Data for Partial Volume Deflagration Experiments with Synthesized Lithium-Ion Battery Thermal Runaway Effluent Gas.

This dataset is associated with the FSRI study of the explosion hazards of lithium-ion battery gas in a residential garage structure. Additional information can be found at FSRI.org.

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Introduction

This dataset contains pressure (raw and processed), methane gas concentration (ATO), gas explosibility properties, and sensor information for 19 tests, an overview of which is provided in the table in the test summary section below. This complete experimental matrix is also provided in a downloadable information file.

Flammable Gas These tests were conducted using a synthesized battery gas. The concentrations of gas species comprising the simulated battery gas are provided below as well as in `General_info.xlsx`. These gas concentrations, as well as the explosibility properties, were determined experimentally.

Table 1: Composition of Simulated Battery Effluent Gas Mixture

	% Volume of Gas			
Simulated Chemistry	CO	CO2	H2	CH4
NCA	36.21	22.16	32.89	8.74
LFP	9.00	20.00	50.00	21.00

Bags/ Release Tests are denoted either 'bag' or 'dispersion'. Bag experiments denote mixtures of flammable gas and air at maximum burning velocity concentration inside of a 0.06 mm thick polyethylene bags. The composition inside of the bag was mixed with an explosion proof blower and recirculation loop until the desired fuel concentration was measured in the bag via non-dispersive infrared (Teledyne Gasurveyor 700) sensor, the blower was then turned off and turbulence allowed to settle for 60 seconds. Volumes of the bags and volumes of the flammable gas used in the mixture are both presented in Table 2. Release experiments denote cases where the flammable gas was released through a 2.5 cm (1 in) orifice at a rate of 527 L/min behind a simulated Residential Energy Storage System (RESS) enclosure at 100% concentration and allowed to disperse naturally in the garage enclosure. Bag tests were ignited using an MJG Technologies Firewire as a single point pyrotechnic initiator. Dispersion tests were ignited using a shower of sparks from a Le Maitre Gerb electrically initiated chemical pyrotechnic.

Structure The garage enclosure consisted of a 6.1 m wide by 6.1 m long by 3.1 m tall interior garage space, supported by a secondary space and additional exterior walls to simulate stiffness granted by additional structure of a normal residence. Walls were constructed of 5.1 cm (2 in) by 12.7 cm (4 in) SPF #2 wooden studs spaced 61 cm (24 in) from center to center, with vinyl siding over 1.3 cm (0.5 in) thick fiberboard, and 1.6 cm (0.625 in) thick Type X gypsum wallboard on the interior with no painted surfaces. The garage door used was a 4.9 m (16 ft) wide by 2.1 m (7 ft) tall steel overhead door. A 76 cm (30 in) wide by 203 cm (80 in)

tall steel-over-polystyrene core 20-minute fire-rated interior door was installed in the center of the opposite wall to the garage door.

Pressure Sensors Pressure data was obtained via flush mount PCB Piezotronics high-frequency ICP® 113B28 piezoelectric pressure transducers connected to a 481A PCB signal conditioner using 003C10 low-noise coaxial cable. These sensors have a measurement range of 344.7 kPa, sensitivity ± 14.5 mV/kPa, rise time ≤ 1.0 µs and a resolution of 0.007 kPa. PCB Model 137B23B pencil probes were also used, these sensors have measurement range of 345 kPa, sensitivity ± 14.5 mV/kPa, rise time ≤ 6.5 µs and a resolution of 0.069 kPa. Thirteen of these pressure sensors were placed in and around the garage enclosure. Locations of sensors in both the bag and dispersion experiments are included in the `sensors.pdf` file. Pressure data was originally recorded at 20 kHz with a Yokogawa DL950 data acquisition recorder. Data recording was triggered simultaneously with the ignition equipment. Data were acquired 1 second before and 9 seconds after the ignition trigger. Original raw datafiles are included where sensor information is presented as voltage only, processed data files are also provided where data has been reduced to 5 kHz and voltages have been converted to pressure (or distance for string potentiometers, see below), these files have also been trimmed to focus on the time-region of interest (-1 to +0.5 seconds relative to ignition).

Gas Concentration Data Gas concentration data was obtained for release experiments using four portable methane gas detectors (ATO model GD200-CH4). Methane concentration was measured at three locations along the ceiling and one central location inside of the garage enclosure (locations in `sensors.pdf`). These devices use a built-in diaphragm pump and non-dispersive infrared gas sensor calibrated for methane to measure and record methane concentration at 0.2 kHz. During the analysis of these data, it was assumed that the relative concentrations of gas species in the flammable gas mixture stayed constant as the mixture dispersed and entrained air. It was also assumed that the methane measurement was a suitable proxy to infer the volume fraction of the overall flammable gas mixture. Data files provided for gas concentration are already converted from methane to total flammable gas concentration.

Other Instrumentation UniMeasure Model PA-25 string potentiometers were also used on the A-side (garage door) and B-side walls, these sensors had a range of 63.5 cm, linearity of ± 0.15% full scale and repeatability of ± 0.015% full scale. String potentiometer data was recorded simultaneously with pressure data and is available in both the raw and converted data files.

Test Summary

Table 2: Test Summary

Test_ID	File_ID	Type	synTREG	Vflamgas (L)	Vbag (L)	%LFL (room)	Vgas (m^3)	V% tot	phi (room)
Test_1	0103	Bag	NCA	31	83	0.25	0.031	0.027	0.0007
Test_2	0105	Bag	NCA	62	165	0.50	0.062	0.055	0.0014
Test_3	0106	Bag	NCA	124	330	1.00	0.124	0.109	0.0028
Test_4	0107	Bag	NCA	62	165	0.50	0.062	0.055	0.0014
Test_5	0108	Bag	NCA	1238	3302	10.00	1.238	1.091	0.0284
Test_6	0109	Bag	NCA	619	1651	5.00	0.619	0.546	0.0141
Test_7	0110	Bag	NCA	310	826	2.50	0.310	0.273	0.0070

Test_ID	File_ID	Type	synTREG	Vflamgas (L)	Vbag (L)	%LFL (room)	Vgas (m^3)	V% tot	phi (room)
Test_8	0111	Bag	LFP	24	85	0.35	0.024	0.021	0.0007
Test_9	0112	Bag	LFP	45	170	0.67	0.045	0.040	0.0013
Test_10	0113	Bag	LFP	91	320	1.34	0.091	0.080	0.0027
Test_11	0114	Dispersion	NCA	310	N/A	2.50	0.3100	0.273	0.0070
Test_12	0115	Dispersion	NCA	619	N/A	5.00	0.6190	0.545	0.0141
Test_13	0116	Dispersion	NCA	1238	N/A	10.00	1.2380	1.091	0.0284
Test_14	0117	Dispersion	NCA	3095	N/A	25.00	3.0950	2.727	0.0721
Test_15	0118	Dispersion	NCA	3095	N/A	25.00	3.0950	2.727	0.0721
Test_16	0119	Dispersion	NCA	10008	N/A	80.82	10.008	8.818	0.2487
Test_17	0122	Dispersion	NCA	7506	N/A	110.22	7.5060	6.613	0.1821
Test_18	0123	Dispersion	LFP	6809	N/A	100.00	6.8090	5.999	0.2137

Repository Structure

As mentioned, this repository includes zip files containing complete 20 kHz raw voltage files (`/Raw_sensor_voltage/`), decimated converted and time-windowed data files (`/Data_converted_decimated/`), gas concentration data (`/ATO_data/`) and explosibility properties (`/Pmax – SL/`). Also included is a general information folder with an information file `General_info.xlsx` on the test matrix, gas composition, channel names, and sensor conversion factors as well as the sensor location drawing `sensors.pdf`. The folder structure is below with files within named for each test apart from the raw sensor voltage files which are named by **File_ID** in the table above.

- `/ATO_data/`
- `/General/`
- `/Pmax – SL/`
- `/Data_converted_decimated/`
- `/Raw_sensor_voltage/`