U.S. Consumer Product Safety Commission
LOG OF MEETING

SUBJECT: Staff teleconference meeting with Honeywell Analytics

DATE OF MEETING: May 23, 2017

LOG ENTRY SOURCE: Janet Buyer, Engineering Sciences

DATE OF LOG ENTRY: May 31, 2017

LOCATION: teleconference

CPSC ATTENDEE(S):

Name	Affiliation
Susan Bathalon	CPSC
Matt Brookman	CPSC
Janet Buyer	CPSC
Stephen Hanway	CPSC
Matthew Hnatov	CPSC
Sandy Inkster	CPSC
Charu Krishnan	CPSC
Mark Kumagai	CPSC
Charles Smith	CPSC
Tim Smith	CPSC

NON-CPSC ATTENDEE(S):

Name	Affiliation
Peter Hsi	Honeywell Analytics
Steve Scorfield	Honewell/City Technology

SUMMARY OF MEETING:

- Staff's purpose in requesting the meeting was to obtain some additional information on the suitability of using current carbon monoxide (CO) sensors for generator-mounted CO detection and shutoff systems as a way to mitigate the CO poisoning hazard associated with portable generators.
- Staff asked the following questions and were provided the following responses:
  - What types of sensor technology do you think would be considered for use with generators? Electrochemical sensors are best (very sensitive with low power requirement). Metal oxide sensors (MOS) used historically, but less common now (less selective/cross react with other chemicals; high power requirement limits use in battery-powered units)

- Do you think that CO sensors used in CO alarms that comply with current requirements of UL 2034 (including specific requirements for RV vehicles and unconditioned spaces or on Recreational boats) are appropriate for use in generator shut-off applications? Yes, these would be a good starting point
  - If so, what, if any, additional requirements do you think would be needed for these sensors to address the unique environment presented by a sensor on board a carbureted engine powered generator? Additional attention needed for expected conditions regarding: exhaust compostion (particulates, and other gasoline chemical constituents); considerable vibration; EM compatibility; temperatures, humidity (particularly with regard to prolonged cold storage in unconditioned areas when used infrequently)
  - Expect wider temperature range compared to residential CO alarms and wider humidity range; below 10 percent RH (low RH is very problematic)
  - SC considers it would be appropriate/possible to make a derivative of an industrial grade CO sensor (City Tech makes industrial grade EC CO sensors these) to perform in the expected generator environment(s). He considers Current, Low cost, residential sensors may experience issues when operated outdoors
- What can be expected in the way of sensitivity loss, response time, or other key characteristics of a CO sensor for this application over the sensor's operating life when exposed to real life and extreme operating conditions of portable generator? Response time is consistent with UL 2034 accuracy requirements, and can meet expected requirements for a period of 10 years without calibration – doesn't expect much change Please consider how a sensor would be able to self-calibrate on a generator that could be stored unused (unpowered) for months to years in unconditioned spaces such as sheds and garages in different climate extremes throughout the US. Reductions in EC sensitivity over lifetime can be addressed by algorithms and use of high surface area platinum . *(SI note per MB's notes: I believe he said platinum re-catalyst rather than plenum).*
- Are you aware of any sensor data that indicates a useful life of over 10 years without calibration? Residential sensors do not need to be calibrated. Does not see any difference in the device working. Residential sensor will maintain necessary accuracy for a period of 10 years. Yes – City Tech has some data showing their CO sensors last this long with small changes in sensitivity
- If so, might they possibly last 15 years? Yes, sensors can probably have a useful life of 15 years without calibration. They haven't collected data out to 15 years, but know that they can have a useful life of 10 years
- What types of filtering, drift compensation, self-testing, interference resistance, etc. can be employed to address the more challenging environmental conditions expected around a generator over the life of a generator (>10 years)? .
- Steve noted that unlike CO sensors in residential CO alarms that do not need to be recalibrated, industrial grade CO sensors do use algorithms to compensate for

expected reductions in CO sensor sensitivity (~1% reduction per year due) caused by changes in catalyst structure over time.

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- To manage normal climates expected in people's living conditions, most EC sensors use sulfuric acid, because it is a highly hydroscopic solution that changes its size/volume based on relative humidity conditions (which are also linked to temperature). EC sensors must be able to manage water uptake and changes in size so must have a large sulfuric acid reservoir to manage this. (SI note – not sure what Matt B's notes meant re "to maximize where the sulfuric acid resides in the sensor". – that info was not captured in my notes)
- Sensitivity is temperature sensitive; can use temperature coefficient (from published tables) to compensate for temperature effects
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- Temperatures within the generator frame can exceed 200 F (~95 C) This would challenge most thermoplastics used to house EC sensors. Very important to use an appropriate generator location to prevent sensor exposure to high temperatures (over $50^{o}C$).
- Humidity ranges expected may be similar to the extremes identified in UL 2034 (no major issues expected if % RH is within UL 2034 ranges, - see above re sulfuric acid reservoir)
- A broader range of contaminants and concentrations of contaminants would be expected in locations where a generator is stored or operated, e.g,
- Inteferant cross-reacting chemicals –
- More aggressive solvents, aromatics, VOCs, etc., would be reversibly absorbed in the activated charcoal filter. This uptake would be so slow that it would most likely not affect the sensor. Other smaller volatile chemicals such as alcohol may permeate the filter faster and affect the sensor
- If the sensor is just stored in an environment with these contaminants, it may not be an issue. Higher exposure levels in generator exhaust might be an issue.
- As far as they know there are no poisons for the EC sensor. A filter is in place to assist with prevention
- Physical filter blocking carbonaceous particulate matter in carb engine exhaust Sensors could get clogged if exposed to high concentrations of large particulates; would be good to have better filters –possibly replaceable filters,
- Hydrogen generated in garages where an electric car or lead battery is charged or for a generator that has a battery (and maybe on a trickle charger)
- Sensors are reactive to hydrogen so there would likely be some cross-reactivity (false alarm) if the concentration of H_2 was high due to a charging battery off-gassing. Typically EC CO sensors listed to UL 2034 are not compensated for H_2 cross-reactivity. There are available industrial grade sensors that are designed to work in a high H_2 environment; they use an H_2 sensor to offset the signal generated by the cross-reactivity within the CO EC sensor.

- It would be unlikely for H_2 concentrations to accumulate sufficiently to cause an issue because it is very light, escapes quickly, and rises away from the height/position where an on-board generator CO sensor would be; high H_2 levels would be more likely to trigger activation of a ceiling-located residential CO alarm.
- Vibration and shock is expected to be more significant than what a typical residential CO alarm would experience Yes, expected vibration is greater… may generate noise, but the magnitude of CO exposue would most likely make this insignificant. Signal smoothing and other methods can limit the vibration effects.
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- Do you know of any effective tamper resistance methods that could be used to prevent deactivation of a CO sensor based safety shutoff system on-board a generator? No experience with this so can't comment.
- What degree of sensor accuracy and reliability would you expect is appropriate for sensors used to react to a proposed CO exposure limit of 400 ppm? Considers ±20% accuracy over the lifetime of the sensor would be sufficient.
- Would you advise using the same sensor for target reaction to 200 ppm, 600ppm or > 1000 ppm, when considering how quickly CO levels can rise (833 ppm/minute per NIST test as quoted in one of the comment responses to the NPR)
- Algorithm would be used to interpret the results. Sees no reason to consider another sensor other than one reacting to same CO range covered by UL 2034 (noted UL 2034 alarm activation range is based on a CO time-weighted average related to 10% COHb)
- Response time – 30 seconds dependent on algorithm *?*
- EC sensor responds very quickly (10-30 seconds)
- Reduce averaging time of algorithm to reduce overall system response time
- Can look at CO rate-of-rise criteria and program this to specifically reflect rapid rise resulting from carbureted generator exhaust
- Can program a ppm CO limit for immediate shut off when reached.
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- **Sensor Availability**
- Are you aware of any sensor manufacturers who have developed/are marketing CO (O_2 or other?) sensors **specifically designed** for use with portable generators powered by
- 1) carbureted engines
- 2) EFI-type engines with reduced CO (NOx and HC) emissions?
- Not aware of manufacturers who have designed sensors specifically for portable generator applications. Estimates it would take 6 months to 1 year to develop CO sensors targeting on-board generator shut-off application
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- Can you provide any indication of estimated unit costs by sensor technology type for products that would be suitable for use in on-board portable generators shut-off systems (not remote sensor shut offs)
- Sensor cost would need to be included with whole shut-off module (however shut-off might be accomplished). Needs to be designed into the generator system , so cost is integrated within the cost of the generator. Looking at cost of residential sensors will give a good starting point for determining cost for generator applications. It would not be a big cost – says in UK, a residential CO alarm (UL-2034) costs about ₤5-6 ($10).
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- Both Peter His and Steven Scorfield noted that City Tech/Honeywell make residential and industrial grade CO sensors. Currently, they were not actively involved in development of CO sensors specifically for use in generator shut-off applications, but would be very interested in a joint venture targeting this application.
- **OTHER**
- Per staff's additional questions, both men reported that although they manufactured CO sensors/alarms for use in typical residential settings, they were not familiar with (and did not produce products specifically meeting) more stringent, selective CO sensor requirements noted in the most recent version of UL 2034 (published March 26, 2015) that are applicable to:
- ***CO Alarms for use in RVs and Unconditioned Areas*** (includes "garages, attics, and the like") ***Sections 70-74***; These target CO sensor performance following exposure to more extreme environments found in less typical residential settings (per temperature, % RH tests[1]; corrosion (salt spray) test; vibration test; and contamination test (cooking by-product) test[2]
- ***CO Alarms for Use on Recreational Boats, Section 75*** (*not Section 76 as SEI previously reported*)
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- Some of these revisions to this version of UL 2034 are noted to have become effective 02/20/2015; some other revisions to the standard are marked as "*revised, effective date to be determined*".
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[1] Section 71: must meet normal sensitivity tests (per table 39.1) after exposure to: (1) up to 66±2°C for 30 days; (2) ≥72 hours at -40±2°C; (3) 93±2% RH at 61±2°C.

[2] Section 74: must meet normal sensitivity tests (per table 39.1) after 5 exposures to vaporized mix of 50g lard, 50g vegetable fat, and 100g beef gravy