

# CHPQA Metering Uncertainties

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# Introduction to Uncertainties

For CHPQA submissions:

- Fuel input, power output and heat output streams are to be metered /monitored.
- In some cases inputs and outputs may need to be calculated or deduced from other metered data:

e.g. where the total input to the boundary is the algebraic summation of several fuel meters, with a deduction for a side stream serving outside the boundary.

# Introduction to Uncertainties

- Metering requirements for fuel inputs to the CHPQA boundary are given in [GN14](#). Those for power & heat outputs are given in [GN15](#) and [GN16](#) respectively.
- Whether inputs and outputs are metered or calculated they will have uncertainty associated with their measured or derived values.
- **Uncertainty:** For CHPQA this is defined as “the range of values, within which there is a high probability (Usually 95%) that the true value of a measured (or calculated) variable is estimated to lie.”

# Introduction to Uncertainties

- The allowed values, and computation of the actual uncertainties, of ***metered* power** outputs is covered in [GN15](#).
- The allowed values, and computation of the actual uncertainties, of ***metered* fuel** inputs or **heat** outputs is covered in [GN17](#).
- The allowed values, and computation of the actual uncertainties for ***calculated* fuel** inputs or ***calculated* power** and heat outputs (i.e. the desired calculated variable) is covered in [GN18](#).
- The [GN18](#) approach requires that the uncertainty of each input parameter is known, or can be estimated. The effect on the desired calculated variable of varying each input in turn is examined by a spreadsheet to yield  $U_o$ , and will not be examined further.

# Introduction to Uncertainties

- The computation of uncertainty adjustment factors (*FOI, FOP and FOH*) for both single or multiple energy streams is covered in [GN19](#). This takes account of best practice allowances and computes excess uncertainty.
- The various GNs contain dispensations for *special cases*, where simplified approaches may be followed. These can be chosen where *minor* energy streams are involved.

# Uncertainty in Metered Inputs and Outputs - Guidance Note 17

- The overall uncertainty ( $U_0$ ) for a metered or calculated value of a variable depends on a number of elements.
- For a simple fluid flow example it can be expressed as:

$$U_0 = \sqrt{[ U_1^2 + U_2^2 + U_3^2 + U_4^2 + U_5^2 ]}$$

Where:

$U_1$  = uncertainty of primary element.

$U_2$  = uncertainty of the signal transmitter

$U_3$  = uncertainty due to the fluid properties

$U_4$  = uncertainty due to lack of transmitter calibration

$U_5$  = uncertainty due to lack of primary element calibration

# Uncertainty in Metered Inputs and Outputs - Guidance Note 17

- RPs would normally be expected to follow the above approach when determining the overall uncertainty of a metering system.
- However, they will need to produce documentation and calculations to support the claimed values for individual uncertainty elements.
- Some R.P.s are having problems with this approach.

# Uncertainty in Metered Inputs and Outputs - Guidance Note 17

- To overcome this, CHPQA & DEFRA produced a *simplified* approach in [GN17](#) for determining overall uncertainties for *metered fluid flow* energy streams.
- It offers R.P.s default values from tables against each uncertainty element & R.P.s can complete Table GN17-1 for each meter.
- But if they wish, they can still use own values for any element, if supported by documentation.
- A worked example for the simplified approach is given in [GN17](#).

**Example GN17-1 – Calculation of Flow Meter Uncertainty(Work Sheet)**

<b>Flow Meter</b>	<b>Tag Number: M9(FQ)</b>	Metered fluid: <b>MP Steam</b>			
Line conditions	Pressure, bar(gauge) <b>10</b>	Temperature, °C <b>200</b>			
Meter type – Primary device (tick appropriate box)	Orifice Plate <input checked="" type="checkbox"/>	Venturi	Averaging pitot	“V-cone”	“Gilflow”
	Vortex shedding	Coriolis	Turbine	Other (please specify)	
Flow rates (including unit of measurement)	Meter maximum flow (Qmax)	<b>20.00</b>	State units <b>tonnes/h</b>		
	Actual average flow (Qav)	<b>12.50</b>	<b>tonnes/h</b>		
	Flow Ratio = Qav/Qmax	<b>0.625</b>			
Table of Uncertainties	Ref GN	Effective Uncertainty			Ue <sup>2</sup>
		Ue			
		Default value of Ue, %	Claimed value of Ue, %	Ref to source data attached	
Primary meter uncertainty	17.34	1.0	<b>0.72</b>	O/P data sheet	<b>0.5184</b>
Transmitter and computations	17.35	Table GN17-2: <b>0.4</b> <b>Electronic</b>			<b>0.1600</b>
Fluctuations in fluid properties	17.36 to 17.44	Table GN17-3: <b>3.0</b> <b>Uncompensated SH Steam</b>			<b>9.0000</b>
Time elapsed since last calibration (transmitter to output value)	17.45	Table GN17-4: <b>0.7</b> <b>18-months</b>	Use default value		<b>0.4900</b>
Time elapsed since last calibration or inspection of primary flow device	17.46	Table GN17-5: <b>3.0</b> <b>6-years</b>	Use default value		<b>9.0000</b>
<b>Sum of all Ue<sup>2</sup> = U<sup>2</sup></b>				<b>Total</b>	<b>19.1684</b>
<b>Overall Uncertainty, U =Square root U<sup>2</sup></b>					<b>4.38%</b>
<b>Acceptable Uncertainty for “Best Practice”,UBP (GN17.12-GN17.14)</b>					<b>3.20%</b>
<b>Excess Uncertainty, U<sub>x</sub> = U minus UBP (U<sub>x</sub> = 0 if U &lt;UBP)</b>					<b>1.18%</b>

## Deemed Uncertainties for Minor Energy Streams

- Where *minor* energy streams are involved an even simpler *deemed* approach for uncertainties of **fuel inputs** (or **heat outputs**) is now being offered.
- R.P.s can *deem* the overall uncertainty (Uo) of the minor energy stream as 14.0%, with  $U_{BP} = 2.0\%$ . This applies to metered or calculated energy streams.
- Obviates need to use [GN17](#) or [GN18](#) for uncertainty computations for minor streams & simplifies [GN19](#). But, R.P.s can still opt for these approaches if they wish.
- Deemed approach can only be used where it is shown that a minor stream (or summation of such streams) is less than 10% of the total fuel input ( $CHP_{TFI}$ ) to the CHP facility, or less than 10% of the useful heat to process from the CHP boundary ( $CHP_{QHO}$ ).

## Adjustment of Energy Inputs & Outputs for Excessive Uncertainty - GN 19 Worked Example

- [GN19](#) enables R.P.s to determine uncertainty adjustment factor applicable to each measured (or calculated) energy stream, so as to take account of any *excessive* uncertainty.
- Enables R.P.s to combine the individual stream factors to determine the overall *weighted* adjustment factors for fuel inputs (FOI), power and heat outputs (FOP) and (FOH) respectively.
- Separate blank worksheets provided for FOI, FOP and FOH.
- Worked examples are given for heat inputs, but similar approaches can be taken with fuel inputs.

## Adjustment of Energy Inputs & Outputs for Excessive Uncertainty & GN 19 Worked Example

- One example uses a deemed uncertainty value for a calculated minor heat stream.
- This is because this heat stream has been shown to account for less than 10% of the scheme Total Useful Heat Output.
- In addition, the example also shows how the computation of the overall weighted adjustment factor can be further simplified (using a *normalisation* procedure) in cases where such streams are heat losses (i.e. have negative values).
- This only affects the adjustment factors by 0.005
- A similar approach can be taken with such fuel inputs.

**WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR**

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output (From Form F4, Section 6c)	Fraction of QHO <b>F</b>	Acceptable Uncertainty for Best Practice <b>UBP</b>	Actual Uncertainty <b>U</b>	Excess Uncertainty <b>U<sub>x</sub> = U – UB<sub>P</sub></b> <b>(if U &lt; UB<sub>P</sub>, U<sub>x</sub> = 0.00)</b>	Individual Adjustment Factor <b>F<sub>I</sub></b> <b>= 1 – (U<sub>x</sub>/100)</b>	Weighed Adjustment Factor <b>F<sub>w</sub></b> <b>= F x F<sub>I</sub></b>
		MWh	(4 decimal places)	% (2 decimal places)	% (2 decimal places)	% (2 decimal places)	(4 decimal places)	(4 decimal places)
M9(FQ)	MP steam to site	77,220	0.7210	3.20	4.38	1.18	0.9882	0.7125
M8(FQ)	LP steam to site and hot well	37,350			7.42			
CALC 1	Deduct LP steam to hot well	-7,470			15.00			
CALC 2	LP steam to site	29,880	0.2790	2.00	10.00	8.00	0.9200	0.2567
	<b>Total</b>	107,100	<b>1.0000</b>		<b>Overall Adjustment Factor FOH</b> (= sum of <b>F<sub>w</sub></b> Factors)			<b>0.9692</b>

**WORKSHEET FOH HEAT OUTPUTS – UNCERTAINTY ADJUSTMENT FACTOR (SIMPLIFIED APPROACH)**

Meter or Calc. No.	Description of Output (e.g. MP steam to site)	Annual Heat Output (From Form F4, Section 6c)	Fraction of Normalised Heat <b>F</b>	Acceptable Uncertainty for Best Practice <b>UBP</b>	Actual Uncertainty <b>U</b>	Excess Uncertainty <b>U<sub>x</sub> = U – UB<sub>P</sub></b> <b>(if U &lt; UB<sub>P</sub>, U<sub>x</sub> = 0.00)</b>	Individual Adjustment Factor <b>F<sub>I</sub> = 1 – (U<sub>x</sub>/100)</b>	Weighed Adjustment Factor <b>F<sub>w</sub> = F x F<sub>I</sub></b>
		MWh	(4 decimal places)	% (2 decimal places)	% (2 decimal places)	% (2 decimal places)	(4 decimal places)	(4 decimal places)
M9(FQ)	MP steam to site	77,220	0.6327	3.20	4.38	1.18	0.9882	0.6253
M8(FQ)	LP steam to site and hot well	37,350	0.3060	4.00	7.42	3.42	0.9658	0.2956
CALC 1	LP steam to hot well	-7,470*	0.0612	2.00	14.00 (deemed)	12.00	0.8800	0.0539
	<b>Normalised Total Heat (NTH)</b>	122,040*	<b>1.0000</b>		<b>Overall Adjustment Factor FOH</b> (= sum of <b>F<sub>w</sub></b> Factors)			<b>0.9747</b>

Note: Negative sign for CALC1 can now be ignored when computing the Normalised Total Heat, but NTH is **not** the useful heat to process.