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Content Based
Chemical Engineering

FAILURE RATE - RELIABILITY - FAILURE PROBABILITY

risk assessment of components and systems

BASIS: CHEMICAL PROCESS SAFETY, FUNDAMENTALS with APPLICATIONS, by Daniel A. Crowl & Joseph F. Louvar; ISBN 0-13-129701-5

NOTE: Always begin a new case by retrieving the original file. Direct entry of data in cells that originally contain table lookups could cause functions to be lost, or incorrect calculations. I format cells requiring entry colored RED; calculated values are black.

1.) Enter the system, reference for calculation at [C5].

2.) Enter up to (6) components in parallel or series configuration at [B9:B14] or [B20:B25]. For components not listed in the lookup table [A48:A131] enter the name and its failure rate μ.

3.) The "combined" parallel or series failure rate, reliability, failure probability, and mean time between failures for each category are calculated and shown at row 15 for parallel and row 26 for series components.

4.) The combined unrevealed failure rate is shown at C29.

5.) Enter any "downtime" for inspections, calibration etc. at [C30]. Eight hours per year would be entered as =8/2080 the corresponding average unavailability and availability are shown at [C32] and [G32].

6.) The (MTBC) Mean Time Between Coincidence; unavailability during a process upset can be calculated by inputting the rate of process episodes Pd at [C37]. And the time interval (year) at [C38]. Using the previously determined unavailability the MTBC is shown at [D45].

NOTE: TO USE FOR COMBINED SYSTEMS, eg. two Parallel groupings in series with each other determine the parallel result, enter the totals for each in the Series section, then utilize the resulting total.

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Failure Rate - Reliability - Failure Probability
risk assessment of components and systems

SYSTEM: Example

parallel

	component	failures/yr. μ	reliability $R = e^{-mt}$	failure probability P = 1 - R	mean time between failures MTBF
1:	pressure switch	0.1400	0.869	0.13064	7.14
2:	solenoid valve	0.4200	0.657	0.34295	2.38
3:		0.0000			
4:		0.0000			
5:		0.0000			
6:		0.0000			
	total	0.0458	0.955	0.04480	21.82

series

	component	failures/yr. μ	reliability $R = e^{-mt}$	failure probability P = 1 - R	mean time between failures MTBF
1:	pressure switch	0.1400	0.869	0.131	7.14
2:	indicator lamp	0.0440	0.957	0.043	22.73
3:		0.0000			
4:		0.0000			
5:		0.0000			
6:		0.0000			
	total	0.184	0.832	0.168	5.43

unrevealed failures

μ = 0.230 faults/yr
= 0.083 yr (insp period, 0.083 = 1/month)

$U = 0.5 * \mu * \tau_i$ = 0.0095 unavailability A = 1 - U = 99.046% availability

Mean time between coincidence (MTBC)

Pd = 2.000 rate of process episodes
Ti = 1.000 time interval (yr)

λ = Pd/Ti = 2.000 process episode frequency

λd = λ * U = 0.01908 avg freq of dangerous coincidences

$$MTBC := \frac{1}{\lambda_d} = 52.420 \text{ years}$$

component	faults/yr
annunciators	0.00647
battery chargers	0.06384
batteries, lead acid	0.0189
batteries, nickel cadmium	0.00211
circuit breakers - AC	0.0147
circuit breakers - DC	0.03192
compressor	12.012
compressor (elec. driver)	20.748
computational module (pneu	0.16296
controller	0.29
controller elec single loop	1.722
control valve	0.6
conveyor (screw)	7.9128
fan (motor driven)	0.07636
fire detection system	0.00958
fire suppression sys. (dry)	0.01184
fire suppression sys. (wet)	0.08114
flame detector	3.6288
flow measure (fluids)	1.14
flow measure (solids)	3.75
flow switch	1.12
fuses	0.00533
gas - liq chromatograph	30.6
generator, emergency diesa	18.9
hand valve	0.13
heat exchanger (shell&tube	0.26124
hose (flexible)	0.00479
indicator lamp	0.044
indicator temperature	2.0832
inverters	0.24108
level measure (liquids)	1.7
level measure (solids)	6.86
motors, AC	0.12768
motors, AC induction	0.02688
motors, DC	0.189
oxygen analyzer	5.65
pH meter	5.88
pipe connection (metal)	0.00479
pipe (plastic)	0.00743
pipe (lined)	0.00371
pipe (metal)	0.00023
pressure measurement	1.41
pressure relief valve	0.022
pressure switch	0.14
pump (motor driven-cent.)	2.4528
pump (turbine driven)	0.74844
recorders	0.21084
relays, protective	0.01604
safety valve (spring-type)	0.01411
solenoid valve	0.42
stepper motor	0.044
strip chart recorder	0.22
switches elec flow	0.22512
switches elec level	0.01462
switches elec pressure	0.41664
switches elec temperature	0.02856
switches elec speed	0.00403
switches pneu/flow	0.0336
switches pneu/level	0.00521
switches pneu/pressure	0.04368
switches pneu/temperature	0.042
thermocouple temp. measu	0.52
thermometer temp. measu	0.027
transducer-current to pneu	0.52752
transformer, power	0.02125
transformer, retifier	0.00899
trans elec capacitance prob	0.21084
transmitter delta pressure	1.8312
trans. pneu flow ëP	0.9912
trans. pneu flow vari. area	0.80892
transmitter pneu level ëP	0.83496
transmitter pne level float	1.5708
transmitter pneu pressure	0.76692
transmitter temperature	0.8148
valve (manual check)	0.02671
valve (manual hand)	0.00128
valve (motor operated)	0.01142
valve (pneumatic operated)	0.03016
valve positioner	0.44
valve (solenoid operated)	0.40908
vessel (atmos metallic)	0.00827
vessel (atmos non-metallic)	0.01016
vessel (pressure-metallic)	9.2E-05