

# Reliability characteristics $MTTF_D$ regarding the functional safety according to EN ISO 13849

$MTTF_D$  values

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## **Determination MTTF<sub>D</sub> values according to EN ISO 13849-1:2015**

Using reliability characteristics MTTF<sub>D</sub> (mean time to dangerous failure) of components, the probability of a dangerous failure per hour PFH<sub>d</sub> of a machine or system is calculated and kept low, to a justifiable degree.

For hydraulic components, the standard EN ISO 13849-1:2015 specifies an MTTF<sub>D</sub> value of at least 150 years if the "basic" and "well-trying" safety principles are complied with. The following is, for example, demanded for hydraulic valves used in safety-related parts of control systems:

- ▶ Automatic reaching of the basic position in case of energy failure
- ▶ Safe keeping of the basic position
- ▶ Sufficient overlap with spool valves in basic position

Hydraulic components not satisfying the relevant safety principles are not suitable to be used in safety-related parts of control systems.

Rexroth has carefully tested their products with regard to all relevant "basic" and "well-trying" safety principles according to a method acknowledged by IFA (Institute for Occupational Safety and Health of the German Social Accident Insurance).

## Compliance with safety principles, application notes

The products listed in the following are suitable to be used in safety-related parts of a control system according to EN ISO 13849-1:2015.

According to EN ISO 13849-2:2012, the products satisfy the

- ▶ **basic** safety principles
- ▶ **well-tried** safety principles.

For evaluating and interpreting the control system's reliability, use the following characteristics for the products:

MTTF<sub>D</sub> = see table page 4 ... 9

T<sub>M</sub> = 20 years (maximum period of use according to EN ISO 13849-1:2016)

In this use, please ensure compliance with the subsequently specified application notes!

### Application notes:

The following basic safety principles according to EN ISO 13849-2:2012 for the implementation and the operation of the products are to be complied with.

- ▶ For operation and handling of the products, comply with the information in the data sheet and the operating instructions.
- ▶ Only use the hydraulic fluids specified in the data sheets and comply with the oil cleanliness class for the whole period of use.
- ▶ If switching spool valves are not actuated for a longer period of time, the spool may get stuck. We therefore recommend switching the valve regularly, at reasonable time intervals.
- ▶ If you use the product for safety-related structures with higher categories (2 to 5) according to EN ISO 13849-1:2015 section 6, consider the requirements (e.g. CCF, DC, PLr, software, systematic errors) specified there.
- ▶ According to EN ISO 13849-1:2015, the maximum mission time - complying with the oil cleanliness according to ISO 4406:1999 - is T<sub>M</sub> = 20 years. In terms of preventative maintenance, it is recommended replacing the components already before expiry of the maximum period of use.
- ▶ Industrial valves are usually designed for 10 million switching cycles. If the maximum number of switching cycles is exceeded within the period of use, accordingly shorter exchange intervals are to be determined.

**Conversion of MTTF<sub>D</sub> into B<sub>10D</sub>** according to EN ISO 13849-1:2015:

$$\text{MTTF}_D = \frac{B_{10D}}{0.1 \times n_{op}}$$

**B<sub>10D</sub>** = Mean number of cycles in which up to 10% of the components have failed in a dangerous manner.

**n<sub>op</sub>** = Mean number of annual actuations.

### Notice:

According to EN ISO 13849-1:2015, higher MTTF<sub>D</sub> values can be assumed with a limited number of operations per year:

<b>n<sub>op</sub></b>	<b>MTTF<sub>D</sub></b>
> 1,000,000	150 years
> 500,000 ... 1,000,000	300 years
> 250,000 ... 500,000	600 years
< 250,000	1200 years

### Use of valves and components with spool position monitoring:

- ▶ The signal of the position switch must not be used for direct activation of a safety-related control function.

### Use of valves with integrated electronics for safety-related control systems:

- ▶ In case a safety function of a system is required, the voltage supply of the valve electronics is to be switched off by a suitable switching element with appropriate reliability. In the table (page 5 and 8), these valves are marked with the comment "Switch off OBE voltage supply".
- ▶ If persons have to enter the danger zone with activated valve electronics, additional measures for guaranteeing their safety have to be taken for the reasons specified above.

### Use of valves with flame-resistant hydraulic fluids HFC:

- ▶ The period of use T<sub>M</sub> must be reduced for applications with functional safety.

	<b>Life cycle as compared to operation with mineral oil HL, HLP</b>	<b>Maximum period of use T<sub>M</sub> according to EN ISO 13849-1</b>
Directional on/off valves, proportional directional valves	30 ... 100 %	10 years
2-way cartridge valves, isolator valves, pressure valves	50 ... 100 %	6.7 years

## Directional on/off valves

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	B <sub>10</sub> value in million switching cycles		Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
				B <sub>10</sub>	B <sub>10D</sub>			
.WE 6 .6X/.EG...	6	23178	-	20	40	optional QM,QR	A, C, D, B, Y, E, F, G, J, L, M, P, Q, R, T, U, W, A9, B9, E67, U10, Y11, J2, X7, X34, X139, L42; < 15 g/11 ms <sup>4)</sup>	Impulse spool design "O" and valves for AC voltage "W" <sup>5)</sup>
.WE . .73-6X/...A12...							A73, D73, B73, Y73, E73, G73, J73, R73, W73; < 10 g/11 ms <sup>4)</sup>	
.WE 6 .6X/.EG...SO407	6	23178-00	-	20	40	optional QM	C, D, D46, Y, E, J, J2, Q, R; < 15 g/11 ms <sup>4)</sup>	
.WE 6 .7X/.H...	6	23164	150 ... 1200	-	-	-	A, C, D, B, Y, E, G, H, J; < 15 g/11 ms <sup>4)</sup>	
.WE 10 .3X/.C...; .WE 10 .4X/.C...	10	23327	150 ... 1200	-	-	optional QM	A, C, D, B, Y, E, F, G, J, L, M, P, Q, R, T, U, W, U10; < 15 g/11 ms <sup>4)</sup>	Impulse spool design "O" and valves for AC voltage "W" <sup>5)</sup>
.WE 10 .5X/.E...	10	23340	-	20	40	-	A, C, D, B, Y, E, F, G, J, L, M, P, Q, R, T, U, W, U10; < 15 g/11 ms <sup>4)</sup>	
5-.WE 10 .3X/.C...	10	23351	150 ... 1200	-	-	optional QM	A, C, D, B, Y, E, F, G, J, L, M, P, Q, R, T, U, W, J2, X84, E67; < 15 g/11 ms <sup>4)</sup>	
5-.WE 10 .5X/.E...	10	23352	-	20	40	optional QM	A, C, D, B, Y, E, F, G, J, L, P, R, U, W; < 15 g/11 ms <sup>4)</sup>	
4WE 10 .5X/H...	10	23343	150	-	-	optional QY	C, D, Y, Y11, E, J, L, M, U; < 15 g/11 ms <sup>4)</sup>	
Z4WE 6 .3X/E...	6	23193	150 ... 1200	-	-	optional QM	D24, D27, E51, E53, E56, E63, E68, E127, E129, E130, E131, E132, E134, E135, E136, E137, E141, E144, E145, E146, E166, X188, X250, X252, X253, X254, X255, X256; < 15 g/11 ms <sup>4)</sup>	Valves for alternating voltage "W" <sup>5)</sup>
.SEC 6 .1X/.C...	6	22035	150 ... 1200	-	-	-	E69A, E35, E100, E13, E22, EA, EB, E, E61, E40, E89, E18	
M-.SED 6 .1X...	6	22049	150 ... 1200	-	-	optional QMA, QMB	PK, NK, UK, CK	
M-.SED 10 .1X...	10	22045	150 ... 1200	-	-	optional QMA, QMB	UK, CK	
M-.SEW 6 .3X...	6	22058	150 ... 1200	-	-	optional QMA, QMB	P, N, U, C; < 15 g/11 ms <sup>4)</sup>	630 bar version
M-.SEW 10 .1X...	10	22075	150 ... 1200	-	-	optional QMA, QMB	U, C	
Z4SE 10 .1X/C	10	<sup>6)</sup>	150 ... 1200	-	-	-	A, B, E	
.WEH . .6E...; .WH ...	10 ... 32	24751	100 ... 800 150 ... 1200	-	-	optional QM	A, B, C, D, E, F, G, H, J, K, L, M, P, Q, R, S, T, U, V, W, Y, Z, U10; < 15 g/11 ms <sup>4)</sup>	Impulse spool design type "O"; spool return hydraulic
Z4WEH ...; Z4WH ...	10 ... 22	24753, 24761, 24768	100 ... 800 150 ... 1200	-	-	optional QM	E62, E63, E68, E50, E51, E52; < 15 g/11 ms <sup>4)</sup>	Valves for alternating voltage "W" <sup>5)</sup>

Explanation of the footnotes see page 10.

Further MTF<sub>D</sub> values for products and special versions not listed here upon request.

**Proportional directional valves**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/limitations
4WRA(E) ...-2X...	6, 10	29055	150 ... 1200	–	E, W; in case of shock load, the spool overlap can be left for a short period	Switch off "OBE" voltage supply
4WRE(E) ...-2X...	6, 10	29061	150 ... 1200	–	E, W; in case of shock load, the spool overlap can be left for a short period	
4WREEM ...-2X...	6, 10	29064	150 ... 1200	yes	E, W; in case of shock load, the spool overlap can be left for a short period	Analysis of the zero position upon request; switch off "OBE" voltage supply
4WRPE 6 ...-2X...	6	29024, 29025	150 ... 1200	–	E, W; < 15 g <sup>4)</sup>	Switch off "OBE" voltage supply; except $q_V = 40$ l/min
4WRPE 10 ...-3X...	10	29122	150 ... 1200	–	E, E1, W6, W8; < 15 g <sup>4)</sup>	Switch off "OBE" voltage supply
4WRPH ...-2X...	6, 10	29028, 29032	150 ... 1200	–	C1, C3, C4, C5; < 10 g <sup>4)</sup>	NG6: except $q_V = 40$ l/min NG10: max. operating pressure 250 bar
4WRPEH ...-2X...	6, 10	29035, 29037	150 ... 1200	–	C1, C3, C4, C5; < 10 g <sup>4)</sup>	Switch off "OBE" voltage supply; NG6: except $q_V = 40$ l/min NG10: max. operating pressure 250 bar
4WRPEH 6 ...-3X...	6	29121	150 ... 1200	–	C1, C3, C4, C5; < 10 g <sup>4)</sup>	Switch off "OBE" voltage supply; except $q_V = 40$ l/min
4WRPNH ...-2X...	6, 10	29191	150 ... 1200	–	C1, C3, C4, C5; < 10 g <sup>4)</sup>	NG10: max. operating pressure 250 bar
4WRPDH ...-2X...	6, 10	29391	150 ... 1200	–	C1, C3, C4, C5; < 10 g <sup>4)</sup>	
4WRKE ...-3X...	10 ... 35	29075	75 ... 600	–	E, R, W; < 15 g <sup>4)</sup>	Switch off "OBE" voltage supply
4WRZ(E) ...-7X...; 4WRH ...-7X...	10 ... 52	29115	75 ... 600 150 ... 1200	–	E, E1, E3, W6, W8, W9; < 20 g <sup>4)</sup>	Switch off "OBE" voltage supply
4WRZ(E)M ...-1X...; 4WRHM ...-1X...	10 ... 25	29117	75 ... 1200 150 ... 1200	yes	E, W; < 9 g <sup>4)</sup>	Switch off "OBE" voltage supply
4WRZ(E) 32 ...-7X...402, 4WRH 32 ...-7X...402	32	7)	75 ... 600 150 ... 1200	yes	E, W; < 9 g <sup>4)</sup>	
4WRL...-3X...; 4WRLEM...-3X...	10 ... 35	29087	75 ... 600	–	E, E1, E(Z), E1(Z), E4, W, W1, W(Z), W1(Z)R, W2, W3, W4, R3, R5; NG10 and 16: < 15 g <sup>3)</sup> NG25 and 27: < 10 g <sup>3)</sup>	Switch off "OBE" voltage supply
4WRLE...-4X...	10 ... 35	29123	75 ... 600	–	E, E1, W6, W8; NG10 and 16: < 15 g <sup>4)</sup> NG25 and 27: < 10 g <sup>4)</sup>	Switch off "OBE" voltage supply
4WRTE...-4X...	10 ... 35	29083	150 ... 1200	–	E, E1, W6, W8, Q2, R	Switch off "OBE" voltage supply

Explanation of the footnotes see page 10.

Further MTTF<sub>D</sub> values for products and special versions not listed here upon request.

**2-way cartridge valves: Directional function**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
LC . A...7X...; LC . B...7X...	16 ... 63	21010	150 ... 1200	–	–	Cracking pressure "00" (without spring)
LC . A...6X...; LC . B...6X...	80 ... 100		150 ... 1200	–	–	
LFA . D-7X...; LFA . H-7X...	16 ... 63	21010	not relevant	–	–	Observe the reliability characteristic of the pilot control valve
LFA . D-6X...; LFA . H-6X...	80 ... 100					
LFA . G-7X...; LFA . GW.-7X...; LFA . KW.-7X...	16 ... 63	21010	not relevant	–	–	
LFA . G-6X...; LFA . GW.-6X...; LFA . KW.-6X...	80 ... 100					
LFA . WE.-7X...; LFA . WEM.-7X...; LFA . WECA-7X...	16 ... 63	21010	not relevant	–	–	
LFA . WE.-6X...; LFA . WE.8-6X...; LFA . WEA9-6X...	80 ... 100					
LFA . E-7X...QM...; LFA . EH2-7X...QM...; LFA . EW-7X...QM...	16 ... 63	21010	150 ... 1200	QM	CA, CB	The closed position is the safe spool position

**2-way cartridge valves: Active logics**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
LC2A . D.-1X...; LC2A . A.-1X...; LC2A . B.-1X...	16 ... 100	21040	150 ... 1200	optional Q7	–	Cracking pressure "00" (without spring)

Explanation of the footnotes see page 10.

Further MTTF<sub>D</sub> values for products and special versions not listed here upon request.

**2-way cartridge valves: Pressure function**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
LC . DB ..7X...	16 ... 63	21050	150 ... 1200	–	–	Cracking pressure "00" (without spring)
LC . DB ..6X...	80 ... 100	21050	150 ... 1200	–	–	
LC . DR ..7X...	16 ... 63	21050	150 ... 1200	–	–	
LFA . DB.-7X...; LFA . DBW.-7X...; LFA . DBWD.-7X...	16 ... 63	21050	150 ... 1200	–	–	With pressure relief valve type DBD
LFA . DBS.-7X...	40 ... 63	21050	150 ... 1200	–	–	
LFA . DBEM-7X...	16 ... 40	21050	–	–	–	Observe the reliability characteristic of the pilot control valve
LFA . DB.-6X...; LFA . DBW.-6X...; LFA . DBWD.-6X...; LFA . DBS.-7X...	80 ... 100	21050	150 ... 1200	–	–	With pressure relief valve type DBD
LFA . DBE-7X...	16 ... 40	21050	–	–	–	Observe the reliability characteristic of the pilot control valve
LFA . DR.-7X...; LFA . DRW.-7X...	16 ... 50	21050	150 ... 1200	–	–	With pressure relief valve type DBD

**Explanation of the footnotes see page 10.**

**Further MTTFD values for products and special versions not listed here upon request.**

## Isolator valves

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
MS-R...-1X...	6 ... 32	20380	150 ... 1200	-	-	-
S...-1X...	6 ... 30	20378	150 ... 1200	-	-	-
SV 6 ..-6X...; SL 6 ..-6X...	6	21460	150 ... 1200	-	-	-
SV . ...-4X...; SL . ...-4X	10 ... 32	21468	150 ... 1200	optional QM	-	-
Z2S 6 ..6X...	6	21548	150 ... 1200	-	-	Only mutual load of channel A and B with max. operating pressure 315 bar
Z2S 10 ...-3X...	10	21553	150 ... 1200	-	-	-
Z2S 16 ...-5X...	16	21558	150 ... 1200	-	-	-
Z2S 22 ...-5X...	22	21564	150 ... 1200	-	-	-
SFA ...-3X...	50, 63	20485	150 ... 1200	-	-	-

## Pressure valves

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/ limitations
DBD...1X...	6 ... 30	25402	150 ... 1200	-	-	-
Z.DB 6 D..-2X...	6	25771	150 ... 1200	-	-	-
Z.DB 10 D..-2X...	10	25774	150 ... 1200	-	-	-
DB...5X...	10 ... 32	25802	75 ... 600	-	-	-
DBW.. A...5X...			60 ... 480	-	< 15 g/11 ms <sup>4)</sup>	-
DBW.. B...5X...			100 ... 800	-	< 15 g/11 ms <sup>4)</sup>	-
DBET(E)-6X...	6	29162	150 ... 1200	-	-	Switch off "OBE" voltage supply
DBEM(E)... -7X...	10 ... 32	29361	75 ... 600	-	-	Switch off "OBE" voltage supply
DR 6 DP.-5X...	6	26564	150 ... 1200	-	-	-
ZDR 6 D..-4X...	6	26570	150 ... 1200	-	-	-
3DREP(E) 6 .-2X...	6	29184	150 ... 1200	-	< 9 g <sup>4)</sup>	Switch off "OBE" voltage supply
(Z)DRE 6 ..-1X...	6	29175	150 ... 1200	-	-	-
Z3DR 6 VP.-1X...	6	26871	75 ... 600	-	-	-
Z3DR 10 V..-1X...	10	26874	75 ... 600	-	-	-
ZDRE(E) 10 VP2-2X...	10	29279	150 ... 1200	-	-	Switch off "OBE" voltage supply
DRE(M)(E) . -6X...	10, 25	29276	75 ... 600	-	-	Switch off "OBE" voltage supply

Explanation of the footnotes see page 10.

Further MTTF<sub>D</sub> values for products and special versions not listed here upon request.



**Flow control valves**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/limitations
Z2FS 10 ..-3X/...	10	27518	150 ... 1200	–		–

**Pressure switches and sensors**

Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	B <sub>10D</sub> value in million switching cycles	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/limitations
HED 5 ..-3X...	–	50056	–	8	–	–	For max. 24 V and max. 5 mA, otherwise B <sub>10D</sub> = 3 m switching cycles
HED 8 ..-2X...	–	50061	–	10	–	–	For max. 24 V and max. 5 mA, otherwise B <sub>10D</sub> = 4 m switching cycles
HEDE 10 A1-3X...	–	30277	258	–	–	–	At 40 °C; most unfavorable case according to EN ISO 13849: MTTF <sub>D</sub> = 26 years
HEDE 11 A1-1X...	–	30279	1026	–	–	–	At 40 °C; most unfavorable case according to EN ISO 13849: MTTF <sub>D</sub> = 103 years
HM 20 -2X/.C...	–	30272	2388	–	–	–	At 40 °C; most unfavorable case according to EN ISO 13849: MTTF <sub>D</sub> = 239 years
HM 20 -2X/.H...	–	30272	2258	–	–	–	At 40 °C; most unfavorable case according to EN ISO 13849: MTTF <sub>D</sub> = 226 years
DSM1-10-1X...	–	30267	75	–	–	–	–

**Inductive position switches**


Type	NG	Data sheet	MTTF <sub>D</sub> value in years <sup>1)</sup>	Spool position monitoring <sup>2)</sup>	Admissible spool designs <sup>3)</sup> ; Maximum longitudinal spool acceleration	Exceptions/limitations
QM	–	24830, 21015	570	–	–	At 40 °C
QR	–	24830	228	–	–	At 40 °C
Q6	–	21015, 21040	310	–	–	At 40 °C
Q7	–	21015, 21040	310	–	–	At 40 °C

Explanation of the footnotes see page 10.

Further MTTF<sub>D</sub> values for products and special versions not listed here upon request.

**Explanation of the footnotes**

- 1) See table on the right.
- 2) Reliability of the position switch see page 9.  
The signal at the position switch must not be used for direct activation of a safety-related control function.
- 3) Spool designs specified here are suitable to be used in safety-related parts of a control system.  
Spool designs not specified here upon request.
- 4) Adequate spool overlap according to EN ISO 13849-2:2012 available under sine-shaped shock and vibration load according to EN 60068-2-27:2009. Observe installation position.
- 5) Use mating connector with installed rectifier.
- 6) Installation drawing R900270193, upon request
- 7) Installation drawing R900277922, upon request

 **Notice:**

According to EN ISO 13849-1:2015, higher MTTF<sub>D</sub> values can be assumed with a limited number of operations per year:

$n_{op}$	MTTF <sub>D</sub>
> 1,000,000	150 years
> 500,000 ... 1,000,000	300 years
> 250,000 ... 500,000	600 years
< 250,000	1200 years

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## Notes

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