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The Annual Mercury Monitoring Report 2017
NAM and GTS

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Contents

Section 1: Executive Summary

As part of the" Joint Principles for Conducting Mercury Monitoring in Sales Gas" agreed between NAM and GTS, NAM and GTS have executed a sampling plan of which the results are reflected in this report.

NAM: For the Groningen facilities, the Groningen Transfer Stations and both the UGS Grijpskerk and UGS Norg, all results are within the indicative mercury content in sales gas.

GTS: All results are within the indicative mercury quantity in sales gas.

Section 2: Measurements

NAM Measurement Plan

NAM has agreed to conduct the tests as part of the" Joint Principles for Conducting Mercury Monitoring in Sales Gas". Please refer to document EP201601204309, Revision 1.

NAM Measurement Results by Plant Type

Transfer Stations Schematic

Below is a schematic of the configuration of Transfer Stations on the Groningen Ring.

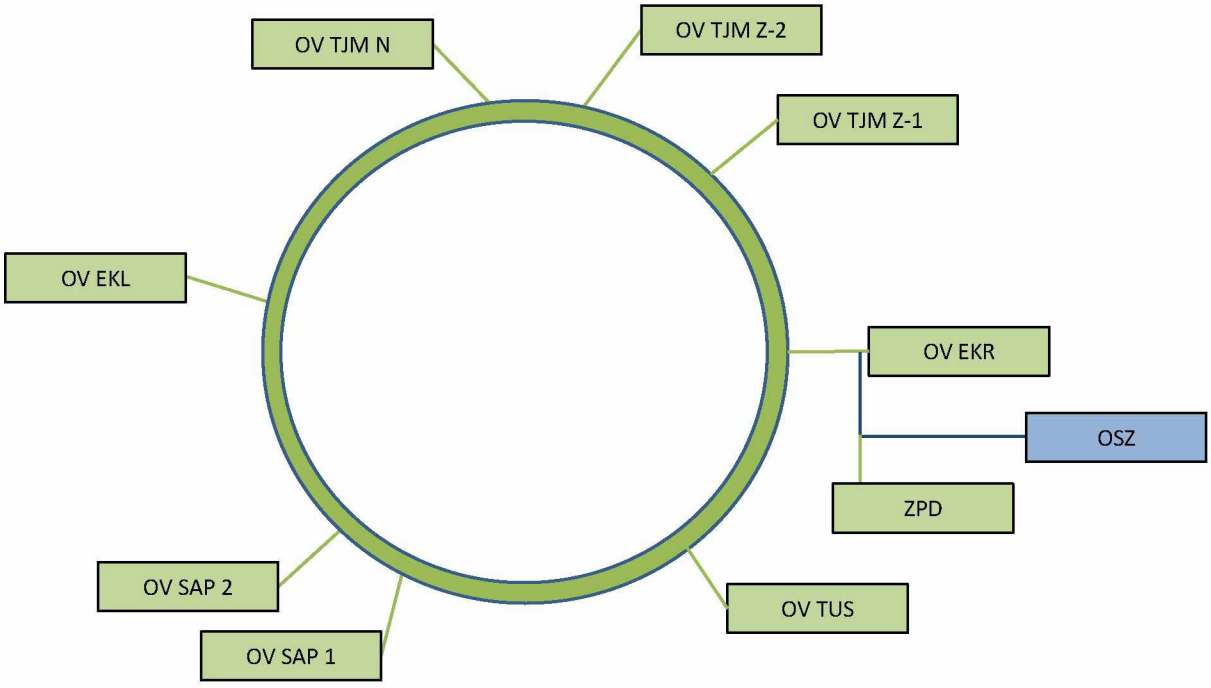

Figure 1: Groningen Ring Schematic (Green is NAM, Blue is GTS)

Oude Statenzijl, OSZ, is a GTS governed transfer facility for Groningen gas fed by both transfer station De Eeker and location Zuiderpolder.

Transfer Stations Results

The table shows measurements of mercury concentrations in sales gas for the past year, as measured at the Transfer Stations on the Groningen Ring, and at the outlet header of location Zuiderpolder, which is compliant with the specification. Since startup of the Norgron pipeline, sales gas transfer at station SAP-1/2 is used irregularly. During the injection season the station is closed to maximize injection capacity, and during the winter season transfer is maximized at the Norg station and at TUS station for clusters. For this reason sales gas at station SAP-1/2 cannot be tested every year.

All results are within the indicative mercury quantity in sales gas.

Transfer Station / Overslag		Measurement [µg/Nm3]			
Location	Acronym	Value	Month/Year	Value	Month/Year
Tjuchem	TJM Z-1	8,4	11/2017	14,0	4/2017
Tjuchem	TJM Z-2	5,6	11/2017	12,0	4/2017
Tjuchem	TJM N	7,6	11/2017	5,3	4/2017
De Eeker	EKR	0,4	12/2017	1,9	3/2017
Tusschenklappen	TUS	4,2	11/2017	8,4	6/2017
Sappemeer	SAP 1	(1)	(1)	(1)	(1)
Sappemeer	SAP 2	(1)	(1)	(1)	(1)
Eemskanaal	EKL	4,0	11/2017	0,9	6/2017
Zuiderpolder (2)	ZPD	15,0	12/2017	13,0	3/2017

(1) Transfer station SAP was used less than 3% of time and, when used, was used very unscheduled.
(2) This is the outlet header at the production location ZPD

Table 1: Transfer Station Mercury Measurement Results

LTS Clusters

The table below shows measurements of mercury concentrations in sales gas according to the monitoring principles in EP201601204309, revision 1, as measured at the outlet of the LTS units of the clusters. From the measurements, one for each LTS unit, the minimum and maximum measurement and average for the measurements from all LTS units is given. The Loppersum area clusters (LOPPZ: Leermens, Overschild, De Paauwen, Ten Post and 't Zandt) are production restrained which results in only one LTS unit being in production for availability purposes. Location De Paauwen has not been in production since Q2 2015.

			Measurement [ug/Nm3]			
Location	**Code**	**Units Tested**	**Average**	**Minimum**	**Maximum**	**Month/Year**
Ten Post	POS (1)	1/5	8,4	(1)	(1)	10/2015
t Zand	ZND (1)	1/5	6,9	(1)	(1)	10/2015
Leermens	LRM (1)	1/5	9,1	(1)	(1)	10/2015
De Paauwen	PAU (1,2)	5/5	11,1	7,6	13,0	12/2013
Overschild	OVS (1)	1/5	7,9	6,5	9,5	9/2016
Bierum	BIR	5/5	11,2	10,0	13,0	9/2016
Tjuchem	TJM	5/5	15,8	15,0	16,0	11/2017
Oudeweg	OWG	5/5	8,5	5,5	11,0	10/2015
Schaapbulten	SCB	5/5	11,3	6,5	15,0	9/2016
Zuiderpolder	ZPD	5/5	12,4	11,0	13,0	3/2016
Zuiderveen	ZVN	5/5	10,6	9,8	12,0	9/2016
Eemskanaal	EKL (3)	2/5	9,5	9,4	9,5	11/2017
Kooipolder	KPD (4)	4/5	12,5	11,0	14,0	9/2017
Amsweer	AMR (4)	4/5	13,3	13,0	14,0	5/2017
Siddeburen	SDB	5/5	14,2	13,0	15,0	3/2016
Scheemderzwaag	SZW (4)	2/3	13,5	13,0	14,0	9/2017
Spitsbergen	SPI	3/3	9,6	5,8	12,0	9/2016
De Eeker	EKR (4)	2/3	15,0	15,0	15,0	9/2017
Slochteren	SLO	3/3	14,0	13,0	15,0	3/2016
Tusschenklappen	TUS (4)	2/3	13,0	12,0	14,0	11/2017

(1) LOPPZ cluster; Due to production restraint, normally only one LTS unit in production
(2) Cluster is not scheduled for production until 2018; Measurements to be rescheduled
(3) Due to production restraint, two LTS units in production
(4) One LTS unit in repair

Table 2: Cluster Mercury Measurement Results

Underground Storages

The below table shows the last test results for gas from the UGS's, and the measurement date. The results show that the mercury in sales gas levels are comparable to the levels in injected gas (for GRK this is 3,0 ug/Nm3 – measured in june 2017; for Norg this is Groningen cluster levels).

Location	Measurement [ug/Nm3]	Month/Year	Measurement [ug/Nm3]	Month/Year
GRK (Production)	1,7	2/2017	1,4	3/2016
NORG (Production)	9,2	1/2017	15	3/2016

Table 3: UGS Mercury Measurement Results

GTS Measurement Plan

GTS has agreed to conduct the following tests as part of the Joint Principles for Conducting Mercury Monitoring in Sales Gas:

Unit Type	Indicative Mercury Quantity in Sales Gas	Sampling Frequency	Plants
HTL - *North-South pipeline corridor* - *North West pipeline corridor*	< 15 µg/m^3(n)	*Once per year.*	North-South pipeline corridor at CS. Ommen North-West pipeline corridor at CS. Oldeboorn
RTL - *Pipeline M&R Scheemda – GOS Nieuweschans*	<15 µg/m^3(n) (M&R Scheemda) < 5 µg/m^3 (n) (GOS Scheemda) < 2 µg/m^3 (n) (GOS Hoorntjesweg, GOS Nieuweschans)	*Once per year*	Measurements are carried out at M&R Scheemda, GOS Scheemda, GOS Hoorntjesweg GOS Nieuweschans Remark: M&R Scheemda is situated downstream of OV De Eeker

Table 4: GTS Tests

GTS Measurement Results by Unit Type

High Pressure Grid: (HTL)

GTS has conducted the agreed measurements on the High Pressure Grid (HTL) in 2017. The measurements at the North-West pipeline corridor have not been taken at Wieringermeer but at Oldeboorn to accommodate for possible reverse flow from Wieringermeer towards Oldeboorn. In Oldeboorn the gas is always flowing in an East to West direction.

The High Pressure Grid is split into in a network transporting Groningen gas (G-gas) and a network transporting High Calorific gas (H-gas). This report focusses on G-gas. The measured values are:

A541 C.S. Oldeboorn : 13 ng/m³(n)
A540 C.S. Oldeboorn : 37 ng/m³(n)
C.S. Ommen : 2959 ng/m³(n)

All results are less than the indicative mercury quantity in sales gas.

The Intermediate Pressure Grid: (RTL)

GTS has conducted the measurements on the Intermediate Pressure Grid (RTL) in 2017.

G-gas passes from the High Pressure Grid to the Intermediate Pressure grid at the Metering and Pressure control stations (M&R). G-gas then travels through the pipeline network, before exiting the Intermediate Pressure Grid via a Metering and Fiscal Measuring Station (GOS). At this station, gas is metered and the pressure is adjusted.

Below is a schematic of the flow of gas through the intermediate pressure grid. The table shows

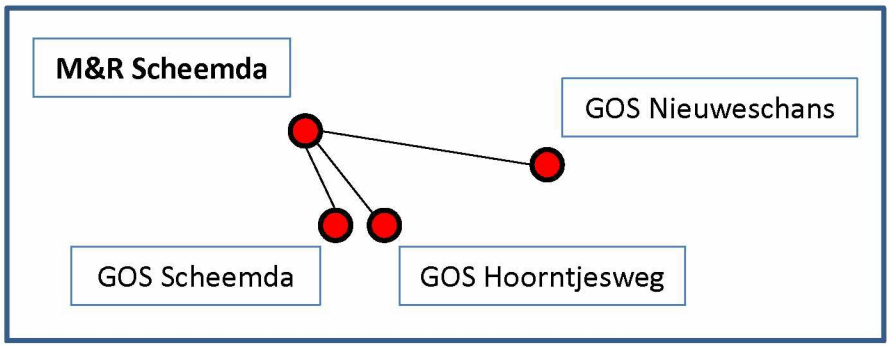

Figure 2: RTL Schematic

measurements of mercury concentrations in gas for the past years. All results are within the indicative mercury quantity in sales gas.

Year/Location	M&R Scheemda [µg/m3(n)]	GOS Scheemda [µg/m3(n)]	GOS Nieuweschans [µg/m3(n)]	GOS Nieuweschans [µg/m3(n)]
2005	11,9	0,6	0,3	0,1
2006	5,7	0,2	0,2	0,4
2007	9	3,8	0,4	0,5
2008	/	/	/	/
2009	3,7	0,5	0,5	0,3
2010	12	0	0	-
2011	6,2	0,3	0,1	-
2012	10,7	0	0,1	0
2013	5,3	0,2	0	0
2014	5,9	1	0	0
2015	2,2	0,0	0,0	0,0
2016	1,7	0,5	0,0	0,0
2017	4,6	0,0	0,0	0,0

Table 5: Test Results RTL Network

Section 3: Analysis

This section provides commentary and analysis, based upon the results in Section 2.

Total Transfer Stations:

The stabling trend for the average concentration of mercury in Groningen Sales Gas that was observed in 2015 and 2016, continues for 2017. Values from October 2015 onward now include the Zuiderpolder outlet manifold content.

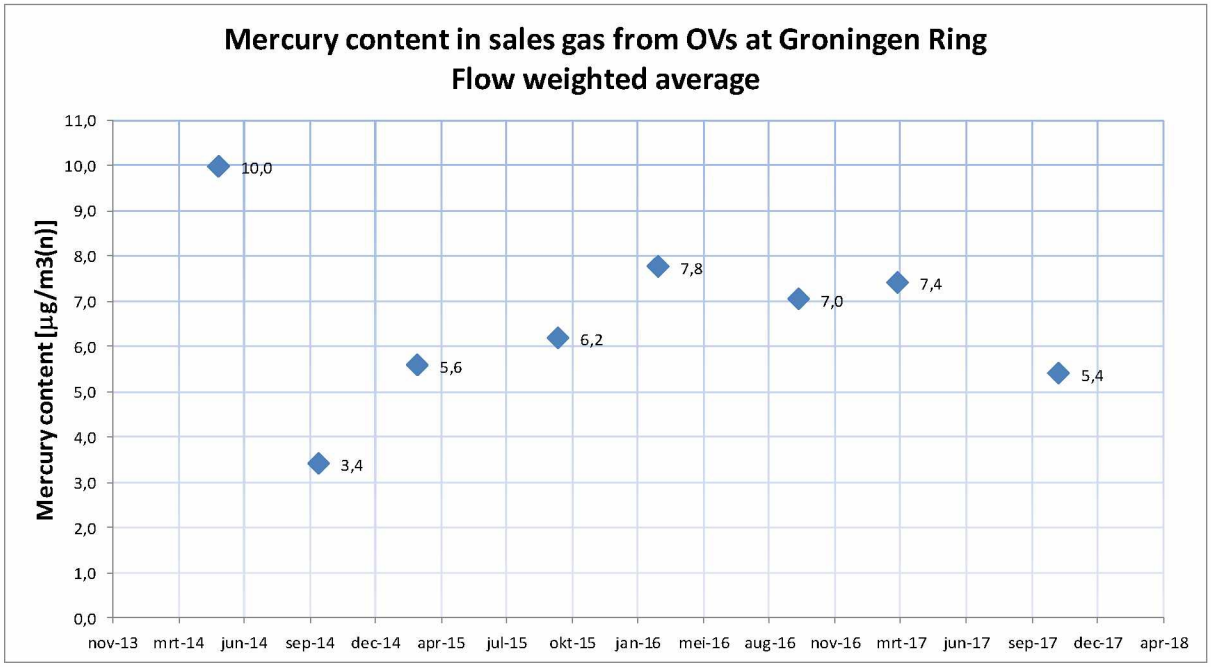

Figure 3: Flow Weighted Average Concentration of Mercury in Groningen Sales Gas

Individual Transfer Stations

Individual Transfer Stations and Cluster measurement results are discussed and drawn out for further commentary and analysis when above the Indicative Mercury Quantity.

Tjuchem Zuid-2

In Q2 2014, a sample of gas taken at Tjuchem Zuid-2 contained a concentration of mercury higher than the 15 µg/m3(n) Indicative Mercury Quantity. The below graph shows the results of tests taken at TJM Z-2 since 2013. Again the 2017 measurements are shown to be well below the indicative level.

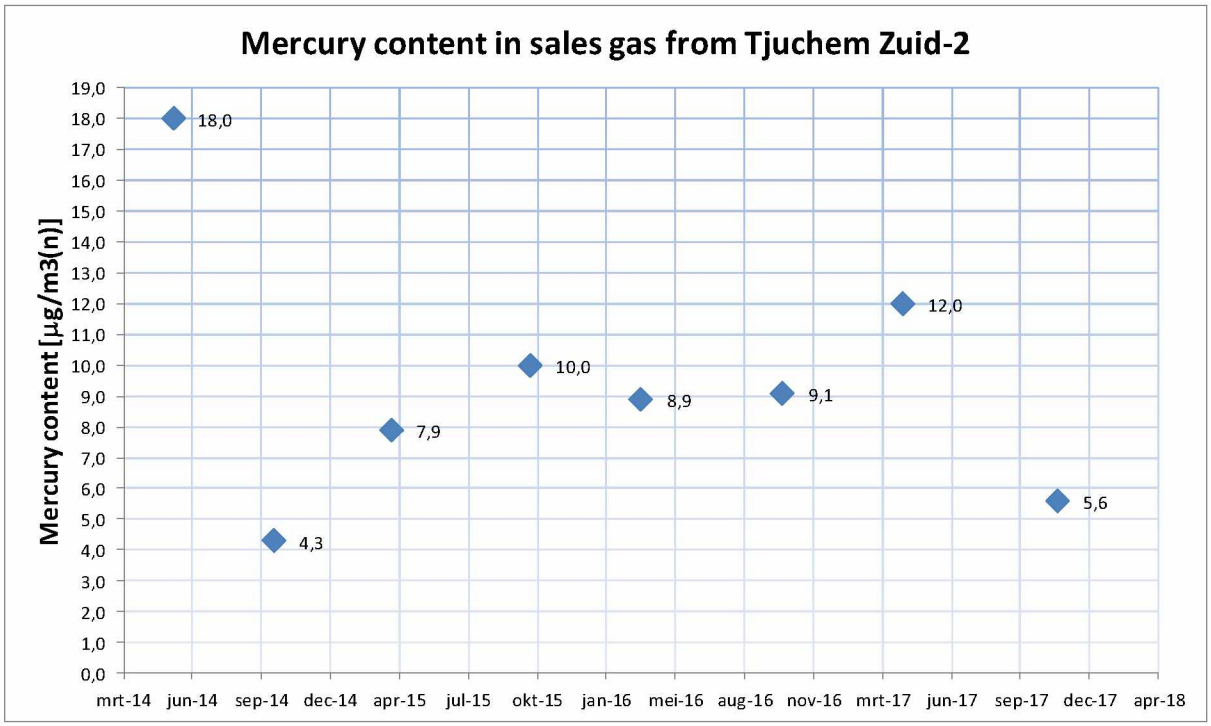

Figure 4: Graph showing Concentration of Mercury in Gas Tjuchem Zuid-2 (µg/m3(n))

"Deep Cooling" was implemented in the LTS units of the Groningen clusters in May 2013. For further details please refer to the Close out Report of the "Kwik Beheersing Studie".

The result on the test in Q2 2014 was followed by five measurements below the Indicative Mercury Quantity. NAM could not identify the cause of the higher result in Q2-2014. No direct intervention was made to lower the concentration of mercury in gas. For further analysis of the Q2 2014 measurement, please refer to earlier revision of this report.

Section 4: Regulations

Note: Having reviewed the latest developments concerning BAT and regulations, there are no changes to this section with respect to the last revision.

Items taken into consideration:

- EU regulation 2017/8520 replacing EU regulation 1102/2008 as per 1st January 2018
- The new Landelijk Afvalbeheer Plan 3 (LAP3) sector 82 vaid as per 1st January 2019
- Changes to the BAT BREF's

NAM & GTS

Introduction

The Joint Principles for Conducting Mercury Monitoring in Sales Gas require that NAM and GTS conduct a review of existing regulations relevant to mercury in sales gas. This is completed in this section of the report.

In the Netherlands, there is not a specific threshold on quantities of mercury in natural gas. However, there are other regulations that must be interpreted and adhered to. These are outlined below, together with NAM's status with regards to compliance.

REACH/CLP

NAM Status: Compliant

Reference: Regulation (EC) No 1907/2006

REACH is the European Regulation on chemicals and their safe use. It deals with the **R**egistration, **E**valuation, **A**uthorisation and Restriction of **Ch**emical substances. This regulation entered into force on 1st June 2007 and is implemented verbatim via the Dutch Environmental Management Act. The aim of REACH is to improve the protection of human health and the environment through better and earlier identification of the intrinsic properties of chemical substances. The REACH Regulation gives greater responsibility to industry to manage the risks from chemicals and to provide safety information throughout the supply chain on these substances. REACH also applies to mercury in sales gas.

According to REACH legislation, mercury as an individual component in natural gas must not exceed the threshold of 0.1 % volume. Groningen sales gas has a concentration of 0.000000000147 vol% (an equivalent of 20 µg/Nm3), as calculated by the NAM Laboratory in 2013. Consequently, NAM is compliant with REACH, and NAM does not have to include mercury in the Safety Data Sheets for natural gas.

GTS Status: Compliant

Best Available Technique (BAT)

NAM Status: Compliant

Reference: Reference Document for the Refining of Mineral Oil and Gas (July 2013)

Best Available Technique (BAT) is a principle in environmental legislation. The EU uses this principle to create a Best Available Technique Reference Document (BREF); a document that lays down the conclusions on current best available techniques that must be applied within a specific industry. Specific to the natural gas producing industry is the BREF titled: "The Refining of Mineral Oil and Gas". Within this BREF, the following techniques and conclusions with regards to mercury are stipulated:

> ***Natural Gas Plants: Techniques to reduce waste generation (Section 4.17.6)***
>
> *Some of the gas fields contain mercury vapour in very low concentrations. This mercury is removed from the gas in a 'cold trap' (e.g. by gas expansion) and recovered as a mercury-containing sludge. A specialised company processes this sludge by treatment in a vacuum distillation unit.*
>
> ***BAT conclusions for the natural gas refinery (Section 5.12)***
>
> *BAT # 43: In order to prevent emissions of mercury when present in raw natural gas, BAT is to remove it and recover the mercury-containing sludge for waste disposal.*

The EU officially adopted this BAT conclusion on 9/10/2014, published in the Official Journal of the European Union.

NAM notes that there are no BAT-associated emission levels set in gas refining for mercury to air emissions, with which it must comply.

NAM executes the techniques of the BAT by using Low Temperature Separation in all of its gas streams, with waste mercury being removed and contained within sludge for treatment by a specialized company. They therefore comply with BAT #43.

GTS Status: Not Applicable

Minimization Principle: ('minimalisatieverplichte stof')

NAM Status: Compliant

Reference: Nederlandse Emissie Richtlijnen, NeR, www.infomil.nl

The Minimization Principle is legislation specific to the Netherlands, and prescribes a five step process to identify and reduce emissions to levels deemed to be both technically and economically viable.

NAM executed the assessment mandated by the Minimization Principle in 2013, as part of the Mercury Management Study 2013 (NAM GTS). This study found that NAM complies with the requirements of the minimization principle, and recorded the following conclusions:

"NAM has reviewed existing regulations related to mercury in natural gas. […]Regarding the Minimization Principle, NAM complies by re-assessing the viability of Filter Removal every five years, along with other reduction techniques. In accordance with the NeR's guidance for applying the

Minimization Principle, the latest review demonstrated that filter removal at NAM locations is not justified."

A re-assessment is planned for later in 2018.

GTS Status: Compliant

The Occupational Exposure Limit

NAM Status: Compliant

Reference: Directive 2009/161/EU - indicative occupational exposure limit values.

The Occupational Exposure Limit is a workplace safety standard set by the EU. It represents the maximum permissible concentration of a given substance in the air of a work place.

For mercury, the EU sets an Occupational Exposure Limit in air for a time window of 8 hours at 0.02 milligrams per cubic meter of air at 20 °C.

When burning Groningen gas in a room with a volume of 15 m3 and a ventilation rate of 2.5 turnovers/hour, one would expect a peak mercury concentration of 0.00035 milligrams per cubic meter of air. Therefore, using Groningen Gas at the workplace will not cause employers to break the Occupational Exposure Limit.

GTS Status: Compliant

Private Households: RIVM Tolerable Concentration in Air

NAM Status: Compliant

Reference: RIVM Rapport 609300021/2011

Within the Netherlands, the RIVM has adopted a Tolerable Concentration of Mercury in Air of 0.05 µg/m3 air for a lifetime exposure limit. Concentrations of mercury in a room are to be tested over a period of 24 hours and one week, in order to detect all sources of mercury and to extrapolate to a lifetime exposure level.

The NAM used a model they developed in-house to establish the threshold concentration for mercury in gas required to breach the RIVM norm in a worst case scenario. This exposure model has received a second look by DNV-GL, in order to verify the assumptions and approach taken in building the model. The threshold concentration for mercury in sales gas at which the RIVM limit is breached is 34 µg/Nm3. Groningen sales gas has a concentration of mercury in gas below this level.

GTS Status: Compliant