Aethel Mobility Systems
Automotive Wiring Harness Design Specification

Document: AEMS-WH-100 Revision: 1.0 Effective: 25 October 2025

Classification: Internal Use Only
Effective Date: October 25, 2025
Prepared By: Vehicle Electronics & Harness Engineering
Approved By: (Peter Nikolas)

Application and Scope of Standard. This document defines the mandatory engineering and manufacturing requirements for all Low Voltage (LV) wiring harnesses ($\leq 60\,\mathrm{V}$ DC) and associated control circuits designed, manufactured, and utilized in Aethel Mobility Systems vehicle platforms. Compliance with the specifications herein is mandatory to ensure product quality, vehicle safety, serviceability, and adherence to the core design drivers: **Weight Optimization (W)**, **Signal Integrity (SI)**, and **Cost Efficiency (C)**.

TABLE OF CONTENTS (abridged)

Page	Chapter Title	Focus Area
1	CHAPTER 1: SCOPE, PURPOSE, AND DEFINITIONS	Design Drivers, Referenced Standards (ISO 6722).
2	CHAPTER 2: CONDUCTOR AND LV TERMINAL SPECIFICATION	Wire Codes (C2H), Color Schemes, Twisted Pair Pitch Rates.
3	CHAPTER 3: LV CONNECTOR SELECTION & APPLICATION MANDATES	IP Ratings, Functional Color Coding, Measurement Ports.
4	CHAPTER 4: HARNESS PROTECTION, ROUTING, AND SHEATHING	Taping Strategy, Tube Cutback Tolerances, Clearances.
5	CHAPTER 5: CONTROL CIRCUIT LOGIC REFERENCE	Application of AND, OR, NOT, XOR logic gates.

1. SCOPE, PURPOSE, AND DEFINITIONS (Page 1 of 5)

1.1 Scope and Application

This standard, **AEMS-WH-100-V1.0**, defines the mandatory design requirements and component specifications for all Low-Voltage (LV) wiring harnesses ($\leq 60\,\mathrm{V}$ DC) utilized in the Aethel Mobility Systems vehicle platforms.

1.2 Core Design Drivers and Rationale

All design decisions must demonstrably align with the following three (3) performance drivers:

Driver	Abbreviation	Design Rationale & Priority
Weight Optimization	W	Mandatory use of thin-wall conductors and minimized sheathing to maximize vehicle efficiency (fuel/range).
Signal Integrity	SI	Use of twisted pairs, shielding, and appropriate connectors to ensure reliable high-speed data transmission (CAN, Ethernet) and sensor accuracy.
Cost Efficiency	C	Adherence to standardized components and designs optimized for high-volume automated manufacturing processes (cut, strip, crimp).

1.3 Referenced Industry Standards

The designer must ensure all specified components comply with the latest revision of the following industry standards:

Standard	Description	Focus Area
ISO 6722	Road vehicles - 60V and 600V single-core cables	Wire/Insulation specifications.
SAE/USCAR-2	Performance Specification for Automotive Electrical Connector Systems	Connector and Terminal Performance.
SAE J1128 / DIN 72551	Low Voltage Wiring and Color Coding	Cable Color Identification.

2. CONDUCTOR AND LV TERMINAL SPECIFICATION (Page 2 of 5)

2.1 Wire Type, Size Selection, and Weight Optimization (W)

Component Code	Conductor Material	Nominal Size (mm^2)	Primary Application
C2H	Thin-Wall Copper (FLRY-A)	0.30 to 0.50	Signal/Low Current ($\leq 5\,\mathrm{A}$): Mandatory minimum size (W).
C5ZK	Thin-Wall Copper (FLRY-B)	0.75 to 1.50	Standard Power ($\leq 20\,\mathrm{A}$): Optimized for C and robustness.
C1P-S	Special, Robust Copper	4.00 (Special Approval)	High-Load Power: Restricted to fused main feeds.

Design Rule: Use 0.30 mm^2 (C2H) wherever possible for maximum Weight Optimization (W).

2.2 Color Coding Schemes and Abbreviations

2.2.1 Single Color Codes (Abbreviation)

Color Name	Abbreviation	Color Name	Abbreviation
White	W	Green	G
Black	BK	Orange	O
Blue	BU	Brown	BN
Red	R	Pink	P
Yellow	Y	Grey	GY

2.2.2 Two-Color Codes (Striped Wires)

Striped wires shall be designated as **Base Color**/**Stripe Color** (e.g., W/BK). Use of **W**/**BK** is mandatory for signal circuits to prevent misidentification.

Code Name	Description	Example Usage	Code Name	Description	Example Usage
STR-A	White / Black	CAN-High Data Line	STR-D	Green / Yellow	Sensor Signal (Positive)
STR-B	Blue / Red	LIN Bus Line	STR-E	Grey / Brown	Sensor Signal (Return)
STR-C	Yellow / Green	ABS Sensor Line	STR-F	Brown / White	Fused Switched Power

2.3 Twisted Pair (TP) Specifications for Signal Integrity (SI)

Twisted pairs must be specified in the Bill of Materials (BOM) using a dedicated code that defines wire size and conductor count to ensure the correct pitch (twists per meter) is maintained for signal integrity and EMI reduction.

Conductors (Qty)	Wire Size (mm^2 Range)	Mandatory Pitch (Twists/m)	Design Rationale (SI)
2 Wires	0.30 to 0.50	13 ± 1	Standard Data Bus (CAN/LIN), optimized for minimal signal delay/crosstalk.
2 Wires	0.50 to 0.75	15 ± 1	Power-over-Data (Ethernet PoE), higher pitch for increased robustness.
3 Wires	0.30 to 0.50	25 ± 2	Triple-phase sensor/motor control, tighter pitch for common mode rejection.
3 Wires	0.75 to 1.50	30 ± 3	High-current sensor/actuator control, maximum pitch for high SI and EMI immunity.

Design Rule: Deviating from the mandatory pitch requires specific EMC Lab verification.

2.4 Terminal, Seal Component List, and Strip Length

The design must specify components from the approved list, using the correct terminal–seal combination per the connector environment.

Component Function	Example Code Name	Key Type Feature	Environment / Application
Terminal 1 (Pin)	TERM65480079	0.64 mm Unsealed	Cabin ECU Interface (High Density)
Terminal 2 (Socket)	TERM2231908	1.5 mm Sealed	Engine Bay Power/Signal
Terminal 3 (Socket)	TERM101901	2.8 mm Sealed	Exterior Lighting / High Current
Terminal 4 (Pin)	TERM440056	0.64 mm Sealed	Body Pass-through (Wet Zone)
Terminal 5 (Socket)	TERM899201	1.5 mm Unsealed	Cabin Infotainment Console
Seal 1 (Single Rib)	SEAL9800364	0.30–0.50 mm^2	Small W Wire, Standard IP67
Seal 2 (Double Rib)	SEAL770001	0.75–1.50 mm^2	Medium Wire, Enhanced IP69K
Seal 3 (Triple Rib)	SEAL512345	2.0–4.0 mm^2	Large Wire, Extreme Sealing
Seal 4 (Cavity Plug)	SEAL11099	Unused Cavity Plug	Mandatory for all empty cavities in sealed connectors
Seal 5 (Splicing)	SEAL80808	Heat Shrink Tube	Mandatory for environmental protection of splice/crimp joints

2.4.1 Mandatory Wire Strip Length

Terminal Family (Size)	Mandatory Strip Length Range	Rationale (C)
0.64 mm (Miniature)	3.0 mm – 3.5 mm	Prevents exposed conductor outside the crimp; optimized for automation.
1.5 mm – 2.8 mm (Standard)	4.0 mm – 5.5 mm	Ensures full conductor capture and robust insulation support barrel engagement.

3. LV CONNECTOR SELECTION & APPLICATION MANDATES (Page 3 of 5)

3.1 Connector Family Selection and Rationale

Terminal Size (Family)	Max Current (Approx.)	Primary Application Zone	Design Rationale
0.64 mm (e.g., MQS)	7 A	ECU, Infotainment, ADAS	SI/W: High pin density for signals; minimal size/weight.
1.5 mm (e.g., JPT)	15 A	Body, Door, Standard Power	C/Reliability: Standardized, high-volume production.
2.8 mm (e.g., Power-Timer)	30 A	External Lighting, High-Load Fans	Reliability: High-current capacity where a fuse box terminal is not feasible.

3.2 Sealing and Environmental Protection

Design Requirement	Connector Status	Mandatory Usage and Rationale
Waterproof (Sealed)	$\geq$ IP54 (Required)	Mandatory for all Zone A (Engine Bay, Chassis) and Zone C (Wet Interior/Trunk).
Non-Waterproof (Unsealed)	IP40 (Allowed)	Allowed only in Zone B (Dry Cabin Interior). Cavity seals are prohibited.
Dummy Seals / Cavity Plugs	Mandatory	All unused cavities in sealed (waterproof) connectors ($\geq$ IP54) must be filled with a specified dummy seal.

3.3 Coding, Color, and Mating Features

*

- **Non-Interchangeability:** If two different connectors have identical size, pin-count, and keying on the same harness, their housing colors **must** be different.
- **Functional Color:** Connector color shall be used to signify functional systems (e.g., Yellow for SRS/Airbag; Blue for CAN/Diagnostics).
- **Measurement Direction (Probing):** All safety or diagnostic circuits must use connectors that allow for back-probing without damaging internal terminal retention features.
- **Tailored Connectors:** Use of custom-geometry connectors requires specific sign-off and must be minimized to support Cost Efficiency (C).

4. HARNESS PROTECTION, ROUTING, AND SHEATHING

4.1 Taping Strategy and Coverage

Taping selection is based on the required protection level, impacting Reliability and Cost Efficiency (C).

Taping Type	Definition and Application	Coverage Rule and Rationale
Spot Tape	Single wrap of PVC or PET tape.	**Mandatory Securement:** Spot tape must be applied every 250 mm of unsupported harness length to maintain bundle integrity (C).
Rough Tape (Overlap $\leq$ 20%)	Tape applied with minimal overlap, leaving some original wires exposed.	**W/C:** Used only in the dry cabin interior where only minor abrasion protection is required, optimizing weight.
Full Tape (Overlap 50%)	Standard overlap to fully cover all conductors and primary insulation.	**Mandatory Protection:** Required for all segments in Zone C (Wet/Under-seat) for full abrasion and splash protection.
Double Full Tape	Two full layers of tape (e.g., PVC over PET fleece).	**Reliability:** Mandatory for extreme abrasion points, high-stress areas (e.g., door hinge), or as a secondary seal around splices.
Branch Tape	Taping applied to the split point of a harness breakout.	Must extend a minimum of 50 mm down each branch leg to ensure strain relief and prevent the branch from opening.

4.2 Tube (Loom) Application and Type

Tubes provide the highest level of mechanical and thermal protection.

Tube Type	Sub-Type/Condition	Mandatory Usage Zone	Rationale
Corrugated Tube (PVC/PA - Split/Non-Slit)	Slit (General Use)	Zone A/C (Engine Bay, Chassis)	**Reliability:** Standard for high abrasion/heat. Slit tube is used for rework and easier harness loading.
Corrugated Tube (PVC/PA - Non-Slit)	Non-Slit (Sealing)	Zone C (Underbody)	**Reliability:** Mandatory for segments exposed to high-pressure wash or potential stone impingement to prevent wire escape.
Twist Tube (PET Braided)	Slit or Non-Slit	Zone B (Cabin)	**NVH/W:** Provides NVH damping and a lighter, more flexible protection for complex routing.

4.3 Grommets and Fixation

*

- **Grommets:** Mandatory application for **all** harness pass-throughs through any stamped, painted, or metal panel (e.g., firewall, body side, quarter panel). The grommet must be a custom-fit design that fully seals the aperture.
- **Tube Fixation:** *
  - **Tube Clips:** All tube segments must be secured with dedicated tube clips/holders. The maximum unsupported tube length is 300 mm.
  - **Tolerance for NVH:** Harnesses routed in NVH-sensitive areas must have an additional 5 mm slack added between clips to reduce noise transmission.

4.4 Tube Length Tolerances (Cutback)

The required tube length cutback (removal) from the terminal/connector face is critical for ensuring full connector mating and must be standardized for automated cutting processes (C).

Tube Type	Cutback Location	Cutback Length (Tolerance)	Rationale
Twist Tube	Near Connector/Branch Point	-10 mm	**C:** Ensures the connector latch is fully accessible and the tube does not interfere with the branch tape application.
Twist Tube	Standard Section (Mid-Run)	-20 mm	**W/C:** Standardized length reduction to save weight and material cost while maintaining coverage.
Corrugated Tube	Near Connector/Branch Point	-5 mm	**Reliability:** Minimal reduction to maximize abrasion protection right up to the connector strain relief.
Corrugated Tube	Standard Section (Mid-Run)	-10 mm	**W/C:** Standardized length reduction while prioritizing mechanical coverage.

5. CONTROL CIRCUIT LOGIC REFERENCE (Page 5 of 5)

5.1 Foundational Logic Gates and Definitions

Gate Name	Boolean Symbol	Output Rule
NOT (Inverter)	$\neg\mathbf{A}$ or $\bar{\mathbf{A}}$	Output is TRUE only if the single Input is FALSE.
AND	$\mathbf{A} \wedge \mathbf{B}$ or $\mathbf{A} \cdot \mathbf{B}$	Output is TRUE only if ALL Inputs are TRUE.
OR	$\mathbf{A} \vee \mathbf{B}$ or $\mathbf{A} + \mathbf{B}$	Output is TRUE if ANY Input is TRUE.
XOR (Exclusive OR)	$\mathbf{A} \oplus \mathbf{B}$	Output is TRUE only if the Inputs are DIFFERENT.

5.2 Control Circuit Application Mandates (The “When”)

The gate selection is mandatory based on the functional requirement of the circuit.

Logic Gate	Application Mandate (The “When”)	Example Automotive Circuit	Rationale for Usage
AND	Simultaneous Conditions: Requires two or more safety-critical inputs to be TRUE.	Wiper High Speed: Requires Wiper Stalk at High $\wedge$ Ignition ON.	Safety/Reliability: Ensures a function only operates when all prerequisites are met.
OR	Independent Conditions: Requires an action (Output) to occur if any one of several inputs is active.	Brake Light Activation: Brake Pedal Switch $\vee$ Parking Brake Sensor ON.	Functional: Provides multiple paths to activate a single output.
NOT	Inhibition/Disabling: Used to inhibit a function based on a single condition being asserted.	Starter Motor Disable: Key in Start $\rightarrow$ NOT(Engine Running Sensor TRUE).	Protection: Prevents an action (e.g., engaging the starter motor) when the condition is met.
XOR	Error/Disagreement Check: Used to monitor two redundant sensor signals that are expected to be identical.	Steering Angle Sensor (Dual Channel): Channel 1 $\oplus$ Channel 2.	SI/Safety: Identifies a single-channel failure in a critical component, triggering a DTC.

Appendix A – Design Responsibility Matrix

Design Element	Responsible Function	Validation Owner	Approval Stage
Wire Selection	Harness Design Engineering	Materials Engineering	DV (Design Validation)
Connector Type	System Architecture	Component Engineering	PV (Production Validation)
Logic Definition	Controls Engineering	Vehicle EE	Software Release
Routing & Packaging	Harness Packaging	Vehicle Integration	Prototype Sign-off

Appendix B – Abbreviations and Symbols

AEMS Aethel Mobility Systems
ECU Electronic Control Unit
SI Signal Integrity
W Weight Optimization
C Cost Efficiency
IP Ingress Protection
DTC Diagnostic Trouble Code

End of Specification – AEMS-WH-100 Rev. 1.0