WATER ADDITION TO
WAMUS DIRTY GAS SYSTEM.

ENGINEERING NOTE
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Water addition to WAMUS Dirty gas system.

Total flow through the whole WAMUS Dirty system – 135 l/min;
Currently, H$_2$O content is 600 ppm (0.45 mg/l).
In order to rise H$_2$O content to 1500 ppm (1.2 mg/l), we need to add 0.75 mg/l.
In order to rise H$_2$O content to 2500 ppm (1.8 mg/l), we need to add 1.35 mg/l.
Gas flowing through a bubbler filled with water at room temperature – 23 C (saturated) has water content of 23 mg/l, therefore, flow through a bubbler has to be 4.4 l/min (to get 1500 ppm); or 7.9 l/min (to get 2500 ppm).
WAMUS Dirty system volume is 240 m$^3$. It will need 180 g to increase H$_2$O content to 1500 ppm or 325 g to go to 2500 ppm. It will take 1.25 days (or 2.25 days to go to 2500 ppm with 4.4 l/min flow.
Steady state flow through a bubbler will be 0.5 l/min to maintain 1500 ppm and 0.8 l/min to maintain 2500 ppm. Water usage will be around 17.5 ml per 24 hours for 1500 ppm; or around 26 ml per 24 hours for 2500 ppm.

Proposed flow diagram:

A bubbler and a flow controller (0-5 lpm or 0-10 scfh) can be connected in parallel with MV-07 pumps bypass valve in room 510 (we have available ports in existing piping to do it). Existing analyzers will be used to check H$_2$O content in gas.
Water addition to a single PDT test.

Total flow through the whole WAMUS Dirty system – 135 l/min;
72 PDT in the system;
Estimated flow through a single WAMUS Dirty system PDT – 1.875 l/min.
Currently, H₂O content is 600 ppm (0.45 mg/l); need to rise to 2500 ppm (1.85 mg/l) – add 1.4 mg/l.
Gas flowing through a bubbler filled with water at room temperature – 22 C (saturated) has water content of 19 mg/l, therefore flow through a bubbler has to be 0.14 l/min or 0.29 ft³/hr.
Water usage will be around 4 ml per 24 hours.
Proposed flow diagram:

SHAW hygrometer might be used to monitor water content. 2500 ppm correspond to -10 C Dew point.
PDT to be tested is one of four suggested by Penny Kasper – 123, 207, 230 or 133 – will be chosen after Collision Hall access and site inspection (the easiest one to reach and access to in-out ports, power outlet nearby, probably a TV camera to watch hygrometer readings).
Water addition to a single PDT

Currently 680 ppm = 0.45 mg/l 
needs 2500 ppm = 1.85 mg/l 
=> add 1.4 mg/l

@ 22°C D.P. → H₂O content = 19 mg/l

Average flow thru a single PDT

1.875 l/min

Flow needed: 1.4 mg/l x 1.875 l/min = 2.625 mg/min

\[
Q = \frac{2.625 \text{ mg/min}}{19 \text{ mg/l}} = 0.14 \text{ l/min} \\
= 0.29 \text{ ft}^3/\text{hr}
\]

Water usage: 2.625 mg/min = 157.5 mg/hr = 3.78 g/day

(1 teaspoon = 5 g)

Flowmeter readings:

\[
Q = \frac{\text{scfm air}}{f} \\
f = \sqrt{\text{spec. gravity}}
\]

\[
SG: C₄H₁₀ = 0.55, \ (CH₄ = 3.038) \ AR = 1.38
\]

\[
SG_{\text{min}} = 0.08 \cdot 0.55 + 0.08 \cdot 3.018 + 0.84 \cdot 1.38 = 1.45
\]

\[
f = 1.2 \quad \text{SCFM air readings} = 0.29 \cdot 1.2 = 0.35 \text{SCFM}
\]
H₂O addition to WAmus dirty (limited)

Dirty WAmus H₂O content ~600 ppm = 0.45 mg/l
1500 ppm = 1.2 mg/l
2500 ppm = 1.8 mg/l
Dirty WAmus flow = 135 l/min
add 1 l H₂O
- for 1500 ppm
  (1.2 - 0.45) mg/l x 135 l/min = 101.25 mg/min
for 2500 ppm
  (1.8 - 0.45) x 135 = 182.25 mg/min
@23°C, Sat. gas has 23 mg/l H₂O
Reg'd flow
- for 1500 ppm: \( \frac{101 \text{ mg/min}}{23 \text{ mg/l}} = 4.39 \text{ l/min} \)
- for 2500 ppm \( \frac{182}{23} = 7.91 \text{ l/min} \)

Water usage:
- 1500 ppm \( \rightarrow 101.25 \text{ mg/min} = 145.89 \text{ g/day} \)
- 2500 ppm \( \rightarrow 182.25 \text{ mg/min} = 262.49 \text{ g/day} \)

Dirty system volume = 240 l
180 g needs to be added to increase to 1500 ppm
124 g \( \rightarrow \) to 2500 ppm
Will take 1.25 days.
The addition to W. Dicky - steady state

- 9-10 lpm make-up flow with 0 ppm
  - at 1500 ppm → 1.2 mg/l
  - at 2500 ppm → 1.8 mg/l

Addition: for 1500 ppm → 12 mg/l/min
  - for 2500 ppm → 18 mg/l/min

Sod. gas @ 23°C → 25 mg/l

Flow req'd: \( \frac{12}{23} = 0.522 \text{ l/min} = (1.14 \text{ l/hr}) \)
  - for 1500 ppm

\[ \frac{18}{21} = 0.863 \text{ l/min} (2.0 \text{ l/hr}) \]

Water usage

- 1500 ppm → 17.3 g/day
- 2500 ppm → 26 g/day