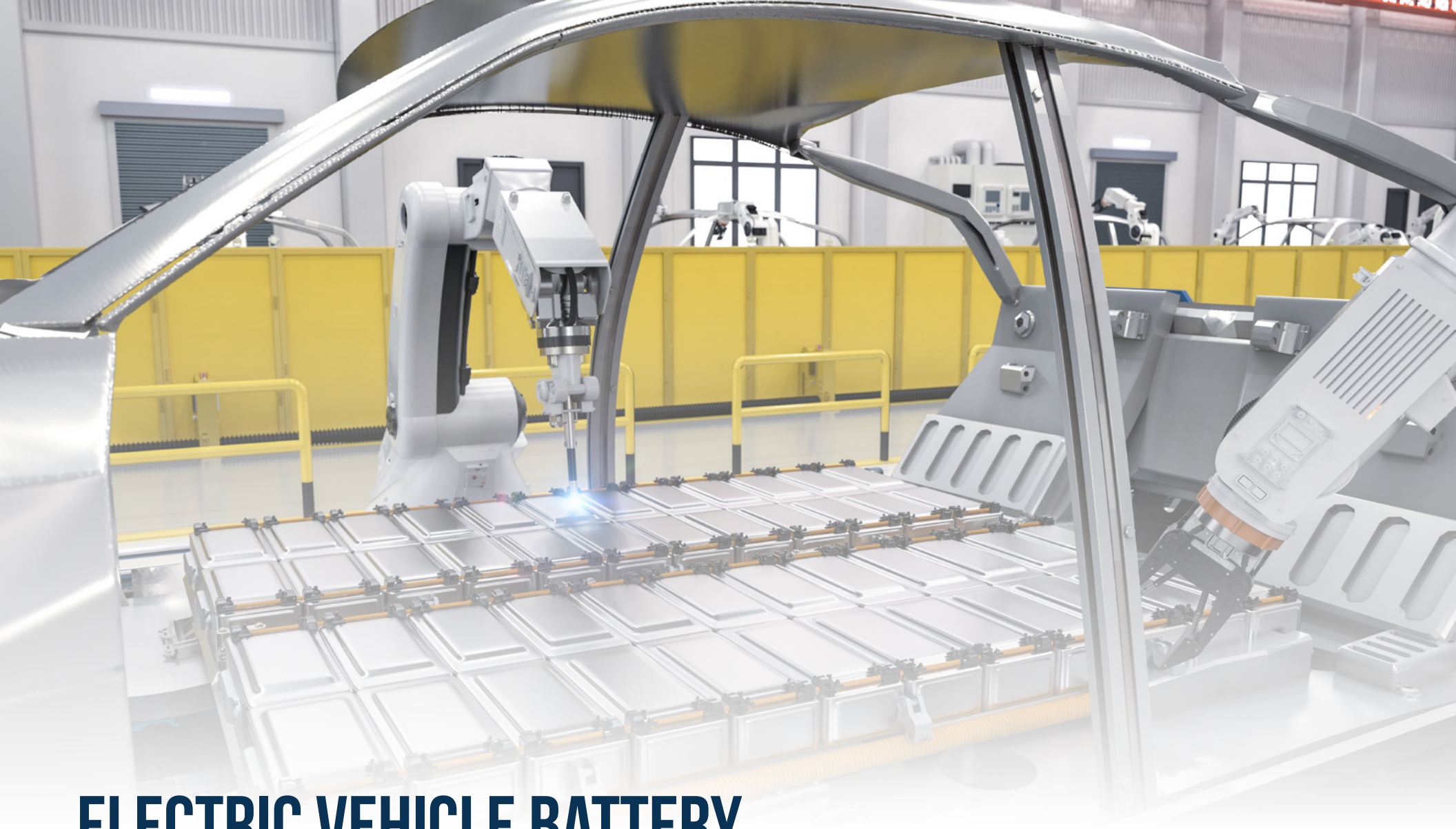

# ELECTRIC VEHICLE BATTERY PACKAGING AND ASSEMBLY

## BODY OF KNOWLEDGE

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# ELECTRIC VEHICLE BATTERY PACKAGING AND ASSEMBLY

BODY OF KNOWLEDGE 2024

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| **1. Fundamentals of Batteries** | | | **11%** |
| 1.1. Energy Storage Systems | High | Apply Knowledge & Analyze Information | |
| 1.2. History of Battery Technology | Medium | Remember and Understand | |
| 1.3. Future Scope | Medium | Remember and Understand | |
| 1.4. General Architecture | High | Apply Knowledge & Analyze Information | |
| 1.4.1. Battery Cell | | | |
| 1.4.2. Battery Module | | | |
| 1.4.3. Battery Pack | | | |
| 1.5. Battery Selection | Medium | Remember and Understand | |
| 1.5.1. Lithium Ion | High | Remember and Understand | |
| 1.5.2. Lithium Polymer | High | Remember and Understand | |
| **2. Commercial Battery Market** | | | **14%** |
| 2.1. Battery Technologies | High | Remember and Understand | |
| 2.2. Stress Factors | Medium | Remember and Understand | |
| 2.2.1. Temperature of the Cell | | | |
| 2.2.2. Energy consumption (discharging power) | | | |
| 2.2.3. Charging power | | | |
| 2.2.4. State of Charge (SOC) | | | |
| 2.3. Factor Tuning | Medium | Remember and Understand | |
| 2.3.1. Temperature | | | |
| 2.3.1.1. Air temperature | | | |
| 2.3.1.2. Heat generated within the Pack | | | |
| 2.4. Cell Component & Inspection | High | Apply Knowledge & Analyze Information | |
| 2.4.1. Cell capacity test | | | |
| 2.4.2. Cell voltage test | | | |
| 2.4.3. Cell internal resistance test | | | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 2.5. Cell Stack Assembly | High | Remember and Understand | |
| 2.5.1. Electrode manufacturing (mixing, coating, drying, calendering) | | | |
| 2.5.2. Cell assembly (slitting, final drying, cutting, winding or stacking, terminal welding, enclosing) | | | |
| 2.5.3. Cell finishing (filling, formation and sealing, ageing, final control checks) | | | |
| 2.6. Cell Types & Chemistries | High | Remember and Understand | |
| 2.6.1. Cylindrical cells | High | Remember and Understand | |
| 2.6.2. Prismatic cells | Medium | Remember and Understand | |
| 2.6.3. Pouch cells | Medium | Remember and Understand | |
| **3. Battery Pack Design** | | | **7%** |
| 3.1. Electrical Design | Medium | Remember and Understand | |
| 3.1.1. Electrical Connectors (busbars, wires, distribution conductors) | | | |
| 3.2. Mechanical Design | Medium | Remember and Understand | |
| 3.2.1. Sealing of the cell | | | |
| 3.2.2. Location of the positive and negative tabs | | | |
| 3.2.3. Venting Control | | | |
| 3.2.4. Controlled failure during thermal runaway | | | |
| 3.3. Thermal Design | Medium | Remember and Understand | |
| 3.3.1. Cooling | | | |
| 3.3.2. Heating | | | |
| 3.3.3. Insulation | | | |
| 3.3.4. Ventilation | | | |
| 3.4. Electronics Design | Medium | Remember and Understand | |
| 3.4.1. Charger (on/off board charger) | | | |
| 3.4.2. DC/DC | | | |
| 3.4.3. Motor Inverter DC/AC | | | |
| 3.4.4. Pulse width modulation (PWM) controlled DC | | | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 3.5. Battery Sizing | Medium | Remember and Understand | |
| 3.5.1. Usable Energy | | | |
| 3.5.2. Discharge Power | | | |
| 3.5.3. Working Voltage Range | | | |
| 3.6. Module Assembly | High | Apply Knowledge & Analyze Information | |
| 3.6.1. Cell inspection | | | |
| 3.6.2. Preassembly | | | |
| 3.6.3. Stacked cells | | | |
| 3.6.4. Connect cells inside the Module | | | |
| 3.6.5. BMS mounting | | | |
| 3.6.6. Cell stack placed into Module Housing | | | |
| 3.7. Cover Sealing and Joining | Medium | Apply Knowledge & Analyze Information | |
| 3.7.1. Upper cover | | | |
| 3.7.2. Bottom cover | | | |
| 3.7.3. Sealing gasket | | | |
| **4. Battery Management System** | | | **14%** |
| 4.1. Basics of the Battery Management System (BMS) | High | Remember and Understand | |
| 4.1.1. Power Management | | | |
| 4.1.2. HV Power Interface | | | |
| 4.1.3. Interface Battery BMS and Control Unit | | | |
| 4.1.4. Battery Management Unit | | | |
| 4.1.5. Control Unit | | | |
| 4.1.6. Wired Connectivity | | | |
| 4.2. Architecture | High | Remember and Understand | |
| 4.3. Fundamentals | High | Remember and Understand | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 4.4. BMS Communication | Medium | Remember and Understand | |
| 4.4.1 Cell Protection | | | |
| 4.4.2. Temerpature Control & Thermal Management | | | |
| 4.4.3. Charge and Discharge Control | | | |
| 4.4.4. Fault Diagnosis/Prognosis | | | |
| 4.4.5. Battery Cell Monitoring | | | |
| 4.4.6. Input/Output Current and Voltage Monitoring | | | |
| 4.4.7. Cell Balancing and Equalization | | | |
| 4.4.8. State Estimation | | | |
| 4.4.8.1. State of Charge (SOC) | | | |
| 4.4.8.2. State of Disequilibrium (SOD) | | | |
| 4.4.8.3. State of Health (SOH) | | | |
| 4.4.8.4. State of Function (SOF) | | | |
| 4.4.8.5. State of Residual Energy (SOR) | | | |
| 4.4.8.6. Remaining Useful Life (RUL) | | | |
| 4.4.9. Power Management Control | | | |
| 4.4.10. Network and Communciation | | | |
| 4.4.11. Data Acquisition/Storage | | | |
| 4.5. Battery State Determination | High | Apply Knowledge & Analyze Information | |
| 4.5.1. State of Charge (SOC) | | | |
| 4.5.2. State of Health (SOH) | | | |
| 4.5.3. State of Power (SOP) | | | |
| 4.5.4. State of Life (SOL) | | | |
| 4.6. User Interface | Medium | Remember and Understand | |
| 4.6.1. Fuel gauging | | | |
| 4.6.2. Communication | | | |
| 4.6.3. Data recording and reporting | | | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 4.7. Electrical Control | Medium | Remember and Understand | |
| 4.7.1. Set of Coils (creates the magnetic forces which provide torque) | | | |
| 4.7.2. Rotor or Armature (Mounted on bearings that turns inside the field) | | | |
| 4.7.8. Communicating device (reverses the magnetic forces and makes the armature turn providing horsepower) | | | |
| 4.8. Safety Protection | High | Apply Knowledge & Analyze Information | |
| 4.8.1. Sealed shells | | | |
| 4.8.2. Testing standards (overcharge, vibration, temperatures, short circuit, humidity, fire, collison, water immersion) | | | |
| 4.8.3. Current and voltage regulation | | | |
| 4.8.4. Thermal management | | | |
| 4.8.5. Fire protection | | | |
| **5. Control Theory** | | | **5%** |
| 5.1. Basics of Control Mechanism | High | Remember and Understand | |
| 5.1.1. Vehicle controller | | | |
| 5.1.2. Motor | | | |
| 5.1.3. Motor controller | | | |
| 5.1.4. Power battery | | | |
| 5.1.5. Power battery management system | | | |
| 5.1.6. Fault diagnosis management unit | | | |
| 5.1.7. Gearbox | | | |
| 5.1.8. Main reducer | | | |
| 5.1.9. Auxiliary system | | | |
| 5.2. Battery Failure Mechanisms | | | |
| 5.2.1. Extreme Temperatures | | | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 5.2.2. Irregular Use | | | |
| 5.2.3. Short Trips | | | |
| 5.2.4. Vehicle Age | High | Remember and Understand | |
| **6. Battery Safety and Disposal** | | | **5%** |
| 6.1. Fire Protection | High | Apply Knowledge & Analyze Information | |
| 6.1.1. Ceramic blanket | | | |
| 6.1.2. Mica sheets | | | |
| 6.1.3. Aerogels | | | |
| 6.1.4. Coatings | | | |
| 6.1.5. Encapsulats | | | |
| 6.1.6. Encapsulating foam | | | |
| 6.1.7. Compression pads (with fire protection properties) | | | |
| 6.2. Hazard and Risk Analysis | High | Apply Knowledge & Analyze Information | |
| 6.2.1. Electric shock | | | |
| 6.2.2. Uncontrolled increases in temperature and pressure (thermal runway) | | | |
| 6.2.3. Battery reignition/fire | | | |
| 6.3. Battery Handling, Storage, and Disposal | Medium | Remember and Understand | |
| 6.3.1. Smelting | | | |
| 6.3.2. Direct recovery | | | |
| 6.3.3. Intermediate processes | | | |
| 6.3.4 Waste Management Recylcing | | | |
| 6.3.5 Temperature Implications | | | |
| 6.3.6 Battery Storage | | | |
| **7. Battery Diagnostics** | | | **26%** |
| 7.1. Number of Charge Cycles | High | Remember and Understand | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| 7.2. Maximum and Minimum Voltage | High | Remember and Understand | |
| 7.3. Temperature Monitoring | High | Remember and Understand | |
| 7.3.1. Internal sensors | | | |
| 7.4. Discharging Currents | High | Remember and Understand | |
| 7.4.1. C-rate | | | |
| 7.5. Automated measurement of the pack's isolation resistance | High | Apply Knowledge & Analyze Information | |
| 7.6. Resistance | High | Remember and Understand | |
| 7.6.1. Internal Resistance | | | |
| 7.7. Battery Monitoring | High | Apply Knowledge & Analyze Information | |
| 7.7.1. Current | High | Remember and Understand | |
| 7.7.2. Voltage | High | Remember and Understand | |
| 7.7.3. Temperature | High | Remember and Understand | |
| 7.7.4. State of Charge (SOC) Measurement | | | |
| 7.11. Data Acquisition | Medium | Remember and Understand | |
| 7.11.1. Maximum discharge current | | | |
| 7.11.2. Discharge capacity | | | |
| 7.11.3. Maximum charge current | | | |
| 7.11.4. Charge capacity | | | |
| 7.12. Safety Protection | High | Apply Knowledge & Analyze Information | |
| 7.12.1. Overheat protection | | | |
| 7.12.2. Time-out protection | | | |
| 7.12.3. Protective cooling shroud | | | |
| 7.13. Thermal Management | Medium | Remember and Understand | |
| 7.13.1. Dividing the battery into small cells | | | |
| 7.13.2. Seperating fire-walls | | | |

| Topics | Importance | Competency | Weighting |
|---|---|---|---|
| **8. Charging Systems and Technology** | | | **18%** |
| 8.1. Charge Port | High | Remember and Understand | |
| 8.2. DC/DC Convertor | High | Evaluate Problems & Create Solutions | |
| 8.3. Onboard Charger | High | Evaluate Problems & Create Solutions | |
| 8.4. Thermal System (Cooling) | Medium | Evaluate Problems & Create Solutions | |
| 8.5. Transmission (Electric) | High | Evaluate Problems & Create Solutions | |
| 8.6. Full-Size Charger | Medium | Remember and Understand | |
| 8.7. Portable Charger | Medium | Remember and Understand | |
| 8.8. Level 1 Charging Station | High | Remember and Understand | |
| 8.9. Level 2 Charging Station | High | Remember and Understand | |
| 8.10. Level 3 Charging Station | High | Remember and Understand | |
| 8.11. Wireless Charging Station | Low | Remember and Understand | |