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Miljöorganisationernas kärnavfallsgranskning

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To: Strålsäkerhetsmyndigheten (SSM)
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**Fourth input to the SSM quality assurance review of the SKB LOT project corrosion results in the autumn of 2020**

On October 8, November 11, and December 11, 2020, the organisation Miljöorganisationernas kärnavfallsgranskning[1], hereafter called MKG, made three inputs to the quality assurance review that is being carried out by Strålsäkerhetsmyndigheten[2], hereafter called SSM, of the copper corrosion results from the LOT project experimental packages A3 and S2 that have been reported by the nuclear waste company Svensk Kärnbränslehantering AB[3], hereafter called SKB. On November 3, MKG answered question from SSM on the first input. On December 17, MKG made a correction and had further comments on the third input[4].

MKG has followed the work of SSM in the quality review during the autumn of 2020 and now also in the beginning of 2021 and has the following to say in this fourth input to the regulator.

1. The problem of SKB controlling and having the formulation initiative in the minutes from the three factual meetings in the review

During the review SSM has asked SKB questions regarding the reporting of the copper corrosion results. The questions have been answered at three meetings between SSM, and its supporting consultants from Galson Sciences, and SKB during

[1] The Swedish NGO Office for Nuclear Waste Review (http://www.mkg.se)
[2] The Swedish Radiation Safety Authority
[3] The Swedish Nuclear Fuel and Waste Management Co.

[4] The first three inputs and answers to questions from SSM on the first input can be found here:
201109: MKG i det andra SSM-bidraget om LOT-försöket: Behov av mer korrosionsstudier
http://www.mkg.se/mkg-i-det-andra-ssm-bidraget-om-lot-f-rs-ket-behov-av-mer-korrosionsstudier
201103: MKG svarar på uppföljande frågor från SSM i kvalitetsgranskningen av LOT
http://www.mkg.se/mkg-svarar-p-uppf-ljande-fr-gor-fr-n-ssm-i-kvalitetsgranskningen-av-lot
201008: MKG bidrar med synpunkter till myndighetens LOT-granskning
http://www.mkg.se/mkg-bidrar-med-synpunkter-till-myndighetens-lot-granskning
201211: MKG i det tredje SSM-bidraget om LOT-försöket: SKB:s underlag saknas
http://www.mkg.se/mkg-i-det-tredje-ssm-bidraget-om-lot-forsoket-skbs-underlagsrapporter-saknas

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the autumn of 2020. For some inexplicable reason SKB has been allowed to make the minutes from the meetings. SKB has been able to formulate their answers and have afterwards been allowed to add further comments to the minutes. Even though SSM has had the possibility to comment on drafts of the minutes, this still means that SKB has had the formulation initiative and has been allowed to freely state its positions in a way that makes it look like the company is providing the final truth regarding the scientific quality of the work that is being reviewed. The minutes of the meetings are enclosed as appendixes 1-3.

2. The risk of a lack of an independent regulatory analysis of the scientific quality of the copper corrosion results

The apparent mistake of allowing the company undergoing review the formulation initiative of important documents in the review is in itself remarkable. Still, it is of course possible for SSM to later make its own objective analysis of the quality of the reviewed activities and results.

There is, however, a risk that this is not forthcoming. It is possible that the scientific quality assurance analysis of SSM could be taking the SKB formulations for granted as absolute truths without any major further analysis. The draft version of the report from the consultants from Galson Sciences and the comments from SSM to the draft contain only minor qualitative scientific analysis and not of the most important issues. The draft report and SSM comments are enclosed as appendices 4-6.

3. The lack of detailed corrosion studies on the most corroded surfaces of the experimental packages

An appropriate scientific analysis is crucial in a quality assurance evaluation project that is to assure that the results reported are of the highest quality and of utmost relevance for the objectives of the study.

In this case the objective of the reporting of the results is to determine the severity and character of the copper corrosion in the experimental packages. It is also of importance to get as much information as possible on the experimental procedure in order to examine whether the explanations given by SKB for the corrosion can be judged to be correct.

To be able to understand the total amount of corrosion in the experimental packages it is vital to make detailed analysis of the most corroded surfaces. This is important for two reasons. Firstly, this makes it possible to determine how severe worst corrosion is and how deep the pitting corrosion is on those surfaces. Secondly, it is vital for an understanding of whether the total corrosion in the packages is possible to correlate with the SKB position that an overwhelming part of the corrosion that has taken place is due to oxygen trapped before closure and start of operation.

The most corroded surfaces of the experimental packages are the hottest part of the central tubes and the bottom of the bottom plates.

The explanation SKB has given for not examining in detail (photographs, metallographic cross sections, corrosion product analysis) the hottest part of the tube is that another part of the tube was for other reasons cut of and examined instead. This is a remarkable explanation that does not hold up as a scientifically based decision.

The reason SKB has given for not examining the bottom plate, where published photographs show a remarkable amount of corrosion, is that the plate is in contact

with sand and not clay. It is inferred that because the copper in a spent fuel repository will be in contact with clay and not sand, it is not important to study the corrosion on the plate. This is a remarkably unscientific explanation. Examining copper corrosion in a repository environment under a condition that is different from that in the repository may rather increase the understanding of how copper corrodes.

SSM cannot accept this stance from SKB and has to insist on detailed corrosion studies of the corrosion on the hottest part of the copper tube and on the copper plate. SSM needs to assure that this is done independently from SKB that has shown interest in suppressing this information.

4. The lack of detailed analysis of the thickness of the copper corrosion products on the hottest part of the central tube

In order to understand the accuracy of the corrosion estimates for the hottest part of the central tube, done by measurements of the copper in the surrounding clay, it is necessary to know how thick the crust of corrosion products remaining on the copper surface is. SKB has just stated that it is very thin without showing proof, so this needs to be scientifically verified.

SSM cannot accept this unverified statement from SKB and has to insist on a detailed study of the crust of copper corrosion products on the hottest part of the copper tube and on the copper plate. SSM needs to assure that this is done independently from SKB that has shown interest in suppressing this information.

5. The statement that it is difficult to distinguish pitting corrosion from original artifacts on the copper surface

SKB states that it is scientifically difficult to distinguish pitting corrosion from original artifacts on the copper surfaces. This statement has no scientific basis as any competent corrosion scientist will verify. This means that SSM needs to understand this issue better and will likely come to conclusion that there is ample pitting corrosion even on less corroded copper surfaces in the experimental packages. This also means that it is of vital interest to perform detailed studies of the corrosion on the most corroded copper surfaces to study the pitting corrosion there (see point 3).

6. No actual evidence of major sulphide corrosion in the corrosion products

For SKB it is important to try and show that there is major sulphide corrosion on the copper surfaces. Otherwise, it is not possible to explain the severity of the total corrosion and especially of the pitting corrosion that has occurred. But there appears to be little evidence of the corrosion products containing much sulphur. SSM needs to examine in more detail the SKB claims of sulphide corrosion. This also means that it is of vital interest to perform detailed studies of the corrosion on the most corroded copper surfaces (see point 3).

7. The need for an independent analysis of the possibility for bacterial consumption of oxygen

SKB claims that the consumption of oxygen in the clay in the experimental packages is low but avoids saying anything about oxygen consumption in groundwater. SSM needs to carefully examine this issue. It is important that that SSM takes into account the question of how fast groundwater becomes anoxic due to bacterial processes,

and the possibility that the bottom plate and the space between the copper tube and clay were anoxic from the start of the experiment. SSM needs to evaluate what this means for the analysis of the severity of the corrosion, especially on the hottest part of the central tubes and the bottom plate.

## 8. Need for a detailed understanding of how anoxic water was fed into the experimental packages at the start of operations

The draft report of Galson Sciences correctly identifies that it is important to understand what the effect was of introducing anoxic groundwater to the experiment as the experimental packages were closed and the heaters started. It is unlikely that much corrosion had taken place before then, considering that the environment surrounding the open packages was cold.

SSM needs to verify with SKB more in detail how the tubing system for water saturation looks like and works. There must be diagrams available explaining this. SSM needs to examine if it can be assumed that the space between the copper tube and the clay, as well as below the bottom plate, were filled with anoxic water early on in the experiment. SSM thereafter needs to evaluate what this means for the severity of the corrosion, especially on the hottest part of the central tubes and the bottom plate.

## 9. Analysis from researchers from KTH

MKG has observed that professor Christopher Leygraf and corrosion specialist Peter Szakálos from the Royal Institute of Technology in Stockholm (KTH) on February 26th have sent substantial comments on the quality assurance work of SSM and on the draft report from Galson Sciences. The document is enclosed as appendix 7.

## 10. Further research that may be needed

After the quality assurance review, including the necessary extra studies of the most corroded areas, there may still be uncertainties about the interpretation of the copper corrosion results in the LOT packages. SKB has indicated that the company is planning further studies. This is clearly insufficient as the only studies that SKB will publish results from are those that show no problems. The best way forward is likely if SSM is prepared to make sure that a few new simplified LOT packages are prepared and installed in the same or similar way as the original packages. But where the oxygen content in various parts of the package is continually measured. After the oxygen is consumed the copper surfaces can be compared to the LOT packages that have presently been examined.

Best regards,

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