- COMPLIANCE FORUM - TASK FORCE "MONITORING" -

FINAL VERSION

WORKING PAPER

ON

DATA GAPS AND NON-CONFORMITIES

Content

1. INTRODUCTION

This working paper focuses on suitable methods to correct or replace data in situations where the monitoring plan could not be followed as approved. The objective is the development of guidance for operators and consequently also for verifiers and competent authorities on how data gaps and non-conformities (erroneous data) could be replaced in an acceptable manner. The described methods shall not serve as regular monitoring methodology and are to be applied in exceptional cases only. According to Art. 23 (1) MRR an operator shall apply the highest achievable tier if for technical reasons it is temporarily not feasible to apply the tier in the monitoring plan for activity data or each calculation factor of a fuel or material stream as approved by the competent authority. Furthermore Art. 65 requires an update of the monitoring plan if no suitable method (procedure) for closing data gaps is set in the monitoring plan, whereas these methods may only apply for some kind of standard situations. Otherwise, gap-closure procedures shall be approved solely for individual cases, parameter and periods.

This working paper does not address continuous measurement of GHG emissions as missing data in this context is particularly regulated within the MRR.

2. REQUIREMENTS BY THE MRR

To some extent data gaps or the need of corrective actions of measured data seem to be inevitable, as nobody can exclude the occurrence of events that may impact the measurement system or data quality. The MRR already addresses such situations requesting corrections or surrogate data delivered by estimation both in a conservative manner to ensure that no underestimation of emissions occurs. Provisions are made in the following articles and paragraphs:

Art. 23 MRR: Temporary changes to the monitoring methodology

Where it is for technical reasons temporarily not feasible to apply the tier in the monitoring plan for the activity data or each calculation factor of a fuel or material stream as approved by the competent authority, the operator concerned shall apply the highest achievable tier until the conditions for application of the tier approved in the monitoring plan have been restored.

Art. 63 MRR: Corrections and corrective actions

Where any part of the data flow activities referred to in Article 57 MRR or control activities referred to in Article 58 MRR is found not to function effectively, or to function outside boundaries that are set in documentation of procedures for those data flow activities and control activities, the operator or aircraft operator shall make appropriate corrections and correct rejected data whilst avoiding underestimation of emissions.

Art. 65 MRR: Treatment of data gaps

Where data relevant for the determination of the emissions of an installation are missing, the operator shall use an appropriate estimation method for determining conservative surrogate data for the respective time period and missing parameter. Where the operator has not laid down the estimation method in a written procedure, it shall establish such written procedure and submit to

the competent authority an appropriate modification of the monitoring plan in accordance with Article 15 MRR for approval.

When submitting an emissions report for verification and later to the authority the following requirements regarding data gaps are applicable:

Annex X MRR, Minimum Content of the Annual Emissions Report, paragraph 11

- *(11) Where data gaps have occurred and have been closed by surrogate data in accordance with Article 65 (1) MRR:*
    - a) *the source stream or emission source to which each data gap applies;*
    - b) *the reasons for each data gap;*
    - c) *the starting and ending date and time of each data gap;*
    - d) *the emissions calculated based on surrogate data;*
    - e) *where the estimation method for surrogate data has not yet been included in the monitoring plan, a detailed description of the estimation method including evidence that the methodology used does not lead to an underestimation of emissions for the respective time period;*

3. TYPICAL SITUATIONS

There are many reasons for data gaps or non-conformities requiring corrective measures or estimations in order to improve or even to deliver data to be used in the annual emissions reporting. The following provides some examples of situations that lead to the requirement of applying corrections or estimations. As every data gap itself establishes non-conformity, distinction is made among those events that require the **closure of a data gap** and those that require the **correction of existing data**. Correcting data implies that data is available and need to be adjusted by a to-be-defined algorithm. Hence corrective measures are only applicable to existing data which is affected by a systematic error. Corrections can be applied when the error itself is understood and did not result in a loss of the sensitivity regarding the measured parameter. In contrast to this, estimations have to be used for real data gaps, i.e. when no information by the applied monitoring approach is available. If data is not rectifiable by any means, the rejection of such data sets is required, thus resulting in the creation of data gaps.

3.1. NON-CONFORMITIES REQUIRING CORRECTIVE MEASURES

- In many installations activity data is monitored continuously or discontinuously by electronic devices connected to a data acquisition system. The transfer from the physical scale (e.g. weight, flow or volume) to a digital reading is made by an algorithm usually known as a calibration function. By applying standard quality assurance procedures (which may refer to metrological control) it might be recognized that the calibration function has drifted to values (e.g. if it is a linear function this means figures for slope or zero-point) which are beyond pre-defined thresholds for the validity of this function. In

such a case the device will be replaced or re-calibrated while the data before the detection of such an error requires corrective measures.

- After evaluating some laboratory analyses it is recognized that samples used for determining a calculation factor are contaminated when using bins of a specific type for transporting the samples. By some tests the degree of contamination could be established enabling to discount the erroneous analysis results.

- By whatever reason an operator misses to run a calibration within the required time span. Thus data quality beyond the expiration period of the calibration certificate is not confirmed and might be assumed to be lower than under regular quality control.

3.2. DATA GAPS REQUIRING ESTIMATION

- Monitoring equipment delivering continuously input data to be used in emission calculation (e.g. belt weighers or gas chromatography devices) is not in operation or delivers erroneous data which cannot be rectified (for a longer time period or randomly), while the production plant is still in operation.

- Manual readings are taken from a device providing accumulative responses. The intervals between readings are long and the device has been malfunctioning for a while without being recognized. No figure is available for the period between the last reading taken when the device was still working well and the first reading after the device has been fixed or replaced.

- The frequency of laboratory analyses does not conform to the minimum frequency of analysis as some analyses were retroactively set invalid (e.g. due to contaminations, sampling mistakes etc.)

- Information taken from paper records (e.g. delivery notes) or stored electronically without any back-up copy is lost by any kind of incident. The loss occurred before the piece of information was transferred to another data storage media

- Some batches of a source stream have not been measured at all for whatever reason. For the rest of the source stream records are available. According to Art. 27 MRR the operator has to determine the activity data based on metering. Hence, not measured data of a source stream are data gaps and have to be closed by a conservative estimate derived from historic records in this case.

4. INDUSTRIAL PRACTICE FOR CLOSING DATA GAPS AND CORRECTIONS (NON-CONSERVATIVE)

This chapter describes industrial best practices without considering the conservative calculation principle of ETS. The approaches presented below do not deliver data to be reported in the context of emissions trading but deliver surrogate data for missing or erroneous values in industry practice.

Although the risk of the occurrence of data gaps or non-conformities should be minimized by developing an appropriate monitoring plan, in many cases it is not possible to completely exclude such scenarios. In determining the best approach to be applied practitioners may follow a stepwise approach by checking responses to the questions below in a hierarchical manner. The first question that is answered by "yes" is considered as the most suitable solution in principle. But in some cases it is better to apply a combination of methods which enables estimation of suitable surrogate data (see last bullet point).

- **Is any other monitoring equipment/procedure installed that delivers data of the same parameter at the same quality?** This refers to redundant systems which are installed and operated in parallel e.g. for reducing risks or by two different entities. Frequently seen examples are redundant gas meters in the main pipeline entering a plant or weighing of goods/fuels performed by the seller and the buyer using different weighing scales. In such a case the redundant system will deliver data to completely replace the missing or incorrect data sets.

- **Is any other monitoring equipment/procedure installed that delivers data of the same parameter at a lower quality?** This refers to systems which are installed and operated in parallel e.g. for collecting downstream information of individual consumers or by two different entities. Frequently seen examples are several gas meters in all sub-stream of the main pipeline not undergoing metrological control or weighing of goods/fuels performed by the seller and the buyer using different weighing scales of which one is not under metrological control. If data at the higher quality is missing or incorrect it will be substituted by data obtained from the secondary system.

- **Is there any suitable algorithm that would enable a reproducible adjustment of the original data set?** This refers to situations where the original data set is available and shows a reasonable response to variations of the signal (the medium being measured). For performing a reproducible adjustment a simple adjustment function (e.g. a linear function) needs to be derived from existing information presuming that only one systematic error caused the malfunction of the monitoring equipment. This is frequently applied if calibration/function tests result in the need of setting a new calibration function. In this case data which has been obtained since the last control/calibration may require adjustment. The adjustment function itself may be a function of time, if appropriate. The corrected data set will have a lower accuracy than data deriving from monitoring without

systematic error as the uncertainty of the adjustment function needs to be added to the original measurement uncertainty.

- **Is there any suitable algorithm that would enable a reproduction of data sets by using another parameter with a close correlation (e.g. R2 > 0.9) to the missing or incorrect one?** This refers to missing data within the original data set of an individual parameter where there is close correlation to another parameter. A typical example is the correlation of energy output (monitored) and the fuel input under stable/known operation conditions. In such a case an adjustment function, which will be a function of the correlated parameter, can be derived and applied for the period covering the data gap. It is self-evident that this approach will deliver data with lower accuracy than direct monitoring.

- **Is there any suitable algorithm that would enable a reproduction of data sets by using one or more parameters with suitable correlation to the missing or incorrect one?** This refers to data gaps within the original data set of an individual parameter when there is knowledge of existing correlation to other parameter. A typical example is the correlation of fuel input to a meteorological parameter in case of seasonal varying energy consumption. The following graph shows an example of how the estimation of a monthly figure would reasonably fit in the expected plant load curve.
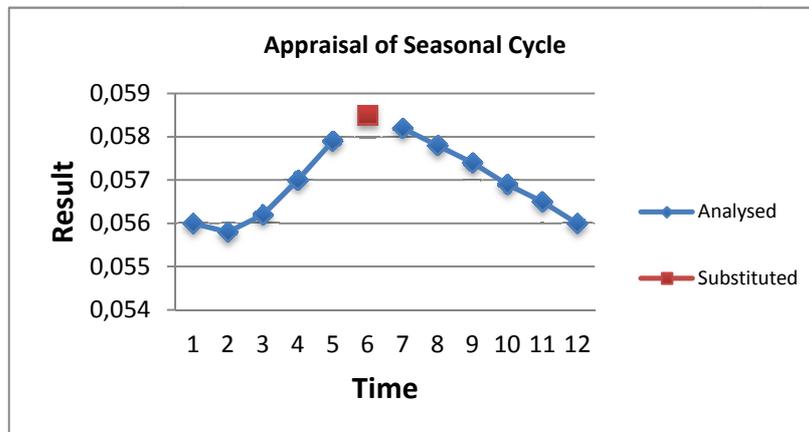

Figure 1: Estimation derived from correlation to meteorological data

- **Is there any information which can be derived from historic records that enables estimation for delivering suitable surrogate data?** This refers to data gaps within the original data set of an individual parameter when information is only available from historic records. A typical example is data which follows a predicted curve. Data gaps are closed by using the expected value. The following two graphs show examples for this scenario.
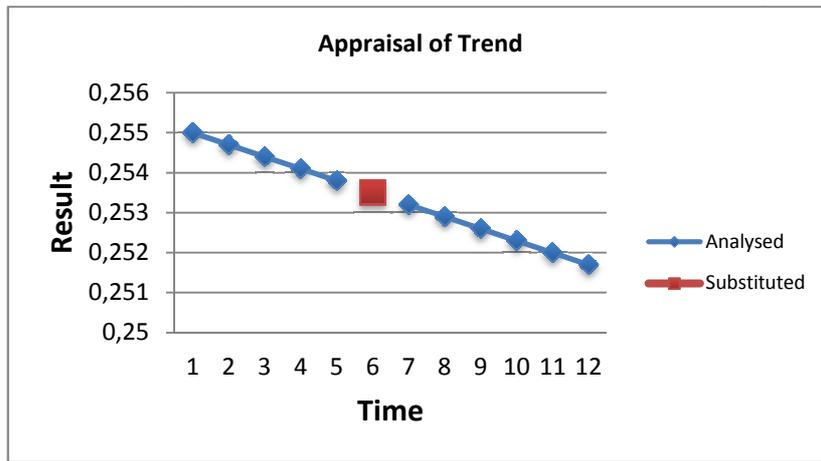
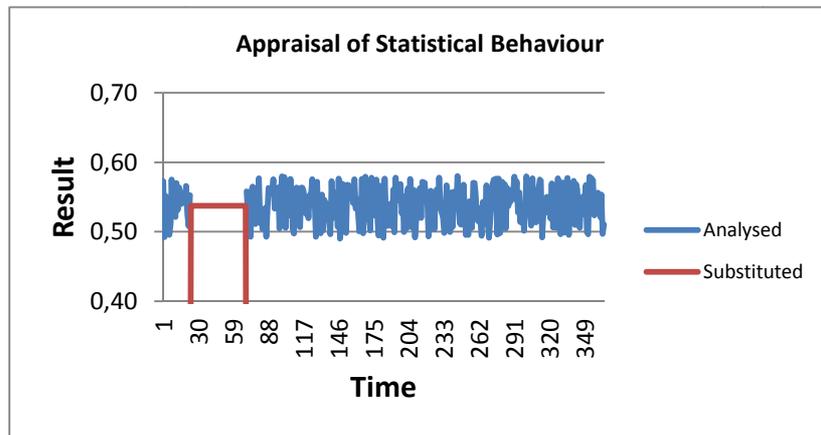Figure 2: Estimation by expected value derived from a trend curve

Figure 3: Estimation by expected value derived from stochastics

- **Is it possible to apply a combination of methods described above which enables estimation of suitable surrogate data?** This refers to data gaps which are closed by using a combination of methods. E.g. a historic trend is used as a basis, but is corrected to fit process conditions relevant for the time of the data gap. These cases are evaluated individually and experts are often involved.

If no standard approach can be applied then more scientific research might be necessary for delivering a reasonable solution. In many cases it is not deemed practicable to spend further resources for closing data gaps, whereas in an emissions trading scheme it is no option to abstain from filling data gaps and not to report emissions of the complete monitoring period.

5. TOOLBOX FOR APPLICATION IN EU-ETS

Emissions trading implies a monetary value to GHG emissions and in consequence also to data accuracy or data quality. Therefore, regulations shall prohibit the possibility to take advantage of missing or corrected data. Consequently, the MRR requests any corrective measure or estimation to be done in a conservative manner in order to avoid underestimation of emissions. Wherever underestimation is possible by applying another methodology than defined in the monitoring plan and approved by the competent authority, it is recommended to establish a **"safety margin"** to be added to the surrogate data, which should relate to the loss of certainty or data quality. It should be noted that in specific situations a conservative approach requires a discount of monitored values instead of an addition, e.g. when material streams leave the plant boundary in a mass balance approach.

The following graph provides a **decision tree** which is derived from the industrial practice as described in the previous chapter. It shows different "tracks" that can be applied to determine suitable approaches to surrogate data.
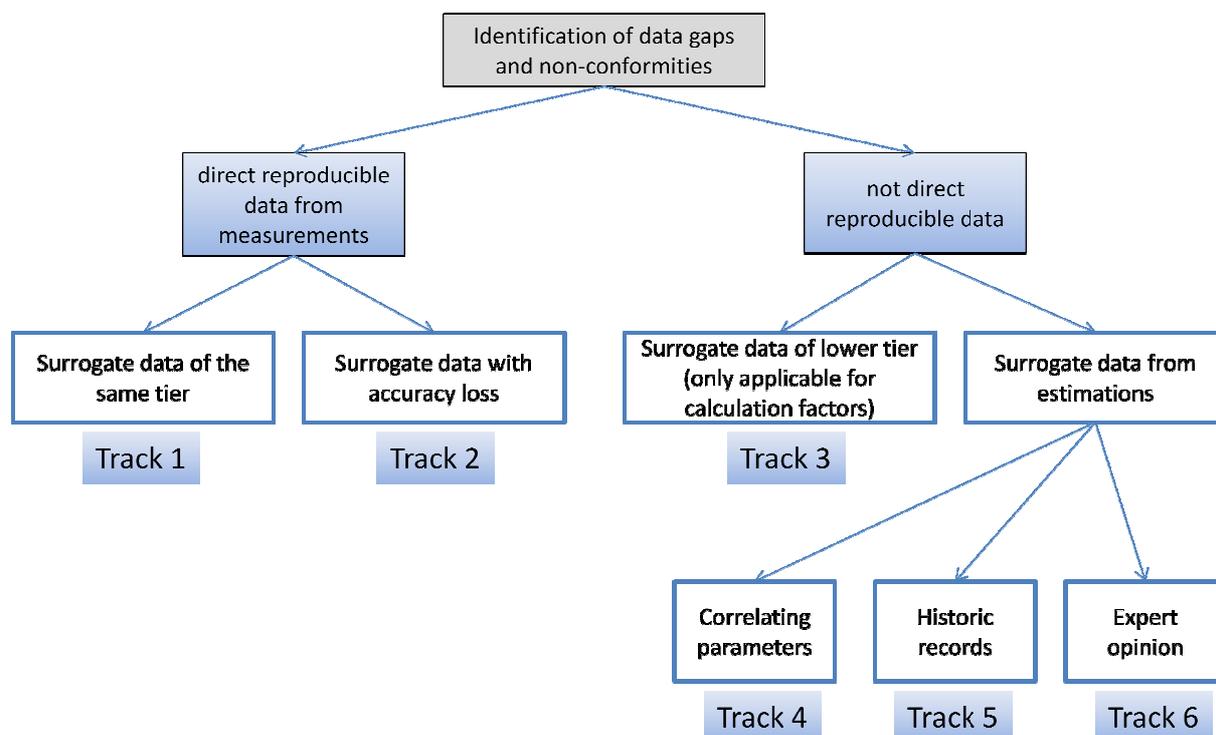
When discussing conservativeness in possible approaches to perform data corrections or estimations for filling data gaps in EU-ETS, it is sometimes necessary to distinguish between approaches for <u>activity data</u> and those for <u>calculation factors</u>. The tier approach in the MRR links tiers for activity data to a maximum acceptable uncertainty for that tier. In contrast to that, tiers for calculation factors rather refer to the sampling and analysis procedure and the quality of laboratories. While calculation factors which are referring to the same batch of a material are usually more influenced by stochastical (random) fluctuations, activity data is more related to the production process and frequently shows correlations to other variables monitored in that context.

These aspects need to be considered when choosing the adequate track for filling data gaps or correcting erroneous data.

It is recommend to apply a **"safety approach"** when determining values to be used for emissions reporting in order to achieve the requested conservativeness. "Safety" will be realized by adding (or discounting) a term in relation to the resulting accuracy loss to the best available surrogate data as described in the previous chapter. The following gives recommendations regarding the application of the tracks shown in the decision tree above. If the loss of certainty cannot be directly quantified, an appropriate safety margin of x % has to be justified and included in the calculation. This individual safety margin must be individually substantiated by the operator. A differentiation of the size of the safety margin between tracks 2 and track 3-5 is justifiable. Data is still reproducible within track 2 albeit with a loss of accuracy. Therefore, a smaller but conservative safety margin is justifiable. The situation within track 3-5 is quite different. There is no individual data available with information on uncertainties or tracks allow using default values (e.g. MRR/IPCC values, literature values, correlation without records of simultaneous monitoring, estimation etc.). Taking the unknown uncertainty of these surrogate values into account the conservative approach justifies an accordingly adjusted higher safety margin

It should be noted that tracks 3-5 are not suitable when data gaps occur in data sets of source streams which vary and/or are unpredictable. With regards to such source streams track 6 should be used.

5.1. TRACK 1: REPRODUCIBLE DATA OF THE SAME TIER

If data can be replaced by surrogate data of the same tier monitored by other devices / derived from other sources as originally outlined in the monitoring plan, then no safety margin is required and the surrogate data can simply replace the missing or incorrect value(s). A different approach for activity data and calculation factors is not necessary.

$D_r = S$

with

D_r = data to be used in emissions reporting

S = surrogate data derived from a redundant system/process

Examples for track 1: Reproducible without quality loss	
Activity Data	**Calculation Factors**
A redundant metering system delivering data of the same tier (e.g. two weights both under metrological control) is installed for the same material or fuel stream and was in operation when a data gap for the primary system was reported.	Both, the operator of an installation and the supplier of raw material, have established procedures according to Art. 32-35 MRR to sample and analyse the carbon content of the source stream by accredited laboratories. If analyses carried out by the operator are considered defective, he may request the supplier to provide this data set.

5.2. TRACK 2: REPRODUCIBLE DATA WITH ACCURACY[1] LOSS

If data can be replaced by surrogate data monitored by other devices / derived from other sources which are associated with a higher uncertainty than the tier of the primary device/source outlined in the monitoring plan, then a safety margin is required. Activity data with lower accuracy is e.g. caused by a missing reference to an external standard (calibration performed by independent third parties). For calculation factors no permissible uncertainties are set in the MRR. Nonetheless the loss of data accuracy e.g. due to an operator's non-accredited laboratory or by corrective measures with regard to systemic errors, should be addressed by a safety margin, too.

In many cases the loss of accuracy is able to be determined by reproducible means (e.g. the results of calibration of secondary devices, comparison testing of laboratories). In such cases this loss shall simply be added to the surrogate data, in order to reflect the concept of conservativeness. For every other case when an accurate quantification of the loss of accuracy might be difficult (e.g. missing conditions for determining the actual accuracy) an appropriate safety margin of x % shall be added to monitoring results. This individual safety margin must be substantiated by the operator. This approach must be applied when using secondary data sources, but is also applicable in the case of corrective measures like those that are required after a failed calibration.

Case 2-1: Surrogate data <u>with accuracy loss quantified for activity data</u>

$D_r = S + S * (U_s - U_t)$

with

D_r = data to be used in emissions reporting

S = surrogate data at lower quality

U_s = quantified uncertainty of the system including corrective measures (see example activity data b))

U_t = uncertainty of the approved tier

Case 2-2: Surrogate data <u>with accuracy loss quantified for calculation factors</u>

$D_r = S + S * (U_s - U_p)$

with

D_r = data to be used in emissions reporting

S = surrogate data at lower quality

U_s = quantified uncertainty of the secondary system including corrective measures

U_p = quantified uncertainty of the undisturbed primary system

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1 According to Art. 3 Nr. 16 MRR (both considering random and systematic factors)

Case 2-3: Surrogate data <u>with accuracy loss not quantifiable</u>

$D_r = S + S * x \%$

with

D_r = data to be used in emissions reporting

S = surrogate data at lower quality

x %= individually demonstrated safety margin by the operator

Examples for track 2: Reproducible with accuracy loss	
Activity Data	**Calculation Factors**
a) A secondary metering system delivering data at a lower level of accuracy (e.g. not undergoing regulator calibration) is installed for the same material or fuel stream and was in operation when a data gap for the primary system was reported (Case 2-1) b) . Corrective measures need to be applied retroactively as the result of a calibration has shown that the calibration function (slope or zero point) has drifted 2 %. (Case 2-1)	a) Corrective actions have been applied to calculation factors after a systematic error has been identified and quantified, such as e.g. a contamination of samples by transport containers. (Case 2-2) b) The operator's own laboratory is taking part at a round robin test. The result of the round robin test is taken as U_s-U_p (Case 2-2) c) Results of an accredited laboratory have been lost or have been considered invalid, whereas additional values are available from regular control performed by the operator's own laboratory (Case 2-3).

5.3. TRACK 3: NO REPRODUCIBLITY: SUBSTITUTION BY LOWER TIER APPROACH

This track is applicable to <u>calculation factors</u> when missing data has to be replaced by default values as usually requested by tier 1 or tier 2 approaches. Default values can be taken from

a) lists as provided by the MRR, the IPCC guidelines (www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html) or national authorities

b) referenced literature

The uncertainty of such default values varies for fuel types and is frequently indicated within relevant publications (case 3-1a). For every other case an appropriate safety margin of x % shall be included in the calculation (case 3-1b). This individual safety margin must be substantiated by the operator.

Case 3-1a: Surrogate data given by <u>regulation or literature</u>

$D_r = S + U_L$ or $D_r = S_U$

with

D_r = data to be used in emissions reporting

S = default value taken from regulation / guideline / literature

U_L = uncertainty as indicated by the same data source

S_U = default value taken from regulation / guideline / literature in case uncertainty is already included

Case 3-1b: Surrogate data given by <u>regulation or literature</u> when <u>information on uncertainty is missing</u>

$D_r = S + x \%* S$

with

D_r = data to be used in emissions reporting

S = default value taken from regulation / guideline / literature

x %= individually demonstrated safety margin by the operator

Examples for track 3: Substitution by lower tier approach	
Activity Data	**Calculation Factors**
Not applicable	A data gap caused by missing/invalid analyzes compared to the required minimum amount is filled by default values after proofing that these default values deliver a good estimate (e.g. low variability, standard commodity) e.g. from IPCC guidelines (case 3-1a)

5.4. TRACK 4: NO REPRODUCIBLITY: SUBSTITUTION BY ESTIMATION BASED ON CORRELATING PARAMETERS

Correlations might be identified and applied for both types of data, <u>activity data</u> and <u>calculation factors</u>, for determining surrogate data. The quality of correlations is usually indicated by the coefficient of determination (with a coefficient R^2 close to 1 indicating an excellent correlation). It needs to be mentioned that a correlation coefficient close to 1 is a suitable indication but no guarantee that the correlation function delivers a proper estimate. The application requires a careful assessment of the rationale behind the identified correlations. Surrogate data derived from correlation functions is usually comparable to the primary system over a period of time by simultaneous monitoring. The gap between surrogate data derived from correlation functions and real data obtained by primary systems can be assessed for delivering the standard deviation when applying the correlation function. Thus, a specific safety margin has been determined (case 4-1). In case no such parallel monitoring took place, where suitable correlation(s) can be assumed due to scientifically proven facts (e.g. correlation between heating degree days and energy consumption of a district heating plant), it is recommended to simply add the safety margin of x % to the surrogate data. This individual safety margin must be substantiated by the operator (case 4-2).

Case 4-1: Installation-specific surrogate data <u>based on correlating parameters</u>

$D_r = S + 2 * \sigma$

with

D_r = data to be used in emissions reporting

S = surrogate data delivered by correlation function

σ = standard deviation of historic simultaneous monitoring

Case 4-2: Installation-specific surrogate data <u>based on proven correlation without records of simultaneous monitoring</u>

$D_r = S + x \% * S$

with

D_r = data to be used in emissions reporting

S = surrogate data derived from correlating parameter

$x \%$= individually demonstrated safety margin by the operator

Examples for track 4: Estimation based on correlating parameters	
Activity Data	**Calculation Factors**
Missing activity data show correlation to parameters which are usually monitored during standard operation conditions and which have not been affected by the cause of the data gap in the primary system. Frequently seen correlations are e.g. • Fuel input to energy output • Energy demand to air temperature • Waste streams to production	The missing calculation factor shows correlation to figures which are available for the period of a data gap. Frequently seen correlations are e.g. • Heat value to net calorific value • Density to heat value • Density to emission factor • Net calorific value to emission factor

5.5. TRACK 5: NO REPRODUCIBLITY: SUBSTITUTION BY ESTIMATION BASED ON HISTORIC RECORDS

This approach might be applicable for both <u>activity data</u> and <u>calculation factors</u>. It is to be applied when an estimation to fill a data gap can be derived from long-term historic records (e.g. trends or seasonal behavior) while no other information is available for a proper estimate. It needs to be demonstrated that the historical data are representative for the operating conditions at the time when the data gap occurred and therefore the historic trend or behavior delivers a reasonable estimate. The standard deviation σ of historic records shall be added to the mean value delivering the surrogate data.

For ensuring the representativeness of this approach for calculation factors, a minimum of 20 analyzed historic samples is proposed for the determination of the mean value (case 5-1a). The 20 analyzed samples should be distributed in the way that analyses of 10 samples took place before and analyses of 10 samples take place after the data gap occurred. The 20 historic samples have to be representative for the situation when the data gap occurred. Also only samples from the same supplier of a fuel shall be used if the 20 samples are related to deliveries. If the underlying data set is smaller than 20 records, then the maximum of the analyzed values shall be taken (case 5-1b).

If the amount of available historical data is not high enough or "exotic" material streams are used not enabling any comparison to other installations (see example on the right side of the table below) a standard deviation used in case 5-1a cannot be reasonably determined. Hence, a safety margin of x % has to be applied. This individual safety margin must be substantiated by the operator (case 5-2).

Case 5-1a: Surrogate data derived from statistical behavior

$D_r = S + 2 * \sigma$

with

D_r = data to be used in emissions reporting

S = surrogate data derived from statistical behavior of historic records

σ = standard deviation of historic records

Case 5-1b: Installation-specific surrogate data based on <u>historic records with limited data set (only valid for calculation factors)</u>

$D_r = S$

with

D_r = data to be used in emissions reporting

S = maximum value of historic data set (less than 20 records)

Case 5-2: Surrogate data where a standard deviation cannot be reasonably determined

$D_r = S + x\% * S$

with

D_r = data to be used in emissions reporting

S = surrogate data derived from historic records

x %= individually demonstrated safety margin by the operator

Examples for track 5: Estimation based on historic records	
Activity Data	**Calculation Factors**
a) A measurement instrument was malfunctioning for a certain monitoring period or there was no measuring process at all for some batches of the source stream while for the rest of the source stream records are available and the missing data can be derived from the statistical behavior of the historic records plus a conservative safety margin (case 5-1a). 	The carbonate content of lime taken from a single mining area shows a constant increase over time following the exploitation of a geological structure. The analyzing of samples failed for some months, leaving a data gap while the continuation of the concentration curve has been observed before and after that gap. (case 5-2)
b) An installation has a regular maintenance shut-down during the summer. During that time some auxiliary installations are fuelled from fuel oil supply by a neighboring installation (outside the ETS) which is metered by a flow meter. The consumption during such shut-down is within the same range. During a reporting period it is not recognized that the meter is not functioning and no other records are available (case 5-2).	

5.6. TRACK 6: NO REPRODUCIBLITY: SUBSTITUTION BY ESTIMATION BASED ON A COMBINATION OF METHODS INCLUDING AN EXPERT OPINION

In the case that none of the tracks presented above are applicable, estimates shall be made by using a combination of methods including an expert opinion. Track 6 should be used in the case of varying and/or unpredictable data, e.g. flaring, or when the analysis result from a batch is missing and there are no representative historical data or values existing from literature or regulation. These data gaps should be evaluated on a case-by-case basis and the safety margin will have to be found in each individual case. The expert opinion has to justify why no higher emissions can be expected than the delivered result.

Examples for track 6: Estimation based on a combination of methods including an expert opinion	
Activity Data	**Calculation Factors**
An operator is missing activity data from a flare source stream. The data gap took place during an unplanned shutdown where varying amounts of gas was flared. Historical values from a similar shut down could be looked at, but differences in process conditions have to be taken into account. Data from other parts of the process can be used for additional information.	As for activity data