U.S. Consumer Product Safety Commission
LOG OF MEETING

SUBJECT: Tech-to-Tech meeting on evaluating the effectiveness of CO safety shutoff devices on portable generators

DATE OF MEETING: October 4, 2018

LOG ENTRY SOURCE: Janet Buyer, Engineering Sciences

DATE OF LOG ENTRY: October 10, 2018

LOCATION: CPSC, National Product Testing and Evaluation Center (NPTEC), 5 Research Place, Rockville, MD 20850

CPSC Attendees: Janet Buyer, Matthew Brookman, Joel Recht, Mark Kumagai, Barbara Little, Andrew Trotta, Andrew Lock, Chuck Smith, Tim Smith, Patty Edwards, Caroleene Paul, Rik Khanna, Sandy Inkster, Troy Whitfield, George Borlase, Gib Mullan

NON-CPSC ATTENDEE(S):

Name	Affiliation
Perry DeYoung	Fireboy-Zintex
Michael Gardner	Techtronic Industries
Joe Harding	PGMA
Don Huber	Consumer Reports
Tom Kim	American Honda
Ed Krenik	Bracewell Law
John Lee	Bracewell Law
Greg Marchand	Briggs & Stratton
Brandon Nye	Briggs & Stratton
Sarah Owen	UL
Mark Rowe	Techtronic Industries
Antonio Santos	MECA
Brandon Schmidt	Generac
Saeid Shokrzadeh	Firman Power Equipment
Mark Swanson	Walbro
William Wallace	Consumer Union
Greg Wischstadt	Generac
Christine Wyman	Bracewell Law

SUMMARY OF MEETING:

The U.S. Consumer Product Safety Commission (CPSC) staff hosted a technical meeting to present an overview of how CPSC staff is evaluating the effectiveness of CO safety shutoff devices on portable generators. Two voluntary standards for portable generators (ANSI/PGMA

G300-2018 and ANSI/UL 2201-2018) have recently been revised to contain requirements for a generator-mounted shutoff system that will shut the generator off when carbon monoxide (CO) accumulates to certain concentrations around the generator. Staff presented the attached, answering questions and listening to concerns throughout the presentation.

U.S. Consumer Product Safety Commission

Testing and Modeling of Portable Generator Automatic Shutoff Systems

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October 4, 2018

What We Will Cover

- Background
- Testing and Simulation
- Empirical Testing
  - Measurements
  - House layout
  - Observations to Date
- Modeling Approach
  - CONTAM
  - CONTAM + CFD0
  - CFD Example
- Death and Injury Analysis
- What's Next

Collaboration

- Staff is committed to collaborating on portable generator voluntary standards
- Welcome comments on publications
- Share test data

Background

- Commission issued NPR on 11/2/16, based on reduced CO emission rates
- NPR's benefits analysis was based on CONTAM modeling, using parameters selected for conservative estimate of effectiveness
- Subsequently, PGMA and UL developed requirements to address CO poisoning hazard in their voluntary standards

Background

- CPSC has an IAA with NIST to study the effectiveness of CO safety shutoff devices on portable generators. Challenges that complicate estimating shutoff effectiveness include:
  - Exhaust velocities and temperature that move CO within and between zones
  - Scenarios with higher ventilation rates than used in NPR
    - Used low-ventilation conditions with reduced CO emission approach because those led to more conservative effectiveness estimate
  - Non-uniform concentrations near the location of the generator
    - Is critical factor for analyzing the shutoff approach; therefore NIST work is extending CONTAM modeling from NPR to use various methods to account for non-uniformity

Testing and Simulation

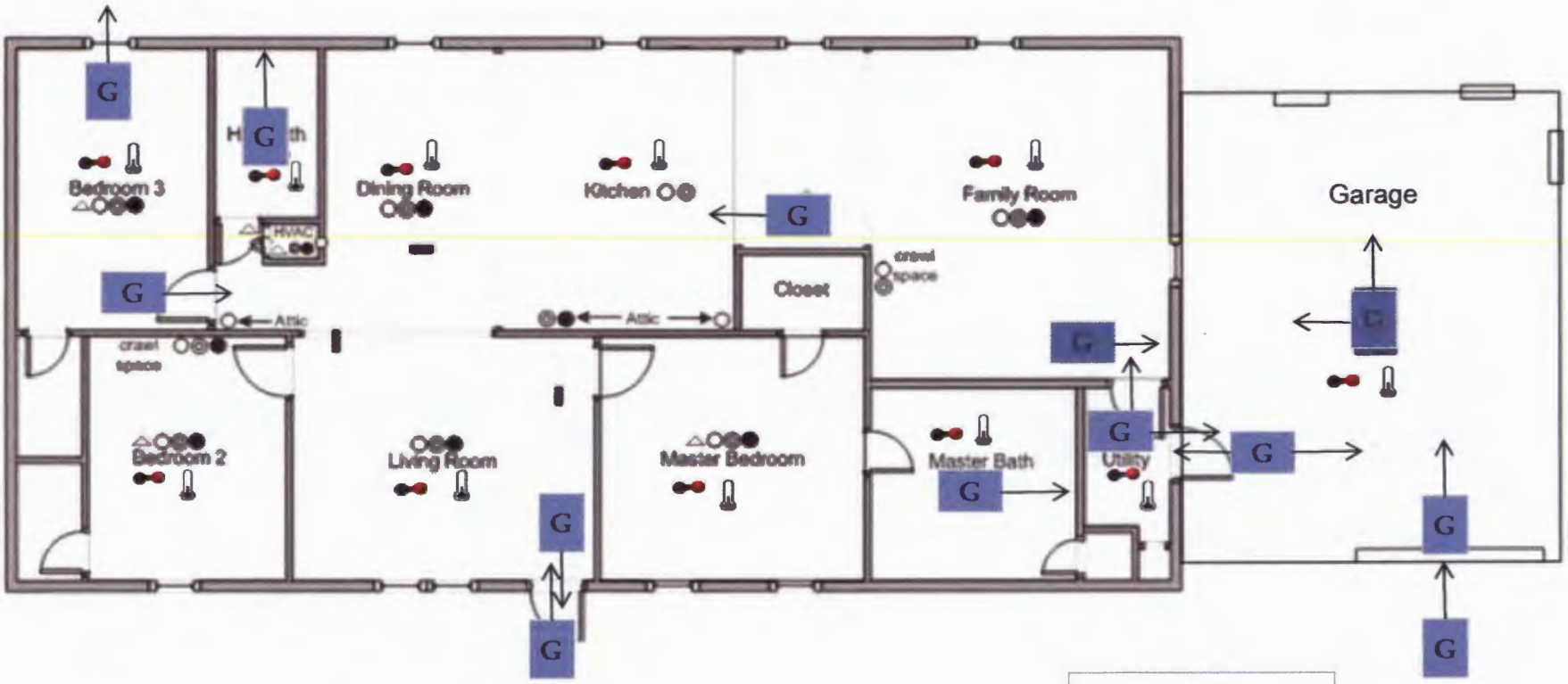
- Empirical Testing at NIST IAQ Test House
  - ~80 test scenarios
  - 5 generators
  - 9 different load conditions

- Computer Modeling: CONTAM and CFD0
  - CONTAM – Multizone IAQ and ventilation analysis program
  - CFD0 – Reynolds-Averaged Navier-Stokes (RANS) based computational fluid dynamics model.

Empirical Testing

- Sample Generators: 2-15 kW
- CO Emission Rates: ~10 – 3000 g/hr
- Measurements :
  - CO concentration
    - Measured throughout the test house
    - One dedicated measurement point located on the generator to activate shutoff
  - Temperature
  - Weather
  - Air exchange rate
    - Tracer gas decay method

NIST Test House Setup



CO Sensor
Thermocouple
G Generator
Exhaust Direction

Source Room Layout

Observations to Date

- Test observations seem to indicate that non-uniformity of CO concentrations plays substantial role in shutoff time of generator.
- Addressing lack of CO concentration uniformity near generator is critical to estimating shutoff effectiveness.
  - Time to shutoff determines mass of CO emitted.
  - Mass of CO emitted is a primary determinant of personal exposure profiles.

Modeling

- CONTAM – Multizone model that assumes uniform gas concentrations within each room
  - Assumption is appropriate for NPR
    - Total CO emissions not dependent on CO measurement location
    - Long time scale until generator runs out of gas (8-10 hr)
  - May not be appropriate for shutoff analysis
    - CO concentration is not same throughout room where generator is running
    - Requires accurate simulation of CO concentration at shutoff sensor location
    - Time to shutoff depends on CO sensor location
    - Shorter time scale (minutes or more)

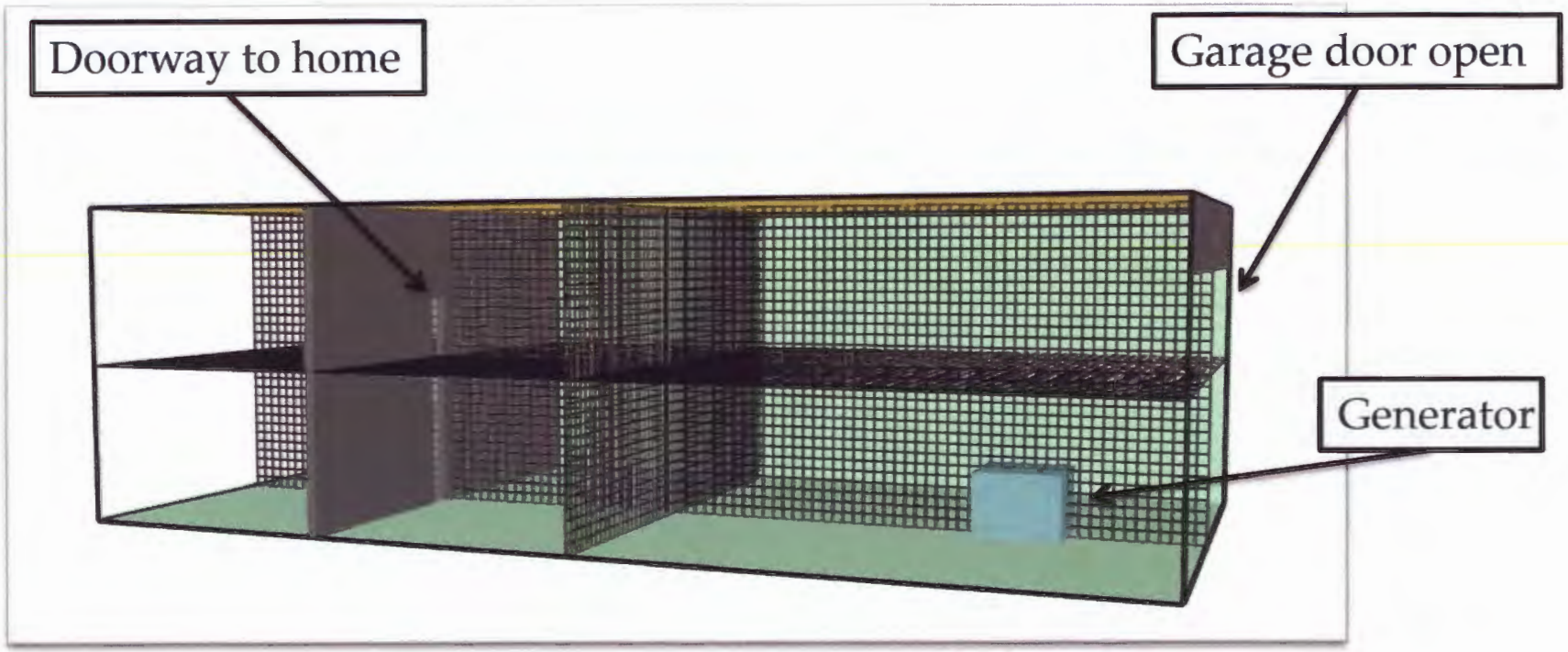
Modeling

- Model Validation:
  - Reproduce select cases performed in triplicate during empirical testing
  - Evaluate strategies to account for non-uniformity of gas concentrations such as CONTAM input modification and CFD0
- Repeat empirical tests without a shutoff device to support benefits analysis

Modeling

- Perform simulations using modified housing models used for NIST TN 1925 report
  - Modifying ventilation
    - Limited ventilation was a conservative assumption for evaluating the reduced emissions approach in the NPR, but is favorable for a shutoff solution.
    - Evaluating effects of higher ventilation rates on shutoff systems.

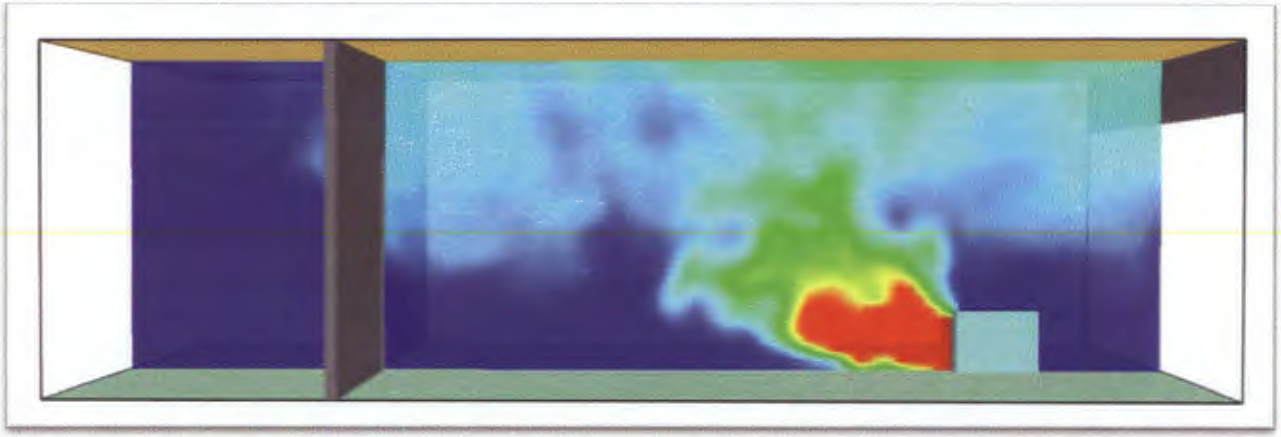
Coupling Computational Fluid Dynamics (CFD) Model to CONTAM



- To accurately determine CO concentrations near generator, CFD model may be used to model source room
  - CO concentrations near onboard sensor can be determined
  - Enhances accuracy of determining shutoff time of a generator while CO concentrations in room are not uniform

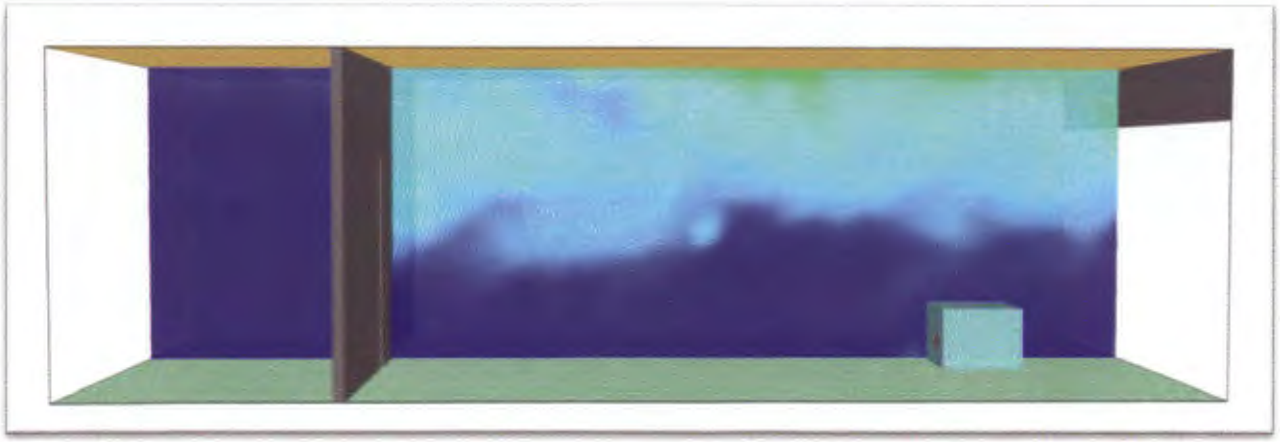
CFD Example

Exhaust volume fraction slice file near exhaust.



CFD simulation models flow of gases. Example shown predominantly driven by exhaust temperature and velocity.

Exhaust volume fraction slice file 1 meter offset from exhaust plane.



Example of stabilized concentrations while generator is running: stratified with higher concentrations near ceiling.

Death and Injury Analysis

- Will model effectiveness in terms of death and severity of injuries
  - Fatality criteria same as used in NPR
  - Criteria for 3 levels of injury
    - minimal or no perceptible symptoms in healthy adults – unlikely to seek medical treatment
    - likely to perceive adverse symptoms and seek medical evaluation, but likely to be released without need for hospitalization or transfer to an HBO-treatment facility or other specialized treatment center
    - likely to perceive adverse symptoms and to seek medical evaluation (in ER or other medical setting); and likely to be hospitalized or transferred to an HBO-treatment facility or other specialized treatment center

What's Next

- Future meeting will be held after NIST publishes interim report on testing and modeling completed to date

- Point of Contact:

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