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UK Regulatory Approach to ALARA / ALARP in Light Water Reactors at the Design Stage

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Presentation Context

- During the next decade, light water reactors (mainly PWRs) are intended to start to replace Advanced Gas Reactors as the nuclear elements of the Government's planned energy mix.
- The Office for Nuclear Regulation (ONR) is responsible for regulating on site risks and doses to the workforce for operating and proposed new nuclear power plants in Great Britain. A key part of the ONR approach to ensuring that doses and risks for new Nuclear Power Plants are reduced to levels that are ALARP is by ensuring that established relevant good practice in areas such as chemistry control and material selection is applied to new reactor designs.

Presentation Scope

- In this presentation ALARP (As Low as Reasonably Practicable) will be used rather than ALARA as in the UK, what is "Reasonably Practicable" has a legal definition but what is "Reasonably Achievable" does not. In practice, ONR considers the ALARA and ALARP concepts to be equivalent.
- This presentation will cover the ONR approach to ALARP, particularly the use of Relevant Good Practice (RGP) and its application to the design of new reactors, through the Generic Design Assessment process applied to all new reactor designs proposed for new build in the UK.
- RGP = Those standards for controlling risk judged by ONR as satisfying the law (i.e. meeting the legal requirement for ALARP), when applied appropriately.

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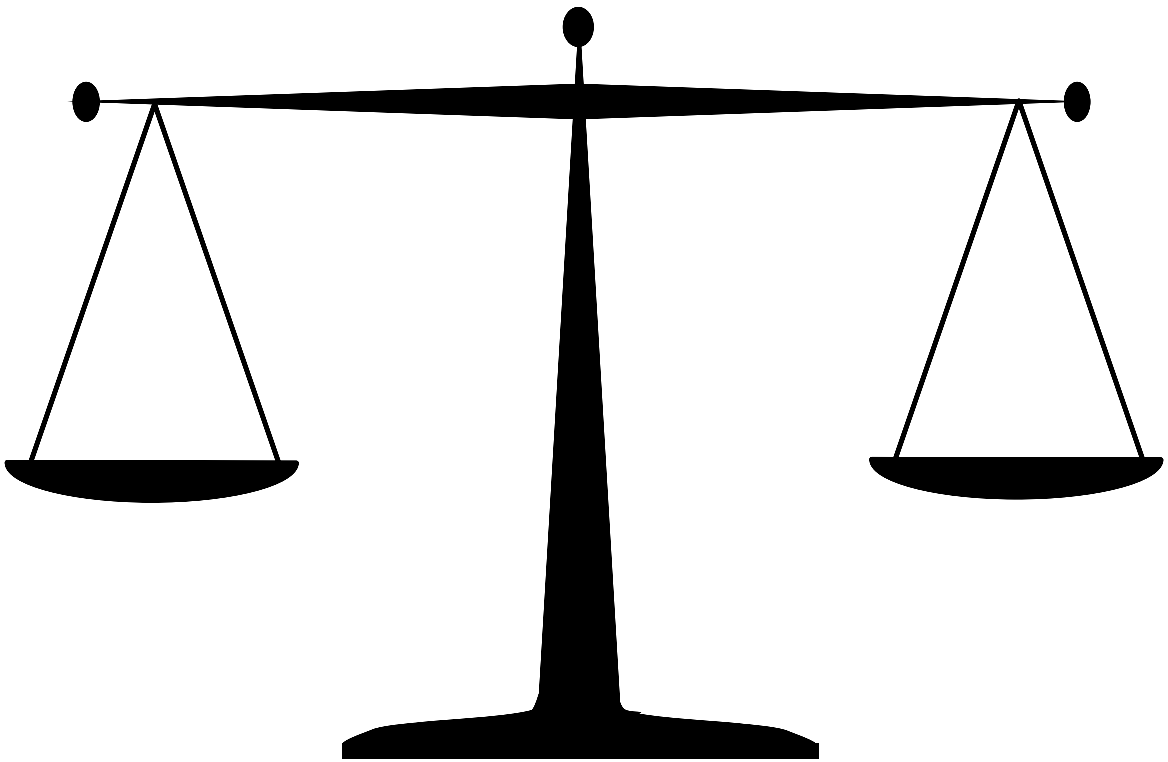
Defining "Reasonably Practicable"

Definition is based on legal precedent set in the trial of Mrs. Edwards vs. National Coal Board, 1949

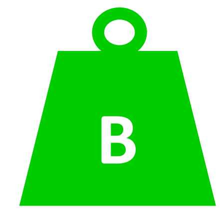
The Judge said..

> "A computation must be made in which the quantum of risk is placed on 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 shown that there is a <u>gross disproportion</u> between them, the risk being insignificant in relation to the sacrifice, the person upon whom the duty is laid discharges the burden of proving that compliance was not reasonably practicable"

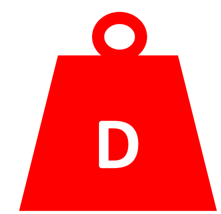
Understanding what ‘Reasonably Practicable’ means



Benefits – risk reduction:



Disbenefits – sacrifice in time, trouble and money:



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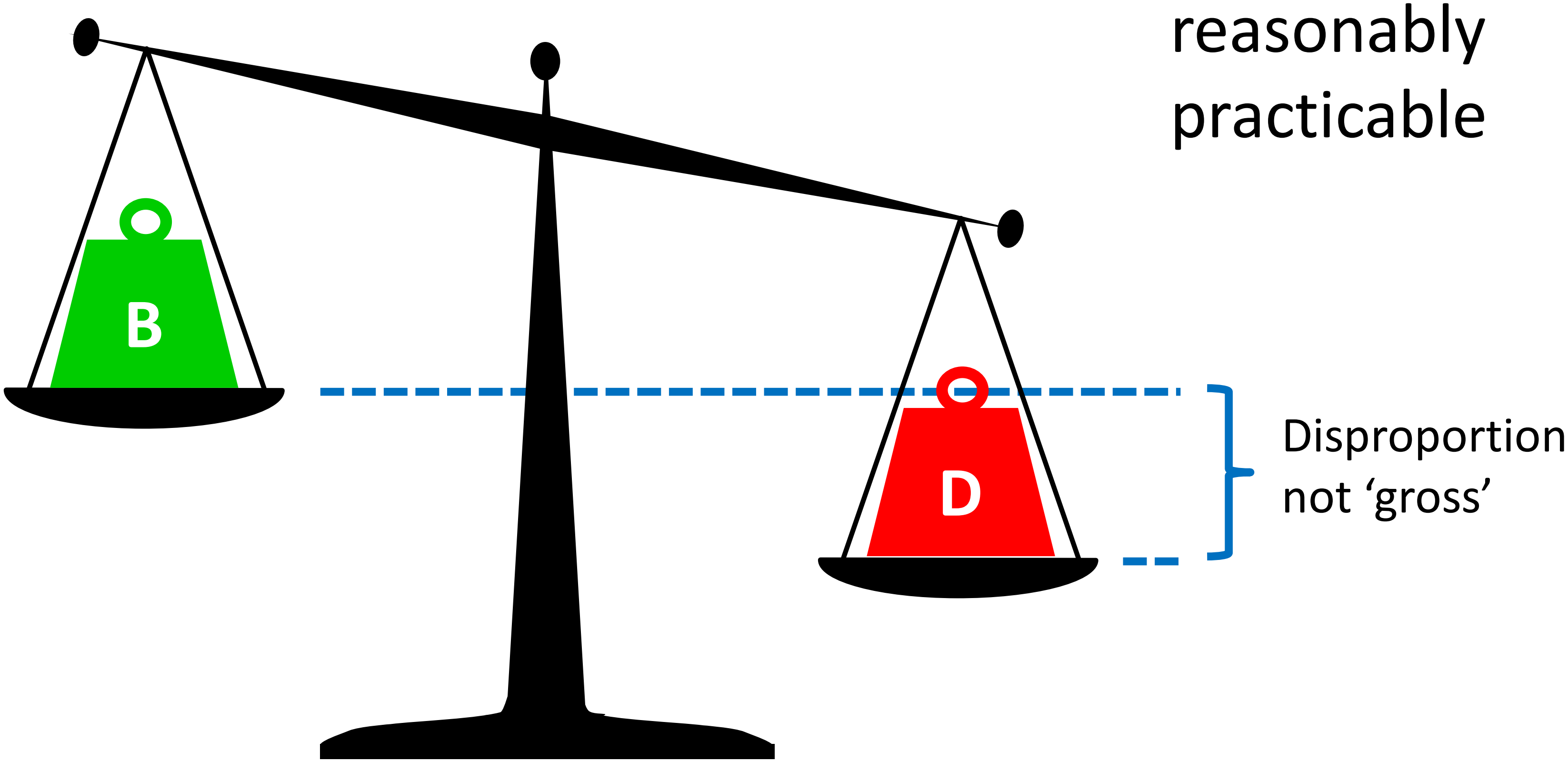
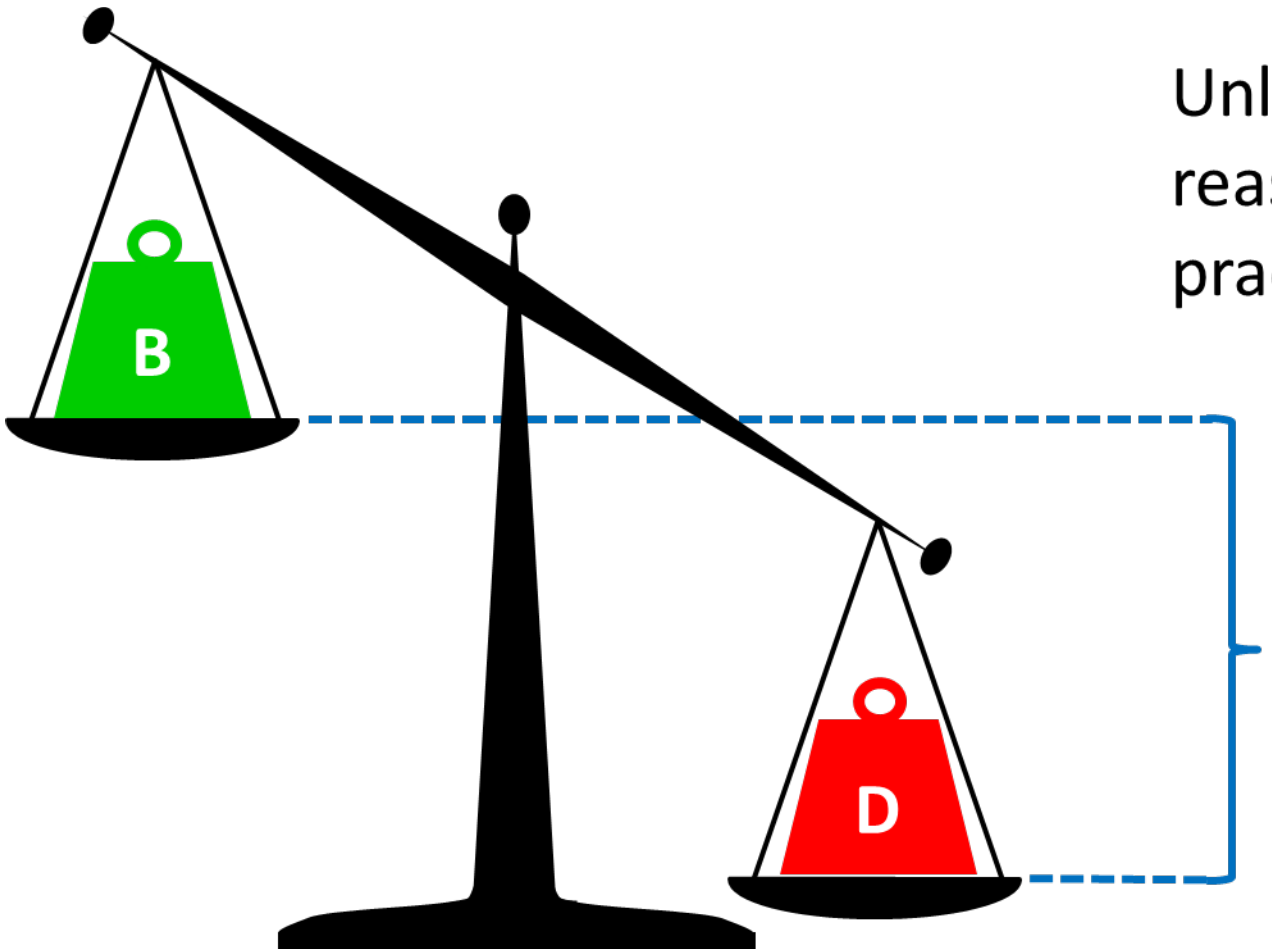
Understanding what ‘Reasonably Practicable’ means



Likely to be reasonably practicable

Understanding what ‘Reasonably Practicable’ means



Unlikely to be reasonably practicable

Gross disproportion

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Sources of RGP

- Approved Codes of Practice (ACoPs) – special status
- British, ISO, IEC, EC Standards
- IAEA, NEA, WENRA
- Industry / sector standards
- ONR:

  - Safety Assessment Principles (SAPs)

  - Technical Assessment Guides (TAGs)

  - Technical Inspection Guides (TIGs)

  - What ONR has accepted previously in similar circumstances

Are Design Improvements Needed to Reduce Operator Doses in NPPs?

- NEA No. 6975 (2010) "Factors such as nuclear safety and operational availability dominated during the design and construction phases of the {Gen I and II} NPP, whereas ORP (Operational Radiation Protection) aspects were addressed to a lesser extent."
- Many improvements in reactor design have focussed on:
  - Increases in thermal / electrical output
  - Better reliability / utilisation
  - Lessons learned from accidents, near misses, component failures, etc.
  - Evolution of fault studies approaches (DBA / PSA / SAA)
  - Regulatory expectations regarding, reduced fault frequencies (e.g. of core melt), improved accident mitigation, improved protection against external hazards, etc.

PWR Doses – Typical Example

Collective doses from an individual Non UK PWR for calendar year 2015 with "average" outage doses

- During normal reactor operation: 90 man mSv.
- During outage period (≈ 6 weeks reactor shutdown):
  - Refuelling: 30 man mSv
  - Maintenance and Inspection: 462 man mSv
- The vast majority of the maintenance and inspection dose during outage is due to activated corrosion products.
- For occupational exposure reduction in PWRs, the main focus is on reduction in activated corrosion products.

Dose data from ISOE

PWR Doses – Leading Example

Non UK PWR with some of the lowest shutdown collective doses. Calendar year 2015

- During normal reactor operation: 14.9 man mSv
- During outage period (≈ 6 week reactor shutdown):
  - Refuelling: 15.7 man mSv
  - Maintenance and Inspection: 70 man mSv
- Very low doses due in large part to source term minimisation including very low Co content in primary circuit.

Dose data from ISOE

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RGP for New Reactors (1)

- RGP, or better, normally required for new designs. The level of safety must be no less than a comparable facility already working or being constructed in the UK or somewhere else in the world.
- In practice, this means that designs submitted to the GDA process will be expected to be as good as leading operational NPPs world wide using standard metrics such as collective dose per year, collective dose per outage or collective dose per GWh generated.
- Lessons can be learnt from the design and operation of leading plants where there are shared design features with the design being assessed and relevant operational practices.
- ONR looks at practice in leading plants around the world and expect designers of new NPPs to do the same.

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RGP for New Reactors (2)

Practice at other leading plants around the world can be examined to see if lessons can be learned in areas such as:

- Material selection (minimisation of Co, Ag, Sb, etc.)
- Surface finishes
- Engineering controls (e.g. automation of reactor opening and closing)
- Chemistry regimes
    - Maintenance regimes
    - Operational practices

ONR looks to see that designers have determined whether potential improvements are ALARP.

Role of Cost Benefit Analysis (CBA)

- CBA is only acceptable as part of a safety submission. An ALARP case built solely on CBA will fail to convince ONR.
- Regulatory guidance on what a CBA submission should be like is available on the HSE website referenced below.

http://www.hse.gov.uk/risk/theory/alarpcheck.htm

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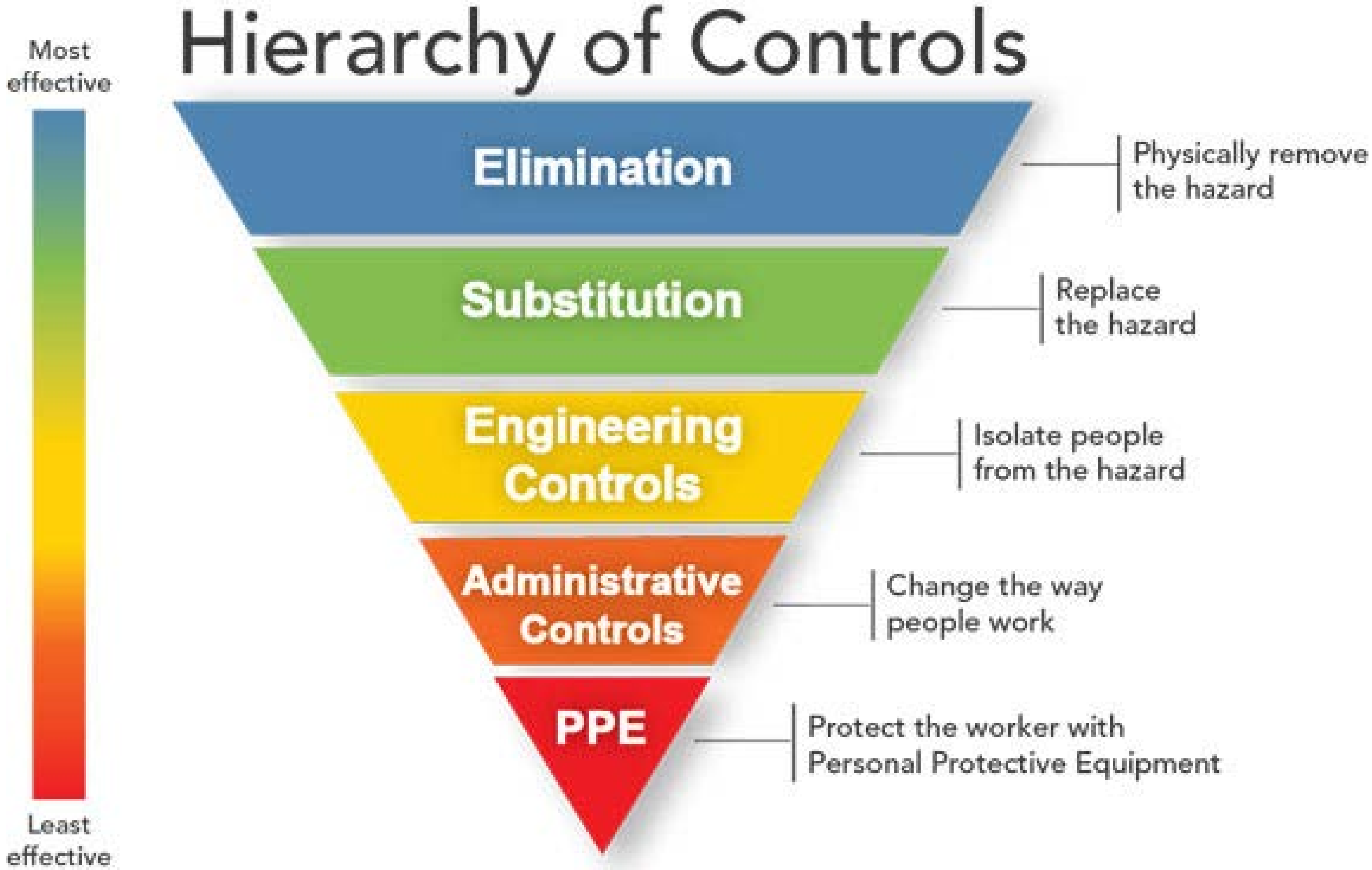
ALARP – Hierarchy of Controls



ALARP can be simple ….

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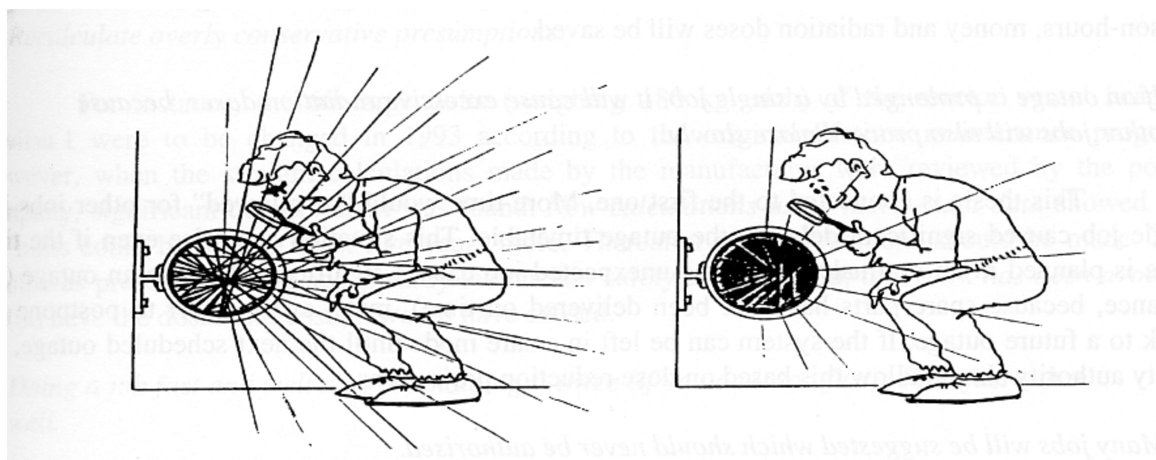
- Consider:
  - **Time**, by reducing the duration of the task
  - **Distance** of staff from high dose items
  - **Shielding**, by improving it where practicable to do so
- Scheduling of maintenance and inspections should consider when doses would be lowest
- But consider if there are aspects of the plant design that make maintenance necessary when doses are high – could they be changed?



Inspection of a drained system

Inspection of a water filled system

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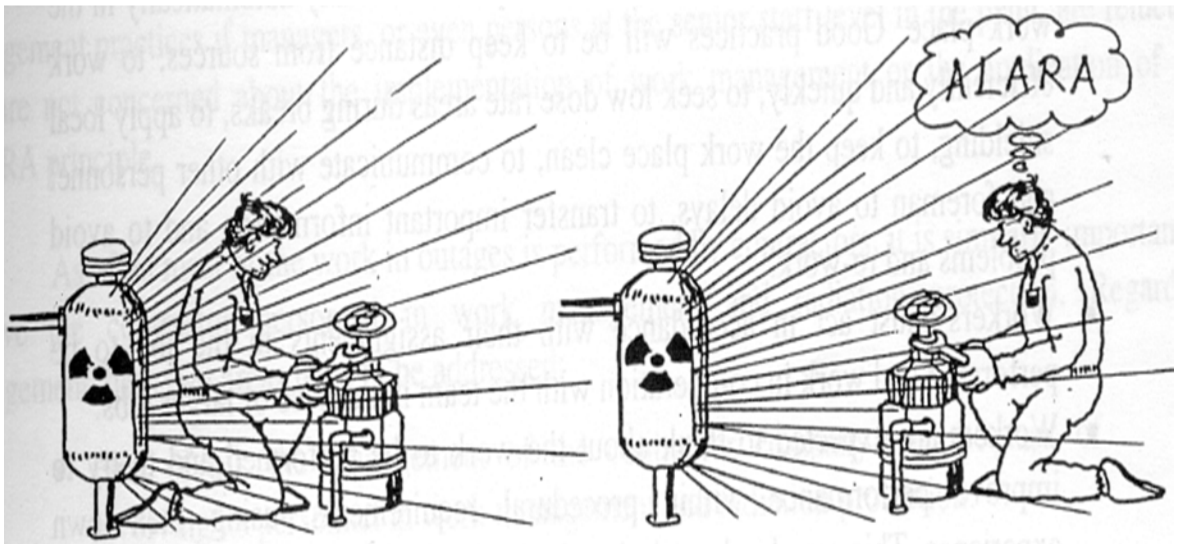
ALARP can be simple ….

Doses can be saved at virtually no cost using simple common sense ……



As long as the plant is designed with ALARP in mind (e.g. is there space to work?)

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Making the ALARP Case (1)

- For an evolutionary design, which has been designed taking account of experience of earlier ones, the designer must show how the evolution improved the design from a dose perspective (occupational exposure and direct shine).
- Operational experience (OPEX) from relevant existing plant should be used to improve the new design. Lessons learnt from current operations e.g. routine access required to high doserate areas that could be designed out in future plants.
- The demonstration should set out how known problem areas (e.g. identified from Operational Experience, improved analysis, or improving standards) have been addressed and how and why the particular solution chosen was arrived at.

Making the ALARP Case (2)

- The ALARP case needs to describe the ALARP process and also demonstrate why key aspects of the plant design and operation are ALARP.
- Key aspects include:
  - Review of shielding
  - Source term minimisation
  - Segregation of staff from high dose areas of the plant
  - Review of tasks that give the highest doses in operational plants (which should be known through dose assessment work)
- The focus will be on external doses, but internal dose aspects must be considered as well, such as control of contamination and doses from gaseous isotopes such as tritium.

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Summary

ONR assesses the evidence that doses and risks for new Nuclear Power Plants are reduced to levels that are ALARP.

The case for why an aspect of the design is ALARP needs to:

- Consider all relevant, legitimate contributing factors, not just radiological and nuclear
- Present all the potential options, including Relevant Good Practice
- Weigh these up in a balanced way, starting with the "safest" crediting positive and negative aspects
- Describe a clear decision consistent with gross disproportion