

In compliance with:  
**CEN ISO 13849 -1**  
 Safety of machinery, safety related parts of control systems  
 Part 1: general principles for design

**MTTF<sub>d</sub> AI Series**

Mean time to dangerous failure for Castell AI Series mechanical access interlocks:

**= 11,363.64 years**

and therefore the average probability of a dangerous failure per operating hour

**= 5.00 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{cycle}$ , mean time between two successive cycles	3600 seconds (i.e. one cycle per hour).
$h_{op}$ , mean operation in hours per day	1 shift x 8 hours.
$d_{op}$ , mean operation in days per year	220 days.
$n_{op} = (d_{op} \times h_{op} \times 3600) / t_{cycle}$	1,760 mean annual operations.
$B10_d$ , no. cycles until 10% of components fail dangerously	2,000,000 cycles.
$MTTF_d = B10_d / (0.1 \times n_{op})$	11,363.64 years.
$\lambda_d = (0.1 \times n_{op}) / (B10_d \times 220 \times 8)$	5.00 E-08 per operating hour.

Signed



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### MTTF<sub>d</sub> AIS Hercules Series

Mean time to dangerous failure for Castell AIS Hercules Series access interlocks with safety switch:

**= 6,250 years**

and therefore the average probability of a dangerous failure per operating hour

**= 9.09 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

t<sub>cycle</sub>, mean time between two successive cycles

h<sub>op</sub>, mean operation in hours per day

d<sub>op</sub>, mean operation in days per year

n<sub>op</sub> = (d<sub>op</sub> x h<sub>op</sub> x 3600) / t<sub>cycle</sub>

B10<sub>d</sub>, no. cycles until 10% of components fail dangerously

MTTF<sub>d</sub> = B10<sub>d</sub> / (0.1 x n<sub>op</sub>)

$\lambda_d$  = (0.1 x n<sub>op</sub>) / (B10<sub>d</sub> x 220 x 8)

3600 seconds (i.e. one cycle per hour).

1 shift x 8 hours.

220 days.

1,760 mean annual operations.

1,100,000 cycles.

6,250 years.

9.09 E-08 per operating hour.

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**MTTF<sub>d</sub> BEMF Series**

Mean time to dangerous failure for Castell BEMF Series movement sensing interlocks:

**= 154.5 years**

and therefore the average probability of a dangerous failure per operating hour

**= 8.69565 E-07 ( $\lambda_d$ )**

- ≡ Performance Level d (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 2 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{\text{cycle}}$ , mean time between two successive cycles	3600 seconds (i.e. one cycle per hour).
$h_{\text{op}}$ , mean operation in hours per day	1 shift x 8 hours.
$d_{\text{op}}$ , mean operation in days per year	220 days.
$n_{\text{op}} = (d_{\text{op}} \times h_{\text{op}} \times 3600) / t_{\text{cycle}}$	1,760 mean annual operations.
$B10_d$ , no. cycles until 10% of components fail dangerously	115,000 cycles.
$MTTF_d = B10_d / (0.1 \times n_{\text{op}})$	154.5 years.
$\lambda_d = (0.1 \times n_{\text{op}}) / (B10_d \times 220 \times 8)$	8.69565 E-07 per operating hour.

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**MTTF<sub>d</sub> X, Y, Z, B and W Series**

Mean time to dangerous failure for Castell X, Y, Z, B and W Series key exchange units:

**= 11,363.64 years**

and therefore the average probability of a dangerous failure per operating hour

**= 5.00 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{cycle}$ , mean time between two successive cycles	3600 seconds (i.e. one cycle per hour).
$h_{op}$ , mean operation in hours per day	1 shift x 8 hours.
$d_{op}$ , mean operation in days per year	220 days.
$n_{op} = (d_{op} \times h_{op} \times 3600) / t_{cycle}$	1,760 mean annual operations.
$B10_d$ , no. cycles until 10% of components fail dangerously	2,000,000 cycles.
$MTTF_d = B10_d / (0.1 \times n_{op})$	11,363.64 years.
$\lambda_d = (0.1 \times n_{op}) / (B10_d \times 220 \times 8)$	5.00 E-08 per operating hour.

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**MTTF<sub>d</sub> KS Series (63 to 250 amps)**

Mean time to dangerous failure for Castell KS electrical switch interlocks:

**= 9,090.91 years**

and therefore the average probability of a dangerous failure per operating hour

**= 6.25 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{\text{cycle}}$ , mean time between two successive cycles	3600 seconds (i.e. one cycle per hour).
$h_{\text{op}}$ , mean operation in hours per day	1 shift x 8 hours.
$d_{\text{op}}$ , mean operation in days per year	220 days.
$n_{\text{op}} = (d_{\text{op}} \times h_{\text{op}} \times 3600) / t_{\text{cycle}}$	1,760 mean annual operations.
$B10_d$ , no. cycles until 10% of components fail dangerously	1,600,000 cycles.
$MTTF_d = B10_d / (0.1 \times n_{\text{op}})$	9,090.91 years.
$\lambda_d = (0.1 \times n_{\text{op}}) / (B10_d \times 220 \times 8)$	6.25 E-08 per operating hour.

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**MTTF<sub>d</sub> KS Series (to 63 amps)**

Mean time to dangerous failure for Castell KS electrical switch interlocks:

**= 39,772.7 years**

and therefore the average probability of a dangerous failure per operating hour

**= 1.42857 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{\text{cycle}}$ , mean time between two successive cycles

$h_{\text{op}}$ , mean operation in hours per day

$d_{\text{op}}$ , mean operation in days per year

$n_{\text{op}} = (d_{\text{op}} \times h_{\text{op}} \times 3600) / t_{\text{cycle}}$

$B10_d$ , no. cycles until 10% of components fail dangerously

$MTTF_d = B10_d / (0.1 \times n_{\text{op}})$

$\lambda_d = (0.1 \times n_{\text{op}}) / (B10_d \times 220 \times 8)$

3600 seconds (i.e. one cycle per hour).

1 shift x 8 hours.

220 days.

1,760 mean annual operations.

7,000,000 cycles.

39,772.7 years.

1.42857 E-08 per operating hour.

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**MTTF<sub>d</sub> KSS Series**

Mean time to dangerous failure for Castell KSS Series solenoid controlled switch interlocks:

**= 25,568.18 years**

and therefore the average probability of a dangerous failure per operating hour

**= 2.22 E-08 ( $\lambda_d$ )**

- ≡ Performance Level e (CEN ISO 13849 -1, Table 3)
- ≡ Safety Integrity Level 3 (CEN ISO 13849 -1, Table 4)
- ≡ MTTF<sub>d</sub> denotation HIGH (CEN ISO 13849 -1, Table 5)

Calculation data assumptions (CEN ISO 13849 -1, Annex C):

$t_{cycle}$ , mean time between two successive cycles	3600 seconds (i.e. one cycle per hour).
$h_{op}$ , mean operation in hours per day	1 shift x 8 hours.
$d_{op}$ , mean operation in days per year	220 days.
$n_{op} = (d_{op} \times h_{op} \times 3600) / t_{cycle}$	1,760 mean annual operations.
$B10_d$ , no. cycles until 10% of components fail dangerously	4,500,000 cycles.
$MTTF_d = B10_d / (0.1 \times n_{op})$	25,568.18 years.
$\lambda_d = (0.1 \times n_{op}) / (B10_d \times 220 \times 8)$	2.22 E-08 per operating hour.

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