Development Of The Diamond Light Source
PSS In Conformance With EN 61508

• Presented by Martin Wilson
• Principal Personnel Safety Engineer
• Diamond Light Source
What is this talk about?

- What is Diamond Light Source?
- Personnel Safety System organisation
- The need for a database
- Quantization
- Calculations
- Report generation
DLS
3 accelerators
Up to 40 beamlines
+ branches

Machine operation
Protection - Shielding
PSS Organisation
Design process

1. Concept
2. Overall scope definition
3. Hazard and risk analysis
4. Overall safety requirements
5. Safety requirements allocation
6. Overall planning
7. Overall operation and maintenance planning
8. Overall safety validation planning
9. Overall installation and commissioning planning
10. Safety-related systems overview
11. Realisation (see DES/PES data lifecycle)
12. Overall installation and commissioning
13. Overall safety validation
14. Overall operation, maintenance and repair
15. Overall modification and retrofit
16. Decommissioning or disposal

IEC 1 666/98

Design process

1. Design
2. Build
3. Test
4. Release
5. Maintain
Database

STUFF

Safety requirements
Safety model
Verification
Validation
Hazard Identification

- Identify hazards
- Estimate frequency
- Estimate consequence
- Identify safety measures
- Control measures
## HAZID Form

<table>
<thead>
<tr>
<th>Ref</th>
<th>Hazard</th>
<th>Consequences</th>
<th>Initiating Event</th>
<th>Frequency of Opportunity</th>
<th>Non-PSS Safeguards</th>
<th>PSS Safety Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1a</td>
<td>Exposure to radiation in Linac Vault</td>
<td>Possibility of fatality</td>
<td>Trained person attempts to enter vault with Linac operating</td>
<td>1 per day</td>
<td>(i) Trained personnel (ii) Card access (iii) Safety Operating Procedures prevent entry while Linac operating. (iv) Use of radiation monitors</td>
<td>(i) Annunciator outside door (ii) Key exchange interlock (iii) Door switches stop Linac (iv) Coloured light system inside</td>
</tr>
<tr>
<td>1.1b</td>
<td>Exposure to radiation in Linac Vault</td>
<td>Possibility of fatality</td>
<td>Visitor attempts to enter vault with Linac operating</td>
<td>1 per week</td>
<td>(i) Supervision by trained guide (ii) Limited group size</td>
<td>(i) Annunciator outside door (ii) Key exchange interlock (iii) Door switches stop Linac (iv) Coloured light system inside</td>
</tr>
<tr>
<td>1.2a</td>
<td>Exposure to radiation in Linac Vault</td>
<td>Possibility of fatality</td>
<td>Linac started with trained person in vault</td>
<td>1 per day</td>
<td>(i) Vault searched before start-up (two trained person search) (ii) Use of radiation monitors (mitigation)</td>
<td>(i) Key exchange interlock (ii) Open door inhibits start-up (iii) Search confirmation buttons (iv) Coloured light system inside (v) Warning announcements (vi) Beam Off buttons</td>
</tr>
</tbody>
</table>

ICALEPCS 2011 14/10/2011 MCW
Database

Hazards
Opportunity
Consequence
Safeguards
Control measures
# Convert from Qualitative to Quantitative

## Hazards

<table>
<thead>
<tr>
<th>hazard_con</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to White Beam - Probable fatality (100%)</td>
<td>1</td>
</tr>
<tr>
<td>Exposure to Pink beam - Probable fatality</td>
<td>0.8</td>
</tr>
<tr>
<td>Exposure to Monochromatic beam - Possible fatality, serious injury</td>
<td>0.01</td>
</tr>
<tr>
<td>Exposure to soft beam - possible blindness, cataracts</td>
<td>0.01</td>
</tr>
<tr>
<td>Overexposure</td>
<td>0.001</td>
</tr>
<tr>
<td>Probable fatality (100%)</td>
<td>1</td>
</tr>
<tr>
<td>Possible fatality (50%)</td>
<td>0.5</td>
</tr>
<tr>
<td>Possible fatality (20%)</td>
<td>0.2</td>
</tr>
<tr>
<td>Serious injury</td>
<td>0.2</td>
</tr>
<tr>
<td>Minor injury</td>
<td>0.01</td>
</tr>
<tr>
<td>Trap hazard - Death or serious injury (minimise inertia by design)</td>
<td>0.8</td>
</tr>
<tr>
<td>Trap hazard - Serious injury</td>
<td>0.2</td>
</tr>
<tr>
<td>Asphyxiation</td>
<td>1</td>
</tr>
<tr>
<td>Breathing difficulties, irritation</td>
<td>0.001</td>
</tr>
<tr>
<td>RF burns, severe injury, cataracts</td>
<td>0.01</td>
</tr>
</tbody>
</table>
Convert from Qualitative to Quantitative

Opportunity

<table>
<thead>
<tr>
<th>hazard_op</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>once every 20mins</td>
<td>26280</td>
</tr>
<tr>
<td>25 per day</td>
<td>9125</td>
</tr>
<tr>
<td>once per day</td>
<td>365</td>
</tr>
<tr>
<td>once per week</td>
<td>52</td>
</tr>
<tr>
<td>once per month</td>
<td>12</td>
</tr>
<tr>
<td>once every 6 months</td>
<td>2</td>
</tr>
<tr>
<td>once per year</td>
<td>1</td>
</tr>
<tr>
<td>1 in 5 years</td>
<td>0.2</td>
</tr>
<tr>
<td>1 in 10 years</td>
<td>0.1</td>
</tr>
<tr>
<td>Not in the life of the machine</td>
<td>0.01</td>
</tr>
</tbody>
</table>
### Safeguards

<table>
<thead>
<tr>
<th>safeguard_ref</th>
<th>safeguard_function</th>
<th>Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL_PSS_SR01</td>
<td>Handheld radiation monitors shall be used to detect radiation in the Beam Line Hutches.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR02</td>
<td>Personnel will be provided with adequate and suitable Beam Line training to enable them to work on the Beam Line unsupervised.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR03</td>
<td>Access to the facility will be restricted by means of a Card Access system.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR04</td>
<td>Operating procedures shall provide details of when it is unsafe to enter the Beam Line Hutches.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR05</td>
<td>The PSS shall provide an external visual indication that it is unsafe to enter the Beam Line Hutches.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR06</td>
<td>The PSS shall close the beam safety shutter if the door to the Beam Line Hutch is unlocked.</td>
<td>0.003</td>
</tr>
<tr>
<td>BL_PSS_SR07</td>
<td>The PSS shall dump the beam if the shutter is open and the door to the Beam Line Hutch is open.</td>
<td>0.003</td>
</tr>
<tr>
<td>BL_PSS_SR08</td>
<td>The PSS shall provide the Beam Line Hutch with an internal visual indication of danger.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR09</td>
<td>All untrained personnel shall be closely supervised to prevent unauthorised access to the Beam Line Hutches.</td>
<td>0.01</td>
</tr>
<tr>
<td>BL_PSS_SR10</td>
<td>The Beam Line Hutches shall be searched by a single trained person before operation of the beam.</td>
<td>0.1</td>
</tr>
<tr>
<td>BL_PSS_SR11</td>
<td>The PSS shall inhibit beam operation until search pattern has been confirmed by operation of search buttons.</td>
<td>0.003</td>
</tr>
<tr>
<td>BL_PSS_SR12</td>
<td>The PSS shall switch the Beam Line Hutch internal lighting to blue following the completion of the search until the system moves to standby.</td>
<td>0.1</td>
</tr>
</tbody>
</table>
HAZID validation

Hazards
Opportunity
Consequence
Safeguards
Control measures

Database

HAZID report

Hazards
Opportunity
Consequence
Safeguards
Control measures

ICALEPCS 2011 14/10/2011 MCW
HAZID validation

RUBBISH
Hazards √
Opportunity √
Consequence √
Safeguards √
Control measures √

Comparison report 1
Comparison report 2
Risk reduction

Figure A.2 – Risk and safety integrity concepts
- Local Rules
- Use of hand held rad mon
- Training
- Card Access

- Annunciator
- Door locked by PSS
- Door open interlock
- Door locked interlock
- Search confirmation
- Blue lights
- Warning tones
- BOB
Database reports – Safety margin and SIL

Hazards
Opportunity
Consequence
Safeguards
Control measures

Safety Margin report
SIL Requirements report
Shortcomings and benefits of calculation

• Independence of safety measures
Shortcomings and benefits of calculation

Shortcomings

- Independence of safety measures
- Common mode effects
- Human Factors

Benefits

- Quick
- Easy
- Good indication
- Reduced number of passes
Refining risk

- Try to reduce the severity
- Try to reduce the frequency of opportunity
- Increase the non E/E/PE safety measures
- Increase the E/E/PE safety measures
Database reports - Safety requirements

Sort the hazard data by area to generate a safety requirements report with SIL ratings
Functional performance test

• For every Safety requirement there will be a functional performance test

Functional tests reference

Functional tests/Safety requirements cross reference Report

Database
Control measures
Database Reports- Logic

Sort the hazard data by area and control measure to generate a logic report for cross checking design

Logic design check  Logic report

Database
Documentation

• Each system has a suite of documents, some of which are common, recorded and linked in the database
Conclusions

• The database strengthens the EN 61508 process in DLS
• It generates useful reports and cross references
• Calculations do not replace more formal assessments
• Shouldn’t be used blindly
• A useful accompaniment to normal process
Questions?

• Martin Wilson
• Principal Personnel Safety Engineer
• Diamond Light Source
• martin.wilson@diamond.ac.uk
• +44 (0)1235-778049