Letter Report to U.S. Consumer Product Safety Commission

CONTAM Simulations of Extended Generator Run Time Supplementing NIST Technical Note 2202

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Abstract

The purpose of this report is to document additional simulations that staff of the U.S. National Institute of Standards and Technology (NIST) performed, at the request of staff of the U.S. Consumer Product Safety Commission (CPSC), to supplement the simulations that NIST performed and reported in NIST Technical Note (TN) 2202 *Simulation of Residential CO Exposures from Portable Generators with and without CO Hazard Mitigation Systems Meeting Requirements of Voluntary Standards*. These additional simulations used a 15 % longer run time (referred to as "extended run time") for UL 2201 generators than the run times provided in Table 3 of TN 2202 in twelve of the structures documented in TN 2202.

Background

NIST Technical Note (TN) 2202 *Simulation of Residential CO Exposures from Portable Generators with and without CO Hazard Mitigation Systems Meeting Requirements of Voluntary Standards* (Emmerich et al. 2022) describes a simulation study conducted to evaluate indoor CO exposure to support CPSC staff evaluation of portable generator CO hazard mitigation requirements in two voluntary industry standards. These two ANSI-approved standards are *ANSI/PGMA G300-2018, Safety and Performance of Portable Generators* and *UL 2201, Standard for Carbon Monoxide (CO) Emission Rate of Portable Generators, Second Edition*. Both voluntary standards have requirements for a system that will shut the generator off when specific CO concentrations are present near the generator in addition to other requirements.

These simulations employed the multizone airflow and contaminant transport model CONTAM (Dols and Polidoro 2015), which was applied to 40 residential buildings including 37 versions of dwellings drawn from an existing collection (Persily et al. 2006) that are representative of the U.S. housing stock plus 3 detached garage buildings. Approximately 140,000 individual 24-hour simulations were conducted that covered a range of house layouts and sizes, airtightness levels, weather conditions, generator locations, generator sizes and generator operation scenarios. The simulated generator locations include interior rooms, attached garages, crawlspaces and basements, in the houses that have such spaces. These concentrations were then used to calculate carboxyhemoglobin (COHb) levels for the house's simulated occupants, which are identified as either an *operator*, who directly interacts with the generator, or a *collateral person*, who is another occupant in the house who does not directly interact with the generator.

Simulation Method
Apart from generator run times, these additional simulations used the same simulation method along with all of the same building models, generator characteristics, weather conditions, and operation scenarios as described in TN 2202. Table 1 provides the extended run times for each generator size used in these additional simulations.

Table 1. Generator Run times Used in Simulations

Generator Size Category	Extended Run Time for UL2201 generators (h)
Handheld (HH)	9.2
Class 1 (C1)	10.35
Class 2 single cylinder (C2S)	11.5
Class 2 twin cylinder (C2T)	10.35

The UL 2201 generators with extended run times were simulated operating in and outside of 12 of the structures listed in TN2202 including: MH1mod, DH45mod, DH21, DH61mod, DH8, DH3, DH34, DH64, DH7, DH63mod1, and garages GAR2 and GAR3.

Sample Results
Sample results of three of the structures with the generator running the extended run time are presented in the following figures. The graphs in the figures also include the results from the same scenario where the generator ran the number of hours under the simulations in TN 2202.

DH45mod (mid-sized detached house with basement and integral garage)

Figure 1: CO exposure profiles of operators in 4 rooms in DH45(mod) with UL 2201 C2S generator and same generator with 15 % longer run time, initially started in kitchen and restarted in kitchen, then restarted a second time outside the kitchen, per B2 scenario on January 1. Note that all of the scenarios are described in detail in TN 2202.

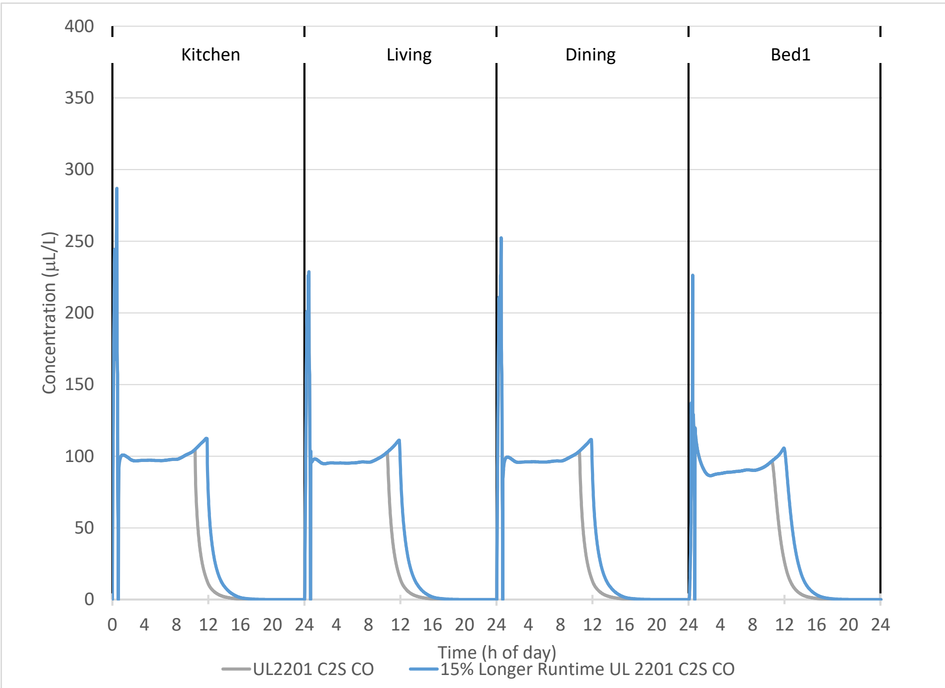
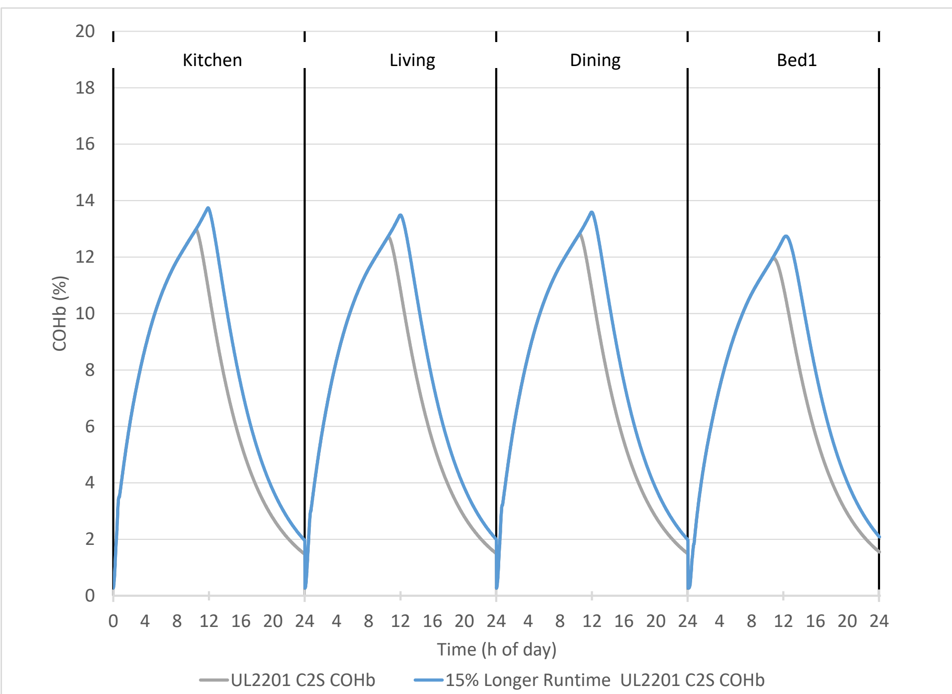


Figure 2: COHb profiles of Operators in 4 rooms in DH45(mod) with UL 2201 C2S generator and same generator with 15 % longer run time, initially started in kitchen and restarted in kitchen, then restarted a second time outside the kitchen, per B2 scenario on January 1.



MH1mod (small manufactured house with crawlspace)

Figure 3: CO exposure profiles of operators in 3 Rooms in MH1(mod) with UL 2201 C1 generator and same generator with 15 % longer run time, initially started and restarted in bedroom 1 with the generator exhaust jet oriented out of the door to the house interior, then restarted a second time outside with CO entering the kitchen, per scenario K2, on July 25.

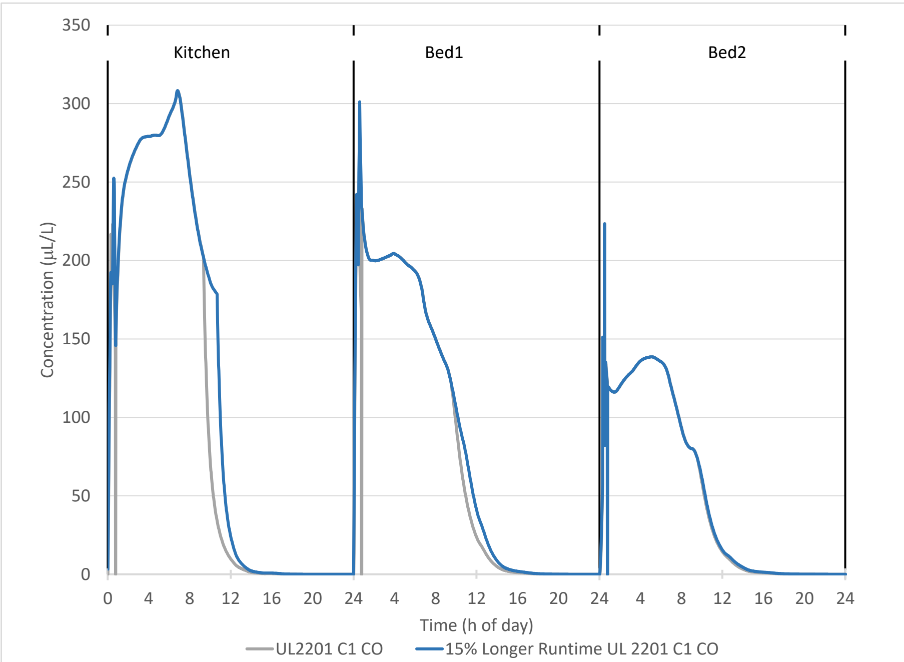
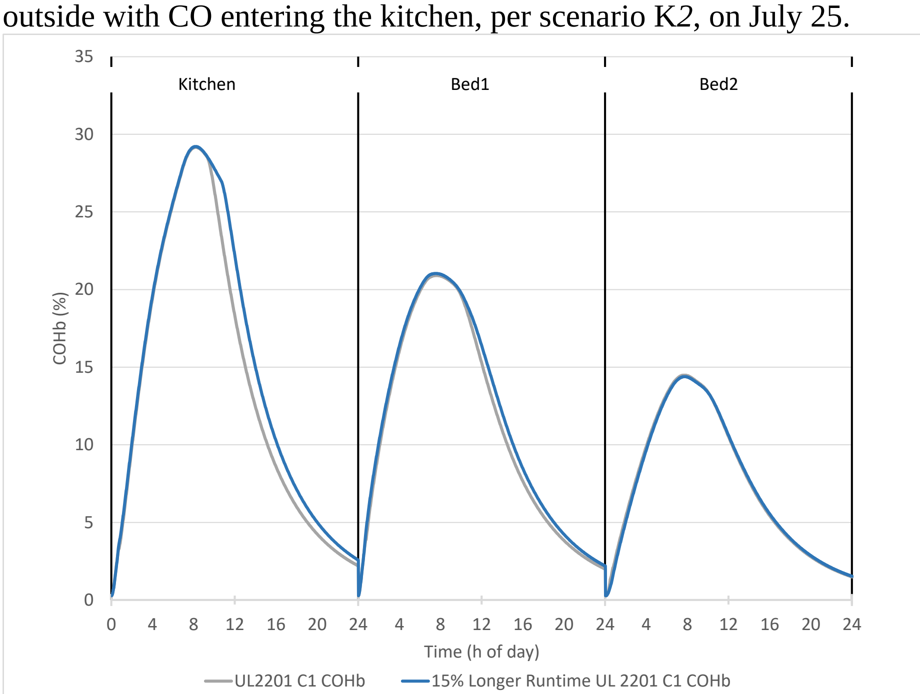


Figure 4: COHb profiles of operators in 3 Rooms in MH1(mod) with UL 2201 C1 generator and same generator with 15 % longer run time, initially started and restarted in bedroom 1 with the generator exhaust jet oriented out of the door to the house interior, then restarted a second time outside with CO entering the kitchen, per scenario K*2*, on July 25.



GAR3 (large garage with workshop)

Figure 5: CO exposure profiles of operators in GAR3 with UL 2201 C2S generator and same generator with 15 % longer run time, initially started in workshop room then restarted in open garage, per scenario C8, on April 4.

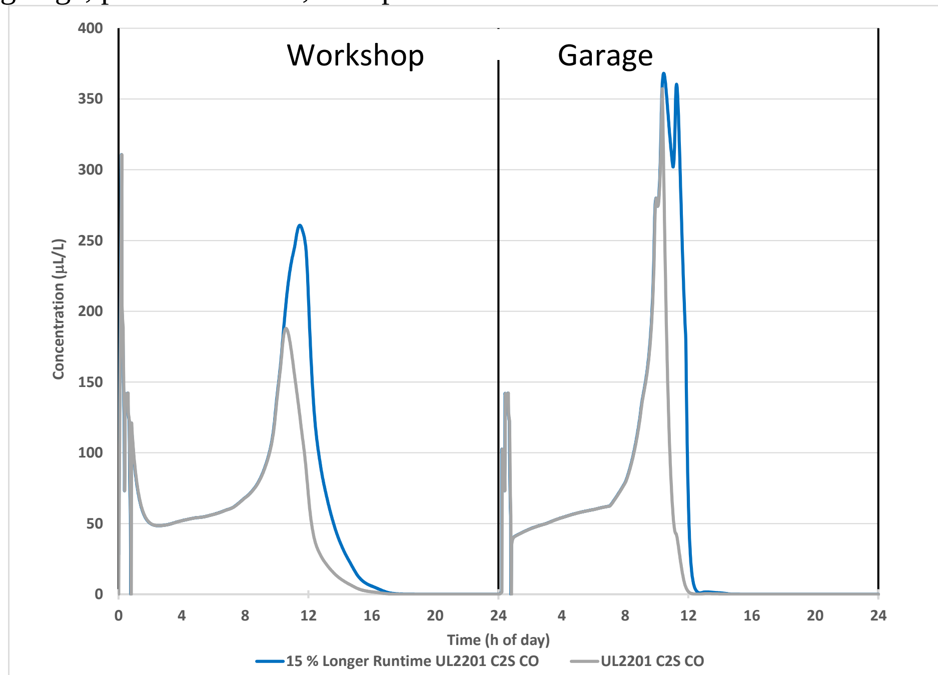
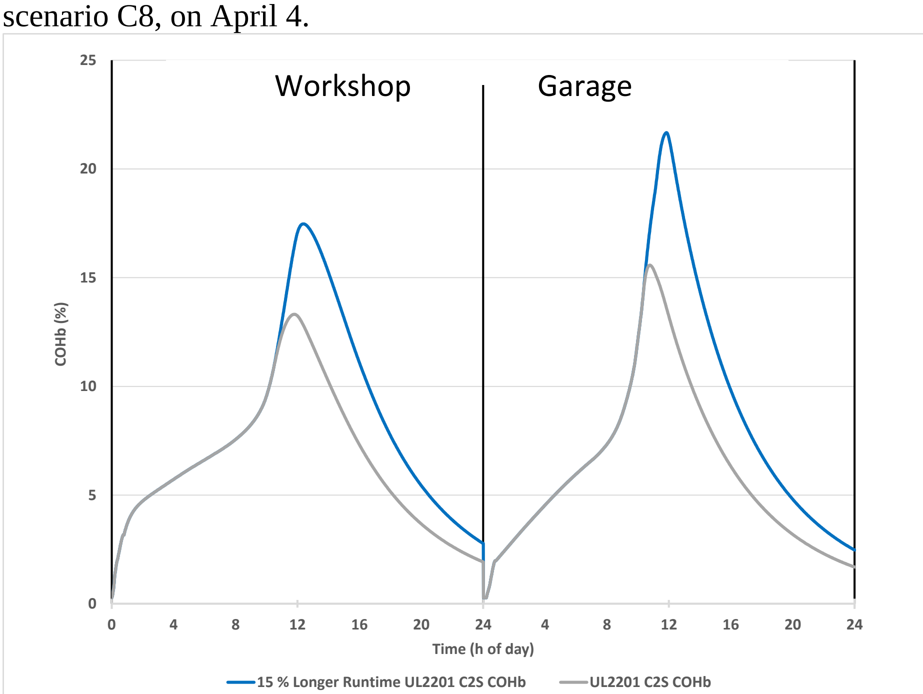


Figure 6: COHb profiles of operators in GAR3 with UL 2201 C2S generator and same generator with 15 % longer run time, initially started in workshop room then restarted in open garage, per scenario C8, on April 4.



Summary

In these sample scenarios, and referring to the criteria that CPSC staff provided in NIST TN 2202 as to what COHb level aligns with different levels of injuries, no one who was hospitalized from the original run time became a fatality with the extended run time. Furthermore, no one who had a CO exposure from the original run time that prompted them to seek medical evaluation but was not hospitalized progressed into an injury requiring hospitalization with the extended run time. Only the operator in the workshop of GAR3 would likely seek medical evaluation but would not be hospitalized with the extended run time compared to not being symptomatic with the original run time. These limited sample cases should not be interpreted as representing the overall results of this additional simulation effort nor as predicting the outcome of any specific real-world incident. These simulation results will be used by CPSC staff to estimate the impact of an additional 15 % run time on all UL 2201 generators in all 40 structures that were modeled in NIST TN 2202.

Acknowledgements

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References

Dols, W.S. and B.J. Polidoro. 2015. CONTAM 3.2 User Guide and Program Documentation. NIST Technical Note 1887. National Institute of Standards and Technology.

Emmerich, SJ, et al., July 2022.NIST Technical Note 2202. Simulation of Residential CO Exposures from Portable Generators with and without CO Hazard Mitigation Systems Meeting Requirements of Voluntary Standards.(Available online at: http://dx.doi.org/10.6028/NIST.TN.2202).

Persily, A.K., A. Musser, and D. Leber. 2006. A Collection of Homes to Represent the U.S. Housing Stock. NISTIR 7330. National Institute of Standards and Technology.

PGMA. 2018. ANSI/PGMA G300-2018, Safety and Performance of Portable Generators, available online at https://www.pgmaonline.com/pdf/ANSI_PGMAG300-2018(ErrataUpdateApril2020).pdf

UL. 2018. UL 2201 Second Edition, Standard for Carbon Monoxide (CO) Emission Rate of Portable Generators.