Failure Rate Data

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Data for Risk Analysis

- Probability of Occurrence for events
- Probability of Failure for components failure
- Failure rates / Probability of failure on demands etc
- Types of data: Technical data, Operational data, Accident data, Hazards data, Reliability data, Maintenance data, Exposure data, Environment data, Stakeholders data, etc

Accidents & Incidents Database

- **Major Accident Reporting System, MARS (EU Seveso Directives, 1996; operated by Major Hazards Bureau, Italy)**

- **Process Safety Incident Data base, PSID (operated by CCPS, USA)**

- **Incident Reporting System, IRS (nuclear power plants, operated by IAEA, Vienna)**

- **The *Aviation Accident Database (*operated by the U.S. National Transport Safety Board)**

- ***International Road Traffic and Accident Database (IRTAD)* was established in 1988 as part of the OECD Road Transport Research Program**

- ***World Offshore Accident Database (WOAD)* since 1975. (operated by Det Norske Veritas, DNV)**

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Accidents & Incidents Database (cont'd)

- Investigation reports of U.S. Chemical Safety Board

- Reporting of injuries, diseases and dangerous occurrence, RIDDOR (UK HSE)

- *Common-Cause Failure Data Base (CCFDB)* is a data collection and analysis system operated by the U.S. Nuclear Regulatory Commission (NRC)

- *European Industry Reliability Data (EIReDA)* gives failure rate estimates for components in nuclear power plants operated by EDF in France.

- *ReliabilityandAvailahilityDataSystem(RADS)* wasdevelopedbytheU.S.Nuclear Regulatory Commissio'n (NRC)3

Generic Reliability Databases

- *Process Equipment Reliability Database (PERD)* is operated by the Center for Chemical Process Safety of AIChE

- *Electronic Parts Reliability Data (EPRD)* is available from the Reliability Informa- tion Analysis Center (RIAC).

- *Nonelectronic Parts Reliability Data (NPRD)* is available from the Reliability Infor- mation Analysis Center (RIAC

- *MIL-HDBK-217F, Reliability Prediction of Electronic Equipment,* contains failure rate estimates for the various part types used in electronic systems

- *Offshore Reliability Data(OREDA)* contains data from a wide range of components and systems used in offshore oil and gas installations

- *MechRel* is an open reliability data source developed for mechanical equipment by the Naval Surface Warfare Center.

- *Reliability Data for ,Control and Safety Systems* data handbook has been devel- oped to support reliability assessments of safety instrumented systems that should comply with IEC 61508 (2010).

- *Safety Equipment Reliability Handbook(SERH)* is a handbook in three volumes covering reliability data for safety instrumented systems.

- *IEEE Std. 500* is a handbook providing failure rate estimates for various electrical, electronic, sensing, and mechanical components (IEEE Std. 500, 1984)

Bath Tub Curve
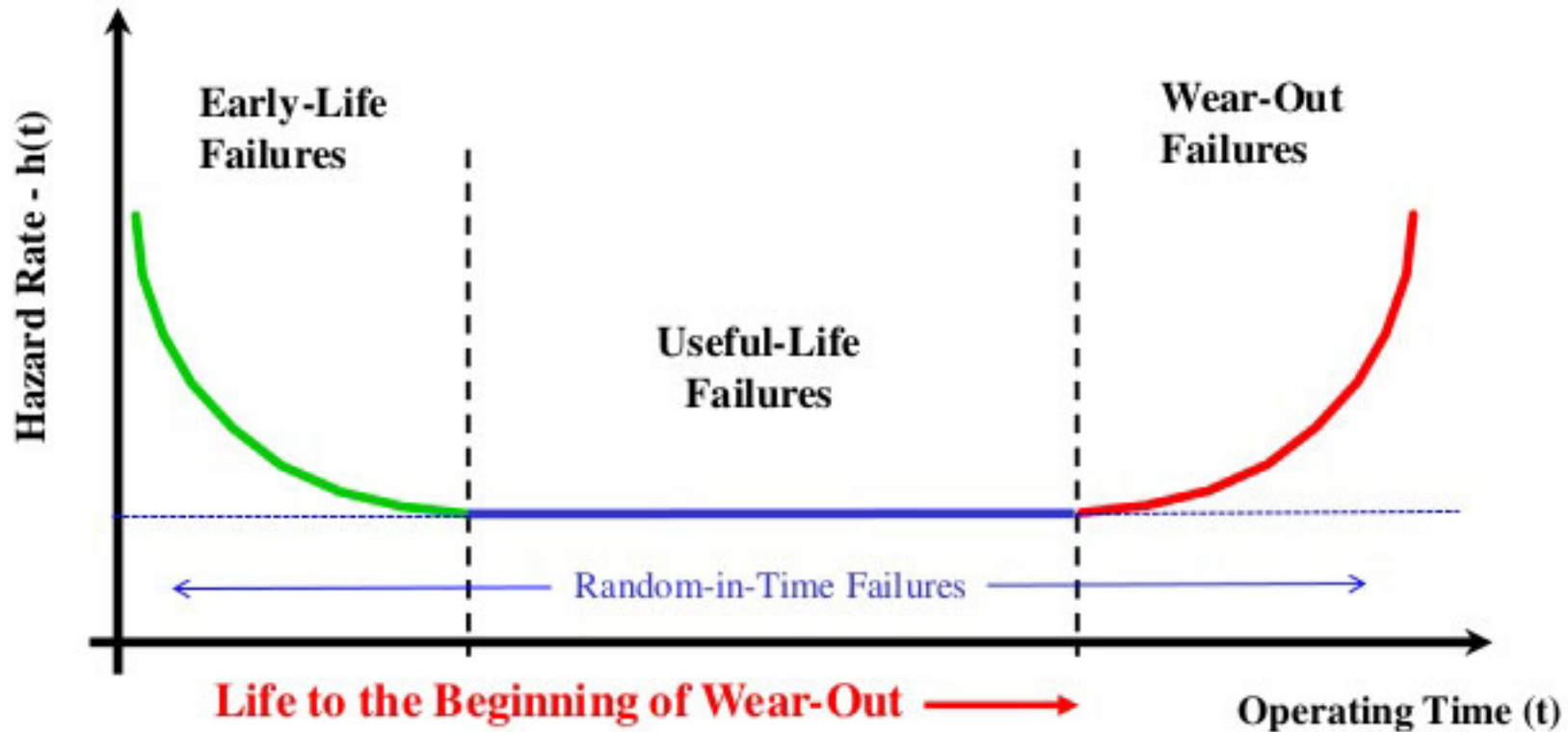
Failure Rate

- It is common to assume that failures occur as homogeneous Poisson process (HPP).

$$\Pr(N(t) = n) = \frac{(\lambda t)^n}{n!} e^{-\lambda t} \quad \text{for } n = 0,1,2...$$

- The mean number of failures during an accumulated time in service t is (expected number of failures):

$$E(N(t)) = \lambda t$$

- The mean number of failures per unit time in operation, or failure rate is

$$\lambda = \frac{N(t)}{t}$$

- So, the failure rate is estimated as

  (observed number of failures)/(accumulated time in service)

Failure Rate (l)

- **Failure rate** is the frequency with which an engineered system or component fails, expressed, for example, in failures per hour.

- It is often denoted by the Greek Letter λ (lambda) and is important in reliability engineering

- The failure rate of a system usually depends on time, with the rate varying over the life cycle of the system.

- Typical Failure rate for control valve is 0.15 yr^{-1}

Example: Control Valve Failure Rate (l)
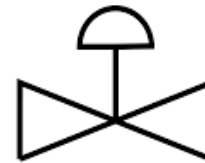
Fail shut	7
Fail open	3
Leak to atmosphere	2
Slow to move	2
Limit switch fails to operate	1
Total	15

Failure Rate (λ)

- Failure rate, which has the unit of t_1, is sometimes expressed as a percentage per 1000 h and sometimes as a number multiplied by a negative power of ten. Examples, having the same value, are:
  - 8.5 per 10^6 hours or **8.5 x 10^{-6} per hour**
  - 0.85 per cent per 1000 hours
  - 0.074 per year
  - 8500 per 10^9 hours (8500 FITS) failure in time, used normally in semiconductor industry

Example: Failure Rate

- Suppose it is desired to estimate the failure rate of a certain component. A test can be performed to estimate its failure rate. Ten identical components are each tested until they either fail or reach 1000 hours, at which time the test is terminated for that component. Let say the total duration is 1 year.

Estimated failure rate is $\dfrac{6 \text{ failures}}{8760 \text{ hours}} = 0.000685 \dfrac{\text{failures}}{\text{hours}} = 6.85 \text{ x } 10^{-4} \dfrac{\text{failures}}{\text{hours}}$

Failure Rates Data

Instrument	Faults/year
Controller	0.2
Control valve	0.15
Flow measurements (fluids)	1.14
Flow measurements (solids)	3.75
Flow switch	1.12
Gas – liquid chromatograph	30.6
Hand valve	0.13
Indicator lamp	0.044
Level measurements (liquids)	1.70
Level measurements (solids)	6.86

Failure Rates Data

Instrument	Faults/year
Oxygen analyser	5.65
pH meter	5.88
Pressure measurement	1.41
Pressure relief valve	0.022
Pressure switch	0.14
Solenoid valve	0.42
Stepper motor	0.044
Strip chart recorder	0.22
Thermocouple temperature meas.	0.52
Thermometer temperature meas.	0.027
Valve positioner	0.44

Examples of Failure Rates Data (Per Hour)

Component	Failure Frequency (hr^{-1})	Component	Failure Frequency (hr^{-1})
Gasket Failure (leak)	1.00×10^{-06}	Pump Seal Failure	8.00×10^{-07}
Gasket Failure (total)	1.00×10^{-07}	Alarm Failure	1.00×10^{-05}
Pipe Rupture (> 3 in)	1.00×10^{-10}	Operator Error	2.00×10^{-05}
Pipe Rupture (< 3 in)	1.00×10^{-09}	Hose Rupture	2.00×10^{-05}
Valve Rupture	1.00×10^{-08}		

Failure Rate Example

Device	Failure rate	Device	Failure rate
Control Valve	0.15 yr^{-1}	Orifice Plate, Flow Switch	0.2 yr^{-1}
Solenoid Valve	0.1 yr^{-1}	Flow Controller	0.1 yr^{-1}
Trip Valve	0.1 yr^{-1}	Flow Transmitter	0.1 yr^{-1}
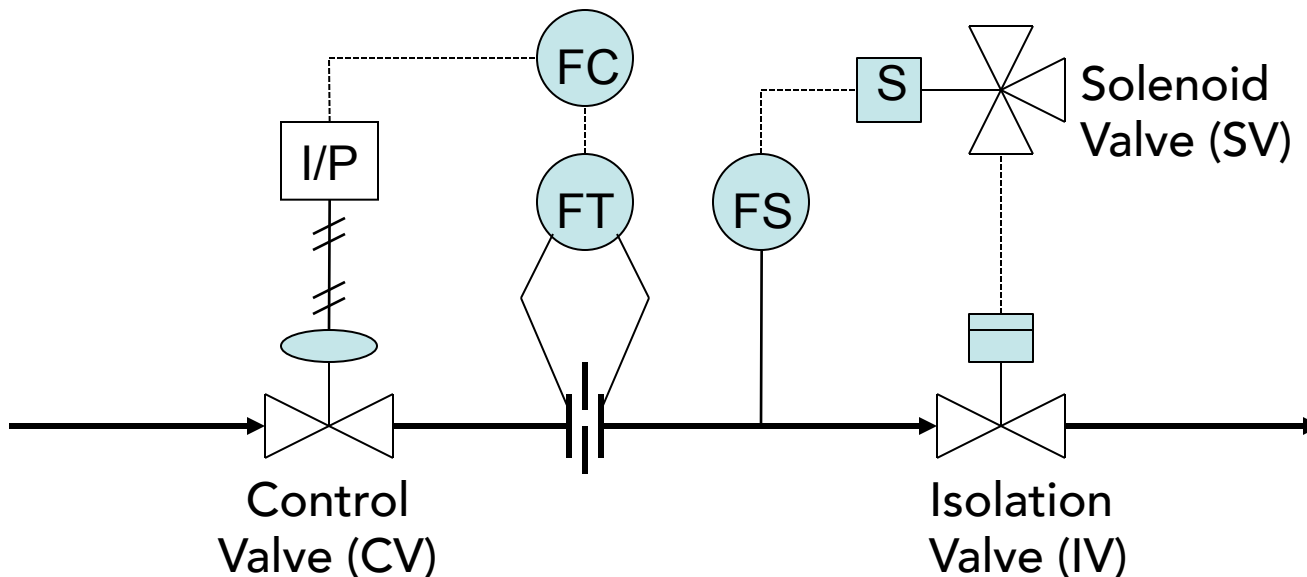
Trip is made up of failure in FS, IV and SV

Total Failure Rate
= 0.2+0.1+0.1
= 0.4 yr^{-1}

What is the failure rate of the flow control Loop ?

Frequency, Reliability and Probability

Component	Failure Rate λ(faults/year)	Reliability $R = \mathrm{e}^{-\lambda t}$	Failure Probability P=1-R
Control Valve	0.6	0.55	0.45
Controller	0.29	0.75	0.25
DP Cell	1.41	0.24	0.76

$$p = 1 - \mathrm{e}^{-\lambda t}$$

where

p is the annual probability of occurrence,

λ is the annual frequency and t is time period (i.e., 1 year).

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Frequency and Probability - Example

Taking the case of gasket failure and assuming that we have 10 gaskets, the annual probability of occurrence is:

$$p = 1 - \exp\left(-\frac{1 \times 10^{-7}}{hr} \left| \frac{8760\ hr}{year} \right| \frac{10}{} \right) = 8.72 \times 10^{-3}\ year^{-1}$$

END OF LECTURE