Health and Safety
Executive

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The application of ALARP* and Cost benefit Analysis

* reducing risks as low as is reasonably practicable

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Risk

RISK: The likelihood of *specified* harm arising from one or more hazards within a *specified* period or in *specified* circumstances

NB: Two elements:

a) risk of what (ie consequence eg fatality)

b) how likely

(ie frequency or probability per unit time/ per demand/per operation)

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Who or what is at risk

Risks to Employees

Risks to Public

Risks to Environment

Risks to Plant & Profits

Individual risk

Societal risk

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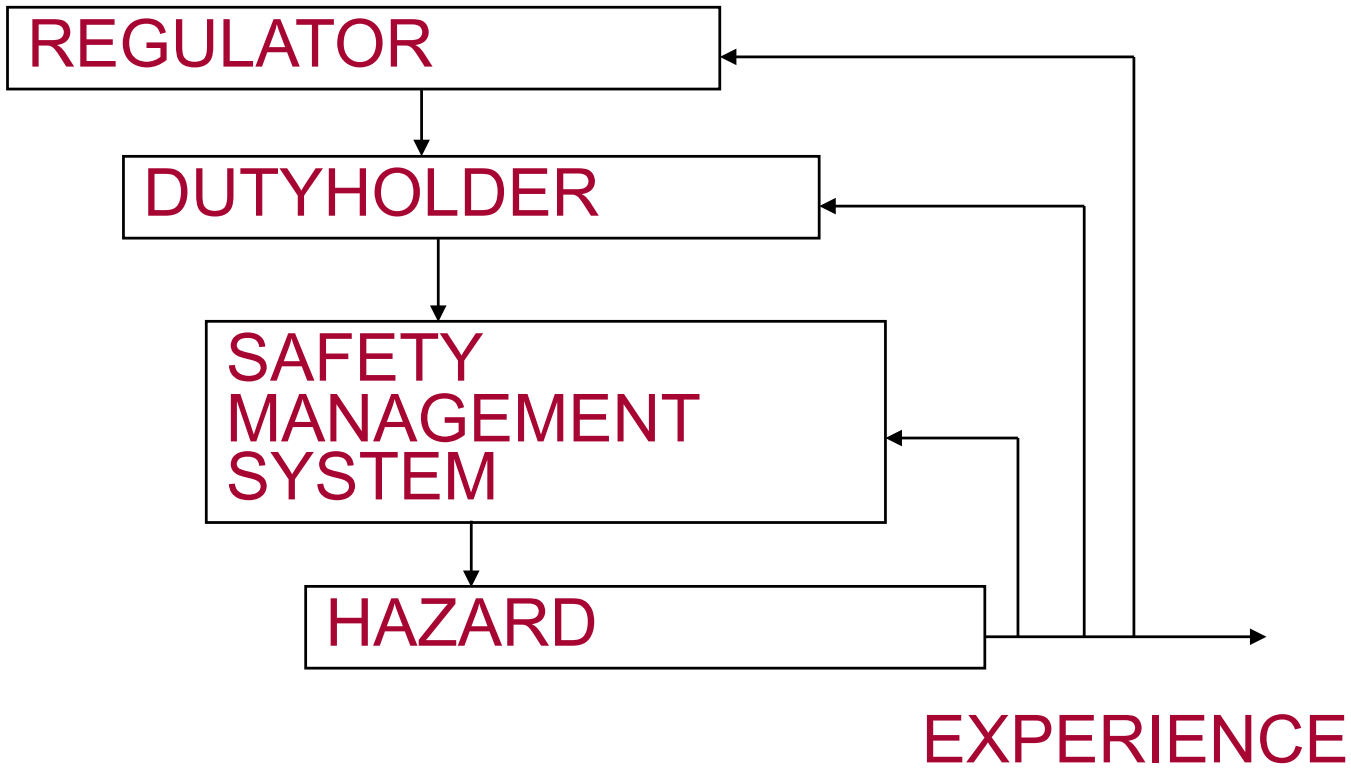
Risk assessment

RISK ASSESSMENT: The process of hazard identification and the estimation, analysis and evaluation of the associated risks

"Risk assessment data is like a captured spy. If you torture it long enough it will tell you anything you want to know"

- *W M Ruckelschaus Former Head of US EPA*

The regulation system



Risk analyses
performing, documenting, sharing

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Health and safety at work etc Act 1974

Management of health and safety at work Regulations 1992

Pipelines Safety Regulations 1996,

+ Gas Safety (Management) Regulations 1996

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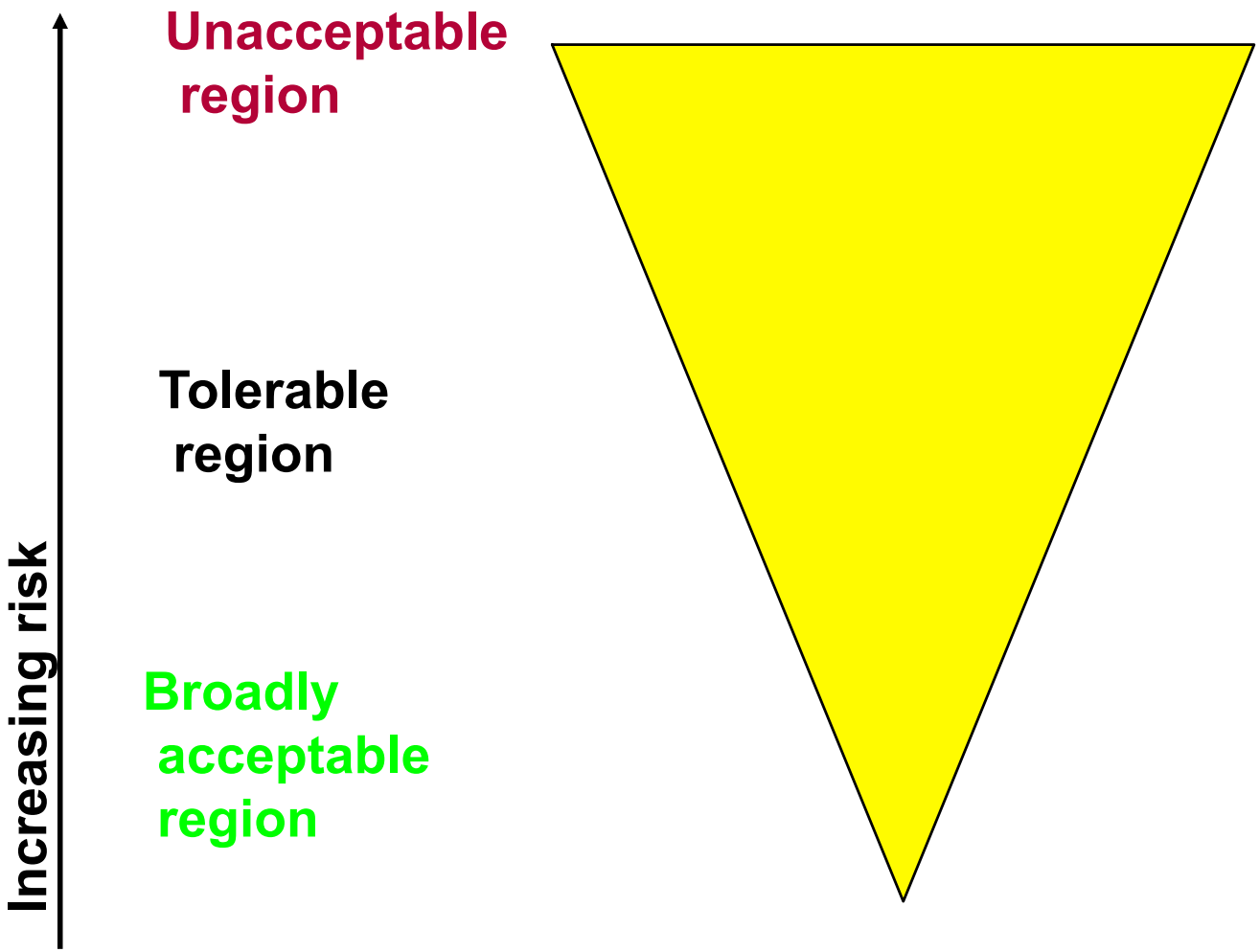
The regulation of industrial risks

The main tests applied are:

- Is the risk so great or the outcome so unacceptable that it must be refused altogether; or
- Is the risk so small that no further precaution is necessary; or
- If risk falls between these two levels, then has it been reduced to the lowest level practicable, bearing in mind the benefits of further reduction and taking into account the costs of any further risk reduction
  ie the risk must be reduced to a level which is ALARP

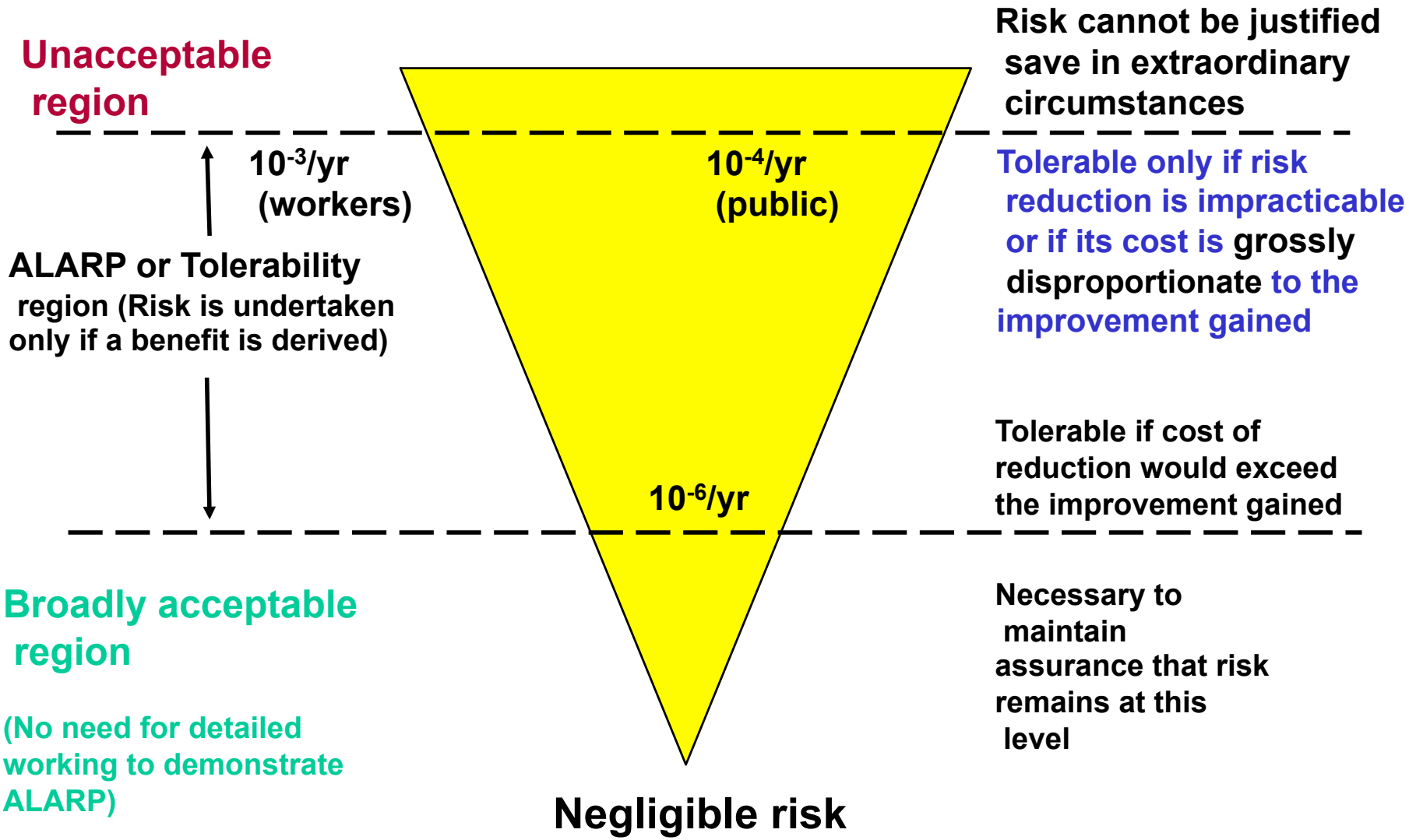
Risk Tolerability Criteria



See HSE 1992, Tolerability of risks from nuclear power Figure 3

HSE 2001, Reducing Risks, Protecting People: HSE's decision-making process p 42

Risk Tolerability Criteria - Individual risk



"Necessary measures"

Measures	"Usual"	"Unusual"
Hazard	Singular	Multiple
	Local effect	Widespread effect
	Simple	Complex
	Established	Novel
Decision basis	Codes	ALARP
	Standards	"Professional judgement"
	"Common sense"	
Framework	Prescriptive	Goal-setting

Decisions on risk reduction measures

Risk decision

"Cost" of a risk reduction measure

Benefit of risk reduction

Sacrifice, whether in money, time or trouble

Change of harm averted, including:
deaths averted;
injuries averted

+ill health, environmental damage

Scenario before measure

Scenario after measure

BP's Approach
(now revised, but here as published1994)

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Cost effectiveness of risk reduction measure

$$\text{Cost per life} = \frac{\text{annualised cost of option - expected losses}}{\text{statistical fatalities averted/yr}}$$

criteria

» worthwhile < $1M

» consider other issues >$1M and <$10M

» not worthwhile >$10M except in extraordinary circumstances

Sub-sea isolation valves - cost per life saved £80M !

See M S Hogh Proc SRD Association Members Conf; AEAT Dec 1994

A B Flieshman & M S Hogh 1989 Proc 6th Intl Symp Loss prevn in process ind

ALARP Principle

(HSE 2001, Reducing Risks, Protecting People: HSE's decision-making process p 62)

EDWARDS V NCB case:

".. a computation must be made in which the **quantum of risk** is placed in one scale and the **sacrifice, whether in money, time or trouble**, involved in the measures necessary to avert the risk is placed in the other; and that, if it be shown that there is a gross disproportion between them, the risk being insignificant in relation to the sacrifice, the person on whom the duty is laid discharges the burden of proving that compliance was not reasonably practicable."

Key questions

"What more can I do to reduce the risks?"

Are there further practicable risk reduction measures?

"Why have I not done it?"

Take the further risk reduction measures or show that they are not reasonably practicable

Cost Benefit Analysis

$$\frac{\text{Costs}}{\text{Benefits}} > 1 \ ?$$

"Cost Benefit Analysis" for ALARP

$$\frac{\text{Sacrifice}}{\text{Quantum of risk}} > \text{Disproportion Factor ?}$$

Sacrifice, whether in money, time or trouble

Quantum of risk (as 'benefits'), sum of harms averted x values

CBA for ALARP …

Pose practicable risk reduction measures

Assess risk reduction

(simplest is to assume elimination)

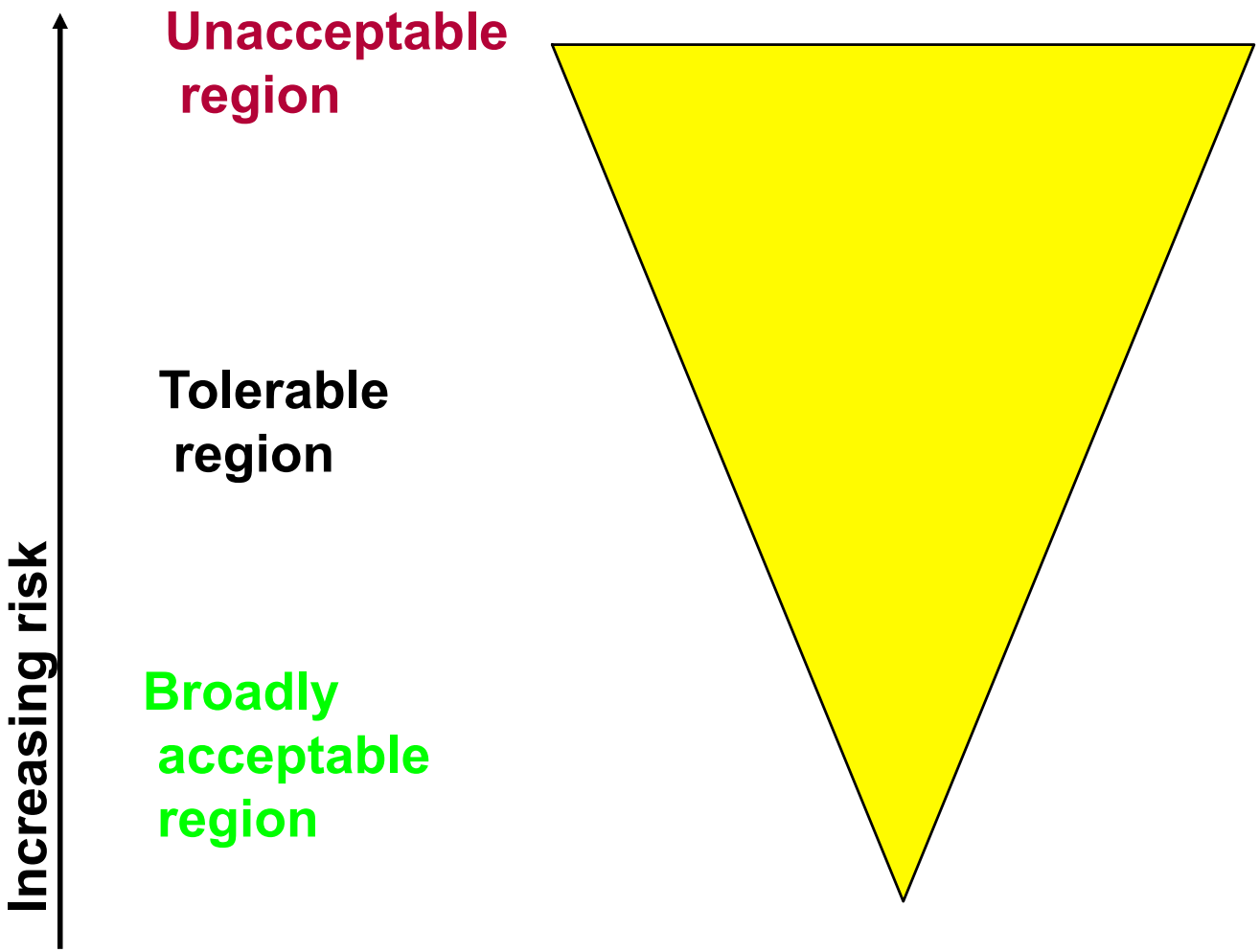
Assess cost (as for normal project costing, simple approaches include scaling factors)

Select values for harms averted

Select gross disproportion factor (rarely >~30)

Inform decision

Risk Tolerability Criteria



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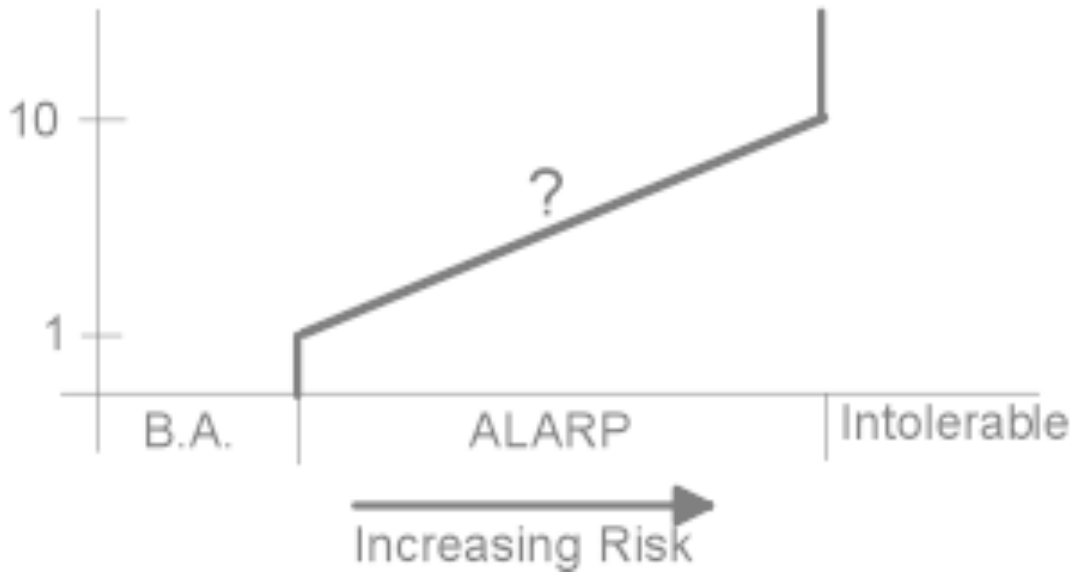
Gross Disproportion

- Change of proportion factor with risk



http://www.hse.gov.uk/hid/spc/perm12.htm

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Demonstration of ALARP

- NEED NOT BE QUANTITATIVE; degree of rigour is proportionate to scale of hazards and risks.
- NOVEL SITUATIONS USUALLY NEED QUANTIFICATION;
- CBA useful for assessing alternatives; Regulator needs to see justification for selected option, assumptions & uncertainties (see Reducing risks, Protecting people, Appendix 3)
- CBA should not be used to undermine good engineering practice.

Cost Benefit Analysis

- A decision support **tool**.
- Costs & benefits put in a single currency
  - Transparency
  - Consistency
  - Comparison
- HSE wide guidance at
  http://www.hse.gov.uk/risk/theory/alarpcba.htm
  and
  http://www.hse.gov.uk/risk/theory/alarpcheck.htm

What costs should be included?

See Checklist but:

- costs of installation, operation, training and maintenance of a new measure.
- business losses from any shutdown of the plant.
- only the costs incurred by the duty holder
- lost production
- no gold plated measures
- savings as a result of the measure should be offset against the above costs.

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Benefits?

- Should include all reduction in risk to:
  - public, workers & wider community.
- Where appropriate, avoidance of:
  - deployment of emergency services
  - evacuation and post accident decontamination,
- Benefits can be broken down into prevented:
  - Fatalities & Injuries (major to minor)
  - Ill health
  - Environmental damage if relevant (e.g. COMAH)

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Benefits valuation

Averted consequence	*Benefit*
Fatality	£1.3M (x2 for cancer),
Permanently incapacitating injury	£200k,
Serious injury	£20k

NB: approximate and date dependent

Benefits estimation for a case

Deaths averted = f(event) x plant life x fatalities

(f x t x N)

e.g. to eliminate a hazard where

f(event) = 1×10^{-4} per yr

t, plant life = 20 yrs

N, fatalities = fatalities prevented by the measure = 2

"Theoretical" lives saved by elimination = 0.004 over plant life

Proportionate spend

"Theoretical" lives saved by elimination = 0.004

Benefit = harm averted x value

~ £5000

If disproportion factor is 10, then proportionate spend would be less than £50000 over plant life

(of the order £2500 to £10000 per annum)

.. how long is a GDF ..

Good business

Poor business

Good humanity but bad business

Going out of business

Increasing gross disproportion factor

Progress (in COMAH)…

Most COMAH "top tier" dutyholders now tackling the "what more and why not" questions

A substantial fraction using simple CBA in support

Practice

HAZARD:
TOXIC
IN
TANK

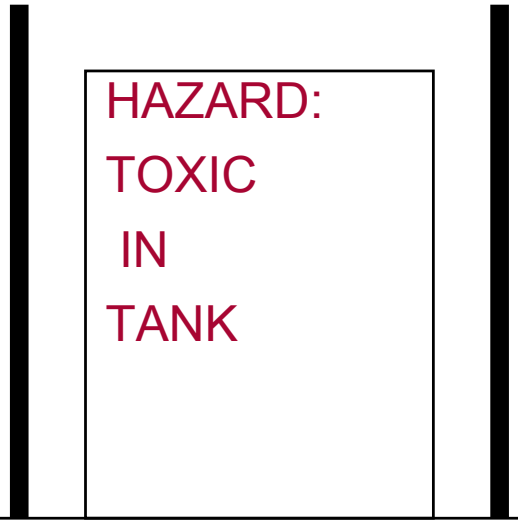
Relocate

HAZARD:
TOXIC
IN
TANK

Bury

HAZARD:
TOXIC
IN
TANK

Protect



What if …

Causal event frequency ~ 10^{-4} yr^{-1} (unconditional)

N ~50 (poor dispersion and direction)

Assumes toxic is in tank

Problem areas …

"Life" valuation – ethics, law

Fear of the unknown

Durability

Reaction of industry…

Hesitation to begin exploration, but generally positive once begun

For any ten plausible proposals then perhaps one is supported by CBA

Helps formalise and communicate engineering support/judgment for management approval

With business benefits can be viewed as effective pseudo-insurance

Has CBA reduced risk?

Some limited improvement in risk (?)

Perhaps more value in risk communication

Concluding remarks

Dutyholders must satisfy themselves first

Regulator may accept that the dutyholder holds that opinion, but leave open the possible development of a contrary opinion that can be tested as and when …

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Summary

- Tolerability criteria help identify the need to apply the ALARP test
- Beyond good practice, the ALARP test, applied in advance, is a requirement of good health and safety management
- CBA is a decision support tool to aid ALARP judgments, but should not be used to undermine good practice

Cost benefit analysis – a decision aid

Cost benefit analysis is the worst technique for supporting risk decisions ….

… except for all the others

with apologies to WS Churchill