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Preparation Worksheet for System Integrity Check

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The following checklist and diagnostic instructions will walk the user through a series of tests which should identify inadequacies in the system setup.

As a compliment to this document, the Mercuric Chloride Generator Technical Bulletin, found in the AQI online library, continues to be updated with troubleshooting techniques.

1. Check version of 80i (should be version .253 or later)

2. Record the following temperatures:
   a. Umbilical ______c
   b. Probe ______c
   c. Converter ______c
   d. Oxidizer ______c

3. Record the following pressures from the 80i while in Sample mode
   a. Analyzer pressure in Hg(o) mode ________ < 70 torr
   b. Analyzer pressure in Hg(t) mode ________ +/- 5 torr of Hg(o)
   c. Orifice pressure ________
   d. Dilution pressure ________
   e. Blowback ________
   f. Eductor ________
   g. Vacuum ________ >17 in Hg

4. Record the following pressures from the 81i
   a. During sample mode ________ <800 mmHG
   b. During system span ________ 800-1100 mmHg
   c. During oxidizer baseline ________ 20-80 more than system span

   *The 81 pressure should never exceed 1200 mmHg

5. Check the flowrate of the 81i Exhaust Port while in System span mode. It should be zero.

6. Ensure check valve in 81i has the arrow pointing toward the rear panel.

7. Record the displayed 81i dilution flow (Diagnostic screen) while in oxidizer baseline mode ______ lpm This value should match the rotometer reading on step 11, within 10%.

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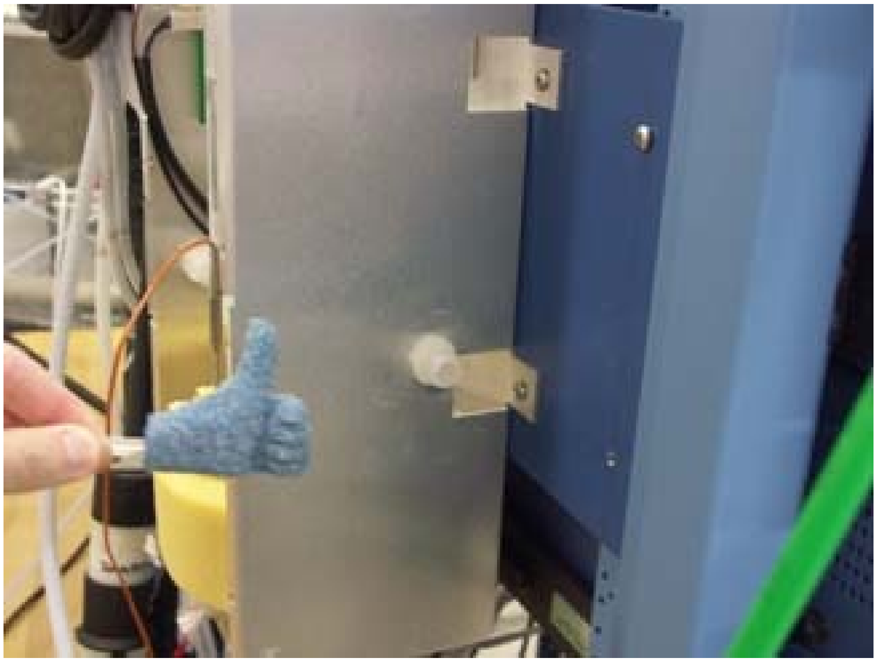
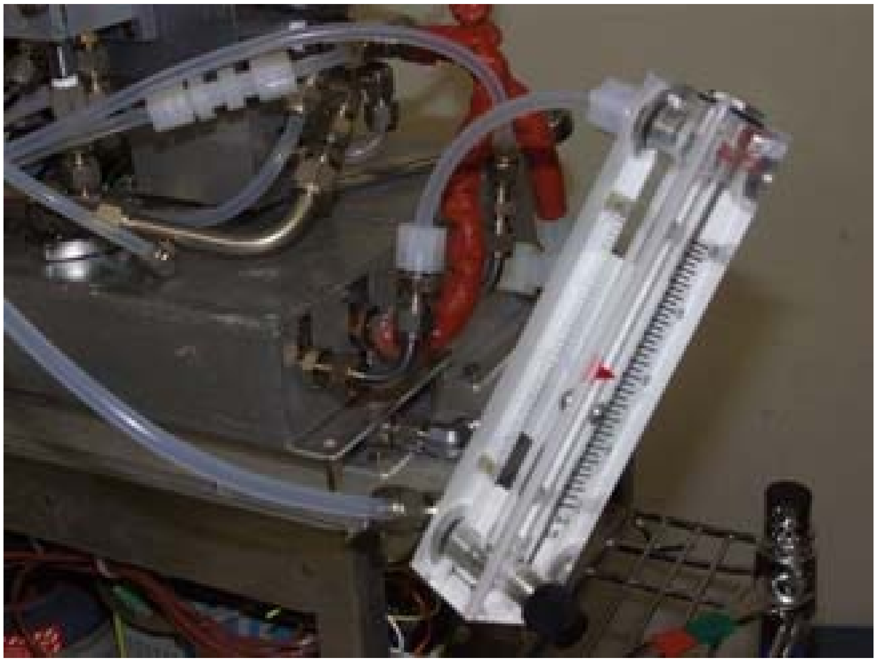
8. Ensure **bottom** reservoir of hydrator is filled half way.

9. Ensure a heated 3/8 line is used for the cal gas (line number 3)

10. Disconnect 3/8 cal line from the outlet bulkhead of the hydrator, put the system in System Span mode, call up the 81 pressure diagnostic screen, and place your thumb over the hydrator outlet. The pressure on the 81i should quickly (~4 seconds) peg out to >1220. Y/N (**do not plug for more than 15 seconds or this may result in the 81 being over pressurized)**. Reconnect tubing.



11. Place 0-20 lpm rotometer inline with the Hg span gas port at the inlet of the oxidizer. Measure the flowrate of Hg span gas while in oxidizer mode (baseline)_______ lpm, Reconnect as normal. Hg(0) and Cl2 inlet may not necessarily be on the same side of the oxidizer from unit to unit. Ensure you connect the rotometer to correct inlet line.



12. Close Cl2 cylinder regulator and isolation valve. Set the Hg baseline duration to zero and the Cl2 duration set to 30 minutes. Put system in Oxidizer mode. Disconnect Cl2 inlet line from the oxidizer, and connect the hand help vacuum pump to the removed line. Pump down to 20 In Hg and record vacuum value ______. Ensure that the needle does not move for more than a minute. Remove Cl2 line from regulator and ensure the needle on the vacuum gauge drops to zero within 2 seconds. (this ensures that the Cl2 valve in the probe is open). Reconnect everything as normal, but add a 0-2 lpm rotameter directly after the orifice, attached to the cylinder regulator.

13. Cap both the Hg span and Cl2 unions on the oxidizer inlets, disconnect the orange insulated sst tube from the cross (oxidizer outlet) and connect a piece of teflon tubing and an elbow to the disconnected tube and pull a vacuum on the oxidizer. The vacuum should be >20 In Hg and the needle should not move for a minute. If it leaks and all of the external fittings are tight, shut off oxidizer (component power) and remove the oxidizer cover and tighten all internal fittings. Leak test again.

14. Ensure the teflon line at the orifice block are not melted or leaking.

15. Ensure that the scrubber below the oxidizer is NOT connected.

16. For 83GC probes only. Set probe temperature to 80C, and set probe into blowback mode, wait for the probe to cool below 100C. Remove probe filter cap, and replace o-ring if required. The Thermo part number for the o-ring is 108087-00. When removing the cap, ensure that threads on the bolts do not gall. If it feels like the threads are starting to gall, STOP. Add water to threads in order to back out the screws. If any of the 4 screws gall, they can not be removed and the entire block assembly must be replaced! Replace cap.

17. Set the following temperature
    a. Probe = 225c
    b. Umbilical: keep as found
    c. Oxidizer = 400c
    d. Converter = 800c

18. Shut off sample pump, and carefully remove orange converter tube assembly which joins the orifice block with the converter (caution the converter core is brittle). Inspect converter elbow fitting for loose quartz wool (remove loose wool if found). Remove rear converter elbow and inspect for loose quartz wool (remove if necessary). Re-attach tube assembly and turn sample pump back on. Ensure that elbows on both sides of the converter are tight, and the chamber pressure returns to normal (<70 mmHG)

19. Re-attach probe cover, and put system in Sample mode. Wait 30 minutes after all temperatures have stabilized before going to the next step.

Initial System Integrity Check.

20. Perform System zero and System span in speciated mode, calibrate if required.
21. Use the following Oxidizer schedule
    a. Hg Baseline 15 min
    b. Cl2 Duration 20 min
    c. Post Condition 10 min
22. Start oxidizer test. After the Cl2 is turned on via the probe valve (15 minutes after start) record Cl2 pressure and flow. _______psi ______ ccm
23. After recording the Cl2 flow, adjust the regulator such that the flow is at least 400 sccm. record corresponding pressure ______psi
24. Download lrecs and calculate total efficiency.
25. Allow system to run in Sample mode for at least 20 minutes
26. If the Total Efficiency is below 90%, repeat the System Integrity test. This time, spike the oxidizer with twice the Hg span concentration for the first 90 seconds of the Chlorine duration cycle, to accelerate the equilibrium period.

Definitions

In order to successfully operate the oxidizer, the terminology as described in Figure 1 should be used.

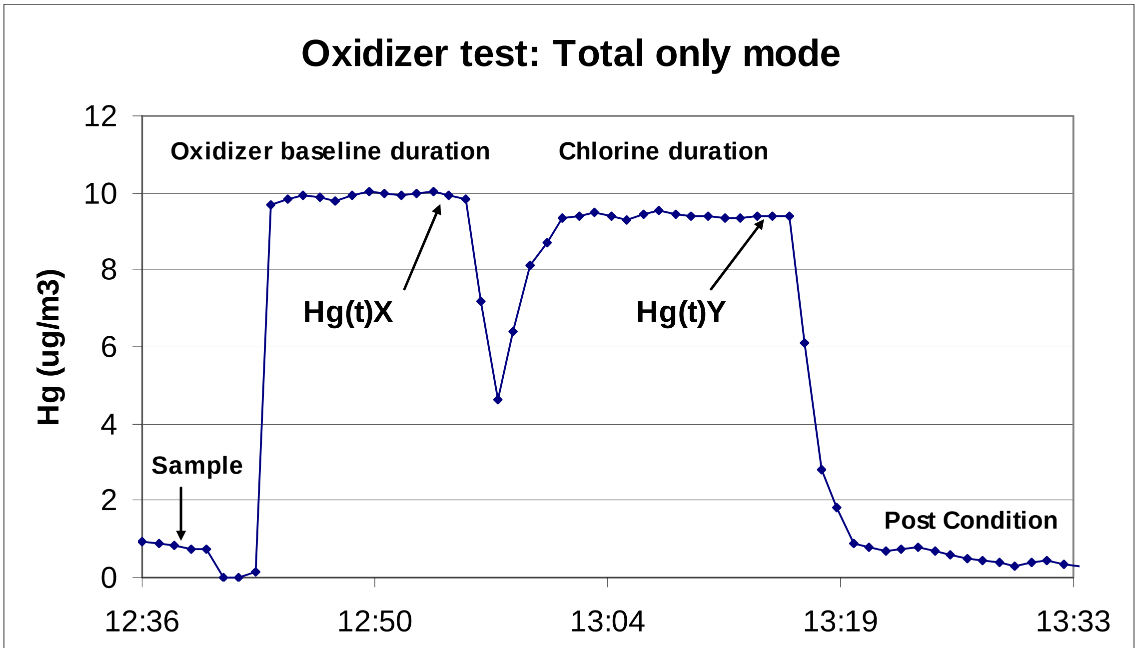


Figure 1

Equations

Dilution Factor equation

The dilution factor will account for the addition of Cl2 gas flow.

$$\boxed{DF = \frac{81\text{i}\ _{\text{flow}} + \text{Cl}_2\,_{\text{flow}}}{81\text{i}\ _{\text{flow}}}}$$

Figure 2a

Where:
DF = Chlorine Dilution Factor
81i flow = 81i Calibrator Output flow
$Cl_{2\ flow}$ = Chlorine gas mixture flow

Adjusted Oxidizer Baseline (Reference value) for chlorine dilution

This equation will adjust (lower) the oxidizer baseline (elemental mercury readings through the oxidizer via the Hg(t) channel) to account for chlorine dilution. The Dilution Factor will be applied to the Oxidizer baseline value, labeled Hg(t)X in Figure 1.

$$\boxed{AOB = \frac{\mathrm{Hg(t)X}}{\mathrm{DF}}}$$

Figure 2b

Where:
AOB = Adjusted Oxidizer Baseline due to the chlorine dilution factor.
Hg(t)X = Hg(t) Concentration at the end of the oxidizer baseline. See Hg(t)X in Fig. 1.
DF = Chlorine Dilution Factor

Total Efficiency Equation

The Total Efficiency equation will show how efficiently the probe transports oxidized mercury and converts oxidized mercury to elemental mercury.

$$\boxed{TE = \frac{\mathrm{Hg(t)Y}}{\mathrm{AOB}} * 100}$$

Figure 2c

Where:
TE = Total Efficiency (System Integrity)
Hg(t)Y = Hg(t) Concentration at the end of the chlorine duration. See Hg(t)Y in Fig. 1.
AOB = Adjusted Oxidizer Baseline due to the chlorine dilution factor.