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MINETA NATIONAL TRANSIT RESEARCH CONSORTIUM

UTC Project Information	
Project Title	Safety of Lithium Nickel Cobalt Oxide Battery Packs in Transit Bus Applications
University	The Pennsylvania State University Mineta National Transit Research Consortium
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Funding Source(s) and Amounts Provided (by each agency or organization)	Research and Innovative Technology Administration University Transportation Centers Program ($84,416) Larson Institute/Penn State ($84,416)
Total Project Cost	$168,832
Agency ID or Contract Number	DTRT12-G-UTC21
Start and End Dates	December 2013 – October 2016
Brief Description of Research Project	The future of mass transportation is clearly moving toward the increased efficiency and greenhouse gas reduction of hybrid and electric vehicles. With the introduction of high-power/high-energy storage devices such as lithium ion battery systems serving as a key element in the system, valid safety and security concerns emerge. This is especially true when the attractive high-specific-energy and power-chemistry lithium nickel cobalt aluminum oxide (NCA) is used. This chemistry provides great performance but presents a safety and security risk when used in large quantities, such as for a large passenger bus. If triggered, the cell can completely fuel its own fire, and this triggering event occurs more easily than one may think. To assist engineers and technicians in this transfer from the use of primarily fossil fuels to battery energy storage on passenger buses, the Battery Application Technology Testing and Energy Research Laboratory (BATTERY) of the Thomas D. Larson Pennsylvania Transportation Institute (LTI) in the College of Engineering at The Pennsylvania State University partnered with advanced chemistry battery and material manufacturers to study the safety concerns of an NCA battery chemistry for use in transit buses. The research team ran various experiments on cells and modules, studying rarely considered thermal events or venting events. Special considerations were made to gather supporting information to help better understand what happens, and most

	importantly how to best mitigate these events and/or manage them when they occur on a passenger bus. The research team found that the greatest safety concern when using such a high-energy chemistry is ensuring passenger safety when a cell's electrolyte boils and causes the ventilation of high-temperature toxic material. A cell-venting event can be triggered by a variety of scenarios with differing levels of likelihood. Also, though the duration of a venting event is relatively short, on the order of just a few seconds, the temperature of the venting material and cell is extremely high. During a venting event, the high-pressure, burning gases tend to burn holes in nearby packaging materials. Most interestingly, the team discovered that following a venting event the large-format cells tested immediately reached and remained at extremely high external skin temperatures for very long periods, on the order of hours. The majority of this report covers the testing designed to better understand how high-energy cells of this chemistry fail and what materials can be used to manage these failures in a way that increases passenger survivability.
Describe Implementation of Research Outcomes (or why not implemented)	
Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	Penn State ME 597 Advanced Vehicle Hardware-in-the-Loop class lectures and group work on both data acquisition system setup and data analysis. Penn College of Technology ABM355, shared testing results and lectured on battery safety. Assisted a group of students to design a battery system using the same cells tested as part of this research.
Web Links • Reports • Project Website	Single cell overcharge test: https://www.youtube.com/watch?v=nMV7pdT1zmU Final report (MNTRC Website): http://transweb.sjsu.edu/project/1247.html
