The measurement of Beta and Gamma Emitting Radionuclides in MOATA Concrete

IAEA R2D2 Project Workshop

7-11 May 2012 ANSTO

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Introduction

- MOATA – was a 100kW Argonaut research reactor located at Lucas Heights
- It operated from 1961 to 1995
- Used for reactor operation training, NAA (neutron activation analysis), neutron radiography, other
- It was identified for decommissioning in August 1996

Introduction

- **Two sources of radionuclides present on MOATA concrete:**
  - **Natural sources**
    - **^{238}U, ^{232}Th and ^{235}U and their daughters**
    - **Present in concrete during construction**
  - **Anthropogenic sources**
    - **Elements present in concrete made radioactive during reactor operation (ie NAA)**
    - **Only long half-lives nuclides were present**
    - **eg ^{152}Eu, ^{60}Co, ^{55}Fe, others**

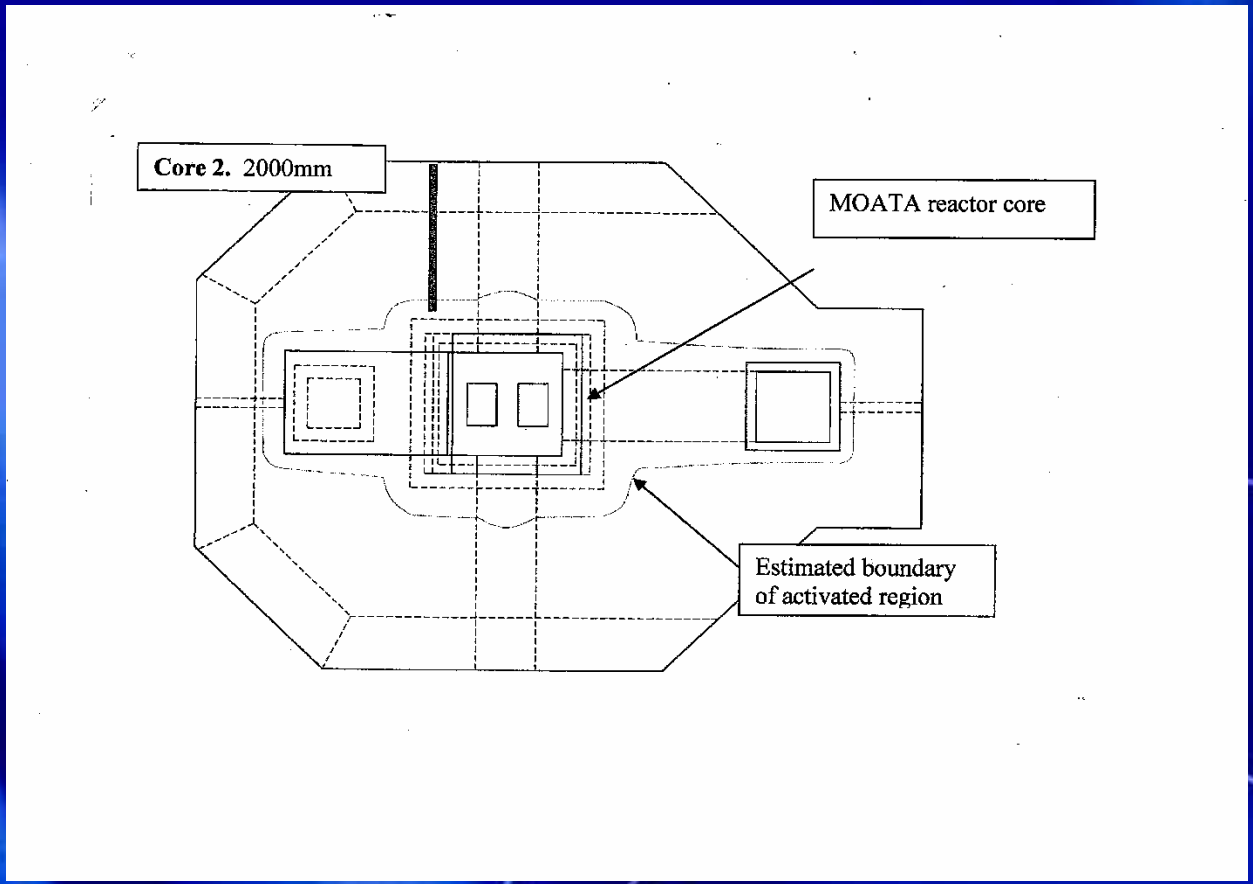
Introduction

- Decommissioning meant the disposal of waste – in MOATA's case this was mainly concrete
- Concrete was removed as blocks
- Need to measure both gamma and beta present
- Blocks fell into two categories
  - Radionuclides below agreed statuary levels ie "Free release"
  - The rest ie radioactive
- Two way to determine which category
  - Analyse beta and gamma in each block before disposal - impractical
  - Measure gamma and then calculate beta

Introduction

- **Gamma emitting radionuclides**
  - **Relatively easy to measure - ISOCS**
- **Beta emitting radionuclides**
  - **More difficult to measure – radiochemistry**
  - **Not available in Australia**
  - **Expensive**
  - **Calculate beta present via beta/gamma association (and allow a margin factor for uncertainty)**

A Suitable core



Sample preparation

- Select a “suitably radioactive” core
- Radioactivity decreases along the core
- Cut into 25mm disks
- Crush and homogenise each disk
- Measure gamma nuclides in each resulting sample
- Send samples overseas for beta analysis
- Correlate data
- Determine correlation between beta and gamma

Gamma analysis results

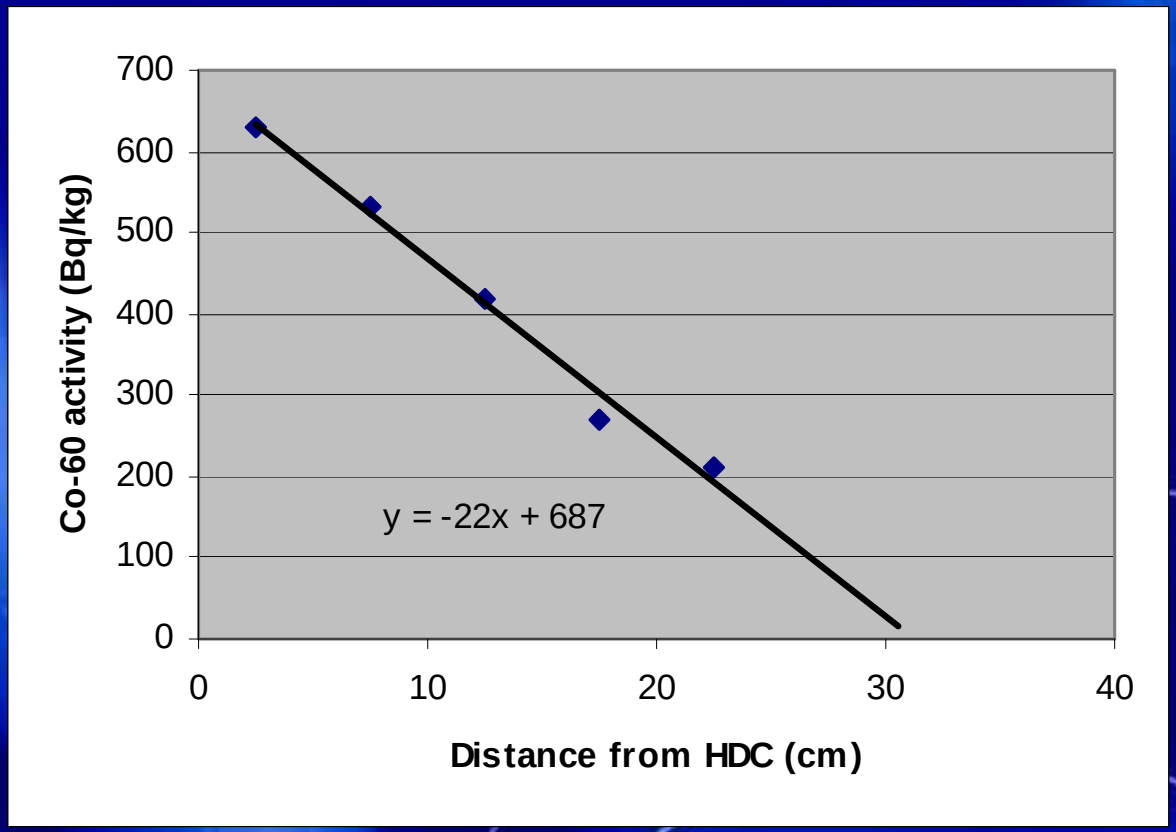
Measured

Calculated

Depth (cm)	Co-60 (Bq/kg)	Eu-152 (Bq/kg)	Eu-154 (Bq/kg)
2.5	630	4100	300
7.5	530	3700	260
12.5	420	3000	180
17.5	270	2000	120
22.5	210	1500	85
27.5	82	790	18
32.5	-	100	-
37.5	-	-	-

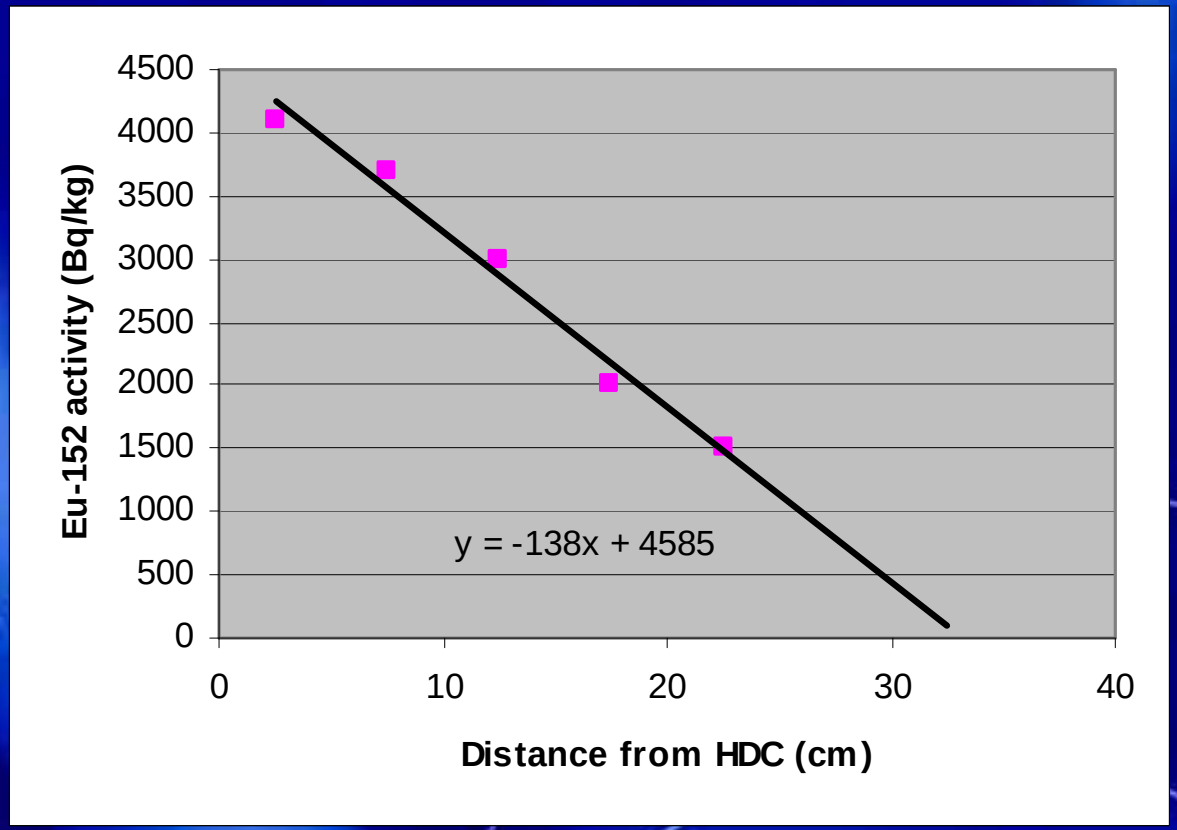
Gamma radionuclide activity vs distance from HDC

Gamma analysis results



Co-60 activity vs distance from HDC

Gamma analysis results



Eu-152 activity vs distance from HDC

Beta analysis results

Depth (cm)	H-3 (Bq/kg)	Cl-36 (Bq/kg)	Fe-55 (Bq/kg)	Sr-90 (Bq/kg)
2.5	29100	2.15	125	7.5
7.5	29100	< 1.75	116	8.0
12.5	24900	< 1.75	61	<1.1
17.5	17900	< 1.75	44	<1.1
22.5	12800	< 1.75	34	<1.1
Detection limit	160	1.75	9.3	1.1

Beta radionuclide activity vs distance from HDC

Beta analysis results

- **Observations**
  - Beta results were acceptable – relatively low beta present in samples, radiochemistry complex, etc
  - ^{3}H and ^{55}Fe found in all samples submitted – need to consider these for “Free Release” samples
  - ^{36}Cl and ^{90}Sr found in more active samples (closer to core)
  - The best beta data for correlation was for ^{55}Fe
  - Use ^{60}Co vs ^{55}Fe correlation

Analysis results

Depth (cm)	Co-60 (Bq/kg)	Eu-152 (Bq/kg)	Fe-55 (Bq/kg)	Fe-55/ Co-60	Fe-55/ Eu-152
2.5	630	4100	125	0.20	0.030
7.5	530	3700	116	0.22	0.031
12.5	420	3000	61	0.15	0.020
17.5	270	2000	44	0.16	0.022
22.5	210	1500	34	0.16	0.023

Analysis results

- **Did it work?**
  - **Good correlation for gamma with distance from HDC**
  - **Acceptable for beta results**
  - **When ^{60}Co vs ^{55}Fe correlation is used you get a reasonable correlation factor.**
  - **Measure gamma in each block by ISOCS then calculate beta present from gamma results**
  - **Only need data for “Free release” consideration (ie low results)**

Conclusions

- This method of estimating beta in each concrete block was successful
- Gamma was measured on each block using ISOCS and the beta was then calculated as described
- The contribution of ^{55}Fe and other beta emitters to the “Free Release” calculation was found to be very small
- This process saved a significant amount of time and money