Radiation protection aspects of a fuel handling incident at Forsmark NPP 2013

Björn Brunefors BBS@forsmark.vattenfall.se
Forsmarks Kraftgrupp AB, SE-742 03 Östhammar, Sweden
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1. Background

Forsmark consist of 3 BWR units and unboxing fuel is done in a unique way compared to most other NPP.

The box is held in place by the box exchange equipment while the fuel bundle is pulled upwards.

The 9th of January 2013 a fuel assembly was in position to remove the fuel bundle from the box for visual inspection of the fuel rods and oxide-measurements, 2 of the fuel rods was to be sent for material testing.

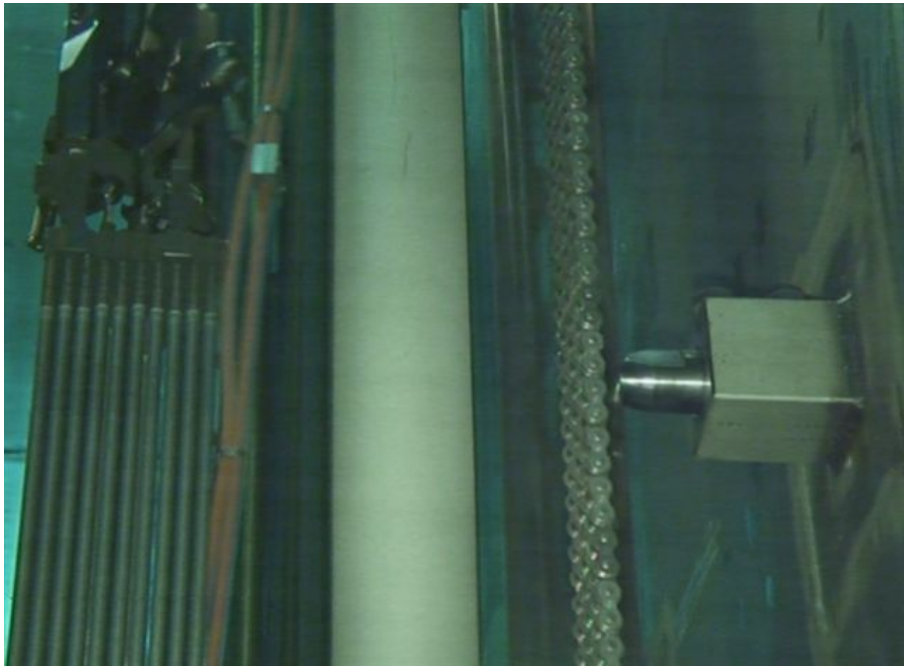
The fuel element was taken out of core in 2012 and was highly burned-out (47 MWd/kgU).

1. Background

Spacer 8, 7 and 6 was pulled out of the fuel box.

At spacer 5, the fuel bundle got stuck just before passing the upper part of the fuel box.

Efforts were made to lower the fuel bundle back into the box; but it remained stuck.



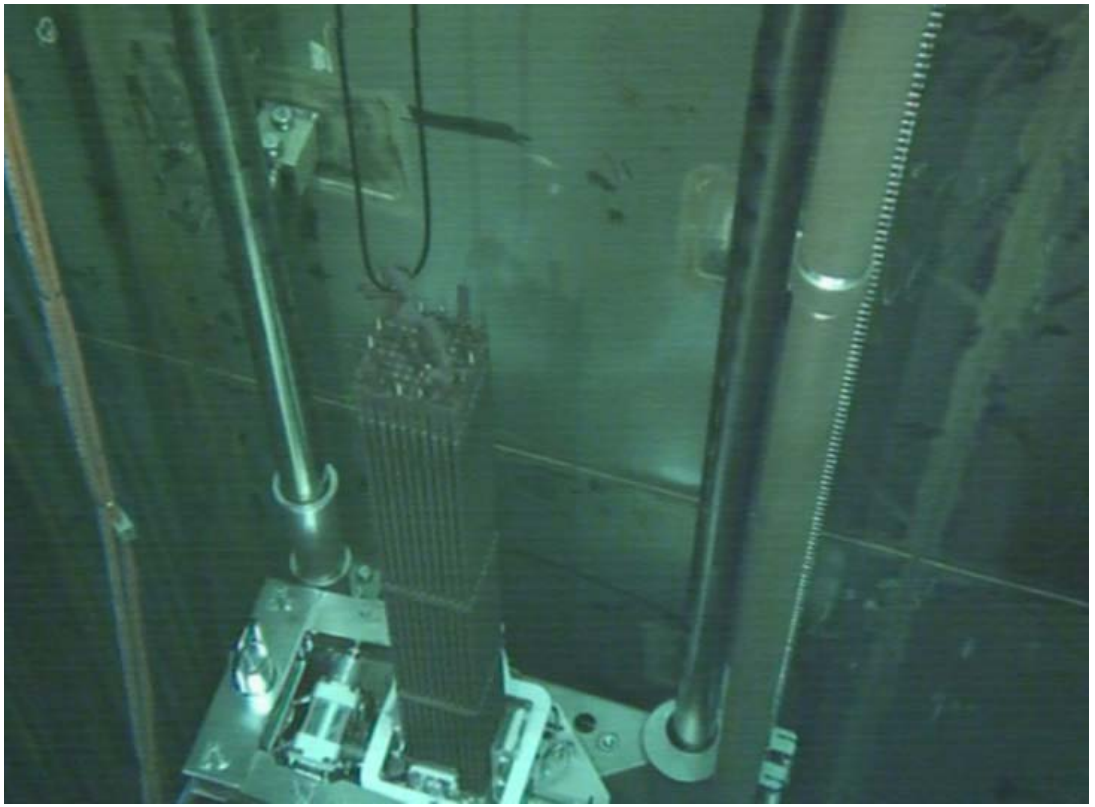
Refuelling machine holding the element.

2. Incident

The decision was made to pull with slightly higher load but the bundle remained stuck.

We were now in a situation with 1,3 meters fuel bundle sticking up out of the box. And it wouldnt go either up or down (except between between spacer 4 and 6)

The bundle was lowered so that spacer 6 rested on spacer 5.



A picture of the fuel bundle stuck 1,3 meter out of the box exchange equipment. (Photo is from later stage; at this time; the fuel handling machine held the element).

3. Solution #1

In next following days a new procedure, with risk assesments made, were developed.

The plan was to pull and release the fuel bundle several times so that the spacers were deformed enough to release the fuel element.

Fastställd av: SNN

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Forsmarks Kraftgrupp

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Riskbedömning och riskhantering inom områdena yttre miljö, arbetsmiljö och brand

Sammanfattning

Syftet med instruktionen är att på ett enhetligt sätt arbeta med riskhantering och undersökning av risker i arbetet. En riskbedömning ska ***alltid*** genomföras vid nya eller förändrade förutsättningar av verksamheten eller förändrade arbetsförhållanden.

Instruktionen är begränsad till person-/brand-/miljörisker. Risker kopplade till reaktorsäkerhet och ekonomi täcks inte av denna instruktion.

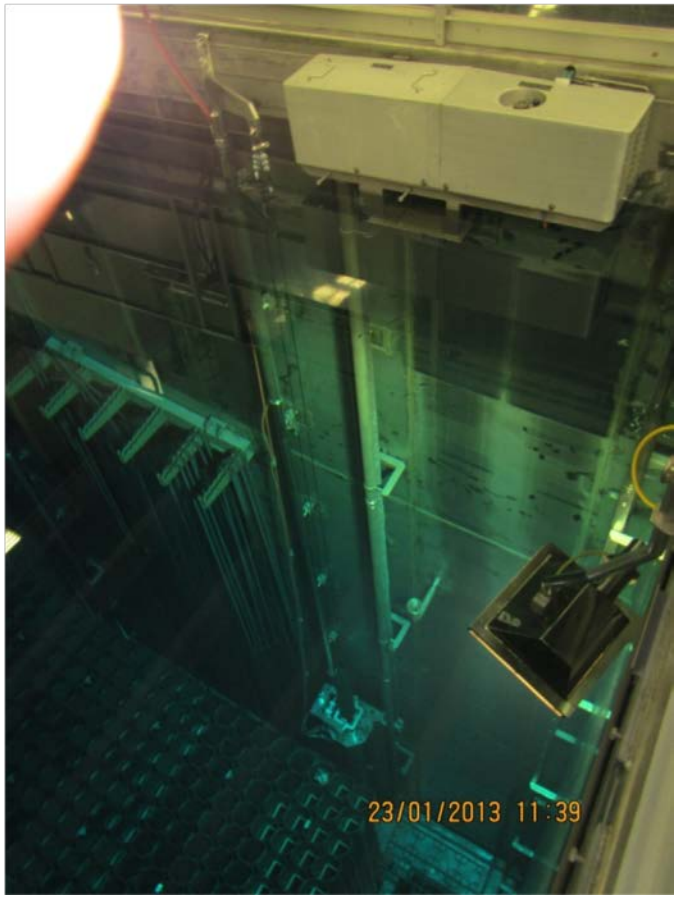
3. Solution #1 - Risks and considerations

Risks

- A crack or break of one or several fuel rods.
- Wear of the fuel cladding.
- The procedure might not release but make the bundle even more stuck.

Consideration

Releasing the grip from the fuel machine was not an option; there was the risk of the fuel assembly falling down.



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3. Solution #1 – Radiological risks

Assumtions for calculation

A person is on the fuelling machine when an incident occures.

Evacuation from the refuelling floor is expected to take 2 minutes.

No safety equipment is used.

Time after removal from core 6 months, time in core: 5 years.

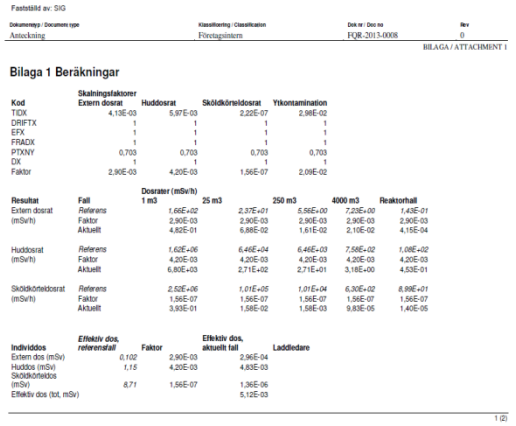
Water depth: 7 meters.

Result

5,1 µSv per cracked rod

(Whole body Dose: 0,3 µSv, Skin dose:

4,8 µSv Thyroid 0,0014 µSv) (Critical nuclide Kr-85)



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Anteckning	Företagsintern	FQR-2013-0008	0

BILAGA / ATTACHMENT 1

Bilaga 1 Beräkningar

Kod	Skalningsfaktorer Extern dosrat	Huddosrat	Sköldkörteldosrat	Ytkontamination
TIDX	4,13E-03	5,97E-03	2,22E-07	2,98E-02
DRIFTX	1	1	1	1
EFX	1	1	1	1
FRACX	1	1	1	1
PTXNY	0,703	0,703	0,703	0,703
DX	1	1	1	1
Faktor	2,90E-03	4,20E-03	1,56E-07	2,09E-02

Resultat	Fall	Dosrater (mSv/h) 1 m3	25 m3	250 m3	4000 m3	Reaktorhall
Extern dosrat (mSv/h)	*Referens*	*1,66E+02*	*2,37E+01*	*5,56E+00*	*7,23E+00*	*1,43E-01*
	Faktor	2,90E-03	2,90E-03	2,90E-03	2,90E-03	2,90E-03
	Aktuellt	4,82E-01	6,88E-02	1,61E-02	2,10E-02	4,15E-04
Huddosrat (mSv/h)	*Referens*	*1,62E+06*	*6,46E+04*	*6,46E-03*	*7,56E+02*	*1,08E+02*
	Faktor	4,20E-03	4,20E-03	4,20E-03	4,20E-03	4,20E-03
	Aktuellt	6,80E+03	2,71E+02	2,71E+01	3,18E+00	4,53E-01
Sköldkörteldosrat (mSv/h)	*Referens*	*2,52E+06*	*1,01E+05*	*1,01E+04*	*6,30E+02*	*8,99E+01*
	Faktor	1,56E-07	1,56E-07	1,56E-07	1,56E-07	1,56E-07
	Aktuellt	3,93E-01	1,56E-02	1,58E-03	9,83E-05	1,40E-05

Individdos	*Effektiv dos, referensfall*	Faktor	Effektiv dos, aktuellt fall	Laddledare
Extern dos (mSv)	*0,102*	2,90E-03	2,96E-04	
Huddos (mSv)	*1,15*	4,20E-03	4,83E-03	
Sköldkörteldos (mSv)	*8,71*	1,56E-07	1,36E-06	
Effektiv dos (tot, mSv)			5,12E-03	

1 (2)

Precautions

Air-monitoring of particles, iodine and noblegases at workplace.
Gamma alarm mounted at the workplace.
Fueling machine alarms.
Protective gear etc.

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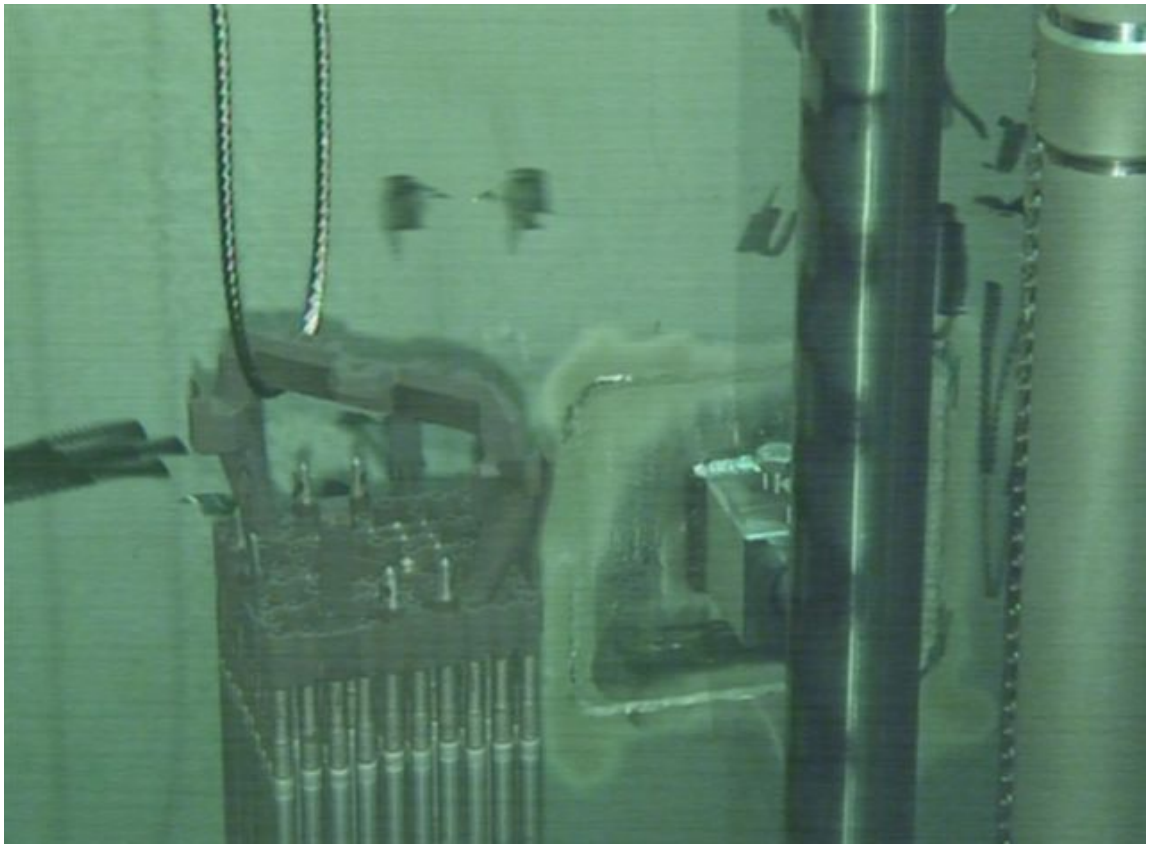
3. Solution #1 - Outcome

However, the bundle remained stuck.

2 weeks later a grip had been constructed and the fuel assembly was secured with a wire and released from the refueling machine.



4. Solution #2

A new procedure was developed that included drilling a hole in the box exchange equipment and the fuel box to secure the bundle with a pin so it could not fall.

This was made so that the wire could be removed and then the top tie plate so that separate fuel rods could be lifted out of the element without the risk of the bottom tie plate falling together with fuel rods.

4. Solution #2 - Risks and considerations

Work was performed at 2 meters depth instead of 7 meters.

Debris from the fuel box could be scattered in the pool from the drilling and other material wear.

Risk of drilling in the fuel itself.

Bilaga 1 Riskbedömning och handlingsplan

Risk, händelse, aktivitet	Bedömning			Åtgärder			
	Allvarlig risk,	Viss risk,	Ingen eller acceptabel risk		Ansvarig:	Klart när:	Kontroll datum:
Förberedelser (FKA)							
Bränsleknippet körs upp från 7 m till 2 m. Knippet delvis ur boxen. Risk för att skada knippet, att det lossnar och faller ner samt vattentäckning <2 m.		Procedur granskas		Vajersäkringen bibehålls i möjligaste mån. Mekaniskt stopp anbringat.	KKA	W1323	
Uppsamling borrspån, presenning			Använd metod	Säkra kylning av använt bränsle	HLO/JIS	W1325	
Borrning (WSE)							
Se WSE riskanalys (bilagd)					WSE	W1326	
Sprint rätt applicerad och håller för belastning samt problem vid utdrag av sprint om den stukas.			Hållf-bedömning visar goda marginaler	Hålposition bestäms mha ritning utgående från spridare 6. Hållfbedömning av sprint och boxvägg.	KKA/6Q4	W1323	
Upptagning av verktyg, risk för aktivt material ovanför vattenytan		Borrspån på verktyg		Noggrann städning Strålskydd på plats. Undervattenprob används.	FMS/ FMM2	W1326	
Rekonstruktion av knippe (GE)							
Risker enligt EXT-2013-2242				Procedurgenomgång, STARK	GE	W1335	
Transport enskild stav		X		Säkra stav	GE/HLO	W1336	

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4. Solution #2 - Radiological risks

Risks

Calculations : 0,37 mSv per cracked rod

(Whole body Dose: 1,3 µSv, Skin dose: 0,37 mSv Thyroid <0.001 µSv) Kr-85 dominates the skin dose. Extra time spent in cloud gives the increased dose compared to previous calculation.

Debris from fuel needs to be collected and taken care off.

Precautions

Air-monitoring of particles, iodine and noble gases at workplace.

Underwater Gamma alarm right under the water surface at the equipment.

Gamma alarm mounted at the workplace.

Underwater sheets to collect debris.

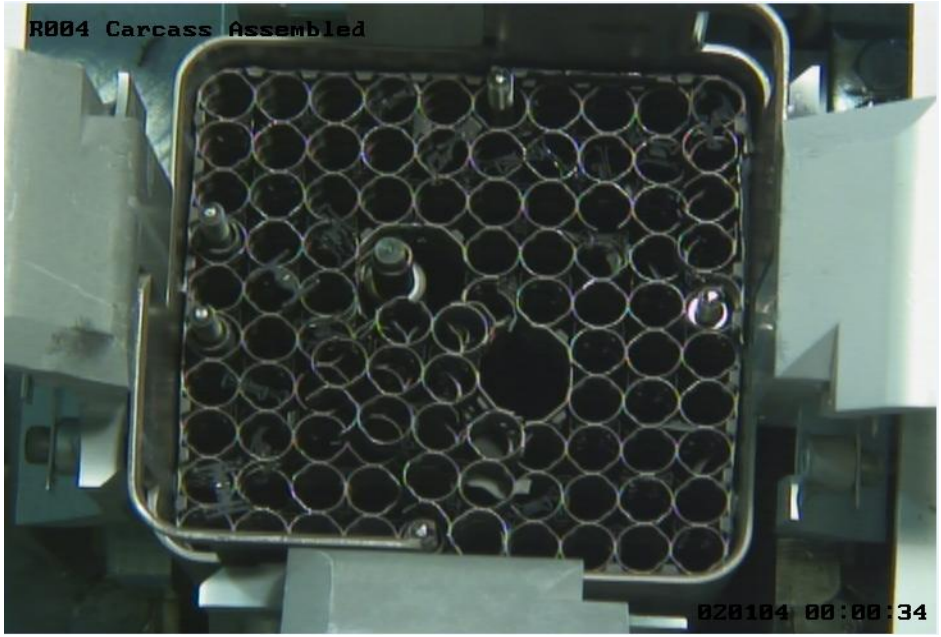
Protective gear etc.

4. Solution #2 - Outcome

In June of 2013, the securing pin was in place and the top tie plate was removed so individual fuel rods could be handled. The bundle was lifted 20 cm before drilling into the box exchange machine and fuel box.

All except 3 fuel rods were removed and placed in a new box in september 2013.

However one spacer on the fuel element was badly damaged.



3 fuel rods remaining with 2 extra dummy rods inserted to hold the upper tie plate.

5. Outcome - Radiological aspects

1. No air contamination.
2. No damaged fuel rods.
3. However, a lot of debris.

Doserates examples
(Underwater gamma probe/
some water shielding)

Collected debris ~3500 mSv/h, was loaded underwater in shielded container. (Mainly spacer 6, 7 and 2 water channel pieces)

5 filters from pool cleaning ~20-350 mSv/h, transportered in shielded container to waste management building.

5. Conclusions

The analysis of spacer 6 and 7 showed that they have grown more than expected; this is likely the cause of the spacer 5 getting stuck.

The fuel handling policy at Forsmark is being changed to a graded approach (however, this was made in parallell with this work and not because of this work). Previous policy was 3 months, now it is 7, 14, or 90 days after removal from core depending on type of work.

It took 9 months to solve the situation!

Risk of iodine and noble gas release was due to decay time not of primary concern when handling the damaged fuel element. Debris and the collection thereof was!

Thank you!

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