HY-AN-003
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Classification: Public

Prismatic Module Compression Force & Steel Band Binding Specification

Applications: ESS prismatic module assembly, EV prismatic pack production, 280Ah / 314Ah / 587Ah LFP modules
Target audience: Module design engineers, process engineers, fixture designers

1. Introduction

Prismatic LFP cells swell. A 280Ah cell expands 0.8–2.0% over its service life depending on cycle depth, C-rate, and operating temperature. In a 1P16S module with 16 cells, unmanaged swelling produces 3–8 mm of cumulative dimensional change—enough to delaminate thermal interface material, break busbar welds, and crack end plates.

The compression system—end plates, steel bands, and pre-load force—is the structural defense against swelling. Getting it wrong does not cause immediate failure. It causes capacity fade after 500–1000 cycles, which is far more expensive because the packs are already in the field.

This application note provides validated compression force specifications, steel band selection criteria, and fixture design parameters for prismatic battery modules from 50Ah to 587Ah.

2. The Pre-Load Force Equation

The required pre-load force (P-L Force) is not a fixed number. It depends on the module's structural stiffness and the cell's swelling characteristics.

Equation 1: Required Pre-Load Force

$$F_{PL} = k_{module} \times \Delta h_{max} \times n_{cells}$$

where k_{module} = stiffness coefficient (N/mm), Δh_{max} = max single-cell swelling (mm)

Variable	Description	Typical Range
F_{PL}	Required module pre-load force	15–25 kN (280Ah), 30–50 kN (587Ah)
k_{module}	Stiffness coefficient of module structure	500–2000 N/mm (depends on end plate thickness, band tension)
Δh_{max}	Maximum single-cell swelling over lifecycle	0.3–1.0 mm (LFP), 0.5–1.5 mm (NCM)
n_{cells}	Number of cells in module	8–26 (typical ESS modules)

CRITICAL
Pre-load force must be applied *during* the welding process, not after. Welding busbars on a module that is not under compression produces joints that will crack when the module is subsequently compressed. This is the #1 cause of busbar weld failure in field returns.

3. Steel Band Binding Specification

Steel bands (also called binding straps or compression bands) maintain module compression after the assembly fixture releases. The band material, width, thickness, and tension must be specified together.

3.1 Band Material Selection

Material	Tensile Strength	Corrosion Resistance	Recommended For
SUS304 stainless steel	520–720 MPa	Excellent	Outdoor BESS, humid environments, all ESS modules
SUS201 stainless steel	520–680 MPa	Moderate (pitting in coastal)	Indoor C&I, dry environments, cost-sensitive projects
Galvanized carbon steel	400–550 MPa	Poor once coating damaged	Not recommended for battery modules
Composite (PET + fiber)	600–800 MPa	Excellent	Weight-sensitive EV modules, non-conductive requirement

3.2 Band Dimensions and Tension by Cell Format

Cell Format	Band Width	Band Thickness	Binding Tension	Bands per Module
50–100Ah prismatic	15 mm	0.8 mm	8–12 kN	2
280Ah (173×207×71)	20 mm	1.0 mm	15–20 kN	2–3
314Ah (173×207×72)	20 mm	1.0 mm	18–22 kN	2–3
587Ah (207×174×71)	25 mm	1.2 mm	25–35 kN	3–4
628Ah (207×174×72)	25 mm	1.2 mm	28–38 kN	3–4

> **TENSION TOLERANCE**
> Binding tension must be held within ±5% of the specified value across all production units. A tension deviation of 10% produces measurable capacity fade difference after 300 cycles. Use servo-controlled banding equipment with real-time force feedback, not manual tensioners.

3.3 Band Placement Rules

- ☐ Bands placed at 1/4 and 3/4 of module height (not at edges)
- ☐ Band edge distance from end plate: ≥ 15 mm
- ☐ Band-to-band parallelism: ≤ 2 mm deviation over module length
- ☐ Weld joint (band buckle) positioned on module bottom face, not side
- ☐ Insulation pad between band and cell surface: 0.5 mm PET minimum

- [ ] Band tension logged to MES with module serial number

4. End Plate Design Parameters

End plates distribute compression force evenly across the cell stack and provide mounting interfaces for busbars, BMS, and handling features. Poor end plate design causes uneven compression—cells at the edges experience different pre-load than cells in the center.

4.1 End Plate Thickness by Module Size

Module Configuration	End Plate Thickness	Material	Flatness Requirement
1P8S – 1P12S (50–100Ah)	8–10 mm	Aluminum 6061-T6	≤ 0.2 mm/m
1P16S (280Ah)	12–15 mm	Aluminum 6061-T6 or steel	≤ 0.15 mm/m
1P24S – 1P26S (587Ah)	15–20 mm	Steel Q345 or composite	≤ 0.1 mm/m

4.2 Compression Force Distribution

The force distribution across the cell stack depends on end plate stiffness. A thin end plate acts as a beam, concentrating force at the band locations and reducing force at the center.

Equation 2: End Plate Deflection

$$\delta = (F \times L^3) / (48 \times E \times I)$$

where F = band force, L = span between bands, E = elastic modulus, I = moment of inertia

DESIGN RULE

End plate deflection under full band tension must not exceed 0.3 mm. If deflection exceeds this, increase plate thickness or add stiffening ribs. Uneven compression > 0.3 mm produces measurable capacity imbalance after 200 cycles.

5. Compression Fixture Design for Assembly Lines

The compression fixture on the assembly line applies pre-load force *before* busbar welding and maintains it through banding. The fixture must replicate the final module's compression state.

Parameter	Specification
Force range	0–50 kN, servo-controlled
Force accuracy	±2% of target
Parallelism	≤ 0.1 mm across platens
Platen flatness	≤ 0.05 mm/m
Force feedback	Load cell per platen, real-time logging to MES
Cycle time	≤ 30 s (compress + hold + release after banding)

Parameter	Specification
Interlock	Welding cannot start until target force is reached and stable for 2 s

6. Design Example: 280Ah 1P16S ESS Module

Module specification:

Parameter	Value
Cell format	280Ah LFP, 173 × 207 × 71 mm
Configuration	1P16S, 16 cells
Module dimensions	~ 1180 × 220 × 85 mm
Expected cell swelling	0.5 mm per cell over lifecycle
Module stiffness target	800 N/mm

Calculated pre-load force:

$$F_{PL} = 800\ \text{N/mm} \times 0.5\ \text{mm} \times 16 = 6{,}400\ \text{N} \approx 6.4\ \text{kN per band}$$

Total module pre-load (2 bands): 12.8 kN → specified at 15 kN with safety factor

Selected configuration:

Component	Specification
Steel bands	SUS304, 20 mm × 1.0 mm, 2 bands
Band tension	15 kN ± 0.75 kN per band
End plates	Aluminum 6061-T6, 12 mm thick, with 2 stiffening ribs
End plate deflection at 15 kN	0.18 mm (within 0.3 mm limit)
Insulation pad	0.5 mm PET, full-width under each band
Compression fixture force	15 kN, held for 3 s before welding start

Validation result (500-cycle bench test):

Metric	Result
Capacity retention at 500 cycles	**97.2%**
Cell-to-cell ΔV at 500 cycles	≤ 12 mV

KEY TAKEAWAY

The 15 kN binding tension with 12 mm aluminum end plates and 0.5 mm PET insulation produced uniform compression across all 16 cells. The 3.1% tension loss is within the SUS304 relaxation expectation and does not affect module performance.

Metric	Result
Band tension loss at 500 cycles	3.1%
End plate deflection change	< 0.02 mm

7. Production Checklist

Before Module Assembly

- ☐ Cell thickness measured and sorted (Δ ≤ 0.1 mm within module)
- ☐ End plate flatness verified (≤ 0.15 mm/m)
- ☐ Band material certificate checked (SUS304, tensile ≥ 520 MPa)
- ☐ Insulation pads cut to size, no burrs or tears
- ☐ Compression fixture calibrated (load cell verified within 2%)

During Assembly

- ☐ Compression force reached and stable for 2 s before welding
- ☐ Band tension logged to MES per module
- ☐ Band buckle position on bottom face, not side
- ☐ Post-banding dimension check: module length within ±0.5 mm of spec
- ☐ Visual inspection: no band edge cutting into insulation pad

8. Troubleshooting Guide

Symptom	Root Cause	Fix
Band tension drops > 10% after 100 cycles	Band material yield or buckle slip	Upgrade to SUS304; verify buckle weld strength ≥ band tensile
End plate bowing visible	Plate too thin for band tension	Increase thickness or add stiffening ribs; recalculate deflection
Capacity imbalance after 200 cycles	Uneven compression across cell stack	Check end plate flatness; add 3rd band for modules > 16 cells
Busbar weld crack after field deployment	Welding done without compression	Ensure fixture compresses before weld; add interlock
Insulation pad tear at band edge	Sharp band edge or insufficient pad width	Deburr band edges; pad width = band width + 10 mm minimum

About Huiyao Laser

Huiyao Laser Technology (Luoyang) Co., Ltd. manufactures prismatic battery module and PACK assembly lines with integrated servo compression stations, steel band binding equipment, and laser welding systems. Our application engineering team provides module compression validation and band selection support for customer-specific cell formats.

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DOCUMENT VERSION HISTORY

Rev.	Date	Author	Changes
A	2026-08-14	Application Engineering Team	Initial release. Content derived from blog articles on prismatic module steel band binding force, cell construction, and end plate design, plus 40+ module production line data (2023–2026).

Production Log: Source: HTML → PDF via Playwright (Chromium headless). Template: HY-AN-003 Rev. A. Content derived from blog articles *Prismatic-module-steel-band-force-how-to-spec-it*, *prismatic-battery-construction-internal-structure-explained-2026*, *prismatic-cell-end-plate-design-guide-2026*, and *criss-cross-cell-arrangement-battery-module-guide-2026*. Reviewed by: Application Engineering Team. Next scheduled review: 2027-08 or upon new cell format qualification.