Definition of Supervised and Controlled Radiation Areas

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author</strong></td>
<td>Günter Muhrer, ESS Shield Design Coordinator</td>
</tr>
<tr>
<td></td>
<td>François Javier, System Engineering</td>
</tr>
<tr>
<td><strong>Reviewer</strong></td>
<td>Peter Jacobsson, Head of ES&amp;H</td>
</tr>
<tr>
<td></td>
<td>Eric Pitcher, Head of Target Division</td>
</tr>
<tr>
<td></td>
<td>Mats Lindroos, Head of Accelerator Division</td>
</tr>
<tr>
<td></td>
<td>Shane Kennedy, Deputy Director for Science</td>
</tr>
<tr>
<td></td>
<td>Kent Hedin, Head of Conventional Facilities Division</td>
</tr>
<tr>
<td></td>
<td>John Haines, Associate Director for ES&amp;H, QA and Operations</td>
</tr>
<tr>
<td><strong>Owner</strong></td>
<td>Günter Muhrer</td>
</tr>
<tr>
<td><strong>Approver</strong></td>
<td>Roland Garoby, Technical Director</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

1 Introduction ..................................................................................................................3
1.1 Purpose ....................................................................................................................3
1.2 Definitions, Acronyms and Abbreviations ...............................................................3

2. Limitations of the assessment and the Guidance .....................................................3

3. Definition of areas ......................................................................................................3
3.1 Public areas ..............................................................................................................3
3.1.1 Swedish law ........................................................................................................3
3.1.2 ESS implementation .........................................................................................4
3.2 Supervised areas ......................................................................................................4
3.2.1 Swedish law ........................................................................................................4
3.2.2 ESS implementation .........................................................................................4
3.3 Controlled areas ......................................................................................................4
3.3.1 Swedish law ........................................................................................................4
3.3.2 ESS implementation .........................................................................................5
3.3.2.1 Unrestricted controlled areas ......................................................................5
3.3.2.2 Restricted controlled areas ..........................................................................5
3.3.2.3 Highly restricted controlled areas ...............................................................6

4. Controls ....................................................................................................................6
4.1 What needs to be controlled? ..................................................................................6
4.2 Public areas ............................................................................................................6
4.3 Supervised areas ....................................................................................................7
4.4 Controlled areas .....................................................................................................7

5. Summary Table .........................................................................................................9
1 INTRODUCTION

For the purpose of clarifying radiological zoning, meetings with SSM have been held in November 2014 and May 2015. Based on these discussions the ESS categorization of radiological areas has been updated.

1.1 Purpose

In accordance to SSMFS 2008:51 the areas at ESS shall be categorized into public areas, supervised areas and controlled areas. Based on the meetings with SSM Nov. 2014, May 2015 and the received clarifications, the definition has been refined as described in this document.

1.2 Definitions, Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Term</th>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>EWBDR</td>
<td>External whole body dose rate</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>Airborne contamination in units of DAC</td>
<td>Concentration of a given radionuclide in air, which if inhaled by the worker for a working year of 2000 hours under conditions of light work (air inhalation rate of 1.2 m³/h), results in an annual dose of 20 mSv.</td>
</tr>
<tr>
<td>DAC</td>
<td>Derived air contamination</td>
<td></td>
</tr>
</tbody>
</table>

2 LIMITATIONS OF THE ASSESSMENT AND THE GUIDENCE

This document is based on the current understanding of the matter and the current guidance from SSM. As this process has not been concluded, this document could be updated as more information becomes available.

3 DEFINITION OF AREAS

Below the definitions for public, supervised and controlled areas can be found. It shall be stated at this time, that the classification of a specific area may change as a function of changing conditions (e.g. beam on or beam off).

3.1 Public areas

3.1.1 Swedish law

In accordance with SSM 2008:51 an area can be declared as public if the annual biological full body dose a person is expected to receive in this area from normal operation and likely accidents (H2 events) is less than 1 mSv, the annual dose to the lens/eye is less than 15 mSv, the dose to the hands, forearms, feet ankles or skin is less than 50 mSv and removable surface contamination and air contamination are indistinguishable from background.
3.1.2 ESS implementation

ESS requires that in all public areas the removable surface contamination and air contamination are indistinguishable from background and no temporary hotspots are present. In addition public areas are subdivided into areas that are permanently occupied and areas that are not permanently occupied. For areas that are not permanently occupied the maximum allowable whole body dose is less than 0.5 μSv/h. For areas that are permanently occupied, in accordance with the ESS General Safety Objectives (ESS-00004) the maximum allowable whole body dose is 25 nSv/h.

3.2 Supervised areas

3.2.1 Swedish law

An area shall be declared as supervised if at least one of the following conditions applies:

1. The expected annual biological full body dose to a person from normal operation and likely accidents, during the time the room is accessible, is between 1 mSv and 6 mSv.
2. The expected annual dose to lens or eye of a person from normal operation and likely accidents is between 15 mSv and 45 mSv.
3. The expected annual dose to a persons’ hands, feet, ankles or skin form normal operation and likely accidents (H2 event), is between 50 mSv and 150 mSv.
4. Removable surface contamination is not significant from a radiological point of view.

3.2.2 ESS implementation

In the meetings with SSM on zoning, SSM has agreed to and therefore required by ESS:

1. The removable surface contamination is detectable but less than 4 Bq/cm² for β,γ or 0.4 Bq/cm² for α.
2. Likely accidents are defined as H2 events.

In addition ESS will have the following requirements for a supervised area:

1. General, long-term whole body dose for normal operation (H1) shall be less than 3 μSv/h.
2. Airborne contamination shall be indistinguishable from background.
3. Temporary hotspots shall not exceed 3 μSv integrated dose over any one-hour period.
4. The dose to a worker in a supervised area from H2 event shall not exceed 2 mSv.
5. Worker will not be allowed to enter the supervised area if the worker’s annual dose has reached 3.5 mSv.

3.3 Controlled areas

3.3.1 Swedish law

An area shall be declared as controlled if at least one of the following conditions applies:

1. The expected annual biological full body dose to a person from normal operation and likely accidents exceeds 6 mSv.
2. The expected annual dose to lens or eye of a person from normal operation and likely accidents exceeds 45 mSv.
3. The expected annual dose to a person’s hands, feet, ankles or skin from normal operation and likely accidents exceeds 150 mSv.
4. The removable surface contamination exceeds 40 KBq/m² for β,γ or 4 KBq/m² for α.

3.3.2 ESS implementation

Controlled areas at ESS shall be subdivided into

1. Unrestricted controlled areas.
2. Restricted controlled areas.
3. Highly restricted controlled areas.

In the meetings with SSM on zoning, SSM has agreed to and therefore required by ESS:

1. Likely accidents are defined as H2 events.

3.3.2.1 Unrestricted controlled areas

In this area an authorised person can manage the work by him/herself.

1. If only external radiation contributes to the whole body dose, then it shall be limited to less than 25 μSv/h.
2. If only airborne contamination contributes to the whole body dose, then it shall be limited to less than 2.5 DAC.
3. If both, external radiation and airborne contamination contributes to the whole body dose it shall be limited by

\[(\text{EWBDR}/25 \text{ μSv/h})+(\text{AC}/2.5 \text{ DAC})<1\]

(see chapter 1.2 for definitions).

4. The removable surface contamination is detectable but less than 40 Bq/cm² for β,γ or 4 Bq/cm² for α.
5. Temporary hotspots shall not exceed 25 μSv integrated dose over any one-hour period.
6. The dose to a worker in a controlled area from H2 event shall not exceed 20 mSv.
7. Worker will not be allowed to enter the controlled area if the worker’s annual dose has reached 10 mSv.

3.3.2.2 Restricted controlled areas

In this area an authorised person needs to seek authorisation for the work on a task per task base by the responsible division leader.

1. If only external radiation contributes to the whole body dose, than it shall be limited to less than 2.5 mSv/h.
2. If only airborne contamination contributes to the whole body dose, than it shall be limited to less than 250 DAC.
3. If both, external radiation and airborne contamination contributes to the whole body dose it shall be limited by
(EWBDR/2.5 mSv/h)+(AC/250 DAC)<1

(see chapter 1.2 for definitions).

4. The removable surface contamination is detectable but less than 100 Bq/cm² for β,γ or 10 Bq/cm² for α.
5. The dose to a worker in a controlled area from H2 event shall not exceed 20 mSv.
6. Worker will not be allowed to enter the controlled area if the worker’s annual dose has reached 10 mSv.

3.3.2.3 Highly restricted controlled areas
In this area an authorised person needs to seek authorisation for the work on a task per task base by the director for operations, if the dose levels are below 50 mSv/h and from the director general if the dose levels are above 50 mSv/h.

1. If only external radiation contributes to the whole body dose more than 2.5 mSv/h.
2. If only airborne contamination contributes to the whole body dose more than 250 DAC.
3. If both, external radiation and airborne contamination contributes to the whole body dose and exceeds

(EWBDR/2.5 mSv/h)+(AC/250 DAC)>1

(see chapter 1.2 for definitions).

4. The removable surface contamination is detectable and more than 100 Bq/cm² for β,γ or 10 Bq/cm² for α.
5. The dose to a worker in a controlled area from H2 event shall not exceed 20 mSv.
6. Worker will not be allowed to enter the controlled area if the worker’s annual dose has reached 10 mSv.

4. CONTROLS

4.1 What needs to be controlled?

From a radiological point of view personal and global controls shall be implemented considering the following conditions:

1. Dose due to prompt radiation.
2. Dose due to non-removable volume activation.
3. Dose due to removable surface contamination.
4. Dose due to airborne contamination.

4.2 Public areas

If an area meets all criteria for a public area no individual radiological controls need to be put in place. Global controls and surveillances shall be put in place as needed and required by law.
4.3 Supervised areas

1. Individual dose monitoring:
   a. Radiation worker A and B, as defined by SSM 2008:51 shall wear passive individual dosimeters.
   b. In case of visitors an active group dosimeter shall be issued.

2. Room monitoring:
   a. Prompt radiation: Stationary monitoring and periodic dose map with transportable equipment.
   b. Removable surface contamination: Periodical swipes
   c. Airborne contamination: stationary offline monitoring

3. Access control and requirements:
   a. An individual entering the area
      i. Become radiation worker A or B
         • Adequate radiation protection training (general & local)
         • Facility access clearance
         • Individual dose meter
      ii. Visitors escorted by an authorised person
      iii. Drinks are allowed in closed containers only
      iv. No food
   b. An individual exiting the area
      i. Portal monitor
      ii. Hand and foot monitor, if there is a likely possibility for detectable removable surface contamination.
   c. Equipment, tools and materials entering the area
      i. If the equipment was not located in a controlled area prior to entering the supervised area no controls are required.
      ii. If the equipment was located in a controlled area prior to entering the supervised area, it needs to be checked if the radiological condition of the equipment is consistent with requirements of the supervised area.
   d. Equipment, tools and materials exiting the area
      i. If the equipment was not located in a controlled area prior to being placed in the supervised area and it was not exposed to removable contamination, the equipment can be removed from the supervised area without any controls, provided a portal monitor is used at the exit.
      ii. If the equipment was located in a controlled area prior to being placed in the supervised area or was exposed to removable contamination, the radiological condition of the equipment needs to be checked before it is removed from the supervised area.

4. Personal Protection Equipment (PPE)
   a. For radiological purposes no PPE is required.

4.4 Controlled areas

1. Individual dose monitoring:
   a. Radiation worker A and B, as defined by SSM 2008:51 shall wear active and passive individual dosimeters.
   b. Radiation worker A and B shall wear dosimeters for extremities if necessary.
   c. In case of visitors an active group dosimeter shall be issued.
2. Room monitoring:
   a. Prompt radiation: Stationary monitoring and periodic dose map with transportable equipment.
   b. Removable surface contamination: Periodical swipes
   c. Airborne contamination:
      i. Stationary offline monitoring for containment class 1 (C1)
      ii. Stationary online monitoring for containment classes higher than 1 (>C1)

3. Access control and requirements:
   a. An individual entering the area
      i. Become radiation worker A or B
         • Adequate radiation protection training (general & local)
         • Facility access clearance
         • Individual dose meter
      ii. No Drinks are allowed in closed containers in areas that are not controlled for contamination.
      iii. No food
      iv. Areas that are controlled for contamination
         • PPE (Coveralls, overshoes, gloves, etc) as needed
         • No workers with skin injury
         • No drinks
         • Specific authorization if required
   b. An individual exiting the area
      i. Not controlled for contamination
         • It is assumed that no controlled area will directly lead to a public area, therefore no controls are required.
      ii. Unrestricted controlled area for contamination
         • Hand and foot monitor.
      iii. Restricted and highly restricted area for contamination.
         • Full body monitor.
   c. Equipment, tools and materials entering the area
      i. If the equipment was not located in a controlled area prior to entering the controlled area no controls are required.
      ii. If the equipment was located in different controlled area prior to entering the controlled area, equipment needs to be checked if the radiological condition of the equipment is consistent with requirements of the controlled area it is moved to.
   d. Equipment, tools and materials exiting the area
      i. Dose rates and contamination levels need to be checked.

4. Personal Protection Equipment (PPE)
   a. Will need to be set on a case by case base depending on what the area is controlled for.
      i. External radiation only: none
      ii. In areas that are controlled for contamination: according to contamination levels and nuclides involved (e.g. respirators, dust mask, compressed air, etc)
### 5. SUMMARY TABLE

<table>
<thead>
<tr>
<th>Public area</th>
<th>Supervised area</th>
<th>Unrestricted Controlled area</th>
<th>Restricted controlled area</th>
<th>Highly restricted controlled area</th>
</tr>
</thead>
<tbody>
<tr>
<td>External whole body dose rate in non permanently occupied areas:</td>
<td>EWBDIR &lt; 3 μSv/h</td>
<td>EWBDIR &lt; 25 μSv/h</td>
<td>External whole body dose rate (without airborne contamination):</td>
<td>EWBDIR &gt; 2.5 μSv/h</td>
</tr>
<tr>
<td>Airborne contamination</td>
<td>No</td>
<td>No</td>
<td>Airborne contamination (without external radiation):</td>
<td>Ac &lt; 2.5 DAC</td>
</tr>
<tr>
<td>Combination:</td>
<td>(EWBDIR/3 μSv/h) &lt; 1</td>
<td>Combination:</td>
<td>(EWBDIR/25 μSv/h) + (Ac/2.5 DAC) &lt; 1</td>
<td>Combination:</td>
</tr>
<tr>
<td>Surface contamination</td>
<td>1.1: γ &lt; 4 Bq/cm²</td>
<td>Surface contamination</td>
<td>1.2: γ &lt; 40 Bq/cm²</td>
<td>(EDWBR/25 μSv/h) + (Ac/250 DAC) &lt; 1</td>
</tr>
<tr>
<td>α &lt; 0.4 Bq/cm²</td>
<td>α &lt; 0.4 Bq/cm²</td>
<td>α &lt; 0.4 Bq/cm²</td>
<td></td>
<td>Surface contamination</td>
</tr>
<tr>
<td>Temporary hotspots</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>1.3: γ &gt; 100 Bq/cm²</td>
</tr>
<tr>
<td>No more than 3 μSv integrated dose over any one-hour period</td>
<td>Temporary hotspots:</td>
<td>No more than 25 μSv integrated dose over any one-hour period</td>
<td>H2 dose to worker &lt; 20 mSv/event</td>
<td>H2 dose to worker &lt; 20 mSv/event</td>
</tr>
<tr>
<td>H2 dose to worker &lt; 2 mSv/event</td>
<td>Worker will not be allowed to enter if annual dose of the worker has reached 3.5 mSv.</td>
<td>Worker will not be allowed to enter if annual dose of the worker has reached 10 mSv.</td>
<td>Worker will not be allowed to enter if annual dose of the worker has reached 10 mSv.</td>
<td>Worker will not be allowed to enter if annual dose of the worker has reached 10 mSv.</td>
</tr>
</tbody>
</table>

Access restriction using physical barriers + administrative procedures. Authorization (division leader level) on a task per task basis. Access restriction using physical barriers + administrative procedures. Authorization on a task per task basis by the director for operations. The dose levels above 50 mSv/week is authorized with concurrence by the director general.