P

P
→ *risk parameter* used in risk graphs (→ *risk graph*) und referred to as → *P1* and → *P2,* it describes the possibility to avoid the consequences of dangerous failures.
DIN IEC 61511-3 (VDE 0810):2004

P1
one of the specifications of the → *risk parameter* P used in risk graphs (→ *risk graph*) describing that it is possible under certain conditions to avoid the consequences of dangerous events.
DIN IEC 61511-3 (VDE 0810):2004

P2
one of the specifications of the → *risk parameter* P used in risk graphs (→ *risk graph*) describing that it is almost impossible to avoid the consequences of dangerous events.
DIN IEC 61511-3 (VDE 0810):2004

parallel system
Figure 19 represents the reliability block diagram for a parallel system.

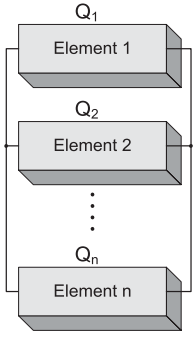

Figure 19: Parallel System

A parallel system has completely failed if all components failed. The → *life time T* of a parallel system is equal to that of the component operating for the longest period and is expressed by:

$$T = T_{(n)} = \max(T_1, T_2, ..., T_n).$$

The probability distribution $T_{(n)}$ can be determined by:

$$P\{T_{(n)} \le t\} = \Phi_n(t) = F_1(t) \cdot F_2(t) \cdot ... \cdot F_n(t)$$

The → *reliability function* of a parallel system with *n* components can be calculated as follows:

$$R_r(t) = 1 - \prod_{i=1}^{n} [1 - F_i(t)]$$

VDI 4009-5:1985-02

Additional important parameters in connection with a parallel system are: → *reliability function, for a parallel system* and → *mean time to failure, parallel system,* to compare with → *series system*

parameter
variable or → *statistic*

- ~ *of stochastics* pertaining to the probability distribution.
VDI 4001-2:2006-07
- *application-related* ~ refers to the survival for the (individual) application such as the application failure rate or application reliability.
VDI 4004-2:1986-08
- *operation-related* ~ designates the survival for the → *operating time* (duration) such as the operating failure rate or → *operational reliability.*
VDI 4004-2:1986-08
- *standby-related* ~ refers to the survival under standby or reserve conditions such as standby failure rate, standby reliability.
VDI 4004-2:1986-08
- *storage-related/non-operation-related* ~ refers to the survival under storage conditions or non-operational conditions such as → *storage failure rate*, → *storage reliability*.
VDI 4004-2:1986-08

partial risk
the overall risk R can be expressed as the sum of the partial risks R_a and these as the product of H_a and S_a:

$$R = \sum_a R(a) = \sum_a H(a) \cdot S(a),$$

where a is an index identifying one of the n possible risk events, $H(a)$ is the frequency of a risk event and $S(a)$ is the expected → *harm*.
VDI/VDE 3542-2:2000
See also → *risk*

parts count method
simple procedure for determining the $MTTF_d$ for each channel or module and consisting in adding the individual $MTTF_d$ values of all components which are part of that → *module* or → *channel*. The general formula is:

$$\frac{1}{MTTF_d} = \sum_{i=1}^{\tilde{N}} \frac{1}{MTTF_{di}} = \sum_{j=1}^{\tilde{N}} \frac{n_j}{MTTF_{dj}}$$

where $MTTF_d$ refers to the complete channel or module and $MTTF_{di}$, $MTTF_{dj}$ are the values for each component contributing to the → *safety function*. Both sums are equivalent, but the first is over each component separately and the second has all n_j components with identical $MTTF_{dj}$ grouped together.
DIN EN ISO 13849-1:2007-07

PC
paired comparison

PCS
process control system (→ *process control engineering*). The following faults and parameters are typical for a PCS:
– *active faults* → *fault, active*
– common-cause failures → *failure, common cause; → common cause failure*
– common-mode failures → *failure, common mode*
– down time → *down time*
– failure *rate* → *failure rate*
– failures → *failure*
– *faults* → *fault*.
– *fault avoidance* → *fault avoidance*
– *fault containment* → *fault containment*
– *fault detection time* → *fault detection, time*
– *systematic faults* → *fault, systematic*
– *passive faults* → *fault, passive*
– *proof test* → *proof test*
– proof test interval → *proof test interval; → T1, → test interval calculation*
– proven-in-use → *proven-in-use*
– *random faults* → *fault, random*
– *self-signalling faults* → *fault, self-signalling*
– *software faults* → *fault, software*
– time between failures → *time between failures*

PDCA
plan-do-check-act is a four-step problem-solving process used in business process improvement.

PDS
pre-developed software.

PE
→ *programmable electronics*

peak voltage
• *recurring* ~ peak value of a generated voltage that recurs in given intervals

performance capacity
the physical and mental state of human beings including their individual disposition and motivation to complete a task.
VDI 4006-1:2002-11

performance level
specifies the probability of a dangerous failure per hour and describes the capability of a (safety-related) system to perform a safety

function under given conditions. The performance level is divided into five categories (levels) such as depicted in Figure 20. DIN EN ISO 13849-1:2007-07

Performance Level	Average probability of a dangerous failure per hour
a	$\geq 10^{-5}$ to $< 10^{-4}$
b	$\geq 3 \cdot 10^{-6}$ to $< 10^{-5}$
c	$\geq 10^{-6}$ to $< 3 \cdot 10^{-6}$
d	$\geq 10^{-7}$ to $< 10^{-6}$
e	$\geq 10^{-8}$ to $< 10^{-7}$
In addition to the average probability of a dangerous failure, further measures are required to achieve a PL.	

Figure 20: Performance Levels

permanent installation

→ *installation, permanent*

PES

→ *programmable electronic system*, → *E/E/PES*

PFD

→ *probability of failure on demand*

PFDavg determination

if limit values are exceeded, messages or alarms can be blocked by passive faults. In accordance with VDI/VDE 2180-4:2007-04, only dangerous undetected faults λ_{DU} must be taken into account. In most cases, the formulas specified below are sufficient. VDI/VDE 2180-4:2007-04 recommends the following pragmatic approach for calculating the PFD_{avg}: input (sensors), logic solver (processing) and output (actuators) are considered separately. First, each individual component among the sensors is defined, then each λ_{DU} and T_i is calculated to determine the individual PFD values. After this step, the PFD value for all the sensors is calculated by adding the individual PDF values:

$$PFD_S = \sum PFD_{S_i}$$

Proceed in the same way to calculate the actuators such that the PFD value for the actuators results from:

$$PFD_{FE} = \sum PFD_{FE_i}$$

The type of logic solver must be defined to be able to calculate λ_{DU} and T_i, and then to determine the PFD_L value (see → PFD_{avg}, *approximation formulas*). Finally, the PFD_{avg} value of the safety-related system can be determined by adding the individual PFD values.

$$PFD_{avg} = PFD_S + PFD_L + PFD_{FE}$$

As an alternative, the PFD_{avg} can also be determined using the safety-related availability (→ *availability, safety-related*) for a system V_S.

$$PFD_{avg} = 1 - V_S$$

VDI/VDE 2180-4:2007-04

– *approximation formulas* the following formulas are based on DIN EN 61508-6 (VDE 0803):2001 and can be used for estimating the PFD_{avg} values of various systems.

$$PFD_{1001} \approx \frac{1}{2}\lambda_{DU}T_I$$

$$PFD_{1002} \approx \frac{\lambda_{DU}^2 T_I^2}{3} + \beta \cdot \frac{1}{2}\lambda_{DU}T_I$$

$$PFD_{1003} \approx \frac{\lambda_{DU}^3 T_I^3}{4} + \beta \cdot \frac{1}{2}\lambda_{DU}T_I$$

$$PFD_{1004} \approx \frac{\lambda_{DU}^4 T_I^4}{5} + \beta \cdot \frac{1}{2}\lambda_{DU}T_I$$

$$PFD_{2002} \approx \lambda_{DU}T_I$$

$$PFD_{2003} \approx \lambda_{DU}^2 T_I^2 + \beta \cdot \frac{1}{2}\lambda_{DU}T_I$$

$$PFD_{2004} \approx \lambda_{DU}^3 T_I^3 + \beta \cdot \frac{1}{2}\lambda_{DU}T_I$$

β refers to the portion of failures simultaneously affecting multiple channels (→ *failure, common cause*)

Usually, when common cause failures are examined, the failures with independent