

ALARP Guidance on Shielding Design for Dose Mitigation in the Event of a Criticality Incident

Stuart Watson

Principal Consultant

SR³C Limited

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1

Aims

- ALARP – Focused on Pre-Accident Measures
- Go through sources of advice and requirements
- Provide Dose Targets
 - IEZ
 - Public Protection
- Provide Proposed Dose Targets
 - Plant Operators
 - Other on site workers

2

Why This Work?

- Good framework for operators and the avoidance of very high doses
- Advice is extensive but elements are predicated upon the Principle of ALARP
- Work on new plant
 - The plant was to be housed in a building with other operations.
 - Close to an administration centre

ALARP

- What's ALARP
 - As Low As Reasonably Practicable.
- ALARP for the Risk of Criticality
 - Reduce the likelihood
 - Pre-Accident Measures to Reduce the Consequences
 - Post Accident Measures
- This work is focused on Pre-Accident Measures
- In the provision of shielding a dose target is very useful

Advice From the HPA

- The UK NRPB now part of the HPA have given advice:
 - Measures that avoid deterministic injury should be implemented
 - Those at risk of receiving a deterministic dose should be identified
 - Dose should be ALARP to all groups

Dose Thresholds

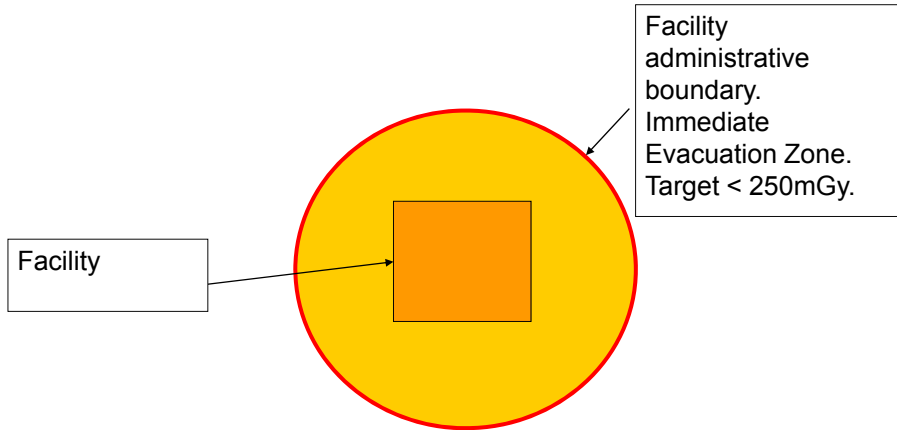
- Large acute dose – Gy → Deterministic Effects
- NRPB Deterministic Thresholds:-
 - 1 Gy for Gamma
 - 500 mGy for Neutron
- Chronic dose and smaller dose – Sv
- Conversion of a given absorbed dose (Gy) to Effective Dose (Sv) is complex
- For neutrons the difference can be very large

Criticality Incident Protection

- This work is focused on Pre-Accident Mitigation
 - Mainly the provision of dose targets for groups of individuals.
- This is SR3C's view
 - ALARP is the real driver
 - It is Guidance
- Targets
- Proposed Targets

Immediate Evacuation Zone

- National Radiological Protection Board advice:-
 - Priority should be given to the avoidance of deterministic injury
 - Those at risk of receiving a dose above the deterministic threshold should be identified.
- This is interpreted as: Provide an evacuation plan for those who may receive greater than the deterministic threshold – 500mGy
- Defined IEZ – dose often lower – 250mGy assumed here



Pre-Accident Measure

- Target
 - Provide sufficient shielding to plant such that the 250mGy contour is within the boundary of a single administrative control
- Evacuation routes should seek to minimise dose to operators

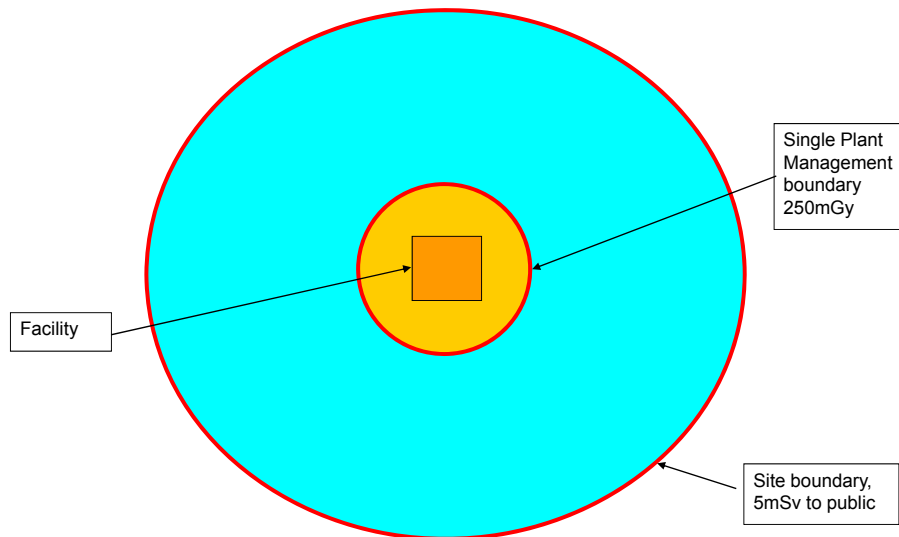
250mGy IEZ Benefits

- A 250mGy IEZ gives the following benefits
- The IEZ is Physically Small Leading to:
 - Those most likely to need medical attention are triaged automatically
 - Emergency Services are not overwhelmed
 - Facilities potentially vulnerable are not left unattended
 - The IEZ is administratively capable of being managed

Harris TransAm Vol 93 Nov 2005.

Public Dose

- Under UK Radiation Emergency Regulations (REPPiR)*:-
 - Incidents come into the regulations if:-
 - They are reasonably foreseeable
 - The effective dose is > 5mSv during the following year to public
 - Limiting dose to public to 5mSv will ensure compliance with REPPiR
- *Radiation (Emergency Preparedness and Public Information) Regulations 2001



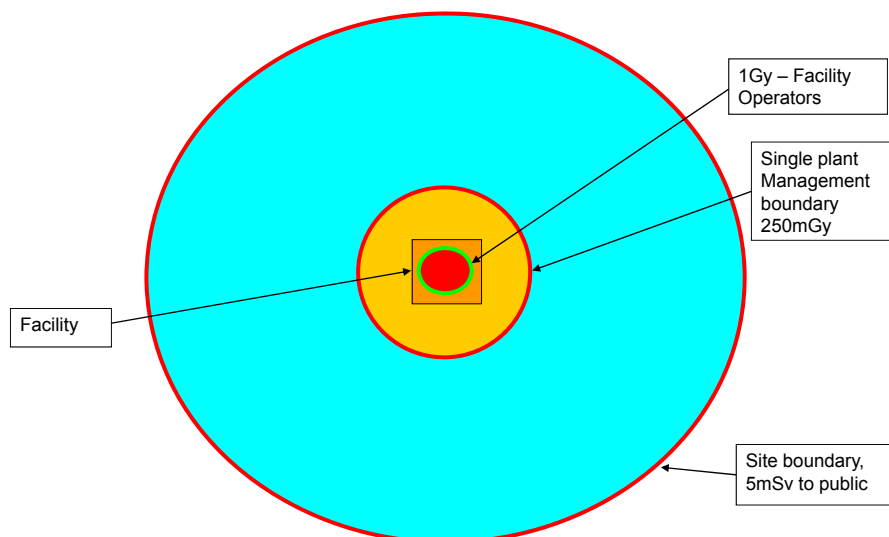
Pre-Accident Measure (Public)

- Target:
 - Provide sufficient shielding to plant such that dose to a member of the public off the nuclear site will not exceed 5mSv
- Public dose will also be a factor in plant siting during optioneering

Plant Operators

- Recap NRPB advice
 - Priority should be given to avoiding deterministic injury
- Deterministic dose levels are 500mGy for neutron and 1Gy for gamma

15



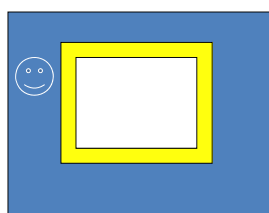
16

Pre-Accident Measure (Plant Operators)

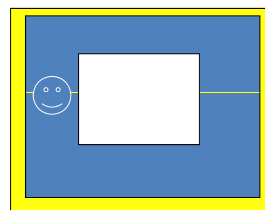
- Proposed Target:-
 - Shielding should be provided, where reasonably practicable, to ensure that 2 x neutron absorbed dose + the gamma absorbed dose does not exceed 1Gy to operators
- The relative (n & γ) effects are unlikely to be strictly linear but provides flexibility and is easily evaluated

17

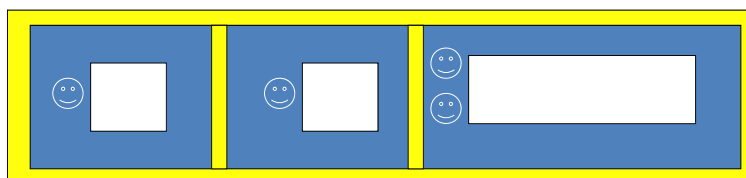
Operator Protection



Shielded Facility



Hands on Facility



Segregated Area Facility

18

Other on Site Workers

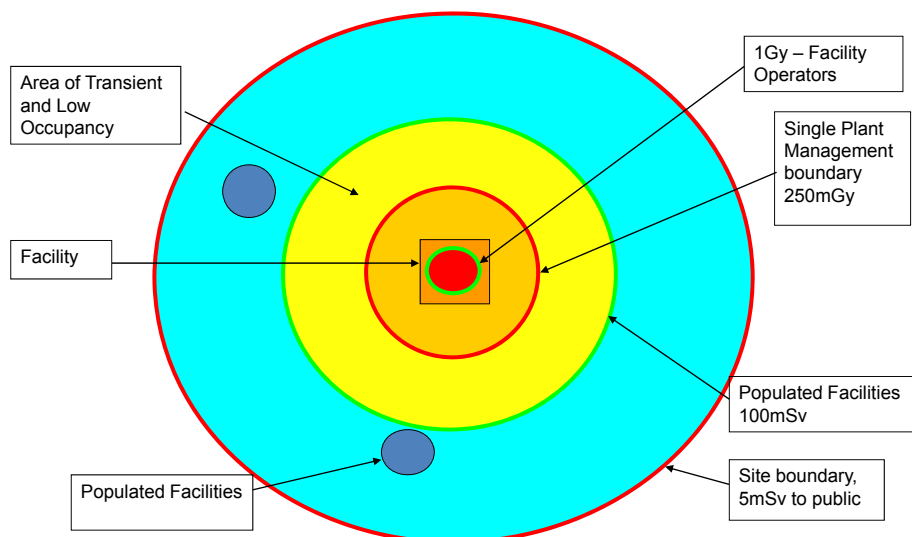
- UK (ONR) Basic Safety Limit (BSL) of 10^{-4} risk of death per year to any individual
- Corresponding Safety Objective (BSO) of 10^{-6} risk of death per year
- Often the site has multiple plant with risk contributions
 - Plant often allocated 10% of site risk
- Criticality is not the only risk from plant – assumed its about $\frac{1}{2}$ the risk
- Applying factors → Apportioned Targets
- BSL of 5×10^{-6} per year : BSO 5×10^{-8} per year

Other on Site Workers

- A dose target of 100mSv has precedence in the UK – Used by some to define the IEZ
- Conditional risk from 100mSv dose is 5×10^{-3}
- Applying a maximum frequency target of 10^{-4} per year for an incident gives a risk of:-
 - 5×10^{-7} per year: Sits between the BSL and BSO
- Reasonable Target: The likelihood of an incident is generally less than 10^{-4}

Other on Site Workers

- Proposed Target:-
 - Shielding should be provided to ensure the dose at neighbouring facilities is less than 100mSv where reasonably practicable
 - Plant siting should also be considered



Practical Application

- Applied these Targets and ALARP Proposed Targets to a new plant
- The plant learnt itself to remote operation
- The shielding designed to limit the 250mGy IEZ met all other targets and proposed targets
- No additional building cost

Summary

- Established Targets:
 - IEZ to be within single management control and limited to 250mGy in extent
 - Dose to Public should not exceed 5mSv
- Proposed Targets to help guide the ALARP process particularly for new plant
 - Dose target for operators should be less than 1Gy (gamma + 2 x neutron) where reasonably practicable
 - Dose target to other on site workers should be less than 100mSv where reasonably practicable

Any Questions?

Further Questions visit www.sr3c.co.uk
