REQUIREMENTS FOR WORKPLACE AIR SAMPLING

Introduction

- Summary of AWE project to investigate and clarify requirements for workplace air sampling
  - Literature review
  - Modelling to establish bounding cases
  - Real operating experience
  - Safety case claims
- Factors affecting air monitoring regime detection capabilities
  - Location of air monitor
  - Dispersion mechanism / effect on dilution
  - Choice of and limitations placed on alarm levels
- Standard on how many and where
- Summary of key conclusions

TYPES OF AIR SAMPLING REGIMES

- Real Time Air Monitoring
  - To provide a prompt alert to breakdowns in control / containment
  - Where require immediate action required to mitigate harm to worker / work area
- General Workplace Static Air Sampling
  - To detect low level chronic releases from engineered containments
  - Detect re-suspension of historic contamination
  - Control of low risk well known operations (incl protected ops)
  - Used to establish trends, allows early action to be taken to avoid internal doses

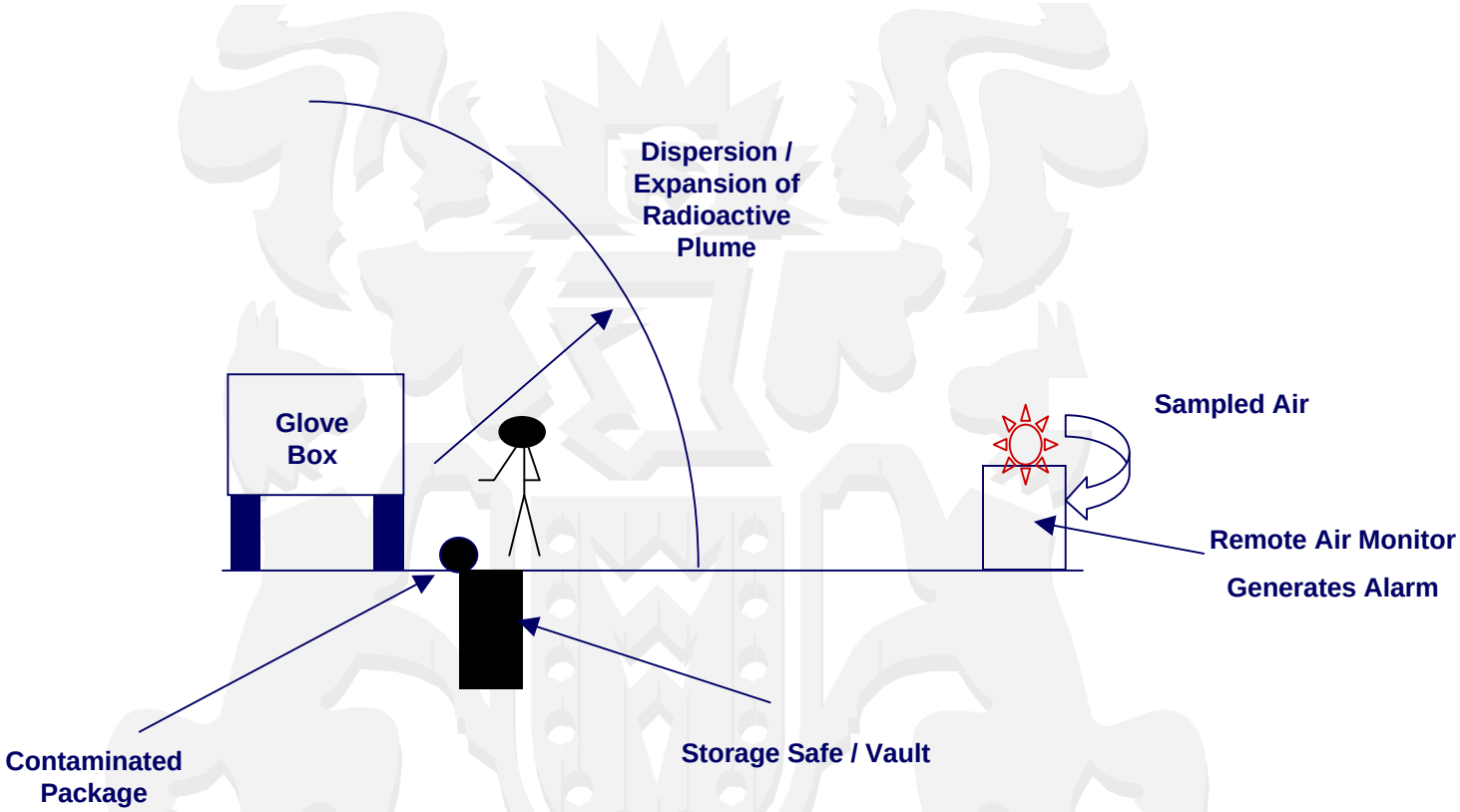
Review of need for air monitors

- **Reviewed literature and AWE incident history**
  - Identified good practice
  - Written into AWE Radiation Protection Standard
- **Real Time Air Monitoring**
  - Routine operations
    - When working in containments, glove boxes, cells etc
    - Entrances to ventilated enclosures, tents, F/Cs and MCSs
  - Protected operations
    - When bagging out, posting operations carried out
    - When breaking into or disconnecting glove box / containment service lines / systems not routinely surveyed
  - Emergency response
    - At pre-designated places of safety, e.g. evacuation points identified in SSOW
    - In areas with potential to release gross levels of contamination (connected to essential supply with a remote readout).

Need for Static Air Samplers

- **STATIC AIR SAMPLING**
  - In all areas where air monitoring carried out
  - RPE is routinely worn in temporary restricted / exclusion areas.
  - Loose contamination can be generated.
  - Inside exclusion / restricted areas to demonstrate suitability of selected RPE.
  - Prior to down designation / de-restriction of areas to demonstrate compliance with RA endpoints.

Requirements for an Air Monitor Alarm



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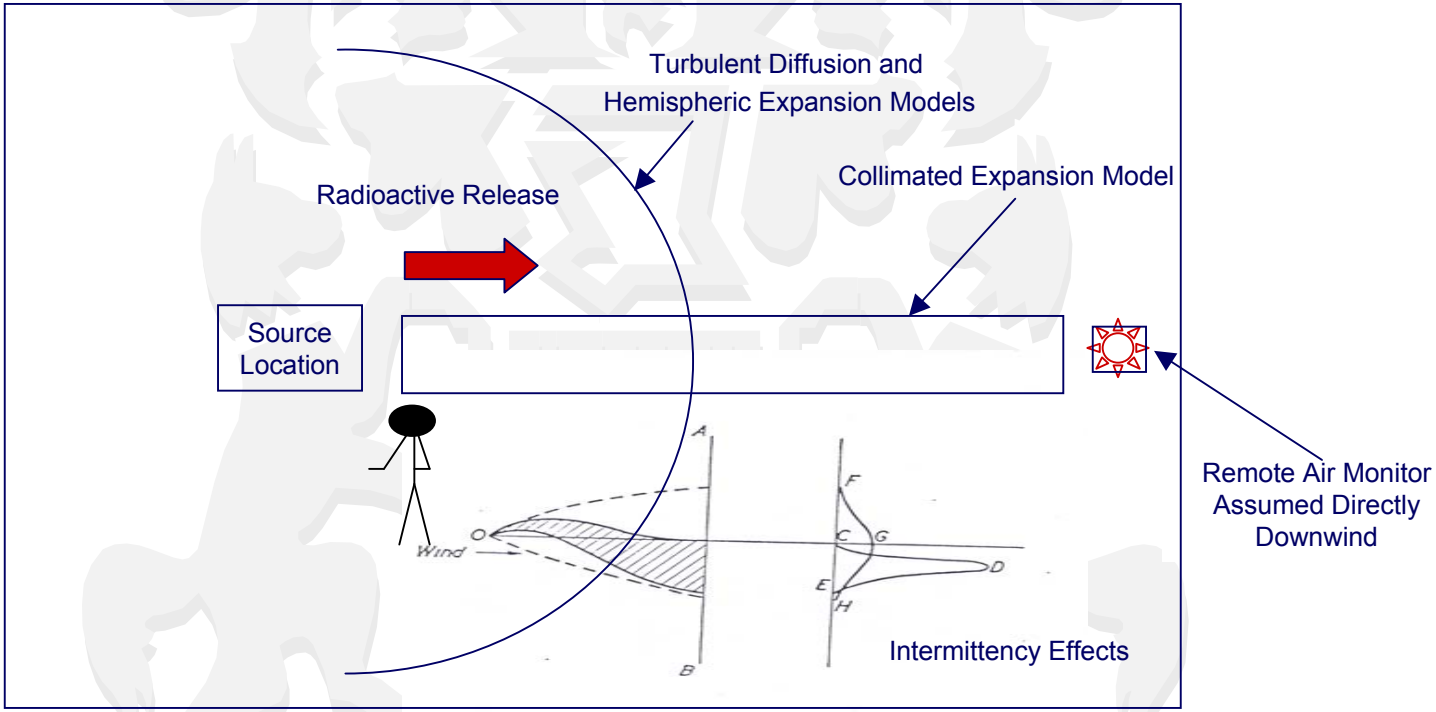
Radioactive Plume Dispersion Modelling



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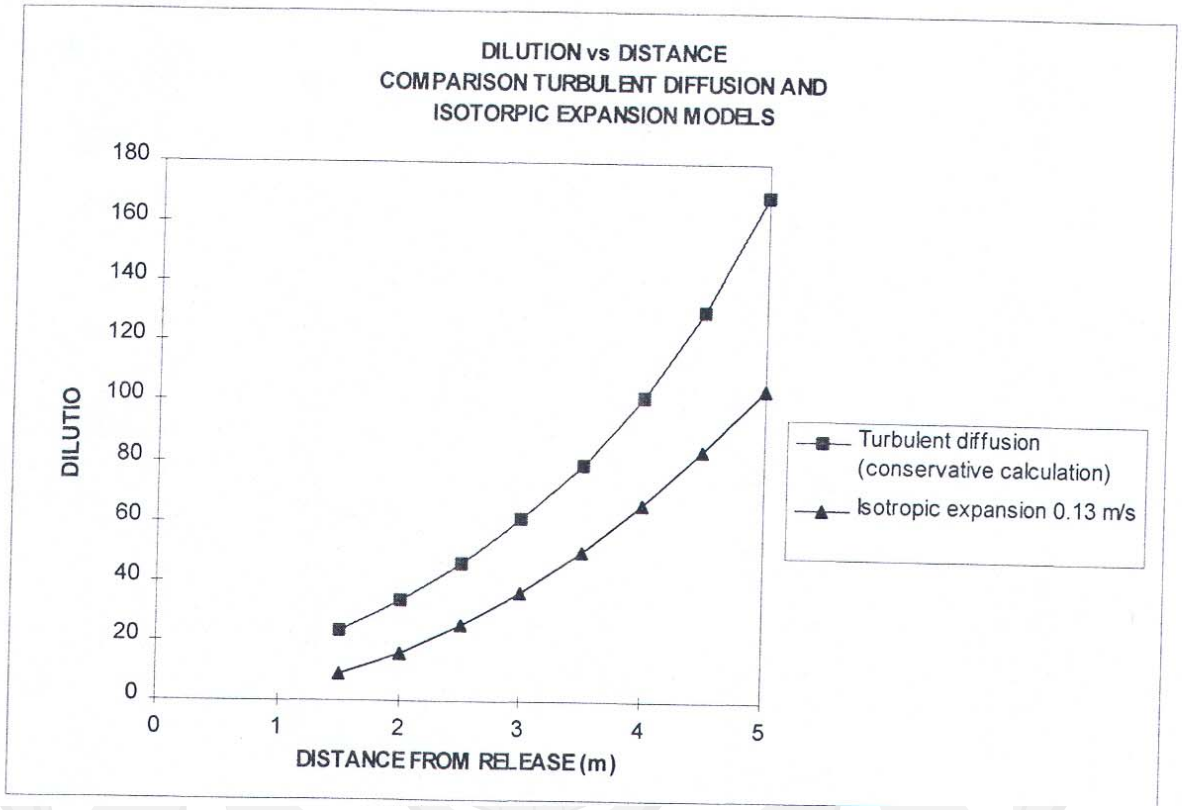
Conclusions from Dispersion Modelling

- Dilution defined:
  - Intake received worker 0.5 m / Intake received by worker at distance X m (Monitor location)
- Models define range of possible dilutions values
  - Dependent upon individual release circumstances
  - Turbulent Diffusion 20 times greater than Collimated Diffusion
- Sensitivity analysis
  - Lower expansion velocity leads to increased dilution values
- Models compared with actual incident intake data and dilutions reported in literature

1 / Dilution Versus Distance



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Intermittency Effect

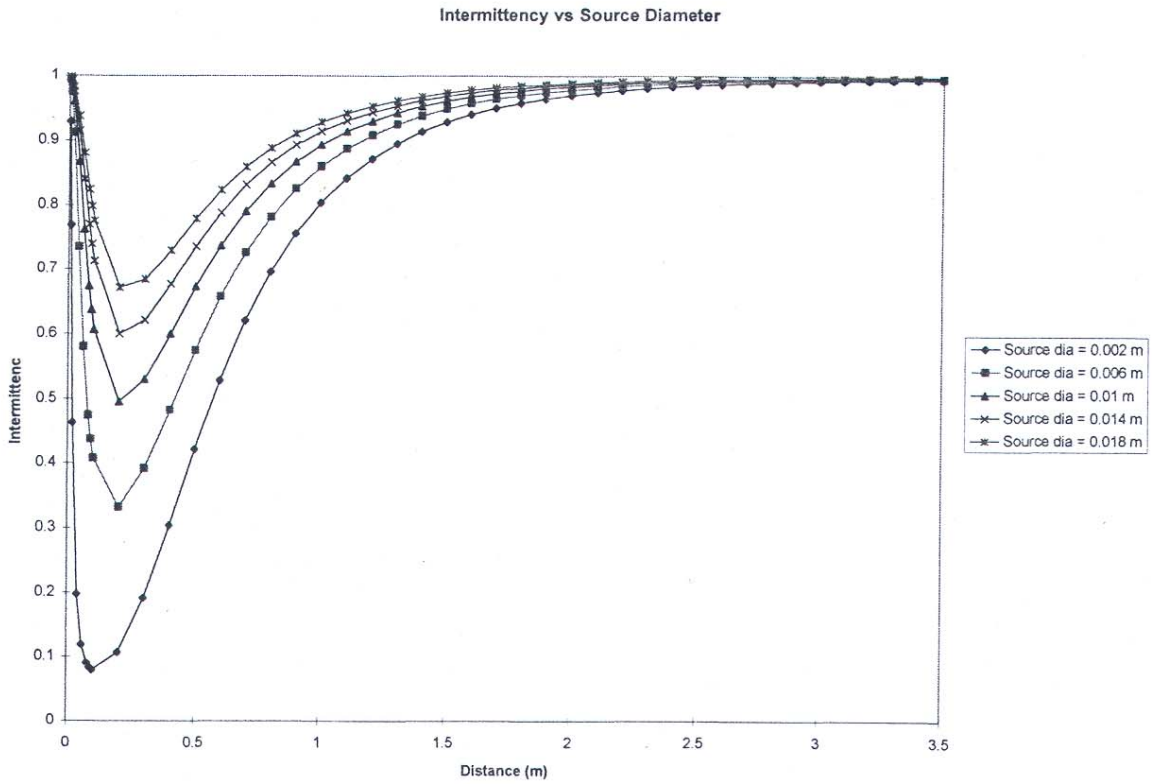

FIGURE 2

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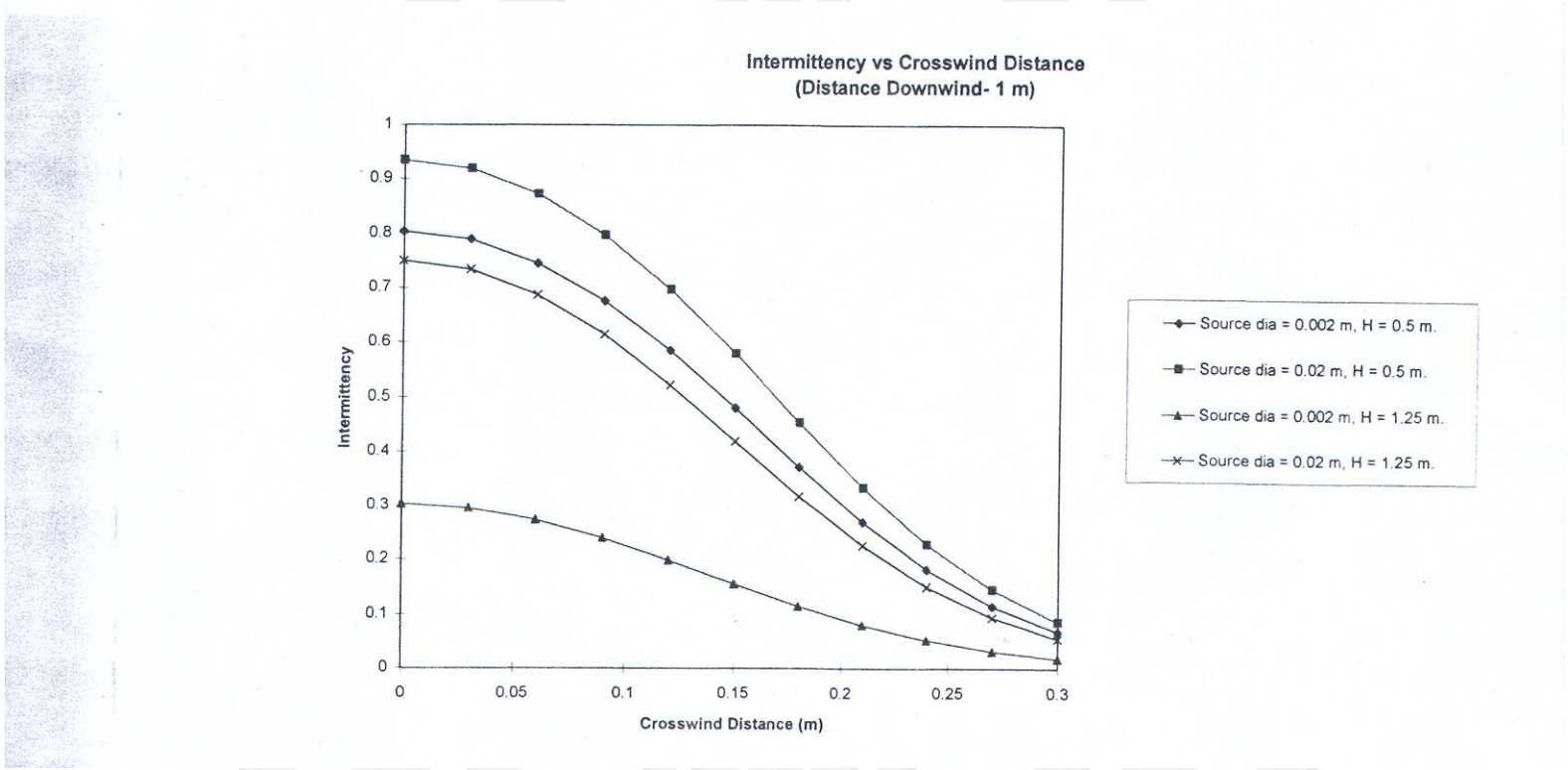
Intermittency Crosswind Effect



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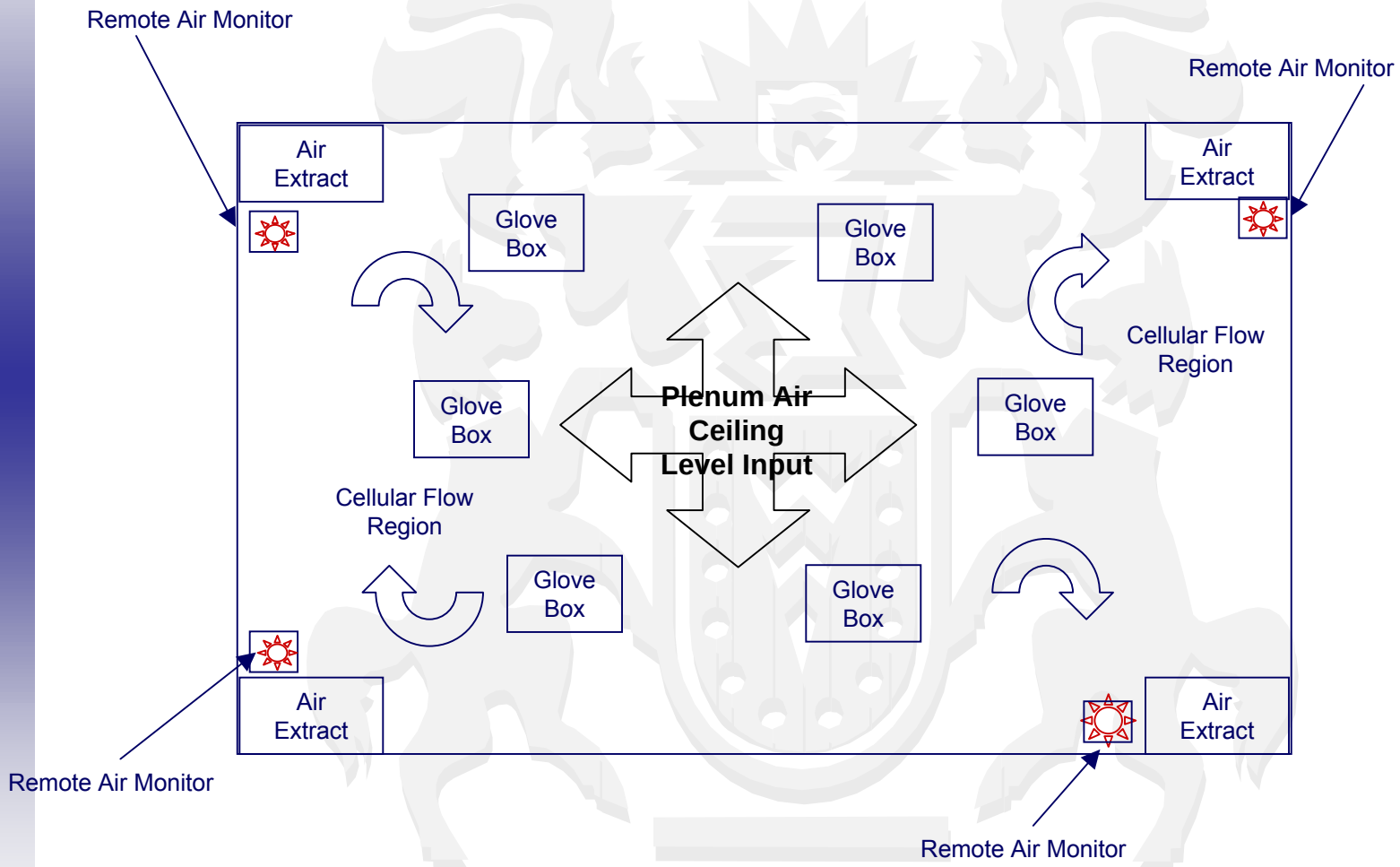
Intermittency Conclusions

- Intermittency - Probability of plume hitting detector
- Investigated using scaled down atmospheric dispersion models
  - Important close to release point
  - Important if off plume centreline
- Worker body heat dominant local influence
  - Convection current
  - Air does not flow directly from plenum to extract
  - Air monitor sited above worker's head
- Small diameter containment breaches result in lower probability plume hitting the sampler
- Two stages air monitoring required
  - Primary close in
    - Low dilution / High monitor sensitivity / Lower collection probability
  - Secondary remote
    - High collection probability / High dilution / Low monitor sensitivity

Cellular Flow Effects



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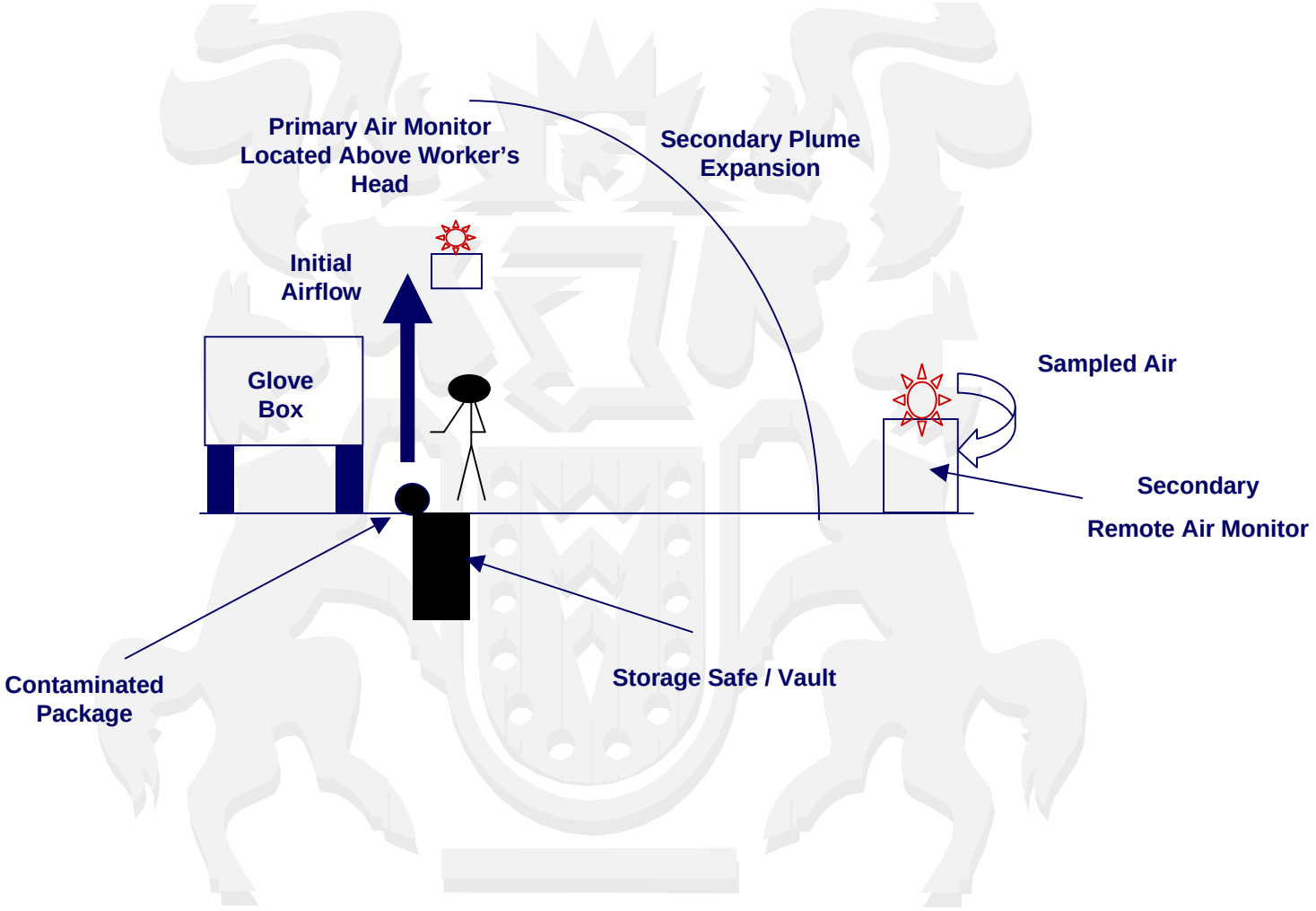
Air Monitor Detection Objectives

- Purpose real time air sampling regime
  - Enable prompt detection and evacuation when a significant dose received by worker
- Proposed detection objective
  - Based on claims made in facility safety cases
  - ALARP argument
- Regime detection level = Alarm Level * Dilution
  - Provide an alert at 2 mSv intake to worker
    - BSO, ICRP Dose investigation level $^{1}/_{10}$ dose limit
  - Within 2 minutes
    - 45 s to reach sampler,
    - 1 min to generate alarm
    - 15 s to evacuate work area

Air Monitor Alarm Levels

- Sampler collection and counting time
  - Integration periods typically several minutes
  - For target alarm response << integration period
    - Time to collect activity on paper becomes significant
    - Doubles calculated alarm level value
- Radon false alarms
  - Too many false alarms lead to worker distrust, apathy and degraded response to alarms
  - Literature suggests < 1 false alarm per month in a work area
  - If 6 monitors in a lab each instrument < 1 false alarm per 6 months per instrument
  - Set alarm level 5 σ background or equivalent based upon experience
- Overall effect reduction “real world” sensitivity of air monitor

Requirements Effective Air Monitor Regime



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Factors Affecting Performance of Air Monitoring Regime

- **Room air flow patterns**
  - Air does not flow directly from plenum to lab extract point.
  - Plume migration time (minimised if sampler directly downwind).
  - Probability of plume hitting sampler.
- **Distance of sampler from release point**
  - Greater the distance the more dilute the plume the less activity a remote sampler collects.
- **The choice of alarm level**
  - If alarm level is set too high may not collect sufficient activity to generate and alarm.
  - If push alarm level too low get excessive no. of radon false alarms.
  - Radon false alarm rate should not exceed 1 per instrument per 6 mts.
- **No single air monitor position that satisfies criteria**
  - Primary air monitor should be located < 6 m downwind

MERITS OF AIR MONITOR LOCATIONS

	Close to release point (Directly downwind)	Remote from release point
Dilution	Low	High
Air monitor alarm setting	Can be higher	Must be set low
Probability plume hitting monitor	Lower	Higher
Regime alarm response time	Short	Long (several minutes)
Regime detection level	Low (good)	High (poor)

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REAL TIME AIR MONITOR DETECTION LEVELS

	Primary monitoring (task specific)	Secondary air monitoing (fixed position)
Location	Above workers head > 1 to 1.5 m downwind < 0.2 to 0.4 m off axis	Adjacent to extract points In cellular flow regions
Dilution	10 (worst case)	100 (10 to 300 been observed) (B393.6 = 30)
Monitor detection level	8 DACh	8 DACh
Overall alarm response time	Lab mixing few seconds + Instr response 3 mins **Total = 3 minutes**	Lab mixing 10 minutes + Instr response 3 mins **Total = 13 minutes**
Regime detection level	8 * 10 = 80 DACh = **0.8 mSv**	8 * 100 = 800 DACh = **8 mSv**

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RP Standard

- Work resulted in issue AWE RP Standard
- Defined when real time air monitors must be used
- Process to determine
  - How many and where located
  - Places restrictions on choice of alarm level
- Static air sampling always used to compliment real time air monitoring

Application Primary Air Monitoring Regime

- Locate air monitor above worker's head
  - Practical high risk / high occupancy fixed work stations
  - Mobile monitors on extendible arms less reliable since dependent upon worker compliance
  - Sampling line / remote sampling head, (50% deposition in hose still better than remote sampling point)
- Application
  - Some glove box work stations
  - Glove changing, posting & bagging operations
  - Sleeving ops, containment service line disconnections
  - Entrances to tents, opening containers
- Influence design new air monitors
  - Encourage air monitor designers to separate sampling head from pump
  - Alarming Personal Air Sampler (Is 100 DACh detection achievable?)