

## Notes; Quality assurance - LOT meeting 1

**Date:** November 5<sup>th</sup>, 2020

**Participants:** *Galson Sciences Ltd*, Tim Hicks, Tamara Baldwin  
*SSM*, Bo Strömberg, Henrik Öberg, Jinsong Liu  
*SKB*, Johannes Johansson, Magnus Kronberg, Magnus Westerlind, Lotta Rubio Lind

The meeting was held virtually using Skype.

SSM provided questions before the meeting which SKB gave written answers to and presented during the meeting. The questions and answers are all documented below. After each issue, the discussion that followed is summarized.

This meeting was the first of three and the focus at the meeting was:

- (i) *Management system & project management (2020-11-05)*
- (ii) *Retrieval, sampling, handling of samples & analysis (2020-11-13)*
- (iii) *Interpretation of results (2020-11-27)*

## Management system and project management

### 1. Long term Management LOT

If retrieval and analysis of S2 and A3 is managed via a dedicated project, how has the LOT project as a whole been managed (i.e. through conception, set-up and long-term running of LOT)?

**SKB's reply/comment:** Test plans were written in the late 1990s.

Installation and dismantling activities have been carried out in the project form. Monitoring and data deliveries to SICADA was managed by Clay Technology AB up to 2012, after which the experiment was transferred to SKB's (Äspö HRL) administration and included in yearly activity plans.

**Discussion:** It was discussed at the meeting if the original expectations for the LOT experiment are still valid after 20 years. LOT is set up stepwise and each dismantling is managed as a separate project with the client assessing previous steps when a new dismantling is planned. Information is carried forward this way, however, SKB needs to double check that all the original expectations are covered.

The LOT project was formed as a collaboration project, and it was discussed if this had impacted the project in any way. SKB cannot see that the collaboration has had any implications on the execution of the project. In practice SKB has only shared the data obtained from the experiment with other organisations.

SKB clarified that all material/samples from the S2 and A3 test parcels are stored.

## 2. Milestones and Tollgates

Were additional milestones added for this project? Were the tollgate decisions and/or criteria revised for this project? Gates T0 to T3 should have taken place according to the PMP programme. Is it possible to see the milestone reports prepared to support tollgates T0 to T3? What decisions were made at each tollgate for this project? Where are the outcomes of the tollgate decisions recorded?

**SKB's reply/comment:** Two updates were made.

- 1) The project time schedule was updated and TG4/5/6 were put forward 2 years due to limitations in the availability of internal resources for bentonite analyses. These analyses are not time critical and thus it is deemed acceptable. It should be noted, that bentonite analyses with a direct connection to copper were prioritised and reported in October 2020.
- 2) In the first project charter, dedicated studies to measure microbial activity and survival were included. Microbial survival was studied in LOT A2, but the results gave no new information compared to other tests. Microbial activity, in the form of sulfate reduction, cannot be studied in the LOT setup. The conclusion during planning was that these questions are better addressed in other dedicated experiments and the studies were thus removed from the project.

The tollgate decisions are recorded in protocols from LOT steering group meetings.

**Discussion:** SSM had read that the experiment was to be retrieved after 5-10 years in the original plans. SKB concluded that from an experimental point of view it has been positive for the long term experiment that the time schedule has been prolonged. At the meeting, SKB was not exactly sure of the background to the original time schedule mentioned by SSM. After the meeting SKB noted that there are internal documents from 1999 mentioning the possibility of running the experiment for a 20 year period.

## 3. Risk assessment

How were risks identified at project initiation? How was learning from previous LOT retrievals and analyses accounted for when planning the project (e.g. risk of damaging parcels during retrieval, any issues in preparation of coupons and tubes for copper corrosion analysis, and possible mitigation measures)? How often is the risk register reviewed and have any risks been added since the start of the project? Have any of the risks been realised?

**SKB's reply/comment:** Risk identification started with the Project Manager (PM) reviewing documentation from previous dismantling activities which provided an initial list of risks. The project group then jointly identified risks and also discussed those prepared by the PM. The project group includes several resources with experience from both earlier LOT dismantling as well as from other Äspö installation and dismantling activities.

Risks are additionally assessed in the risk assessment included in each Activity plan. The authors thus take the main risk list into account when writing activity plans.

Top risks are also reported in Antura where they are included and reported to the client in each monthly report.

The risk list, which is handled as a living document, includes a short risk mitigation plan for each risk. Risks were reviewed and added at working meetings and project group meetings (PGMs).

Two risks were realised:

- 1) For the first parcel there was an edge between the holes of the seam drilling and the risk handling plan to drill core holes had to be implemented. This caused some delays; however, water could be pumped away according to plan and there were no implications for the parcel. The seam drilling equipment was repaired between the parcels and the problem was avoided in the second parcel.
- 2) Another risk relating to the ordering of Mössbauer analysis was also realised and the order was delayed, meanwhile the samples were stored in vacuum sealed bags in order to keep the samples stable.

**Discussion:** It was discussed how SKB ensured that past experiences were taken into account when carrying out the retrieval/dismantling of the test parcels S2 and A3. SKB answered that it was very valuable that Torbjörn Sandén who had been involved from the start of the experiment (installation) was available. Even though experiences are recorded in reports and risks are noted in activity plans from previous test parcel retrievals there are some experiences that are hard to document or transfer to others. It is of course much easier to avoid risks/mistakes since we have retrieved test parcels before and SKB tries to use the same team for retrieval as last time.

SKB gave a short description of the Mössbauer analysis that measures the oxidation state of the iron.

Daily Logs that SKB uses for the purpose to document the different activities in the tunnel and what the supplier/personal have been working with during the day were discussed. The information is used to detect activities that can have affect other measurements that take place in the underground facility.

If something unexpected occurs where do SKB document this? SKB answered that it depends of its character. Deviations are reported in the system Avärs, the laboratory for water chemistry at Äspö uses log books and it can be noted in the daily logs.

#### 4. Tollgate review and lessons learnt

What are the findings of the project assurance reviews undertaken for the tollgates so far? Is a record of lessons learnt during the course of the project so far maintained?

SKB's reply/comment: Four top risks were highlighted in the TG3 decision PM (1867780):

- availability of internal resources,
- times schedule,
- cost
- packages could be damaged by water during dismantling.

With the schedule updated and increased budget which was approved at TG3 these risks have not been realised and both schedule and costs are expected to be met. The key technical risk of water damaging the parcels is closed and the implemented risk handling with suction of water and alarms worked as intended.

Lessons learnt will be reported in the experience report at the end of the project. No formal notes are kept at this stage, although the Project Manager has recorded key findings, like the challenges with the seam drilling of the first parcel and the tight fit of the crane when lifting the parcels which will be even tighter for the final parcel, likely requiring a modified lifting procedure.

## 5. Stakeholders and impartial observers

The project charter notes that there are a number of external stakeholders that want to observe the project (including potential collaboration with Posiva) and that this needs to be taken in to account when planning the project. How were stakeholder needs accounted for in planning the project? Were collaboration activities explored with Posiva before TG1, as required? Was any consideration given to the inclusion of an impartial observer at different stages of the project (e.g. during parcel recovery and analysis) and what was the outcome of such considerations?

**SKB's reply/comment:** The project has discussed with Posiva and samples have been sent, which is of high interest for Posiva due to the relatively long high temperature exposure. Additional samples will be sent upon request.

SKB did consider impartial observers in the early planning stages. Different alternatives were presented and discussed in the steering group for the project. SKB's final decision was to film the retrieval of the experiment and impartial observers were thereby not invited/included. Normally, SKB do not invite impartial observers to the retrieval of long term experiments, but exceptions have been made in the past.

**Discussion:** SKB documented (filmed) the whole retrieval; the drilling, when lifting the test parcels, dismantling, cutting of copper pipes and extraction of the copper coupons. Part of the film was published on the SKB website. All the film material is saved.

Why SKB choose not to invite an impartial observer was discussed. For SKB it was not obvious whom to invite. Different options were discussed, and it was finally decided that filming the whole retrieval was the best option. SKB does not consider the LOT experiment to be a unique experiment and chose to handle it according to normal procedures.

It was discussed how transparent the SKB retrieval plan for LOT was to the stakeholders. In the RD&D programme (Fud-program, in Swedish) it was written that SKB planned to retrieve the test parcels during 2019. SKB agrees that the plans could have been presented in a more transparent way. According to current plans, SKB intends to retrieve the last test parcel in 2023.

It was noted that SKB is willing to provide samples from the test to other organisations so they can perform own measurements. For example Posiva and Chalmers (Co-60) have received bentonite samples. A LOT/ABM meeting was planned to be held in Q2 at Äspö for the organisations involved in ABM, and a lot of interest were expressed in having samples. In the end, the meeting had to be cancelled due to the increase of corona virus.

## 6. Extraction of the Cu coupons

What procedures were applied to the dismantling of parcels to ensure that there was no damage to the Cu coupons when they were extracted from the bentonite blocks?

**SKB's reply/comment:** The dismantling of the blocks was planned in detail and carried out according to AP RD KBP1019-19-010 – Grovdelning och paketering av material. LOT-paket S2 och A3.

The Copper Work Package (WP) leader also participated in person to oversee the safe extraction of the coupons.

A metal detector was used to carefully identify the coupons positions and to minimise the risk of scratching the coupons, hand tools made of wood were used to remove the surrounding bentonite clay and extract the coupons.

Coupon retrieval was successful and any scratches or damages would also have been clearly noticed in the gravimetric analysis and/or in the microscopic examination.

## 7. Transport of coupons and copper tubes

What procedures are used to protect the condition of the Cu coupons and Cu tubes during transport to and storage at laboratories?

**SKB's reply/comment:** The samples (coupons and pipe sections) were directly placed in vacuum bags and transported to the external laboratory, where they were immediately placed in a plastic tent purged with nitrogen gas. The total exposure to dry air is estimated to less than 1 hour.

**Discussion:** It was discussed how the reference samples are stored. SKB stores the reference coupons in dry indoor conditions and the pipes in non-heated storage. Since the pipes are stored in non-heated storage there can be some corrosion effects on the samples.

## 8. Deviations during retrieval, transport and analysis

Were any problems encountered or deviations from the activity plans for retrieval of the parcels and their transport and analysis identified?

**SKB's reply/comment:** The preferred way to dismantle the LOT packages is seem drilling, however, seem drilling has commercially been basically replaced by wire sawing and seem drilling tools are not readily available any more. It turned out that there was some play in the reused tool which leads to the holes not being perfectly straight, and thus leaving edges between them. These edges had to be removed using core drilling (as described in the risk handling plan). Dry conditions were maintained and there were no implications other than a time delay and increased costs and the equipment was updated to the second parcel.

Two risk observations were reported, one relating to the contractor's helmets lacking straps and one relating to a person being unsure of how to operate the elevator. There was also a risk observation reported relating to a door not being locked after the parcels were removed but before the area was formally confirmed as free from radioactive contamination (all Co-60 had been removed together with the parcels). The noted risk observations were addressed directly.

**Discussion:** The deviations that have been noted so far were discussed. SKB stated that all deviations were documented and reported according to procedures and handled directly when discovered. The deviations did not affect the experiment or the results from the experiment.

SKB explained the differences in the two drilling techniques mentioned during the meeting. SKB considers seem drilling to be a more suitable method when retrieving the test parcels since it is a dry method. For core drilling some water is added which SKB wants to avoid.

It was asked how SKB makes sure that everyone knows what to do during the retrieval. Before larger jobs prejob briefing is held.

## 9. Suppliers QA

How do you ensure that, before work is undertaken, suppliers have appropriate QA processes in place that are at least equivalent to SKB's?

**SKB's reply/comment:** ISO certified suppliers are preferred and all contracts signed with suppliers allow for SKB to audit the suppliers. An audit was done for Swerea KIMAB AB in 2017,

Audit report SKBdoc Id 1610897. A supplier evaluation was done for Clay Technology AB in 2017, SKBdoc Id 1590042

**Discussion:** SKB uses Activity Plans (AP) to describe what activities that should be carried out and which methods to be used. Do suppliers write APs as well? SKB answered that both Clay Technology and RISE KIMAB uses similar documents to describe in detail what to do, in which order and what method that should be used. SKB are involved when preparing these documents but SKB do not approve these documents, they are handled according to the supplier's management system.

Before the analysis at RISE KIMAB it was of great importance that the analyses were made in the right order since there were many different analyses made from few samples. It was also important to be able to make changes along the way after evaluation of the analysis made. This work was performed in a close cooperation between SKB and RISE KIMAB.

It was asked to which extent the audits of suppliers were done. SKB answered that audits are done according to standard ISO 9001. SKB looks at the overall picture and the audits are not done on a method level. SKB does also look at the competence of the supplier.

The pickling method was discussed. SKB was involved in the decision when to take the next step in the analysis. If the supplier would notice a problem or suspect that something was wrong they contacted SKB and the issue was discussed and how to proceed was decided.

## 10. Separate/independent contractors

To what extent are contractors regarded as separate/independent of SKB?

**SKB's reply/comment:** All contractors are regarded as capable companies with the major ones in the LOT project all being ISO certified. It is clear that the contractors are independent companies.

Most of the bentonite analyses related to corrosion were performed by SKB staff using scientific equipment available at SKB.

SKB's experts were engaged in assessing results and thus the conclusions are SKB's.

**Discussion:** SKB can't affect the results obtained by the suppliers and it should be noted that around 50 percent of the analyses are made in-house at SKB. SKB's experts are responsible for the conclusions in the TR-20-14 report and the order of the authors in the reports corresponds to the involvement of the different experts', i.e. in same way as for scientific articles.

It was discussed how deep SKB penetrates the analyses done by suppliers. The TEM and diffraction work made by Swerim was mentioned as an example where SKB haven't looked so deeply into the specific analysis, but rather incorporated the conclusions from the analyses as provided by Swerim. TEM was used to further characterize the corrosion products on the coupons (one from each test parcel).

## 11. Laboratory audits

Were audits done of the management/QA procedures used by laboratories? Are there records of audits?

**SKB's reply/comment:** No specific audits were carried out during the LOT project.

- Swerea KIMAB was audited in 2017.
- A supplier evaluation was done for Clay Technology AB in 2017, SKBdoc Id 1590042



## 12. Agreement with suppliers

Were the specific QA procedures, measurement methods, and techniques to be applied in the project discussed and agreed with the suppliers before the analysis was undertaken?

**SKB's reply/comment:** The project asked for offers including what should be measured. This was done in an iterative way through discussions between SKB and the supplier. The orders then refer to the offers, what should be done, and delivered.

**Discussion:** It was discussed that SKB is not obliged to do public procurements. Although SKB tries to do this sometimes for scientific assignments (not done for LOT) it should be noted that there are not that many suppliers available for these types of assignments. In the LOT case SKB considered it valuable using suppliers that had been involved previously in analyses of LOT samples.

## 13. Implications from evolving management system

How has the management process evolved over the course of the LOT programme and what are the implications of the changing QA system (e.g. if improved quality management systems have been introduced, are there implications with regard to the reliability of previous parcel analyses)?

**SKB's reply/comment:** SKB is continuously improving its management system and over the past 20 years, it is clear that some procedures have been improved.

With that said, earlier LOT work was also been carried out in the project form which has been a way to assure a systematic and effective methodology/way of work for achieving high quality results.

In some respects, experiences from earlier installation and dismantling and activities, both within the LOT project and other experiments, play a central role in avoiding potential issues that can affect the quality of the work. It is thus clear that a risk list from 2019 predicts and lowers a greater number of risks than a 1999 version.

**Discussion:** It was discussed whether there are requirements in today's management system that the LOT project have difficulties to meet for the past results. SKB cannot see that there are.

## 14. Handling of data

The project charter and Project Management Plan require that all data generated during the project's implementation, and which form the basis for the project's results, must be traceable and stored in SKB's databases. How do you ensure this is undertaken? What data have been submitted to the databases as a result of this project so far (all primary data or just results of analyses)? What QA procedures are applied before data are accepted for inclusion in SICADA? What records are kept on the project file for data submitted to SKB's databases?

**SKB's reply/comment:** Work carried out at Äspö; the activity plans include an activity table, that lists all individual activities, including steering documents, the deliveries/data they generate and how they are to be stored. This table (physical table) is filled in when the work is done and when deliveries/data is delivered and finally when it is stored and approved.

Work done by contractors; as defined in offers/orders data shall be delivered to SICADA and signed by the WP leader.

1863807 - AP RD KBP1019 – 19 - 009 – Friborring och upptag av LOT-paket S2 och A3

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1866317 - AP RD KBP1019 – 19 – 010 – Grovdelning och paketering av material. LOT-paket S2 och A3

1866344 - AP RD KBP1019 – 19 – 011 – Bestämning av vattenkvots- och densitetsfördelning. LOT- paket S2 och A3

**Discussion:** The type of information/data that are stored were discussed. SKB has stored all data and pictures obtained within the project. At the meeting SKB were not sure if data from the Pilot for LOT was stored. After the meeting this was checked and the data is stored for the Pilot as well.

## 15. FEBEX experiences

To what extent was SKB involved in the FEBEX experiment and the copper coupon measurements for that experiment? Was any learning from FEBEX brought into this project, including the analysis methods and understanding of conditions and corrosion mechanisms? The retrieval and examination of Febex was a collaboration between Nagra, SKB and other organisations.

**SKB's reply/comment:** Since copper was not a material of particular focus in Febex, only two copper specimens were included and initially these were examined very briefly using SEM. SKB considered it relevant to extend the SEM-EDS analysis to examine a larger part of one of the copper coupons in order to get a better understanding of the corrosion morphology observed and to determine corrosion products. In addition, SKB ordered gravimetric analysis of a second copper coupon, in order to quantify the extent of corrosion.

No particular learning from Febex was brought into this project; however, the Febex corrosion results are discussed in both TR-20-14, as in SKBs upcoming safety assessment PSAR.

### **Discussion:**

The differences between FEBEX and LOT experiment were discussed. The FEBEX experiment probably had a longer oxid period that can be a result of leakages (via cables). The clay volume in Febex was much larger than in LOT and the central heater was made of steel.

It was also discussed that SKB have performed more analyses this time than for earlier test parcels from the LOT series. It is not considered possible to analyse old copper samples (old test parcels) further, however, for the bentonite it may be possible.