TAQA Onshore B.V.
Kruseman van Eltenweg 1, 1817 BC Alkmaar, The Netherlands
P.O. Box 233, 1800 AE Alkmaar, The Netherlands
T +31 88 8272 500
F +31 88 8272 898
www.taqaglobal.com

Update Gas Storage Bergermeer operations - March 2018

Gas Storage Bergermeer (GSB) is now in its third year of full operation. Unfortunately the withdrawal performance during February 2018 was again limited by technical challenges. With transparency at the forefront, TAQA has always informed the market of the causes of significant outages through letters published on its GSB website[1]. However, as a result of the recurring technical curtailments that are related to GSB's drying train heaters and compressors, TAQA would like to keep the market informed in more detail in relation to these current challenges and the expected way forward.

This document will cover the following topics:

- Technical processes explained (Q1 – Q4)
- Current challenges explained (Q5 – Q8)
- Impact on customers (Q9)

Technical Processes Explained

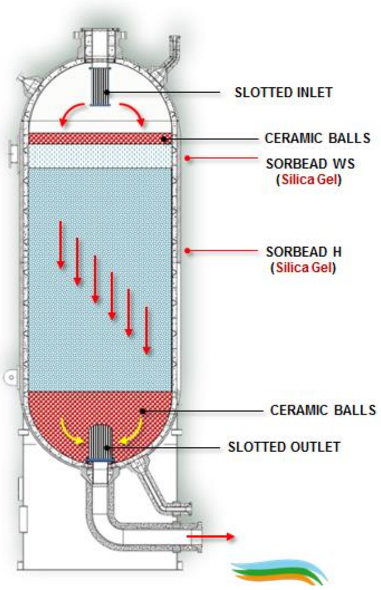
1. How does the withdrawal process work at GSB?
   GSB stores gas in a depleted reservoir. If dry gas from the Dutch national grid is injected into the reservoir it mingles with small volumes of hydrocarbons and water that are present in the reservoir at three kilometers in depth. When gas is subsequently produced/withdrawn, it needs to be dried. This is done in two steps:
   i. First the gas goes through a slug catcher, separating the larger share of liquids and condensate from the gas. It then passes through scrubbers to remove condensed liquids from either free flow operation (no compression required) or with compression.
   ii. The final liquids are then taken out by drying trains, at which point the gas is within the required range of specifications to re-enter the Dutch grid.

   Note: a full reservoir does not need any compression to enter the Dutch grid. However, once reservoir pressure drops below a certain point, and depending on customer nominations, compression is needed to ensure sufficient high rates into the Dutch grid. TAQA has a series of compressors for this process, which are explained further in Q4.

2. What is a drying train?
   As mentioned above, the drying trains take out the final liquids from the gas before the gas enters the Dutch grid. GSB operates two drying trains, also called Dew Point Correction Units (DPCU's). Each of these trains provides half of the total withdrawal capacity.

[1] www.gasstoragebergermeer.com/news-archive

Each DPCU at GSB has six 10-meter high towers filled with silica gel (see above aerial), which is a moisture-adsorbing substance. See below a schematic on the internal process.



Wet gas enters these towers and is pushed through the silica gel which adsorbs any liquids present in the gas. The gas exits the towers in a dry state.

After several drying cycles, the silica gel becomes saturated. Once saturated it needs to be regenerated through drying.

3. <u>How does the regeneration work?</u>
   As mentioned above, once the silica gel in a tower is saturated it needs to be dried. This is done by heating the silica gel up to 270°C with a regeneration heater. The heater has two electrical bundles which use a resistive current to create heat within the gas flow. The hot gas is then routed through the saturated column to dry it out / regenerate it.

Location of electrical heater bundles

Electrical heater bundle in workplace

The design of GSB allows for such regeneration without discontinuing the process as four (out of six) towers per train are sufficient to allow maximum rates of withdrawal. This means two towers can be regenerated at any time. Once the silica gel is dry, the regenerated towers can be taken online for the drying process and the next tower(s) can start the regeneration process.

4. <u>What functionality do the compressors have at what stage of the injection and withdrawal cycle?</u>
GSB has six 12 MW electrically driven, magnetic bearing compressors.

For injection, compression is required over the full range of the injection curve to allow gas injection into the reservoir. Depending on reservoir pressure (which can be between an average pressure of 77-133 bar), national grid pressure (50-65 bar) and total customer nominations, TAQA can then determine how many compressors are required to meet contractual commitments.

Note: the GSB facility is designed with redundant compressor capacity such that the highest injection capacity demand into an empty reservoir can be met with three compressors and the highest injection capacity demand into an almost full reservoir can be met with five compressors. This allows the facility to always have flexible maintenance on at least one compressor with the aim to increase long term availability.

For withdrawal, compression is only required at the back end of the withdrawal curve when reservoir pressure is relatively low. The initial part of withdrawal is performed via free flow, here the reservoir pressure is high enough to enter the grid without compression support. Once the reservoir pressure approaches approximately 40% fullness, and depending on customer nominations, compression is required to support withdrawal. Also on this side of operation there is implied redundancy in compression capacity; in the case of highest capacity demand, five compressors can meet maximum customer nominations.

Compressor area where 6 compressors of 12 MW each are located (logo of manufacturer hidden on purpose).

Current Challenges Explained

5. <u>What is causing the extended withdrawal outages since mid-January 2018?</u>

This winter GSB experienced problems within the DPCU process as well as with the compressors. Questions five to eight address these problems.

DPCU
Technical issues started with electrical connector failures with one of the (two) electrical bundles in one of the (two) drying trains. As a result, one drying train went offline, limiting the technical available withdrawal capacity. This was solved partially by bringing back the DPCU with one electrical bundle in operation, offering access to half of that drying train’s capacity. Unfortunately this set up proved to be unstable and resulted mid-March in taking the decision to operate the remainder of winter with one DPCU.

Compressors
A recurring problem with the electrical motors within the compressors has been identified.

GSB entered January 2018 with only four out of six compressors in operation. One was returning to service after a new motor was installed. Due to balancing issues this took longer than expected. The second compressor also experienced issues with its electrical motor, which meant this compressor also went offline. With the reservoir still at 60 % fill level, this was not limiting maximum withdrawal rates (as explained in Q3 above).

Unfortunately, two other compressors went offline shortly after each other in February, also due to problems in the electrical motors.

Investigations into the failures of these motor problems from the last two compressors show indications that relatively high concentrations of liquids in the compressors caused the damages to the electrical motors.

6. Are these new or recurring issues?

DPCU

During Winter 2016/2017 we experienced failures of heating elements and electrical connections. We replaced the electrical heater bundles during the summer with new bundles based on improvements to the design, addressing the issues related to the earlier failures. The bundles have proven to be more stable compared to last year. However, on one of the newly designed bundles the electrical connections and wiring is not working as it should, causing outages in February and March.

Compressor

The electrical motor problems are not new, as this was the cause of two compressors going off line last year. However, it is only this winter that the results of the root cause analysis concluded that a relatively high concentration of liquids was identified as the main contributor to the failure of the electrical motors.

This can partly be explained by the fact that dry gas from the grid is injected by the compressors in the summer (so no risk of build-up of liquids in those periods); and the duration that the compressors have to aid the withdrawal process in winter is limited, and in some winters even non-existing.

7. What is being done to solve the problems?

DPCU

We completely replaced some of the electrical bundles last summer. During this winter new challenges have surfaced. We therefore re-engaged with the supplier to find a more structural solution to increase reliability and redundancy. As a result the current two heaters will be replaced with four newly designed heaters *including* associated electrical wiring and connections. This should be a more sustainable and reliable set up in the long-term. These new heaters and electrical components have been ordered and we currently plan to install them during the injection season when the heaters are minimally used, so that they are ready to use before the withdrawal season.

Compressor

The final root causes of the compressor failures have only emerged this winter, as we only observed these conditions of liquid build-up during the end of the withdrawal seasons after a longer period of utilization of the compressors with wet gas.

We have installed new motors in two compressors, provided with an improved type of winding insulation to provide a better protection against potential liquid build-up.

Further improvements implemented include an adjustment to the automatic valve sequences to prevent liquid build-up during compressor stand still.

8. What is the forward plan to ensure a stable process?

TAQA is continuously looking at structural solutions to address the current challenges.

DPCU

Newly designed heaters and associated electrical components will be installed during summer. This should structurally improve and stabilize the gas drying process.

Compressors

At the moment of publishing this letter, two compressors are fully operating.

The overall planning with regard to the additional four compressors is that:

- A third compressor will come online shortly
- A fourth compressor with the new motor (and which is currently undergoing balancing activities) is planned to come online in the second half of April.
- The fifth and sixth compressor are planned to come back online in Q3.

In addition, the process design and set-up are undergoing updates, offering improvements for both the short and longer term. Also, modifications to the process to reduce liquid formation and build up have been identified and will be implemented over the coming year.

The highest injection capacity demand into an empty reservoir can be met with three compressors and the highest injection capacity demand into a full reservoir can be met with five compressors.

Impact on Customers

9. How do these technical challenges impact customers?
   GSB continues to publish technical unavailability as per REMIT obligations at http://www.gasstoragebergermeer.com/remit/ and https://agsi.gie.eu/#/unavailability.

   Technical unavailability does not necessarily equate to contractual availability. In other words, during a technical unavailability, as published on the AGSI+ website; GSB can opt to either keep customers whole or (partly) curtail contractually.