# WIRE ROPE SUSPENSION CALCULATION

ISO 4344:2022 · ISO 8100-2:2026 §4.12 · generated by RopeFactor v0.4.169

**DRAFT — not for construction**

## PROJECT INFORMATION

| | | |
|---|---|---|
| PROJECT<br>— | DOCUMENT NO.<br>— | JOB / CALC NO.<br>— |
| CALC DATE<br>— | CUSTOMER<br>— | SPEC SECTION<br>— |
| ENGINEER<br>— | REVIEWER<br>— | COMPANY<br>— |
| BUILDING<br>— | REVISION<br>— | ROPEFACTOR VERSION<br>v0.4.169 |

## PART A · ROPE SELECTION

ISO 4344

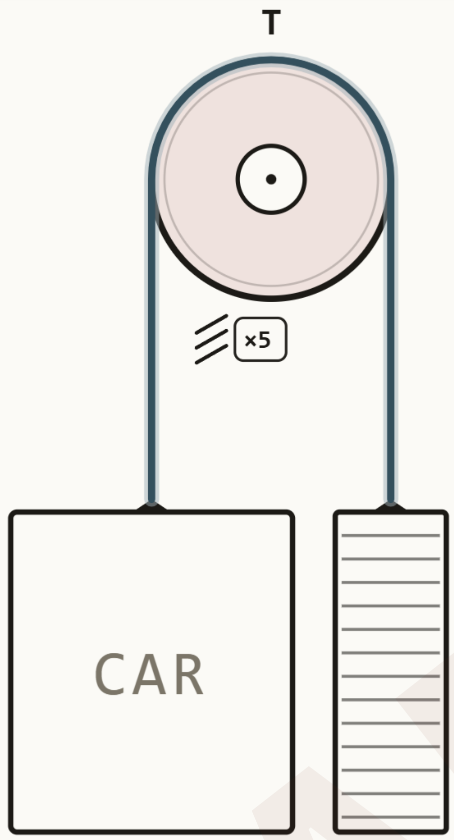
| | | | |
|---|---|---|---|
| Rope (custom) | **8x19 Warrington / IWRC** | | ISO 4344 cl.4 |
| Nominal diameter d | **13.0** | mm | ISO 4344 Table 2 |
| Rope grade | **1770** | N/mm² | R = 1770 |
| MBF (F_min) per rope | **107.00** | kN | Manufacturer certificate |
| *MBF = manufacturer minimum breaking force (from rope certificate) — Custom rope (cert MBF)* | | | |
| Mass per metre m (cert.) | **0.740** | kg/m | Manufacturer certificate |

## PART A · INSTALLATION PARAMETERS

| | | | |
|---|---|---|---|
| Car mass P | **1,450** | kg | job input |
| Rated load Q | **1,600** | kg | job input |
| Counterweight | **2,250** | kg | job input |
| Number of ropes n | **5** | | job input |
| Travel H | **45.0** | m | ~ 147'-7 5/8" · job input |
| Roping ratio | **1:1** | | roping |
| Rated speed v | **1.60** | m/s | job input |
| Traction sheave Dt | **560** | mm | job input |
| Pulleys (simple Nps / reverse Npr) | **1 / 0** | | from reeving |
| Overhead (top landing -> drive-sheave centre) | **4.5** | m | ~ 14'-9 1/8" · drives B5 |

| | | |
|---|---|---|
| Building · floors NF · trips/day | **Office · 12 · 200** | operating profile |
| Groove type · drive wrap | **U-undercut · Single** | ISO 8100-2 Annex |

**REEVING SCHEMATIC — AS COMPUTED, NOT TO SCALE** Roping Studio · read-only




| DT | D | DT / D | α WRAP |
|---|---|---|---|
| **560 mm** | **13.0 mm** | **43.1** | **160°** |
| ROPING | N_S | NPS/NPR | GROOVE |
| **1:1** | **5** | **1/0** | **U-undercut** |

## PART A · SAFETY FACTOR (SF)

ISO 8100-2 §4.12.3

| | | |
|---|---|---|
| Dt / dr ratio | **43.08** | ≥ 40 — ISO 8100-1 §4.5.2.1 (Table 11) met |

*Dt/dr = 560 / 13 = 43.077*

| | | |
|---|---|---|
| N_equiv (pulleys) | **1.000** | Equivalent deflection pulleys |

*N_equiv(p) = (Dt/Dp)^4 × (Nps + 4·Npr) = (560/560)^4 × (1 + 4×0) = 1.000*

| | | |
|---|---|---|
| N_equiv (traction) | **5.0** | ISO 8100-2:2026 §4.12.2.2 Table 2 |

*From §4.12.2.2 Table 2: U-undercut, β = 90° -> N_equiv(t) = 5.000*

| | | |
|---|---|---|
| N_equiv (total) | **6.000** | N_equiv(t) + N_equiv(p) |
| Per-rope tension T_max | **6.31** kN | Controlling: Car side (full load) |

*m·H·N_runs = 0.740 × 45 × 5 = 166.5 kg (hanging rope mass)*

*Car: ((P+Q) + m·H·N_runs)·g / N_runs = ((1,450+1,600) + 166.5) × 9.81 / 5 / 1000 = 6.311 kN*

*CWT: (CWT + m·H·N_runs)·g / N_runs = (2,250 + 166.5) × 9.81 / 5 / 1000 = 4.741 kN; T_max =* **6.311 kN**

*Note: for 1:1 roping m·H·N_runs is the total hanging mass of all rope runs; ÷N_runs leaves m·H per rope.*

| | | |
|---|---|---|
| Sf required (min) | **13.88** | ISO 8100-2 §4.12.3 Formula (36) |

*Formula (36): 10^(2.6834 - log10(695.85×10^6 × N_eq / (Dt/dr)^8.567) / log10(77.09 × (Dt/dr)^-2.894)) = 13.8848*

*Sf_min = max( Formula (36) = 13.885 , flat floor (ISO 8100-1:2026 §4.5.2.2.2) = 12 ) → governing = Formula (36) =* **13.88**

| | | |
|---|---|---|
| Sf actual (computed) | **16.96** | MBF / T_max (per rope) |

*Sf_actual = MBF / T_max = 107.000 / 6.311 =* **16.96**

✓ **PASS** — Sf actual 16.96 ≥ required 13.88

### SAFETY FACTOR — actual vs required

Sf actual
MUST MEET

✓ MEETS **16.96**

*reqd ≥ 13.88*

*Bar = Sf actual · line = required minimum, arrowhead to the safe (reach/exceed) side.*

## PART A · ROPE LOADING

| | | |
|---|---|---|
| % MBF — empty car | **2.81** % | ✓ ≥ 2.5% — IWRC seating floor met |
| % MBF — full load | **5.90** % | Worst-case rope loading |

## PART A · METHODOLOGY & STANDARDS CITED

- *Rope MBF (F_min): ISO 4344:2022 Annex C (F_min = K × d² × R_r / 1000).*
- *Rope properties (mass, metallic area): ISO 4344:2022 Annex D.*
- *T_max: per-rope tension per ISO 8100-2:2026 §4.11.3 Formula (29), static form (a = 0), worst car position.*
- *Safety factor Sf: max of ISO 8100-2:2026 §4.12.3 Formula (36) and the 12 (≥3 ropes) / 16 (2 ropes) flat floor, ISO 8100-1:2026 §4.5.2.2.2.*

- *Out of scope: discard / inspection (ISO 4344 Annex G), guide rails, hydraulic jacks.*

# PART B — Supplemental engineering analyses

SELECTED ANALYSES

## B1 · TRACTION CAPACITY

ISO 8100-2 §4.11 / §4.13.6

*Loading and emergency braking are evaluated against the minimum required traction ratio (available ≥ demand). The stalled / unit-on-buffer condition is evaluated against the maximum permissible ratio for rope slip (available ≤ demand).*

| | | |
|---|---|---|
| Wrap angle α | **160** ° | 2.7925 rad |
| Rope speed v | **1.60** m/s | Car speed × roping |
| Friction f — loading | **0.1849** | μ = 0.100 · §4.13.6.1.2 |
| $f = \mu \cdot 4 \cdot (\cos(\gamma/2) - \sin(\beta/2)) / (\pi - \beta - \gamma - \sin\beta + \sin\gamma) = 0.100 \cdot 4 \cdot (\cos 17.5° - \sin 45.0°) / (\pi - 1.571 - 0.611 - \sin 90° + \sin 35°) = 0.1849$ · Formula 24 | | |
| Friction f — emergency braking | **0.1594** | μ = 0.086 |
| $\mu_{brake} = \mu/(1+v/10) = 0.100/(1+1.60/10) = 0.0862 \rightarrow f_{brake} = f_{load} \cdot (\mu_{brake}/\mu) = 0.1849 \cdot (0.0862/0.100) = 0.1594$ | | |
| Friction f — stalled / on-buffer | **0.3698** | μ = 0.200 |
| $f_{stall}$ = Formula (24) at $\mu_{stall} = f_{load} \cdot (\mu_{stall}/\mu) = 0.1849 \cdot (0.200/0.100) = 0.3698$ | | |
| Loading — available e^(f·α) | **1.676** | ✓ √ PASS · demand 1.607 |
| $available = e^{(f \cdot \alpha)} = e^{(0.1849 \times 2.7925)} = 1.676$ | | |
| Stalled — available e^(f·α) | **2.809** | ✓ √ PASS · demand 8.709 |
| $available = e^{(f \cdot \alpha)} = e^{(0.3698 \times 2.7925)} = 2.809$ | | |
| Emergency braking — available e^(f·α) | **1.561** | ✕ FAIL — emergency-braking traction not met. ISO 8100-2 §4.11.2.2 Formula (23) is a mandatory check, computed with guide-rail friction = 0 per §4.11.3 (unless an ensured minimum is entered). To clear: provide an ensured minimum guide-rail friction (measured or manufacturer-guaranteed), or strengthen the traction (higher-traction groove / better balance / double wrap). · demand 1.846 |
| $available = e^{(f \cdot \alpha)} = e^{(0.1594 \times 2.7925)} = 1.561$ | | |
| *§4.11.3 demand inputs (SI — kg, gn m/s²; force-ratio is dimensionless): P 1,450 · Q 1,600 · G 2,250 · $m_{trav}$ 0.0 · $m_{cr}$ 0.0 · $m_{sr}$ 166.5 · $t_d$ 0.0 · roping r 1 · gn 9.807 · retardation a 0.500* | | |
| Loading $T1/T2 = ((P+1.25Q+m_{trav})/r + t_d + m_{sr}) / ((G+m_{cr})/r + t_d) = ((1{,}450+1.25\times1{,}600+0)/1+0+167) / ((2{,}250+0)/1+0) = 1.607$ (car-bottom); $T1/T2 = \max(\text{bottom}, \text{top } 1.428) = 1.607$ | | |
| Stalled $T1/T2$ (slip) $= \min(\text{car-bottom } 13.514, \text{cwt-bottom } 8.709) = 8.709$ | | |
| Emergency braking $T1/T2 = \max(\text{loaded-low } 1.583, \text{empty-high } 1.846) = 1.846$ — Annex C dynamic form, $m_{sr} \cdot (g_n + r \cdot a)$ with g±a; guide-rail friction = 0 (none ensured, §4.11.3) | | |

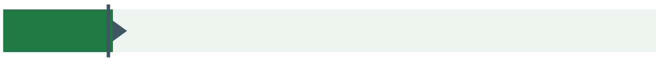
*Dynamic emergency braking (ISO 8100-2 §4.11.2.2 / Annex C C.3–C.6): retardation a = max(input, 0.5 $m/s^2$ floor). Guide-rail (well) friction is taken as zero unless a measured or manufacturer-guaranteed minimum is entered in accordance with ISO 8100-2 §4.11.3; an entered value reduces the demand and is recorded as attested. Pulley rotational inertia is taken as zero; including it would slightly increase the calculated demand.*

*Clause: ISO 8100-2:2026 §4.13.6.1.2 Formulae (24)–(27) (friction f), §4.13.6.1.3 Formula (28) (μ_brake), §4.11.2 (available traction $e^{(f\cdot\alpha)}$), §4.11.3 Formulae (29)/(30) (static loading T1/T2), §4.11.2.3 (stalled T1/T2), §4.11.2.2 / Annex C C.3–C.6 (dynamic emergency-braking T1/T2)*

**✕ TRACTION** loading & braking must grip · stalled must slip

**TRACTION — available vs demand**

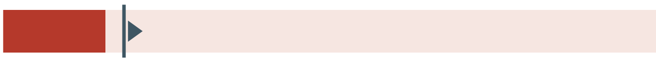
Loading
MUST GRIP



*grip >= 1.61*

✓ GRIPS **1.676**

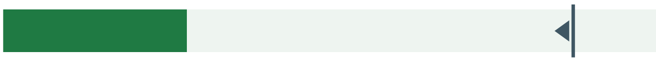
Emergency braking
MUST GRIP



*grip >= 1.85*

✕ FAIL **1.561**

Stalled / buffer
MUST SLIP



*slip <= 8.71*

✓ SLIPS **2.809**

*Bar = available $e^{(f\cdot\alpha)}$ · line = demand T1/T2. Grip rows must reach the line; stalled must stay under it (arrowhead points to the safe side).*

## B2 · ROPE LIFE — BENDING FATIGUE

custom rope · Feyrer 2015

| | | |
|---|---|---|
| Force factors fS1·fS2·fS3·fS4 | **1.485** | combined force factor |

*fS1·fS2·fS3·fS4 = 1.050 × 1.010 × 1.250 × 1.120 =* **1.485**

| | | |
|---|---|---|
| Rope force S / S0 / ΔS | **7,041** N | S0 4,415 · ΔS 2,626 |

*ΔS = S - S0 = 7,041 - 4,415 = 2,626 N*

| | | |
|---|---|---|
| Force-increase fS5 | **1.144** | Feyrer Eq 3.69 (one-sided — conservative) |

*fS5 = 1 + num/den (Eq 3.69), num = (1.31-0.0014·aT·ΔS/$d^2$)·(1.1·ΔS/$d^2$-0.1·S/$d^2$)·aT, den = 145000·(δ/d)·(d/Dt) + 600·(δ/d) + 0.2·aT·S/$d^2$; aT 2.220 · S/$d^2$ 41.661 · ΔS/$d^2$ 15.539 · d/Dt 0.0232 · d/δ 17.0 = 1 + (36.21)/(251.8) = 1.144*

| | | |
|---|---|---|
| Equivalent force S_equ | **8,053** N | S_equ = fS5 · S |

*S_equ = fS5 · S = 1.144 × 7,041 = 8,053 N*

| | | |
|---|---|---|
| Bending length l | **3,750** mm | l = max(accel route, floor pitch) |

*l = max( $v^2/(2a)\cdot 1000$ = 1,280 mm , travel/floors = 3,750 mm ) = 3,750 mm*

| | | |
|---|---|---|
| Groove factor fN3 (Table 3.15) | **0.200** | undercut β = 90° |

*Round and deflector grooves are evaluated at the Feyrer reference r/d = 0.53 (fN3 = 1.00, the only published 1.00 point). For looser groove geometries the calculated service life may be nonconservative. A measured r/d may be entered via the attested override on the groove card.*

| | | |
|---|---|---|
| Endurance factor fC | **1.000** | Feyrer endurance factor (by core) |

*Feyrer N-cycles regression (Eq 3.55): lg N = b0 + (b1 + b3·lg(D/d))·loadFactor + b2·lg(D/d) + lgFd + lgFl*

*b0 -2.064 · b1 1.588 · b2 8.056 · b3 -2.577 · lgFd 0.054 · lgFl -0.055 · loadFactor(S_equ) 1.678*

*Combined bend: $\lg N = -2.064 + (1.588 + -2.577\times1.634)\times1.678 + 8.056\times1.634 + 0.054 + -0.055 \to N = 4.99\times10^6$*

*loadFactor = $\lg(S_{equ}/d^2) - 0.4\cdot\lg(R/1770) = 1.678$ (gradeTerm 0.000); simple/reverse bends use $\lg(S/d^2) \to$ loadFactor 1.620*

| Bending element | n | D/d | fN2 | fN3 | N mean | N 10th |
|---|---|---|---|---|---|---|
| Combined | 1 | 43.1 | 1.000 | 0.200 | 4.99×10^6 | 1.77×10^6 |
| Simple | 1 | 43.1 | 1.000 | 1.000 | 7.09×10^6 | 2.52×10^6 |

| | | |
|---|---|---|
| Rope class | **W-IWRC** | Feyrer construction class |
| Damage per trip Σ(wi/Ni) | **1.14×10^-6** | Palmgren-Miner (Eq 3.70) |

*damage = $\Sigma\, n_i / N_{groove,i}$ where $N_{groove} = N \cdot f_{N2} \cdot f_{N3} \cdot f_C$ ($f_C$ 1.000); summed over the bend rows above $\to 1.14\times10^{-6}$*

| | | |
|---|---|---|
| Trips to discard Z_GF | **8.74×10^5** trips | Z_GF = 1 / damage |
| Holeschak factor f_GF | **0.496** | nF^a (Office) |

*$f_{GF} = n_F^a = 12^{-0.282} = 0.496$*

| | | |
|---|---|---|
| Cycles to discard Z_A (mean) | **1.76×10^6** cyc | Z_A = Z_GF / f_GF (Eq 3.92) |

*$Z_A = Z_{GF} / f_{GF} = 8.74\times10^5 / 0.496 = 1.76\times10^6$ cyc*

| | | |
|---|---|---|
| Z_A10 (10th percentile) | **6.25×10^5** cyc | Feyrer Table 3.14 (b10 scatter) |
| Service life T_AT (mean) | **24.1** yr | Z_A / (trips · 365) |

*$T_{AT} = Z_A / (\text{trips/day} \times 365) = 1.76\times10^6 / (200 \times 365) = 24.1$ yr*

| | | |
|---|---|---|
| Service life T_A10T (10th-pct, design) | **8.6** yr | Z_A10 / (trips · 365) |

*$T_{A10T} = Z_{A10} / (\text{trips/day} \times 365) = 6.25\times10^5 / (200 \times 365) = 8.6$ yr*

## ROPE LIFE — predicted service life

**Predicted service life 8.6–24.1 yr. 10th-percentile estimate 8.6 yr; mean estimate 24.1 yr. Use the 10th-percentile value for planning. Engineering estimate only — no code acceptance criterion is applied.**


*The lower value is the 10th-percentile estimate; the upper value is the mean estimate. Both are derived from the same bending-fatigue model (Feyrer b10 scatter). No code acceptance limit is applied.*

- Feyrer bending-fatigue / Palmgren-Miner estimate. Engineering estimate only; no code acceptance criterion is applied.
- Does not account for sheave material hardness, groove surface quality, lubrication state or sheave-bearing condition.
- fs5 fluctuating-tension is applied one-sided (conservative). fN1 lubrication = 1.0 (well-lubricated assumed).
- Assumes correct installation, alignment within fleet-angle limits, and rope discard at the modeled criterion.
- Predicted life scales with the operating profile (floors, trips/day, building type). Verify these inputs.
- Rope construction: Feyrer's bending-endurance constants are published only for 6- and 8-strand ropes. Ropes with more than 8 strands are credited 8-strand endurance — conservative, as the extra strands are not extrapolated.

• Groove fatigue factor fN3 is tabulated by Feyrer for undercut grooves 75–105° and V-grooves 35–45°. Angles outside these interpolate to the round-groove reference or clamp to the nearest published value (not extrapolated).

• The endurance regression applies within Feyrer's tested ranges (rope class, D/d, rope tension). Results outside the published test ranges should be treated as extrapolations.

Clause: Feyrer 2015 (2nd ed.) Eq. 3.55/3.69/3.92; Palmgren-Miner (Eq 3.70)

## B3 · GROOVE PRESSURE

informational — no pass/fail

*Groove type U-undercut -> pressure model selected accordingly. p0 is the round-seat reference pressure.*

| | | |
|---|---|---|
| Seat geometry (entered) | **β = 90°  γ = 35°** | Undercut angle β / V-included angle γ — drive the friction model and ψ |
| Max line pull S_max | **6,341.27** N | Worst-case rope tension (full car, lowest landing) |
| Round-seat reference p0 | **1.742** N/mm² | p0 = 2·S_max / (d·D) — Feyrer Eq 3.27a |
| *p0 = 2·S_max / (d·D) = 2 × 6,341.27 / (13.00 × 560.0) = 1.742 N/mm²* | | |
| Geometry factor ψ | **5.302** | γ1=β/2=45.0°, γ2=90-γ/2=72.5° — Feyrer §3.1.7.2 Eq 3.31 (Donandt) |
| *ψ = cosγ1 / (0.25·sin2γ2 + 0.5·γ2 - 0.25·sin2γ1 - 0.5·γ1), γ1=45.0°, γ2=72.5° (angles in rad for the linear terms) = 5.302* | | |
| Specific pressure k_max | **9.236** N/mm² | k_max = ψ · p0 — undercut (Feyrer §3.1.7.2 Eq 3.31) |
| *k_max = ψ · p0 = 5.302 × 1.742 = 9.236 N/mm²* | | |
| Reported specific pressure | **9.236** N/mm² | undercut k_max |

No code acceptance limit is applied. Specific groove pressure is reported for durability and wear comparison. undercut concentrates pressure ψ× above the round p0 (Donandt Eq 3.31).

Clause: Feyrer 2015 (2nd ed.) §3.1.7.2 Eq 3.31 (Donandt; ψ·p0 undercut) — no code pressure limit (ISO 8100-2 / A17.1-A17.6)

## B4 · ROPE DYNAMICS — RESONANCE SCREEN

*Inputs (longest rope): M 3,050 kg · nsr 5 · msr 0.740 kg/m · E 77,000 N/mm² · A 77.2 mm² · L 49.50 m · gn 9.807 m/s²*

| | | |
|---|---|---|
| Lateral f1 / f2 / f3 (lowest) | **0.922** Hz | f2 1.843 · f3 2.765 |
| *f1 = (1/2L)·sqrt(M·gn/(nsr·msr) + L·gn/2) = (1/(2×49.50))·sqrt(3,050×9.807/(5×0.740) + 49.50×9.807/2) = 0.922 Hz · f2 = 2f1 = 1.843 · f3 = 3f1 = 2.765* | | |
| Longitudinal f (lowest) | **2.234** Hz | Bounce mode (longest rope) |
| *f = (1/2π)·sqrt(nsr·E·A/(L·M)) = (1/2π)·sqrt(5×77,000×77.2/(49.50×3,050)) = 2.234 Hz* | | |
| Lateral f1 / long f (top) | **10.004** Hz | long 7.408 Hz (shortest rope L 4.50 m) |
| Sheave 1× · once per rev | **0.909** Hz | clear |
| *1× = i·V/(π·Dt) = 1×1.600/(π×0.5600) = 0.909 Hz · 2× = 2×0.909 = 1.819* | | |
| Sheave 2× · twice per rev | **1.819** Hz | coincidence |
| Building / other coincidence | **clear** | clear (other) |

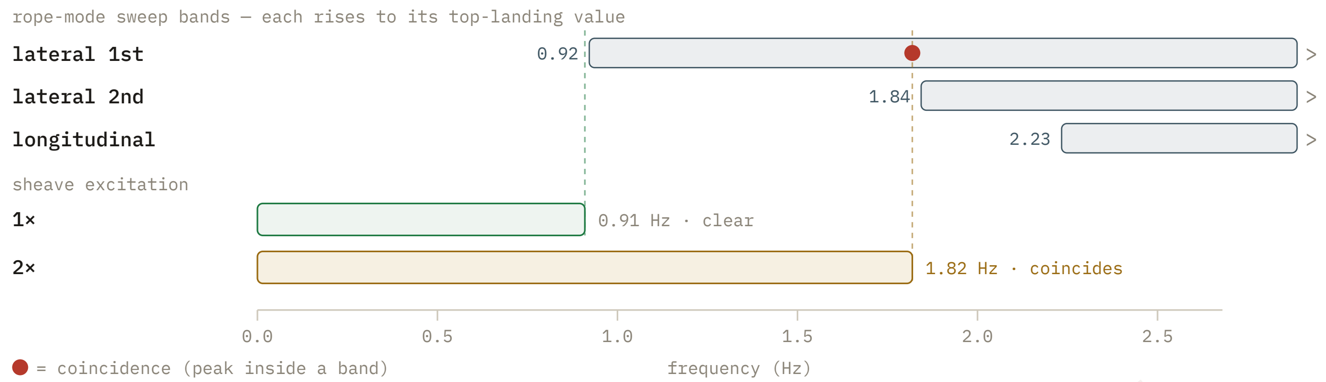
| Frequency separation ε | **0.006** | <<1 -> quasi-stationary valid (snapshot OK) |
|---|---|---|

*ε = V/(2π·f1·L) = 1.600/(2π×0.922×49.50) = 0.006*

⚠ **MONITOR** Frequency crossing identified (2× sheave). This screening calculation identifies frequency crossings only; it does not predict vibration amplitude or duration. Review the identified excitation frequencies.

**DYNAMICS — resonance map**

**2× intersects the lateral-1st rope-mode frequency range mid-travel; 1× clear by 1.3%.**




Snapshot valid: ε = 0.006 ✓ — quasi-stationary validity ratio (is the snapshot frequency valid), NOT the resonance gap.

*Resonance map: rope-mode sweep bands (top — each starts at its lowest-landing frequency and rises right to its top-landing value, off the axis) versus sheave-excitation harmonics (bottom — 0 -> peak). A dashed guide and a dot on a band mark a mid-travel coincidence (the peak lands inside that band). Green = clears every band; amber = enters one or more. lateral 3rd (2.77 Hz) above range, clear.*

The two sheave rows are its first two rotational harmonics: 1× is one excitation per revolution (eccentricity / imbalance), 2× is two per revolution (out-of-roundness / ovality). Both are screened because a real sheave can carry either imperfection, and either frequency can coincide with a rope mode.

[1] Lateral (string) frequencies use Sun's rope-weight correction: f=(n/2L)sqrt[M·g/(nsr·msr)+L·g/2] (Eq 5). The +L·g/2 term (half the rope's own weight) raises the frequency above the bare-string value and makes it fall off less steeply with length — important for long, high-rise ropes.

[2] Longitudinal (axial bounce) fundamental: f=(1/2π)sqrt(nsr·E·A/(L·M)) (Eq 1). The car bounces on nsr ropes in parallel, so the axial stiffness is nsr·E·A/L (A is per-rope); the source eigenvalue Eq 13 reduces to this in the fundamental limit. Harmonics also exist (Eq 12); only the fundamental is shown here.

[3] Frequencies are computed at the lowest landing (longest rope = lowest frequency) and the top landing (shortest rope = highest), and swept between. Transient resonance occurs where a rope frequency crosses an excitation — characteristically near the top, where the rising frequencies meet the excitations.

[4] Quasi-stationary check (ε, Eq 8): when ε<<1 the moving car can be treated as stationary at each position, so the snapshot frequencies are valid. ε is small for all normal speeds (the paper's worst case at 12 m/s was 0.067).

[5] Building sway: tall buildings sway at low frequency in wind (~0.1–0.3 Hz); if a long rope's fundamental coincides, resonant rope sway can result (Sun 1995). Enter the building's sway frequency if known; mitigation hardware is covered by A17.1 §2.30 (sway control guides).

[6] Sheave excitation uses the ROPE speed over the sheave (i·V), not the car speed — so for 2:1 it is doubled. The "other excitation" input may be used to evaluate an additional specified excitation frequency (drive or mains harmonic, guide-joint passing frequency = V ÷ rail length, etc.).

[7] Scope: resonance and sway only. Per Bethlehem EL-TB-11, field "noisy rope" reports frequently originate from rope-to-groove size mismatch, differential groove depths, sheave misalignment or bearing condition, none

of which are determined by a frequency calculation. Where calculated rope-mode frequencies remain separated from the entered excitation frequencies, no coincidence is reported.

[8] Undamped natural frequencies (steel rope damping is small, per the source). 2:1 uses L = travel + overhead for the car-side run; verify against the installed rope length if a precise high-rise figure is needed.

Sources: P. Andrew & S. Kaczmarczyk, "Rope Dynamics," Elevator World, July 2011 (Eq 1 longitudinal, Eq 5 lateral w/ Sun correction, Eq 8 ε). L. Sun, "Building Sway and Elevator Rope Vibration," Elevator World 1995. S. Kaczmarczyk, J. Sound & Vibration 208(2) 1997. K. Feyrer, Wire Ropes (2015) §2.2.4. Field context: Bethlehem Elevator Rope Technical Bulletin 11 (Vibration). Mitigation hardware: ASME A17.1 §2.30 (Sway Control Guides).

The screening method identifies frequency crossings only and does not distinguish a transient crossing from sustained resonance. It is intentionally conservative and may identify crossings that do not result in significant rope response. Investigate identified excitation sources.

Clause: Andrew & Kaczmarczyk EW Jul 2011; Feyrer Eq 2.57/2.67/2.68

## B5 · ROPE ELONGATION

| | | | |
|---|---|---|---|
| Rope class · metallic area A | **77.23** | mm² | 8-strand · steel core |
| $A = C \cdot d^2 = 0.4570 \times 13.00^2 = 77.23\ mm^2$ | | | |
| Rope modulus E | **77,000** | N/mm² | Effective rope elastic modulus — class lookup (CIMAF modulus table) |
| Rated-load force T | **15,691** | N | T = (Q/i)·gn |
| $T = (Q/i) \cdot gn = (1{,}600.0 / 1) \times 9.80665 = 15{,}691\ N$ | | | |
| Suspension length L | **49,500** | mm | travel + overhead |
| $L = travel + overhead = 45{,}000 + 4{,}500 = 49{,}500\ mm$ | | | |
| Elastic stretch δ | **26.121** | mm | δ = T·L / (E·A·n) — Hooke, shared across n ropes |
| $\delta = T \cdot L / (E \cdot A \cdot n) = 15{,}691 \times 49{,}500 / (77{,}000 \times 77.23 \times 5) = 26.1\ mm$ | | | |
| *Elastic stretch per metre = 0.528 mm/m* | | | |
| Constructional stretch (low / high) | **74.250** | mm | 0.15–0.35% of L — permanent bedding-in |
| $Constructional = 0.15\text{–}0.35\% \times L = 74.250\text{–}173.250\ mm$ | | | |
| Total elongation (low / high) | **100.371** | mm | total = δ + constructional · high 199.371 mm |
| $Total = \delta + constructional = 26.121 + 74.250 = 100.371\ mm\ (low)\ \ldots\ 199.371\ mm\ (high)$ | | | |

[1] Elastic stretch is calculated using rated load only (Eq 6: T=(Q/i)·gn). Empty car, hoist ropes, compensation and travelling cable are permanently suspended, so their stretch forms part of the constructional (permanent) stretch rather than the temporary levelling swing. The elastic load case is therefore smaller than the Sf T_max load case.

[2] L is the car-side rope length at the lowest landing = travel + overhead (+ another travel if the machine is bottom-mounted, which doubles the run). This matches the physics of the leveling drop and the standard car-side rope-length basis (travel + overhead, with drive-height and bottom-mount terms as applicable). If overhead is left blank it is treated as 0 and L is flagged as a lower bound. For 2:1, the car-side path is longer — verify against installed rope length if a precise figure is needed.

[3] Area factor C and modulus E are tabulated by 6- vs 8-strand class: ≤7 strands use the 6×19 row, ≥8 use the 8×19 row. These constants depend chiefly on strand count and core type, not the exact wire count.

[4] Modulus E varies with construction, manufacturer and load range, and rises ~20% once used / pre-stretched. Elevators run in a low load range (~2–10% of MBF) where E sits at the lower end, so the 0–20% values are used. Elastic stretch scales inversely with E; treat the figure as a nominal estimate.

[5] Constructional stretch cannot be calculated exactly and is reported as a percentage range of loaded rope length (permanent, bedding-in over the first weeks of service). Manufacturer data should be used where available. Heavier load and more bends push toward the high end; pre-stretching reduces it (BRIDON). Field rule of thumb ~ 3.5 mm per metre.

[6] Construction and core are taken from the entered rope data. Elongation is not calculated for catalogue-only rope selections.

[7] Some elevator stretch calculations report a different quantity — they load the rope with car + ½ rated load + ½ rope weight (Tload) rather than rated load alone — so their stretch figure is larger; this sheet follows the cited elevator source (rated-load swing) by design. The rope-LENGTH basis matches that convention (see note 2).

[8] Out of scope: thermal expansion (Eq 8) and plastic/permanent stretch (only above the yield point — unrealizable at a suspension Sf ≥ 12).

Sources: M. Hadjzaman, "Traction Elevators: A Comparative Study on Wire Rope Stretch," Elevator World, Feb 2018 (Eq 1 / 3 / 6). W. Scheunemann, W. Vogel & T. Barthel, "Steel Wire Ropes for Traction Elevators," Elevator World, July–Sept 2009 (elongation behaviour, rope-length). Bethlehem / Wirerope Works EL_TB_05. K. Feyrer, Wire Ropes (2015). EN 12385-2 & ISO 17893 (area factor). ISO 12076 (rope modulus test). AISI Wire Rope Users' Manual; BRIDON; CIMAF; Gustav Wolf (VDI 2358).

Clause: Hadjzaman EW Feb 2018 (EN 12385-2 / ISO 17893); CIMAF modulus; AISI WRUM constructional

## ROPE & CABLE ORDER ESTIMATE

PLANNING FIGURE — NOT PART OF THE CALCULATION

| | | |
|---|---|---|
| Reeving configuration | **Overhead 1:1** | from the job's roping + machine position |
| Rise / travel | **45.00 m** | job input |
| Overhead | **4.50 m** | top landing (floor level) -> centre of the drive sheave · job input |
| Pit depth | **1.60 m** | order-estimate input |
| Governor rope | **Yes** | order-estimate input |
| Allowance — hoist extra | **7.62 m** | default (field left blank) · added to every hoist rope before rounding |
| Allowance — double wrap | **6.10 m** | default (field left blank) · not applied — single-wrap drive |
| Allowance — governor rope | **6.10 m** | default (field left blank) · added to the governor-rope run |
| Allowance — compensation | **15.24 m** | default (field left blank) · not used — no compensation |
| Round increment | **5 m** | order lengths round UP to this |
| Order per hoist rope | **65 m** | base 55.60 + extra 7.62, rounded up |
| *Order/rope = ROUNDUP((55.60 + 7.62) / 5) × 5 = 65 m* | | |
| Hoist ropes — total | **325 m** | 65 m × 5 ropes · ~ 241 kg |
| Governor rope | **110 m** | qty 1 · +6.10 m governor allowance (default (field left blank); not the hoist extra) · weight per governor-rope spec |
| *Governor = ROUNDUP((2×45.00 + 2×1.60 + 2×4.50 + 6.10 allowance) / 5) × 5 = 110 m* | | |

Rope & cable order estimate (planning figure). Overhead is measured from the top landing to the centre of the drive sheave; a double-wrap allowance is added when the drive is double-wrapped. Every allowance is stated above with its source (default or entered). Verify against the GA layout and rope-shop practice before ordering.