordance with IEC 61508-2, Section 7.4.4.1.2.

#### 5.1.3. Diagnostic coverage DC

The test item itself does not contain any diagnostic measures (**DC=0**). If diagnosis is required for the safety function of the test item then this must be provided through external measures, for example pressure switch, as part of the safety-related overall system.

#### 5.1.4. Hardware fault tolerance HFT

The test item is a redundant system and consequently itself has a hardware fault tolerance of **HFT = 1**.

## 5.2. Inspection

## 5.3. Requirements of safety integrity

The basis of this inspection is

- an FMEA (Failure Mode and Effect Analysis) of the type series
- an endurance test to determine the probability of failure
- the suitable quality assurance system of the manufacturer

## 5.4. Limitation of the safety integrity of the hardware with regard to the architecture

The requisite hardware fault tolerance of a safety-related system in accordance with IEC 61508-2 depends on the requisite safety integrity level (SIL) and on particular characteristics of the elements that are used in order to establish the safety-related system.

The second edition of IEC 61508-2 stipulates two possible ways in which the requisite hardware fault tolerance of a safety-related system is to be determined.

According to IEC 61508-2, Section 7.4.4.2, Route 1<sub>H</sub> requires the determination of the safe failure fraction as well as classification of all components that are used in a safety-related system as Type A or Type B system.

As described in IEC 61508-2, Section 7.4.4.3, Route 2<sub>H</sub> can be used for Type A systems. As described in Section 5.1.2 of this report the test items are classified as Type A system.

Within the framework of this report, the consideration according to Route 2<sub>H</sub> will be used as the upper limit for the permitted hardware fault tolerance.

## 5.5. Determination of Safe Failure Fraction

The safe failure fraction (SFF) states the ratio of safe failures of the safety function of a component to all possible failures of the safety function of the component. Safe failures of the safety function are failures that does not lead to a dangerous situation, or that can be detected before a dangerous situation arises.

The SFF of the test item was estimated through the ratio of faults identified in the FMEA (see annex A02).

**Table 4: Results of the FMEA**

<b>Serie</b>	<b>safe failures</b>	<b>Dangerous undetected failures</b>	<b>total failures</b>	<b>SFF [%]</b>
52, 54	38	16	54	70.4 %
67	48	12	60	70.0 %

## 5.6. Determination of failure probability per hour PFH

The dangerous failure probability per hour  $PFH_D$  has been determined thru the test described in chapter 4 and is equal to the dangerous failure rate  $\lambda_{Du}$ .

Under the assumption of a demand frequency of  $n_{op} = 1/h = 8760/a$ ,  $PFH_D$  lies sufficient below the limit for SIL 3. These limit values refer to safety systems made up of various components, not of individual components.

In order to determine whether the test items are suitable for use in a certain safety-related system, it is necessary to determine the  $PFH_D$  value of the overall system. Usually it is presumed that an actuator utilises up to 50 % of the total available  $PFH_D$  value. As the test item is only part of an actuator, a correspondingly lower value applies.

The  $PFH_D$  value of the test object is sufficient for use in most safety-related systems up to and including SIL 2. In principle the probability of failure determined also enables utilisation up to SIL 3 if the architecture requirements of the overall system are also fulfilled.

These statements are always to be examined taking into consideration the safety-related overall system with regard to the application case in question.

## 5.7. Determination of failure probability on demand PFDavg

For usage in low demand mode applications the failure rates and PFDavg cannot be calculated out of the PFH value. Due to the high amount of successful tests the result would not be in a realistic range.

Therefore the first 300 test cycles of each test item have been evaluated to calculate the specific probability of failure on demand to:

$$PFD_{spec} = 9.07 \cdot 10^{-04}$$

With an assumed Test interval of  $T_i = 1$  year and an assumed number of operation of  $n_{op} = 1$  per year the dangerous failure rate is:

$$\lambda_{Du} = 1.04 \cdot 10^{-07} / h$$

The average probability of failure for the implemented 1oo2 architecture is:

$$PFD_{avg} = 4.65 E-05$$

This value equates to 5 % of the range of probability of failure for a complete SIL 3 system.

## 5.8. Avoidance and control of systematic failures

In addition to the requirements regarding the failure probability and system architecture, requirements regarding the systematic safety integrity have to be fulfilled to prove an adequate safety against systematic failures.



It is the opinion of the Test Centre that the FMEA conducted during this assessment and the measures documented in the FMEA for the design are a suitable proof that the design process of the test item has been sufficient to avoid systematic failures preventing the safe operation of the test item.

Together with the quality control methods documented in the FMEA (especially the factory acceptance test), the manufacturing process of the test item is in the opinion of the Test Centre sufficient to produce components suitable for safety related systems.

### **5.9. Useful lifetime under specified operating conditions**

Based on the positive test results, it is proved, that the design of the test item is able to withstand the specified operation conditions for its intended application.

It is the opinion of the Test Centre that the useful lifetime of the test item in safety-related system is up to 5 years if the manufacturer specification according operation conditions, installation and storage time are obeyed.

### **5.10. Test interval**

In order to avoid reasons for failure that arise through long periods of downtime and which consequently cannot be covered by the test performed for determination of the probability of failure, it is necessary to test the test item during operation. In the opinion of the Test Centre this test should be performed at least once a year in order to ensure the transferability of the certain probability of failure.

It may be necessary to shorten this test interval in certain cases (e.g. when the work medium is not sufficiently clean). The stipulation of suitable test intervals and acceptance criteria should be part of the overall consideration of the safety-related system in which the test items are used.

Corresponding information are included in the instruction manual for operation and SIL User Guide in accordance with IEC 61508.

## 6. Assessment

### 6.1. Systematic safety integrity

On the condition that there is a verified, safety-related quality management system, which contains the measures and testing described in this report and the FMEA, the Test Centre considers the requirements regarding systematic safety integrity up to and including SIL 3 as complied with.

### 6.2. Safety integrity

The component-specific safety integrity is evaluated through the values  $PFD_{avg}$  and SFF of the test items.

#### 6.2.1. Average probability of failure of the safety function on demand

On the assumption of a period of operation of 5 years and a demand frequency of  $n_{op} = 1/h = 8760/a$ ,  $PFH_D < 1.69 \cdot 10^{-8}$  results.

The  $PFH_D < 1.69 \cdot 10^{-8}$  lies sufficiently below 10 % of the upper limit for SIL 3 (IEC 61508-1, 7.6.2.9 Table 2). These limit values refer to safety systems made up of various components, not of individual components.

**Table 5: SIL 3 Limits**

	10 % upper limit	$PFH_D$	10 % lower limit
SIL 3	$10^{-7}$	$< 1.69 \cdot 10^{-8}$	$10^{-8}$

In order to determine whether the test items are suitable for use in a certain safety-related system, it is necessary to determine the  $PFH_D$  value of the overall system. Usually it is presumed that an actuator utilises up to 50 % of the total available  $PFH_D$  value. As the test item is only part of an actuator, a correspondingly lower value applies.

The  $PFD_{avg}$  value of an actuator of  $PFH_D < 1.69 \cdot 10^{-8}$  is, in the opinion of the Test Centre, sufficient for use in most safety-related systems up to and including SIL 2. In principle the probability of failure determined also enables utilisation up to SIL 3 if the architecture requirements of the overall system are also fulfilled.

#### 6.2.2. Limitation of the safety integrity of the hardware with regard to the architecture

As the test item in accordance with 5.1.2 is classified as a Type A system, then in accordance with 5.4 Route 1<sub>H</sub> and 2<sub>H</sub> can be used to determine the requisite hardware fault tolerance.

In accordance with the particular safe failure fraction and IEC 61511, the test item can be used up to and including SIL 2 with HFT = 0. Utilization up to and including SIL 3 is possible in a redundant multi-channel structure with HFT = 1 or higher of the overall system.

## 7. Test Statement

Through the utilisation of the  
**3/2-Way solenoid valve**

of the type series  
**52, 54 and 67**

of the manufacturer

<b>MAC Valves Europe Inc.</b>	<b>MAC Valves Inc.</b>	<b>MAC Valves Asia Inc.</b>
Rue Marie Curie 12	30569 Beck Rd.	No.45 Dongyuan Rd.
B-4431 Loncin	Wixom, Mi 48393	Taoyuan County
Belgium	U.S.A.	Taiwan 320-63

and on the basis of the following test findings and results:

- determination of the failure probability of the assessed components based on results of endurance test of  $PFH_D < 1.69 \cdot 10^{-8}$ ,
- a safe failure fraction of the safety function of  $SFF > 60\%$  determined by means of FMEA,
- the classification of the test items as proven in use (Type A)
- the internal redundancy
- the evaluation of the systematic safety integrity by means of an FMEA
- as a result of the inspection of the testing by the Test Centre as an independent organisation

a safety-related system with a Safety Integrity Level (SIL) can be set up using the inspected valves up to SIL 3 according IEC 61508 and IEC 61511 due to its internal redundancy. Constraints of the calculated Probability of dangerous failures according to frequency of demand have to be considered.

The test item is also suitable for operation in safety related systems with a Performance Level (PL) of up to PL d according EN ISO 13849-1 due to its internal redundancy. If the components are used in a redundant configuration ( $HFT = 1$ ) the system is usable in a safety related system up to PL e according EN ISO 13849-1. A sufficient diagnostics has to be implemented. Constraints of the calculated Mean Time to dangerous failure according to frequency of demand have to be considered.

This statement refers to use of the test items in an operational mode with a high rate of demand over a period of time of 5 years after commissioning plus 1.5 years storage time. The test statement presupposes that during this period of time the valves are maintained and operated in accordance with the manufacturer's specifications.

The test statement is based on the documentation submitted by the manufacturer as well as on the laboratory testing performed. It is only valid for components which correspond to the documentation used for testing as well as to the test specimens used for testing. This test statement is bound to the implementation of a suitable and verified safety-related quality management system.

**Suitability for certain applications can only be realised through the evaluation of the respective safety-related overall system including all safety-related components and the calculation of the application oriented  $PFH_D$  value in accordance with IEC 61508 and EN ISO 13849.**

The Test Centre does not assume any further liability for the application of the values accordingly determined.

## **8. Enclosures**

A 01.1 Datasheet Series 52, 54, 67

A 01.2 MAC Redundant Supply & Exhaust Assemblies

A 02 FMEA

A 03 Test Reports