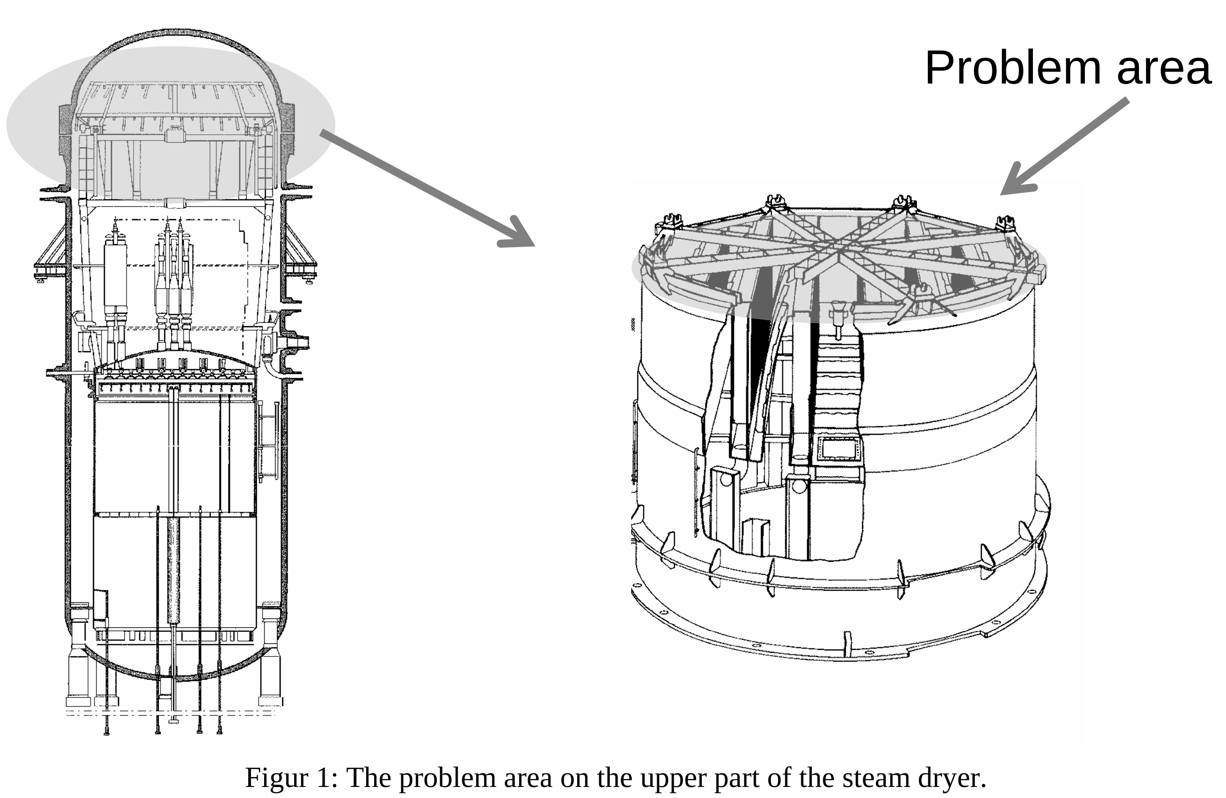
"ALARA" VERSUS REACTOR SAFETY CONCERN - A PRACTICAL CASE

Staffan Hennigor
Forsmarks Kraftgrupp AB
SE-742 03 Östhammar
Sweden
E-mail: sig@forsmark.vattenfall.se

Berndt Ögren
Forsmarks Kraftgrupp AB
SE-742 03 Östhammar
Sweden
E-mail: be3@forsmark.vattenfall.se

Introduction

During the outage 2003 at Forsmark unit 2 it was planned to make a modification to the moist separator (an internal part of the reactor vessel), see figure 1. The work was initiated due to extensive cracking found in welds, which challenged the mechanical integrity of the moist separator and also loose parts lost in the reactor vessel. The cracks had been known for several years but until now no measures were deemed necessary.



Figur 1: The problem area on the upper part of the steam dryer.

Description of the problem

Just before taking Forsmark unit 2 into operation 1980 it was decided to provide additional plates on top of the steam dryer in order to enhance the performance. However, due to operating experience from the Finnish site TVO (which has two reactors similar to Forsmark 2), the plates were not installed. The consoles supporting the plates were left in place, assuming that it was without risk to leave them as it was.

After some years of operation cracks were observed in the weldings connecting the supporting consoles to the beams of the steam dryer, see figure 2.

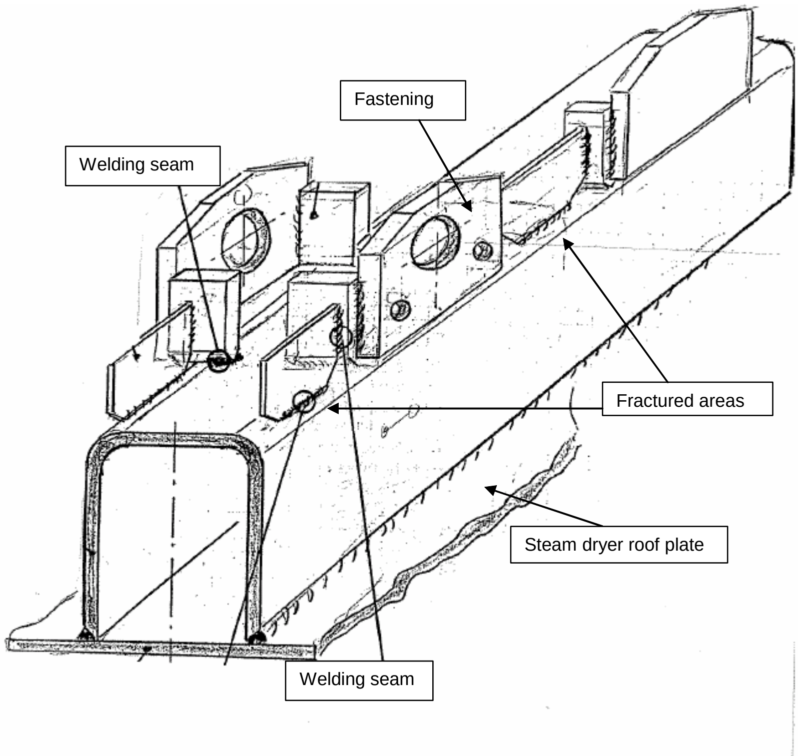


Figure 2: Consoles welded on top of steam dryer.

Not until the beginning of year 2003 the cracks were judged to be a serious challenge to the mechanical integrity of the reactor vessel internals (integrity of the beams) and also the risk of having parts coming loose in the reactor vessel was of concern.

The decision was taken to take measures on the above already during the outage year 2003, only six months ahead in time. One of the reasons was that the outages during 2004-2005 only are scheduled for 9 days, which is to short for this kind of work to be performed.

Measures to be performed were to remove the supporting consoles and to weld an extra beam on to the existing, thus ensuring that the cracks and fractures in the original beams would not endanger the integrity of the structure. Also there will be no need for future materials inspection of the old beams since their function is entirely replaced by the new ones.

<u>Planning of the work</u>

In order to perform the acquired operations it was necessary to expose the upper part of the steam dryer from the water pool.

The short planning time, approximately six months imposed some difficulties:
- Since the work was not known to be performed no dose rate measurements with exposed upper part of the steam dryer were performed during the outage year 2002.
- To short time to develop and implement automatic cutting, grinding and welding machines.
- Limited time to optimize cutting, grinding and welding methods (based on more or less manual work methods)

Of course a critical factor was to determine the dose rate at the working place on top of the steam dryer. This had to be done based on measurements performed at the steam dryer of Forsmark 3 and measurements performed at Forsmark 2 during other previous work on internals. Also additional shielding calculations were performed. Dose rate targets were set to 0,5 mSv/h in general above shielded parts of the working area but higher near the unshielded beams. According to measurements and calculations a radiation shield consisting of steel plates forming a working platform were constructed, see figure 3. The steel plates were to be supplemented by additional lead blankets over the beams not being worked on.

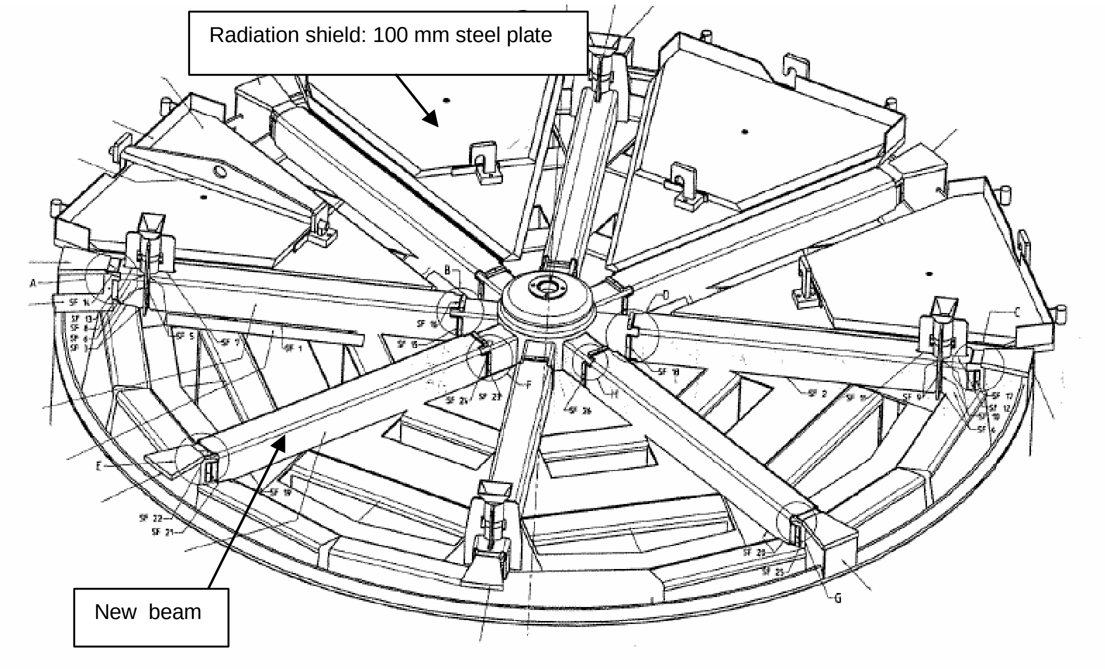


Figure 3: Steel plate radiation shields.

Another problem related to radiation protection was how to minimize the spread of air and surface contamination, especially from the cutting and grinding activities. A related problem would be heat load to workers if they had to work in heavy protection clothing and within a tent. To put focus on the radiological and industrial risks involved a comprehensive risk assessment were performed and distributed to all parties involved, including the contractor chosen for the performance of work. In perspective this was a very effective way to put these questions on the table and acknowledged by everyone involved.

Early dose predictions showed a total collective dose of 250 mmanSv and with individual doses near 20 mSv for several persons. Can this be justified according to the ALARA principle? The immediate answer would be no, since enough time had not been given to proper acquire dose rate data based on measurements, develop and implement suitable working methods and tools and to optimize the protection measures accordingly. There is also an obvious risk that due to dose limitations, and other radiological matters, interruption of the work may be necessary, thus leaving the steam dryer in an even worse condition than before.

Due to the judgment that continued operation without the fixing of the steam dryer, the work planning was continued and the work targeted to be performed as planned during the outage. However, the Forsmark Safety Committee, which has to approve all safety related work on the reactors, required that a set of check points were established. At this check points continued work should be reviewed and evaluated. The evaluation included participation from the Unit Manager and the Radiation Protection Manager.

Check points established were:
- 1) Factory Acceptance Test verifying the contractors working methods and tools: Check for labor time required.
- 2) Lifting of reactor vessel head: Check for source term accuracy.
- 3) When the shielding steel plates were in place: Check the actual dose rate compared with targets set up.
- 4) During work performance: Continuously check collective dose and individual doses. Constraints were set at the maximum collective dose of 350 mmanSv and maximum individual dose of 12 mSv.

The continued planning, together with the contractor, resulted in the following major improvements regarding radiological safety:

- Cutting the consoles by saw blade operated at slow speed and using a semiautomatic method minimizing manual operations.
- Slow speed grinding method.
- Choice of speedy welding method (only manual welding was possible), cutting work time for welding by 2/3 compared to the initial method proposed.
- Training and verification performed at a mock-up built for the purpose.
- Special information given to the workers involved regarding radiological and industrial safety matters for this particular work.

The choice of working methods made it possible to perform the work without tents over the work place, but extra ventilation and thorough cleaning procedures had to be implemented.

An adjusted dose prediction based on this planning and the verification of work methods and tools (check point 1) resulted in a anticipated collective dose of 160-180 mmanSv, with no individual dose in excess of 12 mSv.

Performance of work

Measurements of source term and dose rates with shielding plates in place (check points 2 & 3) showed dose rates on working area in excess of predicted values. General dose rates were in the range of 0,7-0,8 mSv/h with values of about 2 mSv/h on working distance from unshielded beams.

New dose predictions based on this data showed that the work could not be performed within the given constraint given by check point 4. An alternative to the original plan was worked out resulting in only modify 4 of 8 beams during this outage. The 4 “worst” beams were chosen and stress calculations showed that the integrity of the structure would be enough to justify continued operation, even if 4 beams were left unmodified.

The actual work was performed according to the modified plan without any complications, incidents or accidents. Daily meetings were held between contractor’s staff, operational staff and radiation protection staff. During these meetings the resulting doses were closely monitored and communicated to everyone involved.

The total collective dose resulting was measured to be 165,5 mmanSv and the maximum individual dose 10,3 mSv (welder). We considered this to be an acceptable output, taking into account the limited time for optimization and lack of source term data. The involvement of a highly professional and engaged contractor at an early stage greatly promoted the output. But 4 beams still have to be modified in the forthcoming 2-3 years.

Conclusions and lessons learned

- Work of this kind should not be performed without proper time allocated for the collection of realistic measurement data and optimization of working methods, tools and protective measures. At least 12 months seems appropriate.

- Independent shielding calculations should be performed especially on complex geometries. In this case an underestimation of the source term was done, resulting in higher dose rates measured at the working area than calculated.

- Making a formal and comprehensive risk assessment will place focus also on these matters and not only on the technical engineering work. It also provides an excellent base for communication between all involved parties, including contractors.

- Dedicated daily follow-up meetings proved to be of great value in coordinating the work and communicate actual dose figures among all involved.

- Pre mock-up training and additional dedicated information given to the personal involved proved to be of greatest importance. This greatly enhances workers involvement and awareness, besides enhancing the quality of work performed.

- Establishing well defined check points, including alternative actions, before actually starting the work minimizes the risk of having negative surprises which could lead to loss of outage time and poor quality of work.

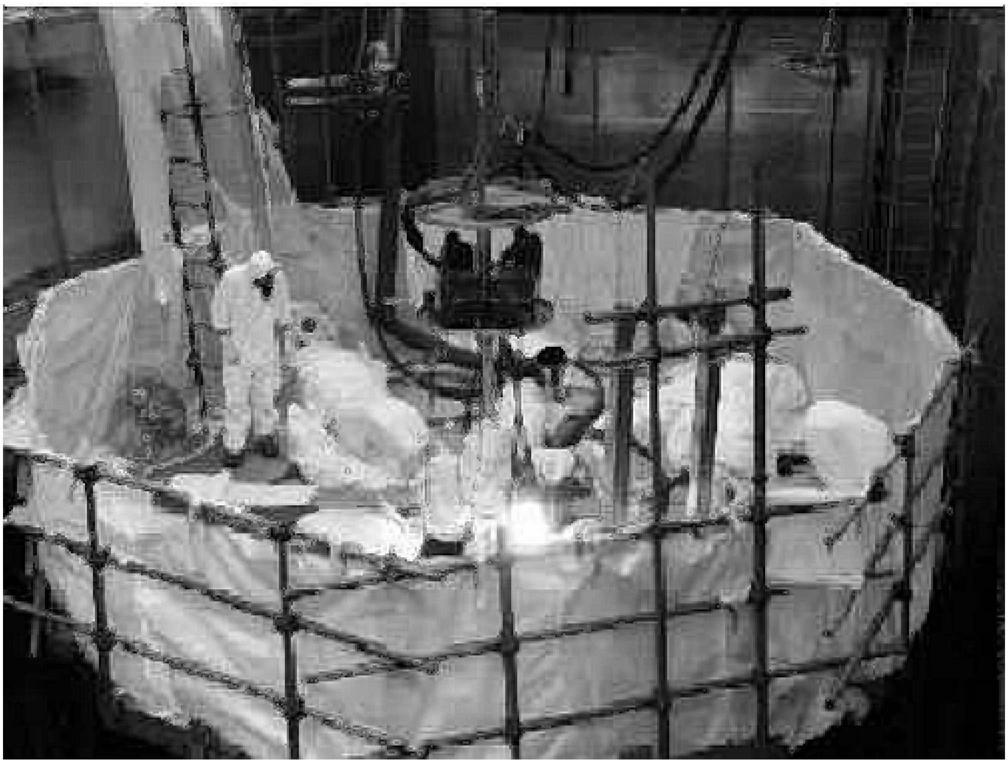


Figure 6: Working area with protective measures implemented