



Feasibility of Using Periodic Manual Sampling to Achieve Auto Sampling Intentions in Gas Export Measurement System

By

Anwar Sutan

Anwar.Sutan@i-vigilant.com



Background

- Flow proportional sample has not been reliable enough
 - Issues:
 - Plant shut down
 - Wrong count
 - Grab sampler stops working in the middle
 - Wrong handling
- Study is performed to see if spot sampling will be sufficient to achieve the intentions of auto sampling system



Why Sampling

- DECC Measurement Guideline Issue 8 paragraph 6.5.1
 - Each system should feature a manual sampling point to permit spot samples to be taken when required.



Reasons for Auto Sampling

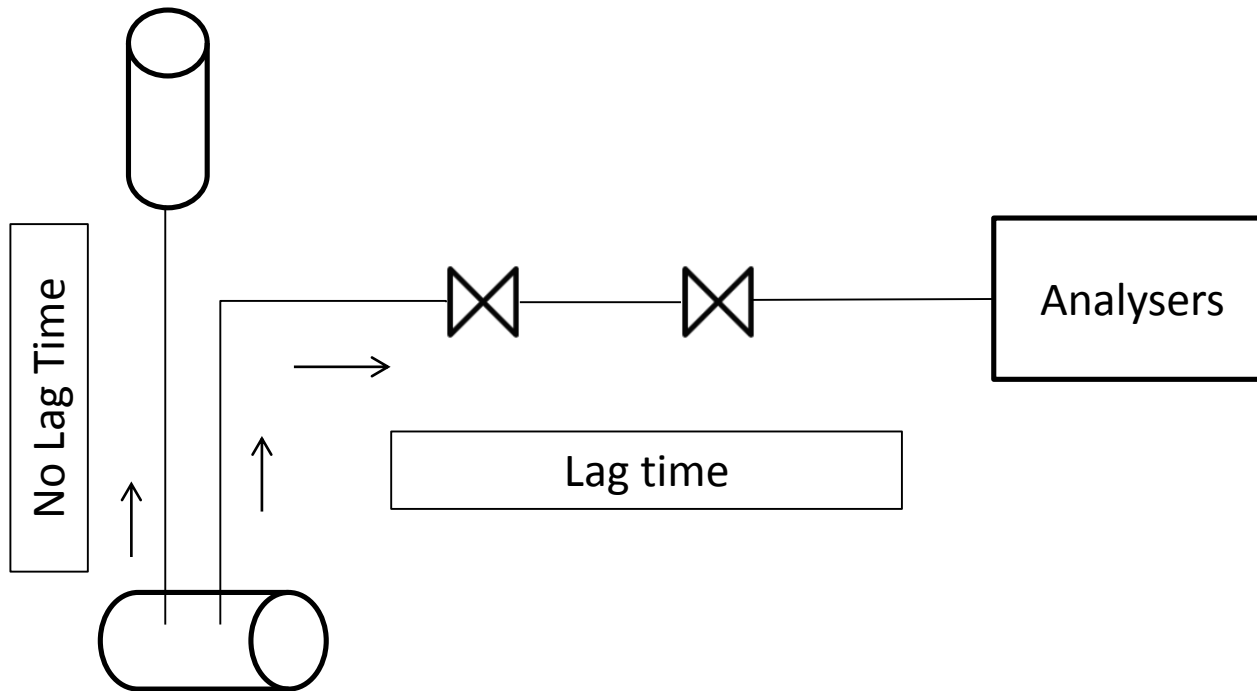
- To provide an independent check of the performance of the chromatographs
- To provide data for the characterisation of components from C6 to C10
- To provide data for the additional components present in the gas which the chromatographs are unable to detect
- To provide analysis data should chromatographs be unavailable due to breakdown or maintenance
- To provide verification of gas chromatograph



Reason 1

- To provide an independent check of the performance of the chromatographs
 - Independent check of GC performance is performed with following method:
 - Yearly ISO 10723 multilevel calibration
 - The use of GC conditional based monitoring tool
 - Spot sampling will provide information on how representative the sample is
 - With spot sampling GC data can be recorded at the same time as the spot sampling time (subject to additional lag time in gas which can be calculated)
 - This will compare the measurement of the same gas with two different methods
 - Similar result is expected when sample conditioning system provides representative sample
 - ISO 10723, GC CBM tool, and spot sampling provides independent check of both gas chromatograph and sampling conditioning system

Spot sampling



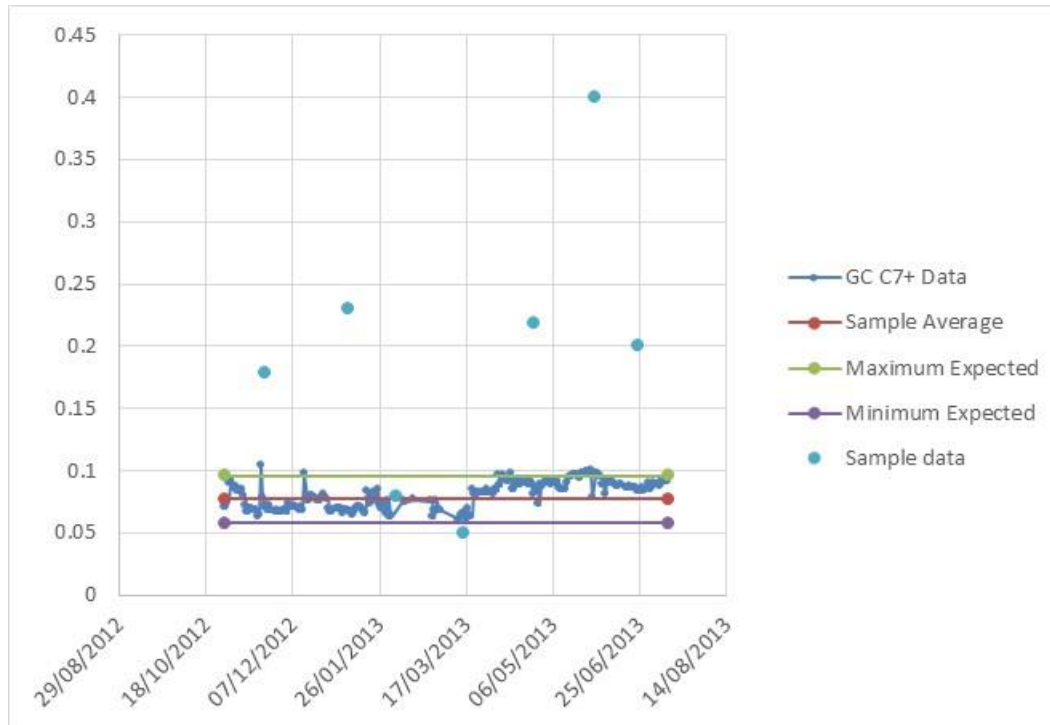
- Take the sample at hh:mm
- Note analysers reading at hh:mm + lag time \pm 1 cycle
- Average analyser reading and compare against spot sampling result
- Comparison of measurement of the same gas
- Provide independent check of the performance of pressure let down system

Finding



- Test on several sites show that heavy end results (i.e. C7+) from spot sampling is significantly higher than GC reading

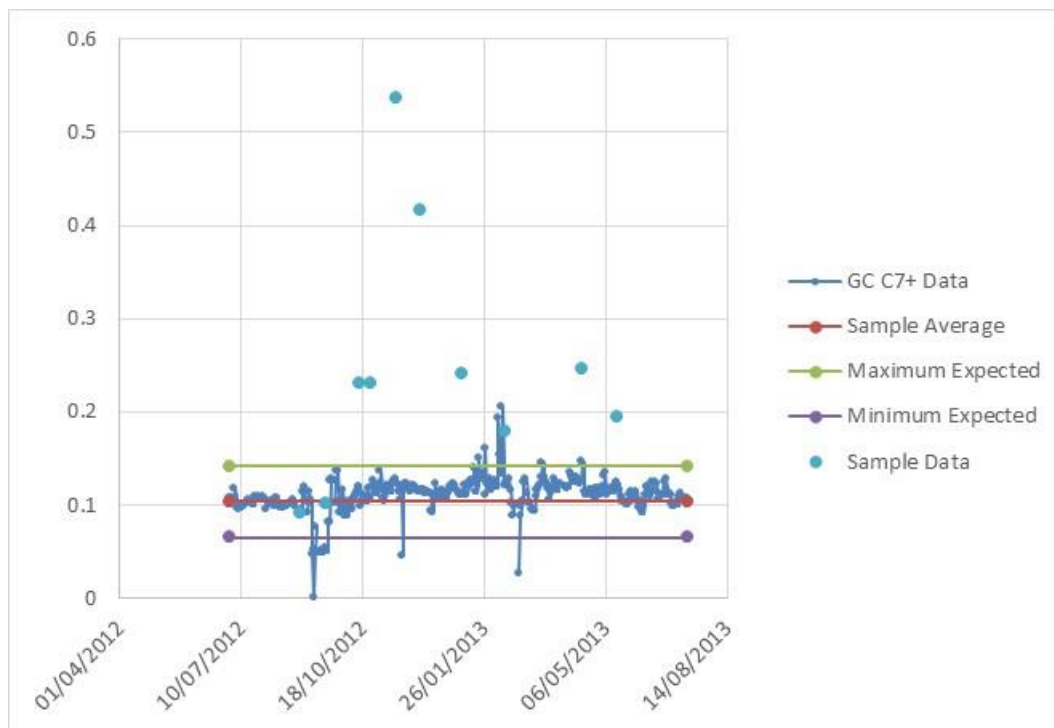
C7+ from Site 1



- **GC vs Spot sample:**
- Daily GC average = 0.077
- Sample average = 0.194
- Difference: 152%

- **Financial Exposure:**
- Lost of roughly **£200,000**

C7+ from Site 2



- **GC vs Spot sample:**
- Daily GC average = 0.104
- Sample average = 0.247
- Difference: 138%

- **Financial Exposure:**
- Lost of roughly **£158,000**

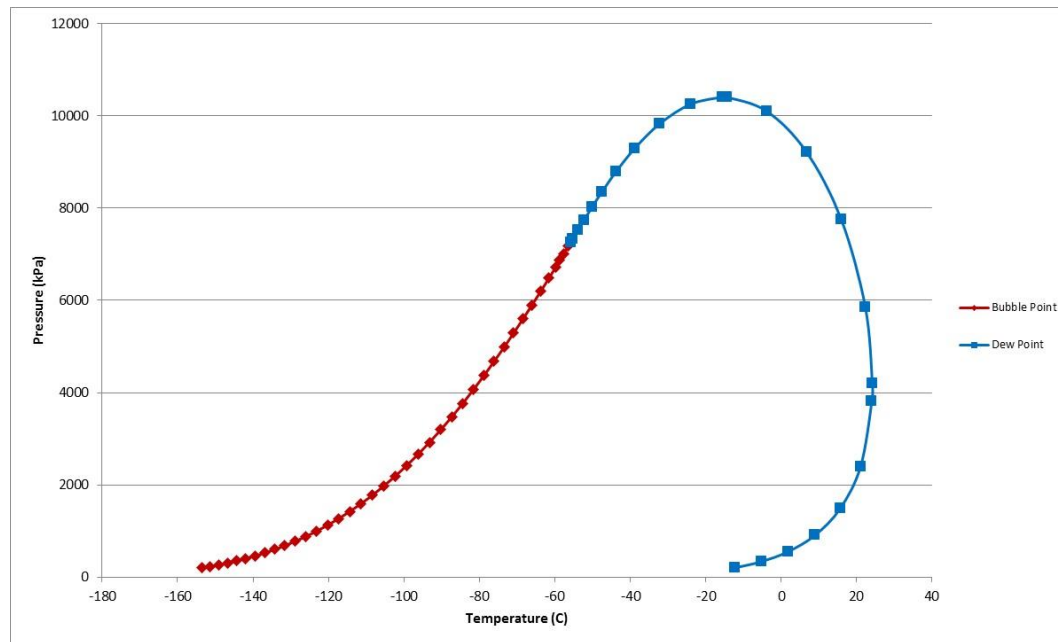
MONTHLY EXPOSURE



>£100,000 LOST in heavy components mis-measurement.

WHY IT HAPPENS

- Most likely because of liquid drop outs
- Not enough heating applied in sample let down system
- High hydrocarbon dewpoint





Reason 2

- To provide data for the characterisation of components from C6 to C10
 - Flow proportional sampling will be the best way of measuring the split, however...
 - If the sensitivity of the split components are very low against the calculation of CV, density, or flow rate uncertainty
 - And if historically, the gas compositions have been fairly stable
 - Spot samplings can provide similar information with less accurate result, however they are compensated by the low sensitivity of the parameters and high stability of gas composition

Split Sensitivity



Name	Value	Unit	Name	Value	Unit
n-Hexane	0.2220	mol %	Methane	86.8250	mol %
n-Heptane	0.0900	mol %	Carbon dioxide	2.6410	mol %
n-Octane	0.0400	mol %	Ethane	5.9890	mol %
n-Nonane	0.0065	mol %	H2S	0.0000	mol %
n-Decane	0.0000	mol %	H2O	0.0000	mol %
Propane	2.1060	mol %	Total	99.9975	mol %
i-Butane	0.4150	mol %			
n-Butane	0.7020	mol %	Base Temp (Tb)	15.0000	deg C
neo-Pentane	0.0040	mol %	Base pressure (Pb)	1.0133	bara
i-Pentane	0.2450	mol %	Combustion/met. temp.	15/15	degC/degC
n-Pentane	0.2330	mol %	Line Temp (T _L)	58.4500	deg C
Nitrogen	0.4790	mol %	Line Pressure (P _L)	112.1200	bara

Component	CV Sensitivity	ρ Sensitivity
C7	0.0036	0.0048
C8	0.0019	0.0025
C9	0.0003	0.0005



Split Sensitivity Toward CV

Component	mole Fraction	Norm mole fraction	Expanded relative uncertainty	Coverage factor	Standard relative uncertainty	Relative Sensitivity	$E(x_i) * S^*(x_i)$
Methane	0.8683	0.8687	0.0957	2	0.0478	-0.0791	-0.0038
Nitrogen	0.0048	0.0048	2.0781	2	1.0391	-0.0048	-0.0050
CO2	0.0264	0.0264	0.6014	2	0.3007	-0.0264	-0.0079
Ethane	0.0599	0.0599	0.5668	2	0.2834	0.0358	0.0102
Propane	0.0211	0.0211	1.1273	2	0.5636	0.0269	0.0151
i-Butane	0.0042	0.0042	1.0677	2	0.5339	0.0081	0.0043
n-Butane	0.0070	0.0070	2.2417	2	1.1208	0.0137	0.0154
neo-Pentane	0.0000	0.0000	0.0000	2	0.0000	0.0001	0.00000
i-Pentane	0.0025	0.0025	1.4920	2	0.7460	0.0064	0.0048
n-Pentane	0.0023	0.0023	1.2807	2	0.6403	0.0061	0.0039
Hexane	0.0022	0.0022	2.4811	2	1.2405	0.0073	0.0091
C7	0.0009	0.0009	3.9137	2	1.9568	0.0036	0.0070
C8	0.0000	0.0000	0.0000	2	0.0000	0.0019	0.0000
C9	0.0000	0.0000	0.0000	2	0.0000	0.0003	0.0000
ISO 6976	N/A	N/A	0.1000	2	0.0500	1.0000	0.0500
Combined Standard Uncertainty							0.0580
Coverage Factor (k)							2
Combined Expanded Uncertainty (%)							0.1159
CV absolute uncertainty (MJ/m3)							0.05475



Split Sensitivity Toward CV

Component	mole Fraction	Norm Mol %	Expanded relative uncertainty	Coverage factor	Standard relative uncertainty	Relative Sensitivity	$E(x_i) \cdot S^*(x_i)$
Methane	0.8683	0.8683	0.0957	2	0.0478	-0.0791	-0.0038
Nitrogen	0.0048	0.0048	2.0781	2	1.0391	-0.0048	-0.0050
CO2	0.0264	0.0264	0.6014	2	0.3007	-0.0264	-0.0079
Ethane	0.0599	0.0599	0.5668	2	0.2834	0.0358	0.0102
Propane	0.0211	0.0211	1.1273	2	0.5636	0.0269	0.0151
i-Butane	0.0042	0.0042	1.0677	2	0.5339	0.0081	0.0043
n-Butane	0.0070	0.0070	2.2417	2	1.1208	0.0137	0.0154
neo-Pentane	0.0000	0.0000	0.0000	2	0.0000	0.0001	0.0000
i-Pentane	0.0025	0.0025	1.4920	2	0.7460	0.0064	0.0048
n-Pentane	0.0023	0.0023	1.2807	2	0.6403	0.0061	0.0039
Hexane	0.0022	0.0022	2.4811	2	1.2405	0.0073	0.0091
C7	0.0009	0.0009	6.4080	2	3.2040	0.0036	0.0115
C8	0.0004	0.0004	23.0969	2	11.5485	0.0019	0.0216
C9	0.0001	0.0001	40.3490	2	20.1745	0.0003	0.0070
ISO 6976	N/A	N/A	0.1000	2	0.0500	1.0000	0.0500
Combined Standard Uncertainty							0.0629
Coverage Factor (k)							2
Combined Expanded Uncertainty (%)							0.1258
CV absolute uncertainty (MJ/m3)							0.05475

Combined Expanded Uncertainty: 0.1159 → 0.1258 ($\Delta 0.01\%$)



Split Sensitivity Toward Density

Component	mole Fraction	Norm Mol %	Expanded relative uncertainty	Coverage factor	Standard relative uncertainty	Relative Sensitivity	$E(x_i) * S^*(x_i)$
Methane	0.8683	0.8687	0.0957	2	0.0478	-0.2062	-0.0099
Nitrogen	0.0048	0.0048	2.0781	2	1.0391	0.0006	0.0006
CO2	0.0264	0.0264	0.6014	2	0.3007	0.0377	0.0113
Ethane	0.0599	0.0599	0.5668	2	0.2834	0.0544	0.0154
Propane	0.0211	0.0211	1.1273	2	0.5636	0.0416	0.0234
i-Butane	0.0042	0.0042	1.0677	2	0.5339	0.0124	0.0066
n-Butane	0.0070	0.0070	2.2417	2	1.1208	0.0208	0.0233
neo-Pentane	0.0000	0.0000	0.0000	2	0.0000	0.0002	0.0000
i-Pentane	0.0025	0.0025	1.4920	2	0.7460	0.0097	0.0072
n-Pentane	0.0023	0.0023	1.2807	2	0.6403	0.0094	0.0060
Hexane	0.0022	0.0022	2.4811	2	1.2405	0.0117	0.0145
C7	0.0009	0.0009	3.9137	2	1.9568	0.0048	0.0094
C8	0.0000	0.0000	0.0000	2	0.0000	0.0025	0.0000
C9	0.0000	0.0000	0.0000	2	0.0000	0.0005	0.0000
Pressure	112.12	112.12	0.2500	2	0.1250	1.1048	0.1381
Temperature	58.4500	58.4500	0.8554	2	0.4277	-0.3159	-0.1351
AGA 8	N/A	N/A	0.1000	2	0.0500	1.0000	0.0500
Combined Standard Uncertainty							0.2045
Coverage Factor (k)							2
Combined Expanded Uncertainty (%)							0.4090
Line Density absolute uncertainty (Kg/m3)							0.37603



Split Sensitivity Toward Density

Component	mole Fraction	Norm Mol %	Expanded relative uncertainty	Coverage factor	Standard relative uncertainty	Relative Sensitivity	$E(xi)*S*(xi)$
Methane	0.8683	0.8683	0.0957	2	0.0478	-0.2062	-0.0099
Nitrogen	0.0048	0.0048	2.0781	2	1.0391	0.0006	0.0006
CO2	0.0264	0.0264	0.6014	2	0.3007	0.0377	0.0113
Ethane	0.0599	0.0599	0.5668	2	0.2834	0.0544	0.0154
Propane	0.0211	0.0211	1.1273	2	0.5636	0.0416	0.0234
i-Butane	0.0042	0.0042	1.0677	2	0.5339	0.0124	0.0066
n-Butane	0.0070	0.0070	2.2417	2	1.1208	0.0208	0.0233
neo-Pentane	0.0000	0.0000	0.0000	2	0.0000	0.0002	0.0000
i-Pentane	0.0025	0.0025	1.4920	2	0.7460	0.0097	0.0072
n-Pentane	0.0023	0.0023	1.2807	2	0.6403	0.0094	0.0060
Hexane	0.0022	0.0022	2.4811	2	1.2405	0.0117	0.0145
C7	0.0009	0.0009	6.4080	2	3.2040	0.0048	0.0153
C8	0.0004	0.0004	23.0969	2	11.5485	0.0025	0.0287
C9	0.0001	0.0001	40.3490	2	20.1745	0.0005	0.0093
Pressure	112.12	112.12	0.2500	2	0.1250	1.1048	0.1381
Temperature	58.4500	58.4500	0.8554	2	0.4277	-0.3159	-0.1351
AGA 8	N/A	N/A	0.1000	2	0.0500	1.0000	0.0500
Combined Standard Uncertainty							0.2071
Coverage Factor (k)							2
Combined Expanded Uncertainty (%)							0.4141
Line Density absolute uncertainty (Kg/m3)							0.38076

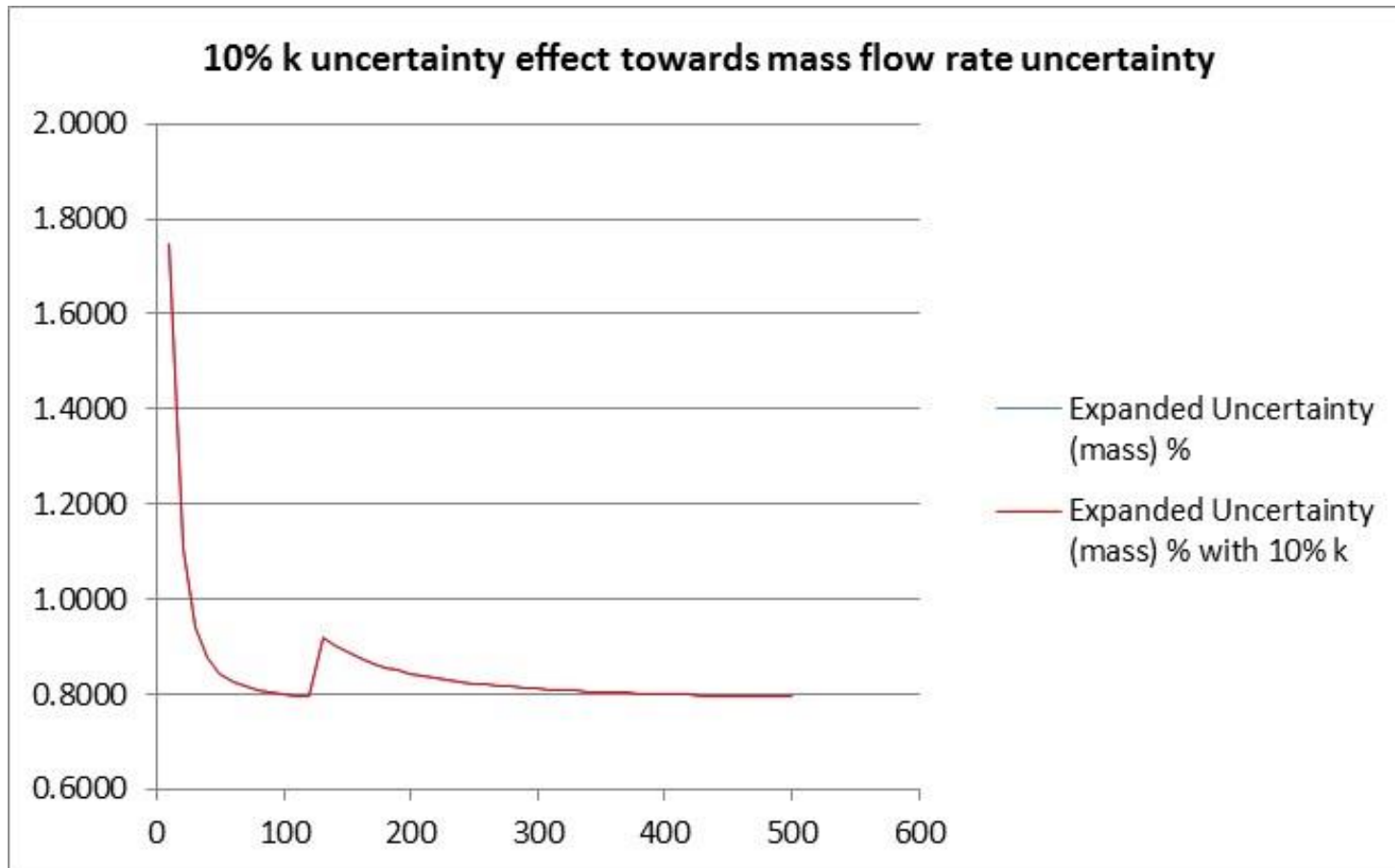
Combined Expanded Uncertainty: 0.409 → 0.4141 ($\Delta 0.01\%$)



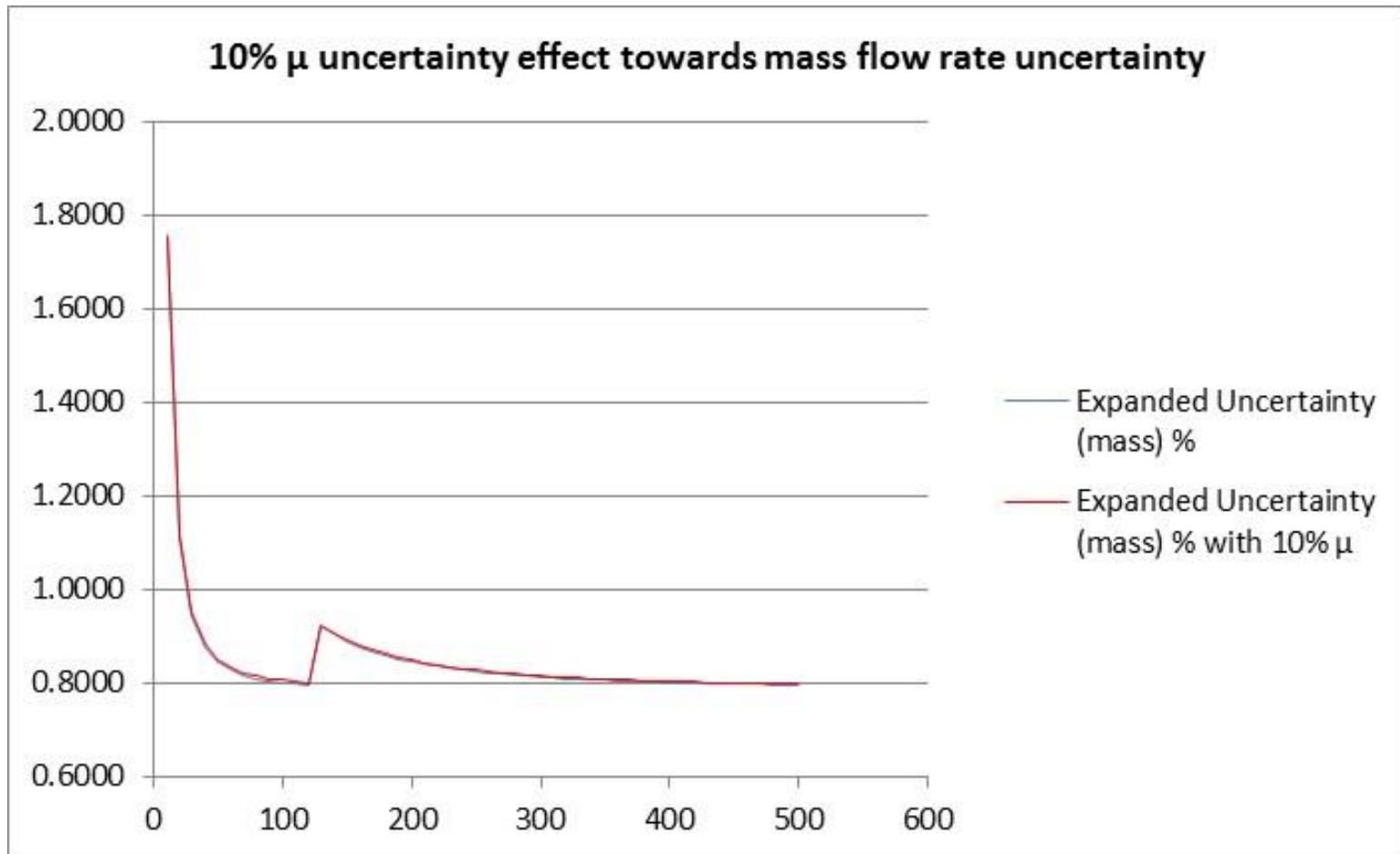
Reason 3

- Provide data for the additional components present in the gas which the chromatographs are unable to detect
 - Spot sampling and other types analysers (i.e. H₂O and H₂S analysers) can provide the same information
 - Isentropic Exponent and Dynamic Viscosity has negligible effect to mass flow rate uncertainty

Isentropic Exponent Effect



Viscosity Effect





Reason 4

- Provide analysis data should chromatographs be unavailable due to breakdown or maintenance
 - GC historical data can provide better function as it will consist of more up to date data (not data from last month average)
 - Using auto sampler, it uses approximately 6 weeks old actual data



Conclusion

- All reasons to perform monthly proportional sample can be fulfilled by performing spot sampling (dependent on gas stability)
- Split determination will be more accurate by performing flow proportional sample, however spot sample can provide similar outcome
- The lower split accuracy can be justified by the low sensitivity of split parameters toward system uncertainty and the high stability of gas composition
- It is feasible to fulfil the intention of auto sampling by performing periodic spot sampling



Thank you