Blue Film Wrapping & Laser Marking Process Qualification Guide for Prismatic Battery Cells

Applications: Prismatic cell insulation lines, blue film wrapping stations, laser marking for cell traceability
Target audience: Process engineers, quality engineers, MES integration engineers

1. Introduction

Blue film wrapping and laser marking are the first two process steps after cell formation and before module assembly. They appear simple compared to laser welding or EOL testing, but they generate the highest scrap rate of any pre-assembly station when poorly executed. Delaminated film causes short-circuit risk during module stacking. Unreadable traceability codes fail incoming inspection at OEM customers and break the EU Battery Passport data chain.

This application note provides the process parameters, qualification protocols, and equipment selection criteria for blue film wrapping and laser marking of prismatic LFP cells from 50Ah to 587Ah. The data is drawn from 25+ insulation and marking lines deployed between 2023 and 2026.

2. Blue Film Wrapping Process

2.1 Film Material Specification

Parameter	PET Film (Standard)	PI Film (High-Temp)
Material	Polyethylene terephthalate	Polyimide
Thickness	0.15–0.20 mm	0.10–0.15 mm
Dielectric strength	≥ 4 kV/0.1mm	≥ 6 kV/0.1mm
Operating temperature	−40 to 85 °C	−40 to 200 °C
Tensile strength	≥ 150 MPa	≥ 180 MPa
Adhesive type	Acrylic pressure-sensitive	Silicone pressure-sensitive
Peel strength	≥ 2.0 N/cm	≥ 2.5 N/cm
Recommended for	ESS modules, standard EV	High-discharge EV, fast-charge cells

2.2 Wrapping Process Parameters

Parameter	Specification
Film overlap	5–10 mm (single-wrap), 100% overlap for double-wrap

Parameter	Specification
Wrapping tension	2–5 N (constant, servo-controlled)
Edge margin	≥ 2 mm from cell terminal face
Terminal area clearance	No film on terminal welding surface (±0.5 mm)
Speed	12–20 PPM (cells per minute)
Bubble detection	Inline vision inspection, reject if bubble > 2 mm diameter
Adhesion verification	Inline peel test sampling: 1 per 100 cells

CRITICAL

Film overlap must not cover the terminal welding area. Even 0.5 mm of film overhang on the terminal surface will cause laser welding contamination, producing porosity and incomplete fusion. The #1 cause of busbar weld defects traced to upstream process is film overhang.

2.3 Wrapping Quality Defects

Defect	Visual Indicator	Root Cause	Corrective Action
Air bubbles	Visible pockets between film and cell surface	Uneven tension, dirty roller, or warped cell	Check roller cleanliness; verify tension consistency ±0.5 N
Film overhang on terminal	Film extends beyond cell body onto terminal face	Cutting blade misalignment or cell positioning error	Recalibrate blade position; verify cell locating fixture
Edge lifting (peeling)	Film edge not adhered, visible gap	Insufficient adhesive activation or low peel strength	Check film batch certification; increase pre-wrap heating to 40 °C
Wrinkles	Film not flat, creased appearance	Excessive tension or misaligned feed path	Reduce tension to 2–3 N; check film feed alignment
Incomplete wrap	Film does not fully cover cell body	Film length calculation error or cell size variation	Verify cell dimensions; adjust film cut length +5 mm safety margin

3. Laser Marking Process

After blue film wrapping, each cell receives a traceability code—typically a Data Matrix Code (DMC)—that binds the cell to MES production records. This code is the foundation of EU Battery Passport compliance and downstream module-level traceability.

3.1 Laser Source Selection by Wavelength

Laser Type	Wavelength	Mark Quality on Blue Film	Equipment Cost	Recommended
UV (355 nm)	355 nm	Excellent — cold ablation, no thermal damage	$$$	✅ Yes (new lines)
Green (532 nm)	532 nm	Very good — minimal heat input	$$	✅ Yes (budget permitting)
Fiber IR (1064 nm)	1064 nm	Acceptable — requires tight parameter control	$	⚠️ Existing lines only

> **RECOMMENDATION**
> For new lines in 2026, UV or green laser is recommended. The tighter process window and elimination of thermal damage risk justify the higher equipment cost. For existing fiber IR infrastructure, the process window can be maintained with proper parameter qualification—but expect higher scrap rates (0.5–1.0% vs <0.1% for UV).

3.2 Marking Parameter Windows

Parameter	UV Laser (355 nm)	Fiber IR (1064 nm)
Power	3–8 W	10–20 W
Scan speed	200–800 mm/s	300–1000 mm/s
Pulse frequency	20–80 kHz	20–100 kHz
Beam spot diameter	15–30 µm	30–50 µm
M^2 (beam quality)	≤ 1.3	≤ 1.5
Mark depth on film	5–15 µm (surface ablation)	10–30 µm (thermal)
Code size (DMC 16×16)	5×5 mm minimum	5×5 mm minimum
Recommended code size	8×8 mm (20×20 module)	8×8 mm (20×20 module)

3.3 Qualification Matrix Protocol

Before production release, a formal qualification matrix must be executed. The minimum matrix is a 5×5 grid of power and scan speed combinations at the nominal pulse frequency.

Pass/Fail Criteria	Specification	Test Method
Film adhesion post-marking	Peel strength ≥ 2.0 N/cm	180° peel test per ASTM D903
Code readability	Barcode grade ≥ C (ISO/IEC 15416) or DMC grade ≥ B (AIM DPM)	Inline vision verification
Film integrity	No delamination, no burn-through	Visual inspection + cross-section
Cell housing damage	No visible thermal mark on cell surface beneath film	Remove film, inspect cell surface
Dielectric strength retention	≥ 4 kV/0.1mm after marking	Hi-Pot test on marked area

> **CRITICAL**
> Dielectric strength must be re-tested after marking. A mark that looks good visually but compromises the film's insulation function will cause short circuits during module stacking. This test is frequently omitted and is the #2 cause of field short-circuit returns traced to marking process.

3.4 Code Content for EU Battery Passport Compliance

Each cell code must encode the following minimum data fields for EU Battery Passport (EU 2023/1542) compliance:

Field	Example	Required
Cell serial number	HY280-20260814-00001	✅ Mandatory
Manufacturer ID	HUIYAO	✅ Mandatory
Cell model	280Ah-LFP-VDA	✅ Mandatory
Production date	2026-08-14	✅ Mandatory
Batch/lot number	B20260814-A	✅ Mandatory
Chemistry identifier	LFP	✅ Mandatory
Carbon footprint (gCO_2e/kWh)	To be added per EU regulation	⚠️ Phase-in by 2027

4. Equipment Selection Criteria

4.1 Blue Film Wrapping Machine

Parameter	Specification
Throughput	12–20 PPM
Cell size range	50Ah to 587Ah prismatic (servo-adjustable)
Film tension control	Servo-driven, ±0.5 N accuracy
Vision inspection	Inline: bubble detection, overlap verification, terminal clearance check
Changeover time	≤ 15 min between cell formats
MES integration	Cell serial number binding with film batch number
Reject mechanism	Automatic divert to NG bin for failed inspection

4.2 Laser Marking Station

Parameter	Specification
Laser source	UV 355 nm (preferred) or green 532 nm
Beam quality (M^2)	≤ 1.3
Galvo repeatability	≤ ±5 µm
Post-mark vision	Inline code reading and grading (every cell)
Fume extraction	PET ablation filtration, HEPA + activated carbon
MES data binding	Code content → cell serial → MES record, verified before pass
Reject mechanism	Auto-divert if code grade < B or read failure

5. Design Example: 280Ah Cell Insulation & Marking Line

Project: European ESS cell preparation line, 280Ah LFP, 15 PPM throughput, EU Battery Passport compliance required.

Station	Equipment	Throughput	Yield
Cell incoming inspection	OCV/IR tester + dimension check	15 PPM	99.8%
Blue film wrapping	Servo wrapping machine, PET 0.15mm	15 PPM	99.5%
Laser marking	UV 355 nm, 5W, inline DMC verification	15 PPM	99.9%

Station	Equipment	Throughput	Yield
Post-mark inspection	Vision + peel test sampling (1/100)	Inline	—
Combined		**15 PPM**	**99.2% (combined)**

Results after 3 months of production:

Metric	Result
Film wrapping scrap rate	0.3%
Marking scrap rate	0.05%
DMC grade distribution	A: 78%, B: 19%, C: 3%
Film overhang on terminal	0 incidents (vision caught 2 in first week)
Dielectric test failures post-mark	0 in 45,000 cells

KEY DECISION

UV laser was selected over fiber IR despite 3x equipment cost. The 0.05% marking scrap rate vs typical 0.5–1.0% for fiber IR paid back the cost difference in 8 months at 15 PPM throughput. Zero dielectric failures confirmed no thermal damage to film.

6. Production Qualification Checklist

Blue Film Wrapping

- ☐ Film batch certificate verified (material, thickness, peel strength)
- ☐ Wrapping tension calibrated (±0.5 N)
- ☐ Vision inspection active (bubble, overlap, terminal clearance)
- ☐ Peel test sampling plan established (1 per 100 cells)
- ☐ Changeover procedure documented for each cell format
- ☐ MES binding: cell serial ↔ film batch number

Laser Marking

- ☐ 5×5 qualification matrix completed and approved
- ☐ DMC code content verified for EU Battery Passport fields
- ☐ Inline vision grading active (every cell, grade ≥ B required)
- ☐ Dielectric strength test passed on marked samples
- ☐ Fume extraction system operational and filtered
- ☐ MES binding: code content → cell serial → production record
- ☐ Reject bin monitoring: scrap rate trended daily

About Huiyao Laser

Huiyao Laser Technology (Luoyang) Co., Ltd. manufactures blue film wrapping equipment, laser marking stations, and integrated cell preparation lines for prismatic battery production. Our application engineering team provides on-site process

qualification and parameter validation for customer-specific cell formats and film materials.

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DOCUMENT VERSION HISTORY

Rev.	Date	Author	Changes
A	2026-08-14	Application Engineering Team	Initial release. Content derived from blog article *blue-film-laser-marking-battery-cells-process-guide-2026* and 25+ insulation/marking line commissioning data (2023–2026).

Production Log: Source: HTML → PDF via Playwright (Chromium headless). Template: HY-AN-004 Rev. A. Content derived from blog article *blue-film-laser-marking-battery-cells-process-guide-2026* (W21). Reviewed by: Application Engineering Team. Next scheduled review: 2027-08 or upon new EU Battery Passport implementation guidance.