ACFR CONDUCTOR INSTALLATION GUIDELINE

(April. 2025)

1 ALUMINUM CONDUCTOR FIBER REINFORCED

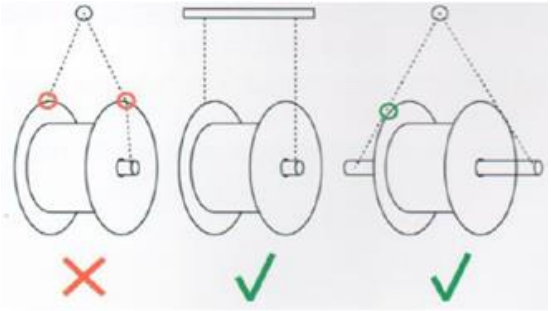
1.1 ACFR conductor uses a high-strength stranded composite core (Carbon Fiber Composite Cable: CFCC) which consists of carbon fibers and thermoset resin matrix. CFCC has 1/5 the weight and 1/12 the thermal expansion coefficient compared to conventional stranded steel wire. The reduced weight of the composite core and lower coefficient of thermal expansion allows the ACFR to carry up to twice the current of conventional conductors while lowering transmission losses.

1.2 Stranded construction of the CFCC provides flexibility, structural redundancy and practical handling. Flexibility of the core translates into lesser chance of breaking the core which prevents re-work and saves time during installation process. Conventional ACSR installation techniques can be used. The upgradation of tools required for installation of ACFR is minimum.

1.3 ACFR conductors are relatively flexible and can tolerate some abuse and round bending to some extent; however, **care shall be taken to avoid sharp bending, twisting and crushing.**

2 TRANSPORTATION AND BASIC HANDLING

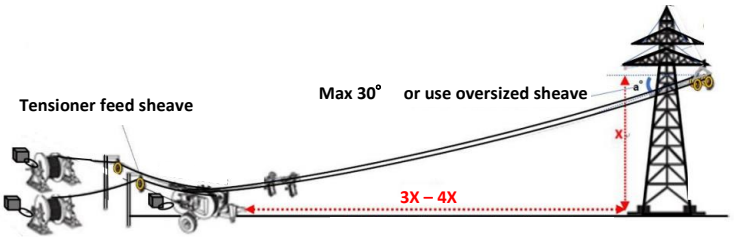
2.1 Conductor drum should remain in vertical position at any stage during transportation in a manner that the reel flanges are not damaged. It is always recommended to store drums inside.



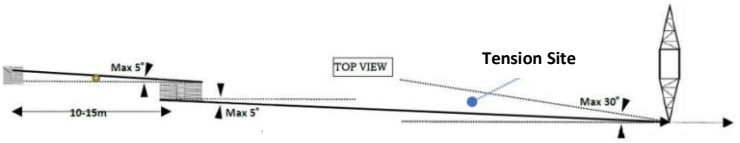
2.2 To rewind, assure that each wrap of the conductor does not cross over. Assure that conductor does not bend more than allowable bend diameter of 40 x conductor diameter at all times. Conductor should not bend, kink, twist, and surface condition should be maintained.

3 TENSION STRINGING METHOD

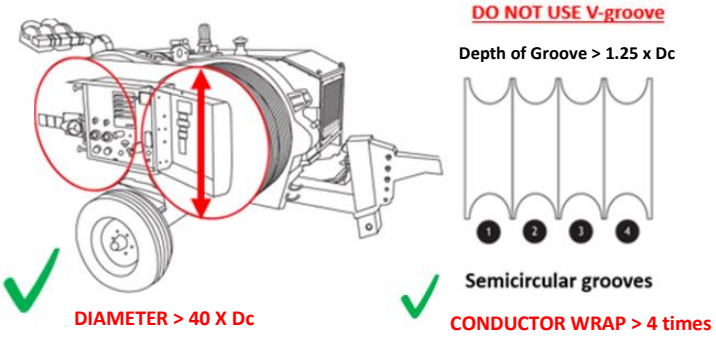
3.1 Tension site



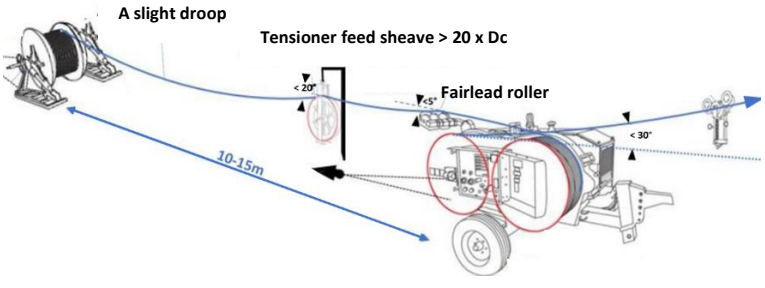
- The puller and tensioner shall be positioned at a distance of min. 3 times the height of the 1st sheave of the phase being strung which corresponds to an entering angle of < 30 degrees.
- In case that this 3:1 rule is not achievable, larger or tandem sheave(s) should be used at the 1st structure or the height of the sheave may be lowered to reduce the entering angle to achieve < 30 degrees.
- The tensioner and the 1st structure sheave shall be aligned with the planned direction of pull. Drum-Tensioner should be positioned in a manner that 1st structure sheave – Tensioner – drum are lined up straight within recommended deviation below.



- **Bull wheel diameter > 40 x Conductor diameter (Dc)**
- Depth of Groove (Dg) > 1.25 x Dc
- Wrapping of conductor over capstan > 4 wraps
- Deviation in drum-tensioner alignment < 5°



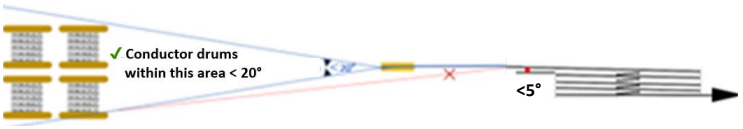
- Conductor should not be twisted, bent or abraded.
- **Tensioner feed sheave** should be used in between drum and the fairlead.
- Conductor(s) should not be bent at the fair lead roller.



- Laying direction of the outermost layer should be checked to avoid loosening of the strand. Deviation from the planned direction of withdrawal should be < 5° .

Right-hand lay ("Z") conductor Left hand lay ("S") conductor

- Conductor can be withdrawn from within 20° angle deviation from the tensioner feed sheave.

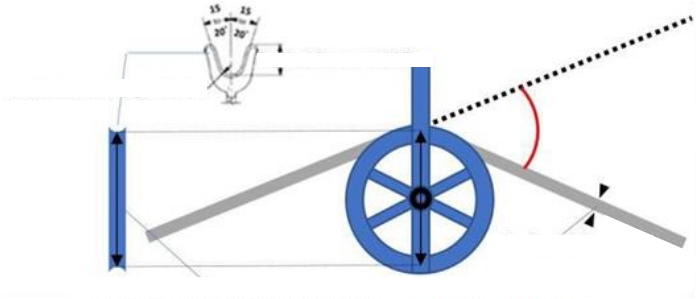


- **The braking force should be kept minimum necessary** and should not exceed 4.5kN. Excessive braking can cause the top wrap of conductor to "crush down" into the underlaying wraps.

- **A slight droop** indicates good back tension to draw conductor smoothly and also to prevent over-rotating backlash or free-spooling when the pulling stops.

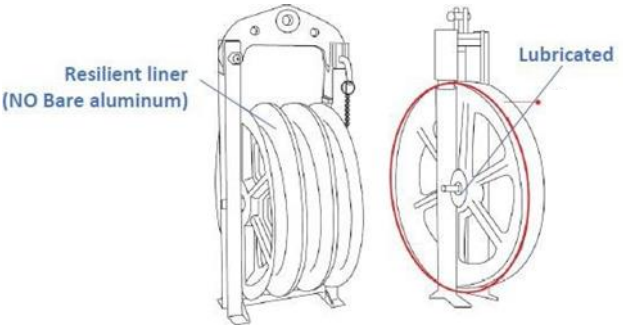
3.2 Running Sheaves

- **A minimum bottom groove diameter (Ds) of 20 x conductor diameter (Dc) and > 60 x core diameter** (whichever bigger should apply) is generally recommended for typical pulls (less than 60°).
- Radius of groove (Rg) and Depth of Groove (Dg) of the sheave should be checked as per conductor size/construction.

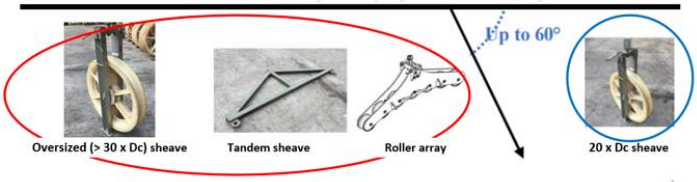


Number of layers of Aluminum wires	Radius of Groove (Rg)		Depth of Groove (Dg)
	Minimum	Maximum	Minimum
1 or 2	0.55 x Dc	1.100 x Dc	1,25 x Dc
3	0.55 x Dc	0.750 x Dc	1.25 x Dc
≧4	0.55 x Dc	0.625 x Dc	1.25 X Dc

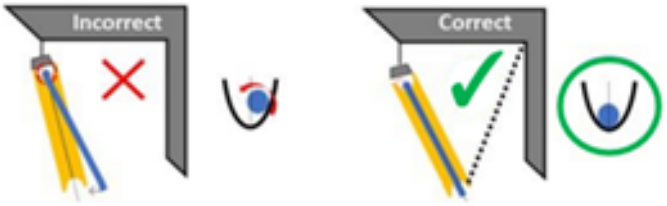
- Sheaves with resilient liner material are recommended. Bare metal sheaves are not recommended for annealed aluminum conductor as it may damage the surface of the conductor.



- All sheaves must be checked for load rating and in smooth rotating condition without damage and properly lubricated prior to use.
- **Selection of diameter of sheaves:**
  - for pulling angles **< 60°** : > 20 x Dc
  - for pulling angles **> 60°** : Oversized (>30 x Dc), Tandem sheaves, or Roller array

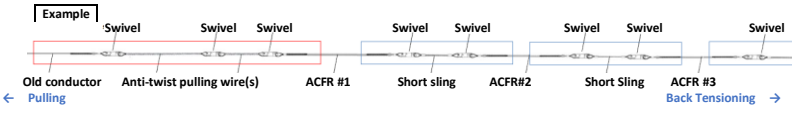


- Sheave alignment at angles:
- Conductor(s)must **run in the center of the groove** to avoid unnecessary rotation of the conductor



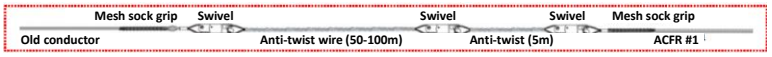
3.3 Back-to-Back Pulling

For back-to-back pulling, it is critical to use proper **torsion-releasing techniques** as torsional stress can be transferred from the old conductor (front) and/or come from newly installed conductor (behind) in case of over-tensioning situation.



- Recommended max. pulling tension is about **10% of Conductor RTS.** Sagging tension should never be exceeded.
- Recommended pulling speed: **5-8km/h**. Change of pulling speed and tension should be gradual.

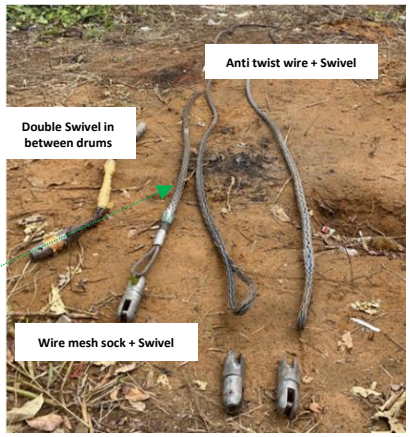
- As a guideline, recommended pulling spans is **< 20 spans and/or 3 drums** to avoid unnecessary increase in pulling tension. In case that site conditions do not allow, please consult with TRI's installation expert.
- It is recommended to use proper torsion releasing swivel(s) at every connection. **Use of swivel(s) and anti-twist wire** between the old conductor and new conductor is recommended.



Old conductor → Pulling wire(s) + Swivels → New conductor #1

New conductor#1 → Swivel(s) → New conductor #2 (and onwards)

- Pulling wire should be lighter than the conductor to avoid an increase in pulling tension.
- In case that the old conductor is used as pulling line, it must be assured that it is entirely free from any damage.
- Core at all conductor ends must be bound with binding wire to **keep the core from slipping inside** the aluminum layers.



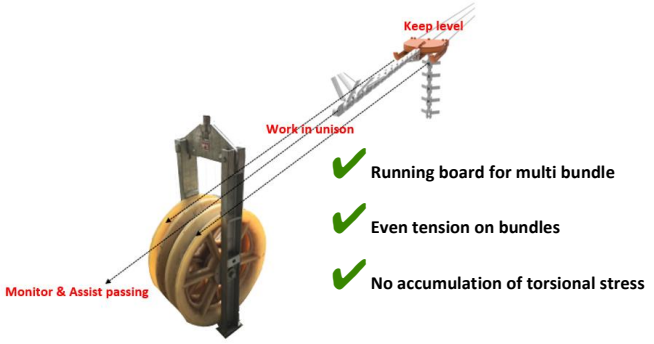
- A correctly sized woven wire mesh grip to fit over the conductor with adequate length should be used. Grip must be secured to prevent slipping.
- Wire mesh sock which does not allow usage of swivel in between drums should not be used.
- Avoid pulling splices through sheaves (Tandem sheaves and protection are required if inevitable). **Splices are usually installed after conductor is pulled into place.**

- Excessive accumulation of torsional stress into short section of conductor will result in distortion of aluminum strand (bird-caging - loosening or squeezing - tightening) which may affect conductivity of the conductor.

- Prior to sagging, installers must visually inspect the condition of the conductors and spot distorted portions of aluminum layers and evaluate the damage in terms of electrical conductivity and mechanical strength. (refer to *7. REPAIR*)

3.4 For pulling multi bundles, use of running board is recommended to keep the conductors from toppling over.

- The weight of the running board shall be sufficient to prevent conductor rotation.
- Accumulation of torsional stress behind the running board should be avoided.
- Tension on bundles should be equalized.

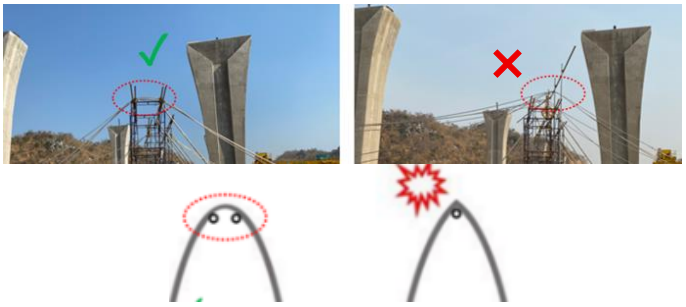


4 SLACK AND LAYOUT METHOD

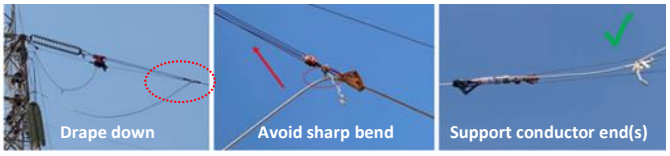
- Slack and Layout method is applicable when maintenance of conductor surface condition is not critical (or matting to protect the conductor surface is provided). This method is not desirable for:
  - Annealed aluminum conductor
  - Urban locations
  - Crossing traffic or energized circuits
  - Hilly terrain

5 MANUAL STRINGING METHOD

- Avoid damaging the soft aluminum layers by dragging the conductor on the ground or over obstacles.
- The conductor should not be dropped or pulled over obstacles or edges such as rocks, walls, fences etc. All obstacles along the way shall be treated in a manner that will not cause excessive bend or dragging on the surface of the conductor.



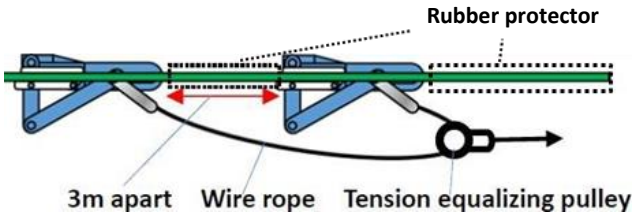
- It is okay to drape slack the conductor across small roller but it would not be acceptable if the bend were sharp and the conductor were under tension.
- Particular care shall be taken when lifting up the conductor not to allow sharp bends of the conductor.



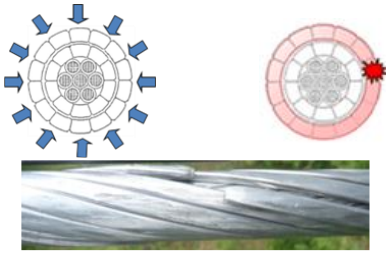
6 SAGGING AND CLAMPING

6.1 It shall be assured that the grip does not over-tension or deform individual strand and capable of holding the conductor to the highest tension anticipated. Any grips, which transmit excessive crushing force to the core, should not be used.

6.2 In case of gripping for higher tension for long span or extra redundancy is needed, double/tandem gripping is recommended.

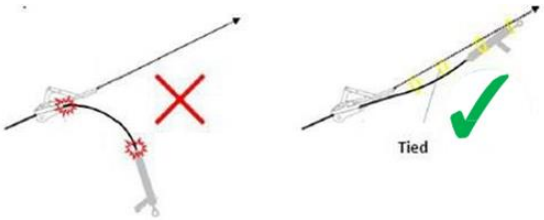


6.3 Conductor using 0-temper aluminum with diameter below 24 mm is recommended to be double gripped and/or it is advisable to use tandem gripping if the tension on conductor is > aluminum outer layer strength.



6.4 In case that installation of dead-end clamp takes place on the ground, **caution shall be used to avoid sharp bending of the conductor at the grip.** Full size sheave (> 20 x Dc) is recommended to be used in between conductor grip and conductor end. (sheave position at 3meters away and slightly below conductor grip is recommended).

6.5 During lifting operation of preinstalled dead-end and/or insulator assembly, it must be ensured that the **conductor(s) do not experience excessive bending.**

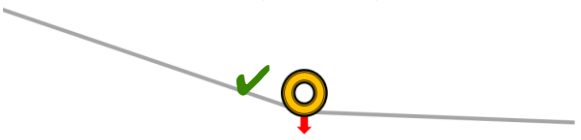


6.6 In case that installation of Dead-end clamp takes place on tower, **conductor end(s) must be always supported.**

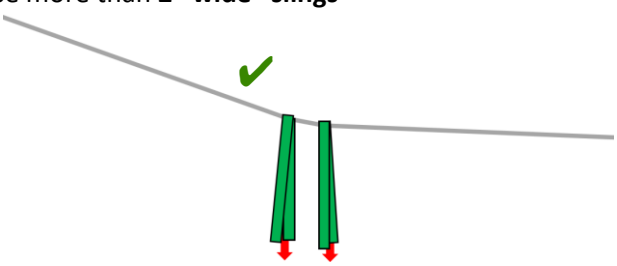
6.7 Installation of splices on ground:

- **Do not use narrow rope or sling for holding-down and/or letting-up conductor(s)**

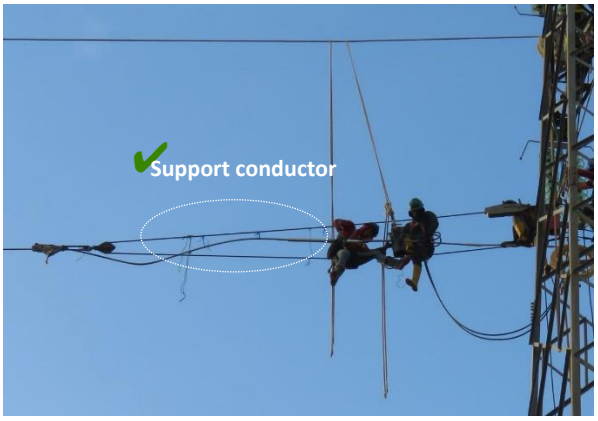
- Use **hold-down sheave** (> 20 x Dc) or



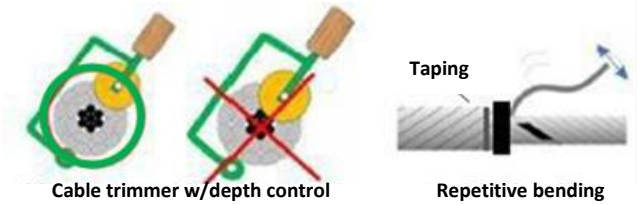
- Use more than **2 "wide" slings**



6.8 In case that installation of splices takes place on tower, **conductor end(s) must be always supported.**

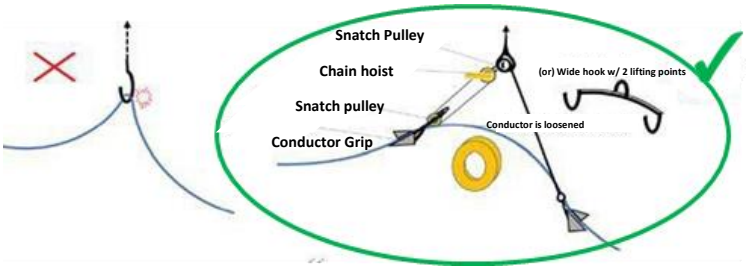


6.9 Cutting the conductor: stripping of aluminum layer shall be done by cable trimmer. The bottom layer shall be stripped by repetitive bending fatigue only. The core shall never be nicked or scratched during the stripping.



6.10 The final cutting of the core must be done by fine-tooth hacksaw or disk cutter to produce a clean cut. It is not recommended to use hydraulic cutter as it may not produce clean cut.

6.11 Appropriate wire lifting hook should be used when transferring the conductor(s) from the running sheaves to suspension clamps.



7 REPAIR:

7.1 Repairing of conductors should be carried out to achieve both electrical conductivity and mechanical strength requirements. In case that damage on the core is observed, damaged section of the conductor should be cut and removed, and full tension splice should be installed.

Repair method	Extent of Damage				
	Number (or %) of damaged aluminum strands in the outer layer			Damage on inner aluminum layer	Damage on CFCC core
	1 (or < 10%)	2 (or ≅ 10%)	More than 2 (or > 10%)		
Armor Rod	✓				
Repair Sleeve	✓	✓	✓	(✓)	
Replace with new conductor				(✓)	✓

8 REFERANCES:

8.1 IEEE 524 Guide for the installation of Overhead Transmission line Conductors (2016)

8.2 IEEE 516 Guide for Maintenance Methods on Energized Power Lines (2003)

8.3 Power line safety 1926.1409 Occupational Safety and Health Administration (2010)

8.4 TLT-5 Kasen kouji gijyutu Kaisetsu, Denki-Shoin (2010)

8.5 Japan TX Line Construction Committee (Soudensen-Kensetsu-Gijyutsu- Kenkyukai) No.22 (Dec.1994)