

Risk assessment: choosing failure rate data

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Essence of accuracy and acceptability of failure rate data in risk assessment

Challenges and the necessity to overcome the uncertainty in the use of failure rate data.

A number of sources are available for data on incident rate, equipment failure rate and equipment reliability e.g. UK's Health and Safety Executive, US Center for Chemical Process Safety. Most of these databases are generic, based on a range of industries, operating modes and failure modes; limitations of some of the databases are - specific to one industrial sector, based over a defined period of years, applicable for particular geographical location of interest, specific to one hazardous material etc.

Challenges in using the data for risk assessment

- Finding the appropriate database suitable for the specific application
- Issues related to the statistical basis of the dataset,
- Issues related to the differences; e.g. like the type of industry
- Understanding the technicalities of the database:
- Criteria to classify and define the sources, failures, failure modes, observation period etc.
- Using the database
- Unknown factors and underlying assumptions
- The need to, and how to, calibrate the available data
- Account for site/industry/corporate specific factors

Definitions

Risk – a mathematical combination of an accident's event probability of occurrence and the consequence of that event should it occur.
Severity – how severe an event could be, is evaluated based on the receptors that could be harmed, considering the potential consequences like thermal radiation, overpressure, toxic effects, reaction, deposition, contamination etc.
Frequency – how frequently an event (release of hazardous substance/energy) could happen and the probability it will result in harm (i.e. the potential consequence).

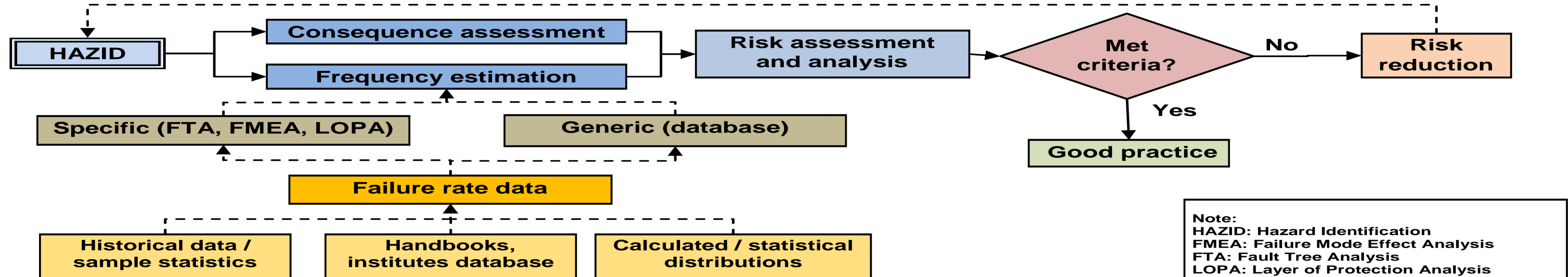
Significance of the use of appropriate data

Affects the risk estimated: The difference in risk estimated for a gasket failure resulting in few injuries using incident rate from five independent data sources is illustrated in the risk matrix:

Frequency per year	Consequence/Severity					Data source	Failure rate (per year)
Probable ($>10^{-2}$)		A				A) Rasmussen report	2.6E-2
Improbable ($10^{-2} < x < 10^{-3}$)		B				B) UKAEA:	4.4E-3 per year
Unlikely ($10^{-3} < x < 10^{-4}$)		C				C) Smith D) Page & Nussey	1.8E-4 4.0E-5
Very unlikely ($10^{-4} < x < 10^{-5}$)		E				E) UK Land Use Planning	5.0E-6
Extremely unlikely ($< 10^{-5}$)							
Risk of injury/fatality	Minor injury	Few serious injuries	Lost time incident	Few fatalities, many injuries	Multiple fatalities	Gasket failure data	

Use of failure rate data in risk assessment

The process involved in risk assessment and how the failure rate data is used in the assessment is illustrated in the flowchart:



Comparing risk estimation for one installation using different set of failure data

Hole size: Risk estimated using three sets of release hole size distributions and illustrated in the graph.
3-10-30-100 => 3mm, 10mm, 30mm, 100mm
5-20-50-100 => 5mm, 20mm, 50mm, 100mm
10-25-50 => 10mm, 25mm, 50mm

Risk estimated for an offshore installation and is compared in terms of

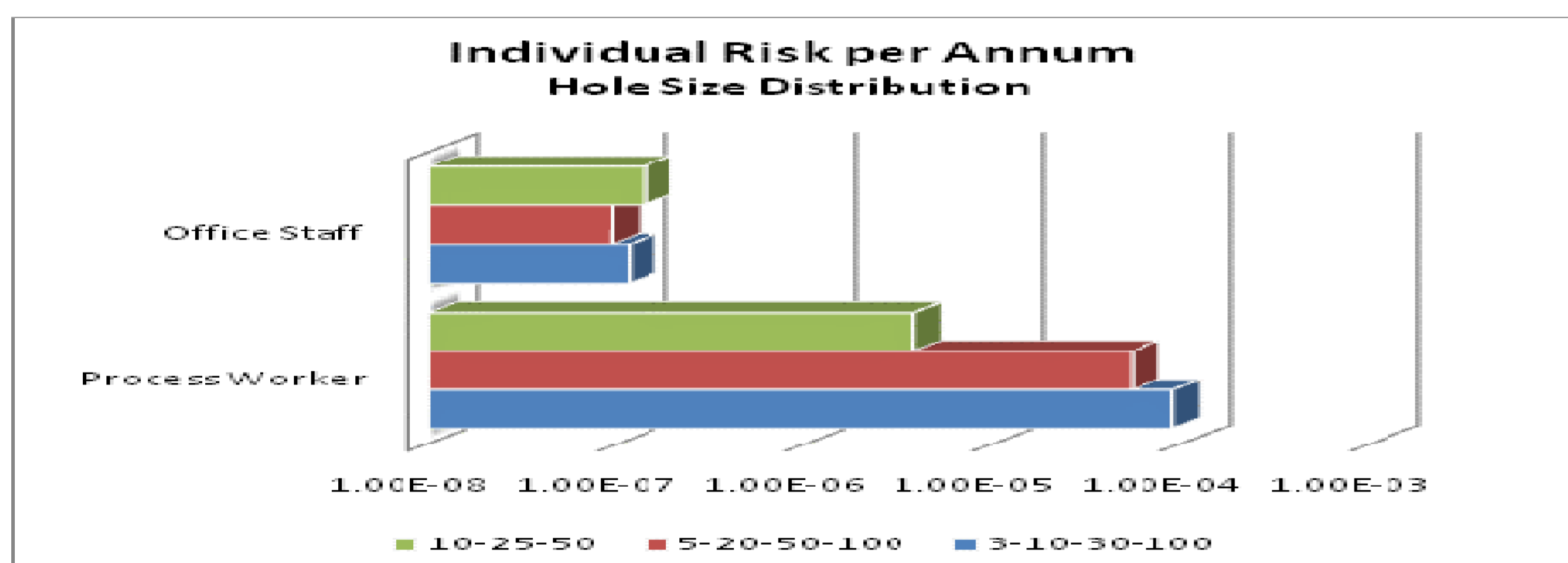
- Potential Loss of Life and
- Individual Risk per Annum

Risk estimation from process related hazards only

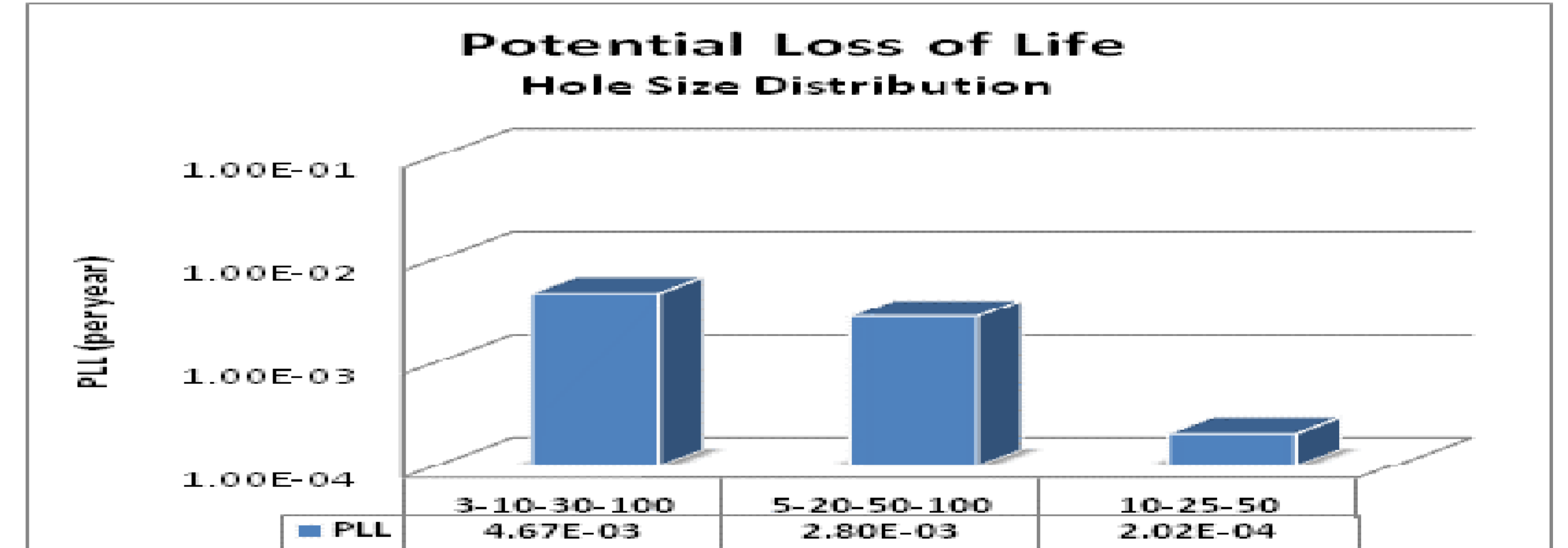
Individual Risk per Annum (IRPA): The chance of an individual becoming a fatality. An IRPA of 1×10^{-3} would mean for each individual, every year, there is a 1 in 1000 chance of a fatal accident. Estimated for two different types of workers

- Process worker – near to process hazards
- Office worker – away from process hazards

Potential Loss of Life (PLL): A measure for societal risk, expected value of the number of fatalities within a specified population (or within a specified area) per annum.



- Highest IRPA estimated for office staff using 10-25-50
- Highest IRPA estimated for process worker using 3-10-30-100



- PLL estimated using 10-25-50 distribution is an order of magnitude less compared to other two hole size distributions
- Highest PLL is for estimation using 3-10-30-100

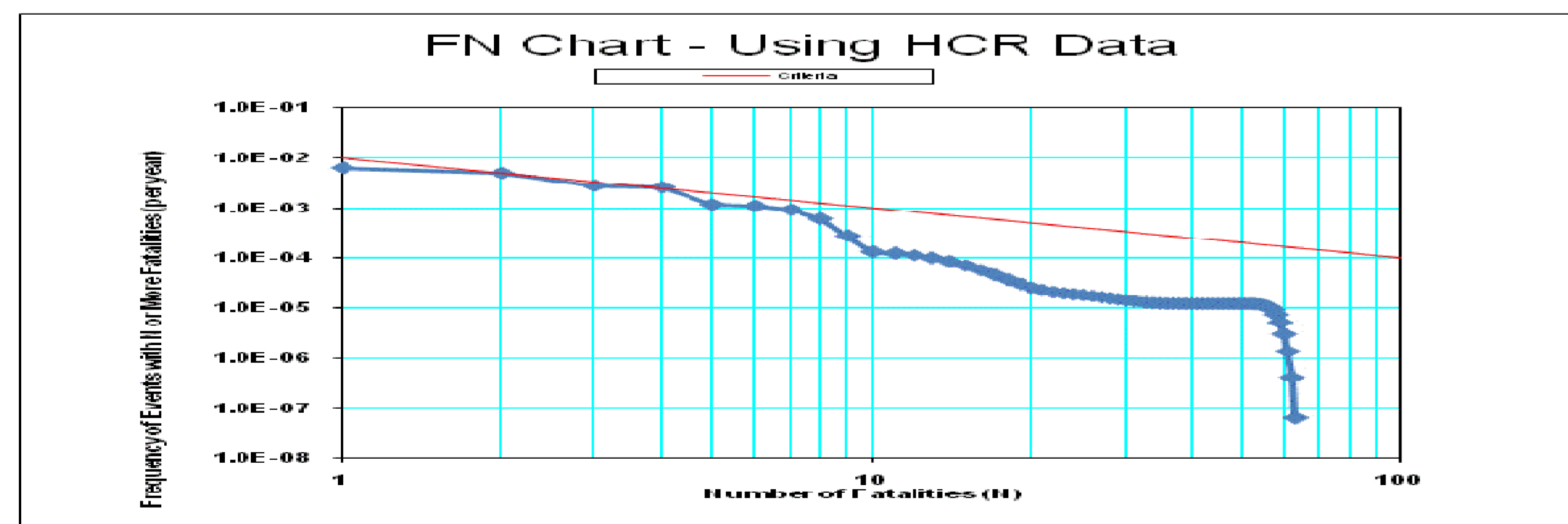
FN curve comparison: Risk estimated using failure rate data from two independent sources is used to plot societal risk (FN Curve) for an offshore installation is compared and illustrated below.

Risk estimated for an offshore installation and has used failure rate data from

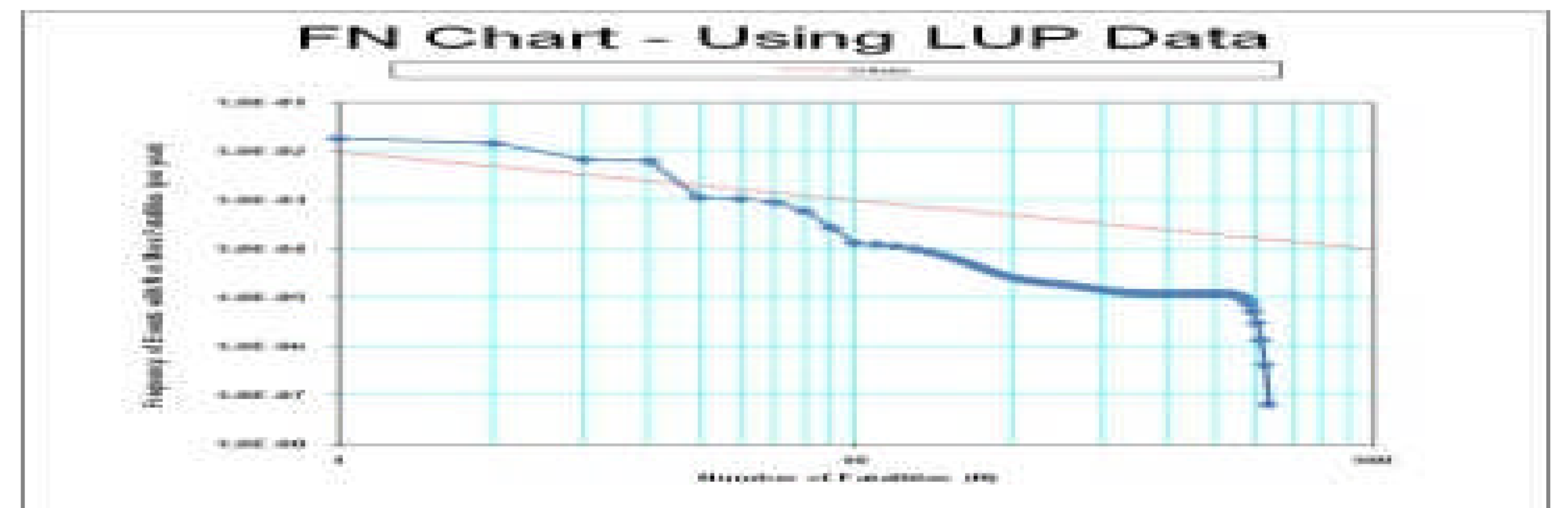
- Hydrocarbon Release Database (HCR) System
- Failure Rate and Event Data (FRED)

HCR – Database system based on all offshore releases of hydrocarbons reported to the UK HSE

FRED – UK HSE recommended data for Land Use Planning risk assessment applications



- Most of the FN curve remains below criteria limit
- This database is more appropriate for Offshore installations



- Estimated risk exceeds criteria limits for up to five fatalities
- This database is more appropriate for offsite risk estimation from onshore hazardous installations

The above examples illustrate that for a hazardous installation, the estimated risk could be different if different sets of failure data is used for frequency estimation.

Conclusion

While performing risk assessment the assessor needs to check the following to ensure that failure rate data are suitable for the purpose:

- Database is current (most up-to-date) and auditable
- Database is suitable and relevant for the particular analysis application.
- Database is developed and maintained from an extensive population (large sample)

Sensitivity analysis shall be performed to identify which data or assumptions are contributing most to the risks. Adequate techniques and data have never been available to produce accurate estimates of absolute risk. Risk analysis efforts should be with the objective of identifying and eliminating or moderating the greatest contributors to risk.