



Formal Analysis of SRS X Ray Hutch Safety Systems

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Outline

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- SRS X Ray Hutches : the Safety Issue
 - Regulations
 - The Formal Study
 - Emphasis on Human Factors
 - Conclusions of the Study
 - Value of this type of Study
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SRS X Ray Hutch





X Ray Hutches

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- 33 enclosures on the SRS
 - 150,000 to 200,000 hutch search and lock up operations per year.
 - Non 'expert' users
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HAZARD - 1

Beam line	Dose rate in Gy per h			
	Within beam		Scattered to 1m	
	White	Monochromatic	White	Monochromatic
Dipole	4.4×10^8	4.4×10^5	1.2	0.001
Wig 9	1.0×10^9	1.0×10^6	16.5	0.017
Wig 16	1.1×10^9	1.1×10^6	18.6	0.019



HAZARD - 2

Beam Line	Time for burn		Time for dose limit	
	Within beam		Scattered to 1m	
	White	Monochromatic	White	Monochromatic
Dipole	16 μs	16 ms	3 s	3000 s
Wiggler 9	7.2 μs	7.2 ms	0.2 s	218 s
Wiggler 16	6.5 μs	6.5 ms	0.2 s	194 s



Regulations

- Council Directive 96/29 Euratom
 - Laying down basic safety standards for the protection of health workers and the general public against the dangers arising from ionising radiation
- Ionising Radiation Regulations 1999
 - Update of UK regulations to include 96/29
 - Enacted 1st January 2000



UK HSE Review of SRS

- Facility reviewed by Specialist Radiation Inspector
- Upgrades required to some systems.
- Discussions on some aspects difficult due to subjective assessments of risk.
- Commission formal study of system safety
 - Nuclear industry safety consultants AEA Consulting - now SERCO.

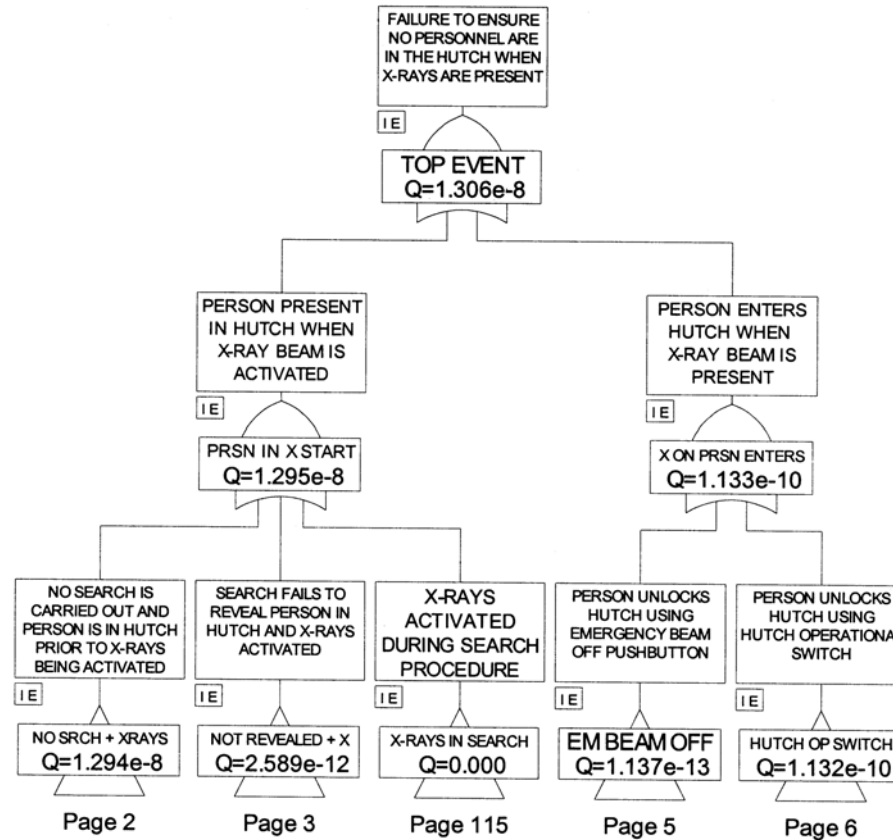


Fault Tree Analysis

- Define Top Event
 - Failure to ensure hutch clear of personnel when X rays are present
- Define all possible sub-events to the top event
- Define all possible sub-events to the sub-events
- Keep going until all base events identified.

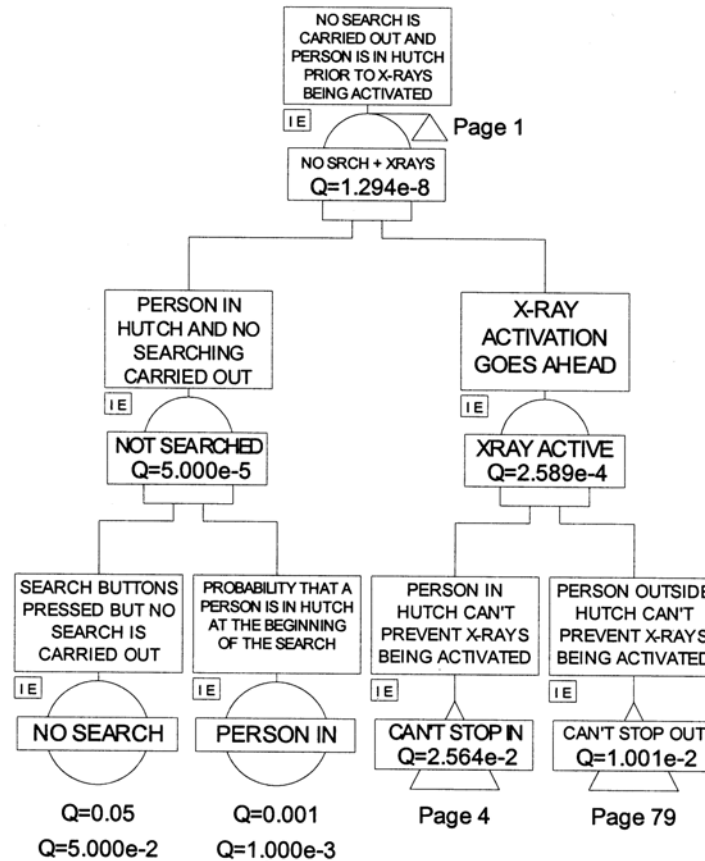


Fault Analysis





Fault Analysis





Typical Base Events

- Relay contact fails closed
- Searcher ignores warning sign
- Pneumatic control valve seizes



Fault Tree Analysis

- Assign probabilities to all events
- Use software to analyse the event tree and minimal cut sets showing combinations that can give rise to the top event.



Human Factors

- Nine base events describing possible human errors in searching a hutch were identified.
- Events are ranked according to likelihood by asking several well informed people to conduct a paired comparison exercise.
- Probabilities assigned using formal techniques and interpolation



Examples of Human Base Events

- Bad Search $1 \times 10E-05$
 - No Search $1 \times 10E-01$
 - Individual incapacitated $1 \times 10E-02$
 - No response $1 \times 10E-02$
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THERP

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- Technique for Human Error Rate Prediction
 - Developed for Nuclear Power Plant Operations
 - Gives data relating to alarm response and inspection tasks
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HEART

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- Human Error Assessment and Reduction Technique
 - Assesses groups of tasks and classifies them
 - Example “Routine highly practised, rapid task involving relatively low level of skill “ is assigned probability of 2×10^{-2}
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Results

- Highest probability of top event is 5×10^{-08}
- Minimal cut sets dominated by human factors
- Hardware failure sequences have probability of failure at 10^{-12} level



Example

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- Person in hutch at start of search ? 0.001
 - Searcher not thinking ? 0.05
 - Searcher fails to see person ? 0.05
 - Person incapacitated ? 0.01
 - Total probability 2.5×10^{-08}
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Issues Arising

- Experimental Area access policy : Users and public
- Staff and user training policy : probabilities are strongly affected by effectiveness of training.
- Site alcohol policy
- Staff / user working hours policy
- X Ray hutch layout and inspection



Risk Tolerability

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- No one will say what is tolerable !
 - High Risk $10^{-04}/\text{year}$ Intolerable
 - Risk reduction possible $10^{-05}/\text{year}$ ALARP
Tolerable
 - Negligible risk $10^{-06}/\text{year}$ Broadly acceptable.
 - - for Workers. Lower risks demanded for members of the public
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Value of the Formal Study

- High : requires comprehensive review of all aspects of the system
- Satisfies duty in law to complete a “suitable and sufficient” risk assessment
- Provides a more objective basis for discussions with the specialist regulator.