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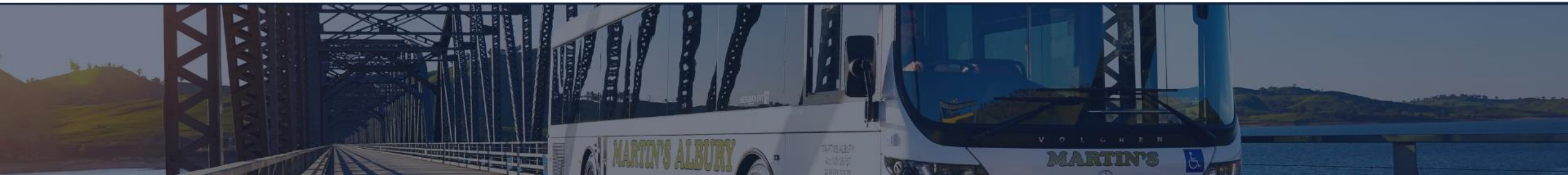
Bus Industry Summit

2023

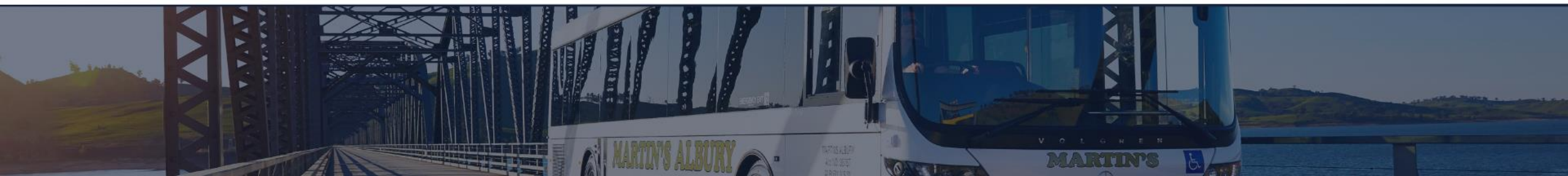
Hosted by the Bus Industry Confederation



BIC ZEB ADVISORIES

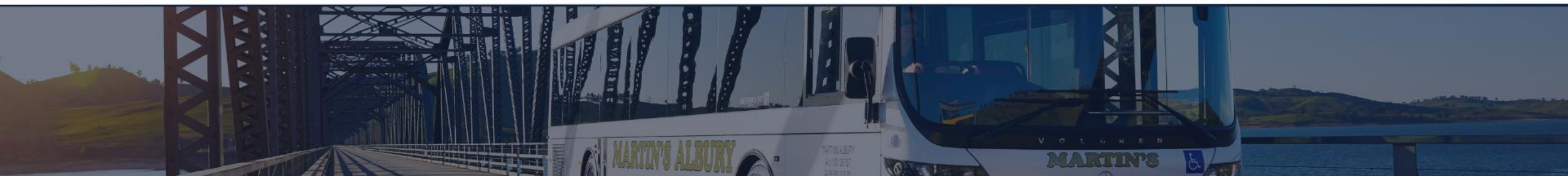
Luke Hardy

Wednesday 22nd March 2023



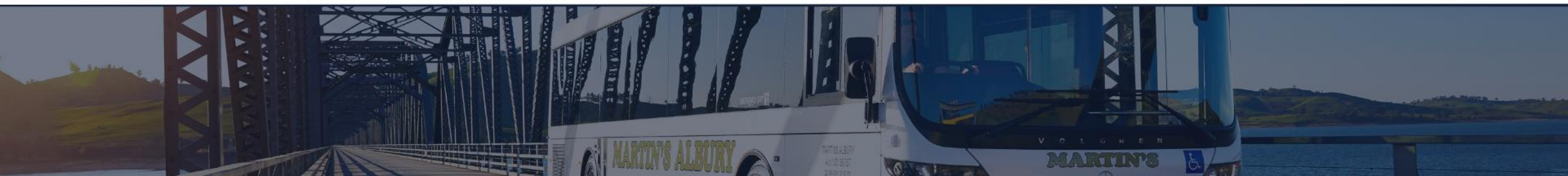
ZEB Advisories

- The BIC undertook a survey of its members to determine what their issues and concerns were in relation to the introduction and operation of the new zero emission buses.
- The key results from the survey, which included sixty-plus formal submissions, in assenting order were:
  - Bus Standards.
  - Infrastructure & Integration.
  - Bus Maintenance.
  - Safety Management Systems.
- As such BIC is developing three separate Advisories to help address these issues.



ZEB Advisories

- The three Advisories being developed are:
- **Advisory 1: ZEB Standards and Specifications**;
  - Specifications and Standards for the buses.
- **Advisory 2: ZEB General Operational Safety Advisory**;
  - Guidance on the operation and maintenance of ZEB's specifically for the new vehicle technology systems.
- **Advisory 3: ZEB General Safety Advisory Depots and Infrastructure**;
  - Fixed systems and infrastructure needed to support these new technology vehicles.
- The project has been funded by the NHVR as a Heavy Vehicle Safety Initiative.



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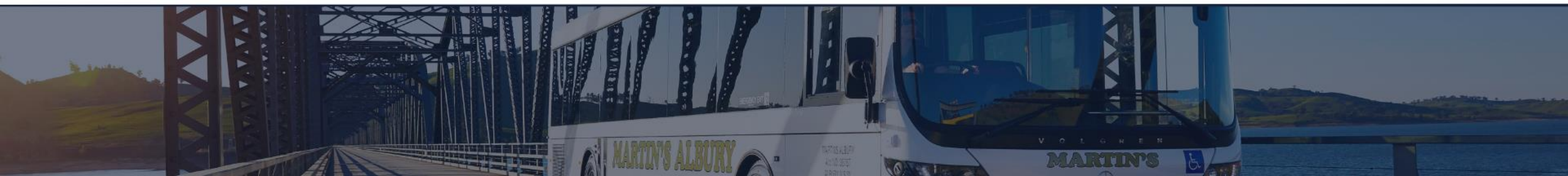
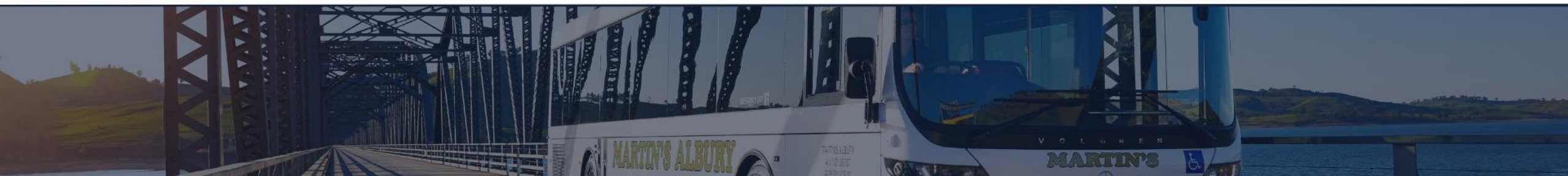
Advisory 1: ZEB Standards and Specifications



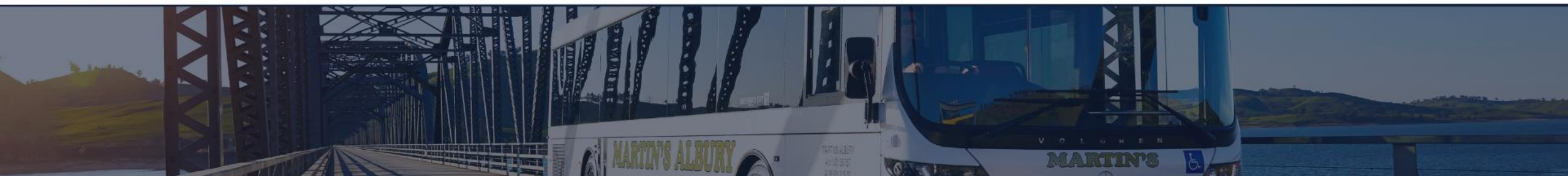
Advisory 1: ZEB Standards and Specifications

- This Advisory is intended to provide guidance on a range of vehicle regulations and standards that can be applied to ZEB's.
- Given that the Fed Dept. is now working to adopt ECE R100 and ECE R138, the advisory is being developed not only as a vehicle specifications recommendation set but also an information/how to that can be used by operators, buyers, and suppliers of ZEB's to implement the new ADR's.
- Some ZEB suppliers to the Australia, due to their respective country of origin, may need to reference regulations other than the UNECE and in this regard for each recommended regulation, information is provided showing related standards or national regulations in nominated other markets.



Advisory 1: ZEB Standards and Specifications

- Although there are some 30 ADR's that apply to omnibuses, currently no ADRs apply to the specialised drive systems and associated componentry found in ZEB's either in pure battery powered or hydrogen powered form.
- The current Australian Standards are also weak in these areas, particularly regarding high voltage componentry (applicable to all ZEBs), and the on-bus high-pressure storage and transfer systems associated with hydrogen fuels.
- There are, however, a large and developing array of overseas regulations and standards and it is these standards that are being reviewed.
- *(Note: Two new ADRs are currently being implemented and these are EU based).*



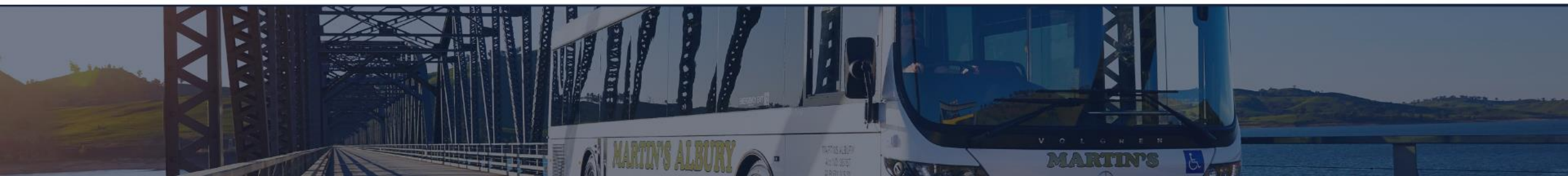
Advisory 1: ZEB Standards and Specifications

The main chapters of this advisory are:

- Componentry of battery and hydrogen ZEB's.
- Heavy vehicle regulations in Australia and ADR's.
- Recommendations for the adoption of UNECE regulations:
  - UNECE R100 (Electric Safety) Series 2 and changes that are required for Series 3.

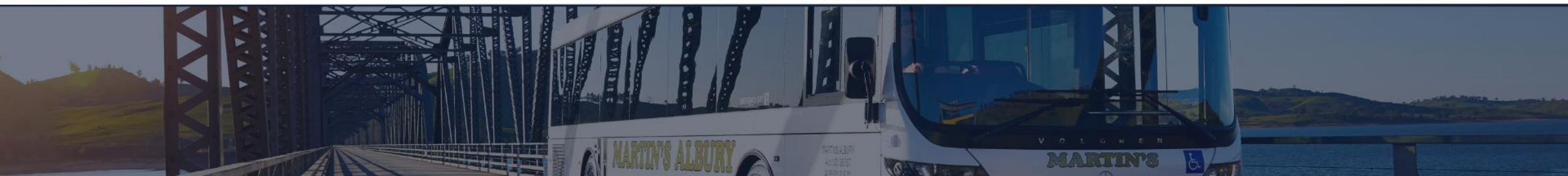
  (ADR 109/00 - Electric Power Train Safety Requirements)
  - UNECE R134 (Hydrogen and Fuel Cell Vehicles (HFCV)) R79 as a base as R134 is similar but later regulation has increased duty cycles and testing resumes.

  (ADR 110/00 - Hydrogen-Fueled Vehicle Safety Related Performance 2023)



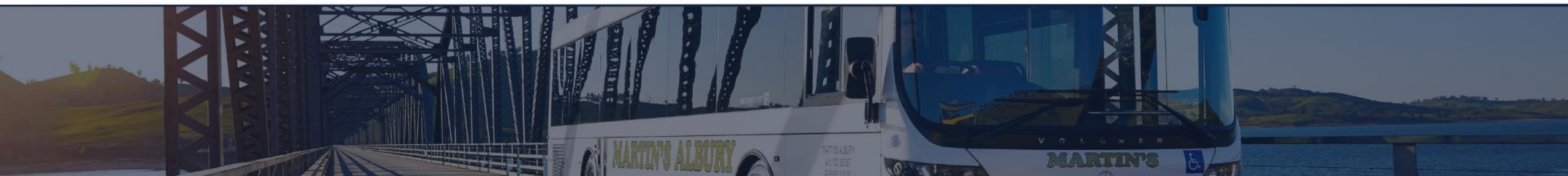
Advisory 1: ZEB Standards and Specifications

- The other relevant UNECE Regs being;
  - R10 (Electromagnetic compatibility).
  - R138 (Uniform provisions concerning the approval of Quiet Road Transport Vehicles regarding their reduced audibility).
- And Referencing;
  - UN GTR No. 20 (Electric Vehicle Safety (EVS)).
  - UN GTR No. 13 (Hydrogen and Fuel Cell Vehicles (HFCV)).
- Plus;
  - Signage and markings for first responders App in accordance with ANCAP requirements ISO 17840-2.



Advisory 1: ZEB Standards and Specifications

- UNECE Regs detail the regulatory requirements as well as the binding administrative provisions for type approvals and their mutual recognition.
- UN GTRs contain globally harmonized performance-related requirements and test procedures.
- UN GTRs do not contain administrative provisions for type approvals and their mutual recognition (individual countries control this aspect).
- (GTRs are a much more recent development than the UNECE Regulations and are only just beginning to have an impact. Only five global technical regulations have been established for the 1998 Global Agreement, all covering minor topics. The number of global technical regulations is expected to increase in the future.)



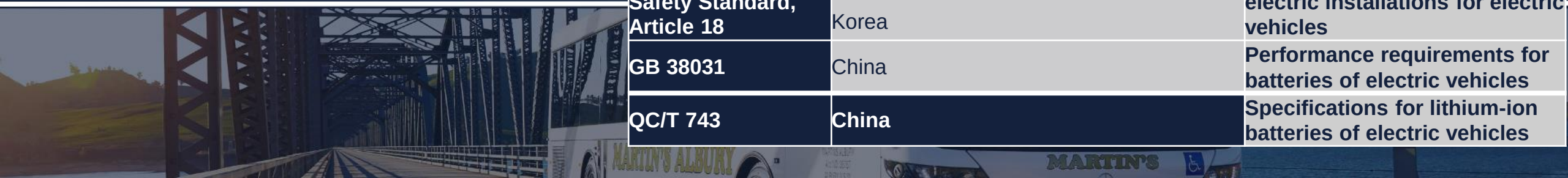
Advisory 1: ZEB Standards and Specifications Pure Battery Vs Hydrogen

Regulation Number	Detail	Pure Battery Powered Vehicle?	Hydrogen Fuel Cell Powered Vehicle?
UN R100	Electric safety	✓	✓
UN R10	Electromagnetic compatibility	✓	✓
UN R134	Hydrogen and Fuel Cell Vehicles (HFCV)	×	✓
UN R138	Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility	✓	✓
UN R153	Fuel system integrity and electric power train safety at rear-end collision small buses only	✓	✓
UN GTR 20	Electric Vehicle Safety (EVS) GTR 20 updates added to R100 Series 3, so only reference GTR as a recommended source of added detail.	✓	✓
UN GTR 13	Hydrogen and Fuel Cell Vehicles (HFCV)	×	✓

Advisory 1: ZEB Standards and Specifications ECE R100

- There are other international regulations and standards that address similar areas to R100, and these are referenced.
- Although the United States and Canada require compliance to Motor Vehicle Safety Standard 305, this regulation FMVSS No. 305 aligns with other UN GTR's No. 13 and No. 20.

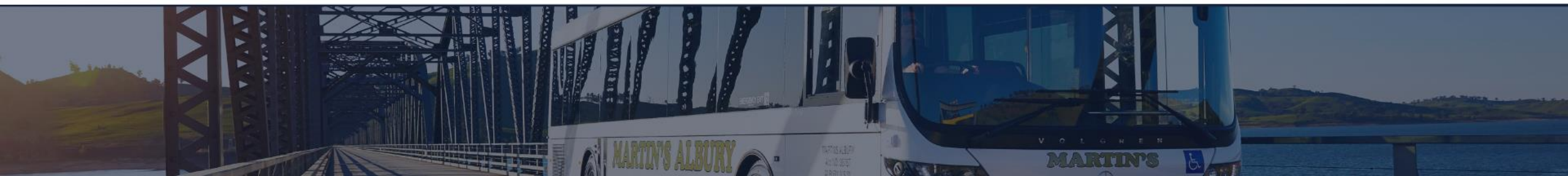
International or national regulation name/code	Adopting economies	Outline
UN Regulation 100	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Egypt, European Union, Georgia, Japan, Kazakhstan, Malaysia, Montenegro, Nigeria, North Macedonia, Norway, Republic of Moldova, Russian Federation, San Marino, Serbia, Switzerland, Tunisia, Turkey, and United Kingdom.	Performance requirements of electric powertrains and batteries
Motor Vehicle Safety Standard 305	Canada, United States	Performance requirements for battery and high voltage systems in the event of a collision
GB/T 31498	China	Performance requirements of electric vehicle following a collision
Motor Vehicle Safety Standard, Article 91	Korea	Performance requirements for high voltage system of electric vehicles
Motor Vehicle Safety Standard, Article 18	Korea	Performance requirements for electric installations for electric vehicles
GB 38031	China	Performance requirements for batteries of electric vehicles
QC/T 743	China	Specifications for lithium-ion batteries of electric vehicles



Advisory 1: ZEB Standards and Specifications ECE R100 or ADR 109/00

UNECE R100 Series 2 and 3: The specific sections that have been updated in series 3 include:

- Updated requirements protection against water effects (added requirements).
- Requirements for Warning in the event of failure in REESS and Warning in the event of low energy content of REESS (added requirements).
- RESSS Testing criteria updated such that there shall be no evidence of:
  - Electrolyte leakage
  - Rupture (applicable to high voltage REESS only)
  - Venting (New added. only for REESS other than open-type traction battery);
  - Fire/Explosion.



Advisory 1: ZEB Standards and Specifications ECE R100 or ADR 109/00

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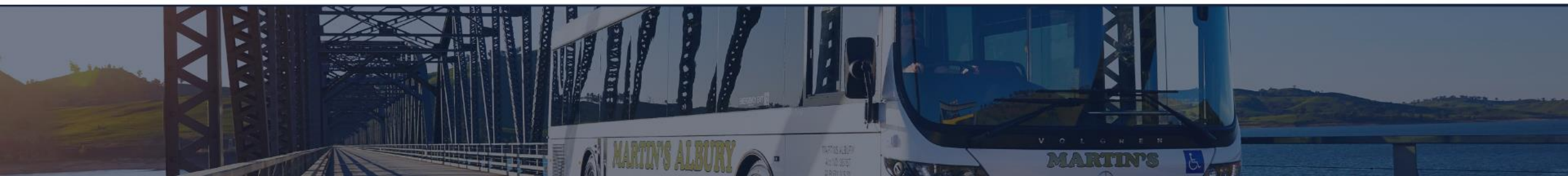
UNECE R100 Series 2 and 3

- The Advisory will detail the requirements considered relevant from each nominated regulation/standard.
- It will detail what these requirements are and how they are tested to confirm compliance.
- For example, R100 has two parts the first applies to a complete vehicle that uses a complaint Rechargeable Electrical Energy Storage System (REESS).
- The second applies to the REESS itself.
- R100 can apply to the componentry or the compete bus (or both).



Advisory 1: ZEB Standards and Specifications ECE R100 or ADR 109/00

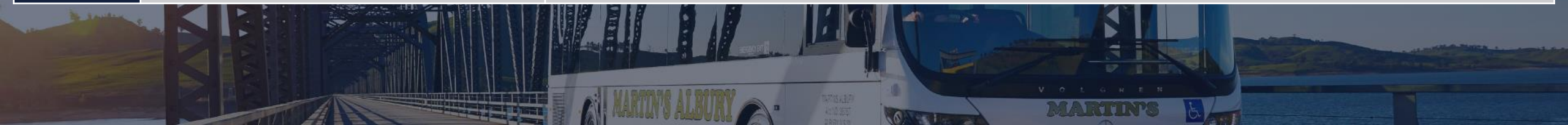
R100 Clause	R100 Requirements	Descriptions/Safety Issues Addressed
5.1	Protection against electrical shock.	Sets criterion for electrical protection barriers, enclosures, solid insulators and connectors to protect against electrical shock in high voltage busses and components.
5.1.1	Protection against electrical shock via direct contact with parts under high voltage	Access probes used to verify the protection of persons against access to live parts (simulates a human finger used to access parts to ensure on access to live parts).
5.1.1.3	Isolation and mechanical protection requirements for parts under high voltage	Isolation and mechanical requirements for high voltage AC and DC busses. Sets the requirements for electrical protection barriers, enclosures, solid insulators and connectors.
5.1.1.4	Marking Requirements	Sets identification and signage of all high voltage busses, cabling and other equipment.
5.1.2	Protection against electrical shock via indirect contact to parts under high voltage	Galvanic earthing requirements of busses, components and systems for protection against electrical shock which could arise from indirect contact.

Advisory 1: ZEB Standards and Specifications ECE R100 or ADR 109/00

R100 Clause	R100 Requirements	Descriptions/Safety Issues Addressed
5.1.3	Isolation resistance *	Sets criterion for the isolation resistance between the high voltage busses and the electrical chassis (or common earths), to ensure that the higher voltage circuits are correctly isolated to avoid electrical shock to humans and or adverse effects on lower voltage circuits (vehicle control and or monitoring systems).
5.1.3.3	Fuel cell vehicles isolation resistance monitoring	In fuel cell vehicles, DC high voltage busses shall have an on-board isolation resistance monitoring system together with a warning to the driver if the isolation resistance drops below the minimum required value of 100 Ω/V.
5.1.4	Protection against water effects	The vehicles shall maintain isolation resistance after exposure to water (e.g. washing, driving through standing water).
5.2	Requirements for Rechargeable Electrical Energy Storage System (REESS)	Sets criterion for the REESS in terms of accumulation of gas, warning in the event of a failure or low energy in the REESS.

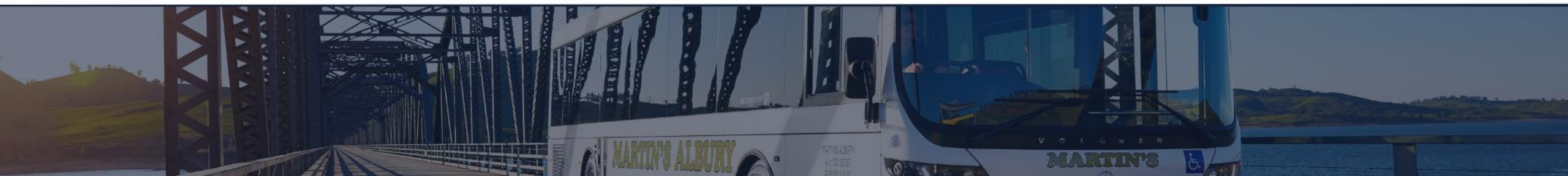
Advisory 1: ZEB Standards and Specifications ECE R100 or ADR 109/00

R100 Clause	R100 Requirements	Descriptions/Safety Issues Addressed
5.3	Preventing accidental or unintended vehicle movement	Driver warnings and isolation requirements in relation to "active driving possible mode" means the vehicle mode when application of pressure to the accelerator pedal (or activation of an equivalent control) or release of the brake system will cause the electric power train to move the vehicle.
6.2	REESS vibration	Requirements for the REESS to resist vibrations.
6.3	REESS thermal shock and cycling	Requirements for the REESS to resist sudden changes in temperature.
6.4	REESS mechanical impact	Requirements for the REESS to resist impact and shock loadings.
6.5	REESS fire resistance	Requirements for the REESS to resist fire from an external source only (not the fire resistance, or fire migration of the REESS itself).



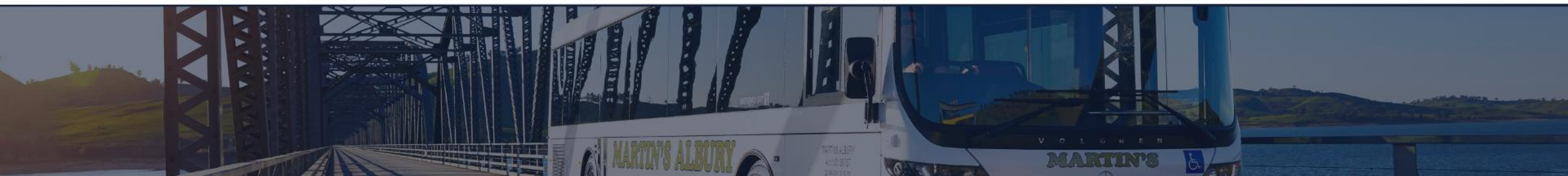
Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

- As stated earlier, battery and hydrogen powered buses share similar componentry and in a regulatory sense, the specific additional hydrogen systems are:
  - **Fuel cell system:** An assembly of individual membrane electrodes that use hydrogen and oxygen to produce electricity. (Applies to all hydrogen fuel cell ZEV only)
  - **Fuel filler:** A nozzle from a fuel dispenser attaches to the receptacle on the vehicle to fill the tank
  - **Fuel tank (hydrogen):** Stores hydrogen gas onboard the vehicle until it's needed by the fuel cell. (Applies to all hydrogen fuel cell ZEV only).



Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

- UNECE R134 has 3 main regulatory parts.
  - **Part I** - Compressed hydrogen storage systems for hydrogen-fuelled vehicles on their safety-related performance.
  - **Part II** - Specific components for compressed hydrogen storage systems for hydrogen fuelled vehicles on their safety-related performance.
  - **Part III** – Hydrogen fuelled vehicles of category M2 and M3 incorporating compressed hydrogen storage system on its safety-related performance.



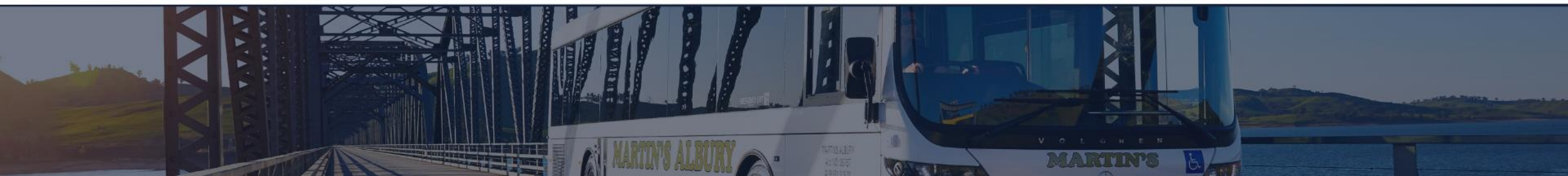
Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

- **Part I** – Specifications of the compressed hydrogen storage system

5.1.	**Verification tests for baseline metrics**
5.1.1.	Baseline initial burst pressure
5.1.2.	Baseline initial pressure cycle life
5.2.	Verification test for performance durability (sequential hydraulic tests)
5.2.1.	Proof pressure test
5.2.2.	Drop (impact) test
5.2.3.	Surface damage
5.2.4.	Chemical exposure and ambient temperature pressure cycling tests
5.2.5.	High temperature static pressure test
5.2.6.	Extreme temperature pressure cycling
5.2.7.	Residual proof pressure test
5.2.8.	Residual strength Burst Test
5.3.	Verification test for expected on-road performance (sequential pneumatic tests)
5.3.1.	Proof pressure test
5.3.2.	Ambient and extreme temperature gas pressure cycling test (pneumatic)
5.3.3.	Extreme temperature static gas pressure leak/permeation test (pneumatic)
5.3.4.	Residual proof pressure test
5.3.5.	Residual strength burst test (hydraulic)
5.4.	Verification test for service terminating performance in fire
5.5.	Requirements for primary closure devices

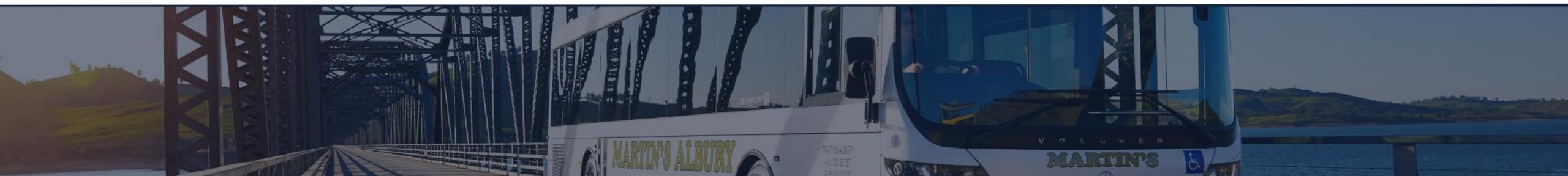
Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

- **Part II** - Specific components for compressed hydrogen storage systems for hydrogen fuelled vehicles on their safety-related performance.
  - Test procedures for specific components for the compressed hydrogen storage system.
  - Appendix 1 - Overview of TPRD tests
  - Appendix 2 - Overview of check valve and automatic shut-off valve tests
  - Test procedures for vehicle fuel system incorporating the compressed hydrogen storage system.



Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

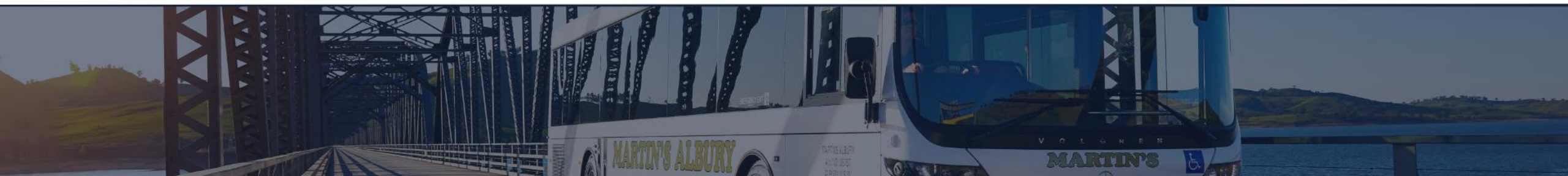
- **Part III** – Specifications of a vehicle fuel system incorporating the compressed hydrogen storage system
- This part specifies requirements for the vehicle fuel system, which includes the compressed hydrogen storage system, piping, joints, and components in which hydrogen is present. The hydrogen storage system included in the vehicle fuel system shall be tested and type-approved in accordance with Part I of this Regulation and produced in conformity with the approved type.



Advisory 1: ZEB Standards and Specifications ECE R134 or ADR 110/00

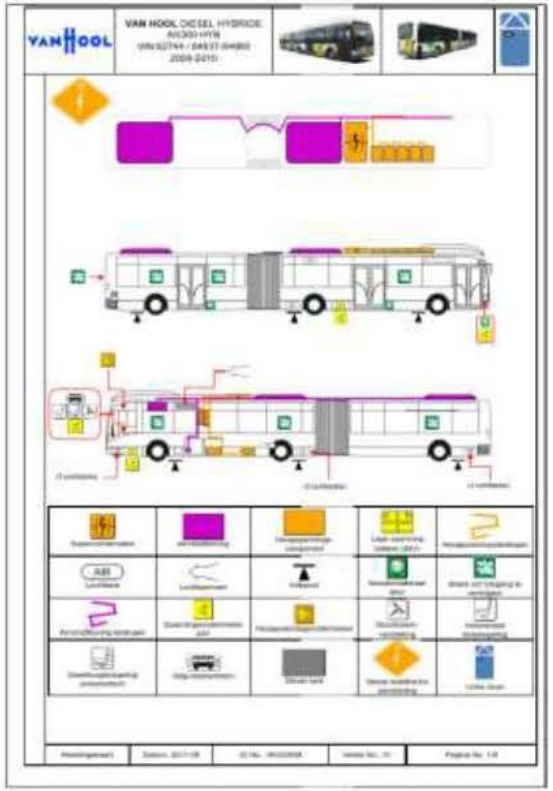
- Overall R138 is like CSA B51 which was the CNG cylinder standard used in the late 1990's and there are other areas of similarity such as AS 2739 mounting strength criterion.

Acceleration direction	Gross vehicle mass ≤ 3.5 t	Gross vehicle mass > 3.5 t
Longitudinal	20.0*g*	10.0*g*
Lateral	8.0*g*	5.0*g*
Vertical	4.5*g*	4.5*g*



Advisory 1: ZEB Standards and Specifications

- **Emergency Response ANCAP:** Example of EU ISO 17840-2: Identification, immobilisation, access to passengers, stored energy, in case of fire and towing.



1. Identification / recognition	Page ...
2. Immobilisation / stabilisation / lifting	Page ...
3. Disable direct hazards / safety regulations	Page ...
4. Access to the occupants	Page ...
5. Stored energy / liquids / gases / solids	Page ...
6. In case of fire	Page ...
7. In case of submersion	Page ...
8. Towing / transportation / storage	Page ...
9. Important additional information	Page ...
10. Explanation of pictograms used	Page ...

1. Identification / recognition	
	Electric bus with inductive charging
2. Immobilisation / stabilisation / lifting	
	Height control bus in driver cabin
	Seat height adjustment in driver cabin
	Use only these lifting points
3. Disable direct hazards / safety regulations	
	To emergency stop engine use CO_2
	Shutdown high voltage possible at two places
4. Access to the occupants	
	Three door exits
	One roof exit
	Break these windows to obtain access

Advisory 1: ZEB Standards and Specifications

- Example of EU ISO 17840-2: Identification

Figure TEC

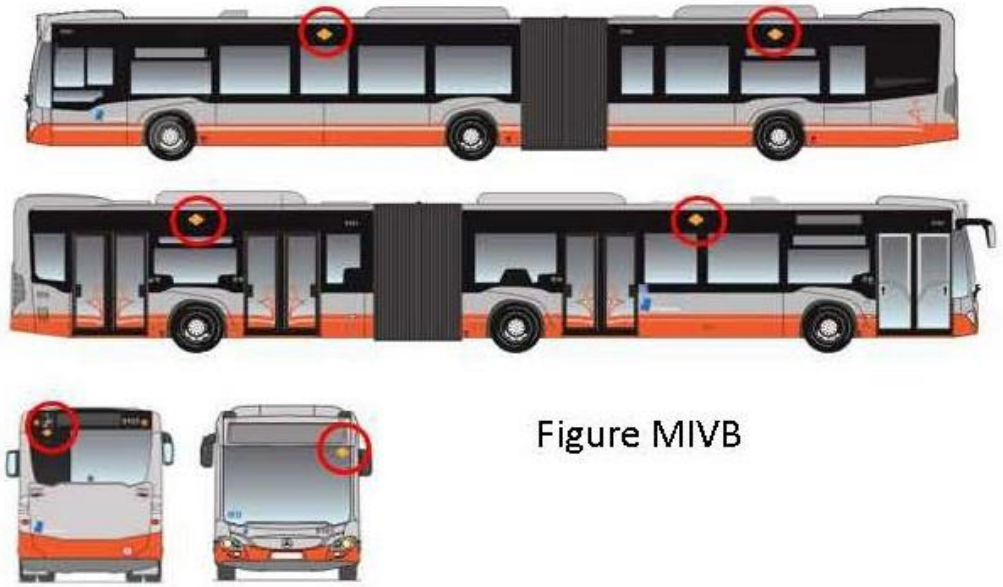
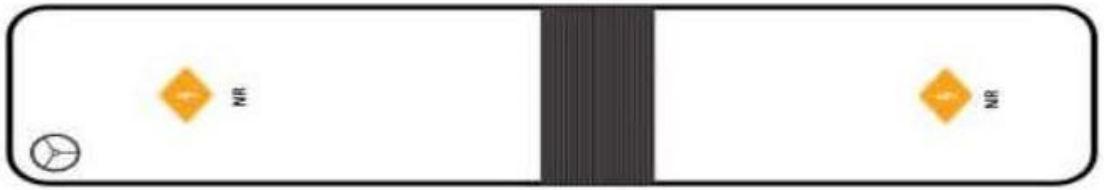


Figure MIVB



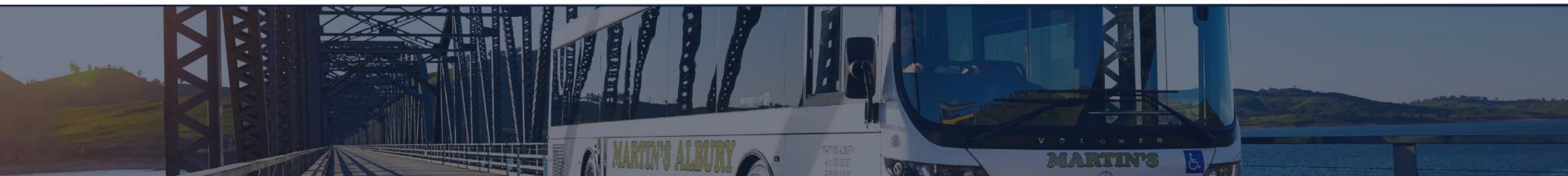
Advisory 1: ZEB Standards and Specifications

Required Specification of Bus (UNECE R100 Standards)		System compliance to specification
1	General	
1.1	Make (trade name of manufacturer):	
1.2	Type:	
1.3	Vehicle category:	
1.4	Commercial name(s) if available:	
1.5	Manufacturer's name and address:	
1.6	If applicable, name and address of manufacturer's representative:	
1.7	Drawing and/or photograph of the vehicle:	
1.8	Approval number of the REESS:	
2	Electric motor (traction motor)	
2.1	Type (winding, excitation):	
2.2	Maximum net power and / or maximum 30 minutes power (kW):	
3	REESS	
3.6	Description or drawing(s) or picture(s) of the installation of the REESS in the vehicle:	
3.7	Type of thermal management	
3.8	Electronic control: *Continued……..*	

- *Given the large array of ZEB bus and REESS types a standard format which describes the respective buses and or energy storage systems is required.*
- *The Advisory provided a Specification Format as detailed in UNECE R100 be used, and tables that can be used for this purpose.*

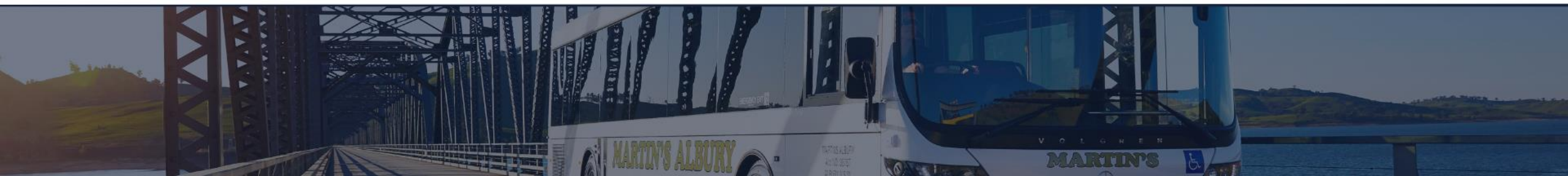
Other ZEB Advisories

- Advisory 2: ZEB General Operational Safety Advisory
- Advisory 3: ZEB General Safety Advisory Depots and Infrastructure



Advisory 2: ZEB General Operational Safety Advisory

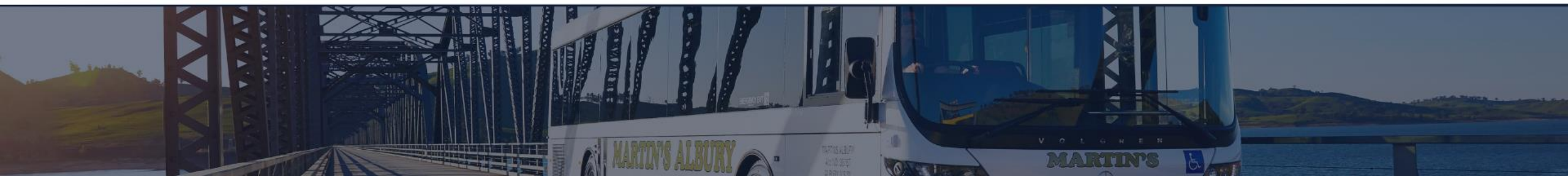
- This Advisory is intended to provide guidance on the operation and maintenance of ZEB's specifically in relation to the new vehicle technology systems such as, battery packs, electrical power control and distribution systems, high-pressure hydrogen storage and distribution componentry, fire protection and emergency response. The main chapters of this advisory are:
  - Requirements of AS 5732:2022 in relation to;
  - Processes for maintenance and repairs not related to the rechargeable electric energy storage system (REESS).
  - Processes for maintenance and repairs which involve working with the REESS and associated hazardous voltage systems.



Advisory 2: ZEB General Operational Safety Advisory

Contents Continued:

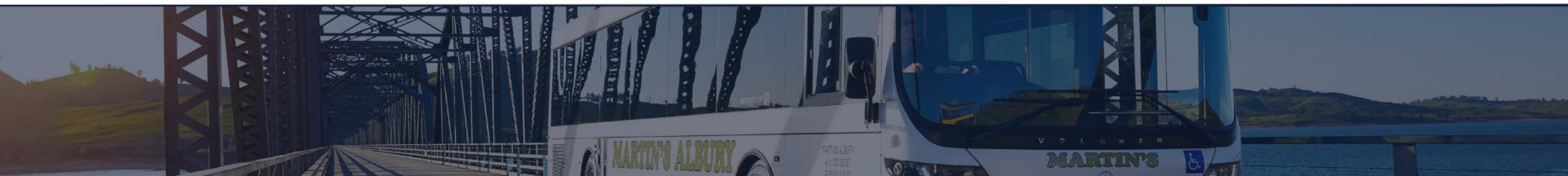
- Handling and storage where a REESS is removed.
- Safe Work Practices.
- Damaged high voltage batteries.
- Fire safety.
- High pressure hydrogen storage tank safety, maintenance, and inspection requirements.
- High pressure piping and components safety, maintenance, and inspection requirements.
- Dangerous goods and transport of Lithium batteries for ZEB's'.



Advisory 2: ZEB General Operational Safety Advisory

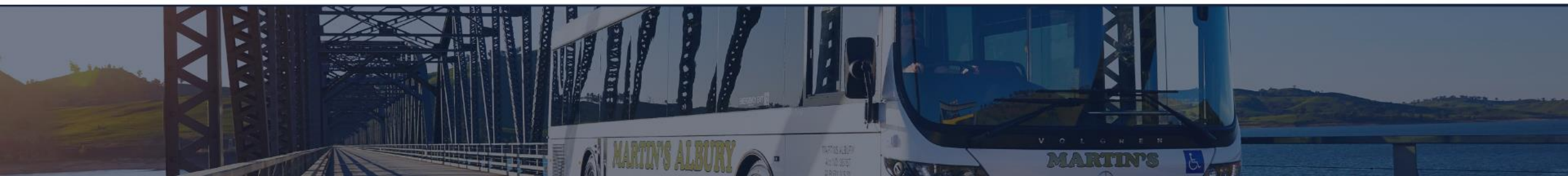
Contents Continued:

- Generic maintenance check sheets.
- Electromagnetic emissions testing and safe levels.
- Training and licensing requirements by State.
- Emergency response.
- Summary of related international standards and codes.
- Break down procedures (including towing).



Advisory 3: ZEB General Safety Advisory Depots and Infrastructure

- This Advisory is intended to focus on the fixed systems and infrastructure needed to support these new technology vehicles. The main chapters of this advisory are:
  - Recharging stations and systems.
  - Periodic maintenance of refuelling/recharging infrastructure.
  - Hydrogen refueling/recharging stations.
  - Traffic/impact protection.
  - Security.
  - Infrared fire protection.
  - Venting.
  - Location in depot.

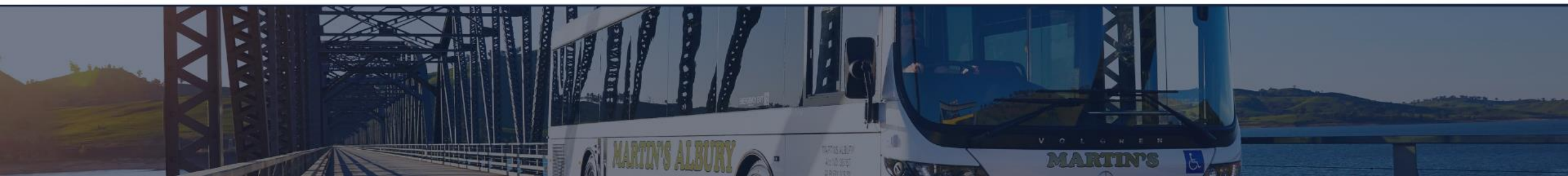


Advisory 3: ZEB General Safety Advisory Depots and Infrastructure

Contents Continued:

- Depot and operating safety.
- Tunnels and on-road infrastructure.
- Operations in enclosed spaces (for example - tunnels) research and identify international best practice.
- Definitions for Battery Electric Buses (BEB's) and fuel cell (hydrogen) electric buses (FCEB's) (currently inadequate).

The BIC, via input from members, can only seek to provide general guidance that is based on existing regulations, standards, or codes. The aim of which is to make people aware of such related requirements.



ZEB Advisories

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END THANKS