Comprehensive Guide to Lithium Battery Fires: Prevention and Control in the South African Context

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Compiled By Des Rielander - local References utilized as contained within the document are subject to further research and development.

Executive Summary

The rapid proliferation of lithium-ion battery technology across South Africa, driven by load-shedding, fuel costs, and the global shift toward electrification, has created unprecedented fire safety challenges. From residential backup power systems and solar installations to electric vehicles (EVs) and personal mobility devices, lithium-ion batteries now form a critical component of daily life. However, their unique fire characteristics—thermal runaway, toxic gas emissions, projectile risks, and re-ignition potential—demand specialized knowledge, detection, and suppression strategies.

This document provides a comprehensive overview of lithium battery fire types, behavior, prevention measures, and control strategies specifically tailored to the South African regulatory and operational environment. It incorporates the newly introduced ISO 3941:2026 Class L fire classification and addresses critical gaps in current South African standards.

Introduction

Lithium-ion batteries have revolutionized energy storage and mobility worldwide. In South Africa, their adoption has accelerated dramatically in response to persistent electricity supply challenges and the transition to renewable energy sources. Battery Energy Storage Systems (BESS), uninterruptible power supplies (UPS), electric vehicles, e-bikes, and countless portable devices all rely on this technology.

While lithium-ion batteries offer exceptional energy density and performance characteristics, they present distinct fire hazards that differ fundamentally from conventional combustible materials. Understanding these differences is essential for fire safety professionals, facility managers, building owners, and emergency responders [1][2].

Understanding Lithium-Ion Battery Technology

Battery Composition and Operation

Lithium-ion batteries consist of multiple electrochemical cells packaged together. Each cell contains:

- Positive electrode (cathode) - typically lithium metal oxide
- Negative electrode (anode) - typically graphite
- Electrolyte - organic liquid containing lithium salts
- Separator membrane - prevents internal short circuits
- Battery Management System (BMS) - monitors and controls cell operation

The electrolyte is highly flammable and stored under pressure within sealed cells. Modern batteries range from small cells in consumer devices to large format cells in EVs and energy storage systems[3].

Types of Lithium Batteries

Several lithium battery chemistries exist, each with different fire risk profiles:

Battery Type	Common Applications	Fire Risk Profile
Lithium Cobalt Oxide (LCO)	Smartphones, laptops, power tools	High energy density, higher thermal runaway risk
Lithium Nickel Manganese Cobalt (NMC)	Electric vehicles, power storage	Moderate risk, widely used
Lithium Iron Phosphate (LFP)	Solar storage, EVs, e-bikes	Lower thermal runaway risk, more stable
Lithium Nickel Cobalt Aluminum (NCA)	High-performance EVs	High energy density, requires robust BMS
Lithium Titanate (LTO)	Industrial applications	Lowest fire risk, lower energy density

Table 1: Common lithium-ion battery chemistries and risk profiles

Understanding battery chemistry helps assess risk levels in different applications. LFP batteries, increasingly popular in South African solar installations, offer improved thermal stability compared to older LCO and NMC chemistries[4].

The New Class L Fire Classification: ISO 3941:2026

Introduction of Class L Fires

In February 2026, ISO 3941:2026 was published, introducing a revolutionary change to fire classification systems worldwide. For the first time, lithium-ion battery fires are recognized as a distinct fire class: **Class L**[2].

This classification specifically addresses fires involving lithium-ion cells and batteries where no metallic lithium is present. The new standard acknowledges that lithium-ion battery fires exhibit unique behaviors that do not align with traditional fire classes (A, B, C, D, F/K).

Characteristics of Class L Fires

ISO 3941:2026 identifies specific hazardous behaviors associated with Class L fires:

- **Higher energy density** - leading to faster heat release rates and rapid fire growth independent of external oxygen supply
- **Thermal runaway propagation** - failure cascades from cell to cell in a domino effect
- **Toxic and flammable gas release** - venting produces explosive and corrosive gases
- **Explosion risk** - constrained build-up of vented gases can cause violent rupture
- **Limited access** - battery construction impedes direct suppression agent application
- **Projectile hazards** - cells can be expelled violently along with burning electrolyte
- **Stranded electrical energy** - creates persistent re-ignition risk even after apparent extinguishment
- **Directional jet flames** - focused high-temperature flames during venting events

These characteristics fundamentally differentiate Class L fires from traditional fire classes and necessitate specialized detection, suppression, and response strategies[2][3].

Implications for South Africa

The introduction of Class L fire classification has significant implications for:

- Fire risk assessments - requiring identification of lithium-ion battery presence, type, quantity, storage, and charging arrangements
- Detection and suppression system design - needing Class L-specific technologies
- Fire extinguisher selection and placement - requiring Class L-rated extinguishers
- Emergency response planning - accounting for unique hazards and re-ignition potential
- Insurance and liability considerations - recognizing distinct risk profiles
- Training requirements - educating personnel on Class L fire behavior and response

South African standards, particularly SANS 10400-T (fire protection in buildings) and SANS 1910 (portable fire extinguishers), currently lack comprehensive guidance on lithium-ion battery fires. The ISO 3941:2026 standard provides an international framework that South African authorities and fire safety professionals should adopt[5][6].

Thermal Runaway: The Core Hazard

What is Thermal Runaway?

Thermal runaway is the fundamental failure mechanism in lithium-ion batteries that leads to fires. It is a self-accelerating, exothermic (heat-producing) chemical reaction within a battery cell that, once initiated, becomes uncontrollable[7].

The thermal runaway process follows this sequence:

1. **Initiation** - A trigger event causes localized heating within a cell (internal short circuit, external heating, mechanical damage, overcharging, manufacturing defect)
2. **Temperature rise** - Internal temperature exceeds critical threshold (typically 80-130°C depending on chemistry)
3. **Separator breakdown** - The membrane separating anode and cathode fails, causing internal short circuit
4. **Electrolyte decomposition** - Flammable organic electrolyte begins breaking down, releasing heat and gases
5. **Gas generation and pressure build-up** - Pressure increases inside sealed cell
6. **Venting** - Safety vent opens, releasing flammable gases and electrolyte vapor (often with jet flame)
7. **Ignition** - Released gases ignite from heat, creating external flames
8. **Propagation** - Intense heat from first cell triggers thermal runaway in adjacent cells
9. **Cascading failure** - Process repeats through entire battery pack in domino effect

Once thermal runaway begins in a cell, it typically cannot be stopped—only managed and prevented from spreading[8].

Thermal Runaway Triggers

Common triggers for thermal runaway include:

Trigger Category	Specific Causes
Mechanical damage	Physical impact, crushing, penetration, vibration damage during transport
Electrical abuse	Overcharging, over-discharging, external short circuit, rapid charging, incompatible charger
Thermal abuse	Exposure to high ambient temperatures, inadequate ventilation, proximity to heat sources, fire exposure
Internal defects	Manufacturing defects, contamination, dendrite formation, separator degradation
Aging and degradation	End-of-life degradation, electrolyte breakdown, internal resistance increase

External fire exposure	Radiant heat from adjacent fires causing temperature rise

Table 2: Thermal runaway trigger mechanisms

Understanding these triggers is fundamental to developing effective prevention strategies[9].

Thermal Runaway Temperatures

Battery fires produce extreme temperatures:

- Initial thermal runaway onset: 80-130°C
- Peak cell temperatures during thermal runaway: 500-1,100°C
- Flame temperatures: 800-1,000°C
- Surface temperatures of burning battery packs: 400-800°C

These temperatures far exceed typical Class A fires (wood, paper) and can damage building structures, melt metals, and cause severe burns. Specialized suppression agents capable of rapid cooling are essential[10][11].

Fire Behavior and Hazards

Fire Development Characteristics

Class L fires exhibit distinct development patterns:

Rapid onset - Thermal runaway can progress from initiation to full involvement within seconds to minutes, providing minimal warning time.

Hidden fire development - Fire may initiate inside battery enclosures, obscured from visual detection until venting occurs.

Explosive venting - Sudden release of pressurized gases creates explosive events with projectile hazards.

Sustained burning - Even with suppression, stranded electrical energy can cause re-ignition hours or days later.

Cell-to-cell propagation - Sequential failure creates extended fire duration as each cell enters thermal runaway[3][8].

Toxic Gas Hazards

Lithium-ion battery fires release an exceptionally hazardous mixture of toxic gases:

- Carbon monoxide (CO) - colorless, odorless, highly toxic
- Hydrogen fluoride (HF) - extremely corrosive to lungs and tissues
- Hydrogen cyanide (HCN) - rapidly acting poison
- Phosphorus pentafluoride (PF_5) - highly toxic and corrosive

- Volatile organic compounds (VOCs) - from electrolyte combustion
- Particulate matter - toxic aerosols and smoke

These gases are far more toxic than typical combustion products. Hydrogen fluoride, in particular, causes severe respiratory injury even at low concentrations. Firefighters and building occupants face significant inhalation hazards, necessitating immediate evacuation and appropriate respiratory protection[12][13].

Physical Hazards

Beyond toxic gases, Class L fires present unique physical dangers:

Projectile ejection - Individual cells can be expelled violently from battery packs, traveling several meters with sufficient force to cause injury or ignite secondary fires[2].

Directed jet flames - Venting often produces focused, high-velocity flames that can extend 1-3 meters from the battery, igniting nearby combustibles.

Electrical shock hazard - Even during fire conditions, high-voltage battery systems (EVs, BESS) retain dangerous voltage levels, presenting electrocution risk to firefighters.

Structural damage - Extreme heat can compromise building structural elements, particularly steel reinforcement in concrete.

Explosion risk - In confined spaces with inadequate ventilation, accumulation of flammable vented gases creates explosion potential[14].

Fire Prevention Strategies

General Prevention Principles

Preventing lithium-ion battery fires requires a multi-layered approach addressing battery selection, installation, use, maintenance, and monitoring.

1. Quality Batteries and Equipment

- Purchase batteries and devices from reputable manufacturers with proper certifications
- Verify UL listing, CE marking, IEC 62133 compliance, UN 38.3 transport testing
- Avoid counterfeit or unbranded batteries, particularly from unverified online sources
- For South African applications, ensure compliance with SABS standards where applicable
- Request manufacturer documentation including safety data sheets and test reports

Quality control during manufacturing significantly reduces defect-related failures. Many documented fires involve cheap, uncertified batteries with inadequate safety features[15][16].

2. Battery Management Systems (BMS)

A robust BMS is essential for safe operation. Quality systems provide:

- Individual cell voltage monitoring and balancing
- Temperature monitoring at multiple points
- Current limiting to prevent overcharge and over-discharge
- Short circuit protection
- Thermal management coordination
- Communication protocols for system monitoring

Never bypass or disable BMS protections. Ensure BMS firmware is kept updated per manufacturer recommendations[17].

3. Environmental Controls

Maintain optimal operating conditions:

- Temperature range: 15-25°C optimal; avoid exceeding manufacturer specifications
- Humidity: 30-60% relative humidity; avoid condensation and excessive moisture
- Ventilation: Adequate airflow to dissipate heat; minimum air changes per hour per manufacturer specifications
- Protection from direct sunlight and radiant heat sources
- Clean environment free from conductive dust and corrosive atmospheres

South Africa's climate varies significantly by region. In hot climates (Limpopo, North West, Northern Cape), additional cooling measures may be necessary. In coastal regions (Western Cape, KwaZulu-Natal), humidity control and corrosion protection are priorities[18].

4. Physical Protection

Protect batteries from mechanical damage:

- Secure mounting preventing vibration and movement
- Impact-resistant enclosures for vulnerable installations
- Adequate spacing between battery units (minimum 10 cm recommended)
- Protection from vehicle traffic, equipment, and potential impact sources
- Proper packaging and handling during transport

Even minor physical damage can compromise internal cell structure, creating latent failure risks[19].

Electric Vehicle (EV) Fire Prevention

South Africa's EV adoption is accelerating, with charging infrastructure expanding across major cities. EV fire prevention focuses on charging practices, parking, and maintenance.

Charging Safety

- Use manufacturer-approved charging equipment only
- Install dedicated circuits with appropriate overcurrent protection
- Avoid extension cords; plug chargers directly into outlets

- Follow manufacturer charging specifications (voltage, amperage, duration)
- Do not charge in extreme temperatures (below 0°C or above 40°C)
- Monitor charging process; investigate any unusual heat, odors, or sounds
- Install charging stations away from building exits and combustible storage

For commercial charging installations in South Africa, consult SANS 10142-1 (wiring of premises) and manufacturer installation guidelines. Consider installing charging stations in open-air locations where fire smoke will disperse naturally[20][21].

EV Parking and Storage

- Where possible, park EVs outdoors or in well-ventilated areas
- If parking in enclosed garages, ensure adequate ventilation (mechanical exhaust recommended)
- Maintain separation from combustible storage and building exits
- Do not park EVs in basements or underground parking without specific fire protection measures
- Install smoke detection in enclosed EV parking areas
- Consider water mist or specialized suppression systems for large EV fleets

Some international jurisdictions are implementing minimum separation distances between EVs in enclosed parking. While South African regulations have not yet formalized these requirements, prudent practice suggests 3-meter minimum spacing between vehicles[22].

EV Maintenance

- Follow manufacturer maintenance schedules
- Have battery systems inspected by qualified technicians annually
- Address recall notices immediately
- Monitor battery health through vehicle diagnostics
- Replace damaged or degraded battery packs promptly
- Document battery service history

E-Bike and E-Scooter Fire Prevention

E-bikes and e-scooters have become increasingly popular for last-mile transportation and delivery services in South African cities. However, they represent significant fire risks, particularly due to aftermarket batteries and charging practices.

Battery and Charger Selection

- Use only manufacturer-supplied or explicitly approved batteries and chargers
- Never use aftermarket, counterfeit, or modified batteries
- Verify battery capacity matches original specifications; oversized batteries often lack proper safety features

- Replace damaged batteries immediately; never continue using swollen, dented, or leaking batteries
- Purchase replacement batteries from authorized dealers with warranty and certification documentation

Many documented e-bike fires in New York City, which faced an epidemic of such incidents, involved aftermarket batteries purchased to extend range. These batteries often lacked proper cell separation, BMS protections, and thermal management[23][24].

Charging Practices

- Never charge batteries unattended or overnight while sleeping
- Charge during daytime when occupants are awake and can monitor
- Do not charge near exits, stairs, or escape routes
- Charge on non-combustible surfaces (concrete, tile, metal) away from combustibles
- Unplug immediately upon reaching full charge; do not leave plugged in after charging complete
- Stop charging immediately if battery becomes hot, emits odors, or makes unusual sounds
- Never charge damaged batteries
- Avoid charging in extreme temperatures (below 0°C or above 35°C)
- Do not use extension cords; plug charger directly into wall outlet

For commercial delivery operations or e-bike rental services, establish dedicated charging areas with:

- Fire-rated separation from occupied spaces
- Smoke detection and alarm systems
- Automatic fire suppression (water mist or specialized systems)
- Non-combustible construction materials
- Adequate ventilation with mechanical exhaust
- Clear emergency procedures

Storage Safety

- Store e-bikes in well-ventilated areas, preferably outdoors or in detached structures
- If indoor storage is necessary, use areas with smoke detection and away from sleeping areas
- Do not store in stairwells, corridors, or exits
- Remove batteries from devices when storing for extended periods
- Store batteries at 40-60% charge for long-term storage (not fully charged or fully discharged)
- Keep batteries away from flammable materials, heat sources, and direct sunlight

Inspection and Maintenance

- Inspect batteries weekly for swelling, deformation, cracks, or leakage
- Check charging cables and connectors for damage
- Keep battery terminals clean and free from corrosion
- Protect batteries from physical impact during use and transport
- Replace batteries showing any signs of damage or abnormal behavior
- Maintain service records

Battery Storage Facility Fire Prevention

Large-scale lithium-ion battery storage—including BESS installations for solar systems, UPS rooms, and warehouse storage of batteries—requires comprehensive fire prevention measures.

Facility Design and Construction

International standards, particularly the International Fire Code (IFC) 2024 and NFPA 855, provide detailed guidance that exceeds current South African standards:

- 2-hour fire-rated separation between battery storage rooms and other building areas
- Non-combustible construction materials (Class A materials per SANS 10177)
- Dedicated fire compartments for battery storage
- Minimum separation distances: 3 meters between battery racks, 10 feet (3 m) between storage containers
- Maximum storage quantities per fire zone (IFC 2024 Section 320: 15 cubic feet per container group for large-scale storage)
- Fire-rated doors with self-closing mechanisms
- Multiple emergency exits meeting SANS 10400-T egress requirements

While SANS 10400-T addresses general building fire protection, it does not provide lithium battery-specific guidance. Facilities should reference IFC 2024 Section 1207 and NFPA 855 for current best practices[25][26].

Ventilation Requirements

Proper ventilation serves multiple critical functions:

- Heat dissipation during normal operation
- Dilution of off-gases during thermal events
- Reduction of flammable gas concentrations below explosive limits
- Removal of toxic gases to protect personnel

Ventilation system design considerations:

- Mechanical exhaust ventilation (natural ventilation insufficient for large installations)
- Minimum 5 air changes per hour during normal operation; 10+ air changes per hour for high-risk areas
- Emergency exhaust activation triggered by gas detection systems

- Exhaust discharge located away from air intakes, exits, and occupied areas
- Explosion-proof electrical components in hazardous areas
- Backup power for ventilation systems (UPS or generator)

Detection Systems

Early detection is critical for Class L fires. Multi-layered detection strategies provide redundancy:

Smoke Detection:

- Very Early Smoke Detection Apparatus (VESDA) or air-sampling systems provide earliest warning
- Conventional photoelectric smoke detectors as backup
- Detectors positioned according to SANS 10139 spacing requirements, adjusted for ceiling height and airflow patterns

Heat Detection:

- Rate-of-rise heat detectors sensitive to rapid temperature increases
- Fixed-temperature detectors as secondary indication
- Thermal imaging cameras for continuous monitoring in critical installations

Gas Detection:

- Carbon monoxide (CO) detectors
- Hydrogen (H2) detectors for early venting detection
- Multi-gas monitors in large facilities
- Alarm thresholds set according to manufacturer specifications and occupational exposure limits

Battery Monitoring Systems:

- Continuous cell voltage monitoring
- Temperature sensors on individual cells or modules
- BMS integration with building fire alarm systems
- Automated alerts for abnormal conditions (over-temperature, voltage deviation, charging anomalies)

All detection systems should integrate with building fire alarm panels and provide both local and remote notification[27].

Suppression Systems

While detection prevents fire development, suppression systems provide last-line protection:

Water-Based Systems:

Water remains the most effective cooling agent for lithium-ion battery fires but requires very special considerations:

- Water mist systems (preferred): fine droplets provide excellent cooling with minimal water damage; effective heat absorption; suitable for electrical environments when properly designed
- Automatic sprinkler systems: traditional sprinklers can control fires but require substantial water flow rates (3-5 times normal Class A densities); electrical isolation concerns must be addressed
- Deluge systems: provide rapid water application for high-hazard areas; require manual activation or specialized detection

Water application rates for lithium-ion battery protection typically range from 12-20 mm/min over the protected area, significantly higher than standard sprinkler densities[28].

Gaseous Suppression:

Gaseous agents have limited effectiveness for Class L fires due to thermal runaway's oxygen-independent nature:

- Inert gases (N_2, Ar): May suppress flames temporarily but cannot halt thermal runaway; primarily useful for preventing fire spread to adjacent areas
- Chemical agents (FM-200, Novec 1230): Limited cooling capacity; unable to stop cell-to-cell propagation
- $C_6F_{12}O$: Shows promise in recent testing but requires high concentrations

Gaseous systems should be considered supplementary, not primary, protection for lithium batteries[29].

Specialized Systems:

Emerging technologies specifically designed for Class L fires:

- Vermiculite-based agents: Encapsulate battery, prevent oxygen access, absorb heat; products like AVD Lithex gaining traction
- Aerosol suppression: Fine particle suppression combined with cooling agents
- Condensed aerosol systems: Solid aerosol generators producing fire-suppressing particles

Operational Controls

Administrative controls complement physical protection:

- Hot work permits required for any work near battery storage
- Restricted access to battery areas (authorized personnel only)
- Regular inspection schedules (weekly visual inspections, monthly detailed inspections, annual comprehensive assessments)
- Battery commissioning and decommissioning procedures
- Temperature and humidity monitoring with documented records
- Clear labeling of battery storage areas, voltages, and hazards
- Maintenance of minimum aisle widths for emergency access
- Prohibition of combustible storage in battery areas

Emergency Planning

Comprehensive emergency plans should address:

- Thermal runaway response procedures
- Evacuation protocols
- Emergency shutdown procedures
- Firefighter notification with specific hazard information
- Site plans indicating battery locations, quantities, and types
- Electrical isolation procedures
- Water supply information for firefighting
- Post-incident battery handling (damaged batteries remain hazardous for extended periods)

Plans should be coordinated with local fire departments and regularly exercised[30].

Consumer Device Safety

While smaller in scale, consumer devices (smartphones, laptops, tablets, power banks) cause numerous fires annually:

- Purchase certified devices from reputable manufacturers
- Use manufacturer-supplied chargers; avoid cheap third-party alternatives
- Do not charge devices under pillows, on beds, or near combustibles
- Remove devices from cases during charging if they become warm
- Do not leave devices charging unattended for extended periods
- Replace swollen or damaged batteries immediately
- Dispose of old batteries properly through designated recycling programs
- Do not transport damaged or recalled batteries

Fire Control and Suppression

Despite best prevention efforts, lithium-ion battery fires do occur. Effective response requires understanding unique suppression challenges and appropriate agent selection.

Suppression Challenges

Class L fires present exceptional suppression difficulties:

- Oxygen-independent combustion - thermal runaway continues without external oxygen, defeating smothering agents
- High energy density - enormous heat generation requires substantial cooling capacity
- Cell-to-cell propagation - suppressing visible flames does not prevent continued thermal runaway spread
- Limited access - battery enclosures prevent direct agent application to burning cells

- Re-ignition potential - stranded electrical energy causes re-ignition hours or days after apparent extinguishment
- Toxic environment - extreme hazards require respiratory protection, limiting firefighter exposure time
- Electrical hazards - high voltages complicate safe approach and agent selection

Traditional fire suppression focused on oxygen removal and flame extinction. For Class L fires, emphasis shifts to cooling and preventing propagation[31].

Suppression Agent Comparison

Agent Type	Advantages	Disadvantages	Effectiveness Rating
Water/Water Mist	Excellent cooling capacity, readily available, non-toxic, continuous supply possible	Electrical conductivity concerns, requires high flow rates, potential water damage	High (if adequate quantity applied)
Dry Chemical (ABC/BC)	Immediate flame knockdown, electrically non-conductive, portable extinguisher availability	No cooling capacity, cannot prevent re-ignition, residue damages electronics	Low (temporary only)
CO_2	Electrically safe, no residue, available in portable and fixed systems	No cooling capacity, cannot stop thermal runaway, asphyxiation hazard	Very Low
Clean Agents (FM-200, Novec)	Electrically safe, minimal residue, fast deployment	Insufficient cooling, high cost, cannot stop thermal runaway	Very Low
Vermiculite-Based (AVD Lithex, SafeQuip products)	Encapsulation prevents propagation, cooling effect, prevents re-ignition, portable extinguisher format	Limited availability, requires direct application, cost	High (when accessible)
F-500 Additive + Water	Enhanced cooling, surfactant improves penetration, reduces water quantity needed	Requires specialized equipment, agent cost, limited South African availability	High

Table 3: Comparison of fire suppression agents for Class L fires

Research consistently demonstrates that water-based suppression with adequate cooling capacity provides the most effective control of lithium-ion battery fires[28][29][32].

Portable Fire Extinguisher Selection

For South Africa: SANS 1910 governs portable fire extinguisher requirements. However, as of February 2026, no lithium-ion fire extinguishers were yet approved under SANS 1910, though SafeQuip was in final certification stages with BSI for a vermiculite-based extinguisher[33]. This has yet to be confirmed

Current recommendations:

A Small Lithium Fire Should not be attempted without proper breathing apparatus / Controlled PPE safety considerations / Expert training on this aspect.

- For small lithium battery fires (consumer devices): Class ABC dry chemical extinguishers provide immediate flame suppression but cannot prevent re-ignition; follow with water application once electrical hazard is managed
- For e-bikes and larger batteries: Water-based extinguishers (water mist type preferred) with minimum 6-liter capacity; apply continuously until battery temperature drops below 80°C
- For EV and BESS facilities: Specialized Class L extinguishers (vermiculite or F-500 based) when available; otherwise, establish hose stations with adequate water supply
- Water-based extinguishers rated for electrical fires (appropriate voltage rating) are preferred over dry chemical for lithium fires

Emerging South African solutions:

- FlameBlock Lithium Black: 6-liter specialized extinguisher capable of reducing battery temperature from 1,100°C to 80°C in under 30 seconds; prevents re-ignition and contains toxic gases[10]
- AVD Lithex (through SafeQuip): Vermiculite-based technology with cooling, encapsulation, and re-ignition prevention; approaching SANS 1910 approval[33]
- Fire blankets: Specialized high-temperature blankets (rated >1,000°C) for containment of small battery fires until self-extinguishment

Installation of appropriate extinguishers should follow SANS 10139 placement guidelines, with additional units located specifically at charging stations and battery storage areas[34].

Firefighting Tactics

Professional firefighter response to lithium-ion battery fires differs significantly from conventional structure fire operations:

Initial Response

1. Establish command and assess situation
2. Identify battery type, quantity, and voltage if possible
3. Evacuate all personnel from immediate area (minimum 30 meters for large batteries)
4. Establish hot, warm, and cold zones
5. Don full PPE including SCBA (mandatory - toxic gas hazards)
6. Approach from upwind position

7. Establish water supply (substantial quantity required)

Suppression Operations

For small batteries (consumer devices, e-bikes):

- Use water from handline or portable extinguisher
- Apply water directly to battery if accessible
- Continue application until temperature drops below 80°C (use thermal imaging camera)
- Move burning device to exterior location if safely possible
- Monitor for re-ignition for minimum 24 hours

For large batteries (EVs, BESS):

- Establish multiple handlines with copious water supply
- Apply large volumes of water (potentially thousands of liters for EV fires)
- Focus cooling on battery compartment; water must reach battery cells
- For EVs, firefighting may require 20,000-40,000 liters over several hours
- Maintain continuous application; thermal runaway can resume if cooling stops
- Consider specialized tactics: drilling access holes in EV battery compartments, using thermal lance techniques, submersion in containers
- Monitor temperature continuously with thermal imaging
- Be prepared for extended operations (EV fires have burned for 24+ hours)

Safety Considerations

- Electrical isolation: Attempt to de-energize systems if safely accessible, but assume batteries remain energized
- Projectile hazards: Maintain safe distance during active venting; protect personnel with shielding
- Structural collapse: Extreme heat can compromise building structure; establish collapse zones
- Toxic atmosphere: Maintain SCBA use at all times; establish decontamination procedures
- Water runoff: Contaminated runoff contains toxic compounds; contain if possible and notify environmental authorities
- Post-fire handling: Batteries remain hazardous after fire; do not approach without thermal monitoring

Post-Incident Considerations

- Establish 24-hour fire watch with thermal monitoring
- Isolate damaged batteries in open areas away from structures
- Do not move damaged batteries without thermal monitoring showing <60°C

- Store in containers with sand or vermiculite if available
- Submerge in water tanks if available (suitable for EVs)
- Coordinate with battery manufacturer for disposal guidance
- Document incident details for investigation
- Provide medical surveillance for personnel exposed to toxic gases

South African Regulatory Context and Gaps

Current South African Standards

Several South African National Standards (SANS) relate to fire safety but lack specific lithium-ion battery guidance:

SANS 10400-T (Fire Protection in Buildings):

- Addresses general building fire protection requirements
- Does not specifically address lithium battery storage or Class L fires
- Fire-resistance ratings and compartmentation requirements apply but lack battery-specific guidance

SANS 1910 (Portable Fire Extinguishers):

- Revised in November 2022 to enable water-based extinguishing agents
- As of February 2026, no lithium-ion fire extinguishers yet approved under this standard
- Certification processes underway for specialized products[33]

SANS 10139 (Fire Detection and Alarm Systems):

- Provides general detection system design requirements
- Does not address specific detection strategies for lithium battery fires
- Smoke control wiring standards apply (your organization's expertise area)

SANS 10142-1 (Wiring of Premises):

- Governs electrical installations including EV charging stations
- Limited specific guidance on lithium battery installation requirements

SANS 10089 (Energy Efficiency in Buildings):

- Relevant to battery storage systems supporting renewable energy
- Does not address fire safety aspects

Regulatory Gaps

South African fire safety regulations lag behind international standards in several critical areas:

1. **Lack of Class L fire recognition** - ISO 3941:2026 classification not yet incorporated into South African standards
2. **Limited battery-specific construction requirements** - IFC 2024 and NFPA 855 provide detailed guidance absent in SANS standards
3. **Inadequate suppression system specifications** - No guidance on water application rates, specialized systems for Class L fires
4. **Minimal EV parking and charging regulations** - Growing EV adoption not matched by regulatory framework
5. **Absence of BESS-specific standards** - Rapid expansion of battery energy storage systems in response to load-shedding lacks corresponding safety framework
6. **Limited enforcement mechanisms** - Installation standards often not enforced, particularly for residential and small commercial applications

International Standards Reference

Until South African standards are updated, fire safety professionals should reference:

- ISO 3941:2026 - Classification of Fires (Class L definition)
- IFC 2024 - International Fire Code, Sections 320, 403.10.6, 1207 (battery storage)
- NFPA 855 - Standard for Installation of Stationary Energy Storage Systems
- UL 9540 - Energy Storage Systems and Equipment (safety testing)
- UL 9540A - Test Method for Evaluating Thermal Runaway Fire Propagation
- IEC 62619 - Secondary Cells and Batteries Containing Alkaline or Other Non-Acid Electrolytes (safety requirements for lithium batteries)
- UN 38.3 - Transport of Dangerous Goods, Lithium Battery Testing

These international standards represent current best practices and should inform risk assessments, system designs, and emergency planning in South Africa[35][36].

Recommendations for South African Fire Safety Professionals

1. Conduct lithium-ion battery risk assessments using international standards as guidance
2. Specify Class L fire protection measures in fire safety plans and risk assessments
3. Advocate for SANS standards updates incorporating ISO 3941:2026 and IFC/NFPA guidance
4. Engage with local authorities having jurisdiction to raise awareness of unique Class L fire hazards
5. Provide training to facility managers, building owners, and occupants on lithium battery fire risks

6. Coordinate with fire departments to ensure they are aware of lithium battery locations and hazards
7. Stay current with evolving technology, standards, and best practices
8. Document incidents and near-misses to build South African-specific knowledge base

Case Studies and Lessons Learned

International EV Fire Incidents

Multiple documented EV fires have demonstrated unique challenges:

Tesla Model S fires (various locations, 2013-present):

- Several incidents involved high-speed impacts with road debris penetrating battery compartments
- Fires required 30,000+ liters of water over 3-6 hours to fully extinguish
- Re-ignition occurred up to 24 hours after initial suppression
- Demonstrated need for extended fire watch and specialized storage of damaged EVs

Cargo ship fires (Felicity Ace, 2022; Fremantle Highway, 2023):

- EV batteries in transport contributed to uncontrollable fires
- Limited water supply on ships prevented effective battery cooling
- Toxic gas accumulation created life-threatening conditions
- Highlighted transport and storage concentration risks

BESS Fire Incidents

Arizona Public Service BESS fire (2019):

- Battery energy storage system experienced thermal runaway
- Deflagration (explosion) occurred when firefighters entered facility, causing injuries
- Investigation revealed inadequate off-gas detection and ventilation
- Led to significant updates in NFPA 855 standard

South Korean BESS fires (2017-2019, multiple incidents):

- Over 25 fires in battery storage installations
- Causes included manufacturing defects, inadequate BMS protection, and environmental factors
- Prompted comprehensive review of installation requirements and safety systems

E-Bike and E-Scooter Fires

New York City e-bike fire epidemic (2022-2023):

- Over 200 fires in two years, causing multiple fatalities

- Most incidents involved aftermarket batteries used by delivery workers
- Fires occurred predominantly during charging in residential buildings
- Led to legislation banning non-certified batteries and requiring safe charging stations

London Fire Brigade reports:

- E-bike and e-scooter fires increased 78% year-over-year
- Charging was identified as highest-risk activity
- Blocking of exit routes during charging contributed to escape difficulties

Key Lessons for South Africa

1. Water supply is critical - facilities with lithium battery installations need adequate water supply for extended firefighting operations
2. Early detection saves lives - investment in multi-layered detection systems provides crucial early warning
3. Regulatory oversight prevents tragedies - uncertified batteries and improper installations create unacceptable risks
4. Emergency planning is essential - coordinated response with fire departments familiar with Class L fire hazards dramatically improves outcomes
5. Re-ignition is the norm, not the exception - post-fire monitoring and safe storage of damaged batteries must be planned
6. Concentration creates risk - multiple battery systems in confined spaces amplify hazards

Training and Competency Requirements

For Fire Safety Professionals

Fire safety assessors and consultants should develop competency in:

- Class L fire characteristics and behavior
- Thermal runaway mechanisms and triggers
- Lithium-ion battery types and chemistries
- International standards (ISO 3941:2026, IFC 2024, NFPA 855)
- Detection and suppression system design for Class L fires
- Risk assessment methodologies specific to battery installations
- Emergency planning and coordination with emergency services

For Building Owners and Facility Managers

Facility management personnel should receive training on:

- Lithium battery fire risks in their specific facilities
- Inspection procedures for battery systems
- Early warning signs of battery failure
- Emergency response procedures
- Evacuation protocols
- Coordination with emergency services

For Firefighters

Emergency response personnel require specialized training including:

- Class L fire behavior and hazards
- Identification of lithium battery installations
- Tactical considerations for battery fires
- Water application techniques and requirements
- Electrical hazards and isolation procedures
- Toxic gas hazards and decontamination
- Post-incident battery handling

For General Public

Public education campaigns should address:

- Safe charging practices for consumer devices
- E-bike and e-scooter battery safety
- Recognition of battery failure warning signs
- Proper disposal and recycling of batteries
- Emergency response (when to evacuate, when to attempt extinguishment)

Future Trends and Emerging Technologies

Battery Technology Evolution

Next-generation battery chemistries promise improved safety:

Solid-state batteries:

- Replace liquid electrolyte with solid material
- Significantly reduced fire risk
- Still in development; commercial availability 5-10 years

Lithium Iron Phosphate (LFP) adoption:

- Lower energy density but improved thermal stability
- Increasing market share in EVs and stationary storage
- Reduced but not eliminated fire risk

Sodium-ion batteries:

- Alternative to lithium with reduced fire hazard
- Lower performance but improving
- Potential future option for stationary storage

Fire Protection Technology Advances

- Cell-level thermal monitoring and intervention systems
- AI-based predictive failure detection
- Advanced suppression agents optimized for Class L fires
- Modular containment systems preventing cell-to-cell propagation
- Improved BMS with enhanced safety algorithms

Regulatory Development

Expected developments in coming years:

- South African adoption of ISO 3941:2026 Class L classification
- Updates to SANS 10400 incorporating battery-specific requirements
- Development of national standards for BESS installations
- EV parking and charging infrastructure regulations
- Mandatory certification requirements for lithium batteries sold in South Africa
- Enhanced enforcement of existing standards

Conclusion

Lithium-ion battery technology has become integral to South African infrastructure, transportation, and daily life. The benefits—reliable backup power during load-shedding, reduced transportation emissions, portable energy storage—are substantial. However, these benefits come with unique and significant fire risks that differ fundamentally from traditional fire hazards.

The introduction of ISO 3941:2026's Class L fire classification represents a critical milestone in recognizing lithium-ion battery fires as a distinct hazard requiring specialized detection, suppression, and response strategies. South African fire safety professionals must embrace this classification and advocate for its incorporation into national standards and practices.

Effective lithium battery fire safety requires a comprehensive approach:

- Risk-based assessment identifying battery presence, type, quantity, and configuration
- Quality equipment selection with proper certifications and safety features

- Proper installation following international best practices where South African standards are silent
- Robust environmental controls and physical protection
- Multi-layered detection systems providing early warning
- Appropriate suppression systems emphasizing cooling capacity
- Comprehensive emergency planning coordinated with emergency services
- Ongoing inspection, maintenance, and monitoring
- Training for all stakeholders from fire safety professionals to end users

As South Africa continues its transition to renewable energy and electric mobility, the prevalence of lithium-ion batteries will only increase. Fire safety professionals bear responsibility for staying current with evolving technology, advocating for updated standards, and implementing best practices that protect lives and property.

The knowledge and practices outlined in this document provide a foundation for managing lithium battery fire risks in the South African context. However, this is a rapidly evolving field. Continued education, information sharing, and collaboration between fire safety professionals, regulators, industry, and emergency services will be essential to ensure safe integration of this transformative technology into South Africa's future.

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