APTA Whitepaper on Battery-Electric and Hydrogen Passenger Rail Equipment

Update for FRA Decarbonization Workshop

American Public Transportation Association

MAY 17, 2023

Current Trend

- The demand for alternatively-powered passenger rail technologies is rapidly growing in North America for passenger rail vehicles.
- Alternative power sources for North American rail vehicles are currently focused on Li-ion battery storage applications often coupled with range extension using compressed hydrogen gas.
- Although batteries and gas storage systems are not new to the passenger rail sector, the peculiarities of Li-ion batteries and hydrogen gas are.
- The following presentation provides an overview of APTA's initiative to begin defining passenger rail industry safety requirements for addressing the hazards introduced by the adoption of these new technologies.

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Terms and Definitions

- EMU – Electric Multiple Unit
- DMU – Diesel Multiple Unit
- BEMU – Battery Electric Multiple Unit
  - Typical for those utilizing OCS or third rail charging
- BMU – Battery Electric Multiple Unit
  - Typical for those utilizing end station charging only
- HMU – Hydrogen Electric Multiple Unit
  - Battery-electric with hydrogen range extender
- HBMU – Hybrid Battery Multiple Unit
  - Internal combustion engine with onboard batteries

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Current / Recent Rolling Stock Projects

- There are already a number of new and rebuild passenger rail vehicles projects using various forms of alternative power technologies.
- A number of these projects are in Europe and UK and mix traditional technologies (e.g., diesel engines and catenary) with Li-ion batteries.
- Most car builders are also introducing all battery vehicles, as well as battery vehicles with hydrogen range extension, which are particularly suitable for the North American passenger rail sector.

Rolling Stock Projects – Europe

LNVG (Saxony) & RMV (Frankfurt) iLint (Alstom) – HMU

- Battery propulsion with hydrogen range extension

NAH.SH & DB FLIRT Akku (Stadler) – BEMU

- Battery powered
- Intermittent charging with catenary

Merseytravel 777 Class (Stadler) – BEMU

- Battery powered
- Intermittent charging with third rail

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Rolling Stock Projects – Europe (continued)

H2goesRail & Niederbarnimer Eisenbahn (Germany)
Mireo Plus H (Siemens) – HMU

- Battery propulsion with hydrogen range extension

Irish Rail X'trapolis (Alstom) – BEMU

- Battery powered
- Intermittent charging with catenary

South Wales Metro FLIRT Trimodal (Stadler) – HBMU
Diesel, traction battery, catenary

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Rolling Stock Projects – North America

SBCTA ZEMU (Stadler) – HMU

- Battery propulsion with hydrogen range extension
  - On track for 2024 revenue service operation

Chemin de fer Charlevoix iLint (Alstom) – HMU

- Demonstration operation in 2023
- Battery propulsion with hydrogen range extension

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Rolling Stock Projects – Japan

JR Central N700S Shinkansen – EMU/BEMU*

- *Battery operations in case of power loss
- Under-floor mounted traction batteries

HYBARI – HMU

- Hydrogen-HYBrid Advance Rail vehicle for Innovation
- Under development
- Underfloor mounted fuel cells
- Battery propulsion with hydrogen range extension

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Rolling Stock – Additional Examples

Siemens
- Mireo Plus B (BEMU)
- Mireo Plus H (HMU)
- Desiro ML (BEMU conversion)

Talgo
- TD-060 TPH2 Prototype (HMU)
- Vittal One (HMU)

Talgo
- $H_2$50 High-Speed Train

Alstom
- Coradia iLINT, Coradia Stream (HMU)
- Coradia Continental, Talent, X'trapolis (BEMU)

Stadler
- FLIRT family (HMU, BEMU, HBMU)

CAF
- Civia (HMU)
- Civity (BEMU)

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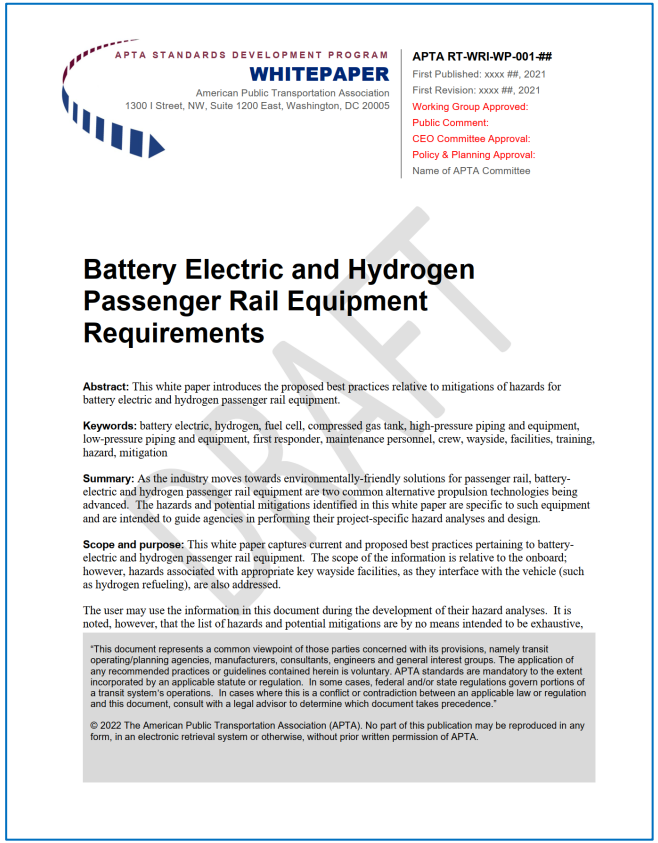
The APTA Whitepaper

- Introduction of proposed best practices
  - Mitigate hazards
  - Leverage worldwide expertise
  - Provide initial set of hazards and mitigations to be considered
- Scope of the whitepaper is limited to:
  - Vehicle onboard
  - Direct vehicle-facilities interfaces (e.g., hydrogen fueling, battery charging, storage, etc.)
- Considerations for first responders and maintenance personnel/crew
- Identification of areas requiring future research

Not intended to specify design requirements at this stage.



APTA STANDARDS DEVELOPMENT PROGRAM
WHITEPAPER
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Name of APTA Committee

Battery Electric and Hydrogen Passenger Rail Equipment Requirements

DRAFT

Abstract: This white paper introduces the proposed best practices relative to mitigations of hazards for battery electric and hydrogen passenger rail equipment.

Keywords: battery electric, hydrogen, fuel cell, compressed gas tank, high-pressure piping and equipment, low-pressure piping and equipment, first responder, maintenance personnel, crew, wayside, facilities, training, hazard, mitigation

Summary: As the industry moves towards environmentally-friendly solutions for passenger rail, battery-electric and hydrogen passenger rail equipment are two common alternative propulsion technologies being advanced. The hazards and potential mitigations identified in this white paper are specific to such equipment and are intended to guide agencies in performing their project-specific hazard analyses and design.

Scope and purpose: This white paper captures current and proposed best practices pertaining to battery-electric and hydrogen passenger rail equipment. The scope of the information is relative to the onboard; however, hazards associated with appropriate key wayside facilities, as they interface with the vehicle (such as hydrogen refueling), are also addressed.

The user may use the information in this document during the development of their hazard analyses. It is noted, however, that the list of hazards and potential mitigations are by no means intended to be exhaustive,

"This document represents a common viewpoint of those parties concerned with its provisions, namely transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any recommended practices or guidelines contained herein is voluntary. APTA standards are mandatory to the extent incorporated by an applicable statute or regulation. In some cases, federal and/or state regulations govern portions of a transit system's operations. In cases where this is a conflict or contradiction between an applicable law or regulation and this document, consult with a legal advisor to determine which document takes precedence."

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Whitepaper – Battery Electric Passenger Rail Equipment

- Hazards include:
  - Fires (internal and external), overheating, explosion, toxic gas emission
  - Leakage (battery and cooling system)
  - Unintended vehicle stops
  - Unexpected contact with live conducted parts
  - General hazards (e.g., loose defective equipment, cover securement, hot surfaces, heavy equipment, sharp edges) were not restated as they are not unique to these alternative-propulsion technologies.

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Whitepaper – Hydrogen Passenger Rail Equipment

- Fuel cell hazards include:
  - Leakage (e.g., mechanical failure)
  - High voltage, over-voltage
  - Overheating
  - Fire and explosion
  - Unreacted hydrogen
- Compressed gas tank hazards include:
  - Leakage (e.g., shock/vibration, embrittlement, fatigue, overpressure, etc.)
  - Permeation (i.e., weeping)
- High-pressure piping and equipment hazards include:
  - Leakage (e.g., poor fittings/welds, resulting jet fire)
  - Fire and explosion (e.g., from disconnection of safety management system)
  - Blockage of vent lines (e.g., accumulation of impurities, water, condensation)
- Low-pressure piping and equipment hazards include:
  - Leakage (e.g., shock/vibration, embrittlement, poor fittings/welds, etc.)
  - Blockage of vent lines

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Whitepaper does not currently address liquid hydrogen and hydrogen combustion engines. However, these topics may be revisited in the future as longer distance travels for passenger rail are evaluated.

Whitepaper – Additional Consideration

- Battery Storage (Removed from Vehicle)
- Hydrogen Component Storage (Removed from Vehicle)
- Battery Charging Hazards
- Hydrogen Fueling Hazards
- Vehicle Storage and Maintenance Facilities
- Maintenance Personnel/Crew Training
- First Responder Training
- Topics for Future Research

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Whitepaper – Activities and Goals

- APTA commenced Working Group (WG) activities on March 28, 2022 to develop the initial Whitepaper which shall ultimately evolve into an industry Safety Standard for Battery Electric and Hydrogen Passenger Rail Equipment.
  - The WG consolidates critical safety issues from industry and leverages worldwide best practices.
  - Completion of draft Whitepaper is scheduled for Q3-2023.
  - After publication, a new WG will commence work on the Recommended Practice with targeted completion by 2025*.
  - Completion of the Safety Standard is targeted for 2027*.

***Anticipated schedule assumes coordination with FRA parallel activities.**

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Future Work

- After closure of the Whitepaper, the future Recommended Practice and Safety Standard will require more detailed research, industry experience and expansion of topics to assure the continued high level of safety for passenger rail service in North America.
- New topics may range from additional operation and mishap scenarios, particular to the North American rail environment, to other new technologies such as cryogenic (liquid) hydrogen applications on passenger rail vehicles.
- FRA has indicated that there may be additional funding for future research.
- APTA and industry will continue to support FRA as additional endeavors are identified and initiated.

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Working Group Contributors

WG Subcommittee:

- ACI
- Alstom
- APTA
- DC Rail Advisory
- HDR
- Jacobs
- Jensen Hughes
- JR Central
- Rotem
- Sandia National Laboratories
- Siemens
- Stadler Rail
- Talgo
- Teumim Technical
- WSP

WG:

- ABB
- ACE Rail
- ACI
- Alstom
- Amtrak
- APTA
- Brookville
- DB Eco
- DC Rail Advisory
- DCTA
- FRA
- Hatch
- HDR
- Jacobs
- Jensen Hughes
- JR Central
- Long Island Rail Road
- MBTA
- Metra
- Metro North Railroad
- Network Rail Consulting
- PGH Wong
- Rotem
- Raul V Bravo + Associates
- Sandia National Laboratories
- SBCTA
- SCRRA
- Siemens
- Stadler Rail
- STV
- Talgo
- Teumim Technical
- Valley Link Rail
- Wabtec
- WSP
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Thank you!

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