German approach to the compilation and evaluation of abnormal occurrences in nuclear fuel cycle facilities

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Abstract:
Nuclear facilities are designed and constructed in a way that they can be operated without any harm to the operational staff, the general public and the environment. However, in a complex facility technical or human failures cannot be completely avoided. Regardless of the implemented countermeasures and procedures, irregularities, when happened, should be evaluated carefully in order to improve plant performance and safety continuously.

As in other countries with nuclear facilities, the German regulatory system includes the requirement to notify significant events to the competent authorities. The criteria for notification are well defined in the Nuclear Safety Officer and Reporting Ordinance. For the registration and evaluation of the events a database has been established which currently contains data on more than 4000 events worldwide. This paper describes the legal background and the procedure for the notification of abnormal occurrences in Germany. It also includes a brief statistical analysis of the database contents and some remarks on the backflow of experiences and lessons learned.

1 INTRODUCTION

Safety has the highest priority in operation of nuclear facilities. Both the competent authorities and the operators of the facilities have a strong interest in the continuous optimization of safety of their facilities. Therefore, all parties involved try to learn from past occurrences in order to avoid them in the future as far as possible and to implement efficient countermeasures. The compilation and evaluation of incidents and other operational experiences contribute to the identification of weak points in the technical design and the processes and the development of improvement measures. The knowledge of abnormal occurrences enables the safety authorities to supervise the safety of the facilities and to take appropriate and timely measures for the protection of the public and the environment.

2 LEGAL REQUIREMENTS

In Germany, the notification of accidents, incidents and other significant events is addressed in the “Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation” (Radiation Protection Ordinance - StrlSchV) [1] and the “Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events” (Nuclear Safety Officer and Reporting Ordinance - AtSMV). Notification criteria are specified in the AtSMV. This ordinance also contains standardized reporting forms.

A significant event must be reported to the competent authority by the licensee within defined time limits. These time limits depend on the potential need for the authorities to initiate adequate measures and are established as follows:

- Events of Category S: Notification immediately
- Events of Category E: Notification within 24 hours
- Events of Category N: Notification within 5 working days
- Events of Category V: Notification within 10 working days
3 PROCEDURE

After the notification has been delivered by the licensee, the regional state (Land) authority analyzes the report with regard to possible safety deficiencies and decides on necessary corrective measures. Normally, external experts from the technical safety organization TÜV are involved in this context. A copy of the event report is submitted to the Federal Office for Radiation Protection (BfS), which is responsible for the central registration of reportable events in German nuclear facilities. The main data are saved in a database. Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), the nuclear safety organization that supports the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), gets involved in the case of events with significant release of radioactivity or potential risk to the public, e.g. events with INES level 2 or more, by preparing a more detailed safety evaluation. Moreover, GRS is in charge of the compilation and evaluation of incidents and other significant events in foreign nuclear facilities, because such experiences also provide valuable information for the avoidance of incidents in German facilities. A flow-sheet illustrating the responsibilities and the procedural steps is shown in Figure 1. In addition, BfS is responsible for notifying (selected) events to the international database FINAS (Fuel Incident Notification and Analysis System) [3] of the IAEA and OECD/NEA.

Figure 1: Reporting procedure for abnormal occurrences in German nuclear facilities
A significant difference exists for the registration of events in German and foreign facilities. While for events in German facilities the organizations involved have direct and legally defined access to the relevant information, for foreign events this information is usually obtained by publicly available sources like the internet, annual reports, professional journals, etc.

4 DATABASE VIBS

In 1986, the ORACLE database VIBS was established for the registration of German and foreign events in nuclear fuel cycle facilities. For each registered event, it can store information on the following issues:

- General information (facility, licensee, event date, INES level, event type, ...),
- Descriptions in running text (chronology, causes, countermeasures, ...),
- Information on systems, components or devices involved,
- Information on radiological consequences (radioactive releases, contamination or radiation levels, ...),
- Key numbers for simplified evaluations.

The input screen for general information is shown in Figure 2.

Figure 2: Input screen of the database VIBS

At present, about 4280 events are recorded in this database, of which 1500 have occurred in German facilities and 2780 in foreign facilities. 1950 events were recorded from reprocessing plants, 1200 from fuel fabrication plants and 350 from uranium enrichment plants. The registered events include about 490 leakages, 300 events with relevance for criticality safety,
210 fires and 70 explosions. The distribution of registered events to different facility types shows Table 1.

**Table 1:** Number of events registered in the database VIBS

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>German facilities</th>
<th>Foreign facilities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reprocessing plants</td>
<td>998</td>
<td>947</td>
<td>1945</td>
</tr>
<tr>
<td>Fuel fabrication plants</td>
<td>402</td>
<td>804</td>
<td>1206</td>
</tr>
<tr>
<td>Research centres</td>
<td>3</td>
<td>379</td>
<td>382</td>
</tr>
<tr>
<td>Enrichment plants</td>
<td>23</td>
<td>332</td>
<td>355</td>
</tr>
<tr>
<td>Spent fuel storage facilities</td>
<td>69</td>
<td>5</td>
<td>74</td>
</tr>
<tr>
<td>Conversion plants</td>
<td>0</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Uranium mining and milling facilities</td>
<td>0</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Others</td>
<td>8</td>
<td>226</td>
<td>234</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1503</td>
<td>2774</td>
<td>4277</td>
</tr>
</tbody>
</table>

Some information concerning the contents of VIBS with regard to important event types are summarized in Table 2.

**Table 2:** Summary of incidents registered in the database VIBS

<table>
<thead>
<tr>
<th>Type of incident</th>
<th>No. of registered events</th>
<th>Injuries, damages</th>
<th>Radiological consequences</th>
<th>Facilities concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Criticality accidents</td>
<td>60 criticality accidents (38 during experiments and in reactor devices, 22 in radi-chemical process devices)</td>
<td>22 fatalities in 15 accidents</td>
<td>Significant radiation doses in many cases; maximum dose: 150 Sv (Los Alamos 1958)</td>
<td>Mainly military research and production facilities, e.g. Los Alamos (13 events), Idaho (7 events), Mayak (7 events)</td>
</tr>
<tr>
<td>Fires and explosions</td>
<td>215 fires, 71 explosions (including 60 in reprocessing plants)</td>
<td>Often damages, rarely injuries</td>
<td>Sometimes significant radiation doses</td>
<td>Most significant incidents happened in reprocessing plants. Worst explosion: Mayak 1957</td>
</tr>
<tr>
<td>Releases of radioactive material (including leakages)</td>
<td>890 leakages and releases (including 341 in reprocessing plants)</td>
<td>Very few cases.</td>
<td>Nearly always contamination of room air or equipment, often operators. Materials involved: UF₆, uranium powder, plutonium dust, uranyl nitrate, liquid waste</td>
<td>All types of fuel cycle facilities; most significant events: Hanford 1973, Sellafield 1983, Gore 1986, Sellafield 2005</td>
</tr>
</tbody>
</table>

Some results of a statistical analysis of events in facilities other than reprocessing plants are shown in the next two figures. Figure 3 gives a rough overview of the main underlying causes. It can be seen that 36% of the events were caused by malfunctions of components or systems while 29% could be attributed to human failures.
Figure 3: Underlying causes for events in facilities other than reprocessing plants

The radiological consequences are illustrated in Figure 4. The majority of the registered events had no or insignificant consequences. For 19% of the events surface contaminations of installations were reported, in 14% of all cases operators were externally or internally contaminated.

Figure 4: Radiological consequences of events in facilities other than reprocessing plants

Access to the database is currently limited to BMU, BfS and GRS. In parallel, a compilation of paper sheets with printouts of the database has been established. This compilation is amended at regular intervals by new sheets. BfS publishes annual reports on reportable occurrences in German nuclear fuel cycle facilities [4], while GRS reports on events in foreign facilities every two months by new data sheets and every two years by more detailed reports.

5 BACKFLOW OF OPERATING EXPERIENCES
Information on abnormal occurrences worldwide are considered useful both by the operators of nuclear facilities and the supervising authorities. The information is checked carefully after being submitted to the competent organization with regard to their relevance for the safety of operating facilities in Germany and taken into account if applicable. The following actions are taken:

- The competent Technical Supervisory Association (TÜV) reviews the events with regard to relevance and applicability on behalf of the regional state (Land) authority according to a general examination order. TÜV recommendations are elaborated if appropriate. Following these recommendations, the authority can give a directive to the operator to implement improvements or corrective measures.

- The licensee of a nuclear facility is obliged by German safety requirements for fuel cycle facilities to take into account operating experiences in other facilities of the same type for a continuous improvement of safety. According to this obligation, the licensee also reviews the events issued by GRS every two months with regard to their relevance and applicability. Improvements are implemented if appropriate.

6 LESSONS LEARNED

Major events like the criticality accident at the JCO plant in Tokai-mura in September 1999 led to extensive investigations in German fuel cycle facilities as well. Abnormal occurrences in nuclear power plants can also contribute to improvements in fuel cycle facilities if the circumstances are transferable. For example, the discovery of defective relays in NPPs triggered an analysis with regard to the relevance of these events for nuclear fuel cycle facilities.

As an example for the implementation of safety related countermeasures after an incident, the release of 35 grams of uranium hexafluoride ($\text{UF}_6$) at the Gronau enrichment plant will be briefly described. The release happened on 21 January 2010 after a connecting pipe had been removed from an $\text{UF}_6$ cylinder of type 30B (see Figure 5) while the valve was still in open position. One operator was slightly contaminated and brought to a Hospital for detailed medical examination.

**Figure 5:** Type 30B cylinder for low enriched uranium

The cylinder involved had been shipped to Gronau from the Västeras fuel fabrication plant in Sweden. The unexpected release was caused by partly wrong declarations in the shipping documents. The cylinder was declared as “clean and washed out” though it still contained a
small amount of uranium hexafluoride. The anomaly has been classified as an INES 0 event as far as the instances at Gronau are concerned [4] and as an INES 1 event with regard to irregularities that happened in Sweden.

In order to prevent such incidents in future, the operator decided to implement some additional measures to check incoming containers with regard to eventually existing UF₆ residues. This includes

- Additional control measures of the shipping document,
- Weighing of incoming containers,
- Measurement of pressure increases followed by a visual inspection of the interior.

The licensee will contact nearby hospitals to discuss the characteristics of the enrichment plant and the resulting consequences for the treatment of people in case of contact with UF₆ or HF.

Based on the experiences from that incident, the monitoring of emissions and immissions at the Gronau plant will be optimized especially with regard to logging by the installed monitoring devices.

7 REFERENCES

Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance)

Ordinance on the Nuclear Safety Officer and the Reporting of Incidents and other Events (Nuclear Safety Officer and Reporting Ordinance)


http://www.bfs.de/de/kerntechnik/ereignisse/berichte_meldepflichtige_ereignisse/jahresberichte.html